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DISCUSSION PAPER

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DEMAND FOR HOUSING AND URBAN SERVICES IN BRAZIL: A HEDONIC APPROACH[1]

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SUMÁRIO

SINOPSE

O objetivo do presente artigo é fornecer uma estimativa da demanda por habitação e serviços urbanos nas principais regiões metropolitanas (RMs) brasileiras, como subsídio para a elaboração de políticas públicas na área de desenvolvimento urbano. A abordagem teórica utilizada é o modelo de preços hedônicos (Rosen, 1974), o qual relaciona o preço com as diferentes características do imóvel. Os dados utilizados derivam da Pesquisa Nacional de Amostras por Domicílio (Pnad) do Instituto Brasileiro de Geografia e Estatística (IBGE) para o ano de 1997, englobando dez RMs. Verificou-se que a provisão de serviços urbanos como água, esgoto e coleta de lixo pode aumentar significativamente o preço dos imóveis nas cidades brasileiras, o que implica que tais políticas podem ter forte impacto redistributivo. Entre as RMs estudadas, São Paulo apresentou os aluguéis mais elevados, independentemente das características dos imóveis. A importância do presente estudo reside em tentar avaliar o impacto das políticas urbanas por meio da análise de regressão, o que permitiria aos formuladores de política obter informações mais detalhadas sobre a natureza da demanda por habitação – com respeito às preferências dos consumidores pelos diferentes atributos e níveis de provisão dos serviços urbanos da moradia –, bem como sobre a capacidade de recuperação de custos e os impactos dos diferentes programas do governo na área de habitação, saneamento e desenvolvimento urbano.

ABSTRACT

This paper seeks to estimate the demand for housing and urban services in the major Brazilian metropolitan areas (MAs), as a contribution for the formulation of public policies of urban development. The theoretical approach used is the hedonic prices model (Rosen, 1974), which relates price with the property characteristics. The data was obtained from the 1997 National Household Survey (Pnad), published by the Brazilian Institute of Geography and Statistics (IBGE), encompassing 10 MAs. We have verified that the provision of proper housing and urban infrastructure services can significantly increase property prices in metropolitan areas, implying that such policies may have strong redistributive impacts and can be used to fight urban poverty in Brazil. Among the MAs studied, São Paulo presented the highest average rent, independently of the characteristics of the properties. The importance of the present study resides in trying to evaluate the impact of the governmental urban policies through regression analysis, what would allow policy makers to obtain more detailed information on the nature of housing demand – regarding the consumers' preferences for the different attributes of the house and levels of provision of urban services – as well as on the capacity of cost-recovery, and the social impacts of the different housing, sanitation and urban development programs.

1 INTRODUCTION

The construction sector participates with approximately 68,0% of the Brazilian Gross Fixed Capital Formation (IBGE, 1997) and is also responsible for employing a large amount of non-qualified labor. The housing sector in particular, has a strong impact on the reduction of poverty[1] and housing deficit[2] in Brazil, with important implications to policy-making.

Despite the importance of the housing sector to the Brazilian economy, studies with theoretical and empirical foundations are still scarce in the country. This paper is an attempt to aid policy-makers to obtain estimates on the nature of the demand for housing attributes, including the levels of provision of urban infrastructure services, as well as on the capacity of cost-recovery of the governmental housing and sanitation programs. It also seeks to identify the way by which such programs affect the welfare and the patrimony of their target population.

Given that different levels of access to urban infrastructure affect significantly the property values, the use of hedonic regressions can provide, furthermore, the bases for the calculation of a specific tribute, the betterment fee ("contribuição de melhoria"), that is hard to implement in practice because of the difficulties to appraise to what extent the provision of urban infrastructure contributes to a change in property values.

This paper is divided into 5 parts, besides this introduction. Section 2 describes the theoretical model. Section 3 presents a review of the empirical works that have used hedonic price models with emphasis on studies carried out in Brazil concerning the Housing Market and articles that have applied hedonic analysis to the formulation of housing and sanitation policies. Sections 4 and 5 describe the data, the methodology and the empirical results. The last section presents the conclusions and suggests new themes for the research agenda on Housing in Brazil.

2 THEORETICAL FRAMEWORK: THE HEDONIC PRICES MODEL

In economic theory, housing has frequently been regarded as a durable good, characterized by its various attributes, that can be independently analyzed.

Hence, housing can be classified as a heterogeneous good with peculiar characteristics such as location, size and quality of construction, among others. Housing demand can, therefore, be thought as a function of the various attributes or characteristics of the property. This approach became known in the literature as the

1. Rocha (1998) estimates that the number of Brazilian poor is around 30 million people (30,0% of which living in metropolitan areas).

2. The official figures for the Brazilian housing deficit are 5,6 million of units, caused mostly by cohabitation (63,0%) and concentrated in the population that earns up to 5 Brazilian minimum wages (85,0%) and in the Northeastern region of the country (44,7%), according to Brasil/Sepurb/Fundação João Pinheiro (1995). However, a study carried out by Ipea suggests that 99% of the cohabitation in Brazil is among relatives, which is not necessarily bad and does not represent a housing deficit in every case. These results show the need for further research in this area.

hedonic or implicit prices models, where hedonic prices can be interpreted as shadow-prices, reflecting the flow of return of certain property attributes.

One of the first works on the demand for the attributes of heterogeneous goods was written by Waugh (1928), who estimated the variation of vegetable prices in Boston. Griliches (1961) applied the regression analysis to evaluate the effects of quality changes in car prices, as did Fisher et al. (1962), Cagan (1965), Triplett (1966) and Dhrymes (1971). Chow (1967) studied the demand for computer services in United States from 1955 to 1965. Recently, hedonic prices models have been applied to assess environmental services, by comparing the prices of properties with the same attributes located in neighborhoods of different environmental qualities (Mieszkowski and Saper, 1978; Nelson, 1978; Graves et al., 1988 and Smith, 1978). Concerning the real estate market, we can point out Bailey et al. (1963), Musgrave (1969), Goodman (1978), Bartick (1983), Cobb (1984), Anas and Eum (1984), Epple (1987) and Wallace (1996), among others. The international experience with the application of hedonic analysis to housing markets is well documented in Sheppard (1999).

However, the classic work that had formalized the hedonic prices theory was Rosen (1974), which will be described here.

Let us assume that the price of the housing unit is determined by the following function:

$P = f(C),$

Where

P is the price of the house and C are its attributes, which determine such prices. The hedonic price of a given component (i) of C is defined as $\partial P/\partial C_i$.

Rosen (1974) has shown that the characteristics presented in the hedonic prices function resulted from the maximization of both consumers and producers.

Assume for simplicity that there is only one heterogeneous good, housing. The household utility function is, then, given by:

$Q = Q(q(x), c)$

Where Q is the utility function, $q(.)$ a function of the property characteristics and c represents all other homogeneous goods, which could also be seen as money.

The housing production function can be represented as the result of the combination of a bundle of property characteristics. Hence,

$t(x, K, L) = 0$

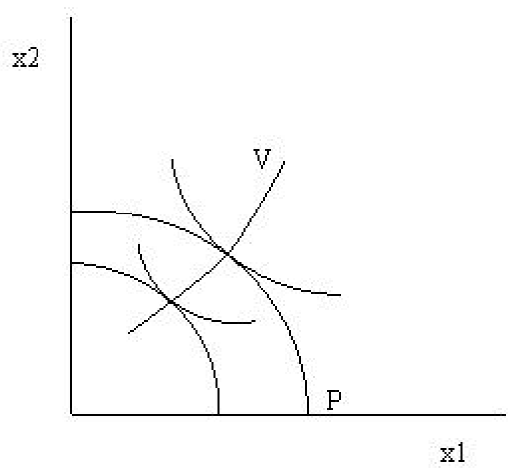
Where $t(.)$ represents the production function and K and L stand for capital and labor.

Notice that the hedonic price equations are not a reduced form of supply and demand, but an optimum solution (binding constraint) for both consumers and producers.

As long as there are increasing marginal costs for the attributes of the house and restrictions for the composition of the bundle of characteristics, the hedonic prices function is likely to be nonlinear, implying that the attributes relative prices are not fixed, being determined by buyers and sellers at each point of the hedonic surface.

In figure 1 we can observe two attributes of housing x_1 (size in square meters) and x_2 (number of rooms) and the producer's restriction *(P)*, whose inclination represents the marginal costs of production. *V* represents the expansion path, i.e., the optimum equilibrium for both producers and consumers, while the other curves correspond to the consumer indifference curves.

FIGURE 1
Equilibrium in the Hedonic Prices Model



Rosen (1974) has shown that, with a large number of consumers and producers, the hedonic prices function will represent all the optimum points, i.e., the expansion path, like in the envelope theory. Only under restricted hypotheses this function would be linear, which implies that hedonic prices models should allow the use of nonlinear specifications in its estimate. However, such model doesn't define *a priori* an optimum functional form for the hedonic equation and, therefore, it's common to use Box-Cox transformation (1964) in empirical estimating, in order to determine the best specification for the hedonic regression, although linear and log-linear forms are more used in the empirical literature.

Some authors describe the coefficients of the property attributes derived from the hedonic regressions, as the households' willingness to pay for those characteristics. However, Follain and Jimenez (1985a) affirm that this approach can lead to simultaneity bias because, implicitly, there would be a market for each individual attribute. For example, for the size of the property there would be an implicit supply and demand in the acquisition by a particular family that should not necessarily be the same to another family. Thus, the authors suggest a two-stage technique as a more robust methodology to estimate the household's willingness to pay for housing and urban services. Nevertheless, they affirm that the coefficients of the hedonic regressions can be used to infer the effect of the characteristics in the property's final price, although we should not interpret these coefficients as estimates of the willingness to pay for the attributes.

3 THE EMPIRICAL STUDIES: A BRIEF SURVEY OF THE LITERATURE

In Brazil, there are only a few studies that have applied hedonic models to the Housing Market. However, most of these studies, despite having used robust econometric techniques, were restricted to a particular market, and have emphasized the middle and high-income market segments, showing almost no concern for policy making.

Dantas and Cordeiro (1988) used data on prices and location of plots, supplied by the Brazilian National Housing Bank (BNH), to estimate a hedonic prices function for 3 neighborhoods in Recife (Pernambuco), using Generalized Least Squares (GLS) and Box-Cox transformation. Barbosa and Bidurin (1991) have also used hedonic models for estimating land prices in Recife, using data on the physical, economic and location characteristics of urban plots. Besides the Box-Cox method (with Maximum Likelihood) and GLS models, the authors proposed the use of cross-validation techniques to obtain an optimum specification for the regression, where the distribution function could be Gamma or Lognormal. They also discussed the possibility of including subjective information supplied by property brokers, using a Baysean approach.

González and Formoso (1994) have applied the hedonic model to study the rental market in Porto Alegre (Rio Grande do Sul), using a sample of flats available for rent during July 1992, taking into account the various segments of the formal rental market, except those properties rented for holiday season. They have used factorial analysis for selecting the variables of the model and the household monthly rent as a *proxy* for the property value, instead of its selling price in the market.

Aguirre and Macedo (1996) have estimated a hedonic function for Belo Horizonte (Minas Gerais), using Box-Cox transformation and data from the Institute of Economic, Administrative and Accounting Research of Minas Gerais (Ipead). The results were obtained by Ordinary Least Square (OLS), Maximum Likelihood (ML) and non-transformed data. The sample is limited to information on flats, with an average area of 120 square meters. However, some of their findings indicate a possible bias in the sample, because the presence of a garage was not significant to increase the property price. This is probably due to the fact that flats with 120 square meters are targeted to higher income groups, who require *a priori* the existence of a garage in the property. Perhaps the inclusion of an extra parking space would be more important to explain the variation in flat prices than the existence of a garage in the building.

Santos et al. (1999), have applied the hedonic prices model to the MAs of Recife, Curitiba and Brasília, using data from the 1997 Pnad. They have used a log-linear model and the OLS technique for the estimation of the regressions for each MA, separating households per income levels. The great contribution of this study was trying to explain the households willingness to pay for housing services, taking into account their income level, with an emphasis on the target groups of governmental housing programs[3] (households with monthly income below 12 Brazilian minimum wages[4]). However, their results can be biased, once the data was censored *a priori*, because of the partition of the sample by income strata.

Figueroa (1993) has estimated a hedonic prices function for Paraguay, by Iterative Least Squares. The advantage of this method is that it avoids the use of ML to estimate an optimum functional form, so that the Box-Cox transformation could be derived by OLS. To find the optimum λ, several values were imputed, and equations were estimated by OLS for each specification, choosing those with the smallest Sum of Squared Errors (SSE). Such methodology permits to obtain the optimum functional form, without the need of using non-linear methods like ML. The data came from a survey carried out especially for this study in housing programs implemented by the Paraguayan government. After estimating the equations, the author analysed the social impacts of housing programs for low-income population. The property price was obtained by questioning the owner directly, in order for him to evaluate the house. According to the author, this would allow to capture how much people are willing to pay for their properties. Figueroa has demonstrated how urban infrastructure policies affect the property's selling price and, consequently, the households' patrimony. He has also shown how hedonic models can be used to estimate some of the positive externalities[5] of urban infrastructure policies, such as the increase in households' wealth and living conditions.

Another study that has used hedonic models to aid public policies is Follain and Jimenez (1985b). The authors have used data from a household survey similar to Pnad for five cities in Colombia, Korea and Philippines. They have used rent as a *proxy* for property value. From the estimates of the household willingness to pay for the property attributes, the authors estimated the optimum size and characteristics of the properties addressed to low-income population, that would maximize the producers' profit and the consumers' utility. In this way, it could be possible to estimate which housing program would be most suitable for the low-income population, at the minimum cost to the government and still respecting the consumers preferences for the various attributes of the property. Hence, such methodology could permit to answer the following question: given a certain cost and a target group previously defined for an urban policy, what would be the best project, in the sense of maximizing the social welfare derived from that policy?

Smeeding *et al.* (1993) analyzed the impact of governmental policies addressed to low-income population on poverty and income inequality reduction in 7 developed countries, through non-pecuniary subsidies in housing, health and

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3. The Brazilian Government's Housing Programs can be broadly divided into 3 categories: (i) Subsidized Funding to help State and local governments to invest in the improvement of the living conditions of households with income below 3 Brazilian minimum wages (Habitar Brasil and Pró-Moradia); (ii) Funding firms, cooperatives and individuals for the construction and improvement of housing conditions of households with income up to 12 Brazilian minimum wages (Carta de Crédito and Programa de Apoio à Produção); (iii) Enabling Market Programs: Programa Brasileiro da Qualidade e Produtividade na Construção Habitacional (PBQP-H) and Programa de Arrendamento Residencial (PAR).

4.The Brazilian minimum wage was equivalent to R$120,00 in September, 1997.

5. Some externalities of urban policies are not captured by the hedonic model, like the decrease in the incidence of contagious diseases caused by sanitation policies, for instance. Nevertheless, the hedonic approach offers a first approximation to the benefits generated by these policies. In the example used, one could say that the households are internalizing the risk of contagious diseases in house prices.

education. The researchers captured the impact of housing on poverty just for some of the countries, due to lack of data. Nevertheless, in countries where this inference was viable, they verified that the benefits on the lower quantiles of the income distribution were quite significant. Analyzing poverty alleviation policies in Brazil, Neri et al. (2000), showed the relationships between poverty, resources distribution and financial market operation in the country. The authors demonstrated that the income-poor have lower rates of access to public services like water, sewage, telephone and waste collection and that the percentage of owner-occupied houses is larger among the poor (71,0%) than non-poor (68,0%). However, one should notice that 15% of the poorest population do not own the plot where the house is built, which seems to support the hypothesis that great part of the low-income population had access to housing through self-construction in irregular settlements (Ipea, 1998). The quality of the housing structure and the living conditions are also more precarious among the poor. Furthermore, using a logistic regression, they showed that having access to a given resource, like housing, implies lower probabilities of being poor. Liu (1999) also showed that the Brazilian poor have lower access to adequate housing and urban services, and that the proportion of poor is larger in the periphery of urban areas, where the basic services are more scarce. He stressed that under land tenure security, improvements in housing and urban services will raise the values of the houses occupied by the poor, and thus, reduce urban poverty. These 3 papers mentioned above show a strong research agenda, which is the relationship between poverty, housing and urban services. Unfortunately, the studies that deal with poverty alleviation in Brazil have just emphasized exhaustively the returns of educational policies in poverty and income inequality reduction. However, we think that poverty reduction strategies should include a combination of policies and not rely exclusively on a single instrument. Therefore, the formulation of consistent housing and urban services policies can have a strong impact in urban poverty reduction in Brazil.

The hedonic prices models supply a theoretical framework that allows us to appraise the social costs and benefits of housing and urban policies. Construction costs are relatively easy to obtain, while property market values depend on their attributes. Thus, with estimates derived from hedonic equations, one can infer the social impacts of the governmental policies in urban development, like the improvement of urban infrastructure in poor neighborhoods, for example. The coefficient of each characteristic of the dwelling unit, derived from the hedonic model reflects that attribute shadow-price, and its contribution to the house's final price. Such methodology also permits to obtain estimates of the willingness to pay for the attributes of the house, through the construction of the household's utility function. The existence of estimates of the willingness to pay for housing services can induce cost recovery practices and thus reduce the need for public subsidies, as well as increase local government revenues by means of betterment fees and development charges collection and increased property taxes.

4 THE DATA AND METHODOLOGY

The data used in this study was obtained from the 1997 Pnad[6] of IBGE, encompassing 10 Brazilian MAs: Recife, Rio de Janeiro, Fortaleza, São Paulo, Curitiba, Belém, Belo Horizonte, Porto Alegre, Salvador and Brasília.[7] We considered only the data on the rental properties used as permanent private residences, located in urban areas. Pnad was not originally designed as a research on housing conditions, but rather as a survey on employment and income, which limits the amount and the quality of the available information on housing units. Although Pnad contains information on some of the property attributes like the number of inhabitants, number of rooms, level of urban services, it lacks important information like age, size (square meters) and market price. Despite these limitations, Pnad is representative at the national level and allows for a comparison among several metropolitan housing markets, thus leading us to draw important conclusions for the formulation of public policies of urban development.

Following other empirical studies, we have used the rent paid in the month of reference of Pnad[8] as a *proxy* for the property value, in the absence of information on its market price. Since housing is a durable good, rent can be seen as the payment for the residence services or, alternatively, as the present value of the flow of income derived from the ownership of the house. In principle, rent should maintain a direct relationship with property value, justifying its use in the hedonic regressions, replacing the price. However, such methodology is not problem-free, once the rental market in Brazil presents serious imperfections, being highly regulated and relatively small in international terms, representing just 13,7% of the Brazilian private housing stock in 1997, as we can observe in the table below.

TABLE1

Metropolitan Brazil: Housing Tenure Types - 1997

Tenure Conditions	Number of Units	(%)
Own Already Paid	27.484.799	67,6
Own still paying	2484.240	6,1
Rented	5.561.748	13,7
Ceded by entrepreneur	1.790.088	4,4
Ceded by other means	3.138.918	7,7
Other tenure condition	184.264	0,5
Not informed	566	0,0
Total	40.644.623	100,0

Source: Ipea/Dirur from the 1997 Pnad/IBGE microdata.

To define the attributes of the housing unit we considered the following aspects: quality of the physical structure (walls and roof); size of the dwelling unit (number of bedrooms and other rooms); access to public services (water, sewerage, waste collection, phone connection and electricity); quality of the neighborhood

6. Pnad is an annual survey that contains data on randomly selected households of the MAs.

7. Pnad's data refers to the Federal District only, although the MA of Brasília is larger, and includes neighboring municipalities in the Sates of Goiás and Minas Gerais.

8. September, 1997.

(household *per capita* income); living conditions (density per bedroom and exclusive bathrooms) and characteristics of the local housing markets (MA where the property is located).

The household *per capita* income was included in the regression in order to capture the quality of the neighborhood, because one expects that people with lower *per capita* income live in poor neighborhoods and vice-versa. In the same way, high densities per bedroom and absence of exclusive bathroom, reduce the rent one is willing to pay for the house, due to the worsening in living conditions. We also included *dummies* for each MA, in an attempt to capture specific characteristics of the local housing markets.

One of the main problems encountered in this study is the absence of a measure of accessibility of the residence in the model, despite its relevance in explaining urban land prices, and consequently, housing unit values. The omission of a location variable can be accounted to difficulties with the database. Although Pnad has a variable that could serve as *proxy* for property accessibility, such as commuting time to work, we decided not to include it in the model, once the location decision is taken by the household's head and this information is missing in many cases, and that would have rendered an excessive reduction in the sample size.

After eliminating the *missings*, the *outliers* and having proceeded to restrict the sample to the private rental housing located in urban areas of the 10 MAs under study, we have obtained a total sample of 5.284 observations.

Considering the adequacy of the housing structure and levels of urban services we first used IBGE criteria. According to this methodology, housing units possess proper sewerage when they are connected to public sewerage network or have septic tanks (*dummy*=1). For walls IBGE arbitrates that masonry (brick, cement and concrete) and processed wood are adequate (*dummy*=1), while other materials are inadequate. For the roof, concrete or cement, tile and processed wood are considered durable (*dummy* = 1), while other materials are inadequate. In a second regression we have considered the qualitative differences among the variables "quality of construction" and "public services" classified as adequate by IBGE criteria. As we can observe in the next sections, these 2 models can have quite different outcomes.

5 MAIN RESULTS

The model's independent variable was the value of the monthly rent, which served as *proxy* for the property price. The explanatory variables are described as follows:

RENT = *f* (Number of bedrooms, number of other rooms, quality of the walls, quality of the roof, household *per capita* income, density per bedroom, exclusive bathroom, piped water, sewerage system, garbage collection, electricity, phone connection and local characteristics of each MA).

The variables telephone and electricity were later removed from the model, because phone presented missing correlations with rent and electricity is present in all sample units.

Table A.3, in Annex I, shows the descriptive statistics of the main variables used in both models.

One possible shortcoming of the study is the fact that there could be a bias in the sample selection, once rental housing presents, in general, better structural quality and enhanced access to urban services (see tables A.2 and A.3). However, such bias is due to the limitations of the information captured by Pnad. One possible sequence to this study could be working with other databases like IBGE's Survey on Patterns of Life (PPV) and Seade's Survey on Living Conditions (PCV). Although those databases possess more information on the quality of housing and urban services, they don't have Pnad's spatial scale, being available for just a few years and are restricted to a few or even a single MA.

Despite the limitations described above and the preliminary nature of this research, the hedonic regressions and estimates presented here are innovative because they compare the Housing markets of the major Brazilian MAs simultaneously. We have made 2 regressions, gathering data from the 10 MAs, pondered the households by their weight in Pnad, through the weighted least squares method (WLS), and included a *dummy* for each MA, taking São Paulo for comparison.

We have tested several specifications for the hedonic regressions, like linear, semi-log and double log. The semi-log regressions appears to have adjusted better to the data, presenting a smaller SSE than the linear, as well as coefficients with the expected signs, according to economic theory and statistically significant at a 95,0% confidence level. The R^2 adjusted was 0,585, which represents a good explanatory power of the model, considering that we were using cross-section microdata. From the analysis of the correlogram we can infer that the residuals were normal and independent, and showed no sign of heteroscedasticity. The linear regression didn't respect the hypothesis of normality of the residuals, among others, while the double-log specification, in spite of having the highest R^2 adjusted, presented some coefficients with the wrong signs, as well as a certain tendency in the graph of the residuals. The results of the hedonic regression with semi-logarithmic specification and IBGE criteria for housing adequacy can be seen in the table below.

All the MAs *dummies* were statistically significant and had negative signs, indicating that rent in São Paulo is higher than in any other MAs, independently of the characteristics of the properties, which implies that the inhabitants of São Paulo should pay more for houses of similar quality and supply of urban services. Brasília, Rio de Janeiro and Belo Horizonte were the MAs that approached more the value of the rent in São Paulo, corresponding to 73,7%, 73,3% and 63,8% of that value, respectively.

For the urban infrastructure services analyzed (water, sewerage and garbage collection) the coefficients of the regression are positive and significant, indicating that each public service separately would raise rent by 36,3%, 37,0% and 55,6% respectively, which demonstrates that such policies can have strong redistributive impacts. Permanent walls can increase rent by 40,1%, while a proper roof increases rent by 29,4%.

TABLE 2

WLS regression with semi-log specification and IBGE adequacy criteria

Dependent variable: ln rent

Attributes	Parameter Estimate	Standard Error	t – test
Intercept	3,042	0,143	21,318
Bedrooms	0,256	0,010	25,443
Other Rooms	0,156	0,005	32,029
Solid Walls (masonry and processed wood)	0,337	0,106	3,177
Solid Roof (concret, tile and processed wood)	0,258	0,090	2,875
Piped Water	0,310	0,040	7,680
Exclusive Bathroom	0,134	0,036	3,738
Proper Sewerage (netwok and septic tank)	0,315	0,026	12,253
Proper Garbage Collection	0,442	0,047	9,340
Density per Bedroom	-0,016086	0,007	-2,374
Household per capita Income	0,000234	0,000	23,992
Dummy Belém	-0,470	0,059	-7,916
Dummy Fortaleza	-0,754	0,036	-21,206
Dummy Recife	-0,707	0,035	-19,988
Dummy Salvador	-0,655	0,033	-19,802
Dummy Belo Horizonte	-0,450	0,026	-17,043
Dummy Rio de Janeiro	-0,311	0,017	-17,880
Dummy Curitiba	-0,486	0,033	-14,615
Dummy Porto Alegre	-0,460	0,029	-15,635
Dummy Brasília	-0,305	0,033	-9,301
R^2 Adjusted			0,585

Source: Dirur/Ipea from the 1997 Pnad/IBGE microdata.

As for the number of rooms in the house, an additional bedroom can increase rent by 29,2%, whereas an increase in the number of other rooms would raise rent by 16,9%.

The coefficient associated with the household *per capita* income presented a positive sign, showing that living in a neighborhood with high average income is valued positively by the households, contributing to an increase in rental values. Conversely, a high density per bedroom, typical of poor neighborhoods, worsens the living conditions, causing a decrease in rents. Finally, the presence of an exclusive bathroom increases rent by 14,3%, due to better living conditions.

Taking into account that housing prices represent several times the household's annual income and that housing corresponds, most of the times, to people's most valuable asset, and that there is an important relationship between housing conditions and poverty, the great social benefits derived from the implementation of proper housing and urban development policies become evident. As some of the positive externalities associated with proper housing and sanitation provision are not reflected in the hedonic model, one can infer that the gains in social welfare derived from such policies are even higher. It should be stressed, however, that there may be a location bias in these results, since the coefficients of the regression might be reflecting other attributes associated with properties located in high-income neighborhoods, that are not being captured by the model, because these neighborhoods have higher probability of offering higher levels of urban infrastructure and other amenities.

When we considered the different qualities for proper structure and public services as they appear in Pnad, the results become more impressive and the R^2 adjusted increases to 0,614. All the parameter estimates were significant at a 95,0% confidence level and presented the expected signs.

In this model São Paulo still presents the highest rent, followed by Belém (79,5%), Porto Alegre (76,6%), Brasília (76,0%), Curitiba (74,8%), Rio (73,9%) and Belo Horizonte (62,0%). These surprising results indicate that the local markets characteristics have great importance in explaining rents and property prices. The rents in the northeast are almost half of the rents in São Paulo, ranging from 54,3% in Salvador to 52,4% in Fortaleza. Although the results seem quite unexpected, they are consistent with IBGE data on construction cost per square meter for September 1997, as can be seen in table A.1. The ranking of the MAs obtained in this second model is almost the same as the ranking derived from IBGE construction cost, where São Paulo State presented the highest average cost per square meter (R$381,74), with Pará coming in second position (R$377,78), followed by Rio Grande do Sul (R$362,43) and Brasília (R$356,01). Among the MAs studied, Belém presents the highest housing deficit to total housing stock ratio (22,0%), as well as one of the largest population average annual growth rate (2,2%) and the highest growth rate within the peripheral areas (6,4%). One possible explanation could be the fact that Belém is almost totally comprised of marine areas, an environmental protected area with special land use regulations, that can be accounted for land scarcity in the core municipality, thus making the city growth in the periphery to occur at vertiginous rates.

TABLE 3

WLS regression with semi-log specification and different qualitative for proper housing and services

Dependent variable: ln rent

Attributes	Parameter Estimate	Standard Error	t – test
Intercept	3,138	0,007	447,895
Bedrooms	0,263	0,000	532,310
Other Rooms	0,145	0,000	601,561
Masonry Walls	0,371	0,005	71,352
Processed Wood Walls	0,0742	0,005	13,636
Tile Roof	0,168	0,004	38,187
Concrete Roof	0,347	0,004	78,434
Processed Wood Roof	0,09541	0,007	13,707
Piped Water	0,259	0,002	130,441
Exclusive Bathroom	0,102	0,002	57,606
Sewerage Network	0,362	0,001	273,617
Septic Tank connected to Network	0,253	0,001	171,243
Septic Tank not connected	0,102	0,002	57,640
Direct Garbage Collection	0,391	0,002	167,387
Indirect Garbage Collection	0,371	0,003	142,968
Density per Bedroom	-0,009518	0,000	-28,578
Household per capita Income	0,0002077	0,000	427,579
Dummy Belém	-0,230	0,003	-75,084
Dummy Fortaleza	-0,646	0,002	-358,603
Dummy Recife	-0,629	0,002	-354,893
Dummy Salvador	-0,611	0,002	-352,978
Dummy Belo Horizonte	-0,478	0,001	-368,449
Dummy Rio de Janeiro	-0,302	0,001	-342,221
Dummy Curitiba	-0,291	0,002	-163,350
Dummy Porto Alegre	-0,266	0,002	-154,085
Dummy Brasília	-0,274	0,002	-169,546
R^2 Adjusted		0,614	

Source: Dirur/Ipea from the 1997 Pnad/IBGE microdata.

From the above model we can also infer that households pay higher rents for houses with masonry walls (44,9%), concrete roof (41,5%), connection to sewerage network (43,6%), direct garbage collection (47,9%), piped water (29,6%), exclusive bathroom (10,7%) and housing units located in higher-income neighborhoods, while an increase in the density per bedroom accounts for a decrease in rent. Taking into account the qualitative differences, houses connected to sewerage network presented rent 29,7% higher than houses with a septic tank without network connection and 11,5% higher than houses with septic tanks connected to the sewerage network. For roof materials, concrete increases rent by 19,6% and 28,6% comparing to tile and processed wood, respectively. For walls, masonry increases rent by 34,9% in relation to processed wood.

The results of these models could help policy-makers to design housing and sanitation programs that match the consumers' preferences for the different housing attributes, as well as perceive the potential for cost recovery of the different policies and to what extent governmental interventions affect the properties rents and values. This could help the local governments in development fees and property taxes collection. These results are even more important, once they can increase local and state governments autonomy in obtaining funds for investment in urban development, considering that Brazil is going through a fiscal crisis in the context of macro adjustment policies and many local and state governments show little debt capacity to be eligible for federal government grants. The study also stresses the need for more detailed research on the Real State Markets at the local level, such as the nature of urban land regulations and tax systems, as well as the supply and demand for housing, among others.

6 CONCLUSIONS

This paper intended to estimate hedonic prices regressions in order to infer the impacts of the provision of housing and urban services on property values in 10 Brazilian MAs, as a mean of subsidizing public policies of urban development. The results point out that the supply of proper housing and urban infrastructure services like water, sewerage and garbage collection can increase significantly the rental prices and property prices in these areas, which demonstrates that such policies can contribute to urban poverty reduction in Brazil.

The results are highly dependent on the criteria used to classify housing materials and urban services as proper or inadequate. São Paulo has shown the highest rent among the 10 MAs surveyed, followed by Rio de Janeiro, Brasília and Belo Horizonte, that presented rents about 30,0% to 36,0% lower than the rent in São Paulo, for houses with the same attributes, when we consider the IBGE adequacy criteria. When we consider the qualitative differences among the quality of walls and roof and type of sanitation system, São Paulo still presents the highest rent, followed by Belém, Porto Alegre and Brasília. These unexpected results show the importance of local markets characteristics to determine property rents and prices, and the need for further research at the local level, as well as a better definition of what constitutes proper housing quality and services, considering local and cultural differences.

Despite its preliminary nature, this study innovates, as compared to other research that have been produced in Brazil so far, by trying to assess the impact of urban development policies through hedonic prices regressions and demonstrating the existence of a fertile research agenda in Brazil in Housing and Urban Economics, that are still practically unexplored. One possible sequel to this study could be the application of Blinder (1973) and Oaxaca (1973) model of salary discrimination to the Real State Market, which could allow us to visualize that a house with the same physical attributes can have different rents and prices, depending on local characteristics, such as a more rigid urban regulation, for example. Another interesting use for hedonic regressions is the estimation of the household's willingness to pay for housing and urban services. Thus, one could supply an estimate of how different levels of land use regulations and housing and urban service provision could explain differences in the property prices, as well as estimate the costs and benefits and the potential for cost-recovery of different urban development policies and programs.

This study sought to contribute for the formulation of public policies in urban development, allowing to obtain important results like the strong redistributive impact derived from the provision of proper housing and urban infrastructure services and its crucial character to urban poverty reduction in Brazil. However, there is still a lot to be done and researched in this area, and one of the first tasks might be to improve the available data on the Brazilian housing sector.

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APPENDIX

TABLE A.1

Characteristics of the MAs studied

Metropolitan Area	State	Urbanization Rate in the State (%)	Distance to São Paulo (km)	Share in State's Population	Population Average annual growth rate (1991/1996)	Number of Municipalities	Population (1996)	Area (ksquare meters)	Demographic Density (hab/ksquare meters)	Demographic Density at the core municipality	Construction cost per square meters (R$) September 1997	Housing Deficit* 1991	Housing deficit/ total Urban Housing Stock* (%)
Belem	Pará	53,51	2.452,5	28,57	2,23	5	1.574.487	1.936,50	813,1	1.050,8	377,78	67.042	20,45
Fortaleza	Ceará	69,21	2.360,5	37,93	2,32	9	2.582.820	3.388,20	762,3	6.259,6	320,59	93.522	16,02
Recife	Pernambuco	74,02	2.124,5	41,73	1,14	14	3.987.967	3.121,40	989,3	6.146,3	280,74	130.483	17,35
Salvador	Bahia	62,41	1.451,1	21,6	1,68	10	2.708.818	3.068,50	882,8	3.114,8	309,72	89.427	12,76
Belo Horizonte	Minas Gerais	78,42	489,1	22,87	2,09	26	3.812.888	6.464,40	589,8	6.299,5	279,78	83.511	8,78
Rio de Janeiro	Rio de Janeiro	95,53	358,1	76,02	0,77	19	10.192.097	6.143,20	1659,1	4.392,0	354,24	297.992	9,49
São Paulo	São Paulo	93,11	0	48,54	1,46	39	16.561.333	7.963,70	2079,6	6435,2	381,74	371.422	8,37
Curitiba	Paraná	77,88	338,8	26,94	3,4	24	2.425.361	13.309,30	182,2	3.425,2	342,90	34.448	5,94
Porto Alegre	Rio Grande do Sul	78,67	851,2	33,68	1,42	23	3.245.306	6.152,80	527,5	2.562,4	362,43	75.468	7,88
Brasília	Distrito Federa/Goiás/ Minas Gerais	92,88*	870,5	-	2,66	22	2.561.123	59.584,50	43,0	312,9	356,01	63.542	15,00
Brazil		78,36	-	31,04	1,38	4.074	157.070.163	8.547.403,5	18,38	-	339,67	4.988.371	15,8

Source: IBGE Statistical Yearbook – 1997.

Notas: *Fundação João Pinheiro (1995).

**Refers to Federal District only.

TABLE A.2

Housing indicators: average values for Brazil and the main MAs, 1997

Attributes	Brazil	Metropolitan Area									Federal District
		Belém	Fortaleza	Recife	Salvador	Belo Horizonte	Rio	São Paulo	Curitiba	Porto Alegre	
Number of Rooms	5,63	5,05	5,61	5,64	5,41	5,99	5,29	5,14	6,05	5,54	6,00
Number of Bedrooms	1,98	2,10	2,13	2,05	1,97	2,04	1,78	1,81	2,01	1,86	2,11
Density per Bedroom	2,05	2,36	2,09	2,06	2,06	2,03	1,98	2,25	1,93	1,88	2,01
Density per Room	0,60	0,66	0,63	0,62	0,61	0,59	0,59	0,64	0,57	0,56	0,60
Household Monthly Income (R$)	928,69	1.101,78	837,35	771,63	1.028,83	1.206,95	1.201,12	1.531,84	1.388,80	1.225,25	1.825,76
Household per capita Income (R$)	301,66	304,98	246,15	244,57	334,56	380,54	451,53	505,49	444,93	456,59	580,82
Monthly Rent (R$)	229,19	277,48	176,33	191,81	212,49	270,76	327,38	356,94	265,77	287,25	318,00
Rent to Income Ratio(%)	28,37	29,47	29,38	31,70	30,66	31,26	32,49	33,58	28,00	29,52	31,24
Solid Walls (%)	96,10	98,40	99,30	97,50	99,10	99,90	99,90	99,00	99,5	98,70	97,50
Solid Roof(%)	96,70	99,60	99,90	99,70	99,60	99,40	99,20	99,30	97,60	98,40	99,70
Piped Water(%)	83,30	85,30	80,50	90,60	94,10	97,80	96,30	99,00	97,20	98,20	96,40
Exclusive Bathroom(%)	97,40	89,10	97,90	96,10	97,10	97,60	98,90	98,20	96,80	95,60	94,50
Proper Sewage(%)	69,50	80,30	52,50	54,30	74,80	80,70	91,10	91,20	71,00	94,70	96,10
Proper Garbage Collection(%)	76,30	89,80	90,70	88,80	90,90	87,90	91,60	98,50	96,50	97,70	95,80
Eletricity (%)	93,40	99,90	99,20	99,90	99,90	99,90	99,80	100,00	99,90	99,70	99,80
Phone Connection(%)	27,90	38,90	37,80	25,70	44,00	45,40	30,70	43,30	41,40	33,60	65,50

Source: Ipea/Dirur from the 1997 Pnad/IBGE microdata.

Notas: *All values refer to September 1997.

**Average exchange rate in September 1997: R$/US$ = 1,0936.

TABLE A. 3

Housing indicators: average values for the rental housing attributes used in the hedonic models – 1997

Attribute	Brazil	Metropolitan Area									Federal District
		Belém	Fortaleza	Recife	Salvador	Belo Horizonte	Rio	São Paulo	Curitiba	Porto Alegre	
Number of Bedrooms	1,62	1,80	1,90	1,87	1,66	1,70	1,57	1,52	1,88	1,65	1,71
Number of other Rooms	3,05	2,96	3,31	3,51	3,13	3,42	3,19	2,70	3,66	3,38	2,93
Density per Bedroom	2,21	2,11	2,06	1,98	2,04	2,10	2,02	2,51	1,97	1,82	2,11
Density per Room	0,83	0,97	0,84	0,75	0,80	0,77	0,71	0,95	0,71	0,63	0,89
Household Monthly Rent (R$)	311,96	272,13	179,65	199,23	215,36	275,60	327,00	355,21	269,29	288,02	323,15
Rent to Income Ratio	0,32	0,29	0,30	0,32	0,31	0,31	0,33	0,34	0,28	0,29	0,31
Household Monthly Income (R$)	1314,43	1347,63	981,83	938,89	1135,25	1200,98	1266,16	1425,22	1377,41	1345,07	1524,25
Hosehold per capita Income (R$)	496,84	479,05	321,07	330,39	419,73	468,35	537,73	506,48	455,56	593,32	566,35
Solid Walls (%)	99,60	98,30	99,80	98,30	99,80	100,00	100,00	99,70	99,10	99,50	98,10
• Masonry	95,40	69,80	99,80	97,60	97,90	99,80	99,50	99,30	63,10	71,90	92,90
• Processed wood	4,20	28,50	0,00	0,70	1,90	0,20	0,50	0,40	36,00	27,60	5,20
Solid Roof (%)	99,40	99,50	100,00	99,70	99,80	99,70	98,90	99,70	98,60	99,40	99,70
• Tile	53,40	69,30	80,90	68,10	41,30	42,10	42,30	54,80	73,40	54,00	65,60
• Concret or cement	45,70	26,30	18,90	31,40	58,00	57,40	56,30	44,80	22,60	45,20	34,10
• Processed Wood	0,30	3,90	0,20	0,20	0,50	0,20	0,30	0,10	2,60	0,20	0,00
Piped Water (%)	96,70	91,60	80,50	92,50	95,00	98,20	95,70	99,20	98,60	98,50	95,70
Exclusive Bathroom (%)	95,80	86,00	96,30	93,90	90,90	95,60	96,90	96,90	96,30	94,00	90,50
Proper Sewage (%)	90,70	91,70	52,20	58,60	80,90	93,60	94,60	95,80	77,70	99,30	99,80
• Sewerage Network	67,40	19,00	24,10	35,50	40,90	92,60	63,70	85,60	49,70	5,60	94,80
• Septic Tank conected to Network	17,80	36,90	6,00	8,00	26,50	0,30	27,40	8,30	18,60	83,30	1,20
• Septic Tank not conected	5,50	35,80	22,10	15,10	13,50	0,70	3,50	1,90	9,40	10,40	3,80
Proper Garbage Collection (%)	97,90	96,70	96,30	94,60	96,60	96,10	95,50	99,70	100,00	99,80	99,70
• Collected directly	90,50	59,80	83,40	76,40	53,00	91,50	92,00	94,50	98,90	98,80	92,40
• Collected indirectly	7,40	36,90	12,90	18,20	43,60	4,60	3,50	5,20	1,10	1,00	7,30

Source: Ipea/Dirur from 1997 Pnad/IBGE microdata.

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