Housing stock in Brazil: estimation based on a hedonic price model

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1. Introduction

As an important aspect for the level of wealth, social welfare and economic growth, the housing stock, and more specifically, home ownership are significant structural mechanisms in the reduction of poverty and social inequalities.[3] Nevertheless, the difficulties in measuring the prices of real capital such as housing are very well known. These difficulties stem, in part, from the heterogeneity of these non-standard assets and the infrequency of observed transactions with individual properties. Therefore, accurate measurement of real estate prices is important for both practical and theoretical purposes. In particular, we believe that our empirical findings regarding this subject will make a valuable contribution to the housing policy debate in Brazil, where the housing sector must perform efficiently to provide affordable homes, especially to lower income people.

Statistics on the Brazilian economy show that in 1999 rent expenditures reached 14% of GDP and 17% of household consumption (National Accounts, IBGE (2000)). Ipea's estimates indicate that in this same year housing investment corresponded to 28% of total investment and 5% of gross domestic product (Morandi (2002)). According to the National Household Survey (*Pesquisa Nacional de Amostragem de Domicílios* - PNAD) conducted by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE), 74% of households inhabited their own property in 1999. These figures show how meaningful housing investment is in the capital accumulation process of the Brazilian economy. Moreover, it suggests that housing is the main component of wealth for most Brazilian households.

This study is part of a broader project called "Estimates of the Stock of Capital and Wealth of Brazil (1970-99) and applications in the analysis of public and regional policies". The main objective of the latter is to estimate the value of the capital stock and wealth in Brazil according to: (i) categories (residential, non-residential, machinery and equipment, domestic and imported); (ii) productive sectors (industry, agriculture and infrastructure); (iii) property (government, government-owned enterprises and private companies and families); and (iv) location (states and municipalities).

The purpose of this study is to estimate the housing stock in Brazil from 1970 to 1999. Estimations are based on the value of the rent payments of rented residences and the imputed rents of owned proprieties. Based on the monthly rent paid and the physical and locational characteristics of the property, a hedonic function is estimated to serve as a base to impute the rent for all residences. The conversion of the rent into the price of the property is done indirectly using an average discount rate of 0.75% per month (9.38% per year), found in empirical works on the subject. The source of data for the census years (1970, 1980, and 1991) was the Demographic Census, and for other years the National Household Survey (PNADs).

This study is organised as follows: in Sections 2 and 3 we present the hedonic price model and the model to evaluate the housing capital stock, respectively. Section 4 describes the data used for the estimation and Section 5 presents the estimation. The results are discussed in Sections 6 and we sum up with concluding remarks in Section 7.

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[3] See Wolff (2000), Spilerman (2000), Neri et al (1999), among others. Other relevant aspects for the analysis are: taxation on capital gains or taxation on imputed rents of owned residences (Poterba (1992), Hendershott and White (2000)); the construction of price indices (Zabel (1999)); and the demographic determinants of housing prices (Green and Hendershott (1993)).

2. Hedonic price model

Hedonic price models are used to identify factors or influences on the price of goods based on the idea that price is based on both intrinsic characteristics and external factors. These models are most commonly applied to housing markets in which the price of housing is based on the physical characteristics of the house (size, appearance, features) and the surrounding neighbourhood (accessibility to schools and shopping, quality of other houses, availability of public services). Estimating hedonic prices makes it possible to identify the extent to which specific factors affect the housing price.

In our model, we assume that the value of the monthly rent (R) of a property has a stable relation with its price (P), $R = \alpha P$, where α is the opportunity cost of renting housing.[4] Therefore, hedonic pricing relates the housing price to its attributes as follows:

$$R = X\beta + Z\delta + \varepsilon, \tag{1}$$

where R is a vector of the rents of the good (housing, in our case); the explanatory variables correspond to the physical attributes (X) of the housing unit and the location attributes (Z), which is related to amenities, public and service infrastructure, construction quality, among others; the coefficients β and δ correspond to the implicit price of housing attributes, and ε is the stochastic residual.

The vector of physical attributes aggregates 19 variables, where 17 are dichotomic variables and the other two are polythomic variables. The vector of location attributes consists of three variables, where one is a continuous variable and the remainders (two) are dichotomic variables.

Regarding location variables, one method of modelling it is to change each location's intercept. In other words, when we include dummy variables, we handle all specifications of each location *i* related to a reference community. The other alternative to attain the location effect in the model is to apply a proxy variable. As Zabel (1999), in our model we also use a proxy variable, the median income of the location, along with two other location dummies.

We assume that rents (R) have a distribution close to log-normal. The functional form that best fits this hypothesis is the log-linear form. The original equation which relates the rent to the other variables is:

$$R = \exp(X\beta + Z\delta + \varepsilon). \tag{2}$$

3. Method of hedonic income

In this section we briefly discuss four classical methods of measuring the capital stock. They are: (i) physical inventory stock; (ii) perpetual inventory; (iii) accounting value; and (iv) present value of hedonic prices. There are two other methods found in Brazilian literature: (v) data from income tax returns; and (vi) to use credit balance of the *Caixa Econômica Federal* (the federal savings and loan bank) as a proxy for the housing capital stock (Rebelo (1998)).

These methods are presented in the table below.

In this work we use an adaptation of Method IV - Present value of prices. The reason is the impossibility of using all the others. In Brazil, there is no information on residential housing prices or the flow of investments in residences. This makes it impossible to use Methods I and II. Method III also is not suitable because we do not have a financial census of households. There is only one for companies, which was conducted in 1985, and was subsequently substituted by sampling surveys. The information required by Method V is confidential and difficult to obtain. Method VI has a selection bias because only properties financed by the *Caixa Econômica Federal* (federal savings and loan) are covered, and these data are subject to great fluctuations that are more a reflection of macroeconomic financial conditions than real ones.

[4] We discuss more about this relation between rent and price of housing in the next section.

Table 1

Methods	Description
i. Physical inventory stock	It is a direct account of each capital unit through its average value. Example: estimation of the automobile stock in the United States;
ii. Perpetual inventory	The capital value is estimated through the accumulation of the investment flows over time. The net capital stock and depreciation rate are indirectly calculated. This is the method that has been most commonly used in the literature for its simplicity and adequacy to the available data;
iii. Accounting value	It uses the carrying value of asset on firms' balance sheets, collected by economic censuses;
iv. Present value of prices	It consists in discounting the estimated future income flows (wages and rents, respectively) to present values;
v. Data from income tax returns	Property statements are in income tax returns;
vi. Credit from *Caixa Econômica Federal* (the federal savings and loan bank)	Data from the credit balances of the *Caixa Econômica Federal* (the federal savings and loan bank) could be used as a proxy for the housing capital stock (Rebelo (1998)).

The method we use in this study is the present value of hedonic prices. We call here the "method of hedonic income". It differs from the "classical" present value of prices method in two ways. First, the data of rents used are not observed, but imputed rent for both rented and non-rented residences (owned, granted, others) through the hedonic price method. Second, we assume a perpetual capitalisation. Therefore, if we assume that residential property is a perpetual asset, its price P can be obtained by dividing the rent R by a parameter (α), which is the opportunity cost of renting a property:

$$P = R/\alpha. \tag{3}$$

Another way to shed light on the relationship between housing price and rent is to assume housing as a financial asset. In this case, "the families arbitrate between the gains in the rent market and those in the financial assets markets" (Rebelo (1998, p 25)). Parameter α is a function of the market interest rate (r) and the expected appreciation of the property (a), $\alpha = f(a, r)$. At equilibrium, $R = rP - aP$, which implies that $\alpha = r - a$.

The imputation is obtained as follows: the regression coefficients β and δ of equation (2) are estimated for 1999 and are applied to the values of X and Z obtained in each year of the period under analysis. The estimation is made in terms of September 1999 prices and is based on fixed weights.

An alternative process to the rent imputation is to construct a housing capital index based on annual weights. The advantage of this process is that it is able to capture changes in the relative prices of the attributes and the possible changes in variable definitions. The drawback is that it also captures changes in rent relative to prices and the other prices of the economy, including real estate prices.

In particular, the 1980s and early 1990s were a period of severe macroeconomic instability in Brazil. The economy had to cope with chronic and accelerating inflation. As rents have a large rigidity in relation to the general level of prices, the housing capital index would not reflect the physical behaviour of the housing stock, but only the changes in the relative prices caused by macroeconomic imbalances. The solution in this case could be to impute trend values to the coefficients. However, using a tendency can be as arbitrary as the choice of a particular year (1999, in our case) as a fixed base for the prices of the attributes. For example, during the high inflation period, particularly from 1986 to 1994, when the Real Plan currency reform finally stabilised the economy, rent increases generally lagged behind the inflation rate, since readjustments were legally limited to every six months. Then, in the first year after the Real Plan, there was an over-correction until market forces came more fully into play and rents stabilised.

In terms of national accounts, using a fixed base means, for instance, that the difference of the value added of building an apartment and that of building a house remains constant over the years. Or, it means that the value added of building a house with piped water, sewage, electricity and masonry walls (generally the most desirable construction in Brazil), among other attributes, is the same as the

value added of building a house without these attributes. As we have no information available from the building industry, using a fixed base for the prices of attributes seems to be a reasonable assumption.

The correct calculus of each attribute's price depends on the objective of estimating the housing capital stock. In this study we use the fixed base as reference. In order to compare the housing index GDP in absolute terms, we assume that the parameter α is constant with the time and equals 0.75%.[5]

4. Data

The data sources for this study are the demographic censuses of the IBGE for 1970, 1980 and 1991 and all National Household Surveys (PNADs) conducted from 1981 to 1999. PNAD is a survey that interviews from 65,000 to 115,000 households yearly. The ratio between the sample and universe is close to 1:400. The interviews occur in the last quarter of each year, with September the reference month. The demographic censuses data consist of a sample of 25% of the housing in 1970 and 1980 and 12.5% from the 1991 census. The reference month of the censuses is August. We used 12,000 observations (number of rented residences) to estimate the hedonic model.

In this study we follow the definition of a housing property made by the demographic census, which classifies it as "permanent private houses". A house is considered permanent and private if at the moment of the data collection there are at most five households living in a residence, which provided specifically residential use for the households (FIBGE (1996, p 15)). Therefore, residential properties such as those classified as "collective houses"[6] and those classified as "improvised private houses"[7] are excluded in this study.

The variables used in the rent imputation are presented on Chart 1. The dependent variable is the declared value of the monthly rent payment stated in the PNADs and in the censuses.

The median incomes are obtained in the censuses. We expect that the larger the median income, the better the location quality (infrastructure, amenities, etc). Nevertheless, due to the high inflation faced by the Brazilian economy prior to mid-1994, we had to control the income variable in order to measure the location effect appropriately.[8]

The effect of changes in the inflation rate on real income is excluded from the calculation of property appreciation in the following manner: income for all years is calculated as a deviation from the 1999 average income, as we use the latter as a standard level. The adjusted median income in the year t (MEDIADJ(T)) is described as:

$$\text{MEDIADJ}(T) = \text{MEDI} + \text{LOG}(\text{AVERAGE INCOME\_1999}/\text{AVERAGE INCOME\_}T).$$

Therefore, the average of each year is modified, but the original income variance is maintained. Any change in the variance is treated as if the quality of the location has actually changed so that the average of the variable MEDIADJ of each year t does not correspond to the average for 1999. The impact of a residence's redistribution that favours higher income locations increases the average income and vice versa. For instance, imagine that the only change in the stock of residences for a year is the destruction of an apartment building in a poor neighbourhood and the construction of a building with the same characteristics in a rich neighbourhood. This fact increases the quantum of residences because a residence in a rich neighbourhood is worth more than one in poor neighbourhood. Regarding national accounts, the construction value added of a residence in a wealthy neighbourhood is larger than the same in a poor neighbourhood. One explanation for this is

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[5] This value corresponds to the average of the monthly gross returns of 0.5% and 1% found in the literature. See Malpezzi (1991) and Halfeld (2002).

[6] Examples of collective dwellings are hotels, boarding houses, inns, nursing homes, orphanages, convents, penitentiaries, soldier's barracks, military posts, ships, workers' housing, etc.

[7] Improvised dwellings include those located in industrial and commercial establishments, vessels, truck trailers (but not house trailers/campers/motor homes, which are rare in Brazil), rail cars, tents, rudimentary shanties, lean-tos, etc.

[8] Considera et al (1997).

that the fit and finish of a residence in a rich neighbourhood, which is not an observable variable, demands more qualified labour with higher wages, implying larger profits.

Chart 1

Variables

RENT	Monthly rent payment
APT	1 if apartment; 0 if house.
	Wall type
WALL_1	1 if type1 (masonry); 0 otherwise (reused wood, straw or other lower quality material).
WALL_2	1 if type 2 (standard cut lumber); 0 otherwise (reused wood, straw or other lower quality material).
WALL_3	1 type 3 (bare wattle and daub); 0 if otherwise (reused wood, straw or other lower quality material)
	Roof type
CEILING_1	1 if ceiling type 1 (reinforced concrete slab); 0 otherwise (standard cut timber, reused wood, thatch or other lower quality material).
CEILING_2	1 if ceiling type 2 (clay tiles); 0 otherwise (standard cut lumber, reused wood, thatch or other lower quality material).
CEILING_3	1 ceiling type 3 (zinc sheeting); 0 otherwise (standard cut lumber, reused wood, thatch or other lower quality material).
	Water supply
WATER_1	1 if water system of type 1 (public water system); 0 otherwise (tank truck, rainwater collection or other).
WATER_2	1 if water system of type 2 (well or spring); 0 otherwise (tank truck, rainwater collection or other).
	Sewage type
SEWA_1	1 if sewer system of type 1 (public sewer system); 0 otherwise (ditch, river, lake or sea, others).
SEWA_2	1 sewer system of type 2 (septic tank); 0 otherwise (ditch, river, lake or sea, others).
SEWA_3	1 if sewer system of type 3 (rudimentary septic pit); 0 otherwise (ditch, river, lake or sea, others).
	Garbage collection
GARB_1	1 if garbage collection of type 1 (if there is direct or indirect garbage collection); 0 otherwise (thrown in river, lake or sea).
GARB_2	1 if garbage of type 2 (burned or buried); 0 otherwise (if thrown in river, lake or sea).
GARB_3	1 if garbage of type 3 (if disposed of on vacant lot); 0 otherwise (if thrown at river, lake or sea).
ELET	Electricity 1 if electric lighting; 0 if pressurised bottled gas, oil, kerosene, others.

Chart 1 (cont)

Variables

Garbage collection (cont)	
ROOMM	Number of rooms besides sleeping quarters (varies from 0 to 29).
ROOMSL	Number of rooms serving as sleeping quarters (varies from 1 to 15).
BATHROOM	1 if housing has indoor bathroom; 0 if no indoor bathroom.
MEDI	Median income of census sector.
MEDIADJ	Adjusted LMEDREN to measure deviation from the 1999 average.
H_MA	1 if housing is located in a metropolitan area. 0 otherwise.
H_AUTO	1 if housing is located in a non-metropolitan area. 0 otherwise

Table 2 presents the average of the variables shown in Chart 1.

Table 2

Descriptive statistics: average

Year	Sample	Expanded sample (thousand)	APT	WALL_1	WALL_2	WALL_3	CEILING_1	CEILING_2
1970	4,410,847	17.643	…	…	…	…	…	…
1980	6,302,660	25.211	0.12	0.77	0.18	0.04	0.17	0.69
1981	103,075	26.029	0.07	0.73	0.17	0.08	0.14	0.79
1982	111,359	27.401	0.08	0.75	0.16	0.07	0.14	0.79
1983	113,463	28.185	0.08	0.75	0.16	0.07	0.15	0.79
1984	115,748	29.164	0.08	0.77	0.15	0.06	0.16	0.79
1985	119,055	30.585	0.09	0.78	0.15	0.06	0.16	0.79
1986	65,236	31.100	0.09	0.78	0.14	0.06	0.18	0.76
1987	68,449	32.136	0.09	0.79	0.14	0.05	0.17	0.78
1988	68,773	33.167	0.10	0.80	0.13	0.05	0.17	0.78
1989	70,586	34.339	0.10	0.81	0.13	0.04	0.16	0.79
1990	72,941	34.111	0.10	0.82	0.13	0.04	0.17	0.78
1991	4,342,929	34.743	0.14	0.85	0.13	0.02	0.26	0.56
1992	78,058	35.903	0.09	0.82	0.12	0.04	0.16	0.80
1993	79,948	36.819	0.09	0.83	0.12	0.04	0.18	0.78
1995	85,043	38.474	0.09	0.84	0.11	0.04	0.18	0.79
1996	84,749	39.682	0.09	0.85	0.11	0.03	0.20	0.76
1997	89,696	40.645	0.09	0.86	0.10	0.03	0.19	0.78
1998	90,714	41.840	0.09	0.86	0.10	0.03	0.20	0.77
1999	93,793	42.851	0.09	0.87	0.10	0.03	0.19	0.78

Table 2 (cont)

Descriptive statistics: average

Year	CEILING_3	WATER_1	WATER_2	SEWA_1	SEWA_2	SEWA_3	GARB_1	GARB_2
1970	…	0.26	0.11	0.08	0.12	0.19	…	…
1980	0.01	0.76	0.15	0.38	0.20	0.30	ND	ND
1981	0.02	0.60	0.25	0.30	0.14	0.34	0.49	0.15
1982	0.02	0.61	0.24	0.29	0.17	0.31	0.51	0.15
1983	0.02	0.65	0.22	0.30	0.16	0.31	0.54	0.14
1984	0.02	0.66	0.23	0.31	0.17	0.31	0.56	0.15
1985	0.02	0.68	0.22	0.34	0.16	0.30	0.58	0.15
1986	0.02	0.70	0.21	0.38	0.14	0.29	0.58	0.16
1987	0.02	0.70	0.20	0.34	0.19	0.27	0.60	0.16
1988	0.02	0.71	0.19	0.39	0.16	0.26	0.60	0.15
1989	0.02	0.73	0.19	0.40	0.15	0.28	0.63	0.14
1990	0.02	0.73	0.19	0.41	0.16	0.27	0.64	0.14
1991	0.01	0.88	0.07	0.44	0.10	0.24	0.76	0.07
1992	0.01	0.68	0.09	0.39	0.10	0.24	0.62	0.16
1993	0.01	0.70	0.09	0.39	0.11	0.23	0.65	0.15
1995	0.01	0.71	0.09	0.40	0.12	0.23	0.66	0.14
1996	0.01	0.74	0.09	0.40	0.12	0.21	0.66	0.13
1997	0.01	0.74	0.09	0.41	0.12	0.23	0.69	0.13
1998	0.01	0.75	0.09	0.42	0.11	0.22	0.70	0.12
1999	0.01	0.76	0.09	0.44	0.12	0.23	0.72	0.12

Year	GARB_3	ELET	ROOMM	BATH-ROOM	ROOMSL	MEDI	H_MA	H_AUTO
1970	…	0.36	1.18	…	0.92	6.73	…	…
1980	…	0.88	…	…	2.68	7.03	…	…
1981	0.29	0.75	3.17	0.80	2.05	6.30	0.33	0.18
1982	0.25	0.76	3.21	0.80	2.00	6.29	0.34	0.18
1983	0.24	0.78	3.26	0.82	2.01	6.29	0.34	0.18
1984	0.23	0.79	3.31	0.83	2.01	6.31	0.34	0.19
1985	0.18	0.81	3.34	0.84	2.00	6.29	0.35	0.18
1986	0.18	0.83	3.34	0.84	2.05	6.30	0.35	0.19
1987	0.16	0.84	3.37	0.85	2.03	6.26	0.35	0.19
1988	0.16	0.86	3.50	0.85	2.00	6.22	0.35	0.19
1989	0.18	0.87	3.48	0.86	1.99	6.20	0.35	0.19
1990	0.17	0.87	3.52	0.86	2.00	6.23	0.33	0.20
1991	0.10	0.97	2.15	0.86	1.72	6.30	0.33	ND
1992	0.15	0.89	3.48	0.86	1.98	6.31	0.32	0.21
1993	0.13	0.90	3.52	0.87	1.98	6.30	0.33	0.21
1995	0.12	0.92	3.62	0.89	1.98	6.27	0.33	0.21
1996	0.12	0.93	3.62	0.90	2.01	6.26	0.32	0.21
1997	0.10	0.93	3.65	0.90	1.98	6.26	0.32	0.21
1998	0.08	0.94	3.69	0.91	1.98	6.27	0.32	0.22
1999	0.07	0.95	3.70	0.92	1.97	6.28	0.32	0.22

5. Estimation

The residential real estate market is characterised by its desegregation in physical and location attributes. Pavlov (2000) shows that the coefficients of hedonic attributes of a residence vary substantially among Los Angeles neighbourhoods. The author used an econometric technique which allows smooth space variation of parameters.

Our estimation provides the coefficients to evaluate residences. We divide the real estate market for residences into two sectors: the rural market and the urban market. The definition of rural and urban area follows census and PNAD criteria. According to these sources, an urban area is defined as all areas, whether urbanised or not, of cities and towns, besides isolated urban areas. Other areas are considered as rural: rural agglomerations of urban extensions; isolated rural agglomerations, villages, and other rural zones.

Table 3 presents the estimated coefficients. In the urban area regression, 18 of the 23 coefficients are statistically significant different than zero at the 5% level, and of these, 16 are statistically significant at 1%. The five that are not significant are: intercept, wall_2 (wood walls), wall_3 (wattle and daub walls), ceiling_2 (clay tile roofs) and ceiling_3 (zinc sheeting roofs). This is an expected result in the sense that the attributes do not differ significantly from the attributes used for the comparison. In particular, regarding the wall case, the comparison is made from "walls of reused wood, straw and other lower quality material", which was the case for close to 1% of all residences in 1999. The roof case is very similar. The "standard cut lumber, reused wood, thatch or other lower quality material" classification corresponded to less than 2% of the total residences in 1999.

Table 3

Estimated coefficients - 1999

Brazil: rural, urban and total

Observations Adjusted R2	Rural 346 0.57		Urban 12,390 0.67		Total 12,736 0.68		Difference
Variable	**Estimated**	**P**	**Estimated**	**P**	**Estimated**	**P**	**URB - RUR**
Intercept	–0.84	0.19	–0.04	0.79	–0.15	0.29	0.80
APT	0.05	0.85	0.12	0.00	0.12	0.00	0.07
WALL_1	0.49	0.09	0.24	0.00	0.24	0.00	–0.25
WALL_2	0.32	0.28	0.01	0.87	0.01	0.88	–0.31
WALL_3	0.05	0.89	–0.02	0.83	–0.02	0.83	–0.07
CEILING_1	0.23	0.44	0.19	0.00	0.17	0.01	–0.05
CEILING_2	0.01	0.97	0.10	0.13	0.07	0.24	0.09
CEILING_3	–0.45	0.50	0.14	0.08	0.10	0.17	0.59
WATER_1	0.11	0.27	0.28	0.00	0.27	0.00	0.17
WATER_2	0.19	0.10	0.28	0.00	0.26	0.00	0.08
SEWA_1	–0.26	0.08	0.08	0.00	0.08	0.00	0.34
SEWA_2	–0.11	0.44	–0.04	0.02	–0.04	0.02	0.07
SEWA_3	–0.14	0.29	–0.21	0.00	–0.20	0.00	–0.08
GARB_1	0.84	0.00	0.18	0.05	0.25	0.00	–0.66
GARB_2	0.35	0.22	–0.12	0.23	–0.08	0.40	–0.47
GARB_3	0.11	0.70	–0.12	0.23	–0.12	0.17	–0.24
ELET	0.28	0.12	0.24	0.00	0.24	0.00	–0.04
ROOMM	0.07	0.00	0.11	0.00	0.11	0.00	0.05
ROOMSL	0.01	0.91	0.17	0.00	0.16	0.00	0.16
BATHROOM	0.25	0.14	0.37	0.00	0.36	0.00	0.12
MEDI	0.52	0.00	0.42	0.00	0.42	0.00	–0.10
H_MA	0.52	0.00	0.43	0.00	0.44	0.00	–0.08
H_AUTO	0.22	0.03	0.22	0.00	0.23	0.00	0.00
Urban dummy					0.08	0.00	

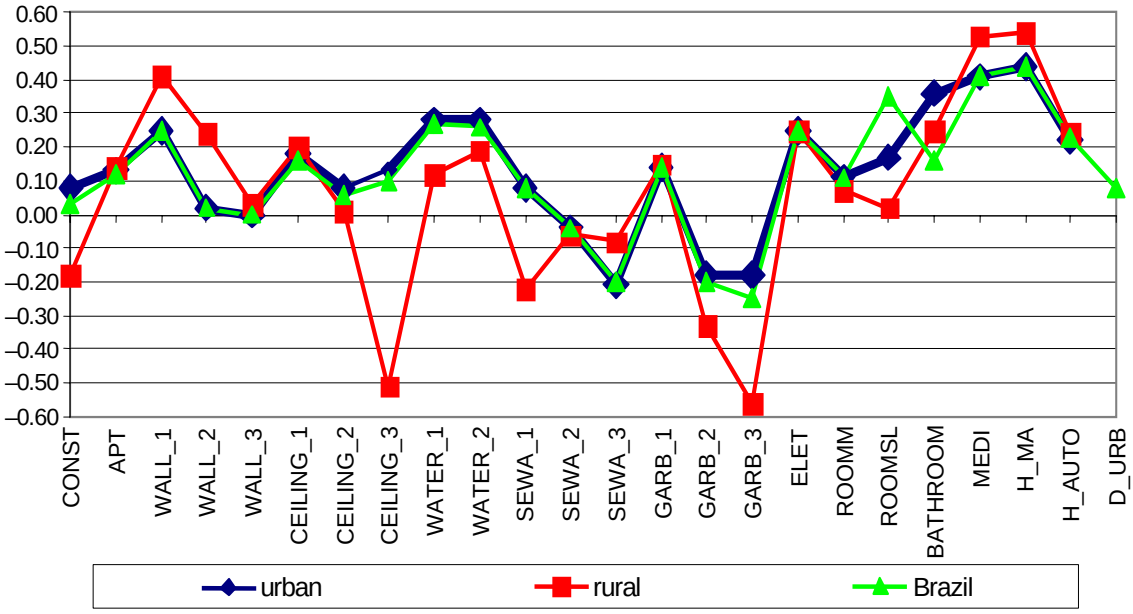
Source: PNAD (1999).

As we expected, two coefficients for the urban area are significantly negative. The sewa_2 (sewage through septic tank) and sewa_3 (sewage through rudimentary septic pit) variables are comparable to the variables sewage through ditch, river, lake and sea. Therefore, many of the residences are located close to beaches or lakes, which explains the higher values.

On the other hand, the regression for the rural area presents only six coefficients that are significantly different from zero. The lack of precision in the estimates is due to the reduced number of observations. However, this fact does not cause distortions in the value of the residence imputations. Figure 1 displays the differences between the urban and rural estimates. We note that the differences are not very high in absolute terms. For seven coefficients, the difference reaches 0.05 and for eight coefficients it attains no more than 0.20.

Figure 1

Estimated coefficients, Brazil: 1999



There are two additional problems regarding the parameter estimates. The first regards the lack of explanatory variables in the rent equation. The two main omitted variables are the state of conservation of the property (including the internal finish) and the existence of parking. These omissions may underestimate the residential values of large urban centres. The second problem is the sensitivity between stock and parameter estimates. It was beyond the scope of this work to conduct sensitivity tests of this nature.

6. Results

This section presents the residential capital and residential investment series estimated through the method of hedonic income (MHI).

Our methodology follows the estimation of the residential stock by the number of residential units. This stock aggregates its physical and location attributes and varies according to the variation of the units and the attributes. If there is an increase of more valued attributes, such as apartments, number of bedrooms, among others, the residential stock growth rate is higher than the residential units growth rate.

The problems mentioned in Section 4 indicate that the estimates should be taken with caution and could undergo future revisions.

Table 4 presents the results. The stock of residences (SR) is obtained from the rent series and it is transformed into monetary values based on the hypothesis that the median monthly rent/residential price relation is 0.75%. The stock of residences more than tripled in the last three decades, with annual growth of 4.2%. The stock of residences divided by the number of residential units corresponds to the average unitary value of the total of residences in the country (AUV). According to our estimates, the AUV increased from R$ 17,532 to R$ 23,755 (in R$ of 1999), corresponding to a growth of 35.5% or 1.05% a year.

Table 4

Housing capital value, number of residences, and GDP

Year	SR (R$ billion)	Residences (million)	AUV R$	GDP R$ billion	SR/GDP
1970	309.33	17.643	17,532	275.11	1.12
1980[1]	504.48	25.211	20,011	629.32	0.80
1981	520.86	26.029	20,011	634.18	0.82
1982	553.24	27.401	20,190	639.45	0.87
1983	584.88	28.185	20,751	620.71	0.94
1984	612.86	29.164	21,015	654.23	0.94
1985	652.29	30.585	21,327	705.59	0.92
1986	676.65	31.100	21,757	758.43	0.89
1987	696.44	32.136	21,672	785.21	0.89
1988	739.74	33.167	22,303	784.74	0.94
1989	761.27	34.339	22,169	809.53	0.94
1990	760.63	34.111	22,299	774.32	0.98
1991[1]	774.74	34.743	22,319	782.31	0.99
1992	790.21	35.903	22,010	778.06	1.02
1993	819.29	36.819	22,252	816.37	1.00
1994[1]	856.67	37.647	22,755	864.15	0.99
1995	894.05	38.474	23,238	900.65	0.99
1996	931.19	39.682	23,466	924.60	1.01
1997	951.97	40.645	23,422	954.85	1.00
1998	996.96	41.840	23,828	956.11	1.04
1999	1,017.94	42.851	23,755	963.87	1.06

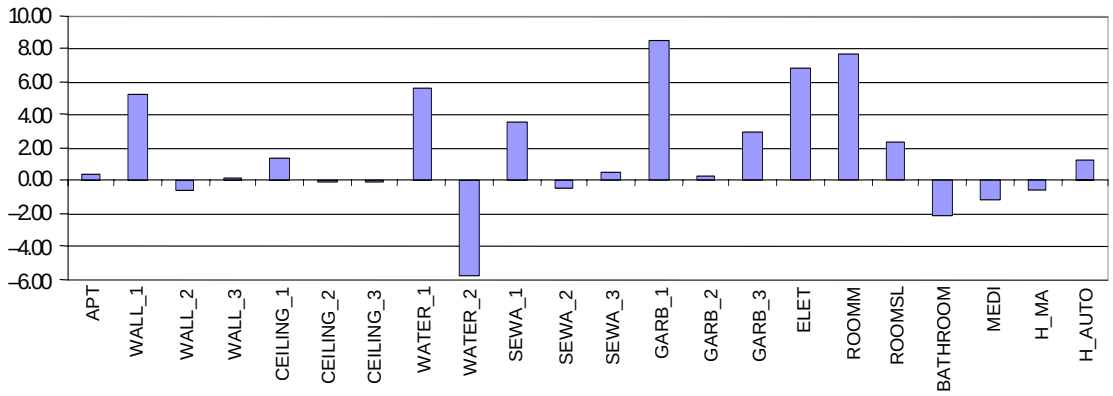
[1] Estimates obtained by interpolation.

Sources: IBGE; IPEA.

This variable measures the evolution of the quality of residences in Brazil. The residential quality growth is related to several factors. The three most important are: (i) the improvement of garbage collection; (ii) the addition of other rooms such as living rooms and kitchens in many Brazilian residences; and (iii) expanded electrification. These three characteristics contributed 22.9% out of the 35.5% total growth in quality, or 64.5% of that total (see Figure 2).

Figure 2

Growth decomposition of the residence attribute

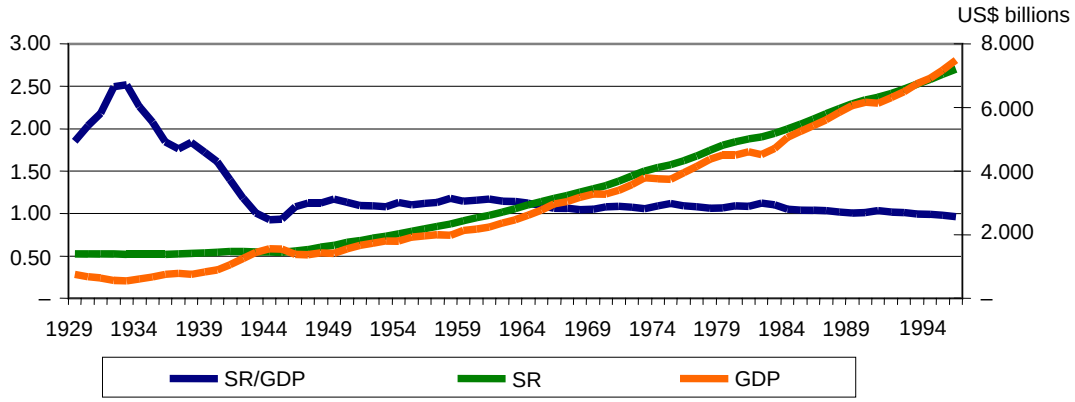


Regarding Brazil's gross domestic product (GDP), SR has shown a cyclical tendency over the last three decades. In the seventies, the SR/GDP ratio decreased from 1.12 to 0.85, which indicates that GDP increased 33% (1.12/0.85) above SR. In the two following decades, this ratio presented a constant growth trend. Therefore, we conclude that SR/GDP is strongly related to the cyclical movement of the product. See Table 4.

This cyclical movement is also observed in the North American economy. Figure 3 shows that the stock of residences behaves more smoothly than GDP, which indicates that the SR/GDP ratio changes according to GDP changes. It is worth noting the sudden fall of this ratio after the economic recovery from the economic crisis of the thirties.

Figure 3

Net stock of residences/GDP, US: 1929-97 (US$ 1992)



The SR/GDP ratio stabilised from 1946, varying only between 0.96 and 1.18. Figure 4 depicts this series and presents the economic growth cycles, such as the economic growth of the 1950s and 1960s, the two oil crises of the 1970s, and the vigorous growth of the 1990s.

Figure 5 presents the SR/GDP ratio for the period of the "Brazilian economic miracle" in the seventies and the stagnant economic growth in the eighties and nineties. The figures are similar to the ones for the North American economy, except for the tendency. While the American SR/GDP ratio presents a decreasing trend, there is an upward tendency for the Brazilian economy. There are two alternative views of these differences. One point of view is that the stock of residences in Brazil will tend to increase over GDP growth in upcoming years, and the SR/GDP ratio will tend to return to the pattern of the seventies (around 1.12). Another view is that this increase can indicate the end of a cycle of low growth of the product, which may point to economic recovery in the next few years.

Figure 4

Net stock of residences/GDP, US: 1946-97 (US$ 1992)

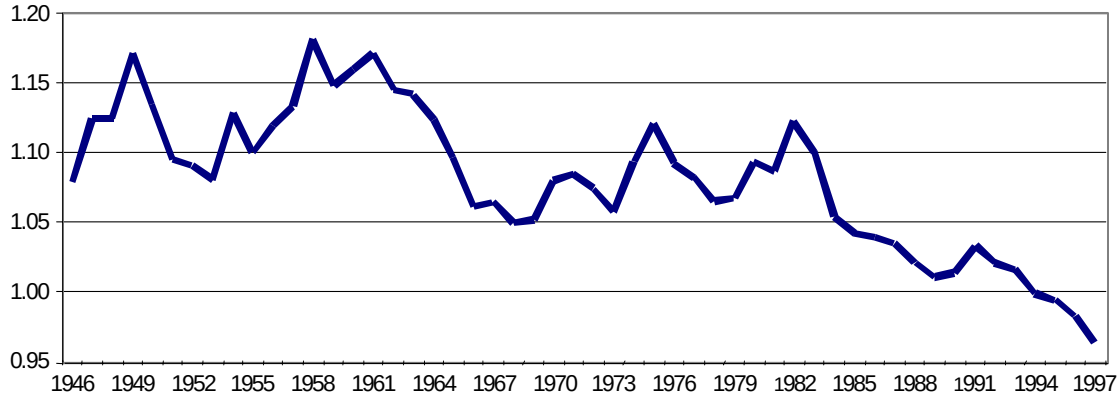
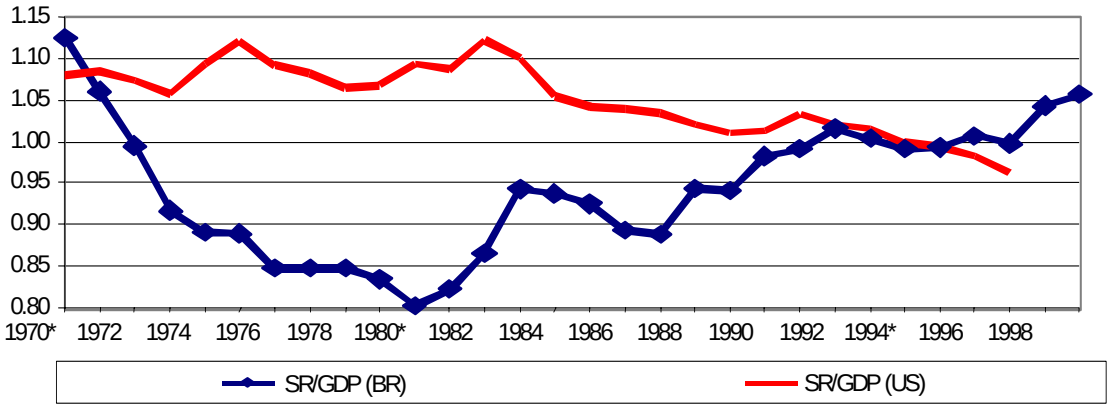


Figure 5

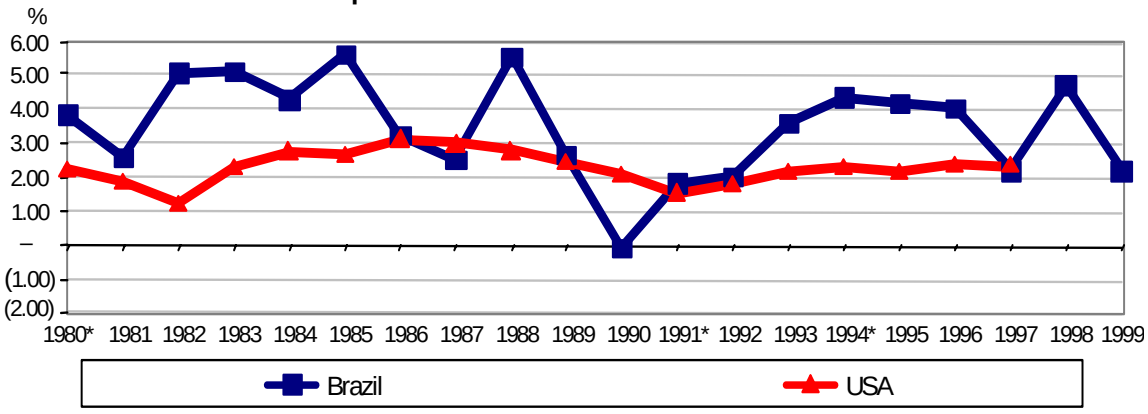
Stock of residential capital/GDP: Brazil and US: 1970-99



Finally, Figure 6 presents a comparison of the investment in residences in Brazil and in the United States from 1971 to 1999. Our estimates indicate that the residential investment in Brazil is more volatile than that in the United States of America. However, the tendency in both countries is the same. Brazilian housing investment attained around 4-5% of GDP in the seventies and decreased to 3% in the eighties and nineties. In the United States of America, the ratio of housing investment to GDP was 3% in the seventies and 2% in the nineties.

Figure 6

Net investment in residences/GDP: 1971-99
comparison between Brazil e United States



7. Concluding remarks

The work estimated the residential capital stock in Brazil for the period 1970-99. It is an exploratory work attempting to expand the range of statistics available on the residential property sector in Brazil. There are many applications of the data estimated here, such as use as an indicator of the level of real estate activity, an indicator of the level of welfare, disaggregation of investment in civil construction, imputation of rents in the national accounts, and compilation of consumer price indices.

The data available for Brazil do not allow us to use conventional methods to estimate the level of capital stock, namely the perpetual inventory method and the accounting value method. Hence, we used an innovative method called the "hedonic income method", by which we used the hedonic price model to impute the rent and then transform the rent (income) into a value, dividing by a discount rate, which is known as the "income method".

The results indicate that the magnitude of the residential capital (KR) is near the magnitude of the GDP. They also indicate that the residential capital series has lower variance than the GDP series, so that the fluctuation in the KR/GDP ratio is governed by the economic cycle. These results also are observed for the US economy, which we used as a benchmark in our analysis.

A secondary derivation of the residential capital series is the net residential investment series, which is not made available in the national accounts. Once again, using data from the United States as a benchmark, our estimates cannot be disregarded.

We can suggest three questions and extensions that can lead to future revisions of the residential capital series. The first refers to the starting data of the series data, 1970. The set of variables that describe residences is smaller than that from 1981 onward - there are nine variables available for 1970 against 22 for the remaining years. Besides this, one must consider that the source of data for 1970 is the Demographic Census, while for the period after 1981 the source is the PNAD, with the values for 1980 and 1991 estimated only using the number or residences obtained in the census. At first glance, this problem would lead us to conclude that the series is more consistent from 1981 on. But the fact that the data from 1970 capture the expanding cycle of the Brazilian economy in the 1970s is indicative that the estimate for that year is not totally absurd.

A possible extension of the work would be to transform the fixed-base series into a moving-base series. This would avoid the arbitrariness of choosing 1999 as the base year, besides capturing the price variables relative to the attributes of the properties occurring over the years.

A third question/extension, related with the second, is the estimation of the parameters. One could undertake some analysis of the consistency of the residential capital series by modifying or expanding the areas of the estimations of the parameters. For example, instead of estimating them by rural and urban area, they might be estimated for metropolitan and non-metropolitan region, or other divisions along these lines.

Finally, greater coverage of rural areas is needed.

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