House Price Indexes and Cyclical Behavior

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Abstract

We use data on new apartment offerings in the municipality of Sao Paulo, Brazil to illustrate our main claim that the hedonic direct method using time dummies as well as the simple average method include cyclical behavior of observables and non observables in a house price index that may overestimate or underestimate the actual change in house prices, well beyond the composition effects. We propose the use of alternative characteristics hedonic functions to compute alternative Laspeyres house price indexes that differentiate the sources of observable shocks in the index. Our decomposition allows for the inclusion of level and cyclical behavior of sets of aggregate variables into the index.

Keywords: House price index, real and nominal shocks.

JEL Classification Codes: R3, E3

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1. Introduction

The housing market has become an important part of the modern economy and more recently, the sophisticated securitization of the real estate sector in the US has brought about a financial crisis of large proportion. Thus, it is important for modern economies at the local, state and national levels to measure the evolution of prices in the real estate sector.

In general, house price indexes measure the average or median price of houses sold in a particular period. However, the mix of houses included in the sample can change significantly over time. In particular, if the proportion of low quality houses in period t is much higher than in period $t+1$ then the change in the average sale price from period t to $t + 1$ will overestimate the actual change in house prices. Another common form of price index used is the hedonic price index. This uses the characteristics of the house to evaluate the evolution of prices over time. We claim in this paper that the hedonic direct method using time dummies, as well as the simple average method includes cyclical behavior of observables and non observables in the index that may over/understate the actual change in house prices, well beyond the composition effects mentioned above.

There has not been much research on this specific issue. In the U.S., Del Negro and Ostrok (2007) have examined the role of monetary policy in explaining house price movements. Their main finding is that the effects of aggregate policy shocks on house prices were small, relative to the magnitude of house price fluctuations in the early 2000s. However, more recently Aragon et al (2010) have criticized certain house price indexes in the U.S. claiming that they underestimate the potential downturn in house prices in recent years.[1] In general, a house price index can be used to provide a signal to market participants on adjustments for rents, collaterized debts, other securities tied to the housing market, and risk assessment for mortgages and other instruments such as derivatives (MBS-mortgage backed securities). Hence, it is important that a house price index reflects the variation and cyclicality of the housing sector and does not incorporate other sources of real, nominal and other shocks that can potentially bias the index.

We use a data set on new apartment offerings in the municipality of Sao Paulo, Brazil to illustrate our main claim that the hedonic direct method using time dummies, as well as the simple average method includes cyclical behavior of observables and non observables in the index that may

[1] In their study of consumer price indexes, Reis and Watson (2010) use dynamic factor models to separate the CPI components into relative price and pure overall inflation components. Their pure overall inflation component is then related to aggregate variables. Our study has a different focus on house price indexes and a different methodology, but it shares a similar motivation in determining the specific components of price variation in a given price index.

over/understate the actual change in house prices. Data from Brazil are important because this is a country that, at the time of this writing, does not have a house price index available. We propose the use of alternative characteristics hedonic functions to compute alternative Laspeyres (or Paasche) house price indexes that differentiate the sources of observable shocks in the index, say nominal, real, and other sources. Our decomposition allows for the inclusion of cyclical behavior of sets of variables into the index. We discuss alternative sets of variables, real versus nominal and potentially other variables for an index of nominal real estate prices, where the own characteristics of the property are included to capture the own cyclicality of the real estate market.

Section 2 describes the data, while section 3 presents the main methods, models and results. Section 4 concludes.

2. Data

The Brazilian Property Studies (Embraesp) collects data on residential and commercial initial offerings in São Paulo. We use information about vertical residential initial offerings (apartment buildings), monthly observations of residential properties from January 2001 to March 2008, with a total of 1,487 observations.[2] Other variables representing the characteristics of the property were obtained from alternative sources. Location and size of parks from the Department of the Environment of São Paulo; location of subways and trains stations from the Laboratory of Urban Metropolis, University of Sao Paulo; location and size of slums from the Centre for Metropolitan Studies. The aggregate macroeconomic variables were obtained from the Central Bank of Brazil; and U.S. Variables from the US Fed, and Bloomberg.

Table 1 presents the distribution of initial offerings by bedrooms per year and Figure 1 the density functions. The median number of bedrooms is 3. The years of 2005, 2006 and 2007 show a skew towards more bedrooms both in Table 1 and Figure 1 while the first 3 months of 2008 show a skew towards 2 bedrooms. Table 2 presents the distribution of initial offerings by number of bathrooms per year, while Figure 2 gives the associated densities. The data shows a median of 2 baths; and in 2005, 2006 and 2007 a slightly higher average. In 2008, the mean declines consistently with the evidence of bedrooms.

[2] The observations refer to one unit (apartment) in the vertical building, hence the trimmed number of total observations.

Table 3 presents the distribution of nominal prices per square meter of livable space in Brazilian currency per year while Figure 3 shows the densities. The median price in 2006 is the highest in the sample and the histograms show more dispersion in 2006 as well. Figures 4 and 5 show the nominal prices by bedrooms and by baths. More bedrooms and more bathrooms show more dispersion in the price as expected.

Overall, the evidence from the data is that the composition of offerings has varied in the sample. Thus, we would expect that an average index will suffer from the usual composition bias.

3. Price Indexes and Cyclical Behavior

The simplest and commonly used price index is the average of all offerings in a given period of time. This can be estimated as a geometric average of the nominal prices, that is the nominal price per square meter of livable space, as

$$Mean\ (log\ p_t) = \frac{1}{n_t}\sum_i log\ p_{i,t} \tag{1}$$

where n_t is the number of new offerings in period t. As mentioned above, the average has several problems when applied to housing. The issue we are interested in this paper is the extent to which an index like the geometric average contains cyclicality that goes beyond the own cyclicality of the housing market. To illustrate this point, consider (1) estimated through time dummies with the monthly data available in this study

$$log\ p_{i,t} = \beta_0 + \sum_{m=Feb,2002}^{March,2008} \beta_m\ month_{m,i} + \epsilon_{i,t} \tag{2}$$

where ε is an error term, for property i in period t. Expressions (1) and (2) give exactly the same estimated mean (log) of the nominal price. The time dummies will capture much of the cyclical behavior in the economy influencing the determination of the (log) of the price. Those include the own cyclicality of the real estate market plus observables such as interest rates, investment, stock prices, growth of GDP, and the list goes on; as well as non observables such as time trends, aggregate (and potential idiosyncratic) risks and expectations. In particular, an economy will be subject to several shocks, nominal and/or real in nature, and the average index will contain all those without much discrimination.

3.1 Hedonic Price Index by the Time Dummy Direct Method

In order to improve upon an average price index, it is common that models are estimated to control for characteristics of the real estate. A hedonic price index is any price index that makes use of a hedonic function.[3] A hedonic function is a relation between the prices of different varieties of a product, such as the various types of houses and/or residential apartments, and the quantities of characteristics in them. For example a hedonic function may be given by:

$$p_{i,t} = f\left(chracteristic_{i,t}\right) + \varepsilon_{i,t} \quad (3)$$

where p is the price of the property i in period t , f is the hedonic function of the characteristics, and ε is an error term. Econometrically estimating a hedonic function is the first step in computing a hedonic price index. As the definition of a hedonic price index implies, hedonic indexes may be computed in a number of ways. The direct method provides an estimate of hedonic indexes from an OLS regression. Hence, using the full sample, from January 2001-March 2008 we can estimate the semi-log (OLS-robust) regression:

$$log\ p_{i,t} = \beta_0 + \beta_1 dorm_{i,t} + \beta_2 dorm_{i,t}^2 + \beta_3 bath_{i,t} + \beta_4 gar_{i,t} + \beta_5 elev_{i,t} + \beta_6 u\_floor_{i,t} + \sum_{m=Feb,2002}^{March,2008} \beta_m\ month_{m,i} + \epsilon_{i,t} \quad (4)$$

The characteristics include number of bedrooms (including the square of it for nonlinearities), number of bathrooms, number of garage spaces, number of elevators, and number of units per floor.[4] The constant coefficients on the time dummies β_m for the month of the new offering provide sufficient information to estimate a price index for this sample, i.e. the index is $e^{\beta m}$. We plot the results in Figure 6 from December 2005 to March 2008, where December 2005 is normalized to equal 100. Table 4 shows the statistics of the indexes in Figure 6. The geometric mean and the hedonic characteristics indexes both show volatility, although the model of characteristics is slightly less volatile. While expression (4) provides controls for the characteristics of the real estate in the sense that those are held constant as we extract information from the time dummies β_m; the time dummies themselves continue to capture the own cyclicality of the real estate market plus other observables and non observables associated with the business cycle in general. This is clear from Figure 6.

We illustrate the point above by considering the following thought experiment. We estimate a time dummy index by the direct method using the whole sample, or monthly observations from January 2001 to March 2008 as in a version of model (4) including house characteristics and geographic factors, denoted td_index_t. The resulting monthly index is then regressed on a set of variables representing blocks of observable aggregate factors. The choice of aggregate factors is

[3] See Triplett (2004) for a comprehensive study of hedonic price indexes.

[4] Each characteristic could also be included as a set of dummy variables to better capture nonlinear effects.

arbitrary and could include several potential important elements. We choose three basic blocks representing real factors, nominal factors and potential U.S. factors that can influence the Brazilian market.[5]

The block of real variables includes the total credit over GDP for the country and is meant to capture the effects of credit availability on house prices. In particular, we would expect that the higher the credit available, the higher the demand for real estate and the higher the prices. The second variable in the real block is a Sharpe index of the risk in the Brazilian Bovespa stock market. The booms and busts in the stock market can potentially influence demand and supply of real estate through expectations and confidence.

The block of nominal variables includes the risk-free nominal interest rate for the nation, the Selic, and the national currency vis-à-vis the U.S. dollar nominal exchange rate. The nominal interest rate is the counterpart of the real credit channel at the nominal side. The nominal exchange rate captures the potential effect of foreign direct investment and other sources of income through the export channel.[6] Finally, we choose the Case-Shiller index in the U.S. as a barometer of the influence of the U.S. into the local real estate market, and the measure of risk associated with the U.S. S&P500. Table 5 presents the descriptive statistics of the blocks of aggregate variables.[7]

Then, the regression is estimated as

$$td\_index_t = \beta_0 + \beta_1 sharpe\_bov_t + \beta_2 cred\_gdp\_br_t + \beta_3 selic_{i,t} + \beta_4 fx\_br_t + \beta_5 case\_shiller_t + \beta_6 sharpe\_sp500_t + \epsilon_t \quad (5)$$

where real variables are given by the Sharpe ratio of the Bovespa Brazilian stock market, and the proportion of total credit over GDP; nominal variables are given by the Selic (overnight) nominal interest rate in Brazil (rate per month), and the nominal exchange rate with the US (Fx, BRL$/US$); and US variables given by the Case-Shiller house price index and the Sharpe ratio of the S&P500; and Table 6 presents the results for model (5) where a lagged dependent variable was appropriately accounted for autocorrelation of errors.

[5] Recent work by Bianconi and Yoshino (2010a, b) show that U.S. aggregate variables have important effects in markets all around the world, and particularly in the real estate sector in Brazil.

[6] Brazil is a large exporter of commodities and movements in the nominal exchange rate can provide large gains/losses for producers and ultimately consumers.

[7] In the paper by Simizu and Watanabe (2010), p. 460; they discuss the effect of housing demand on house prices in Japan using a dynamic VAR. They condition their estimation on aggregate variables including the fundamentals real GDP in Japan and the United States, an average lending rate in Japan and a mortgage rate in the United States.

The three blocks of aggregate variables are statistically significant from the F-tests as we suspected. The real variables block shows that the Credit/GDP significantly increases the house price index as we expected. The nominal variables block shows a positive effect of the nominal exchange rate as well, but the magnitude is about 3 times larger than the real effect. The US variables block shows a significant positive effect of the Case-Shiller index, but of an order of magnitude about 10 times smaller than the real effect.

Figures 7-9 show the time paths of each of the variables in the blocks together with the house price index, as well as the sample cross-correlation functions of the differenced filtered data. Figure 7 shows in the first row the monthly time series plots of the house price index *td_index*, the Sharpe_Bov and Credit/GDP variables. The real variables show relatively larger correlations at small time leads, -3 to about -10, with a minimum at the lead -5; this indicates that the Credit/GDP ratio leads the Sharpe_Bov by about 5 periods and the correlation is negative. The lower row shows the cross correlations of the two variables with the house price index. The lower left is *td_index* with the Sharpe_Bov. There is no particular cyclical pattern, thus there is feedback among the series. The same occurs on the lower right graph regarding the Credit/GDP variable.

Figure 8 shows the monthly time series plots of the house price index *td_index* and the nominal variables, interest rate Selic and exchange rate. The nominal variables do not show much cross cyclicality and there is feedback among them. The lower left row shows the cross correlation of the house price index and the Selic rate. There is a clear large correlation at lag 1 indicating that the Selic interest rate lags the house price index by 1 period. The correlation is positive showing procyclical behavior between the Selic interest rate and the house price index. The lower right graph is the *td_index* with the exchange rate and there is no particular cyclical pattern; thus there is feedback among the series.

Figure 9 shows the monthly time series plots of the house price index *td_index* and the US variables, the Case_Shiller index and the Sharpe_sp500. The US variables themselves do not show any cross cyclicality; and the lower left row shows no cross cyclicality between the house price index and the Case_Shiller index. However, the lower right graph shows that the *td_index* and the Sharpe_sp500 have relatively more cross cyclicality with an inconclusive pattern, i.e. there is feedback among the series.

To sum, the analysis above shows that there is the potential for influence of aggregate factors on a house price index generated by a hedonic time dummy direct method. The cyclical pattern with the aggregate variables is mixed, but the house price and the Selic are procyclical at lag one, and all blocks of variables have some cross cyclicality with the house price index. We proceed next by discussing an alternative method for the estimation of a house price index that takes into account the aggregate variables.

3.2 Hedonic Price Index by the Characteristics Method

Our thought experiment above leads us to propose to add blocks of characteristics and potential real and nominal variables to the hedonic function that can better capture the cyclical behavior, as in model (5). We see in Table 6 and Figures 7-9 that real, nominal and US factors can potentially influence the house price index and the cyclical behavior of the housing market. Thus, we propose a hedonic function which will have a more general form

$$p_{i,t} = f\left(characteristic_{i,t}, geographic_{i,t}, real_t, nominal_t, other_t\right) + \varepsilon_{i,t} \qquad \text{(6a)}$$

where the additional blocks of geographic variables, real, nominal and other variables are described below.

However, it is clear from (5) that the potential real and/or nominal economic variables vary over time, but not across units. Those variables do compromise the estimation of a house price index by the direct method, i.e. at least one of the time effects would be perfectly correlated with one additional aggregate factor. Hence, we propose using the hedonic function to estimate the price by an alternative characteristics method.[8]

Given the constraints imposed by our data set, in the sense that we do not have enough cross-sectional units per month, we proceed by computing indexes on an annual basis, as opposed to the monthly basis. As an example, we estimate for each year *t=2002,…2007* the OLS-robust regressions (6 regressions total):

$$\log p_{i,t} = \beta_{0,t} + \beta_{1,t} dorm_{i,t} + \beta_{2,t} bath_{i,t} + \beta_{3,t} gar_{i,t} + \beta_{4,t} dist\_slums_{i,t} + \beta_{5,t} selic_{i,t} + \beta_{6,t} sharpe\_bov_{i,t} + \beta_{7,t} cred\_gdp\_br_{i,t} + \beta_{8,t} fx\_br_{i,t} + \beta_{9,t} case\_shiller_{i,t} + \beta_{10,t} sharpe\_sp500_{i,t} + \epsilon_{i,t} \qquad \text{(6b)}$$

where the monthly variation within the year for the aggregate variables is used in each yearly regression. The choice of variables in (6) is meant to illustrate the main points discussed above and

[8] See Triplett (2004). The Bureau of Labor Statistics (BLS) uses a linear-linear version of the model below for a price index calculation, but to our knowledge does not add the aggregate factors as we do here.

follows the same set of variables of model (5), including the blocks of real, nominal and foreign aggregate variables. First, we have the real estate characteristics given by number of bedrooms, number of bathrooms and number of garage spaces; one geographic component given by distance to nearest slum (in 1,000 meters); nominal variables given by the selic and the nominal exchange rate; real variables given by the Sharpe ratio of the Brazilian stock market, Bovespa, and the proportion of total credit over GDP; and US variables given by the Case-Shiller house price index and the Sharpe ratio of the SP500. Figure 10 presents the annual average values of the nominal house price (log of price per square meter of livable space), the real variables, the nominal variables, and foreign variables, all normalized to 2003 equal to100.

The average nominal property price trends upwards and the nominal variables trend downwards. Both measures of risk, the Sharpe of the Bovespa and the Sharpe of the SP500 are below the average property price. The credit/GDP ratio and the Case-Shiller index trend together with the property price.

The price index is obtained by using two consecutive yearly regressions. A Laspeyres price index[9] for the characteristics is then computed by the formula:

$$Index_{t+1} = \exp\left(\sum_{j=0}^{10} \beta_{j,t+1} q_{j,t} - \sum_{j=0}^{10} \beta_{j,t} q_{j,t}\right) \tag{7}$$

where β's are the estimated coefficients from regressions (6b) in years t and $t+1$, and the q's are the weights representing the units of characteristics in the bundles. The constant has $q=1$ and all others are set to the median of the variable (characteristic) in their respective year.

In order to identify the different contributions of the nominal, real and other variables on the index, we compute (7) with alternative mixes of variables in the estimation of the regressions. For the housing characteristics only case, the model is:

$$log\ p_{i,t} = \beta_0 + \beta_1 dorm_{i,t} + \beta_2 bath_{i,t} + \beta_3 gar_{i,t} + \beta_4 dist\_slums_{i,t} + \epsilon_{i,t} \tag{8}$$

For the inclusion of the real block, representing real shocks, the model is given by

$$log\ p_{i,t} = \beta_0 + \beta_1 dorm_{i,t} + \beta_2 bath_{i,t} + \beta_3 gar_{i,t} + \beta_4 dist\_slums_{i,t} + \beta_6 sharpe\_bov_{i,t} + \beta_7 cred\_gdp\_br_{i,t} + \epsilon_{i,t} \tag{9}$$

For the nominal block representing nominal shocks, the model is

$$log\ p_{i,t} = \beta_0 + \beta_1 dorm_{i,t} + \beta_2 bath_{i,t} + \beta_3 gar_{i,t} + \beta_4 dist\_slums_{i,t} + \beta_5 selic_{i,t} + \beta_8 fx\_br_{i,t} + \epsilon_{i,t} \tag{10}$$

[9] We use the Laspeyeres index, but a Paasche index would be feasible since would require simply a change in the base.

And for all shocks, we have the model in (6b). Figure 11 shows the indexes obtained in the four cases.

The indexes differ substantially depending upon the pricing of the characteristics and the accountability of shocks. The thick blue line is the housing characteristics only index. It shows a minor declining trend of (nominal) prices in the period up to 2005, and up in 2006 but down in 2007. This index filters out other shocks and only contains the housing characteristics (including the geographic variable). The red line is the index with the inclusion of real shocks. It provides an upward bias relative to the housing characteristics for most of the years in the sample. The inclusion of nominal shocks (the green line) provides a downward bias. The inclusion of all shocks provides an upward bias until 2007, but biases downward in 2007 relative to the property characteristics. In the geometric mean and hedonic direct (time dummies) methods above in Figure 6 those shocks are all mixed together and not identified separately.

Figure 12 provides the real, nominal and all effects netted from the housing characteristics, i.e. the respective index minus the characteristics only index. The real shocks give an upward bias in 2004, 2005 and 2006, and a downward bias in 2007. The nominal shocks give a downward bias in all years of the sample. By including all components in the hedonic regression shows that the US variables amplify the upward bias in 2004, 2005 and 2006, but not in 2007.

One key question then is criteria to discriminate an index and which variables to include in the construction of the index. The real estate property price is nominal and the characteristics of the property are real.[10] Thus, including nominal variables in the index would capture the nominal variation of the property (nominal) price besides the real variation captured by the characteristics. Moreover, the seminal papers by Gray (1976) and Fischer (1977) showed that indexing nominal wages stabilizes output when shocks are nominal and destabilizes output when shocks are real. Under this rubric, including nominal variables in the index would provide some 'neutrality' to the index in terms of housing output. On the other hand, including real shocks could be more problematic. When a real shock hits the real estate sector, it may be magnified by the destabilizing effect in output *a la* Gray-Fischer, and it may amplify to other sectors, especially the ones that are indexed by a house price index such as derivatives (MBS-mortgage backed securities), money market, and global stock market.[11]

[10] See Rosen (1974) for a classic reference on hedonic indexes and the real and nominal components; and Diewert (1993) for a discussion of the appropriateness of a particular index.

[11] For example, as illustrated in the heat map of the IMF Report (2010).

The recent experience of the U.S. financial crisis shows that current indexes in general are not free from sources of real shocks, and they may have exacerbated the subprime crisis in all sectors of economy, including overseas. This is probably one of the main challenges for designing an appropriate housing index in a national real estate market, that is how to balance and buffer real (and nominal and/or foreign) shocks. Our models for a (nominal) housing price index do “price” variables that account for the characteristics of the property, and other potential variables, including foreign variables.

3.3 Hedonic Price Index by the Characteristics Method: Implementation Issues

We estimated the indexes above as an illustration of the main problems facing a housing index that uses a simple mean or time dummy hedonic methodology, i.e. those indexes include cyclical components that are not part of the cyclicality of the real estate sector per se.

Given that our data set is constrained, in the sense that we do not have enough cross-sectional units per month, we computed the hedonic characteristics index using monthly variation per year for all variables, including the aggregate ones. In the case data are available and we want to estimate a monthly index using the cross-sectional variation of units per month, those aggregate variables would be the same for all units within a month. In that case, we would suggest estimating a 12 month annual rolling regression for each consecutive month. Then, we can estimate the Laspeyres (or Paasche) index for every consecutive two month regressions. In this case, the aggregate variables could be taken into account in the same manner discussed above.

Another potential implementation issue refers to the statistical inference for the specific variables to be included in the hedonic function representing different sources of shocks. Once the variables are included in the regression, an F-test (with the appropriate degrees of freedom) for each of the blocks of variables can be used to guide the influence of variables in the determination of the price in the hedonic function.

In Table 7, we report the regressions for the model with all variables in expression (6b). The property characteristics block is always significant for every year as the F-tests show. However, the other blocks are not significant, except for the block of real variables in 2007. We find this latter result encouraging, given the small sample, the restricted set of variables in the blocks and the restricted time period.[12]

The inclusion or not of blocks can be guided by economic theory and statistical tests, and may be adjusted over time. However, it should be clear that the blocks of variables are identifying the separate sources of shocks that can be analyzed in detail by the researcher and/or policy maker. All those sources would otherwise be mixed together in an average or hedonic time dummies index.

4. Conclusions

House price indexes provide an important metric for the well being of individuals in a nation and can be important barometers of the financial health of a nation. In this paper, we point to some pitfalls in some popular methods of house price indexes, beyond the composition problem of average indexes. Our main claim is that averages and the hedonic time dummies methods incorporate sources of level and cyclical behavior in the index that may overestimate or underestimate the value of the index, well beyond the composition problem. We propose an alternative that decomposes the sources of level and cyclical behavior, focusing on real versus nominal versus other (foreign) sources of shocks.

In our limited sample from the city of Sao Paulo, Brazil, our main finding is that real shocks and US foreign shocks give an upward bias in the house price index, while nominal shocks give mostly a downward bias. The results are encouraging and we envision further research in extending the sample of properties as well as extending the analysis to other indexes as well.

[12] The degrees of freedom of the F-tests for the aggregate blocks are adjusted for the monthly observations of the aggregate variables since they do not vary within months. There are 87 months in the sample.

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Table 1: Distribution of Initial Offerings in the Municipality of Sao Paulo by Bedrooms per Year:

Year	Mean	Med	StdD	Min	max
2001	2.71	3	1.00	0.5	4
2002	2.98	3	1.01	1	5
2003	2.87	3	0.95	1	5
2004	2.91	3	0.97	1	5
2005	3.06	3	0.94	1	5
2006	3.16	3	0.97	1	6
2007	3.05	3	0.91	1	5
2008	2.67	2.5	0.76	2	4

Table 2: Distribution of Initial Offerings In Sao Paulo by Number of Bathrooms per Year:

Year	Mean	Median	StdDev	min	Max
2001	2.0	2	0.9	1	4
2002	2.3	2	1.0	1	5
2003	2.1	2	0.9	1	5
2004	2.3	2	1.0	1	5
2005	2.4	2	1.0	1	5
2006	2.5	2	1.0	1	6
2007	2.3	2	1.0	1	5
2008	1.7	2	0.8	1	4

Table 3: Distribution of Initial Offerings In Sao Paulo: Nominal Prices; Price per Square Meter of Livable Space (in BR$ per Year)

Year	Mean	Median	StdDev	Min	Max
2001	2,130	1,931	1,200	790	11,532
2002	2,440	2,214	973	848	6,588
2003	2,760	2,506	1,232	871	9,452
2004	3,175	2,852	1,609	940	12,093
2005	3,160	2,881	1,488	1,218	10,964
2006	3,510	3,234	1,550	1,310	9,886
2007	3,342	3,096	1,266	1,105	10,711
2008	2,904	2,789	1,288	1,530	8,623

Table 4: Descriptive Statistics – Geometric Mean and Hedonic Characteristics - Direct

	Geo. Mean	Hed. Char. Direct
Mean	120.4	113.9
Median	118.4	116.0
Std	15.9	11.6
Min	89.7	86.7
Max	151.8	139.6

Table 5: Descriptive Statistics – Aggregate Variables

	Sharpe_Bov	Cred/GDP	Selic	FX	Case Shiller	Sharpe_500
Mean	0.10	28.41	1.33	2.52	163.96	0.00
Median	0.10	27.50	1.33	2.41	169.31	0.06
StD	0.93	3.09	0.29	0.48	32.67	0.99
Min	-1.88	23.80	0.80	1.67	112.39	-2.07
Max	2.33	36.37	2.08	3.61	206.52	2.06
Obs.	87	87	87	87	87	87

Table 6: Time Dummies Index Regression

Dep. Vble	td_index
L. td_index	0.571***
	(0.0679)
Sharpe_Bov	0.445
	(0.478)
Cred/GDP	1.332***
	(0.335)
Selic	-4.019
	(2.496)
Fx	4.744**
	(1.400)
Case_Shiller	0.113***
	(0.0262)
Sharpe_sp500	-0.335
	(0.457)
Cons	-24.33*
	(11.05)
N	86
Adj R-sq	0.935

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

F-Tests
Real Variables: Sharpe_Bov; Cred/GDP
F(2, 78)= 8.81***
Nominal Variables: Selic; Fx
F(2, 78)= 5.86***
US Variables: case_shiller; Sharpe_sp500
F(2, 78)= 9.42***

Table 7: Regressions for Model Including All Variables - Equation (6b)

Dependent Variable: Log price per livable square meter

Year	2002	2003	2004	2005	2006	2007
BedRooms	-0.170***	-0.174***	-0.177***	-0.105**	-0.0765*	-0.0299
	(0.0287)	(0.0345)	(0.0310)	(0.0399)	(0.0316)	(0.0345)
Bath	0.183***	0.138**	0.222***	0.156***	0.187***	0.152***
	(0.0335)	(0.0436)	(0.0498)	(0.0431)	(0.0477)	(0.0405)
Garage	0.168***	0.210***	0.160***	0.154***	0.0928*	0.0923**
	(0.0223)	(0.0294)	(0.0379)	(0.0327)	(0.0380)	(0.0277)
Dist_slum	0.137***	0.106***	0.114***	0.0742**	0.109***	0.121***
	(0.0185)	(0.0197)	(0.0189)	(0.0236)	(0.0196)	(0.0175)
Sharpe_Bov	0.0462	0.0365	0.0199	-0.00468	0.0298	0.0509
	(0.0353)	(0.0383)	(0.0447)	(0.0183)	(0.0322)	(0.0393)
Cred/GDP	-0.0528	0.0796	0.0651	0.00388	0.102**	0.204*
	(0.0880)	(0.0829)	(0.147)	(0.0238)	(0.0388)	(0.0911)
Selic	0.0896	0.0650	-0.642**	0.371	0.382	-0.287
	(0.298)	(0.229)	(0.217)	(0.226)	(0.294)	(0.302)
Fx	-0.120	0.323	0.208	-0.784	0.0719	0.732
	(0.193)	(0.256)	(0.305)	(0.526)	(0.420)	(0.610)
Case_Shiller	-0.000778	0.0134	-0.00388	-0.0129	0.0258	0.0143
	(0.0194)	(0.0146)	(0.0139)	(0.00974)	(0.0241)	(0.00776)
Sharpe_Sp500	0.0153	0.0943	0.0450	-0.0211	0.0463	-0.0374*
	(0.0345)	(0.0623)	(0.0405)	(0.0265)	(0.0654)	(0.0168)
Cons	8.136*	1.724	5.886*	10.76***	-2.081	-4.036
	(3.990)	(3.477)	(2.535)	(3.114)	(5.586)	(5.220)
N	238	256	198	180	162	203
adj. R-sq	0.673	0.609	0.697	0.634	0.650	0.627

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

F-tests:

Test	2002	2003	2004	2005	2006	2007
Characteristics Block: Dorm Bath Garag Dist_slum	F(4, 227)=123.27***	F(4,245)=96.03***	F(4,187)=85.26***	F(4,169)=45.25***	F(4,151)=48.03***	F(4,192)=72.25***
Real Variables: Sharpe_Bov Cred/GDP	F(2,76)=0.30	F(2,76)=0.22	F(2,76)=0.19	F(2,76)=0.24	F(2,76)=1.38	F(2,76)=4.81**
Nominal Variables: Selic Fx	F(2,76)=0.08	F(2,76)=0.40	F(2,76)=1.72	F(2,76)=0.63	F(2,76)=0.32	F(2,76)=0.76
US Variables: Case_shiller Sharpe_sp500	F(2,76)=0.04	F(2,76)=0.42	F(2,76)=0.27	F(2,76)=0.29	F(2,76)=0.31	F(2,76)=1.19

* p<0.05, ** p<0.01, *** p<0.001

Figure 1:

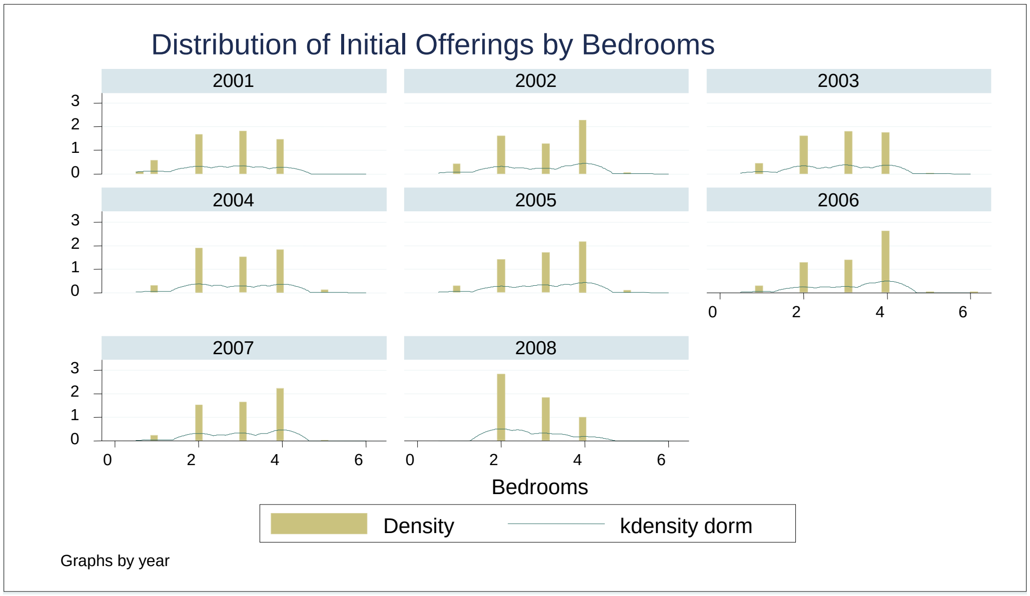


Figure 2:

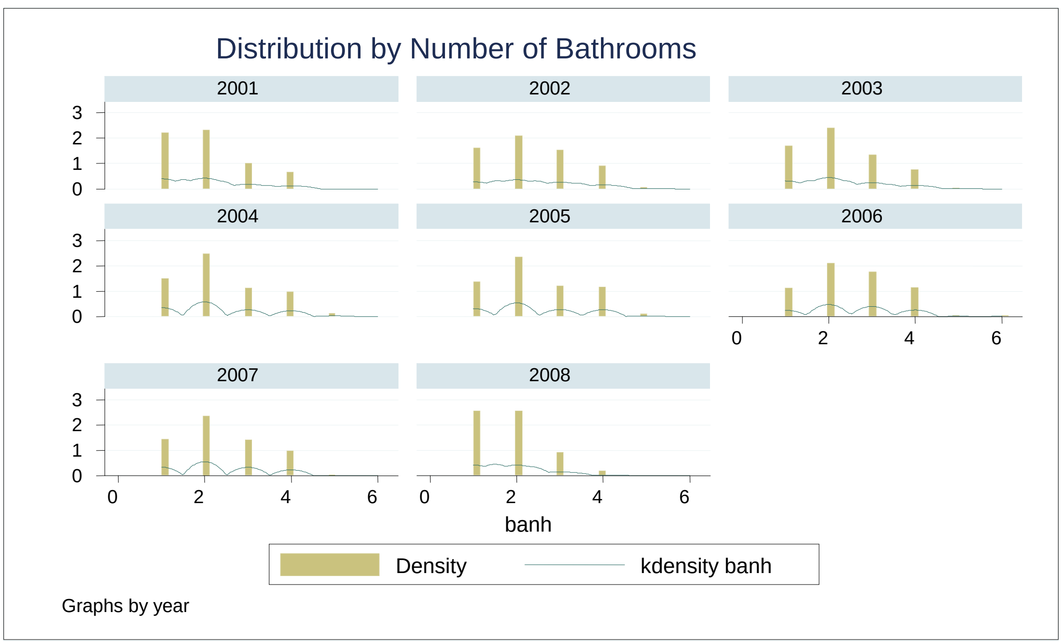


Figure 3:

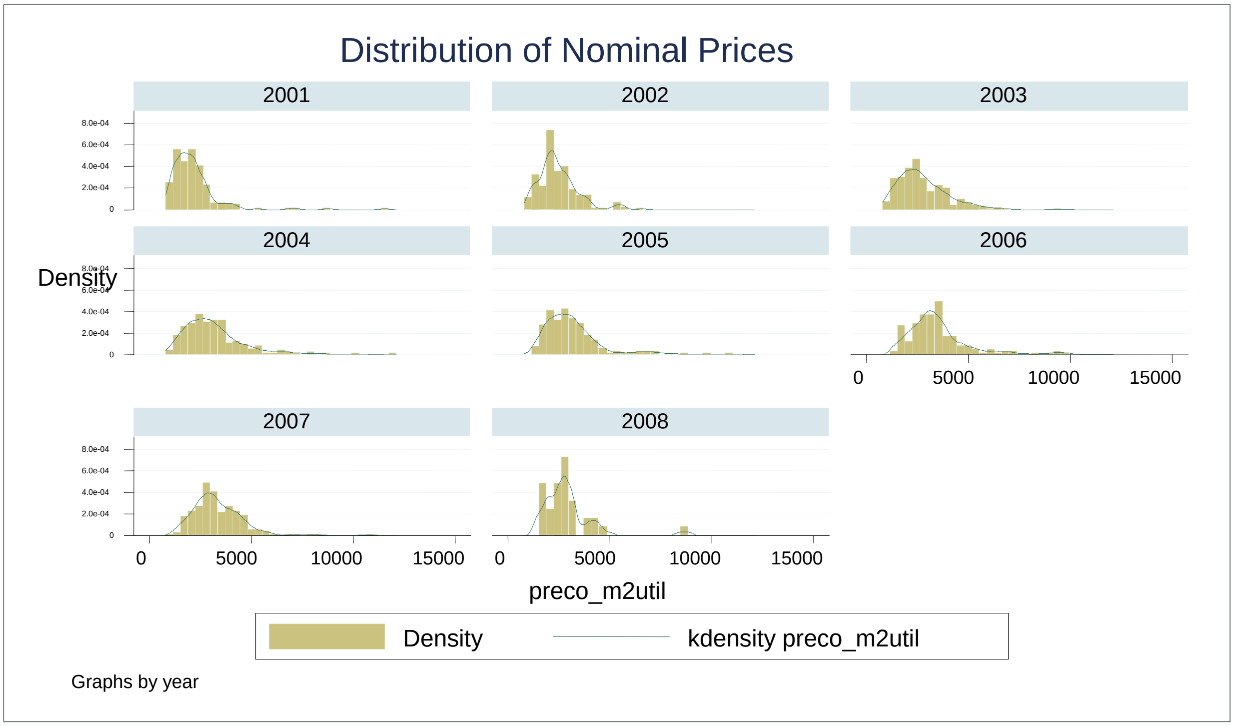


Figure 4:

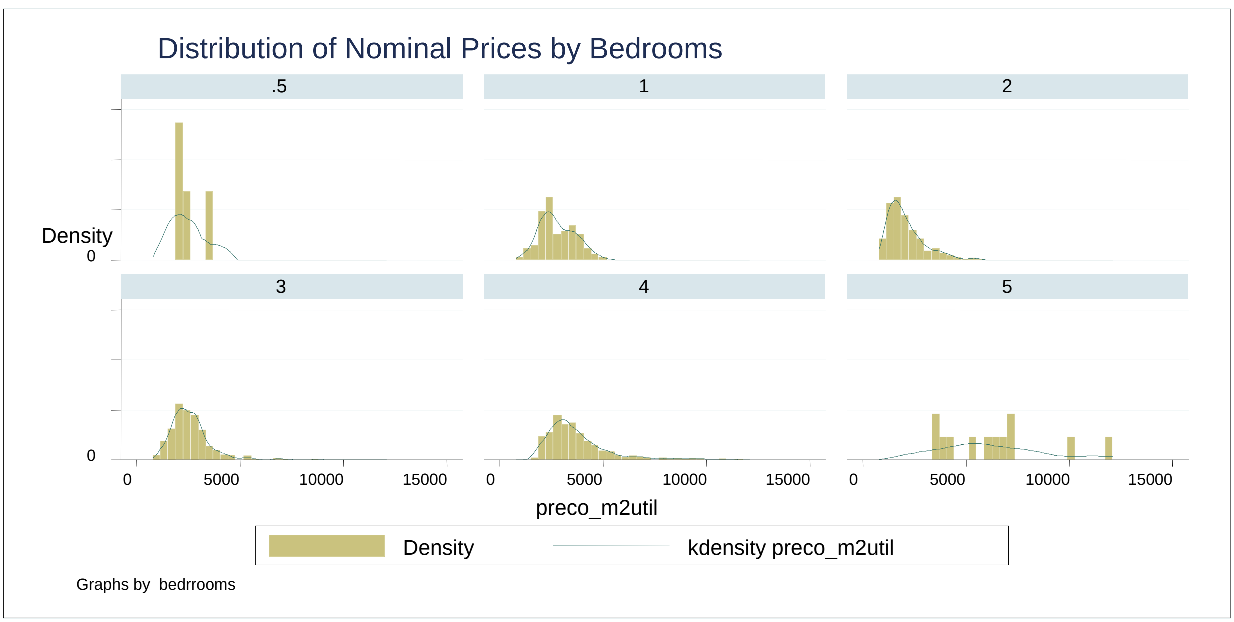


Figure 5:

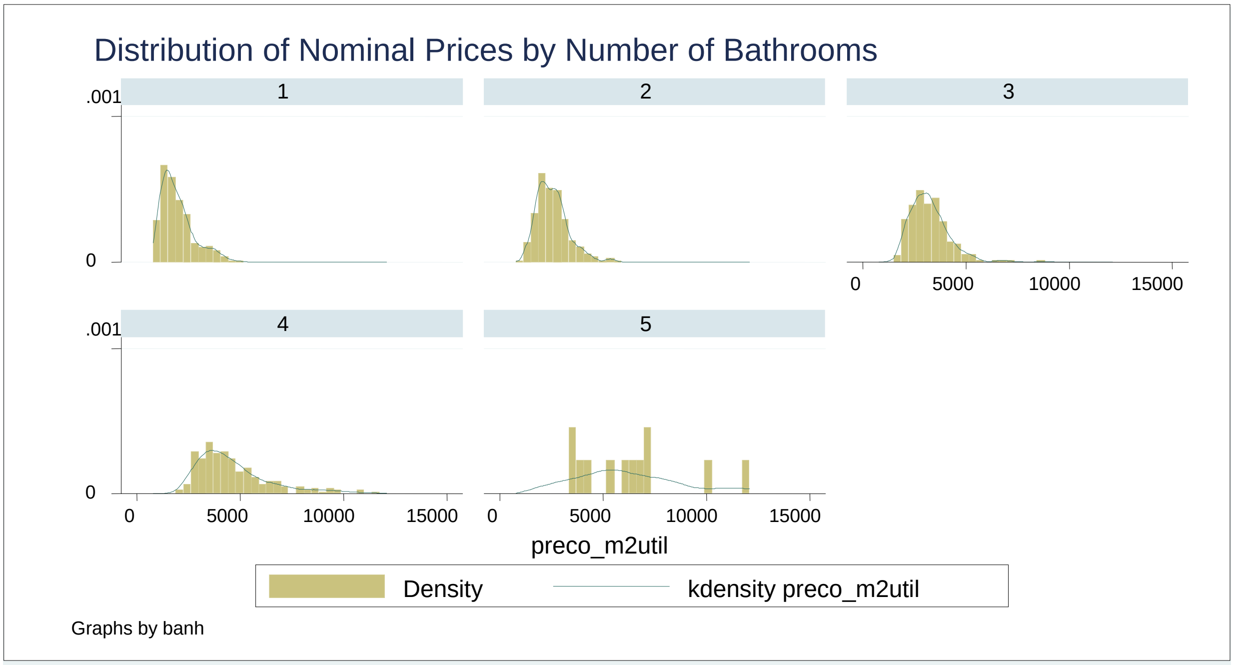


Figure 6:

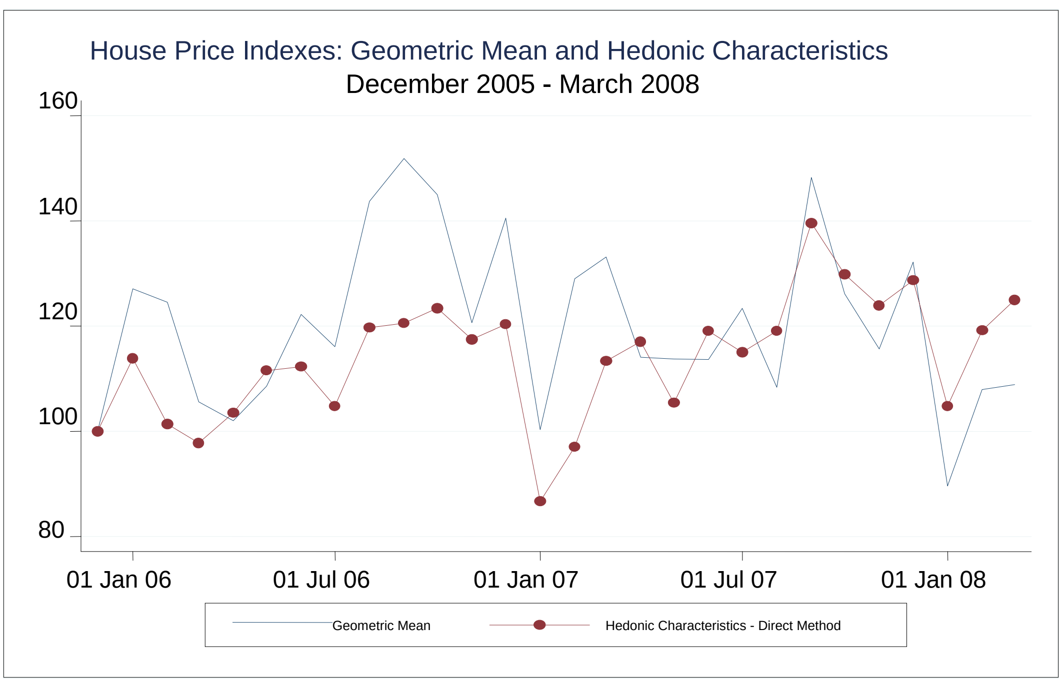


Figure 7:

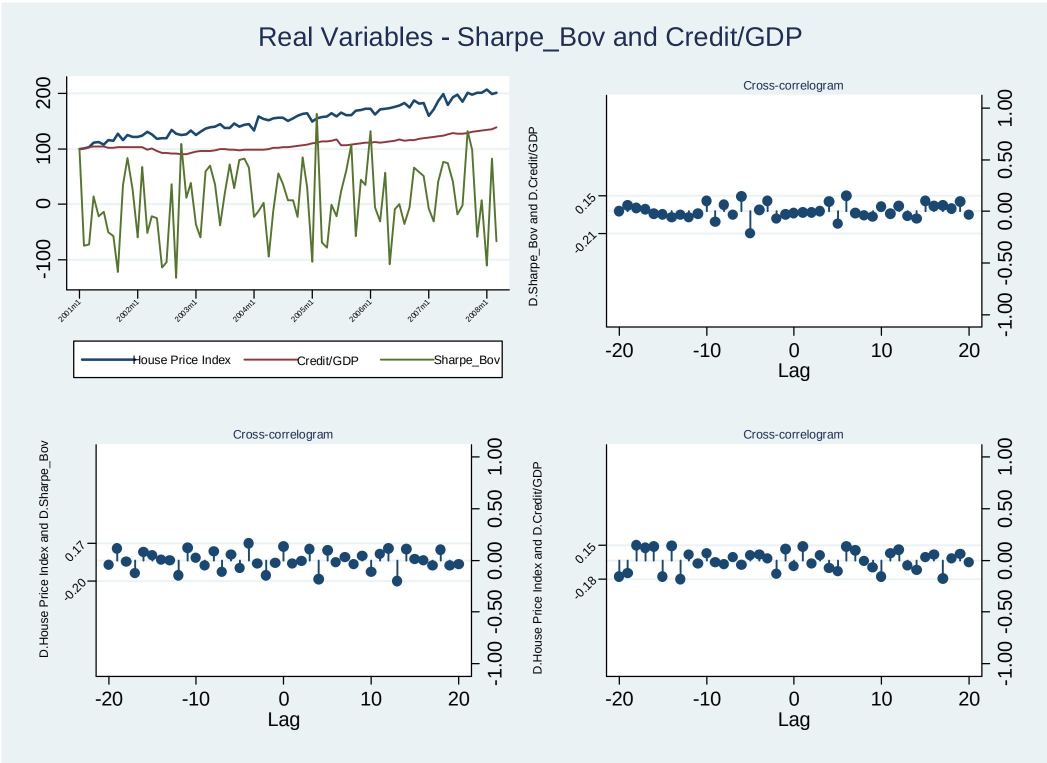


Figure 8:

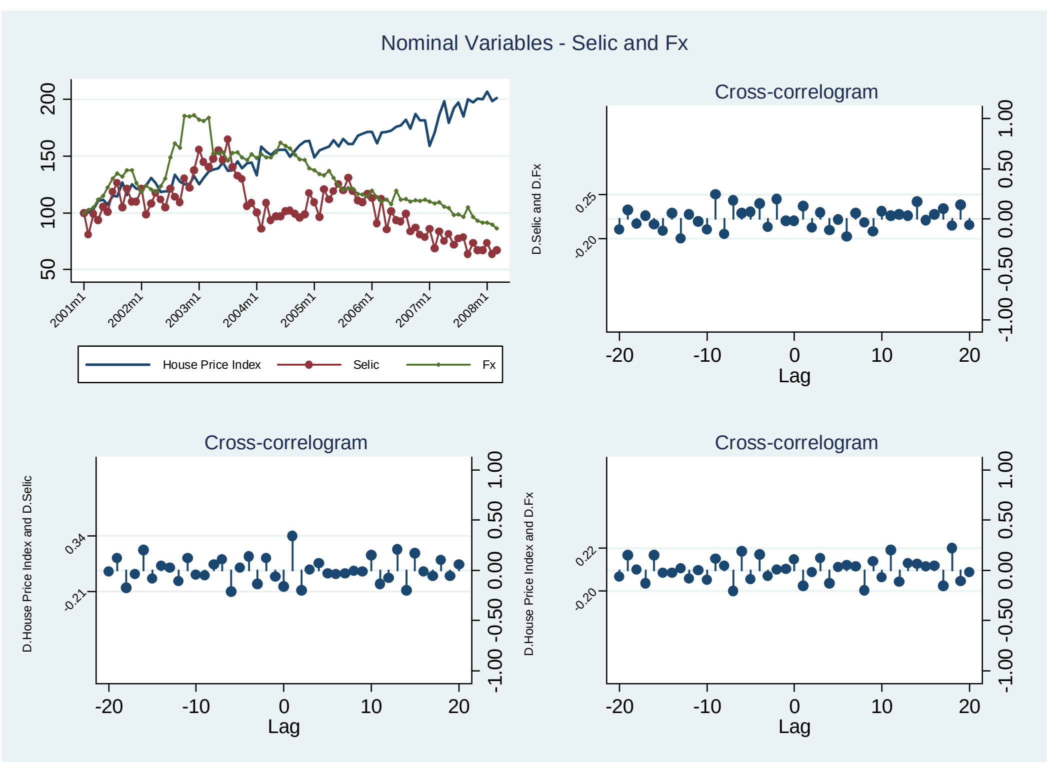
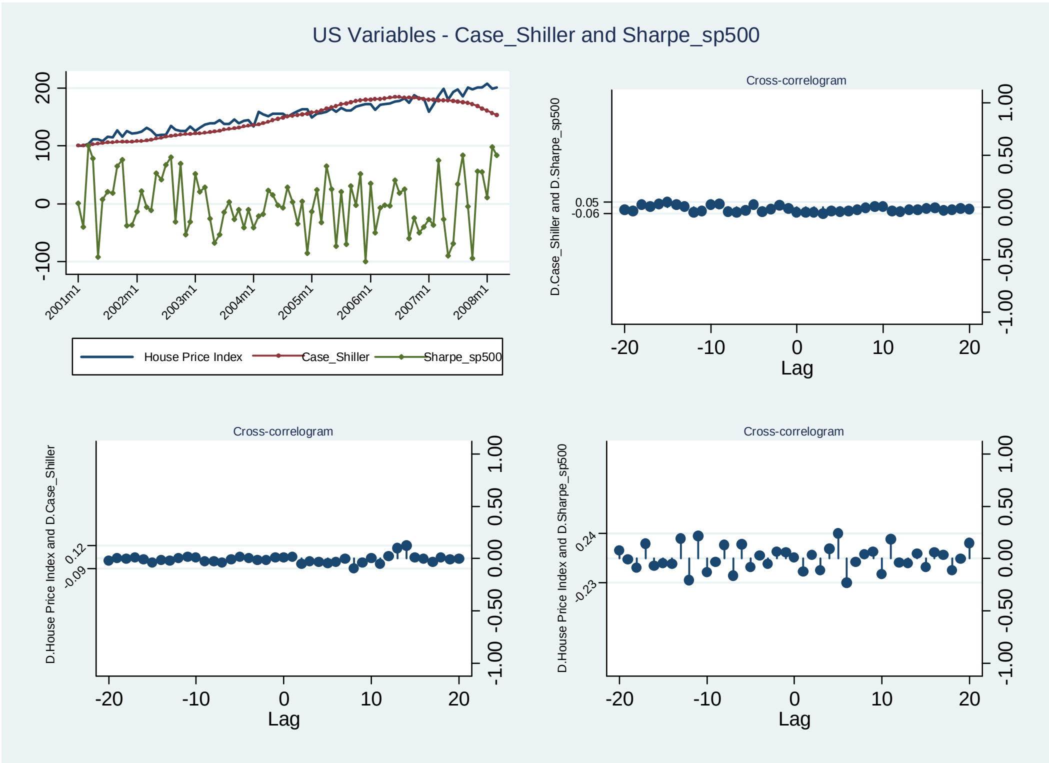


Figure 9:



US Variables - Case_Shiller and Sharpe_sp500
200
100
0
-100
2001m1
2002m1
2003m1
2004m1
2005m1
2006m1
2007m1
2008m1
House Price Index
Case_Shiller
Sharpe_sp500
Cross-correlogram
D.Case_Shiller and D.Sharpe_sp500
0.05
-0.06
-1.00 -0.50 0.00 0.50 1.00
-20 -10 0 10 20
Lag
Cross-correlogram
D.House Price Index and D.Case_Shiller
0.12
-0.09
-1.00 -0.50 0.00 0.50 1.00
-20 -10 0 10 20
Lag
Cross-correlogram
D.House Price Index and D.Sharpe_sp500
0.24
-0.23
-1.00 -0.50 0.00 0.50 1.00
-20 -10 0 10 20
Lag

Figure 10:

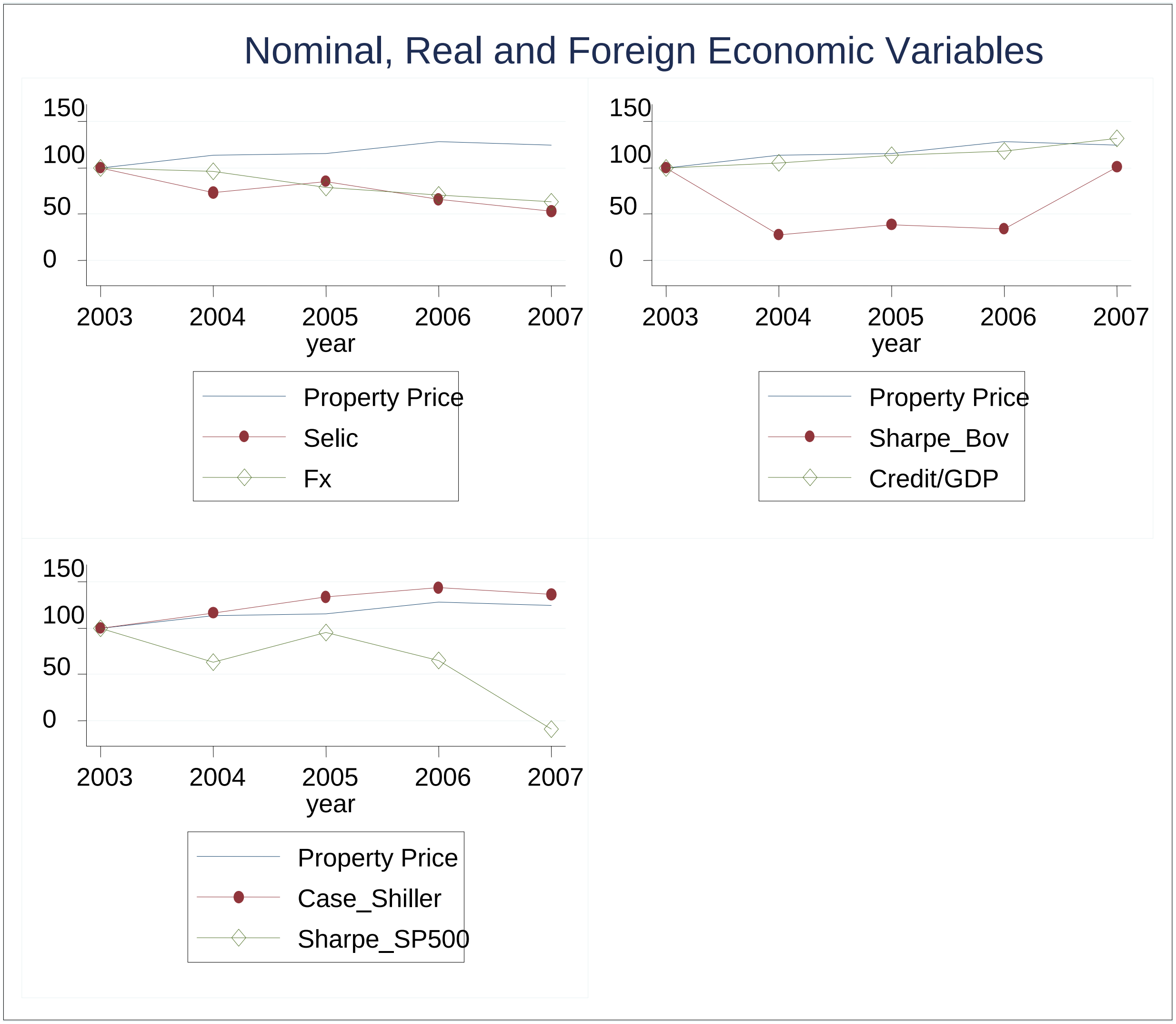

Nominal, Real and Foreign Economic Variables
150
100
50
0
2003
2004
2005
2006
2007
year
Property Price
Selic
Fx
150
100
50
0
2003
2004
2005
2006
2007
year
Property Price
Sharpe_Bov
Credit/GDP
150
100
50
0
2003
2004
2005
2006
2007
year
Property Price
Case_Shiller
Sharpe_SP500

Figure 11:

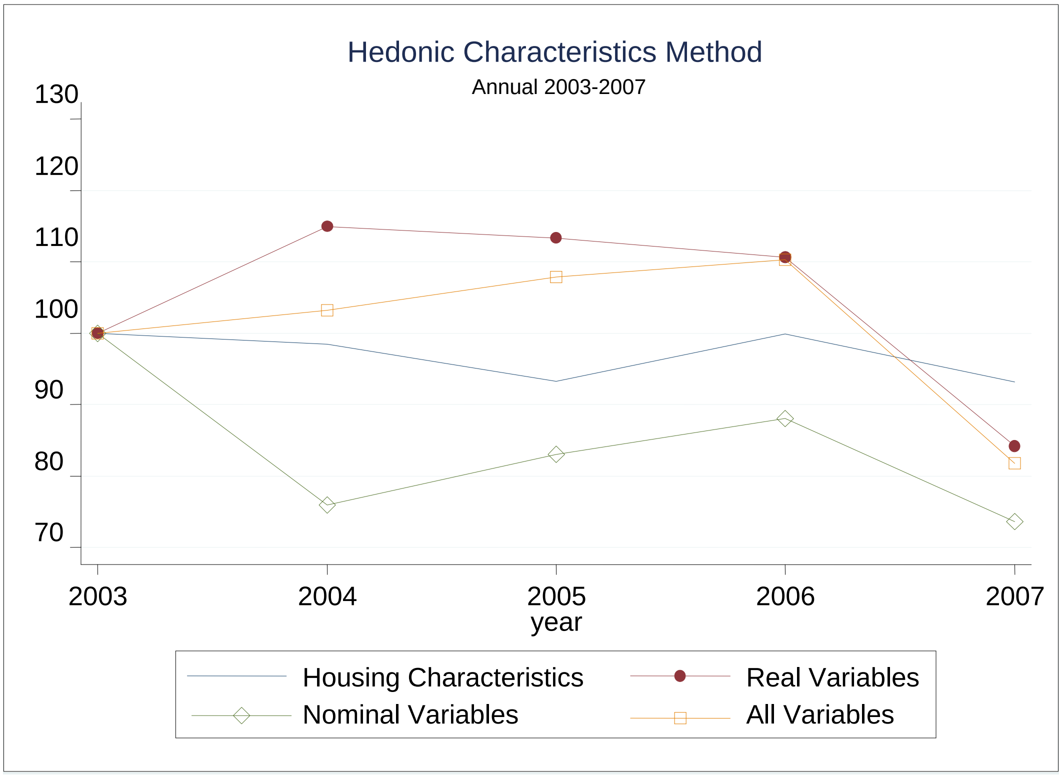


Figure 12: