Bubbles in the prices of housing? Evidence to Brazil's economy
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Abstract

This research aims to test the hypothesis of price bubbles in Brazilian housing. The empirical formulation adopted will be divided into two steps. The first will analyze the ratio price / rent and cointegration tests. The results show that there is evidence of validity of the model rational bubbles as opposed to the present value model. The second step shows, through Monte Carlo simulation, that the results obtained by cointegration analysis can be biased for small samples, indicating that it is still early to reach the conclusion that there are price bubbles in Brazilian real estate.

Keywords: Rational bubbles. Linear cointegration. Monte Carlo simulation.

Resumo

Esta pesquisa tem o propósito de testar a hipótese de existência de bolhas nos preços das habitações brasileiras. A formulação empírica adotada irá se subdividir em duas etapas. A primeira irá se limitar a análise da razão preço/aluguel e dos testes de cointegração. Os resultados mostram que há evidência de validade do modelo de bolhas racionais em oposição ao modelo de valor presente. A segunda etapa mostra, por meio de simulação de Monte Carlo, que os resultados obtidos pela análise de cointegração podem ser viesados para pequenas amostras, indicando que ainda é cedo para se chegar a conclusão que há bolhas nos preços dos imóveis brasileiros.

Palavras-Chave: Bolha racional. Cointegração linear. Simulação Monte Carlo.

Área 8 - Microeconomia, Métodos Quantitativos e Finanças

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1 Introduction

In recent years, housing prices in the Brazilian economy increased substantially and, based on the characteristics of the subprime crisis, it has been hypothesized that Brazil is presenting a bubble in real estate. Despite this behavior, is important to note that not necessarily rapid and prolonged increases in prices implicate in the presence of a bubble, as well as drastic price reduction does not indicate a bubble rupture. The increase in prices can, for example, only reflect changes in fundamental economic factors such as a reduction in interest rates or credit facilities.

In the Brazilian context, the concern about a bubble in housing prices has been the subject of debate by authorities as the former president of Brazil's Central Bank, Meirelles (2013), who states that:

> "(...), Brazil faces a housing bubble problem. The fact is clearly in some regions of Rio de Janeiro and parts of São Paulo, markets where real estate prices have skyrocketed".

Later, Shiller (2013), said:

> "I suspect that there is a housing bubble in Brazil. The buildings more than doubled in price in Rio de Janeiro and Sao Paulo in the last five years. What happened in five years that made the prices increase so much like this? Inflation was not much less? Prices felt 25% in Los Angeles and New York in the same period. And why did the prices increase in Brazil uninterruptedly? I can not stick that there is a bubble in Brazil because I do not know in depth the characteristics of the local market. But comparing Brazilian data with those of other countries, I can say that the increase in prices suggests caution. Property prices in Japan had the same movement in the late 1980s and later, in the early 1990s, it began to fall without stopping and lost two-thirds of value so far".

Aligned to alerts issued by the authorities, we consider that the importance of this study is linked to the fact that the housing bubble is the most recent example of growth excessive asset price. This is a spurious component, often responsible for destabilizing effects on national financial systems and for contributing to a prolonged recession. In this sense, Reinhart e Rogoff (2009) conducted a comparison table between the phases of collapse in housing prices cycles, including the US episode and a significant number of other countries who have faced or are facing banking crises: Austria, Hungary, Iceland, Ireland, Spain and the UK.

The results showed that the cumulative decline in housing prices compared to the peak was on average 35.5%. And the most severe falls in the prices of dwellings were presented by Finland, the Philippines, Colombia and Hong Kong. Their reductions were 50 to 60%, measured from the peak to the minimum value reached. In relation to the United States, the decline in housing prices in the subprime crisis is already more than the double recorded during the Great Depression. In particular, the duration of housing prices fall is quite long, with average of six years. Even excluding the Japanese experience (with 17 consecutive years of prices falls), the average remains over five years.

In addition, the discussion of bubbles in the real estate market differs from analysis in other assets because housing, as highlighted Poterba (1984), presents a dual nature, being commodity and investment assets, normally responsible for a significant fraction of the families? equity. It brings another component to the analysis, given not only by the economic perspective, but also by the social question.

Related to this discussion, Mendonça e Sachsida (2012) had discussions both at the microeconomic level and at the macro level in order to verify the possibility of a bubble in the Brazilian real

estate market. Based on the fundamentals of the Austrian School of economics, these suggested that there is a bubble evidence in this market and that the federal government, through tax policies and credit stimulus, was primarily responsible for the emergence of this bubble.

Thus, unlike the discussion proposed by Mendonça e Sachsida (2012), this discussion intends to present some evidence, based on the models of rational bubbles, which can contribute to this debate. This analysis will be held in the period from March 2001 to March 2015, according to data availability.

Models of rational bubbles show that the relationship between asset prices and its dividends can be used to investigate the existence of bubbles, in both real estate market and stock market, and there are a number of authors who have used this relationship to investigate the presence of rational bubbles in markets active (Campbell e Shiller (1986), Diba e Grossman (1988), Froot e Obstfeld (1989), Evans (1991), Timmermann (1995), Wu et al. (1997), Crowder e Wohar (1998), Bohl (2003), Nasseh e Strauss (2004), Cuñado et al. (2005), Mokhtar (2006), Chang et al. (2007), among others).

The occurrence of rational bubbles means that there is no long-term relationship between asset prices and their dividends. Seeking to determine whether asset prices and dividends have long-term relationship, mostly empirical studies have used co-integration techniques. To that end, the cointegration tests of Engle-Granger and Johansen Phillips-Ouliaris were applied, and all of them suggest that there is not a long-term relationship between the prices of housing and dividends, ie, they indicate that there are bubbles in housing prices.

As much as it may seem, this is not the final result of this discussion, because there are some limitations on this analysis that should be kept in mind before drawing conclusions. Some of these are linked to the limited number of price data real estate for Brazil. Because this component, some studies[1] have questioned the validity of the results obtained for estimating a long-term relationship involving short series. For this reason, it is important to investigate more properly the performance results in cointegration analysis for small samples.

In this sense, the second part of this study attempts to show, through Monte Carlo simulation, that the results obtained by cointegration analysis are biased to small samples, indicating that it is still early to reach the conclusion that there are bubbles in the prices of Brazilian homes.

Besides this introduction, the article has five other sections. The next section presents the theoretical discussions about the definition of bubbles and the model of rational bubbles. Then, it shows the cointegration method and set to strategy empirical identification bubbles. In particular, it presents the used databases and their limitations. Section 4 shows and discusses the main results of the strategy empirical. In addition, we investigate, through Monte Carlo simulation, if the results generated from the cointegration tests are biased for small samples. Lastly, the final considerations of this work are woven.

2 Rational bubbles in the assets prices and the cointegration implications

The discussion of rational bubbles presented in this section was proposed by Gürkaynak (2008) e Mikhed e Zemčík (2009). The wording proposed by Gürkaynak (2008) assumes that economic agents are paid by the job offer and the appreciation of assets in period $t + k$. The consumer optimization problem can be used to derive the relative pricing of assets, assuming cases of non-arbitration and rational expectations. It is assumed that the expected utility consumption derived from $u(c_t)$ is maximized from the following budget constraint:

[1]For more details on this discussion see Cheung e Lai (1993), Montalvo (1995), Dhrymes e Dimitrios (1997)

$$max\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \left[u(c_{t+k})\right] \tag{1}$$

s.a.

$$c_{t+k} = w_{t+k} + (P_{t+k} + D_{t+k})z_{t+k} - (P_{t+k})z_{t+k} \tag{2}$$

where w_t is the income; β is the discount rate of future consumption; z_t is the stock of assets; P_t is the price of assets and D_t are the dividends. In this research, the focus is given to the rooms where P_t is the price of housing and D_t is the dividends; for the housing sector, this indicator can be represented by the rental price, as Kivedal (2013), Himmelberg et al. (2005) and Besarria (2014).

This association between housing prices and rents, as Klyuev (2008) analyzed, is best described when it goes on to describe the house as an asset that combines the aspects of a good durable consumer with the characteristics of an investment asset . But the rent is an alternative for individuals who do not intend or do not have money to buy the house itself, which produces a flow of housing services for a family. From a financial point of view, the rent is the price to pay for that stream or the opportunity cost of renting a home instead of buying it. The price-rent must equalize the costs and benefits of owning a home or renting and should, over time, maintaining a broadly stable relationship between house prices and income.

When applying the first order conditions in the optimization problem, it has:

$$\mathbb{E}_t \left[\beta[u'(c_{t+k})][P_{t+k} + D_{t+k}] = \mathbb{E}_t \beta[u'(c_{t+k-1})][P_{t+k-1}]\right. \tag{3}$$

Assuming that the utility function is linear[2], it follows that equation (1) can be represented by:

$$\beta\mathbb{E}_t \left[P_{t+k} + D_{t+k}\right] = \mathbb{E}_t[P_{t+k-1}] \tag{4}$$

Admitting the existence of the link between the risk free assets with the interest rate, it has the standard model of present value. Where the determination of asset prices involves their expected values and dividends, according to the following specification:

$$\mathbb{E}_t[P_{t+k-1}] = (\frac{1}{1+R})\mathbb{E}_t[P_{t+k} + D_{t+k}] \tag{5}$$

where R is the interest rate.

Gürkaynak (2008) points out that equation (5) is the starting point of most empirical tests of assets pricing. Assuming the non-bubble condition, as proposed Mikhed e Zemčík (2009),

$$\lim_{k\to\infty}[(\frac{1}{1+R})^k\mathbb{E}_t[P_{t+k} + D_{t+k}] = 0 \tag{6}$$

Then, the solution to this difference equation results in:

$$P_t^F = \sum_{k=0}^{\infty}(\frac{1}{1+R})^k\mathbb{E}_t[D_{t+k}] \tag{7}$$

which is often referred as the value of fundamentals or fundamental asset prices.

Following Campbell e Shiller (1986) and Wang (2000), as proposed Mikhed e Zemčík (2009), it defines the spread between the price of housing and the dividend flow as $S_t \equiv [P_t - (\frac{1}{1+R})D_t]$. If P_t and D_t are $I(1)$,this implies that S_t is also first order steady. This result can be shown by rewriting S_t

[2]Linear utility function implies constant marginal utility and risk neutrality.

as:

$$S_{i,t} = (\frac{1}{R})\mathbb{E}_t \sum_{k=1}^{\infty} (\frac{1}{1+R})^k \Delta D_{t+k+1} = (\frac{1}{R})\mathbb{E}_t[\Delta P_{t+k+1}] \tag{8}$$

The first equality stems from the fact that the conditional expected value of future dividend flows is given by its current value. The second equality follows the equation (7). It can be seen that the stationarity of S_t implies the stationarity of P_t/D_t (and its inverse), since $S_t = 0$ implies in, $P_t/D_t = (\frac{1}{R})$.

Assuming that the non-bubbles proposal condition is violated in equation (7) , in this case, housing prices and the flow of income are not cointegrated, and can be represented by:

$$P_{i,t} = \sum_{k=0}^{\infty} (\frac{1}{1+R})^k \mathbb{E}_t[D_{t+k}] + B_t \tag{9}$$

$$\mathbb{E}_t[B_{t+k}] = (1+R)B_t \tag{10}$$

Thus, in case of bubbles existance, Gilles e LeRoy (1992) determined the expression (9) as a dynamic pricing system that may be divided into two components: essential and blister component. In other words, the expression (9) shows that the price of the asset (housing) must be equal to the present value of all future dividend payments (rent). Discussions on this issue show that the fundamental value associated with housing prices is the price of rent, and the long-term divergence between these indicators may suggest the presence of a bubble in the housing market.

Kivedal (2013) shows that, when analyzing the period leading up to the Subprime crisis, we found that the increase in housing prices in the United States was not accompanied by increases in the same proportions in the prices of rents, when these should be moving together.

2.1 Literature review

The bubble detection methods have been extensively studied in the literature. By observing the development of methods of identification, it is emphasized that this analysis basically left over from tests of variance and covariance proposed by cross Shiller (1980) and Blanchard e Watson (1982). The analysis proposed by Shiller (1980) has been developed originally for the stock market and this test was used to verify if the asset price variance exceeds the differential of dividends. If there is a difference among these measures, then the excess variance of asset prices is identified, providing evidence of the existence of speculative bubbles in the price formation.

But the cross-covariance test presented by Blanchard e Watson (1982) came from hypothesized that the presence of bubble decreases the correlation between the fundamentals and the price of active. However, the results obtained by the tests given above are strongly connected with the specification adopted for the equilibrium model and, therefore, the acceptance possibility of the bubble can be due to model specification and not the existence of bubbles.

Based on analysis of studies aimed at identifying bubbles, we found the most frequently used detection methods are model derived from present value and rational bubble assumption. Yiu et al. (2013) summarizes a series of studies that adopted the co-integration method as rational bubbles identification process. This discussion comes from the study proposed by Campbell e Shiller (1986) in which the authors propose an alternative method based on the idea that the difference between the asset price and the fundamental value will exhibit explosive behavior during the process of bubble formation.

In particular, Campbell e Shiller (1986) showed a unit root test as first step to test the explosive potential and the presence of a bubble. If there is a bubble, the price of the asset and the fundamental value can be characterized in two possible cases. In the first case, the price of the asset is non-stationary, but the fundamental value is stationary. In the second case, both the price of the asset and the fundamental value are not stationary. However, for the second case there is not enough evidence for the presence of a bubble, and therefore, the cointegration test is adopted as a supplementary method. As described above, if there is a bubble, then the price of the asset and its fundamental value are not cointegrated.

Diba e Grossman (1988) also indicate that the explosion on the difference between the price of asset and the fundamental value is sufficient for detection of bubbles, and the unit root tests and cointegration are the tools for the identification of this overgrowth. Since its proposal, the unit root and cointegration tests have been widely used for the detection of active bubbles.

As highlighted Yiu et al. (2013), the unit root and cointegration tests were applied to detect bubbles in the housing market in several economies in the two decades. For example, Drake (1993) used this method to study the boom prices in the mid-1980s, in the housing market in the UK, and Arshanapalli e Nelson (2008) use the cointegration test to identify the housing bubble in the mid-2000s, in the US housing market. As for Market Real Estate Hong Kong, Peng (2002) used this method to detect the bubble 1997 in the residential real estate market. The test was also extended to different forms over time, such as using data panel and regime change techniques.

Directing the analysis for the Brazilian economy, this is a little explored discussion and most part of the discussions related to this theme is focused on the analysis of the stock market. The fact that there are few studies focusing on housing market might be explained not by the lack of importance of this sector, but by the limited number of dwellings pricing information in Brazil (the options that exist have emerged recently) and by the recent growth of this sector, started with the housing program Minha Casa Minha Vida.

At the current stage of this research, only the studies of Leister (2011), Mendonça e Sachsida (2012) and Besarria et al. (2014) were found, which are meant for the analysis of bubbles in the housing market. The discussion proposed by Leister (2011) came from the debate about the definition of asset bubbles on the theory of efficient markets and theory irrationality / flaw in the behavior of economic agents. Subsequently, these sought to analyze the behavior of central banks in conducting monetary policy when there are bubbles of real estate assets. Associating theory of behavioral finance to financial deregulation environment, Leister (2011) described the behavior of economic agents in this environment as well as the advantages and disadvantages of adopting a passive monetary policy and proactive before the bubbles. Finally, it was analyzed how Brazilian economic agents behave in this context, the potential for generating bubbles in the domestic economy and which are the difficulties that may be faced by Brazil's Central Bank in the case of speculative bubbles appearance.

But the study by Mendonça e Sachsida (2012) aimed to evaluate, exclusively, the possibility of a speculative bubble in the Market Brazilian real estate. The theoretical basis that these authors used in their analysis was the one proposed by the Austrian School of economics. According to these, from the perspective of School Austrian, a market bubble does not appear because of an irrational behavior, but results exogenously a created signal which causes the agents to target wrongly investments in a particular segment of the economy, making with prices in this market follow a strongly upward trend. Such lifting can not extend indefinitely, causing the agents at some instant (breaking point) realize that the return on investment is lass than expected.

The empirical approach adopted by these authors was based, firstly, on a conjunctural analysis in which these sought to determine whether the conduct of some variables related to construction and real estate (industrial product construction, real estate developments, sale price and rental, credit de-

velopments banking, construction costs, among others) has some evidence detachment the evolution of these variables in relation to the rest of the economy.

Subsequently, sought to estimate the current real estate prices and the construction structure of cost, using the ordinary least squares method, instrumental variable and methods of moments, based on the data of sales prices real estate, rental price, interest rate and expected appreciation of the asset. These estimates were used to test the hypothesis that the causality is towards Property price towards its cost and not on the contrary, as proposed by the School Austrian. And, based on exogeneity and endogeneity tests, the authors concluded the the property price puts pressure on the cost, and not the reverse, which constitutes as a favorable argument to the perception of the Austrian School.

Recently, Besarria et al. (2014) evaluated the response of the Central Bank to the effects of a bubble in the prices of Brazilian homes. This study started from obtaining the structural parameters of the DSGE model, using the generalized method Moments (GMM) and, through these, it was carried out the simulation of the shocks effects in the prices of dwellings in the artificial economy, developed on the basis of Brazilian economy data. Subsequently, it was used the autoregressive model Vectors (VAR), in which the shocks were identified by signal restriction based on the theoretical model. The results showed that the effects of bubble in the Market Brazilian housing positively affected the subsequent movements in the product and inflation, however, the effect of this shock occurred transiently on these variables, bringing lasting effects only on the interest rate, where the answer given by the Central Bank was the increase of interest rates.

3 Methodological procedures

Based on the model of rational bubbles described in section (2), the methodology proposed to capture the relationship between asset prices and their fundamental values is given by tests of linear and structural break cointegration.

The first step in the establishment of cointegration is given by the stationarity of series test. For that purpose, it is applied the Dickey-Fuller (1981) and KPSS (Kwiatkowski, Phillips, Schmidt and Shin) test. It has been exhaustively discussed in the literature that the Dickey-Fuller test (1981) can not reject the hypothesis of stationarity for a multitude of economic series, and for this reason it is important to compare the results obtained by this test with others who can distinguish the unit root series whose data are not enough conclusive.

The next step is to verify if the house price series and rental prices are cointegrated. The most traditional methodologies to test the cointegration are: Engle e Granger (1987) and Johansen (1991). The first methodology states that the variables in studies will be cointegrated, if they are integrated on the same order d (where $d > 1$) and if there is a linear combination of these variables to be stationary. This technique is not suitable for testing the cointegration when there is the possibility of existing more than one cointegration vector. In this case, the recommended approach is the one proposed by Johansen (1991).

In the tests shown above, it will be implemented the method of identifying cointegration proposed by Phillips e Ouliaris (1990). This method aims to test the null non-cointegration hypothesis against the presence integration alternative, using unit root tests applied to waste. The idea is basically conflicting the results generated from different cointegration tests.

It is important to highlight two components that are not taken into account in the tests presented above. The first is that in the presence of structural changes in the serial data, the results obtained from the tests of stationarity presented above may be biased. This may lead to the acceptance of a false hypothesis, like, accepting the hypothesis of unit root in the series when these are stationary

around a broken trend.

To work around this limitation, we adopted the unit root test proposed by Lee e Strazicich (2003). The authors propose a test that allows the evaluation of the presence of unit root in the possibility of structural breakage, based on Lagrange minimum multiplier. In this case, the moments of breakages are determined endogenously.

The second limitation is related to the results of cointegration tests in structural changes presence in the temporal series. Bierens (1997) pointed out that the conventional cointegration tests may not be suitable for identifying the relationship of cointegration, since these tests consider that the adjustment process is symmetrical, without considering the fact that the true nature of the adjustment process may be non-linear. Furthermore, the presence of structural breaks, it increases the chances of the tests accepting null hypothesis, although there is a stable relationship between the co-integration parameters.

So, if it is identified the presence of a structural break in the series, it will be adopted the cointegration test Gregory e Hansen (1996), which explicitly incorporated a structural break in the cointegration relationship of the series. The test statistics can be viewed as a univariate extension of endogenous structural break tests.

In addition, the analyzed period of time is very short to draw convincing conclusions about the existence of bubbles, considering the fact that the analysis methods proposed above require more than a sufficiently long sample, but also a long period of time to provide adequate results. This discussion is very well addressed in Shiller e Perron (1985). Thus, the second part the study analyzes the performance of the cointegration analysis for short samples. The importance of this discussion is linked to the fact that the cointegration tests are derived from asymptotic results and statistical inferences in endless samples. In this case, the critical values of short data derivative tests may generate unreliable results.

3.1 Data base

The data base used in this analysis is composed by the monthly price observations sale and leasing of Brazilian households, covering the period from March 2001 to March 2015. It is noteworthy that the selection of these variables was made based on the work of Himmelberg et al. (2005) and Kivedal, 2013, in which these show that the relationship between housing prices and the rent can be used to investigate the existence of a bubble in real estate. The period of analysis was determined by the availability of data.

The number of property prices is represented by the Guarantee and Exchange index Financed Real Estate Residential (IVG-R) of the Central Bank and the real estate lease index can be represented by three different series, IPCA (housing), IGP-M and the index real estate leasing the Economic Research Institute Foundation (FIPE).

The real estate lease series FIPE covered the period from January 2008 to March 2015. However, the temporal dimension of the sample to the cost series of national rent does not cover the entire period from 2001 to 2015, presenting less than ninety observations, a factor that compromises the results obtained in analysis. In order to enlarge the data set was adopted interpolation method linear, making the rental cost to have the same periodicity obtained for prices of dwellings.

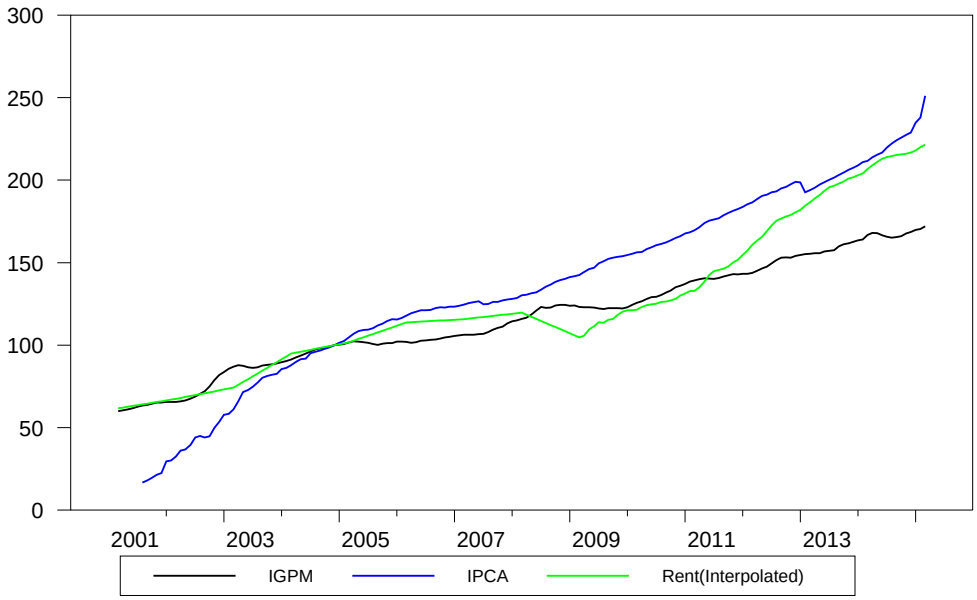

Figure 1: Lease cost represented by the IPCA (housing), IGP-M and FIPE.

Source: Prepared

As shown in Figure (1), there are no significant differences between sets. Thus, the IGP-M was used as the main determinant of the rent, since this is the index used for the correction of rental agreements in Brazil.

4 Empirical Evidence

This section will refer to the discussions about the proposed methods for bubbles analysis in the prices of Brazilian homes. Figure (2) presents the monthly series of selling price indices and rental of dwellings, as well as the ratio price / rent, from March 2001 to March 2015.

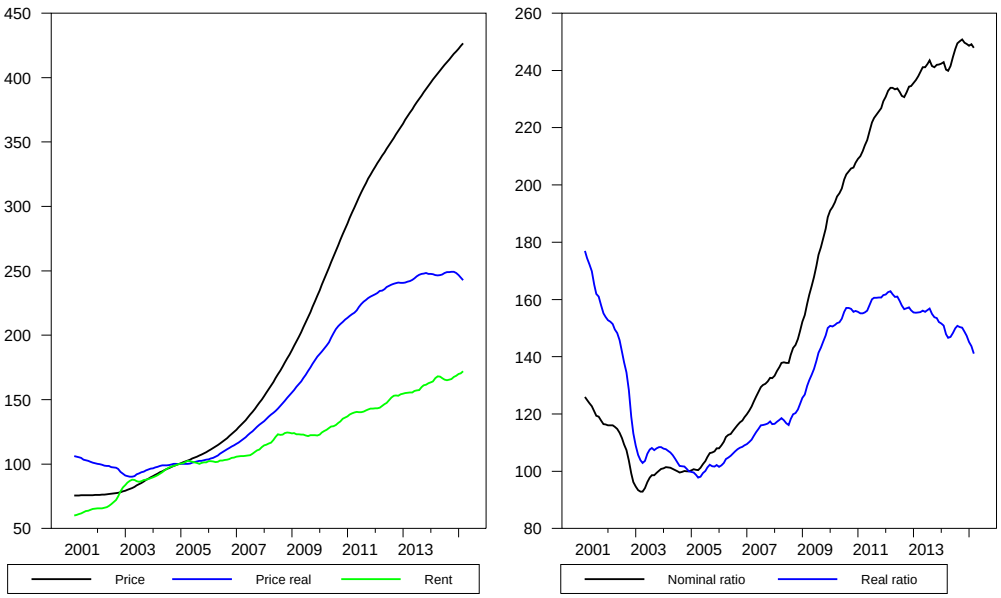

Figure 2: Price, rent and rent price ratio of the Brazilian real

Source: Prepared

In Figure (2) you can see that the average selling price of housing and the average rental showed strong recovery from 2008. One can not deny that situational factors, such as GDP growth, housing credit, income available, interest rates, international events like the World Cup in 2014 and the Olympics in 2016 contributed to the recovery of real estate. But the recent US experience has shown that, in addition to cyclical factors, it is possible that the prices of houses are influenced by the emergence of bubbles.

Regarding the ratio price / rent, the analysis that can be drawn from this indicator comes from the value model presented above, in which the determination of housing prices is linked to earnings flow from the real state rental. In this case, it is expected that property prices and rent grow together or accordingly, considering that if the cost of dwelling use exceeds the cost of rent, it is expected that individuals start to rent the buildings rather than buying them. This result is observed when individuals are indifferent between renting or owning their own property, as described by Poterba (1984).

By observing the ratio price / rent, present in Figure (2), you can check that this condition is rejected for the Brazilian economy, since there is an uptrend tendency on this indicator started in 2007, and currently it is about 20% lower than the last peak reached in 2012. This discussion suggests that house prices in Brazil are overvalued, as observed for the American economy in the period before the Subprime crisis.

This is a first indication that the asset price exceeds its fundamental value by apparently large margins. However, it is necessary to analyze other factors before drawing conclusions about the presence of speculative components in prices of housing.

An analysis that has been widely used in the literature is the cointegration. This methodology will be used to test the model of rational bubbles, defined by Gilles e LeRoy (1992) in the expression (5), , in which, in addition to the key value, it is inserted a bubble component in the determination of asset prices. Dickey Fuller and Kwiatkowski Phillips-Schmidt Shin-(KPSS)[3]tests were initially

[3]The null hypothesis Dickey Fuller test is that the series is not stationary, unlike the KPSS test, whose null hypothesis

applied for comparison reasons, in order to determine the stationarity and integration order of the used variables. As can be seen in Table (1), for the case analyzed, the Dickey-Fuller and KPSS tests showed that the selling and rental price series of dwellings have unitary (non-stationary) root level and are stationary in difference.

Table 1: Testing stationarity

	Dickey-Fuller		*KPSS*		*Lee-Strazicich*	
	t_α	$t_{critical}$	$\hat{\eta}_\mu$	η_μ	t_α	*Break*
Price	-1.45	-2.87	0.47	0.21	-3.21	2008:03
Location	-0.60	-2.87	0.40	0.21	-2.79	2011:11
$\Delta Price$	-3.22	-2.87	0.19	0.21	-	-
$\Delta Location$	-3.05	-2.87	0.16	0.21	-	-

Source: Authors' calculations.

Although there is no divergence between test results as the acceptance of series stationarity in the first difference, it is important to note that these lose validity in the presence of a series structural break. Thus, the following step of Research refers to the application of unit root tests with endogenous structural break proposed by Lee e Strazicich (2003), in the series of selling and rental prices (level). As it can be seen, the results of the Lee-Strazicich test show that the calculated value Student-t statistic was less than the critical value -4.45, to the significance level of 5%. It represents that the null hypothesis of a unit root with structural break was accepted and that the structural change period identified in the series of sales prices and rental corresponds to March 2008 and November 2011[4], respectively.

The subsequent discussion is focused on the cointegration tests between the prices housing and rents. In order to provide robustness to the obtained results, it is prepared a comparison table between the cointegration tests of Engle-Granger, Johansen and Phillips-Ouliaris, as shown in Table (2) , on the appendix of this study. The results of the cointegration tests presented in Table (2) show that there is a target bubble in the Brazilian housing prices, since no test suggested the acceptance of the hypothesis of association between prices and dividends series for the analyzed period.

However, it is known that conventional cointegration tests such as those used in the previous year are not able to capture the true nature of the adjustment process of the series when this process is given in a non-linear form or when there is a regime change. For this purpose, it was adopted the nonlinear cointegration test with structural break proposed by Gregory e Hansen (1996).

is that the series is stationary.

[4]Among the factors that may have influenced the regime change in sales price of series housing, there is the release announcement of the Growth Acceleration Program (PAC) to January 2007, having as a major goal the increased volume of credit intended for housing sector. Regarding the number of rentals, it turns out that the Price-Market General Index (IGP-M), generally used to adjust the lease agreements, had accumulated value of 10.78% per annum, against the accumulated value of -1.72% in 2009.

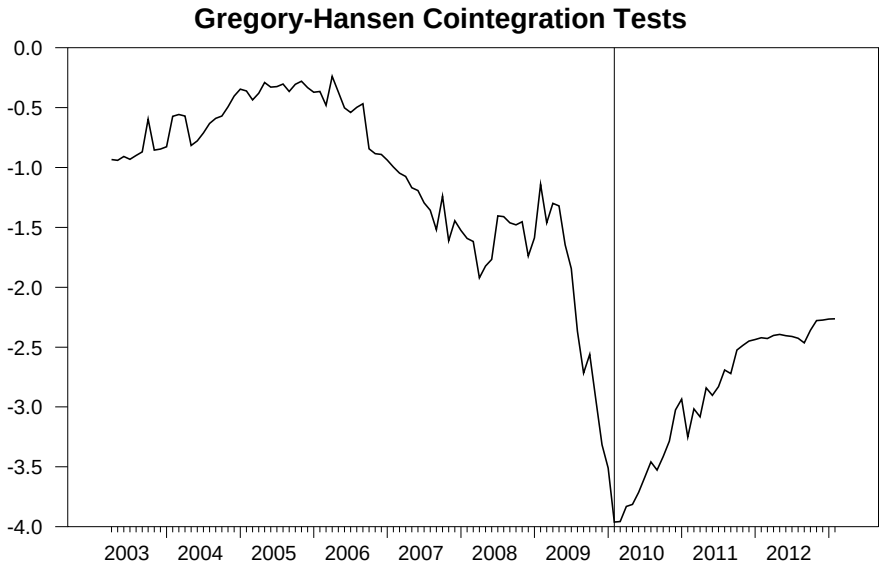

Figure 3: Gregory-Hansen Cointegration Tests

Source: Prepared

When analyzing the results of the cointegration test with structural break proposed by Gregory e Hansen (1996) , we can see that the calculated value of the statistic $Z_{\alpha}^{*}(C/S)$ was under the critical value of 95% significance. It represents that the null hypothesis of non-cointegration was accepted and that there was a structural change in the relation between housing prices and their dividends in 2009.

We emphasize that this result is reinforced by policies that were aimed at the housing sector in Brazil from the year 2008, considering that the Brazilian financial system, as well as the most part of the world economies, has been exposed to the effects of volatility in international markets, especially the credit ones. And, among the anti-cyclical measures adopted in reaction to the subprime crisis in Brazil, it stands out the stimulating policy to the construction sector.

4.1 Monte Carlo Simulation

The results from the cointegration analysis showed that the price series and dividends are not cointegrated and that there are indications of bubbles in the Brazilian economy. Is this result robust? Do we really have a bubble in housing prices? Taking into consideration that the bubbles identification process given above was carried out from a sample of only 168 observations, this section intends to investigate whether the results generated from the cointegration tests are biased for small samples.

The importance of this analysis is linked to the fact that the results generated from the cointegration tests are biased, generating potentially underestimated results or overestimated for the true cointegrating factor. This discussion will be held from Monte Carlo experiments. This is not a recent debate in the literature. Considering the studies that addressed this issue, the analysis performed by Toda (1995) are highlighted. The discussion proposed by Toda (1995) emerges from a bivariate relationship, as well as the most part of Monte Carlo studies, and it is worried only about the likelihood ratio (LR) test. Their results show unequivocally that for achieving an acceptable performance for the LR test, a relatively large sample is required. He also thinks that the underestimation of the cointegration rank occurs quite frequently for small samples.

It assumes the following data generating process to the price series of housing and rents:

$$P_{1,t} = \mu_1 + \beta_1 D_{2,t} + \alpha_1 P_{1,t-1} + \hat{u}_{1t} \tag{11}$$

$$D_{2,t} = \mu_2 + D_{2,t-1} + \hat{u}_{2t} \tag{12}$$

where u_{1t} and u_{2t} are random variables.

It is noticed that the data generating process imposes a relationship between the variables. From this relationship, it was possible to artificially generate two time series with dimension of 3400 periods, as illustrated in Figure (4).

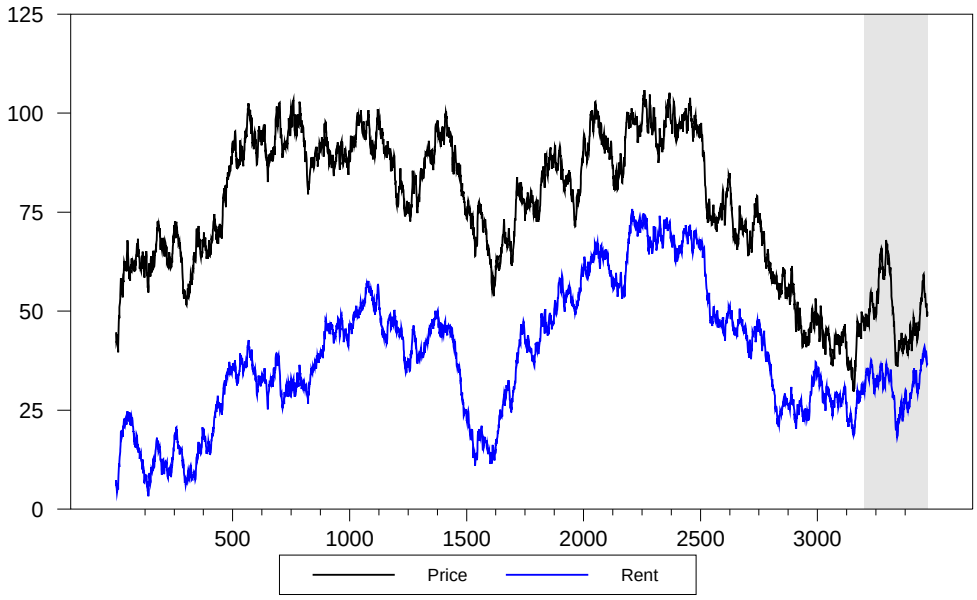

Figure 4: Simulated data

Source: Prepared

Two sample sizes are considered for the remainder of the analysis, T = 168 [Concerning the data set available for the first analysis and illustrated by the shaded portion of Figure (4)] and T = 3400. The choice of different sample sizes intendes to provide information on the performance of cointegration tests used as bubbles identification method. The choice of the sample T = 3400 was given to evaluate the performance of such tests on large samples so that the results approximate the actual distribution of the estimators and the test statistics.

The Table (3), presented in Appendix A, shows the results of several cointegration tests discussed in the previous sections for a finite sample of simulated data. The results obtained show that when analyzing the complete series of data, it is verified that there is cointegration between the series. However, when the analysis is directed to the subset of data, represented by the 168 observations, it can see that the results are changed, indicating that the series are not cointegrated. This fact is related to the asymptotic properties of the estimators of the cointegrating vector, in which, in the case of not having long series to justify the use of methods based on the principles of the asymptotic theory, there are strong evidences that the results generated in this analysis will be biased.

With regards to testing, as it can be observed, there were changes in the obtained results when the sample size increased from 168 observations to 3400 periods. This suggests that the analysis of

bubbles in Brazil, presented above, is not yet conclusive, considering the temporal limitation of data.

5 Conclusion

The subprime crisis is an important example of the effects that fluctuations in housing prices can make to economic performance. Based on this fact, this study sought to determine if there is evidence of rational bubbles in the Brazilian housing prices, and adopted some indicators that can assist in this analysis, which are: why price / income and cointegration tests.

At the current stage of this research, it was possible to verify that this is the first discussion that aims to identify rational bubbles in the prices of Brazilian homes through cointegration tests. For this reason, and also because of the difficulties associated with the properties of the methods applied to relatively short time series, the test results must be interpreted with some caution.

Based on this, a number of conclusions can be drawn. Among the analyzed indicators, there is reason to price / rent and, from that, it was found that housing prices grew rapidly in respect of income, suggesting dissociation between asset prices and their fundamentals.

Subsequently, the analysis was described from the dynamic co-movements between selling price series of housing and rent prices. The results of the cointegration tests have shown that there may be rational bubbles in the prices of these assets, as these series do not show a common stochastic trend of long-term, ie, they are not cointegrated.

In short, despite being early to ensure that there is a bubble in housing prices, for all the reasons that were earlier presented, one can not neglect that since 2008 fiscal and monetary stimulus packages have been adopted (strong credit expansion) in the Brazilian economy that contributed to the excessive growth in property prices.

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A Appendix

Table 2: Linear cointegration tests for prices and rents of Brazilian real estate

	Johansen				*Engle-Granger*		*Phillips-Ouliaris*	
	Eigenvalue	Maximum eigenvalue	Trace	Trace (95%)				
0	0.085	14.57	15.03	15.41	Stat. test	-2.21	Stat. test	-1.55
1	0.003	0.46	0.46	3.84	Critical value	-3.37	Critical value	-3.37

Table 3: Tests for linear cointegration simulated data

	Johansen				*Engle-Granger*		*Phillips-Ouliaris*	
3400 obs.	Eigenvalue	Maximum eigenvalue	Trace	Trace (90%)				
0	0.085	307.87	572.42	15.41	Stat. test	-17.52	Stat. test	-18.58
1	0.073	264.54	264.54	3.84	Critical value	-3.33	Critical value	-3.33
168 obs.								
0	0.087	13.14	13.72	15.41	Stat. test	-2.73	Stat. test	-3.46
1	0.004	0.58	0.58	3.84	Critical value	-3.37	Critical value	-3.83