

## Brazilian Residential Real Estate Bubble

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*Abstrac:* - The rapid pace of credit expansion in Brazil, combined with the strong growth in real estate sales prices, has prompted considerable speculation on the presence of an asset bubble in the residential real estate market. There are signs that the residential real estate is overheated in Brazil and this can be observed by the number of new launches and the increase of residential real estate sales prices on recent years. Due to the growing importance of the real estate market in Brazil and the virtual nonexistence of research related to the empirical identification of bubbles in the Brazilian residential real estate market this research assessed whether the upward movement is justified by fundamental factors in order to assess the existence of a housing bubble in the period of 2001-2013. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit-root tests, as well as Johansen cointegration and Granger causality tests were conducted to detect changes in time series behavioral patterns. The housing price index was based on monthly Residential Real Estate Collateral Value Index (IVGR). Six variables were used as proxies for residential property fundamental value based on residential property rent-price and cost-price indexes. The results showed that the development of residential real estate prices can be well explained by fundamental variables. Furthermore, cointegration and causality tests reveal the existence of a long relationship between real estate prices and fundamental variables, suggesting the absence of a bubble. These results, however, do not indicate that prices of residential real estate cannot fall. Instead, it is likely that changes in the macroeconomic scenario could put downward pressure on house prices.

*Key-words:* - Brazilian, bubble, Speculation, Dickey-Fuller, Phillips-Perron, Johansen cointegration

## 1 Introduction

Academics and policymakers have a progressively increasing interest in asset market developments and asset pricing in recent decades. Attention has been paid more specifically in relation to price misalignments (bubbles) in the asset prices, since bubbles can have severe consequences for the financial system and the economic scenario as a whole.

According to [1], recognizing an asset price bubble prior to a price crash is notoriously difficult. Furthermore, market-price deviations from fundamental values over a short time period do not guarantee that market prices will decline – the often-predicted bubble crash. Proving the existence of bubbles is difficult even after its collapse, as it is not possible to identify whether the movement of prices was due to market inefficiency or failure in the pricing model used in quantifying the right price [2].

Helbling and Terrones [3] documented 20 severe housing market declines in fourteen countries over the period of 1970-2002. The authors also noted that these housing market declines generally overlapped or coincided with recessions, and that recessions coinciding with housing market declines resulted in output losses roughly twice as big as those associated with severe equity market declines.

In Brazil the bubble phenomenon drew attention more specifically in the residential real estate sector due to the rapid increase in real estate prices in main conurbations. According to data from the Brazilian Central Bank and residential real estate industry, there is strong evidence that the sector is overheated in Brazil.

The average price of residential real estate properties has expanded 225.79% from March 2001 to December 2013. The credit volume in the Brazilian market also increased significantly, 242.6% between March 2001 and December 2013, which led to an increase in the credit-to-GDP ratio of 28.3% to 56.1% according to Brazilian Central Bank data. Even with the rapid growth in recent years, according to International Monetary Fund (IMF) data, the credit-to-GDP ratio in Brazil is still reduced when compared to other Latin American countries, China and the G7.

The credit expansion was also observed in the residential real estate sector, after a long period of contraction caused by the collapse of residential mortgage in the 1980s, especially since 2004 [4]. Brazilian Central Bank data supports this statement and demonstrates that from March 2001 to

December 2013 the volume of mortgage loans increased from R\$ 22.9 billion to R\$ 395.2 billion.

Although common in other countries, researches related to the empirical identification of bubbles in the Brazilian residential real estate market are virtually nonexistent. One of the few empirical researches on this subject was made by [5] based on the Austrian Business Cycle Theory. It is expected that the results of this research contribute to the theoretical framework of residential real estate cycles and speculative bubbles since, despite the existence of several researches on price fluctuations in the residential real estate sector and the existence of several theories, applied models and descriptive analyses, there are still many controversial points.

Based on the endogenous hypothesis of real estate cycles and the bubbles theory this research proposes to carry out a sequence of empirical procedures in order to assess the existence of the housing bubble in the Brazilian residential real estate market in the period 2001-2013.

The following section presents a brief review of the theoretical framework developed to provide a clear understanding of the dynamics of the real estate sector based on the cycles and housing bubbles theories. Section 3 then presents the methodology of investigation of the relationships between house prices and fundamentals while Section 4 presents the results of this research. Finally, Section 5 provides conclusions and opportunities for refining identified in this research.

## 2 Theoretical Framework

The theoretical framework developed was intended to provide a clear understanding of the dynamics of the real estate sector based on the cycles and housing bubbles theories, both focusing on the study of economic fluctuations. Discussions about the fundamentals that explain the relationship between economic agents and the real estate capital allowed finding consistent answers on the oscillatory movements of real estate investments and therefore a greater understanding of the cycle fluctuations and the formation of bubbles.

### 2.1 Fundamental Value and Market Value

The bubble concept is closely related to the pricing formula, which is used to represent the correct price of an asset: a price that is based on the values of fundamentals, *vis a vis* those economic factors and variables that determine the prices of assets [6].

One way to identify the existence of a bubble and approach the fundamental value in the residential real estate market would be to examine the rent-price ratios. The rent-price ratio can be seen as corresponding to the dividend-yield ratio in the stock market, as dividends and rents represent the underlying capital component. Using the rent-price ratio, it is possible to measure the profitability of investing in real estate, obtained by an individual who chooses to buy a property and rent it rather than investing in other asset [7].

Using the rent-price ratio, the bubble concept becomes easier to define as the developments in house prices or rents should not differ greatly from each other, otherwise this would mean that a bubble is developing in housing markets [6].

According to Krainer and Wei [8] it is tempting to identify a bubble as a large and long-lasting deviation in the price-rent ratio from its average value. But it is not precisely clear how large and how long-lasting a deviation must be to resemble a bubble. There is no reason to believe that a price-dividend ratio should be constant over time, even in the absence of bubbles. Campbell and Shiller [9] showed that the value of the ratio can increase only if there are expected future increases in dividends, expected future decreases in returns, or both. This simple model of the price-dividend ratio is based on a simple identity and the definition of a return as the sum of a dividend yield and a capital gain/loss.

The association between residential property prices and construction costs can also be considered as an element that contributes to explaining the development of residential property prices in the long term. Developments in house prices or costs should not differ greatly from each other, otherwise this could be considered a further indication of the existence of a housing bubble.

Prior to the subprime crisis in US, Case and Shiller [10] demonstrated disparity between US house prices, population increase and building costs and suggested there was a strong element of speculation in the housing market not justified by fundamentals. Using aggregated data on home prices, including building costs, Gallin [11], reached a similar conclusion showing that changes in fundamentals do not explain the rapid growth of U.S. house prices after 2000.

Rising prices are not a synonym for bubbles, but rising prices without any explanation in the cost structure are indeed effects of market disruption and identify the occurrence of a bubble [12]. An inherent limitation in the concept of Residential Property Prices to Construction Costs is that it fails to consider land prices, a decisive factor in urban

agglomerations.

The debate and the lack of a unified response arise since the problem is how to properly measure the fundamentals. In relation to the Brazilian real estate sector the problem is even more serious as reliable statistics are scarce. The informality and lack of a robust structure in the sector does not allow the systematic collection of such information.

## 2.2 Real Estate Cycles Endogenous Hypothesis

Real estate cycles are dependent on economic cycles; in other words, the evolution of the main macroeconomic fundamentals. However, it is considered that there is a standalone component which confers specific dynamics to the real estate industry at certain times and spaces, explaining the speculative changes in asset prices in relation to their fundamental values as well as its consequences, such as speculative bubbles. This stand-alone component in the real estate market is associated with psychological behavior of speculating agencies involved in the real estate process; information asymmetries on markets and real estate values and the free-rider behavior of some economic agents as well as management of liquidity preference [13].

The prosperity of the post-war overshadowed the theoretical debates around the long construction cycles, which would find renewed academic effect only after the emergence of the Bretton Woods agreement crisis, when turmoil in foreign exchange markets and stagflation contributed to further investigations in respect to real estate cycles [14]. The resumption of economic studies brought a relevant theoretical debate between two academic schools regarding the relevance of real estate cycles [13].

The first one used as argument for the non-relevance of real estate cycles the EMH. According to Fama [15], the price of a financial asset should always reflect all available information, hence indicating that the market price should always be consistent with the fundamentals and therefore agents should not expect the return of this asset to be higher than the normal return. However, according [16], to believe in market efficiency is equivalent to believe that the market is in permanent equilibrium, reflecting unquestionably the fundamentals on the assets value.

The latter indicated that investors should use the theory of cycles to determine the impacts on the assets' return and the risks of investing in certain assets. Thus, the understanding of the real estate cycles becomes strategic to maximize the returns

on investments.

Based on an extensive economic literature [17] demonstrated, with theoretical arguments and empirical evidence, the existence of cyclical movements in the real estate market, rejecting the conclusions proposed by EMH theorists and simultaneously recognizing the importance of understanding the real estate cycles.

Real estate cycles may partially be caused by endogenous market imperfections. The most important of these imperfections is the existence of the time lags, which can be classified into three types: the price-mechanism lag, decision lag and the construction lag [18].

The price-mechanism lag occurs when there is a mismatch between supply and demand due to rapid and unexpected increase in demand. Consequently, in an environment where supply is greater than demand, the market reactions towards a temporary equilibrium take place in form of price or quantity adjustments. Therefore, rents go up while vacancy goes down. As soon as the vacancy is absorbed below the natural level, the short run market reaction can only occur in the form of price movements. Because of the internal decision processes of large companies, investors also react with a lag to rising prices (decision lag). When they finally decide to invest, new construction has to be planned and construction companies have to be contracted. The time that passes until a project has been built is called construction lag.

Based on the conception that there is a relevant time lag between the increase in demand and the delivery of new properties, the logic of the cyclical movements in the real estate market and the effects of price transmission to the economy became consistent [13]. In this sense, according [19], a deficit resulting from delay in meeting demand is directly reflected in rents and real estate prices, generating a heating phase (hot real estate) and real estate euphoria.

According to [18] the expectations of real estate valuation become elevated, encouraging industry entrepreneurs to start an excessive volume of new constructions, which tends to drive the market to overbuilding. However, when these additional real estate stocks are delivered, there is an oversupply of new built-up areas, impacting rents and real estate prices and the growth dynamics of the real estate sector, which tends to go recessive for a long period.

[20] Suggest that recurring imbalances in the real estate market mainly reflect problems arising from delays in the production of new units. According to the authors, in admitting the truth of

this conclusion, a behavioral analysis of economic agents and their influence on market structure would become necessary. However, given the multiplicity of relationships and real estate agents working in the production chain, the key players could be grouped and classified into four broad groups: builders, investors, users and public authorities.

According [13] the initial causes of endogenous movements (real estate cycles) are exogenous influences (economic cycles) in the real estate market, and occur in the form of demand shocks of different sizes which, depending on the situation, can speed up or slow down the process of real estate valuation.

As exemplified by [21], exogenous influences in the real estate market can be driven by expansion of credit by the monetary authorities. The expansion artificially reduces interest rates, increasing real estate construction and the purchase of real estate, which reduces vacancies and raises rentals and real estate prices.

According [18], these exogenous factors can be categorized as medium and long-term influences. Medium-term influences are based on the economic development of a country and its domestic Market; they consist of movements in key economic variables such as inflation, interest rates and GDP growth. Long-term influences are based on structural changes such as changes in economic structures, policies, new technologies and information and communication.

Taking as a starting point the existence of a time lag in the real estate market, price corrections are consistent; however, the possibility of a cycle starting from an initial deficit of residential properties, leading to an increase in real estate prices - with direct impact on agents' expectations - encouraging new enterprises and therefore new properties can lead to an oversupply situation, reverting the cycle [13].

### 2.3 Bubble Theory

According to [22], a bubble may be defined loosely as a sharp rise in the price of an asset or a range of assets in a continuous process, with the initial rise generating expectations of further rises and attracting new buyers – generally speculators interest in profits from trading the asset rather than in its use or earning capacity. The rise is usually followed by a reversal in expectations and a sharp decline in price, resulting in a financial crisis. In his book, *Manias, Panics and Crashes*, [23] adds that “in the technical language of some economists, a bubble is any deviation from fundamentals”.

In its most common form, the pricing formula says that the price of an asset reflects all available information on the discounted future random payoffs associated with the asset. This is also the crux of the efficient market hypothesis (EMH), which says that asset prices in financial markets should always reflect all available information and hence that market prices should always be consistent with the 'fundamentals'. Validity of EMH would therefore rule out the possibility of bubbles in asset prices.

The existence of bubbles in the housing, and more widely for real estate prices, was heavily debated in the years preceding the financial crisis that broke out in 2007. According to [6], looking at the speed of the rise in real house price indices in several Organisation for Economic Co-operation and Development (OECD) countries from year 2000 onwards, it seems clear that some real estate markets might have experienced a bubble during the last decade.

The channels of contagion through which the problems began were numerous and can be mostly divided into two: direct (via balance sheets) and indirect (via market behavior) contagion.

The real estate market was impacted via both channels. Indirectly, problems started to accumulate as a result of negative valuation of financial instruments backed by US mortgages. Concerns in relation to the true risk owners and investor's exposures deteriorated the financial system conditions due to the rising mistrust leading to a worse economic performance, which led to an increase in loans delinquency. As a result, market liquidity was reduced due to distrust and governments were required to provide financial support for the banking system.

According to [24], on the global scale, the economic system went through a period of greater openness of operations and increasing interlinkages, which exposed the whole system to idiosyncratic shocks. According to the author, inflation was stable in many developed countries and economic growth in many countries seemed to be on a steady path: prior to the crisis cyclical fluctuations in both activity and inflation had trended down.

The stable economic environment had largely reduced risk awards and interest rates were at low levels for a long period in many developed countries. Combined with an environment of low interest rates, financial innovation led to credit growth. In many countries the credit expansion was very high when compared to GDP growth, which should provide a reference for productivity growth

and therefore a reference for the long-term sustainable rate of growth in indebtedness.

According to [6], especially in the case of the US, overly accommodative monetary policy is cited as one of the main reasons for the emergence of bubbles. Such criticism has been presented for example by [25-28]. Nevertheless, this assessment is not unanimous. [29] Argue that US monetary policy was well aligned with the goals of policymakers and that the monetary policy stance was not the primary contributor to the robust housing market.

Although the access to loans in the housing market was positively impacted by financial liberalization and innovations, the relaxation of lending standards brought a substantial macroeconomic stability risk to the financial system. In the US, the credit criteria were significantly reduced during the pre-crisis period: as per OECD data, only 8% of home purchases occurred without a down payment in 2001, but by 2007 this proportion increased to 22%.

The key question to identify a bubble in real estate prices is when prices have detached from their fundamentally justified level. According to [6], determining whether prices are detached from the fundamentally justified level is not a simple task, as there is not unanimous agreement on what factors actually establish the fundamental price in the real estate market. The pricing process in the real estate markets is regarded as a relatively complex one where expectations as well as real economic variables together determine the final market price. Among the core variables which are seen to affect the pricing of the real estate are the following: (i) household incomes, (ii) interest rates, (iii) supply (especially in the short-run), (iv) financial market institutions, (v) demographic variables, (vi) availability of credit, (vii) taxes, (viii) public policies directed at housing etc. The movements in asset prices are not exogenous fluctuations, they should reflect the purchasing power of current and future homeowners and therefore be tightly bound to overall macroeconomic developments [30].

As argued by [6] one way to approach the fundamental value in the real estate market would be to examine the rent-price ratios. According to the author, the rent-price ratio can be seen as corresponding to the dividend-yield ratio in the stock market, as dividends and rents both represent the underlying capital component. As argued by [31], whereas in the stock market this relationship is between discounted dividends and stock prices, it could be between rents and house prices in the housing market.

Although there are some important differences between rents and dividends, by using rent-price ratios, the bubble-concept is easier to define: the movements in house prices and rents should not differ significantly from each other; otherwise this would mean that a bubble is emerging in the housing markets.

## 2.4 Real Estate Cycles Hypothesis and the Bubble Theory

In one hand, the theoretical framework was intended to support the hypothesis that real estate cycles are dependent on economic cycles. Economic growth would stimulate economic agents to expand the demand for housing, which would trigger an imbalance in the market due to an endogenous imperfection in the real estate market - the time lag, which would delay a fast response to demand shocks.

On the other hand, due to endogenous imperfections, the pricing process in the real estate market has a stand-alone component that explains the speculative changes in asset prices, motivated by the behavior of agents in the housing market. This stand-alone component, responsible for the formation of speculative bubbles, is associated *a priori* to the psychological behavior of agencies involved in the real estate process, information asymmetries on market and housing prices, the free-rider behavior of some economic agents and liquidity preference.

As explained by [21] speculators can accelerate demand, increasing land values. The expansion brings pressure on price inflation and the authorities reduce the monetary expansion by raising interest rates. On the other hand, higher interest rates and higher prices for real estate reduce business profits and investment in real estate. Rising interest rates increases mortgage payments and may lead to higher delinquent rates. Rising unemployment also increases foreclosures. According to the author, real estate speculators switch to buying foreclosures at below-market rates and flipping them for quick sale to naive buyers who do not understand the real estate cycle.

Behavior analysis of economic agents in the real estate market shows that the explanatory capabilities of these two approaches to price movements may alternate significantly over the time as explained by [13]. Indeed, differences in approaches by identifying the causes of price fluctuation of real estate assets may be minimized if the assumption that these explanations are not mutually exclusive and the integration of these two approaches would make much more comprehensive

understanding is admitted.

As supported by [13] and demonstrated by [21], instead of establishing a theoretical boundary between real estate cycles and speculative bubbles it is understood that there is greater consistency in saying that speculative bubbles are manifestations that occur in a given stage of the real estate cycle. The explanatory capability of these two approaches may vary over time and thus causes for fluctuations in asset prices do not make the two theories mutually exclusive, but complementary, making the understanding much more comprehensive. Exacerbated investor optimism about future earnings with the valuation of real estate assets tends to generate an upward spiral in the prices and leads "rational agents" towards making collective mistakes, inflating bubbles.

## 3 Methodology

In order to assess the existence of the housing bubble in the Brazilian residential real estate market this quantitative research used monthly data. Data was collected from the following institutions: Brazilian Central Bank (BCB), Instituto Brasileiro de Geografia Estatística (IBGE) and Fundação Getúlio Vargas (FGV). Monthly data set used spans from March 2001 to December 2014 [32, 33]. The choice of the data period for the empirical analysis was purely based on the availability of data series. The data on variables include housing price, rent and building costs indexes. The housing price index is based on monthly Residential Real Estate Collateral Value Index (IVGR) estimated by the Central Bank of Brazil. It is a general measure (mean) of housing prices in Brazil. Six variables were used as proxies for residential properties' fundamental value based on residential property rent-price and cost-price indexes. Fundamental value based on residential property rent-price index:

- 1) General Market Price Index (IGPM).
- 2) National consumer price index – Rental cost (INPCALU).

3) National consumer price index – Housing cost (INPCHAB).

Fundamental value based on residential property construction cost-price index:

- 4) Housing construction cost index (CUB).
- 5) National Index of Building Costs – Working force (INCCMO)
- 6) National Index of Building Costs – Services and materials (INCCMO).

In the case of Brazil, testing for bubbles in residential real estate market has been scarce. For this purpose, tests applied in this research were

similar to those used to test for bubbles in other emerging market economies [34, 35]. The general idea was to verify or reject the existence of a stable relationship among housing prices, rent and building costs. Hence, the tests were oriented toward examining the stationary behaviour of the log rent-price and construction cost-price indexes and the existence of a stable relationship among these variables and the log housing price index.

To test for cointegration in housing price equation, first, one needs to ensure that the variables are integrated in the same order. Therefore, unit root tests were conducted for each variable using Augmented Dickey Fuller (ADF, 1979) tests for stationarity [36]; however, due to its limitations in correcting for heteroscedasticity, a non-parametric test devised by Phillips-Perron (PP) was performed to verify ADF results [37]. PP tests are also recommended due to the occurrence of structural breaks in time series in Brazil. For this test the intercept or trend were not included because there were indications from the ADF test that those terms were not required.

Secondly, the result of the Cointegration test can be quite sensitive to the lag length. Therefore, it is imperative to check an optimal lag length. The study usually selects an appropriate lag according to Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC). It usually prefers the latter as it selects longer lags. The logic of preferring a longer lag is that it can show the effects of housing price determinants, in the current period, over a longer time. Lagged effects of determinants of housing price may persist after their immediate impacts.

Tests for stationarity only take into consideration the individual behaviour of the time series, not considering possible mutual influences that long-term trajectories of the time series may have one over the other. Therefore, Johansen cointegration tests were used as a suitable strategy to examine the co-movement between housing price and their fundamentals (rent-price and cost price indexes).

Regression analysis assumes the idea of dependence on a variable in relation to others, but this dependence does not imply causality. The Granger causality test was performed in order to provide more robustness to the cointegration tests since, according to [38], when time series are cointegrated there must be Granger causality between them.

Although Granger causality can be bi-directional, it is expected that fundamental value cause (precede) the market value of an asset. More

specifically in relation to this research, it is expected that fundamental value based on residential property rent-price index and cost-price index cause residential property market value, thus the fundamentals are relevant to explain the prices of residential properties.

### 4 Analysis and Results

As mentioned in previous section, it was necessary to check the order of integration of the level variables for an appropriate econometrics method. Thus, unit root tests of each variable at their levels as well as first difference of non-stationary level variables were conducted. The results from Table 1, 2 and 3 show that all variables were non-stationary at their levels except INPCHAB. However, all the non-stationary variables were found to be stationary at their first differences, and consequently, are integrated of order one. As recommended by [39], the analysis was performed using logarithmic transformation for the time series.

**Table 1.** Estimated Augmented Dickey-Fuller (ADF) unit-root test results

ADF Test	Intercept		1 differentiation	
	with no trend	with trend	with no trend	with trend
IVGR	-1.0690 [0.7269] (13)	-2.5000 [0.3278] (13)	-1.9565 [0.3058] (12)	-1.3833 [0.8618] (12)
CUB	-0.4173 [0.9019] (13)	-4.3847 [0.0032] (13)	-3.3807 [0.0132] (2)	-3.6926 [0.0258] (2)
INCCMO	0.5325 [0.9873] (13)	-3.1282 [0.1039] (13)	-3.0469 [0.0331] (12)	-3.7286 [0.0236] (13)
INCCMS	-2.0884 [0.2497] (1)	-1.3878 [0.8609] (1)	-5.5346 [0.0000] (0)	-5.7532 [0.0000] (0)
IGPM	-2.5362 [0.1090] (1)	-3.4358 [0.0505] (3)	-5.6883 [0.0000] (0)	-4.4227 [0.0028] (8)
INPCALU	-2.4808 [0.1222] (1)	-1.9961 [0.5985] (1)	-4.7015 [0.0001] (0)	-6.2279 [0.0000] (0)
INPCHAB	-3.1023 [0.0285] (1)	-3.5962 [0.0334] (1)	Data is stationary I(0)	

**Table 2.** Estimated Phillips-Perron unit-root test results

Phillips-Perron Test	Intercept		1 differentiation	
	with no trend	with trend	with no trend	with trend
IVGR	1.1137 [0.9975]	-3.5467 [0.0380]	-3.0457 [0.0330]	-3.0195 [0.1304]
CUB	0.9812 [0.9963]	-3.2912 [0.0716]	-10.872 [0.0000]	-11.3786 [0.0000]
INCCMO	-0.0916 [0.9473]	-2.6195 [0.2724]	-8.5374 [0.0000]	-8.5096 [0.0000]
INCCMS	-1.7034 [0.4276]	-0.9797 [0.9428]	-5.5562 [0.0000]	-5.7870 [0.0000]
IGPM	-2.3486 [0.1583]	-2.3486 [0.2908]	-5.8417 [0.0000]	-5.9094 [0.0000]
INPCALU	-2.9964 [0.0375]	-2.0853 [0.5495]	-4.6542 [0.0002]	-6.2449 [0.0000]
INPCHAB	-2.9348 [0.0437]	-3.2777 [0.0739]	Data is stationary I(0)	

**Table 3.** Unit-root hypothesis tests conclusion

VARIABLE*	CONCLUSION
LIVGR	Data needs to be differenced once to make it stationary
LCUB	Data needs to be differenced once to make it stationary
LINCCMO	Data needs to be differenced once to make it stationary
LINCCMS	Data needs to be differenced once to make it stationary
LIGPM	Data needs to be differenced once to make it stationary
LINPCALU	Data needs to be differenced once to make it stationary
LINPCHAB	Data is stationary and does not need to be differenced

#### 4.1 Johansen Cointegration Test

Johansen Cointegration Tests via unrestricted VAR model was estimated for the rent-price and construction cost-price indexes in order to identify the existence of a stable relationship among these variables and the housing price index. The VAR model involved selection of appropriate lag length, as an inappropriate lag selection could give rise to problems of incorrect parametrization. The objective of estimation was to ensure that there was no serial correlation in the residuals. Akaike Information Criterion (AIC) was used to select optimal lag lengths.

The analysis was performed between two variables: IVGR and  $X$ , IVGR as the housing price in Brazil and  $X$  as one of the six variables considered as *proxy* for fundamental value based on residential property construction cost-price index (INCCMO, INCCMS and CUB) or residential property rent-price index (IGP-M, and INPCALU INPCHAB). The results are shown in Tables 4 and 5, respectively:

#### 4.1.1 Fundamental value based on residential property construction cost-price index

**Table 4.** Johansen cointegration testing results

Variables	Testing results	
Property construction cost-price index	Johansen Cointegration	Conclusion
INCCMO	Cointegrated	No bubble
INCCMS	Cointegrated	No bubble
CUB	Cointegrated	No bubble

- IVGR *versus* INCCMO: The best adjusted model for the time series IVGR and INCCMO based on AIC was a VAR(13), both variables I(1). The same approach was adopted for the other Johansen cointegration tests. The unrestricted VAR model residual analysis allowed the confirmation that the model was well adjusted and adequate for the data, as evidenced by the Lagrange Multiplier method (LM) applied for residuals autocorrelation.

- IVGR *versus* INCCMS: following the same procedures applied for the first pair of variables, both series were considered cointegrated although in this case it was necessary to consider only 2 lags in the estimated unrestricted VAR model. Cointegration evidences between IVGR *versus* INCCMS were stronger when compared to IVGR *versus* INCCMO.

- IVGR *versus* CUB: cointegration evidences between IVGR and CUB were less strong when compared to the previous two pairs of variables, but nonetheless a cointegration vector was identified in the linear model with intercept and trend and another in the quadratic model with intercept and trend (these two situations are less

common in economic data). The results were similar regardless of lag choice. In this model it was not possible to completely eliminate the residuals autocorrelation in lags 11 and 12.

#### 4.1.2 Fundamental value based on residential property rent-price index:

**Table 5.** Johansen cointegration testing results

Variables	Testing Results	
Residential property rent-price index	Johansen Cointegration	Conclusion
INPCALU	Cointegrated	No bubble
INPCHAB	Not applicable	Not applicable
IGPM	Cointegrated	No bubble

- IVGR *versus* INPCALU: the best adjusted model based on AIC was a VAR(13) for the time series IVGR and INPCALU, both variables I(1). Johansen testing results demonstrated strong evidence of cointegration between the variables.

- IVGR *versus* INPCHAB: INPCHAB was not used in this analysis since the variable is I(0) and both variables must be of the same order of integration to form a cointegrating relationship. Further investigation was performed applying Granger causality test for this variable.

- IVGR *versus* IGPM: the best adjusted model based on AIC was a VAR(13) for the time series IVGR and IGPM, both variables I(1). Johansen testing results demonstrated evidence of cointegration between the variables. The unrestricted VAR model residual analysis demonstrated that it was not possible to eliminate the residual autocorrelation, even using different lag lengths.

#### 4.2 Granger Causality Test

The lack of Granger causality between market value and fundamental value of an asset suggests evidence of bubbles in asset prices [40-42]. The Granger causality test was performed in order to give more robustness to the cointegration tests since, according to [38], when time series are cointegrated there must be Granger causality between them. Although Granger causality can be bi-directional, it is expected that fundamental value cause (precede) the market value of an asset. More specifically in relation to this research, it is expected that fundamental value based on residential property rent-price ratio and cost-price ratio cause residential property market value, thus the fundamentals are relevant to explain the prices of residential properties. Testing results are presented in Tables 6 and 7.

#### 4.2.1 Fundamental value based on residential



**property construction cost-price index**

**Table 6.** Granger causality testing results

Variables	Testing Results	
Property construction cost-price index	Granger Causality	Conclusion
INCCMO	Bidirectional causality	No bubble
INCCMS	FV precedes MV	No bubble
CUB	FV precedes MV	No bubble

- IVGR *versus* INCCMO: there is bidirectional Granger causality between IVGR and INCCMO variables, validating cointegration testing results in previous section.

- IVGR *versus* INCCMS: setting a level of significance of 10% there is unidirectional Granger causality from variable INCCMS to IVGR, validating the absence of bubbles.

- IVGR *versus* CUB: setting a level of significance of 5% there is unidirectional Granger causality from variable CUB to IVGR, confirming testing results in previous section and the absence of bubbles.

**4.2.2 Fundamental value based on residential property rent-price index**

**Table 7.** Granger causality testing results

Variables	Testing Results	
Residential property rent-price index	Granger Causality	Conclusion
INPCALU	Bidirectional causality	No bubble
INPCHAB	Bidirectional causality	No bubble
IGPM	FV precedes MV	No bubble

- IVGR *versus* INPCALU: there was no Granger causality between the variables refuting the findings of Johansen cointegration testing in previous section. At this point there is a caveat to point out the need to take the annual differences in the series, due to the presence of seasonality. In taking the annual differences of the time series, there is bi-directional Granger causality between the variables, supporting the findings in previous section.

- IVGR *versus* INPCHAB: although cointegration testing was not performed as both variables must be of the same order of integration to form a cointegrating relationship, a VAR model can be estimated using stationary variables [I(0)] and apply Granger causality testing in order to seek for bubble evidences.

Estimating a VAR(3) model using IVGR and INPCHAB variables it was possible to identify whether residential property rent-price index (INPCHAB) was causing housing price (IVGR) and vice versa. Testing results demonstrated that both lagged values of the time series predicted current values thus indicating bidirectional Granger causality and absence of bubble. Although using a VAR(3) model, testing results were robust

regardless the number of lags used.

Similar results in relation to bidirectional Granger causality between housing and rental prices can be observed in other researches. [43] evidence based on panel data Granger causality tests suggested that house price changes are helpful in predicting changes in rents and vice versa.

- IVGR *versus* IGPM: setting a level of significance of 5% there is unidirectional Granger causality from variable IGPM to IVGR, confirming testing results in previous section and the absence of bubbles.

Although empirical research for the identification of bubbles in the Brazilian residential real estate market are virtually nonexistent, results achieved in this research are not unanimous. The existence of a bubble in the real estate sector of the economy using VAR model, Impulse Response Function and Variance Decomposition of Cholesky [5].

The reason why there were no common results may be connected to the different approach in both researches. While in this research the general idea was to verify or reject the existence of a stable relationship among housing prices, rent and building costs, *vis a vis* housing price and its fundamentals, [5] focused their research of how housing prices behave against shocks in macroeconomic variables (exogenous to the system), such as Brazil's gross development product, inflation, interest rate and government expenditures. On the other hand, [44], using cointegration test and vector error-correction model (VECM), demonstrated that there was a dominance of fundamental factors over the non-fundamental factors in explaining housing prices in India. This shows that empirical results may vary depending on the methods employed for estimating the relationship and the time series selected.

**5 Final Considerations**

The purpose of this research was to assess the existence of a bubble in the Brazilian residential real estate market in the period of 2001-2013. The techniques employed for the analysis included Johansen cointegration and Granger causality tests to verify or reject the existence of a stable relationship among housing prices, rent and building costs. As a result, all tests evidenced cointegration between residential properties' market value and fundamental value and causal relationship, suggesting the absence of a bubble.

Although housing prices growth has been significant in recent years, some aspects of the Brazilian market corroborate the results of this

research. The recent performance observed in the real estate sector is linked to broader causes and many factors can be pointed to explain the accelerated growth in recent years. Price stability with the beneficial effects of inflation control, the lengthening of loan terms up to 35 years, which allowed the reduction of the monthly installments, the sharp fall in interest rates, which reduced the cost of mortgages, the economic growth that increased the average real wages and consumer purchasing power, are some of these factors.

In addition, according to Central Bank Stress Test [32, 45], performed in order to measure the direct impact of a decrease in housing prices in the financial sector, only one Bank would be insolvent after a 55% decrease in housing prices. This shock is larger than the decline experienced in the United States during the subprime crisis, 33%. The financial system as a whole would not be impacted even in extreme cases of housing prices reduction.

That is not to say the economy is likely to continue to perform at the pace seen in the past years. The reduction in sales indicates that the purchasing power does not grow in the same pace observed in housing prices in the past years. This factor, coupled with other changes in macroeconomic variables such as unemployment and consumer delinquency rates may change the real estate price dynamics in the coming years.

In conducting this analysis a number of opportunities for refining the research were identified:

(i) To investigate price dynamics and the possibility of an asset bubble in the Commercial Real Estate market. Although Commercial Real Estate price has not grown so significantly as the housing prices in recent years, the increase in the sector's vacancy rate draws attention.

(ii) To investigate the residential real estate bubble phenomenon using other alternative data available in the main cities of the country, for example, FIPEZAP index. Although this specific index is calculated based on sale offer prices and therefore not reflecting the discounts in the sale negotiation process, the analysis could nevertheless determine in which cities housing prices could be more biased.

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