Intrinsic and Rational Speculative Bubbles in the U.S. Housing Market 1960-2009

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Abstract
We examine the residential property market in the United States during the period 1960–2009, focusing on the long run relationship between house prices and rents. Using a Markov regime switching model, we find that a structural break occurred in the price-rent ratio series in 1998, which may have been caused by the presence of a bubble in the market. We first test for the presence of an intrinsic bubble, and our results provide strong evidence that one existed during the pre-1998 period only. Constructing a separate test on the post-1998 period, we find that house prices were driven only by past price increases and not by fundamentals, implying the presence of rational speculative bubbles. The second goal of this paper is to provide a better understanding of whether changes in rents are useful in predicting house price movements, as earlier research in this area has been inconclusive. We contribute to the debate by examining how changes in rents influence returns in periods distinguished by whether or not there were intrinsic bubbles. Our results show that changes in rents can predict future returns in the housing market only in periods when there is an intrinsic bubble.

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1. Introduction

Over the last decade, residential property prices in the United States have attracted much attention from the media. According to the house price index provided by the Federal Housing and Finance Agency, nominal house prices rose by 61% between 1999 and 2009. This sharp rise has attracted the attention of academic researchers, many of whom are interested in establishing whether this increase in property prices is due to the existence of a bubble in the market.

An extended deviation of house prices from their fundamental values could be detrimental to the economy if it leads to a subsequent collapse in the housing market; research shows that homes are the major assets in household portfolios (see Englund et al., 2002). Changes in housing-based wealth are shown to be more important in their effect on the economy than changes in wealth caused by movements in stock prices (Helbling and Terrones, 2003; Rapach and Strauss, 2006). Pavlidis et al. (2009) find that bubbles in the housing market account for a significant share of changes to consumer expenditure. Hence, if house prices are not monitored closely, a crash could have a large adverse impact on the economy. The study of housing bubbles is therefore an important contribution to the literature on future economic development.

Speculative bubbles are certainly not new phenomena, with bubbles identified in commodity and financial markets at least back to the seventeenth century in the Netherlands (Garber, 1990). Many researchers have investigated the possible presence of speculative bubbles in numerous asset classes and several new models have been proposed. An important class of such models is based on rational speculative bubbles. These arise when the expectation of the future price of an asset has an abnormally important influence on the valuation of the asset, which could stimulate demand and thus lead to a deviation of asset prices from their fundamentals. In the context of a rational bubble, investors are justified in paying ever-higher prices for the asset because they are compensated for the risk that the bubble will collapse by increasing returns.

Blanchard and Watson (1982) introduce a model of rational speculative bubbles which addresses this phenomenon, albeit with two key disadvantages. The first is the implicit suggestion that bubbles will grow exponentially and can never be negative, as rational investors would never expect the future price of a stock to be below zero. The second is that the model assumes two states of nature, with the first state being one in which the bubble
survives and the second state of nature representing the bubble collapse. They propose that if a bubble were to collapse, its value would drop to zero, and thus the collapse would not be a gradual or partial process. It follows that once the bubble pops, it would never be able to regenerate. Diba and Grossman (1988) further develop this theory and additionally conclude that for a rational bubble to exist, stock prices’ successive differences will be non-stationary.

However, a series of papers by van Norden and Schaller (vNS, hereafter) dispute this approach, arguing that it is theoretically unjustifiable and leads to empirically implausible results. vNS (1993) propose a model in which bubbles could regenerate after a collapse, as can be seen in observed successions of rallies and crashes in stock markets. Furthermore, they argue that bubbles could be negative, as actual prices might fall below the fundamental price of an asset; they show that the probability of a bubble collapsing would depend on the relative size of the bubble.

Froot and Obstfeld (1991) introduce a different class of bubbles called intrinsic bubbles. Intrinsic bubbles, unlike rational speculative bubbles, are influenced solely by fundamentals such as dividends (in the case of stock prices), albeit in a nonlinear way. Intrinsic bubbles revert back to their fundamental values periodically. This class of bubbles is also rational and relies on the self-fulfilling expectations of market participants. The difference between intrinsic bubbles and standard rational speculative bubbles is that in the former case, deviations are caused by a non-linear relationship between fundamentals and prices rather than extraneous factors that would not normally be expected to influence the value of the asset. Froot and Obstfeld show that intrinsic bubbles closely capture the overreaction of stock prices to changes in dividends. Focusing on the US stock market, they find strong evidence of the presence of intrinsic bubbles. Ma and Kanas (2004) provide further evidence supporting the model for intrinsic bubbles by examining the nonlinear cointegration between stock prices and dividends. They show that the intrinsic bubble model outperforms the rational bubbles model and the random walk in capturing the movements of actual stock prices.

There have been a number of studies designed to test for the existence of bubbles in real estate prices, stimulated by the persistent rising trend in house prices which appeared to have been unrelated to economic variables such as construction costs, disposable incomes and unemployment. Bjorklund and Soderberg (1999) examine the possibility that house prices in Sweden are driven by the presence of speculative bubbles. They observe the dynamics of the Gross Income Multiplier (GIM, hereafter), asserting that only the presence of a speculative
bubble can cause the GIM to have a different trend from the real estate cycle. Kim and Lee (2000) adopt a cointegration approach to test for the presence of a bubble in the Korean property market. They infer the presence of a bubble in the market on the grounds that, in periods when the bubble is expanding, the variables are not cointegrated and therefore that there is no observable long-run equilibrium relationship between the variables.

A more econometrically robust test for bubbles is performed by Roche (2001). Using a regime-switching model based on the vNS approach, Roche tests for and finds the presence of periodically collapsing rational bubbles in the Dublin residential property market. More recently, Lai and Van Order (2010) test for housing bubbles in the U.S. by examining the momentum of house price growth in several metropolitan statistical areas (MSAs). They find momentum to have increased significantly after 1999, which led to the inception of a bubble.

The only notable test for bubbles in the real estate market that is not based on an econometric approach is conducted by Zhou and Sornette (2006). They apply their test on the housing market of different states in the U.S. Using an “econophysics” method, their approach examines the speed at which house prices grew. A faster than exponential growth in house prices could be concluded to indicate the existence of a bubble. They find that twenty-two out of the fifty States in the U.S. exhibited evidence of bubbles.

All of the above studies in real estate address the existence of rational bubbles. However, existing evidence concerning the presence of intrinsic bubbles is sparse. Black et al. (2006) and Fraser et al. (2008) represent the only studies that test for the presence of intrinsic bubbles in the real estate market, focusing on the United Kingdom and New Zealand property markets. The two papers apply the same methodology in calculating the fundamental values. They measure fundamentals based on the present value of the expected future disposable income of households. By testing for the presence of intrinsic bubbles in the two countries, they investigate whether deviations of house prices from their fundamentals are caused by an overreaction of households to changes in the expected future values of their disposable incomes. Both papers find intrinsic bubbles to be present only in the United Kingdom, whilst deviations from fundamentals in New Zealand appear to have been influenced by price dynamics alone and therefore classified as a rational but not intrinsic bubble.

The presence of bubbles in the housing market may have contributed to the inconclusive results of several papers that sought to identify whether price changes could be predicted by rents. Mankiw and Weil (1989) find the relationship between future price changes and the
rent-price ratio to be statistically insignificant. Even with the use of an error-correction model, Gallin (2004) shows that the power of the rent-price ratio for predicting future house prices is inconclusive. Hatzvi and Otto (2008) also find no concrete evidence to suggest that an increase in real rents would strongly influence variations in the prices of residential property. Referring to the UK housing market, Baddeley (2005) concludes that modelling of the market is more efficient when factors that might destabilize it are accounted for in the analysis. Such factors might include the presence of bubbles, herding and frenzies. Building on Baddeley’s conclusion, we aim to establish whether or not there have been intrinsic or rational speculative bubbles in the US housing market and we examine the role of fundamental factors in forecasting future price changes differs between bubble and non-bubble periods. In this paper, our objective is to understand the price dynamics of the U.S. housing market over the last 50 years. In our analysis, we test to see whether house prices differ from their fundamental values, and, if so, whether such deviations are driven by an overreaction of house prices to changes in rents i.e. whether there is an intrinsic bubble or not. Although Black et al, (2006) and Fraser et al, (2008) have, as reported above, tested whether, in the UK and New Zealand, deviations of house prices from their fundamental values were due to an overreaction to changes in fundamentals, this is the first paper to have addressed the issue in the US market.

The contributions of this paper to the literature on housing bubbles are two-fold. Firstly, it examines whether deviations of house prices from their fundamentals are caused by changes in the observed rental values. Unlike previous studies on intrinsic bubble models that use disposable income as the key fundamental driver of house prices, we use rents as our fundamental measure. The main reason we opt to use rents rather than disposable income is that they directly represent the consumption market for physical space. A shortfall in the supply of space will lead to an increase in rents. But a bubble in the sense of financial market bubbles should not affect the nominal level of rents since rent is essentially the spot price for immediate space occupation and is not itself an investible asset. From the real estate investor’s viewpoint, rent is analogous in cash flow terms to dividends for equity market investors. Rents provide better fundamental measures than disposable incomes in countries with easy access to credit facilities, like the U.S. (historically at least), where the ability of individuals to acquire mortgages did not depend solely on their disposable income. In those countries, changes in disposable income have not necessarily been associated with fundamental changes in the demand for housing. The second contribution of this paper is that
we test whether or not changes in rents predict future investment returns on residential properties during periods in which bubbles are present and during periods of no bubbles. This research is the first of its kind as no previous paper has accounted for the presence of bubbles when testing for the predictive power of rents.

The outline of this paper is as follows. In Section 2, we provide a detailed description of the sample. Section 3 explains the methods implemented in this research, focusing on the Markov regime switching model structural break test, the intrinsic bubble model and the econometric tests used to determine the predictability of house prices. The following section, Section 4, provides our findings. And finally, in Section 5, we summarise and draw conclusions.

2. Data

For this study, we use data on average purchase / sales prices of houses from 1960 to 2009, provided by Davis et al. (2008) for the Lincoln Institute of Land Policy and the house prices extracted from the S&P/Case-Shiller national house price index, which was previously called the Case-Shiller-Weiss index. Note that this index is calculated using the repeat sales method of index calculation and it tracks the value of single-family home prices. We also use rental data provided from the same source. The rental data used does not account for income taxes and inflation.¹ The discount rate we use in this study is the federal funds rate which was obtained from the FRED (Federal Reserve Economic Data) database. The other macroeconomic variables included in this study are the unemployment rate, provided by the Bureau of Labour Statistics (BLS), and the home ownership rate given by the U.S. Census Bureau.

There has been a persistent rise in the average house sales price in the U.S., as illustrated in Figure 1. From the graph, it is clear that there was a faster than average growth in house prices just after 1999, with prices peaking in 2006, where the price of the average house sold in the U.S. was $303,265. This represents a 98% rise in prices in just 7 years. Over that same period, gross rents rose by only 28%, as shown in Figure 2. Shortly after the peak of 2006, there was a significant decline in house prices of 39% to $217,505 by 2009, amounting to the

¹ More information on the construction of the data can be found at Land and Property Values in the U.S., Lincoln Institute of Land Policy, http://www.lincolninst.edu/resources/
largest sustained drop in the housing market over the previous 50 years. This decline in prices has been attributed to a contraction of credit facilities caused by the well-documented subprime mortgage crisis. Others argue that this decline in prices was the result of the collapse of a speculative bubble that had grown in the U.S. housing market over the preceding decade.

![Figure 1: Average Price of Houses Sold](image1.png)

![Figure 2: Annual Gross Rent](image2.png)

![Figure 3: Price-Rent Ratio](image3.png)

![Figure 4: Effective Federal Funds Rate](image4.png)

The price rent ratio is examined in Figure 3. Before the period of aggressive increases in house prices during 1999 – 2006, the average price-rent ratio was just 19. However, by the peak of housing market in 2006, this ratio had risen to 32, implying that house prices diverged significantly from rents. This divergence may be the result of speculative bubbles. The effective federal funds rate, which represents the cost of borrowing, has continued to fall since the 1980s. Figure 4 shows that as at 2008, the rate was around 2% compared to 16% in 1981. It has been suggested that these persistent cuts in interest rates contributed to the sharp rise in house prices over this period.
3. Methodology

Examining the price-rent ratio provides information on when the trend in prices departs from the growth trend in rents, which could imply the presence of a bubble (see Mikhed and Zemcik, 2009). The underlying assumption is that the asset price series at some point starts to include a bubble and at a later point, the bubble bursts. But from casual observation, bubbles are not equally likely to occur at any point in time; rather, they usually occur when the market is in a state predisposed for a bubble. We take the view that bubbles are more likely to occur when the market is more volatile. In order to work within this view, we choose to model the market using a Markov switching approach in which the market may be classified into two regimes: low return/high volatility and high return/low volatility. We test for regime switching in the price-rent ratio series. Applying a Markov regime switching methodology, we use the probabilities generated to determine when the price-rent ratio series switches regimes. Using the computed probabilities from the Markov regime switching model, the data are then split into two sub-periods. We test for the presence of intrinsic bubbles in the housing market in both sub-periods.

3.1 Locating regimes in the price-rent ratio series

In order to determine the sub-periods, we assume that the price-rent ratio, \( \frac{P}{R} \) can be modelled by the following process:

\[
\frac{P}{R}_t = a + \frac{P}{R}_{t-1} + \zeta,
\]  

(1)

where

\[
\zeta_i \sim i.i.d(0, \sigma^2)
\]  

(2)

and \( a \) is constant drift term

This means that the price-rent ratio in the current period is equivalent to the previous period’s price-rent ratio plus a constant representing the drift of the process.

Re-arranging (1):
Applying the Markov regime switching methodology to (3), we obtain (4):

\[
\frac{P_t}{R_t} - \frac{P_{t-1}}{R_{t-1}} = a + \xi_t
\]

This is now a Markov switching model,\(^2\) with \(s_t\) being a latent state variable that is assumed to follow a first-order Markov chain with constant transition probabilities i.e.

\[
\begin{align*}
\Pr (s_t = 1 | s_{t-1} = 1) &= p \\
\Pr (s_t = 0 | s_{t-1} = 1) &= 1 - p \\
\Pr (s_t = 0 | s_{t-1} = 0) &= q \\
\Pr (s_t = 1 | s_{t-1} = 0) &= 1 - q
\end{align*}
\]

This state variable can be either zero or one, representing the two possible regimes of the price-rent ratio series, namely state 0 and state 1. In this case, the probability of being in one regime is influenced only by the state that prevailed during the previous period. For more information on the estimation of equation (4), refer to Hamilton (1989, 1994).

By implementing this Markov regime switching random walk with a drift model, we could then use the probabilities generated to determine the period in which the price-rent ratio switches to a separate regime with different mean and variance. Hence, we split our data into sub-periods based on these probabilities and apply the intrinsic bubble test to the sub-periods.

### 3.2 An intrinsic bubble test

As described in Section 1, Froot and Obstfeld (1991) introduce the concept of intrinsic bubbles which, unlike rational speculative bubbles, are deviations of observed prices from the fundamental price driven by fundamentals in a nonlinear fashion. As we are examining the

\(^2\)Although Markov switching regression models date back to Goldfeld and Quandt (1973), we use the Hamilton (1994) approach, whereby the transition from one state to another is modelled using a Markov chain. See Hamilton (1989, 1994) for more details on how the probabilities are generated.
presence of this bubble specification in the housing market, we use rents as the fundamental
driver of house prices. To carry out the test for intrinsic bubbles in the U.S. housing market,
we follow the Froot and Obstfeld approach, but replace dividends with rents. Hence, the
present value relationship describing house prices is given by:

\[ P_t^{pv} = \sum_{s=t}^{\infty} e^{-ir(t-s+1)} E_t(R_s) \]  \hspace{1cm} (6)

where \( P_t^{pv} \) is the present value of the house price in period \( t \), \( ir \) is the constant interest rate, \( R \)
is the gross rents value and \( E \) is the expectation of the market given information at the start of
period \( t \). A standard bubble model is given as:

\[ P_t = P_t^{pv} + B_t \] \hspace{1cm} (7)

where:

\[ B_t = e^{-ir} E_t(B_{t+1}) \] \hspace{1cm} (8)

The actual price of a house is given by \( P_t \) while the bubble term, \( B_t \), is the difference between
the actual price and the fundamental value. However, the intrinsic bubble model considers
bubbles that are generated by a nonlinear function of rents. Hence the intrinsic bubble is a
function of rents satisfying (8):

\[ B(R_t) = cR_t^\lambda \] \hspace{1cm} (9)

where \( c \) and \( \lambda \) are constants explained below.

The model also assumes that log rents are generated as a martingale. Hence, the process for
log rents, \( r_t \), must follow a random walk with a drift \( \mu \) :

\[ r_{t+1} = \mu + r_t + \epsilon_{t+1} \] \hspace{1cm} (10)

where:

\[ \epsilon_{t+1} \sim N(0, \sigma^2) \] \hspace{1cm} (11)

From (6), the house price’s present value ought to be proportional to rents if the rent during
period \( t \) is known:
$P_t^{pv} = \kappa R_t$ \hfill (12)

where:

$$\kappa = (e^\mu - e^{\mu + \sigma^2/2})$$ \hfill (13)

The sum in (6) is assumed to converge, thereby implying that $ir$ must be greater than $\mu + \sigma^2/2$. Also, this condition is required to ensure that we do not yield negative present values. Therefore, if a bubble is present, the observed house price, $P_t$, can be thought of as the sum of $P_t^{pv}$ and $B(R_t)$:

$$P(R_t) = P_t^{pv} + B(R_t) = \kappa R_t + cR_t^2$$ \hfill (14)

where $c$ is an arbitrary constant and $\lambda$ is the positive root of (15), which is obtained from the inequality condition $ir > \mu + \sigma^2/2$:

$$\sigma^2/2 \lambda^2 + \mu \lambda - ir = 0$$ \hfill (15)

Based on (15), the inequality $ir > \sigma^2/2 \lambda^2 + \mu \lambda$ is used to indicate that $\lambda$ must be greater than 1 at all times, and it is this explosive nonlinearity that allows house prices to overreact to changes in rents. Like Froot and Obstfeld, we then divide (14) by $R$ due to the presence of collinearity, using

$$\frac{P_t}{R_t} = \kappa + cR_t^{\lambda-1} + \zeta_t$$ \hfill (16)

to test for the presence of intrinsic bubbles in the housing market. The null hypothesis in this case is $c = 0$, implying that there is no intrinsic bubble present.

In the absence of an intrinsic bubble, we could still observe a speculative bubble if market prices are increasing because of positive feedback from previous prices. This is the case of the speculative rational bubble which is not linked to an over-reaction to fundamental variables but is generated by investors (buyers) observing high returns in the recent past and

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3 This implies that if $\lambda$ satisfies equation (15), then (9) clearly satisfies the definition of the bubble in (8). Therefore, this can be defined as an intrinsic bubble. Froot and Obstfeld prove this mathematically in equation (14) on page 1192 of their paper.

4 There would be collinearity amongst the explanatory variables if we decided to test for the presence of an intrinsic bubble using the formula $P(R_t) = \kappa R_t + cR_t^4$. 

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expecting them to continue in the future. We therefore test for this type of bubble if we do not find an intrinsic bubble in the regime. Our expectation is that the speculative rational bubble will be more likely to occur in the regime associated with high returns.

Following these tests aimed to distinguish between the types of bubble in each regime, we investigate the predictive nature of returns in the housing market. Our aim is to establish whether changes in rents predict returns in the sub-periods that we identified using the Markov-switching approach, i.e. can rents drive returns on investing in residential property at times when an intrinsic bubble is present the housing market? To perform this analysis, we test for cointegration between the variables, prices and rents. If no cointegration is found, we would implement a vector autoregressive (VAR, hereafter) model, otherwise we would use the vector error correction model (VECM, hereafter). This is consistent with Granger’s (1986) conclusion that when variables are cointegrated, a VAR model in differences would be mis-specified whereas the VECM has the ability to capture the deviations from the long term equilibrium. Then a Granger-causality test is employed to determine whether or not changes in rents predict the returns on investing in the US housing market.

4. Results

To check for regime switches in the price-rent ratio series, we implement a Markov regime switching methodology discussed in Section 3.1 estimating the parameters of equation (4) by maximum likelihood, and these are presented in Table 1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
<th>Standard Errors</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_0^2$</td>
<td>0.0004</td>
<td>0.0001</td>
<td>0.00</td>
</tr>
<tr>
<td>$\sigma_1^2$</td>
<td>0.0108</td>
<td>0.0064</td>
<td>0.10</td>
</tr>
<tr>
<td>$\alpha_0$</td>
<td>0.0115</td>
<td>0.0036</td>
<td>0.00</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>-0.0241</td>
<td>0.0329</td>
<td>0.47</td>
</tr>
</tbody>
</table>

The results in Table 1 show that there are two distinct states: State 0 represents a regime with relatively low volatility ($\sigma_0^2$) and a positive mean ($\alpha_0$). State 1, on the other hand, represents a
regime which has a negative mean \( a_1 \) and higher volatility \( \sigma_1^2 \) in the price-rent ratio series. All the variables except for \( a_1 \) are statistically significant at the 10% level.

Based on the transition probability matrix calculated from the Markov regime switching model, we compute the smoothed states probabilities, which locate the probability of being in the high volatility state in the price-rent ratio series, and these are presented in Figure 5.

![Figure 5: Probabilities of being in State 1](image)

From the Markov regime switching model, the probabilities generated (see Figure 5) indicate that price-rent ratio is likely to have changed regime around 1999\(^5\) because the probability of being in state 1 starts to increase from 1999 onwards until the model predicts a 100% probability of being in State 1 soon after 2000. Based on these findings, we split our data into two sub-periods. Sub-period ‘A’ represents the period 1960–1998, while sub-period ‘B’ (1999 – 2009) represents the period corresponding to an increased probability of the price-rent ratio coming from the high volatility regime.

Evidence of a very large departure of house prices from rents is also given in Figure 6. It shows that house price and rents grow at almost the same rate over the years until the late 1990s, whereafter house prices began to grow at a faster rate. The increase in the growth rate of house prices may have led them to deviate from their fundamentals. Since the growth rate of rents was relatively stable, this rise in prices may not have been caused by an overreaction to changes in rents; rather, it could have been due to other exogenous factors. This unusually fast growth in house prices lasted until 2006, and then prices fell 37% by 2009. Therefore, we test for the presence of intrinsic bubbles in the two sub-periods and if we find that there is no

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\(^5\) This is in line with Lai and Van Order’s (2010) finding that there was a regime shift in house prices which saw a rise in momentum from 1999 onwards.
intrinsic bubble in the housing market in either of the periods, we test for the presence of rational speculative bubbles.

4.1. The intrinsic bubble test

In this sub-section, we aim to find out whether or not intrinsic bubbles exist in the two sub-periods. Following the steps in (6) to (16), we compute the parameters. Table 2 represents information on the estimated parameters in sub-period ‘A’, whilst Table 3 represents results from the intrinsic bubble test in sub-period ‘B’. It shows that between 1960 and 1998, $\mu$, which represents the rents’ trend growth rate, is calculated to be approximately 5.70% per annum. Its standard deviation from the log rents regression, $\sigma$, is estimated to be 2.6% per year, indicating little fluctuation in rents. With these parameters estimated, we compute the value of $\lambda$, the quadratic solution of equation (15), which we find to be 1.109.\(^6\)

Using ordinary least squares (OLS, hereafter) to carry out the hypothesis test in (16), we find $\hat{\kappa} = 8.428$ and $\hat{c} = 4.527$, with corresponding $t$-statistics of 4.850 and 6.170 respectively. Therefore, there is strong evidence to reject the null hypothesis of the absence of intrinsic bubbles in the U.S. housing market. The positive value of $\kappa$ signifies that, as the cost of renting increases, house prices increase at a faster rate than rental growth. This provides more evidence to support the presence of intrinsic bubbles in the housing market.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficients</th>
<th>t-stats</th>
<th>p-values</th>
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</thead>
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<tr>
<td>$\mu$</td>
<td>0.057</td>
<td>13.765</td>
<td>0.000</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.109</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>8.428</td>
<td>4.850</td>
<td>0.000</td>
</tr>
<tr>
<td>$c$</td>
<td>4.527</td>
<td>6.170</td>
<td>0.000</td>
</tr>
</tbody>
</table>

$R^2 = 0.507$

All the parameters above are estimated using OLS (on equation 16) except $\lambda$, which is the positive root of the quadratic equation given in (15).

As explained earlier, the presence of an intrinsic bubble in the housing market implies that house prices diverge from their fundamentals due to an overreaction to changes in the values...

\(^6\)We must find $\lambda$ to be greater than one to show that a nonlinear explosive relationship exists between the rents and bubbles. This would mean that house prices may overreact to changes in rents.
of rents and this intrinsic bubble could have been sustained by a widely held belief by investors/homebuyers that house prices would continue to rise based on the ever-increasing cost of rents. Also, the availability of credit facilities to borrowers with poor credit-ratings (subprime borrowers) may have led many renters to buy houses rather than to continue renting because as rents continued to rise, more individuals were encouraged to apply for mortgages even in the face of rising unemployment.

We also test for the presence of intrinsic bubbles in the second sub-period, 1999 – 2009. Table 3 presents the results for this period. The trend growth in rents, $\mu$, is 0.033 (3.3% per annum), which is 2.4% less than in the first sub-period. The standard deviation obtained from random walk with drift model of log-rents is 0.01. Using these estimates and the average interest rate for the period (3.5%), we calculate $\lambda$ to be 1.075.

<table>
<thead>
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<th>Coefficients</th>
<th>t-stats</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu$</td>
<td>0.033</td>
<td>10.244</td>
<td>0.000</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>1.075</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>-83.305</td>
<td>-0.512</td>
<td>0.621</td>
</tr>
<tr>
<td>$c$</td>
<td>54.803</td>
<td>0.667</td>
<td>0.521</td>
</tr>
</tbody>
</table>

Table 3: Results from the test for intrinsic bubbles in the US Housing Market between 1999 and 2009

All the parameters above are estimated using OLS (on equation 16) except $\lambda$, which is the positive root of the quadratic equation given in (15).

Table 3 shows that the coefficients of $\kappa$ and $c$ are statistically insignificant, which therefore implies that intrinsic bubbles were absent from the housing market between 1999 and 2009. This means that price rises during the more recent period were not caused by an overreaction to changes in the cost of renting, but may have been influenced by changes to other exogenous factors such as easily accessible credit and the increased popularity of mortgage-backed securities products. These may have been important in generating a rational speculative bubble in which house prices would depend positively and solely on their own rate of change in the previous period.\(^7\) Here, only the self-fulfilling expectations of changes in

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\(^7\) Note that in periods absent of rational speculative bubbles, past price movements are also expected to influence current price changes, as investors in general observe previous price changes before making an investment decision. This is based on the rational expectations theory (Muth, 1961). However, when a rational speculative bubble exists in the market, the impact of previous price movements on the current changes in prices would be significantly greater and fundamental drivers of the housing market such as unemployment and interest rates should have little or no impact in determining price changes.
price, which is based on previous movements in prices, would influence future changes in prices.

In order to examine whether a rational speculative bubble existed in the residential property market post-1998, a separate test is conducted. Based on the positive feedback theory, a rational speculative bubble arises when previous increases in house prices alone influence present investments in the residential property market i.e., when rational speculative bubbles exist in the market, house price changes are not moved by key macroeconomic factors but by past price increases only. Considering the two sub-periods, we run OLS regressions on each separately where the dependent variable is the current increase in price ($\Delta p_t$). The explanatory variables are past price changes ($\Delta p_{t-1}$), changes in interest rates ($\Delta i_t$) and in the unemployment rate ($\Delta u_t$). These explanatory variables are chosen because they are important in determining the demand for houses. The interest rate level represents the cost of borrowing, which should have a negative effect on house prices. The unemployment rate should also have a negative impact on house prices, as high unemployment levels would suppress housing demand. A rational speculative bubble would be implied if none of the fundamental variables were significant in the regression and only the changes in past prices explained current price changes.

Table 4 shows the results of the test for the presence of rational speculative bubbles in the housing market. Pre-1999, changes in the level of unemployment and changes in past prices significantly influence changes in current prices. The parameter attached to changes in the interest rate level, which had a negative relationship with house price changes as expected, is statistically insignificant. However, in the second regime (between 1999 and 2009), the only variable that is statistically significant to at least the 10% level is the past price increase. Neither interest rates nor changes in the level of unemployment had an impact on house price changes, implying that house prices were only moved by changes to prices in the previous period. A Wald test is implemented to check for the joint significance of interest rates and unemployment in both sub-periods. We find a very low probability value in sub-period A, indicating that unemployment levels and interest rates jointly influence changes in prices; however, in sub-period B, we find no evidence of joint significance.\footnote{For sub-period A, the value of computed $F$-statistic is 3.371 with a corresponding probability value of 0.047. Hence there is evidence to reject the null hypothesis of the joint insignificance of interest rates and unemployment in predicting changes in house prices. In sub-period B, however, the $F$-statistic is 1.973 with a probability value of 0.139 and so we cannot reject the null hypothesis.} Hence, there is evidence
that a rational speculative bubble existed in the housing market during that period, as only appreciations in lagged prices significantly explain price growth. House prices, based on the average price-rent ratio methodology for computing the fundamental value of houses, were overvalued by as much as 46% in 2006. The subsequent collapse of the rational speculative bubble saw house prices fall by 37% between 2006 and 2009. According to the model, house prices as at the end of 2009 were undervalued by 6%.

Table 4: Test for the presence of rational speculative bubbles in the sub-periods.
OLS Regression: \( \Delta p_t = \text{Constant} + \Delta ir_t + \Delta u_t + \Delta p_{t-1} + u_t \)

<table>
<thead>
<tr>
<th>Sub-periods</th>
<th>Variable</th>
<th>Coefficient</th>
<th>t-stats</th>
<th>Probability value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 - 1998</td>
<td>Constant</td>
<td>0.014</td>
<td>1.772</td>
<td>0.094*</td>
</tr>
<tr>
<td></td>
<td>( \Delta ir_t )</td>
<td>-0.016</td>
<td>-0.946</td>
<td>0.357</td>
</tr>
<tr>
<td></td>
<td>( \Delta u_t )</td>
<td>-0.068</td>
<td>-2.545</td>
<td>0.016**</td>
</tr>
<tr>
<td></td>
<td>( \Delta p_{t-1} )</td>
<td>0.779</td>
<td>6.919</td>
<td>0.000***</td>
</tr>
<tr>
<td>1999 - 2009</td>
<td>Constant</td>
<td>-0.022</td>
<td>-0.526</td>
<td>0.615</td>
</tr>
<tr>
<td></td>
<td>( \Delta ir_t )</td>
<td>-0.094</td>
<td>-1.722</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>( \Delta u_t )</td>
<td>-0.224</td>
<td>-1.273</td>
<td>0.244</td>
</tr>
<tr>
<td></td>
<td>( \Delta p_{t-1} )</td>
<td>1.072</td>
<td>2.260</td>
<td>0.058*</td>
</tr>
</tbody>
</table>

***, ** and * denote rejection of the null hypothesis at the 1%, 5% and 10% significance levels respectively.

4.2. Can rents predict returns?

In order to test whether rents can predict returns in the housing market, the data are again split into the same two sub-periods as above: ‘A’ representing the period 1960 – 1998 and ‘B’ representing 1999 – 2009. Sub-period ‘A’ corresponds to the time of an intrinsic bubble while ‘B’ is for the period where rational speculative bubbles existed in the residential property market.

Firstly, we test for the presence of cointegration between house prices and rents using the Johansen approach. The cointegration test results are shown in Table 5. House prices and rents are found to be co-integrated in both of the sub-periods as the null hypotheses are rejected.
Table 5: Johansen’s unrestricted cointegration rank (trace) test for the sub-periods

<table>
<thead>
<tr>
<th>Sub-periods</th>
<th>Null</th>
<th>Trace Statistics</th>
<th>0.05 Critical Value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 - 1998</td>
<td>$r = 0$</td>
<td>87.458</td>
<td>15.495</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>$r \leq 1$</td>
<td>0.038</td>
<td>3.841</td>
<td>0.091</td>
</tr>
<tr>
<td>1999 - 2009</td>
<td>$r = 0$</td>
<td>27.166</td>
<td>15.495</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>$r \leq 1$</td>
<td>2.596</td>
<td>3.841</td>
<td>0.107</td>
</tr>
</tbody>
</table>

Note: $r$ is the number of cointegrating vectors under the null hypothesis; Mackinnon-Haug-Michelis (1999) p-values are employed.

Based on these findings, we apply a standard VECM model rather than a VAR to the variables shown in equations (17) and (18).

\[
\Delta p_t = \alpha_1 + \beta_{11} \Delta p_{t-1} + \beta_{12} \Delta r_{t-1} + \gamma_1 z_{t-1} + u_t \tag{17}
\]

\[
\Delta r_t = \alpha_2 + \beta_{21} \Delta p_{t-1} + \beta_{22} \Delta r_{t-1} + \gamma_2 z_{t-1} + u_z \tag{18}
\]

Note that $\Delta p_t, \Delta r_t$ and $z$ are the log differences in prices i.e. returns, rents and the disequilibrium term, respectively.

Using the VECM model obtained, we aim to determine whether rents can predict returns in the housing market by applying a Granger causality test. Table 6 presents the results from the Granger causality tests on the two sub-periods.

Table 6: Granger causality test for the sub-periods with house prices being the dependent variable

<table>
<thead>
<tr>
<th>Sub-periods</th>
<th>Excluded Variable</th>
<th>Chi-Sq</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 – 1998</td>
<td>$\Delta r_t$</td>
<td>1</td>
<td>0.000</td>
</tr>
<tr>
<td>1999 – 2009</td>
<td>$\Delta r_t$</td>
<td>1</td>
<td>0.168</td>
</tr>
</tbody>
</table>

From Table 6, changes in rents Granger-cause housing returns in the period where there is intrinsic bubble in the housing market. However, as we move into the period where house prices were influenced by the presence of rational speculative bubbles (1999 – 2009), there appears to be no causal relationship between changes in rents and the returns to investing in the residential housing market. This shows that changes in rents can predict future house
returns only when there is an intrinsic bubble; when rational speculative bubbles exist, changes in rents do not predict returns, mainly because the only driver of house price increases is the previous period’s price increase itself. Such findings confirm that house prices are more sensitive to changes in rents during periods when an intrinsic bubble is present.

To further investigate the relationship between house prices and rents, we examine the impulse response of house prices to a positive unit shock in rents in the two sub-periods.

Figures 7(a) and 7(b) focus on the degree of sensitivity of house prices to changes in rents in the two sub-periods, and further evidence supporting the intrinsic bubble model for the earlier sub-period is shown in the figure. Positive unit shocks to rents cause increases in house prices in the intrinsic bubble period only, whilst they have a negative impact on house prices during the rational speculative bubble period. When houses are overvalued as a result of an overreaction to changes in rents, further increases in rents may encourage individuals to purchase their own homes.

6. Summary and Conclusions

This paper has established that the US housing market has witnessed two types of bubble in the last fifty years. By using a Markov-switching model, we first identified that the housing market appeared to switch from one regime to another at or around 1999. The earlier period
was represented by a high expected return and low volatility regime whilst the later period exhibited low (even negative) returns and high volatility.

Given these two regimes, it is not surprising that different kinds of bubbles might be expected to appear over the whole period. From our analysis, we conclude that in the first period, the market behaved in a manner consistent with an intrinsic bubble, with buyers over-reacting to changes in fundamental variables. In the second period, the price series behaved as if it contained a rational speculative bubble in which the driver of house price changes was focused solely on previous price changes. In other words, buyers ceased to be influenced by underlying fundamental factors and instead became fixated on non-linearly extrapolating the historical growth in house prices.

Previous studies aimed at determining the predictive power of rents on house prices have found conflicting results, and that may have been a result of differences in periods studied. While some papers studied the impact of rents and other factors on house prices during a bullish housing market (e.g. pre-2007 in the U.S.), others selected periods of downturns in the market. In this paper we have been able to shed light on why previous research has found conflicting or insignificant results. The type of bubble is important in determining whether rents influence returns in the housing market; our tests show that this was the case. Using a Granger-causality test, we examined how important rents were in determining changes in house prices. Our results showed that changes in rents Granger-cause and could therefore predict future returns in the housing market only when there is an intrinsic bubble in the market.

Even though real estate bubbles have been extensively scrutinised over the years, there is further research to be conducted on establishing the factors that led to the inception and subsequent collapse of a rational speculative bubble. There is widespread speculation regarding the true causes of house price rises between the late 1990s and 2006. Some attribute this to the consistent decline in interest rates whilst others conclude that it was caused by aggressive subprime lending, especially in states such as California and Florida. To date, there is no cohesive conclusion on this matter. Hence, further research might reveal the relative importance of the possible causes of the rational speculative bubble.
References


