Housing and equity bubbles: Are they contagious to REITs?

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Abstract
This paper uses a regime switching approach to determine whether prices in the stock, direct real estate and indirect real estate markets are driven by the presence of speculative bubbles. The results show significant evidence of the existence of periodically partially collapsing speculative bubbles in all three markets. We then develop and implement a multivariate bubble model to evaluate whether the stock and housing bubbles spill over into REITs. We find the underlying property market bubble to be a stronger influence on the securitized real estate market bubble than that of the stock market. Furthermore, our findings suggest a multi-directional transmission of speculative bubbles between the direct real estate and stock markets, although this link is not present for the returns themselves.

Key words: periodically collapsing speculative bubbles, spillovers, contagion, REITs, real estate

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1. Introduction

Formally authorized by Congress in 1960, Real Estate Investment Trusts (REITs) are exchange-listed closed-end investment firms that offer investors the opportunity to gain indirect exposure to the real estate market. REITs are legally required to have at least 75% of their assets and income derived from real estate and to pay 95% of their taxable income as dividends. These requirements are designed to make investing in REITs attractive since they will provide a stream of dividends to investors that is directly related to the rental income received by the REIT. Since the introduction of REITs, there has been a series of favorable structural reforms in the regulations guiding REITs.\(^1\) One consequence of the regulatory changes was a surge in initial public offerings (IPO) in the mid-1990s. Reports from the National Association of Real Estate Investment Trusts (NAREIT) show that there were 95 IPOs in the industry in 1993 and 1994 compared to 48 between 1988 and 1992.\(^2\)

The surge in the size of the REIT market (also referred to as the securitized, indirect or public real estate market) prompted the interest of academic and industry researchers. Whilst many researchers focused on primary offerings in the indirect real estate market, others investigated the relative influence of the equity market and the private real estate market on the behavior of REIT prices. The conclusions of these papers are far from being cohesive.

One stream of literature essentially concludes that the indirect real estate market is related and more sensitive to changes in the stock market than the underlying unsecuritized real estate market. Goetzmann and Ibbotson (1990) is one of the earliest papers to study the relationship between the markets for the period 1972 – 1989. They find REIT returns to be more correlated with the equity market than with the direct property market, concluding that REITs are not close substitutes for the unsecuritized real estate market. Similarly, Seiler et al. (1999) find that returns to the direct and indirect real estate markets differ from one another. Glascock et al. (2000), who control for the structural change of the REIT market in 1992, find that the returns from equity REITs are more closely related to the returns from stocks post-1992 than to the returns from the private real estate market.

\(^1\)Changes in tax regulation given in the Tax Reform Act of 1986 which allowed REITs to be better managed. The introduction of the umbrella partnership REIT (popularly referred to as UPREIT) at the start of the 1990s was, though, the major propelling factor of growth in the industry mainly because this structure facilitated acquisitions of depressed private real estate properties following the housing market downturn of 1989.

\(^2\)Various publications by NAREIT show that funds from IPOs in REITs exceeded $15bn for 1993 and 1994 while the total of funds raised from IPOs in non-REIT firms was about $49.5bn. This shows that around 30% of funds raised from IPOs in the US came from the REIT sector alone. The percentage in 1992 was 3.82%, with 1.28% the year before, hence signifying that 1993/1994 was the hottest year in the REIT market.
A second stream of literature, however, makes opposing inferences of the relationship, generally finding a linkage between the direct and securitized real estate markets. Regressing the returns on both the Russell-NCREIF index and the NAREIT Equity REIT index on stock and bond markets’ returns separately, Giliberto (1990) finds the regression errors to be correlated and concludes that there is a common fundamental factor driving both the securitized and unsecuritized real estate markets. This view is also supported by Geltner (1993), who concludes that both direct and indirect real estate markets have similar long run fundamentals. Han (1991) finds that returns in the underlying unsecuritized real estate market lead REIT returns, while several others including Gyourko and Keim (1992), Liu and Mei (1992) and Barkham and Geltner (1995) find that price discovery happens in the REIT industry before transmitting to the direct real estate market. More recently, the regression analyses performed by Clayton and MacKinnon (2003) and Lee et al. (2010) provide further results that equity REIT returns are very closely linked with the underlying real estate market.

A parallel research program has followed the behavior of prices in the securitized real estate prices investigating whether the market has exhibited “bubble-like” behavior. An early paper by Brooks et al. (2001) applies a variance bound test for bubbles in publicly traded real estate stocks in the UK. The variance bound test, introduced by Shiller (1981) and LeRoy and Porter (1981), identifies a bubble if the stock prices are more volatile than the fundamental prices. Brooks et al. find strong evidence to suggest that there was a bubble in these stocks between 1987 and 1989, as well as from 1996 onwards. Jirasakuldech et al. (2006) test for rational speculative bubbles in equity REIT prices using unit root and co-integration tests.3 The literature on speculative bubbles in the REIT industry is, however, still very limited.

A natural extension to the research that identifies bubbles is to explore whether a bubble in one market leads to a bubble in another, related market. In other words, are bubbles infectious? In the light of the heavily publicized collapse of bubbles in both the housing and stock markets in the late 2000s, this research aims to provide a more detailed analysis of whether speculative bubbles in the REIT market are exacerbated by bubbles in the private market in real estate as well as by bubbles in the equity market. The methods used in this paper could also be used to determine whether there is a multi-directional transmission of speculative bubbles between these markets. Our findings are particularly relevant to investors

3It is important to note, however, that cointegration tests are poor at detecting bubbles that burst and regenerate (Evans, 1991).
since they could be used to distinguish the different impacts on the REIT market of bubbles in the private market for real estate and the stock market.

Using a regime-switching model, we test for the presence of periodically collapsing bubbles in the equity market and the private and public real estate markets between 1972 and 2010. With an extension of the regime switching model, the paper proceeds to investigate possible bubble spillovers between the markets. The outline of this paper is as follows. Section 2 explains the methods implemented, focusing on the regime switching test used in determining speculative bubble-like behavior in the markets. In Section 3, we provide a detailed description of the sample used in this research. The following section gives an overview of the fundamental measures of the real estate and stock markets. Sections 5 and 6 provide our findings and check for bubble contagion amongst the markets respectively. Finally, in Section 7, we summarize and draw conclusions.

2. Methodology

2.1 The regime-switching bubble model

We start with the simple observation that the price of a stock \( P^a_t \) today is given by its expected price in the next period plus the income generated from holding that stock in the next period:

\[
P^a_t = \frac{E_t(P^a_{t+1} + D^a_{t+1})}{(1+i)}
\]

(1)

where \( D_t \) represents the income stream of the asset (e.g. dividends for stocks and rents for real estate), \( E_t(.) \) is the expectation operator and \( i \) is the discount rate.

In order to test for asset bubbles, it is necessary to determine the fundamental value of the asset. The fundamental price \( P^f_t \), as its name suggests, is influenced solely by market fundamentals and is defined as the sum of the asset’s future dividends (or distributed income) discounted to the present time as shown in Equation (2).

\[
P^f_t = \sum_{g=1}^{\infty} \frac{E_t(D^f_{t+g})}{(1+i)^g}
\]

(2)
Empirically, the actual asset price often deviates from the fundamental price. These deviations can arise as a result of speculation in the asset’s market, where excessive demand by market agents induces price jumps that may exceed the fundamental value of the asset. Hence in the speculative bubble literature, asset prices are split into two separate components, namely the fundamental price and the non-fundamental component (or the bubble component, subject to the conditions discussed in Section 2.2 below), $B_t$:

$$P_t = P_t^f + B_t + u_t$$  \(3\)

where $u_t \sim N(0, \sigma^2)$ is the unexpected innovation of the fundamental and non-fundamental values. The difference between the actual price and the fundamental price in period $t$ is the non-fundamental component.\(^4\)

The first notable bubble model was proposed by Blanchard (1979) and Blanchard and Watson (1982). In this model, the bubble component grows exponentially and cannot be negative, i.e. the fundamental price cannot be greater than the actual price of the asset. This model also assumes that there are two possible bubble states: one being a state in which the bubble survives ($S$) and the other being a collapsing state ($C$). Blanchard and Watson propose that the bubble process is:

$$E_t(B_{t+1} | S) = \frac{(1+r)}{q} B_t$$

with probability $q$

$$E_t(B_{t+1} | C) = 0$$

with probability $1 - q$ \(4\)

where $q$ is the probability of the bubble surviving and $1 - q$ is the probability of a collapse, both in period $t + 1$.

Equation (4) implies that in period $t + 1$, if the bubble does not collapse, the bubble component is expected to grow at a rate higher than the real rate of return. This compensates the investor for risk-taking.\(^5\) However, if the bubble collapses, its value diminishes immediately to zero (the collapse of a bubble is not a gradual process) and prices

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\(^4\) Note that the non-fundamentally driven component of price must satisfy equation (1). Therefore, weighted across the surviving and collapsing regimes, this non-fundamental component is expected to grow at the discount rate or the rate of return.

\(^5\) The derivation of equation (4) is fairly straightforward. Blanchard and Watson (1982) show the expected size of the bubble in the next period is given as:

$$E_t(B_{t+1}) = E_t(B_{t+1} | S)q + E_t(B_{t+1} | C)(1 - q)$$

This is then re-arranged to give the stochastic process in equation (4).
subsequently return to their fundamental value. This model also concludes that the bubble cannot regenerate once it collapses. These are empirically unrealistic conclusions, as there have been significant episodes of bubble crashes and regenerations, e.g. the stock market “Great Depression” of 1929 and the “dot-com” bubble of the late 1990s. There were significant price corrections and bubble collapses after those episodes.

Van Norden and Schaller (1993, 1999) lift these unrealistic assumptions by modifying the Blanchard and Watson model in two ways. First, they allow the probability of the bubble surviving and continuing to expand to depend on the relative size of the bubble component \( h_i = \frac{B_i}{P_t} \), implying that the probability of being in the surviving state falls as the relative size of the bubble grows:

\[
\frac{\partial q(b_i)}{\partial |b_i|} < 0 
\]

The second modification by van Norden and Schaller involves allowing for partial collapses in bubbles, where the size of the bubble gradually decreases in the collapsing state:

\[
E_i(B_{t+1} | C) = u(b_i)P_t^a
\]

where \( u(b_i) \) is a continuous and everywhere differentiable function:

\[
0 \leq \frac{\partial u(b_i)}{\partial b_i} \leq 1
\]

Given these two modifications, van Norden and Schaller introduce the modified bubble process:

\[
E_i(B_{t+1} | S) = \frac{(1+i)B_i}{q(b_i)} - \frac{1-q(b_i)}{q(b_i)}u(b_i)P_t^a \quad \text{with probability } q(b_i)
\]

\[
E_i(B_{t+1} | C) = u(b_i)P_t^a \quad \text{with probability } 1 - q(b_i)
\]

Unlike the bubble process in Blanchard and Watson’s model, the expected size of the bubble in the collapsing regime is not necessarily equal to zero. But when \( u(b_i) \) equals zero and \( q(b_i) \) is a constant, \( q \), the process reduces to that of Blanchard and Watson.
Returns to the asset under the van Norden and Schaller bubble specification depend on whether the bubble is in the surviving or collapsing regime, i.e. returns are state dependent. Van Norden and Schaller (1997) propose that the gross return on the asset \((M)\) follows a non-linear switching process:

\[
E_t(R_{t+1} | S) = \left[ M(1-h_t) + \frac{Mb_t}{q(b_t)} - \frac{1-q(b_t)}{q(b_t)}u(b_t) \right] \quad \text{with probability } q(b_t)
\]

\[
E_t(R_{t+1} | C) = M(1-h_t) + u(b_t) \quad \text{with probability } 1 - q(b_t) \tag{9}
\]

Equation (9) shows the gross return of the asset at time \(t + 1\) depends on the regime in the previous time period. Using a first-order Taylor series approximation method, the model is linearized and estimated. A linear switching regime model for returns is derived with a single state-independent probability of a regime switch, \(q(b_t)\):

\[
R_{t+1}^s = \beta_{s,0} + \beta_{s,1}h_t + u_{s,t+1}
\]

\[
R_{t+1}^c = \beta_{c,0} + \beta_{c,1}h_t + u_{c,t+1}
\]

\[
P(R_{t+1} | S) = q(b_t) = \Phi(\beta_{q,0} + \beta_{q,1} | h_t) \tag{10}
\]

where the unexpected returns in the collapsing and surviving regimes are represented by \(u_{c,t+1}\) and \(u_{s,t+1}\) respectively, and they have constant variance and zero mean. \(\Phi\) is the standard normal cumulative distribution function and so \(\Phi(\beta_{q,0})\) is the probability of being in the surviving regime conditional upon a bubble size of zero, whereas \(\beta_{q,1}\) measures how the probability of being in the surviving regime changes with respect to the absolute bubble size. The condition that the probability of the bubble surviving depends inversely on its size as in equation (5) implies that \(\beta_{q,1} \leq 0\). By modeling the probability of being in the surviving regime as depending on the absolute size of the bubble, the van Norden and Schaller model allows for the possibility of negative bubbles in assets. Negative bubbles occur in periods where the fundamental value of an asset exceeds its actual price.

Estimation of the parameters in equation (10) is achieved by maximizing the following log-likelihood function, \(\ell:\)
\[
\ell(R_{t+1} | \xi) = \sum_{t=1}^{T} \ln \left[ P(R_{t+1} | S) \frac{\phi \left( \frac{R_{t+1} - \beta_{t,0} - \beta_{t,b_1}}{\sigma_s} \right)}{\sigma_s} + [1 - P(R_{t+1} | S)] \frac{\phi \left( \frac{R_{t+1} - \beta_{t,0} - \beta_{t,b_2}}{\sigma_c} \right)}{\sigma_c} \right]
\]

(11)

where \( \xi \) represents the set of parameters to be estimated by maximizing the likelihood in (11). The estimated parameters consist of \( \beta_{t,0}, \beta_{t,1}, \beta_{t,0}, \beta_{t,1}, \beta_{t,0}, \beta_{t,1}, \sigma_s \) and \( \sigma_c \). Here, the notation \( \phi \) represents the standard normal probability density function, \( \sigma_s \) and \( \sigma_c \) are the disturbances’ standard deviation in the surviving and collapsing regimes respectively.\(^6\) Given these estimates, it is possible to make inferences on whether or not bubbles exist.

2.2 The test for periodically collapsing speculative bubbles

If periodically collapsing speculative bubbles are present in the asset market, the non-fundamental or bubble model must efficiently predict returns; there are four restrictions on the coefficients that imply that the estimated bubble model is plausible. Firstly, \( \beta_{t,0} \) and \( \beta_{t,0} \) must differ. This means that the average return in the collapsing and surviving bubble regimes must not be the same. Secondly, \( \beta_{t,1} \) must be less than zero, showing that the expected return on the asset is negative in the collapsing bubble regime. Thirdly, \( \beta_{t,1} \) must be greater than \( \beta_{t,1} \), implying that the return yielded by the bubble is greater in the surviving regime. And finally, \( \beta_{t,1} \) should be less than zero, implying that as the bubble size increases, the probability of being in the surviving regime is expected to fall.

To ensure that there are no misspecification errors, this bubble model is tested against three other stylized alternatives using a set of likelihood ratio tests. These specifications may mimic stylized features of asset returns. The first specification, referred to as the volatility regime model, was introduced by Schwert (1989). This model examines whether returns switch only as a result of changes in its volatility, and so imposing equal constants across the regimes. Therefore, \( \beta_{t,0}, \beta_{t,1}, \beta_{t,0} \) and \( \beta_{t,1} \) equal zero and the model collapses to:

---

\(^{6}\)Note that in this study, the estimation of van Norden and Schaller’s bubble model is conducted using Matlab 7.9 and we use the BFGS method for solving optimisation problems that are non-linear.
\[ R_{t+1} = \beta_0 + u_{t+1} \]  \hspace{1cm} (12)

where

\[ u_{t+1} \sim N(0, \sigma_s) \hspace{2cm} \text{with probability } q \]

\[ u_{t+1} \sim N(0, \sigma_c) \hspace{2cm} \text{with probability } 1 - q \]  \hspace{1cm} (13)

The second stylized alternative is the mixture-normal model due to Akgiray and Booth (1987). In this model, returns are not related to the stock price deviation from its fundamental value, but are distinguished by a mixture of two separate normal distributions. This implies that only means and variances differ across the regimes and not the error terms. Therefore, \( \beta_{s,i} \), \( \beta_{c,i} \) and \( \beta_{q,i} \) are all set to equal zero. The model is expressed as:

\[ R_{t+1} \sim N(\beta_{s,0}, \sigma_s) \hspace{2cm} \text{with probability } q \]

\[ R_{t+1} \sim N(\beta_{c,0}, \sigma_s) \hspace{2cm} \text{with probability } 1 - q \]  \hspace{1cm} (14)

The final stylized alternative is the fads model introduced by Cutler et al. (1991). This model assumes that returns can be predicted linearly and that average returns do not vary across the two regimes. Therefore, \( \beta_{s,0} \) and \( \beta_{c,0} \) are both set to equal \( \beta_0 \), \( \beta_{s,1} \) and \( \beta_{c,1} \) are both equal to \( \beta_1 \), and \( \beta_{q,1} \) is equal to zero. The fads model is expressed as:

\[ R_{t+1} = \beta_0 + \beta_1 b_t + u_{t+1} \]  \hspace{1cm} (15)

where

\[ u_{t+1} \sim N(0, \sigma_s) \hspace{2cm} \text{with probability } q \]

\[ u_{t+1} \sim N(0, \sigma_c) \hspace{2cm} \text{with probability } 1 - q \]  \hspace{1cm} (16)

Section 5 presents the results for the bubble model’s estimated parameters and the likelihood ratio test of the model against the stylized alternatives.
3. Data

In this study, the S&P 500 Composite index is selected as a proxy for the stock market as it is the consensus choice as a benchmark. Quarterly S&P 500 real prices and dividends are obtained from Robert Shiller’s webpage. For more information on the data, see Shiller (2000). As for the direct real estate market, we use data on average sales prices of houses provided by Davis et al. (2008) for the Lincoln Institute of Land Policy. The house prices are obtained from the S&P/Case-Shiller national house price index, which was previously called the Case-Shiller-Weiss index. This index is calculated using the repeat sales method of index calculation and tracks the value of single-family home prices. The rental cost data are also retrieved from the same source and do not account for income taxes. The data are observed quarterly from 1972Q1 to 2010Q4. Figures 1a – c graphically illustrate the changes in the markets’ prices over the sample period.

Pre-2000, although the stock market was far more volatile than the direct real estate market, there were similarities in the patterns of the direct real estate and the stock markets as both generally grew at an increasing rate. The stock market, however, witnessed more cycles than the housing market and had more peaks and troughs over the period. This could have been due to the presence of periodically collapsing bubbles. In the early 2000s, stock prices declined significantly as a result of the collapse in the technology sector. House prices, on the other hand, kept growing at a faster rate than their historical average. However, between 2006 and 2009, both markets witnessed sharp falls in value. The stock market fell by 25.7% whilst house prices declined by 32.5% following the subprime market meltdown.

Like the stock market, the REIT industry is more volatile than the unsecuritized real estate market. The indirect real estate market witnessed two major crashes. The first occurred at the beginning of the 1970s, where rising inflation and increases in interest rates negatively affected mortgage lending activities. This had an adverse impact on the REIT industry and many REITs were liquidated. The second major crash, caused by the downturn in the subprime mortgage market, occurred between 2006Q4 and 2009Q4. The value of the REIT industry fell by 47.4%.

8More information on the construction of the data can be found from the Land and Property Values, Lincoln Institute of Land Policy, http://www.lincolninst.edu/resources/.
4. Models for estimating fundamental values

As stated earlier, testing for periodically collapsing bubbles using the van Norden and Schaller approach requires one to first determine the fundamental price of the asset. In this section, we discuss the measures of fundamental values for the housing market and the stock market at any given time.

In calculating the fundamental values of stocks and of REITs, we use the dividend multiple approach. Assuming that log dividends follow a random walk with a drift process, van Norden and Schaller (1999) show that the fundamental price of a stock is equal to the average \((\text{ex post})\) price-dividend ratio multiplied by the dividend at the selected time period:

\[
P_{i}^{f} = \frac{\bar{P}}{D_t}
\]  

(17)

and so the non-fundamental or bubble component of the stock is given by simply subtracting the actual price of the stock from its fundamental component, as shown in equation (18):

\[
B_{i} = P_{i}^{a} - \frac{\bar{P}}{D_t}D_t
\]  

(18)

In the case of the direct real estate market, there is no general agreement on the measurement of fundamental house prices. However, given the direct influence of several macroeconomic variables on the real estate market, some researchers use a regression-based measure, relating the fundamental value of house prices to disposable incomes, mortgage rates and the level of unemployment.\(^9\) However, we believe that rents provide better fundamental measures than disposable incomes in countries with relatively easy access to credit facilities, such as the US (historically at least), where the ability of individuals to acquire mortgages did not depend on their disposable incomes. Also, from the real estate investor’s point of view, rent is analogous in cash flow terms to dividends for investors in the stock market. Therefore, we use rents to determine the fundamental value of the underlying property market. Using a slight variation of the aforementioned methodology used in calculating stocks’ fundamental values in equation (17), the fundamental value of housing at a given point in time is simply the mean price-rent ratio multiplied by the rent in that period.

\(^9\)This approach is similar to the Roche (2001) measure of non-fundamental house prices. Roche uses the residual from a regression of house prices on the mortgage rate, disposable income and a demographic variable as a proxy for the non-fundamental price.
5. Results and Findings

In this section, we first test for the presence of bubbles in the stock, direct and indirect real estate markets. Using the techniques discussed in Section 4, we compute the fundamental values for the three markets. A comparison of the observed prices against the fundamental prices is given in Figures 2a–c.

< Insert Figures 2a – c >

There have been periods of over-valuation and under-valuation in all three markets since 1972, especially in the stock market. In parts of the 1970s and 1980s, stocks traded, on average, below their warranted fundamental values. This was due to the oil crisis of 1973 and the subsequent recession of the early 1980s that was caused by counter-inflationary increases in interest rates by the Federal Reserve. From 1986 onwards, stock prices began to deviate significantly from their fundamental values, as the demand for information technology stocks intensified. The market and price-dividend ratios of many information technology stocks reached unprecedented levels, influencing other sectors. But by 2000, the market began to free-fall as interest rate increases led to a slowdown in economic activities. The stock market fell by around 55% between 2000 and 2003, causing the Federal Reserve Board of Governors to respond with sharp cuts in federal funds rate. This helped propel the stock market and prices rose again until 2008. The subprime crisis led to a collapse in lending activities and the bankruptcy of several important financial institutions, and by the end of 2008, stock prices had fallen well below their intrinsic values for the first time since the early 1980s.

Until 2000, the residential real estate market had been over-valued by a maximum of only 10%, with peaks in the late 1970s and 1980s. Prices in that period grew at a relatively stable rate. However, by the start of the 2000s, the market dynamics had changed. The expansionary monetary policies adopted by the Federal Reserve meant a general increase in the availability of credit facilities in the economy. This allowed financial institutions to easily lend to individuals and the number of subprime loans issued rose significantly. The housing market began to overheat as the demand for properties rose. Highly leveraged speculators looking to profit from rising prices jumped on the bandwagon of homebuyers causing bidding frenzies nationwide. And so, by 2005, house prices had risen by 83% in just 5 years, while rents rose by only 27% over the same period. However, between 2004 and 2006, the Federal Reserve increased interest rates by over 4%, causing a reversal in the bullish market trend from 2006 onwards. The number of delinquent loan payments and foreclosures hit extreme levels,
causing a collapse in the equity and securitized real estate markets. By the end of 2008, house prices had fallen below their fundamental values, causing further distress to the economy as a whole.

As for the REIT industry, it faced serious difficulties at the start of our sample period in the early 1970s. A large number of mortgage REITs dragged the entire indirect real estate industry into disarray due to the inefficient underwriting of loans and the increasing federal funds rate. There were many bankruptcies and liquidations of REIT firms, causing a crisis of confidence in the industry. By 1974, REIT prices were grossly undervalued and neglected by investors. Prices, on average, traded below their intrinsic values until 1991. At the start of the 1992, there was a significant structural change in the industry. The introduction of the UPREIT legislation and the surge in the number of IPOs made the securitized real estate market extremely attractive to investors. Increasing funds allowed REIT managers to be more flexible, investing in a wider range of properties and yielding healthy returns annually. This boom lasted until around 1997, and by 1999, the market had dipped back below its fundamental value. However, by the 2000s, the securitized real estate market, buoyed by the underlying direct real estate market, began to flourish again. This boom continued and prices accelerated at a faster rate than fundamental values. But by the end of the decade, the underlying real estate market downturn began to take its toll on the industry. Between 2007 and 2009, the REIT index value had plummeted by over two thirds, from 222 to 69, causing prices to trade far below their fundamental values for the first time in 10 years.

To determine whether these deviations of the observed prices from their fundamentals were a result of the presence of periodically collapsing speculative bubbles, we apply the regime switching model to returns as discussed in Section 2 and the results from these tests are given in Table 1.

< Insert Table 1 >

From the table’s first panel, there is significant evidence to support the notion that speculative bubbles existed in all three markets. Firstly, a very large number of the estimated parameters are statistically significant at the 5% level, implying that mean and volatility of returns in the two regimes are significantly different. Secondly, from the second panel, a large proportion of the likelihood ratio tests for the restrictions on the coefficients are statistically significant in all markets. The findings imply that the first regime is one where the bubble survives and continues to grow, yielding a positive return, while the other regime refers to a state where
the bubble collapses and prices fall. Realized returns, according bubble theory, should be greater in the surviving bubble regime than the collapsing state. Volatility should be larger, however, in the collapsing bubble state. Lastly, referring to the third panel of the table, the likelihood ratio tests to determine whether the bubble model can explain returns better than other stylized return alternatives such as the volatility regimes, fads and mixture-normal models, provides more evidence that speculative bubbles existed in all three markets. The results show that the van Norden and Schaller bubble model captures returns more efficiently than the stylized alternatives for REITs, and the direct real estate and stock markets.

The coefficient estimates of the mean returns in the surviving regime $\beta_{s,0}$ for the direct real estate market, the stock market and the indirect real estate market are 1.53%, 6.41% and 1.11%, respectively. On the other hand, mean quarterly returns in the collapsing regime, $\beta_{c,0}$, are -5.82% (i.e. $1 - 0.9418$) for the direct real estate market, -0.81% for the stock market, and -0.89% for the securitized real estate market. These represent the expected yields in each market when observed prices equal their fundamental values, i.e. there is no bubble. In the three markets, the coefficient on the bubble term is negative and less than in the collapsing regime, $\beta_{c,1}$, implying that the bubble in the collapsing regime yields negative returns. In all the markets, $\beta_{q,0}$ is greater than zero, which signifies that the probability of being in the surviving regime is positive when there is no bubble. Also, the coefficient of $\beta_{q,1}$ is less than zero and so that the larger the size of the bubble, the higher the probability of the bubble collapsing in the following period. Given these findings, there is enough evidence to suggest that speculative bubbles led to price deviations from their intrinsic values in all three markets between 1972 and 2010.

< Insert Figures 3a – c >

Figures 3a – c provide further evidence of how well the regime-switching bubble model captures returns in the markets. Here, the probability of being in the collapsing regime, $P(R_{t+1} \mid C) = 1 - \Phi(\beta_{y,0} + \beta_{y,1}b_t)$, is plotted against observed prices using the coefficient estimates from the model. In the direct real estate market, the probability of being in the collapsing regime increases significantly prior to the downturn of the market in 2006. Similarly, the model fits the stock market’s dynamics fairly well, although one would have expected the probability to rise shortly before the market collapsed at the end of the 2000s. Also, the probability of a collapse in the REIT market rose shortly before the dip in REIT
prices in the 1970s. The probability also rose shortly before the market downturns of the late 1990s and 2006.

6. Are speculative bubbles in the markets contagious?

Given the above findings in favor of speculative bubbles in the markets, this paper proceeds to investigate possible inter-market transmission of bubbles. This part of the study provides a broader understanding of the relationship between the three markets by investigating whether bubble cycles in the indirect real estate market are influenced by speculative bubbles in the underlying unsecuritized real estate and equity markets or vice-versa.

To check for the spillover of speculative bubbles between the markets, we extend the van Norden and Schaller model by allowing the returns in each of the assets to be dependent on the size of the bubble in its own market and in the other two markets. Similar to the approach used by Anderson et. al. (2010) to detect bubble spillover effects between stocks in different industries, we allow for the probability of being in the surviving/collapsing regime to depend not only on its lagged bubble size, but also on the lagged bubble sizes in the other markets. Thus, the mathematical expression of the extension to the model is as follows:

\[
R_{t+1}^e = \beta_{e,0} + \sum_{k=1}^3 \beta_{e,k} b_{t,k} + u_{e,t+1}
\]

\[
R_{t+1}^c = \beta_{c,0} + \sum_{k=1}^3 \beta_{c,k} b_{t,k} + u_{c,t+1}
\]

\[
P(R_{t+1} | S) = q(b_{t,k}) = \Phi \left( \beta_{q,0} + \sum_{j=1}^3 \beta_{q,j} b_{t,k} \right)
\]

Note that \( k \) denotes the three different markets. Similar to Equation (11), estimation of the parameters of the bubble spillover model (19) are achieved by maximizing the following log-likelihood function:
By observing the \( p \)-values of the coefficient estimates above, inferences on whether speculative bubbles spillover from one market to another may be drawn. The statistical significance of \( \beta_{s,1,k} \), \( \beta_{c,1,k} \), \( \beta_{q,1,k} \) implies that the size of one market’s bubble influences the returns in the surviving (collapsing) regime and the probability of a collapse in other markets respectively.

< Insert Table 2 >

Table 2 shows the results from the multivariate bubble model. Overall, it is evident that there is considerable evidence for bubble spillovers, and in particular the probability of a crash in one market has a significant impact on the probability of a crash in the others. The returns in the collapsing regime for direct real estate are significantly and negatively affected by the size of the bubble in the indirect market. The exception is the REIT bubble, which does not affect the probability of a bubble crash in the direct property or stock markets.

Focusing now on the statistical significance of the estimated coefficients \( \beta_{q,1} \) in the indirect real estate column, there is clear evidence of a speculative bubble spillover from both the underlying direct real estate market and the stock market. An increase in the sizes of the housing and equity bubbles not only increase the probability of a collapse in their respective markets, but also increase the probability of a collapse in the REIT market. Furthermore, the coefficient of the direct real estate market \( \beta_{q,1} \) on the indirect real estate market exceeds that of the stock market, implying that the housing bubble has a stronger impact on the REIT market than the equity bubble. An illustration of this is given numerically: The forecasted probability of the bubble collapsing in the indirect real estate market in the next period is 39.4\%, assuming that the stock, direct and indirect real estate markets are all overvalued by 10\%. If the bubble size in the real estate market relative to prices increases to 20\%, \textit{ceteris}
paribus, the forecasted probability of a collapse increases to 48.9%. However, if the relative bubble size of the stock market rises to 20% while the relative bubble sizes in the other two markets remain unchanged at 10%, the indirect real estate market’s forecasted probability of a collapse in the next period only rises by 1.8% to 41.2%. These findings are to some extent expected. One would particularly expect the condition of the direct real estate market to have a significant effect on the REIT dynamics because, by law, a large percentage of assets held by REITs should be directly linked with the underlying property market. A bullish trend in the equity market as a whole is also highly likely to lead to a positive run in REIT stocks that may cause prices to systematically deviate from their fundamental values. By observing the \( p \)-values of the estimated coefficients, it is clear that the transmission of bubbles across the markets is multi-directional.

The final panel of Table 2 shows the results from likelihood ratio tests of the restrictions that the three parameters relating to the bubble from a specific market do not affect either the returns in the surviving and collapsing regimes or the probability of the bubble collapsing for another market. In other words, this tests the null hypothesis that the true values of each set of \( \beta_{s,t,1} \), \( \beta_{c,t,1} \) and \( \beta_{q,t,1} \) are all zero at the same time. In a sense, these are akin to Granger causality or block exogeneity tests.

The results show that the size of the stock market bubble does not affect the REIT market bubble while that of the direct property market does to some extent (\( p \)-value 0.08). Likewise, REIT bubbles have a marginally insignificant (\( p \)-value 0.11) effect on bubbles in the direct property market after allowing for bubbles in the other two markets. The sizes of bubbles in both the direct and indirect real estate markets have a statistically significant impact on the stock market bubble process.

In the period studied, the size of the bubble in the equity market, in particular, negatively (positively) influences the returns in the direct real estate market during bull (bear) states of the market, respectively. This could be explained by capital switching between the two markets – i.e., when the stock market is booming and a positive speculative bubble persists, institutional investors are less interested in the performance of the direct real estate market and so they may reduce their real estate holdings to fund investments in the equity market. The relative size of the equity bubble also has a positive impact on the probability of the housing bubble collapsing, which would subsequently drive prices downwards. A possible explanation for this finding is that whenever there is a growing bubble in the equity market
and there is an abnormal run up in the prices of stocks, the aggregate wealth of investors grows. These investors may choose to diversify their portfolios by acquiring properties, thus leading to a rise in the demand for houses, and if such growth in the demand for houses is not monitored or carefully regulated, it could subsequently trigger the inception of a speculative bubble in the housing market. Thus, a widening of the stock market bubble may lead the widening of the real estate market bubble, which would subsequently increase the probability of a collapse in the unsecuritized real estate market.

Similarly, the reverse linkage between the direct real estate and the stock markets is found, where the housing bubble influences the survival or collapse of speculative bubbles in the equity market. One major reason why this could be the case is that during periods of speculative bubbles in the housing market, homeowners are more inclined to re-finance their mortgages, and they may re-invest the proceeds in the stock market. This is another form of capital switching between markets. If the amount of money generated from re-mortgaging is large enough to distort the equity market, the prices of stocks may significantly exceed their fundamental values, which may lead to subsequent overheating of the market. Additionally, it may be the case that rising house prices induce a “feel good factor” among home owners that increases the confidence of consumers to make large purchases, thus increasing corporate profits and putting upward pressure on stock valuations.

Although the number of parameters in the bubble spillover model makes it difficult to interpret the individual estimates precisely, a key point to note is the multi-directional flow of bubbles between the real estate and equity markets. The implications of the findings are relevant to investors, especially those whose portfolios are REIT stock-biased. Such investors may be able to form profitable REIT trading strategies or to time the market to avoid likely bubble collapses based on forecasts of the overvaluation in the underlying property and equity markets.

< Insert Table 3 >

As a final piece of analysis and for comparison with the results from existing studies, the bubble spillover model is compared to a similar spillover model for returns, which focuses on investigating whether lagged returns in the markets Granger cause returns in other markets. The result from the return spillover test is given in Table 3 and they are fairly similar to that of the bubble spillover test. Here, we find that there are also multi-directional spillovers of returns among the markets, with the direct real estate returns influencing the returns on the
indirect real estate market. Lagged stock market returns, on the other hand, do not forecast changes in indirect real estate returns, and hence it is possible to conclude that returns do not spillover from the stock market to the REIT market. Also, we find that returns on the indirect real estate market Granger cause returns on the direct real estate market. Another key finding, however, from the Granger causality test on returns is that there is a unidirectional relationship between the equity market and the direct real estate market. This result is consistent with the findings of Okunev et al. (2000), but in contrast with those from the multivariate bubble model discussed above. The latter shows a link from the real estate markets (both direct and indirect) to the stock market whereas there is no such causal relationship between the returns themselves.

7. Summary and Conclusions

With the use of a regime-switching bubble model of returns, this paper finds that periodically collapsing positive and negative bubbles persist in the stock, direct and indirect real estate markets between 1972 and 2010. We employ likelihood ratio tests to show that the bubble model fares better in predicting returns than other stylized alternative models such as the fads, volatility regime and mixture-normal models, providing proof that periods of under- and over-valuation in the markets were fuelled by investors’ speculative behavior. We also show how the estimated probability of a collapse in the next period significantly increases as the bubble size increases the markets.

Due to the lack of consensus in the literature regarding the linkage between the equity, direct and indirect real estate markets, the paper proceeds to further investigate the relationship by examining whether speculative bubbles in the markets were contagious. The question here is whether increases in any of the markets’ bubbles spurred an increase in the probability of a collapse in another market. Focusing on the impact of speculative bubbles in the direct real estate and the equity markets, we test and find that there is a spillage of these bubbles to the securitized real estate market. The housing bubble, however, has a stronger effect than the stock bubble on the REIT bubble. In addition, we find the transmission of speculative bubbles to be multi-directional – i.e., there is a reciprocal spillover relationship between the direct real estate market and the stock market, providing an indication of possible capital switching between industries. Finally, we observe that bubbles spill over from housing (direct and indirect) to equities but day-to-day returns do not.
Our findings could be useful to investors, as they could possibly use the forecasted probability of a collapse or a crash in the equity and real estate markets to form profitable trading rule for REIT stocks. More importantly, the findings from this paper are relevant to regulators and policymakers, as they may be able to more accurately forecast the probability of a collapse in any of the markets, at any given time. For example, the regulators may predict the probability of switching to a collapsing regime in the stock market by observing the degree of over-valuation in the direct real estate market. This could assist policymakers in forming decisions that may possibly avoid a complete and simultaneous collapse in both the stock and the real estate markets as occurred in the late 2000s.

This study also sets a potential path for further research. Given the findings of the paper, additional research may investigate how long it takes for speculative bubbles in any given market to filter into other markets and how long the impact persists for. Furthermore, one could also examine whether it is possible to create a dynamic portfolio mix of the three assets that is based on forecasting the probabilities of collapses in all three markets.
REFERENCES


Han, J. 1990. The return-generating process of Real Estate Investment Trusts, Working paper, Massachusetts Institute of Technology.


\[
R_{s,t+1}^s = \beta_{s,0} + \beta_{s,1}b_{t} + u_{s,t+1}, \\
R_{c,t+1}^c = \beta_{c,0} + \beta_{c,1}b_{t} + u_{c,t+1}, \\
P(R_{s,t+1} | S) = q(b_t) = \Phi (\beta_{q,0} + \beta_{q,1}b_t)
\]

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Direct real estate market</th>
<th>Stock Market</th>
<th>Indirect real estate market</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta_{s,0})</td>
<td>1.0153 (0.0000)</td>
<td>1.0641 (0.0000)</td>
<td>1.0111 (0.0000)</td>
</tr>
<tr>
<td>(\beta_{s,1})</td>
<td>0.0575 (0.0003)</td>
<td>0.0552 (0.0165)</td>
<td>0.1489 (0.0090)</td>
</tr>
<tr>
<td>(\beta_{c,0})</td>
<td>0.9418 (0.0000)</td>
<td>0.9919 (0.0000)</td>
<td>0.9911 (0.0000)</td>
</tr>
<tr>
<td>(\beta_{c,1})</td>
<td>-0.1533 (0.0273)</td>
<td>-0.1260 (0.0002)</td>
<td>0.2028 (0.6971)</td>
</tr>
<tr>
<td>(\beta_{q,0})</td>
<td>2.2970 (0.0000)</td>
<td>1.4914 (0.0565)</td>
<td>1.4204 (0.0064)</td>
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<tr>
<td>(\beta_{q,1})</td>
<td>-7.9879 (0.0000)</td>
<td>-2.4237 (0.1535)</td>
<td>-5.2415 (0.0057)</td>
</tr>
<tr>
<td>(\sigma_s)</td>
<td>0.0111 (0.0000)</td>
<td>0.0398 (0.0000)</td>
<td>0.0482 (0.0000)</td>
</tr>
<tr>
<td>(\sigma_c)</td>
<td>0.0255 (0.0001)</td>
<td>0.0732 (0.0000)</td>
<td>0.1209 (0.0000)</td>
</tr>
</tbody>
</table>

**LIKELIHOOD RATIO TEST OF RESTRICTIONS**

<table>
<thead>
<tr>
<th>Restrictions</th>
<th>Test statistic</th>
<th>(p)-values</th>
<th>Test statistic</th>
<th>(p)-values</th>
<th>Test statistic</th>
<th>(p)-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta_{s,0} \neq \beta_{c,0})</td>
<td>7.3183</td>
<td>0.0068</td>
<td>8.1872</td>
<td>0.0042</td>
<td>3.0154</td>
<td>0.0825</td>
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<tr>
<td>(\beta_{c,0} &lt; 0)</td>
<td>3.4074</td>
<td>0.0649</td>
<td>2.9568</td>
<td>0.0855</td>
<td>0.1496</td>
<td>0.6989</td>
</tr>
<tr>
<td>(\beta_{s,1} &gt; \beta_{c,1})</td>
<td>5.7905</td>
<td>0.0209</td>
<td>3.8164</td>
<td>0.0508</td>
<td>2.9358</td>
<td>0.0934</td>
</tr>
<tr>
<td>(\beta_{q,1} &lt; 0)</td>
<td>18.6981</td>
<td>0.0000</td>
<td>1.4785</td>
<td>0.2240</td>
<td>3.9429</td>
<td>0.0471</td>
</tr>
</tbody>
</table>

**BUBBLE MODEL MISSPECIFICATION TEST AGAINST STYLISED ALTERNATIVE MODELS**

<table>
<thead>
<tr>
<th>Restrictions</th>
<th>Direct real estate market</th>
<th>Stock Market</th>
<th>Indirect real estate market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fads</td>
<td>92.4663</td>
<td>0.0000</td>
<td>11.0091</td>
</tr>
<tr>
<td>Mixture-normal</td>
<td>93.2478</td>
<td>0.0000</td>
<td>11.3110</td>
</tr>
<tr>
<td>Volatility regime</td>
<td>87.3437</td>
<td>0.0000</td>
<td>10.9678</td>
</tr>
</tbody>
</table>

This table provides results from the tests for speculative bubbles in all three markets. The figures in parentheses represent the \(p\)-values of the parameter estimates which are computed by taking the inverse of the Hessian matrix. The likelihood ratio test is of the four restrictions implied by the bubble model while the misspecification test checks whether other stylized alternative models explain returns better than the regime-switching bubble model.
TABLE 2: Results from the bubble spillover model

\[
R^{s}_{t+1} = \beta_{s,0} + \sum_{j=1}^{3} \beta_{s,1,j} h_{s,j} + u_{s,t+1}
\]

\[
R^{c}_{t+1} = \beta_{c,0} + \sum_{j=1}^{3} \beta_{c,1,j} h_{c,j} + u_{c,t+1}
\]

\[
P(R_{t+1} \mid S) = q(h_{s,j}) = \Phi \left( \beta_{q,0} + \sum_{j=1}^{3} \beta_{q,1,j} h_{c,j} \right)
\]

<table>
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<tr>
<th>Independent variables</th>
<th>Dependent variables</th>
<th>Indirect real estate market</th>
<th>Direct real estate market</th>
<th>Stock market</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>(\beta_{s,0})</td>
<td>1.0118 (0.0000)</td>
<td>1.0164 (0.0000)</td>
<td>1.0163 (0.0000)</td>
</tr>
<tr>
<td>Constant</td>
<td>(\beta_{c,0})</td>
<td>0.9931 (0.0000)</td>
<td>0.9739 (0.0000)</td>
<td>0.9963 (0.0000)</td>
</tr>
<tr>
<td>Constant</td>
<td>(\beta_{q,0})</td>
<td>1.8871 (0.0012)</td>
<td>3.8518 (0.0000)</td>
<td>2.1059 (0.0006)</td>
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<tr>
<td></td>
<td>(\sigma_{s})</td>
<td>0.0422 (0.0000)</td>
<td>0.0092 (0.0000)</td>
<td>0.0361 (0.0000)</td>
</tr>
<tr>
<td></td>
<td>(\sigma_{c})</td>
<td>0.1065 (0.0000)</td>
<td>0.0215 (0.0000)</td>
<td>0.0800 (0.0000)</td>
</tr>
<tr>
<td>Indirect real estate</td>
<td>(\beta_{s,1})</td>
<td>0.1294 (0.0375)</td>
<td>0.0056 (0.2731)</td>
<td>-0.0555 (0.2321)</td>
</tr>
<tr>
<td>Indirect real estate</td>
<td>(\beta_{c,1})</td>
<td>0.0147 (0.8418)</td>
<td>-0.0891 (0.0180)</td>
<td>-0.0009 (0.9841)</td>
</tr>
<tr>
<td>Indirect real estate</td>
<td>(\beta_{q,1})</td>
<td>-13.1837 (0.0177)</td>
<td>0.0618 (0.5495)</td>
<td>-1.6933 (0.9968)</td>
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<tr>
<td>Direct real estate</td>
<td>(\beta_{s,1})</td>
<td>0.1262 (0.1637)</td>
<td>0.0688 (0.0003)</td>
<td>-0.0455 (0.4251)</td>
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<td>Direct real estate</td>
<td>(\beta_{c,1})</td>
<td>-0.0505 (0.7646)</td>
<td>0.0827 (0.1637)</td>
<td>0.1997 (0.3697)</td>
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<tr>
<td>Direct real estate</td>
<td>(\beta_{q,1})</td>
<td>-2.4237 (0.0000)</td>
<td>-49.1708 (0.0023)</td>
<td>-0.6799 (0.0000)</td>
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<td>Stock market</td>
<td>(\beta_{s,1})</td>
<td>-0.0297 (0.2732)</td>
<td>-0.0185 (0.0000)</td>
<td>0.1010 (0.0002)</td>
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<td>Stock market</td>
<td>(\beta_{c,1})</td>
<td>0.0306 (0.6179)</td>
<td>0.1427 (0.0002)</td>
<td>0.0440 (0.2319)</td>
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<td>Stock market</td>
<td>(\beta_{q,1})</td>
<td>-0.4688 (0.0000)</td>
<td>-0.1878 (0.0000)</td>
<td>-7.8916 (0.0103)</td>
</tr>
</tbody>
</table>

**BUBBLE MODEL MISSPECIFICATION TEST AGAINST STYLED ALTERNATIVE MODELS**

<table>
<thead>
<tr>
<th>Models</th>
<th>Fads model</th>
<th>Mixture-Normal model</th>
<th>Volatility Regime model</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>43.3632 (0.0000)</td>
<td>47.0088 (0.0000)</td>
<td>43.8416 (0.0000)</td>
</tr>
<tr>
<td></td>
<td>158.9271 (0.0000)</td>
<td>159.6251 (0.0000)</td>
<td>154.1727 (0.0000)</td>
</tr>
<tr>
<td></td>
<td>40.9762 (0.0000)</td>
<td>51.3307 (0.0000)</td>
<td>47.7254 (0.0000)</td>
</tr>
</tbody>
</table>

**BLOCK EXOGENITY TESTS FOR BUBBLE SPILLOVERS**

<table>
<thead>
<tr>
<th>Markets</th>
<th>Indirect real estate</th>
<th>Direct real estate</th>
<th>Stock market</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14.6361 (0.0022)</td>
<td>6.0271 (0.1103)</td>
<td>1.305 (0.7101)</td>
</tr>
<tr>
<td></td>
<td>9.33744 (0.0247)</td>
<td>7.9791 (0.0464)</td>
<td>24.1689 (0.0000)</td>
</tr>
</tbody>
</table>

The block exogeneity tests provide evidence on whether there is contagion of bubbles from one market to another. Here, the misspecification test checks whether other stylized alternative models explain returns better than the regime-switching bubble model. Note that the p-values are obtained by computing the diagonal of the Hessian matrix’s inverse and they are the numbers in the parentheses.
TABLE 3: Results from the return spillover model

\[ IRE_t = \alpha_0 + \sum_{j=1}^{6} \alpha_j DRE_{t-j} + \sum_{j=1}^{6} \beta_j SM_{t-j} + u_t \]

\[ DRE_t = \gamma_0 + \sum_{j=1}^{6} \gamma_j IRE_{t-j} + \sum_{j=1}^{6} \delta_j SM_{t-j} + \eta_t \]

\[ SM_t = \psi_0 + \sum_{j=1}^{6} \psi_j IRE_{t-j} + \sum_{j=1}^{6} \theta_j DRE_{t-j} + \varepsilon_t \]

<table>
<thead>
<tr>
<th>NULL HYPOTHESES</th>
<th>F-statistic</th>
<th>Prob.</th>
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</thead>
<tbody>
<tr>
<td>Indirect real estate returns do not Granger cause direct real estate returns</td>
<td>3.4069</td>
<td>0.0037</td>
</tr>
<tr>
<td>Indirect real estate returns do not Granger cause stock returns</td>
<td>1.2464</td>
<td>0.2867</td>
</tr>
<tr>
<td>Direct real estate returns do not Granger cause Indirect real estate returns</td>
<td>2.6726</td>
<td>0.0175</td>
</tr>
<tr>
<td>Direct real estate returns do not Granger cause stock returns</td>
<td>0.7943</td>
<td>0.5761</td>
</tr>
<tr>
<td>Stock returns do not Granger cause Indirect real estate returns</td>
<td>1.2104</td>
<td>0.3047</td>
</tr>
<tr>
<td>Stock returns do not Granger cause direct real estate returns</td>
<td>2.0260</td>
<td>0.0664</td>
</tr>
</tbody>
</table>

The pairwise Granger causality tests provide evidence on whether there is a spillover of returns from one market to another. Here, IRE, DRE and SM represent the returns on the indirect real estate market, the direct real estate market and the stock market respectively. To conclude that there is a spillover of returns between markets, we would have to reject the null hypothesis. Note that the optimal lag chosen (six) is based on Akaike’s Information Criterion (AIC).
Figure 1: Asset Prices between 1972Q1 and 2009Q4

(a) The direct real estate market

(b) The stock market

(c) The indirect real estate market
Figure 2: Actual Price, Fundamental Value and the relative bubble size (1972 – 2010)

(a) The direct real estate market

(b) The stock market

(c) The indirect real estate market
FIGURE 3: The probability of switching to the collapsing regime (1972 – 2010)

(a) The direct real estate market

(b) The stock market

(c) The indirect real estate market