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Regime-dependent linkages between securitized real estate market and major financial markets: some international evidence

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ABSTRACT

We employ Markov regime-switching approach to explore the regime-dependent linkages between securitized real estate market and stock, money, bond and foreign exchange markets for 10 economies. During high-volatility periods in securitized property markets, stock market return, and to some extent, changes to foreign exchange market rates impose stronger and positive impact on securitized real estate market returns. Moreover, stock and bond market risks are linked negatively to securitized real estate market risk. Although the asymmetrical regime-dependent influences of the financial market performance indicators on the SRE market do vary across the 10 economies studied in terms of direction and significance, the results highlight the risk of increased exposure of securitized property markets to financial markets during high-volatility market conditions which the investors and policymakers should be alerted to.

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Background, motivation and research questions

Securitized real estate (SRE), stock, money, bond and foreign exchange markets are five major financial markets in many developed economies.[1] Understanding the linkages between SRE and other major assets can be important for investors to construct mixed-portfolio strategies and for policymakers to analyze volatility transmission channel and manage possible contagion across real estate and other financial markets. Strong linkages between real estate and financial markets were evident during the recent global financial crisis. Moreover, it is possible that the joint distribution of returns across these assets varies over time, thereby affects portfolio allocation strategies (Chan, Treepongkaruna, Brooks, & Gray, 2011). However, prior to real estate studies with this topic such as Liu et al (1990), researchers do not consider significant structural breaks in SRE prices resulting from significant changes in market conditions; instead they assume that the relationship between SRE and other asset market returns is stable and constant. Failing to account for volatile periods can produce results which may not reflect a true picture of the asset market linkages. One notable difference is that our asymmetrical regime-dependent study reveals asymmetric responses of the various

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performance shocks on SRE is significant at both return and volatility levels and deepens our understanding of SRE behavior in stable and crisis conditions. In contrast, the standard-state studies may inappropriately provide an incomplete view of the asset market linkages.

In this context, we propose to investigate the regime-dependent linkages between SRE market and financial markets (stock, bond, money and currency markets) in 10 developed economies across Asia, Europe and North America. Our research question is whether the linkage of the SRE markets to the four domestic financial markets is regime dependent. We will appeal to the Markov-regime-switching (MRS) approach to allow for variation in the relationships between SRE market and four popular and intuitive indicators of economic and financial performance of a country, namely, (a) changes in stock market prices (equity), (b) changes in short-term interest rates (money), (c) changes in long-term interest rates (bond) and (d) exchange rate returns (currency), thereby providing information on how the four performance indicators influence SRE market returns and volatilities depending on whether the SRE market examined is in a "boom" or "bust" regime (a two regime-switching context). Markov-switching models are particularly appealing because this switching process is endogenous, and allow for inferences regarding the timing and nature of such switches (Chou & Chen, 2014). These advantages thus motivate us to adopt MRS models to conduct our empirical analyses.

There are three broad reasons why we think this research should be undertaken. First, in an international environment, the expansion in market capitalization of Asian listed property investments in the last decade was accelerated by the prosperity and stability of the economies, implying stronger linkages between SRE markets and macroeconomic/financial market development. Unlike general stocks, the underlying asset of SRE is physical properties, whose future cash flows are mainly discounted by the market interest rate. Moreover, depressing economic environment will cause increasing vacancies and declining rents, resulting in depreciation of property values. Overall, given that property industry is highly cash flow dependent and capital intensive, macroeconomic/financial markets variables are critical for valuation and development of property markets as well as their equity returns.

Second, since SRE is an important sector of national economy and broader equity market, changes in SRE prices may be evolved in close relationship with domestic economies and financial markets. SRE markets are affected by not only macroeconomic conditions, but also risk factors from the broader equity market and other financial market activities. Since real estate industry is highly cyclical in nature, its performance is expected to experience regime swifts to the extent that economic and financial market indicators may exert different impact on SRE markets between market bust and market boom period. As highlighted above, this may lead to biased results by examining the full sample period under a constant coefficient modeling. Moreover, the regime of SRE markets is expected to show stronger switching behavior since it possesses the characteristics of direct property and general stock. With SRE market return and volatility profiles being different from those of stock markets especially in the long run, regime-switching results from stock markets may not be automatically extended to the SRE markets, and requires rigorous empirical scrutiny.

Finally, in recent years, although much of the real estate research has focused on performance analysis and the inter-relationships between the physical and SRE markets, there is lack of comparable research work devoted to an investigation of dynamic linkages between SRE and other key asset of a domestic economy. With impressive growth in the public property industry in many countries over the last two decades, the dynamic linkages between SRE and other asset markets deserve closer attention. This is because if different financial assets are largely interconnected during periods of market crisis, there are strong implications for policymakers and market regulators in managing common asset risks and restoring financial stability, as the GFC has demonstrated.

In advancing the body of knowledge on regime shifts, the main contribution of this paper is, unlike previous studies which concentrated on national/international stock markets, it is one of very few to explore the issue of regime-dependent linkage between SRE markets and their domestic financial markets in an international environment. Unlike previous studies which distinguish market performance by positivity or negativity of returns and volatilities, in this study the market states are generated by the MRS models in an endogenous way, thereby avoid the problem of subjectivity in determining the break points. Instead of focusing solely on the US REITs, this study analyses SRE markets in 10 developed countries across 3 geographical regions to provide comprehensive evidence on this topic in an international context. Another added contribution is that we also find asymmetric responses of the various performance shocks on SRE is significant at both return and volatility levels, thereby deepening our understanding of SRE behavior in stable and crisis conditions. Although some researchers have found significant impact of economic and financial performance indicators on the volatilities of SRE (Cotter & Stevenson, 2006; Devaney, 2001), SRE volatility behavior needs to be understood better from an asymmetrical regime-switching perspective.

The remainder of this paper is structured as follows. The next section briefly reviews the relevant literature. Second section presents the sample data and the four financial market factors used in this study. Third section describes the settings of MRS methodology. Fourth section presents the empirical results and the conclusion follows in the final section.

Relevant literature

In adding to the body of knowledge regarding the regime-switching effect of financial market linkage, our study is related to two broad strands of literature. In what follows, we provide a concise review of some major approaches and studies.

Relationship between asset markets, and between asset market and macroeconomy

Earlier studies on the asset linkages focus on smaller subsets of financial asset classes. These studies include Barsky (1989) (stock-bond), Panchenko and Wu (2009) (stock-bond), Baur and Lucy (2009) (stock-bond), Baur (2010), Fleming, Kirby, and Ostdiek (1998) (stock-bond-money). They have generally applied constant coefficient regression modeling to examine the relationship between different asset markets. Generally, they provide evidence of strong linkages, as well as observations on some state-dependent co-movements across the financial markets. In addition, studies of the time-variant relationship between stock and real estate assets include Liu et al (1990) (stock and real estate), Lizieri and Satchell (1997) (stock and property company share) and Quan and Titman (1999) (stock returns and changes in property values and rents).

Some other studies have also established the links between RE markets and financial markets by evaluating the impact of economic and financial performance indicators such as interest rates, inflation and economic growth on changes in real estate prices (Chen, Hsieh, & Jordan, 1997; Chen, Hsieh, Vines, & Chiou, 1998; Chen, Roll, & Ross, 1986; McCue & Kling, 1994). In these studies, macroeconomic and financial market variables are treated as factors within the asset pricing theory context. Naranjo and Ling (1997) find real per capita consumption and real Treasury bill rate are priced consistently across different SRE portfolio groups. However, the term structure of interest rate and unexpected inflation rate are not priced constantly, but vary over time. Additionally, researchers have found whether the economy is in growth or recession can impact SRE market performance. When there is signal of economic contraction, SRE markets may respond negatively in face of increasing credit constraint. Ewing and Payne (2005) find the unanticipated changes in macroeconomic factors (e.g. a sudden tightening monetary policy) are associated with price declines in REITs. Although positive and negative unexpected changes in monetary policy were distinguished in Bredin, O'Reilly, and Stevenson's (2007) study, no evidence of asymmetry emerged.

Regime-switching theory and evidence

Our research is further related to a large literature on regime change which is associated with a significant shift in the fundamental relation between risk-return trade-off from one regime to another (Liow, Zhu, Ho, & Addae-Dapaah, 2005). The regime-switching theory starts from the investigation of structural breaks, which are used to capture instability in the time-series data dynamics. There is strong evidence of regimes in international stock market returns (Ang & Bekaert, 2002). Moreover, international stock market returns are more correlated with each other during bear markets than during bull markets and in normal times, and this asymmetric correlation phenomenon is statistically significant (Longin & Solnik, 2001). Hence, it is important that international investors account for state-dependent regime switching and consider structural mean-variance implications in the optimal asset allocation and performance measurement exercise. Other earlier literature focused on the regime change in stock market returns include Schaller and Van Norden (1997), Nishiyama (1998), Ang and Chen (2002), Guidolin and Timmermann (2007) and more recently Ahmad, Bhanumurthy, and Sehgal (2015)

Moreover, using Hamilton's volatility regime-switching models (Hamilton, 1990; Hamilton & Susmel, 1994), we can allow discrete shifts in the stochastic volatility model driving the financial markets. For example, Hamilton and Susmel (1994) consider a model with sudden discrete changes in volatility. They estimate models with two–four regimes in which the latent innovations come from Gaussian and Student *t*-distributions. They find that Markov switching model provides a better statistical fit to the data than ARCH models without switching. Similarly, Liow et al. (2005) find that SRE markets perform differently in different economic environments. This change in investment behavior results in discrete changes in the time-series risk-return characteristics of public real estate market indexes and the resulting dependence with other financial markets.

Since 1980s, the MRS emerged to study the interaction between macroeconomic variables and stock returns during market boom and bust periods. Hamilton and Susmel (1994) note that low and high-variance regimes estimated from the MRS models usually correspond to periods of tranquil and turmoil markets, respectively. One key feature of the MRS model is it assumes there is a certain probability of staying in the current state or moving to the other state and regime-switching models treat expansions and contractions as outcomes of different probabilistic objects.

There are several reasons why Markov-switching models have been popular in financial and economic modeling. First, it does not require a priori dating of crisis episodes; instead, identification and characterization of crisis periods are determined endogenously in the model. Since it is estimated jointly with the probabilities of regimes in a maximum-likelihood framework, it can avoid the subjective problem of sub-period analysis or threshold dating procedure. Second, MRS models can capture many stylized facts of financial time series, especially volatility persistence and clustering (Lamoureux & Lastrapes, 1990). Most of the volatility persistence is attributed to persistence of high- and low- volatility states. Moreover, large amount of non-linear effects can be characterized by assuming a different conditional distribution in each regime. Finally, the non-linearity of financial returns can be estimated from linear specifications or normal distributions within each regime. Specifically, the distribution of normality can be achieved in each regime, so that the model can be solved in closed form. Since then, there are some studies that examined the regime-dependent linkages between different financial markets using the MS approach.

Henry (2009) employs a MS-EGARCH model to investigate the relationship between short-term interest rates and UK equity returns. His findings indicate in a low-return, high-volatility regime, the conditional variance of equity returns respond persistently but symmetrically to equity return innovations. In a high-return, low-volatility regime, equity volatility responds asymmetrically and without persistence to shocks to equity returns. Chan et al. (2011) use a general MS model to examine the relationships between returns on the US stocks, US Treasury Bonds, Oil, gold and US housing (Case Shiller Index). Their univariate MS analysis indicates that two regimes exist for each of the five assets examined. Their stock and oil markets are characterized by negative return, high volatility and positive returns, low-volatility states. However, the bond, gold and real estate markets are characterized by negative returns, low volatility and positive returns, high volatility states. In addition, they conduct a more formal multivariate MS analysis. Kal, Arslaner, and Arslaner (2015) use a MS-VAR model to investigate the dynamics of the relationship between stocks, bonds and exchange rate. Among others, they find that the relationship between economic fundamentals and nominal exchange rates is regime dependent.

In the real estate market context, Anderson et al. (2012) use a MS model with **error-correction** term to demonstrate significant difference in the effect of unanticipated monetary policy on REIT returns between high- and low-variance regimes. Nneji, Brooks, and Ward (2013) apply a three-regime Markov-switching model to investigate the impact of the macroeconomy on the dynamics of the US residential real estate market. Their results show that the sensitivity of the real estate market to economic changes is regime dependent. Chou and Chen (2014) investigate whether monetary policy has asymmetric effects on US equity REIT returns. They find substantial regime switching in the response to monetary policy actions that correspond to "boom" and "bust" regimes. They extend the analysis to REIT markets in Australia, Japan and the UK, where similar conclusions are reported.

Literature gap

As can be seen from the above review, although there is adequate literature that examines the dynamic relationship of smaller subsets of financial markets, most of papers surveyed consider a single-regime return perspective with the concept of "regime-switching" either ignored or given insufficient scientific attention, which may not be appropriate in todays' turbulent financial environment. Since switching regime is a notion that the behavior of financial market is changing between different market states, there is certainly room for appealing to the MRS approach to model the non-linear-dependent behavior in return and volatility of financial markets. With the emergence of SRE as an important asset class in investors' portfolios in several developed countries with an active stock market, in this paper, we attempt to fill this identified gap in the existing literature and offer international findings (as opposed to single country's evidence) regarding the joint regime-dependent impact of four traditional financial markets (stock, bond, money and currency) on SRE market at both return and volatility levels. Our findings have important investment and policy implications.

Data

We include 10 developed SRE markets globally: Australia (AU), Hong Kong (HK), Japan (JP), Singapore (SG), France (FR), Germany (GR), Switzerland (SW), the UK, Canada (CA) and the US.[2] The total market capitalization of these markets constitutes around 84% of listed real estate market capitalization in the world market. Because of their high economic activity levels (as developed economies) and active stock market exchanges, stock and SRE markets in these developed countries tend to be more responsive to changes in the fundamental economic and financial performance indicators. Thus, our developed sample is more appropriate for this research purpose.

Among them, the US market has the longest history of real estate investment as well as has the most mature and transparent market structure. European SRE markets are also well developed, with FR, GR and the UK as three major players in the regional property markets. SW is known for its stable economy and its less-risky property market appears to be welcomed by global mutual funds to hedge against risk. In Asia-Pacific region, JP has a long tradition of SRE and plays a dominant role in Asian financial markets. For SG and HK, the size of SRE markets increased rapidly in recent years and achieved better performance due to their favorable economic environment. AU is another most matured global SRE market, with its listed property trusts highly regarded as a successful indirect SRE investment vehicle.

The SRE market data consist of weekly property market **price** index in local currency from the S&P Index database from October 1994 to March 2014. The weekly percentage return is calculated in natural logarithmic form as $\Delta \ln ST_t = 100 \times (\ln P_t - \ln P_{t-1})$

where P_t is the **price** index at time$t$.[3] The S&P indices have been popularly used as the benchmark of global real estate securities for investment and research, with the property price index covers a diversified universe of both REITs and global public-traded real estate companies that involve in property investment, development or management. Table 1 provides the usual descriptive statistics of the SRE markets' weekly return data. Our index data provider is Thomson Reuter Datastream. As the numbers indicate, all real estate markets report positive returns over the full sample period. Comparatively, the three European real estate markets have derived higher weekly returns and lower risk than the three Asian counterparts. As observed, all series have a high kurtosis coefficient which contributes to the rejection of normality (see J**B** test results). Hence, a conditional GARCH specification appears appropriate for the return dataset.

Second, we select four relevant economic and financial performance indicators to jointly proxy for a set of latent variables that influence the linkage between SRE and major financial assets of a country (Ling and Naranjo, 1999). They are changes in 3-month Treasury bill rate (ΔTB_t) (money), changes in 10-year government bond price indices (ΔBO_t) (bond), changes in exchange rate ($\Delta \ln FX_t$) (foreign exchange/currency) and changes in stock market **total/price** return indices ($\Delta \ln ST_t$) (equity).[4] These indicators are expressed as "changes" which are consistent with economic theory that the respective unexpected changes will impact SRE. The four indicators have been selected because of their significant contribution to the dynamics of real estate pieces suggested in the literature, and are regarded as the key investment performance measures of the financial markets. For example, in studying the effect of economic risk factors on growth in the US commercial real estate, Naranjo and Ling (1997) identify the Treasury bill rate as one of key drivers. The chosen drivers are expected to have the following impacts on real estate prices: (a) the short-term and long-term interest rates (TB and BO) constitute two major risk factors in money and bond markets for real estate companies since they are used to discount the varying income streams from the underlying property portfolio. They are also used as monetary policy instrument by the central banks to influence the financial market performances (Peterson & Hsieh, 1997). The bond market indices employed are 10-year benchmark government bond prices indices of each of the countries considered. The 10-year interest rate incorporates market expectation about the future prospect for the economy

Table 1. Summary statistics for securitized real estate market returns: October 1994–March 2014.

	Mean	Std. Dev.	Max	Min	Skewness	Kurtosis	JB test
AU	0.12	2.37	15.31	−17.08	−0.69	11.66	3367.43***
HK	0.08	4.25	19.03	−33.74	−0.54	8.39	1320.28***
JP	0.09	4.34	21.84	−21.58	−0.03	5.75	331.57***
SG	0.07	4.32	27.15	−30.36	0.00	10.65	2557.95***
FR	0.21	2.50	11.02	−16.90	−0.73	8.59	1459.28***
GE	0.11	3.42	15.48	−29.02	−0.99	11.99	3710.99***
SW	0.17	1.62	11.30	−8.89	−0.02	8.32	1236.55***
UK	0.12	2.87	19.61	−20.65	−0.57	10.91	2790.61***
CA	0.11	2.47	12.01	−23.46	−1.78	19.68	12,721.59***
US	0.18	3.25	30.11	−39.50	−1.72	38.90	56,896.97***

Notes: All price returns are taken logarithm differentials and in local currency. *** indicates significance level at 1%, ** and * indicate significance level at 5% and 10%, respectively. The markets are: Australia (AU), Hong Kong (HK), Japan (JP), Singapore (SG), France (FR). Germany (GE), Switzerland (SW), United Kingdom (UK), Canada (CA) and the United States (US).

and determines the cost of borrowing. Thus, long-term rates are likely to influence investment decisions and profitability of real estate firms and hence on their performances. As SRE is a hybrid of equity and bond, the long-term interest rate can impact positively or negatively on SRE markets, while the short-term interest rate parameter estimate is expected to be largely negative; (b) the ST movement is an important driver of SRE markets since SRE market is an industry of domestic stock market (Anderson *et al.* 2012); and (c) the FX performance indicator has been of increasing concern for listed property companies and REITs as many of them are expanding their business abroad. Its parameter estimate can, however, be positive in the long-run due to effect of purchasing power parity. Exchange rate is measured as local currency to US$. **Finally, the inflation effect is included in the indicators as they have not been deflated.**

Figure 1 plots the time-series trend of the price/return index data for each market over time. An observation made is there was a drop in the SRE and stock market prices from mid-2007 to the end of 2009, which coincides with the outbreak of the global financial crisis. Following the trough of the financial markets, the TB rate also fell substantially to almost zero level in JP and the UK, while the BO prices of many countries also fell; but to a lesser extent. Except for HK, the FX rate generally co-moves with the SRE markets.[5]

Methodology

Our empirical analysis comprises two key steps for each SRE market: (a) an MS return regression model to assess the linkage between SRE and the four financial assets; (b) an MS-GARCH volatility model with an exogenous variable specification to explore the impact of the four financial performance risk indicators on the SRE markets' conditional volatilities (Hamilton, 1990, 1994, Hamilton, 1996). The MRS methodology can be considered as the generalization of the simple dummy variable approach. As such, applying Hamilton (1989)'s regime-switching model can allow discrete shifts in the stochastic volatility process driving the SRE markets. In both models, the coefficients of the four economic and financial performance indicators are time dependent and switch between regimes. These two MS models keep the same structure of the original single-state return and GARCH specifications; but allow the possibility of sudden jumps between two market states. It has been recently becoming popular in finance literature because it can well deal with return/volatility persistence and determines the market states endogenously. Our focus is to detect whether there are clear differences in the signs, significances and sizes of the estimated betas depending on the regime. The procedures are explained below:

(a) As a base case, the influence of the four financial market indicators on SRE market returns is investigated based on a single-regime linear regression model given in (1):

$$\Delta \ln RE_t = \alpha + \beta_1 \Delta \ln RE_{t-1} + \beta_2 \Delta \ln ST_t + \beta_3 \Delta TB_t + \beta_4 \Delta BO_t + \beta_5 \Delta \ln FX_t + \varepsilon_t \quad (1)$$

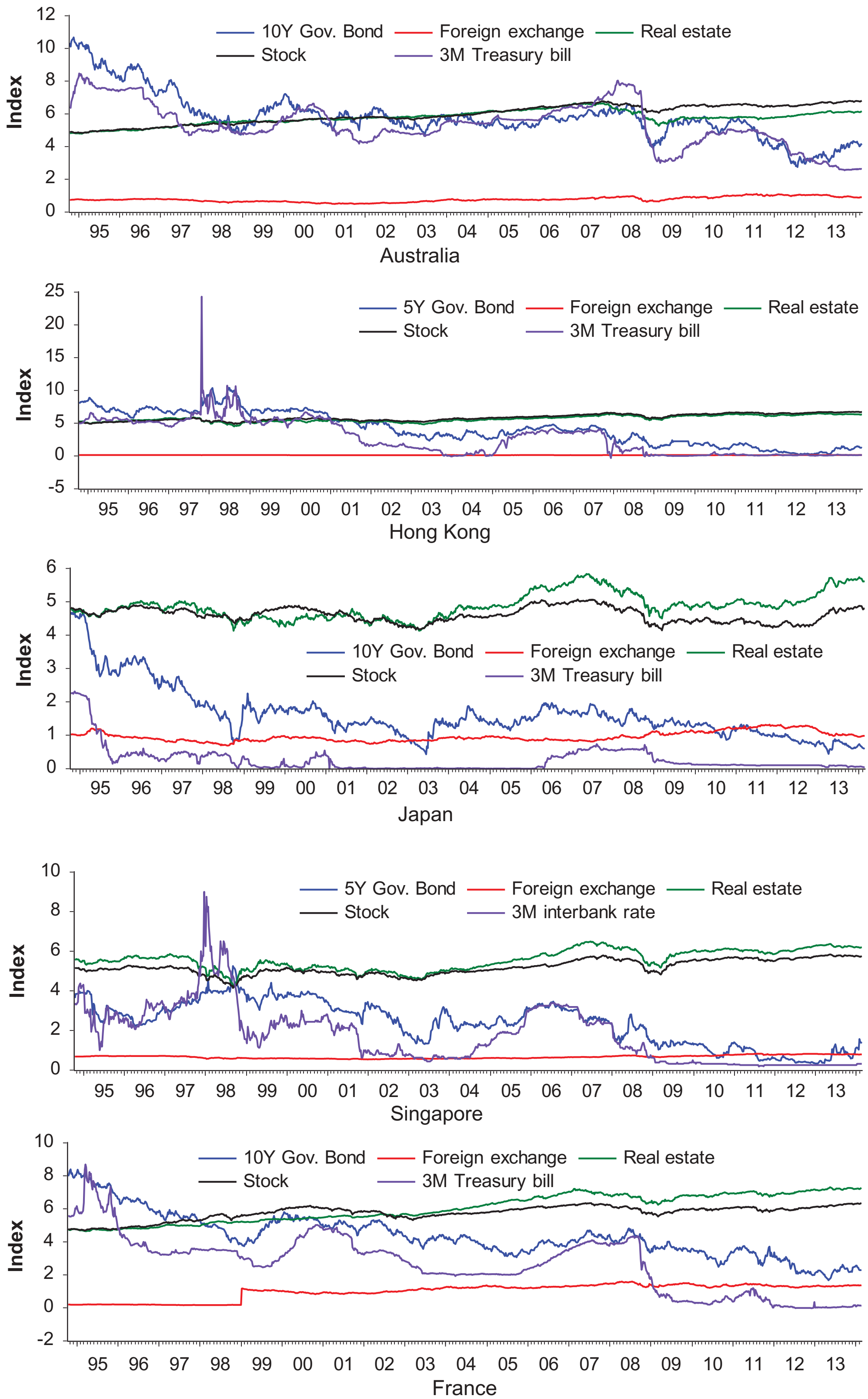

Figure 1. Time-series plots.

Note: All references to the vertical axis are "Index/rate" and not "index" only.

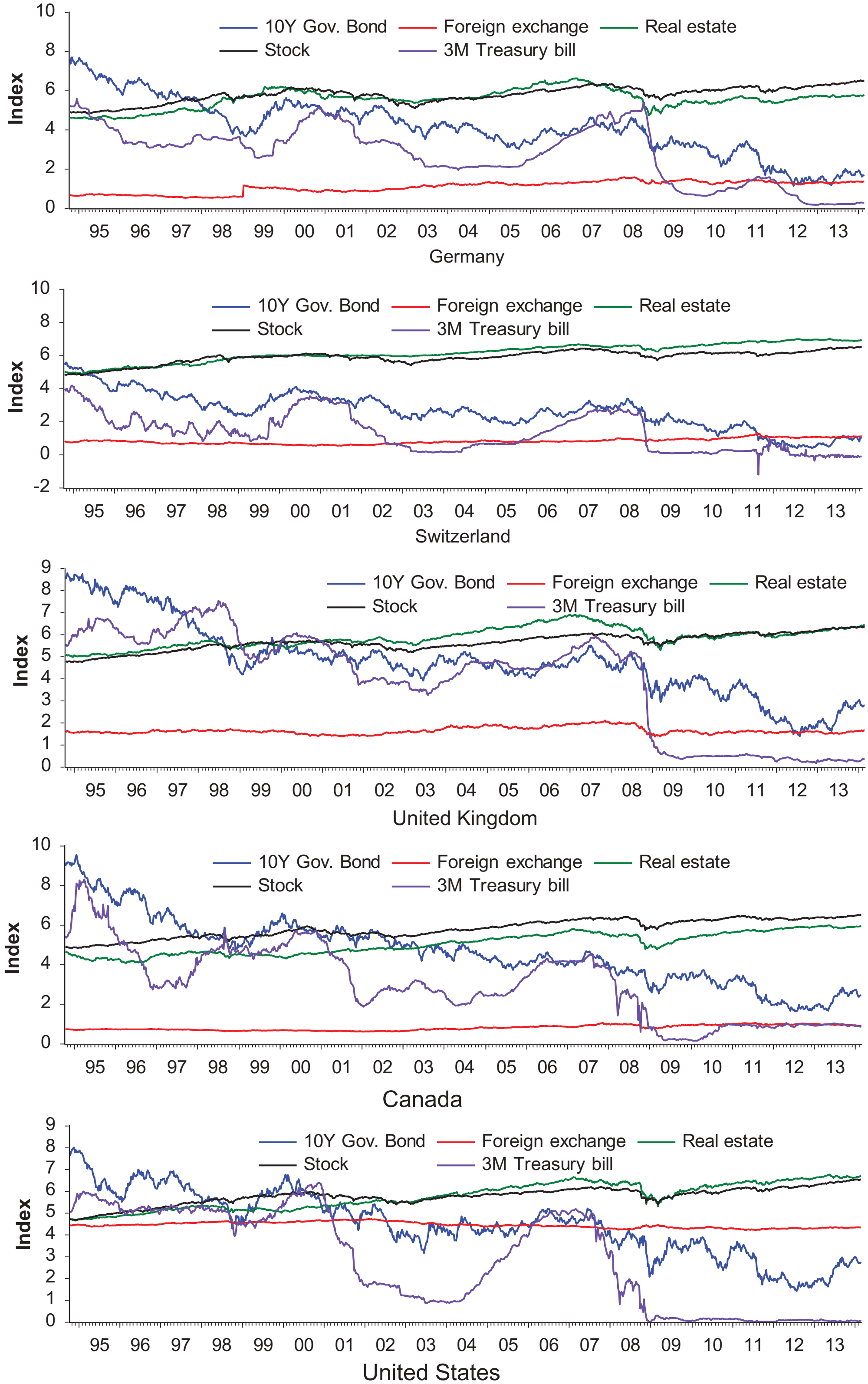

Figure 1. (Continued).

where β_i is the parameter for the factor loading of the four explanatory variables, i.e. as a measure of the sensitivity of SRE **returns** to changes in the stock market prices (ST), short-term interest rates (TB), long-term interest rates (BO) and exchange rates (FX).

(b) We consider an MRS return regression of SRE. Using model (2), the hypothesis that the SRE returns respond differently to performance, depending on the state of the markets is tested.

$$\Delta lnRE_t = a + \beta_{1,st}\Delta lnRE_{t-1} + \beta_{2,st}\Delta lnST_t + \beta_{3,st}\Delta TB_t + \beta_{4,st}\Delta BO_{4,st} + \beta_{5,st}\Delta lnFX_t + \epsilon_{t,st} \tag{1}$$

where $\epsilon_{t,st}$ follows the distribution of $N\left(0, \sigma^2_{S_t}\right)$. S_t is a Markov chain with two states and transition probability matrix P.[6] The unobserved state variable S_t takes the value of either 0 or 1, which indicates bust and boom stage of the SRE market. a_{st} and $\propto_{st}$ are the state-dependent mean and standard deviation of $\Delta \ln RE_t$, respectively. Further, each regime is characterized by a distinct conditional normal distribution:

$$\Delta \ln RE_t = \begin{cases} \mu_0 + \Sigma_0 \varepsilon_t & \text{if} s_t = 0 \\ \mu_1 + \Sigma_1 \varepsilon_t & \text{if} s_t = 1 \end{cases} \tag{2}$$

The transition probability of the above model is governed by a two-state Markov process and takes the following structure:

$$P = \begin{bmatrix} P_{00} & 1 - P_{11} \\ 1 - P_{00} & P_{11} \end{bmatrix} \tag{3}$$

Finally, the factor loading β_{i,S_t} takes the form of:

$$\beta_{i,S_t} = \beta_{i,0}(1 - S_t) + \beta_{i,1} S_t \tag{4}$$

(c) In the final step, we develop an MRS-GARCH with an exogenous variable in the variance equation in order to evaluate the state-dependent effect of the four financial risk factors on SRE market volatilities. Specifically, this MS-GARCH model governs the change between different variance regimes so that in each regime, the variance is expressed by a unique GARCH process. To examine the influence of external variables on conditional variance, we introduce an exogenous variable specification in the variance equation to control for the compounding effect. This effect is however not constant over the sample period, but is instead conditioning on the current market state. This method is designed to capture the asymmetric response of the SRE volatility performance to changes in the economic and market conditions. The exogenous variable is the four economic and financial market risk factors which are included in the variance equation one at a time.

A simple illustration of the model is given below:

$$\Delta \ln RE_t = \mu_t + \varepsilon_t \tag{5}$$

where $\varepsilon_t \sim$ student-t(mean = 0,n_t,h_t), n_t is the degree of freedom in the dependent variable $\Delta \ln RE_t$. The conditional mean $\mu_t$can switch according to a Markov process governed by a state variableS_t, indicating good time when $S_t = 1$ and bad times when $S_t = 0$.

$$\mu_t = \mu_l + \mu_h(1 - S_t) \tag{6}$$

$$h_t^{(j)} = \gamma + \frac{\alpha}{g(S_{t-1} = j)}(\varepsilon_{t-1}^{(j)})^2 + \beta \hat{h}_{t-1} + \lambda \times z_t(S_{t-1} = j) \times X_t^{(j)} \tag{7}$$

The regime-dependent conditional variance is given by (7), where γ and β are constant and $g(S = 1)$ is the relative factor to scale down$(\varepsilon_{t-1}^{(j)})^2$. $X_t^{(j)}$ is the external factor at state j that explains the variation of conditional variance $h_t^{(j)}$. The coefficient is given by $\lambda x z_t$, the latter of which is allowed to switch between different states. We replace the exogenous variable $X_t^{(j)}$ with $\Delta \ln ST_t$, ΔTB_t, ΔBO_t and $\Delta \ln FX_t$ to examine the effects on the conditional variance $h_t$one at a time .

Results

Table 2 reports the results using the single-regime Equation (1). Table 3 reports the results from a MRS return regression model (2).

From Table 2, the sign of the stock market returns is significantly positive in both good and bad market states, with the absolute magnitude of such impact much larger during the downside market (Table 3). Hence, investors are reminded that the stock market returns would impose a higher impact on SRE market returns when the SRE markets are in recession. In contrast, the TB indicator is not consistently priced in the 10 markets. While there are significant and negative β_3 for AU, GR and CA for the full period; in the regime-switching setting (Table 3), the statistical significance of TB disappears in AU in both states; but only holds in bust state for GE and CA and their absolute magnitudes are larger than the full linear estimation. These findings indicate that the dynamic relationship between the SRE and money markets may not be as evident as the real estate–stock return linkage. Moreover, the regime-switching estimates could be more reliable than the single-state estimations.

We also observe that changes to BO (β_4) are positive and significant for AU and GE in a single-regime context. However, the impact of BO becomes statistically insignificant for all SRE markets during the market turbulence periods, results which are in broad agreement with those of Liu and Mei (1992), as well as Naranjo and Ling (1997). The impact of the FX returns varies between good and bad states. A significant and positive sign of the estimated coefficient (β_5) for JP, SW and UK in boom periods is broadly consistent with the expectation that a positive change in the FX rate (currency appreciation) will probably lead to more inflow of capital and contribute to the boom of the SRE markets. Except for the US and CA which have a significantly negative FX coefficient in boom periods, the estimates for other markets are either insignificantly positive or negative in the two states. Finally, the FX markets in SG, FR, GE and UK are positive and significantly linked to the respective SRE markets in bust state, and with a much larger FX coefficients each than those in boom state, thereby indicating presence

Table 2. Single-regime regression results: October 1994–March 2014.

	AU	HK	JP	SG	FR	GE	SW	UK	CA	US
β_1	−0.068***	0.007	−0.105***	−0.002	−0.002	0.029	0.075***	0.043*	0.002	−0.057**
	(0.024)	(0.011)	(0.021)	(0.025)	(0.025)	(0.027)	(0.029)	(0.025)	(0.026)	(0.022)
β_2	0.771***	1.183***	1.151***	0.529***	0.529***	0.599***	0.280***	0.748***	0.584***	0.894***
	(0.030)	(0.014)	(0.034)	(0.023)	(0.023)	(0.031)	(0.019)	(0.032)	(0.030)	(0.030)
β_3	−0.147**	−0.029	−0.209	−0.015	0.017	−0.332***	−0.079	0.017	−0.113*	−0.025
	(0.069)	(0.046)	(0.378)	(0.075)	(0.075)	(0.107)	(0.068)	(0.053)	(0.061)	(0.067)
β_4	0.134**	0.015	0.076	−0.074	−0.076	0.216**	0.047	−0.047	0.009	0.026
	(0.064)	(0.048)	(0.188)	(0.097)	(0.097)	(0.106)	(0.069)	(0.075)	(0.066)	(0.103)
β_5	−0.035	0.140	0.114*	0.298***	0.290***	0.239***	0.057*	0.444***	0.062	−0.263***
	(0.038)	(0.693)	(0.064)	(0.047)	(0.047)	(0.067)	(0.031)	(0.058)	(0.062)	(0.077)
α	0.002	−0.059	0.024	0.448	0.453	0.043	0.108	0.171	0.335*	−0.003
	(0.249)	(0.107)	(0.256)	(0.276)	(0.276)	(0.285)	(0.131)	(0.235)	(0.199)	(0.317)
R^2	0.438	0.878	0.546	0.771	0.363	0.292	0.182	0.377	0.347	0.511

Notes: The coefficients reported are based on the following regression:
$\Delta \ln RE_t = \alpha + \beta_1 \Delta \ln RE_{t-1} + \beta_2 \Delta \ln ST_t + \beta_3 \Delta TB_t + \beta_4 \Delta BO_t + \beta_5 \Delta \ln FX_t + \varepsilon_t$
The statistics in the brackets are standard errors for the estimated coefficients. ***, ** and * indicate significance level at 1%, 5% and 10%, respectively.

of asymmetric response on the SRE markets. As reasonably expected, this finding indicates that property investment (and SRE) returns are rather sensitive to currency returns, due to effect of purchasing power parity in these countries. The larger absolute magnitude of the currency impact during market downturn implies a closer relationship between SRE and currency returns.[7]

Two additional tests are conducted. First the Wald test results (Table 4) indicate the null hypothesis of no-regime shifts in the beta coefficients is rejected for ST (eight markets), TB (two markets), BO (two markets) and FX (four markets). Second, the log-likelihood ratio test is implemented to compare if the switching-regime model fits significantly better than the single-regime model. As indicated by Table 5, the log-likelihood statistics reject the null model in favor of the alternative two-state regime switching at the 1% significance level for all 10 SRE markets.

In **summary**, we may conclude that the regime-dependent return linkage results are generally supportive of inequality in the SRE market return's asymmetrical linkages to the four financial market performance indicators, though the variations in the significant results between the two states depend upon the individual markets involved, i.e. these financial market factors influence differently on SRE market returns in market bust and boom periods, with the absolute magnitude of the impact from the financial market return factor (especially stock and currency markets) larger during low-return period, which is broadly in agreement with Harvey (1989) who documents that equity excess return is higher at market troughs than it is at peaks. One important implication from this finding is that previous literature that overlooked structural breaks might result in biased conclusion on the asymmetrical regime-dependent linkage between the SRE market returns and major financial market performance indicators.

In the final section, Table 6 reports the estimated state-dependent coefficients from the MS-GARCH model. As before, State 1 is denoted by S_1 that indicates the up-SRE

Table 3. Results of MS-regime return regressions: October 1994–March 2014.

	AU	HK	JP	SG	FR	GE	SW	UK	CA	US
$\beta_{1,1}$	−0.074***	−0.023*	−0.021	−0.007	0.143***	−0.027	0.055	0.110***	0.007	0.066*
	(0.023)	(0.013)	(0.023)	(0.019)	(0.037)	(0.030)	(0.042)	(0.031)	(0.034)	(0.034)
$\beta_{2,1}$	0.597***	1.204***	1.136***	1.110***	0.209***	0.400***	0.118***	0.659***	0.322***	0.388***
	(0.025)	(0.018)	(0.033)	(0.023)	(0.022)	(0.041)	(0.018)	(0.026)	(0.031)	(0.027)
$\beta_{3,1}$	0.010	0.066	−0.022	0.109	−0.001	−0.141	−0.060	0.056	−0.080	−0.010
	(0.061)	(0.048)	(0.277)	(0.083)	(0.076)	(0.114)	(0.048)	(0.044)	(0.051)	(0.045)
$\beta_{4,1}$	−0.010	−0.052	−0.031	−0.046	−0.101	0.065	0.031	−0.092*	0.071	−0.049
	(0.050)	(0.044)	(0.131)	(0.078)	(0.083)	(0.094)	(0.055)	(0.053)	(0.060)	(0.064)
$\beta_{5,1}$	−0.049	−1.035	0.173***	0.040	0.019	0.095	0.044*	0.187***	−0.220***	−0.115*
	(0.030)	(0.652)	(0.060)	(0.072)	(0.042)	(0.063)	(0.027)	(0.048)	(0.061)	(0.060)
α_1	0.129	−0.089	0.230	0.024	0.736***	0.173	0.089	0.386**	−0.007	0.524**
	(0.180)	(0.079)	(0.173)	(0.108)	(0.245)	(0.193)	(0.113)	(0.154)	(0.043)	(0.207)
$\beta_{1,0}$	−0.117**	0.021	−0.151***	−0.016	−0.034	0.033	0.082*	−0.005	−0.007	−0.063**
	(0.058)	(0.019)	(0.038)	(0.023)	(0.035)	(0.048)	(0.044)	(0.056)	(0.043)	(0.029)
$\beta_{2,0}$	1.134***	1.170***	1.159***	1.204***	0.876***	0.939***	0.415***	0.817***	0.767***	1.288***
	(0.113)	(0.024)	(0.066)	(0.038)	(0.045)	(0.097)	(0.044)	(0.085)	(0.060)	(0.056)
$\beta_{3,0}$	−0.310	−0.058	−0.616	−0.222	0.031	−0.541*	−0.085	0.247	−0.289**	0.027
	(0.239)	(0.086)	(0.882)	(0.253)	(0.121)	(0.285)	(0.137)	(0.223)	(0.127)	(0.149)
$\beta_{4,0}$	0.878	0.013	0.308	0.145	−0.156	0.305	0.006	−0.879	0.175	−0.058
	(0.618)	(0.098)	(0.464)	(0.251)	(0.240)	(0.540)	(0.130)	(0.789)	(0.136)	(0.314)
$\beta_{5,0}$	−0.161	0.965	0.058	0.453***	0.169*	0.290*	0.052	0.771***	0.182	−0.086
	(0.151)	(1.498)	(0.119)	(0.174)	(0.085)	(0.160)	(0.059)	(0.158)	(0.124)	(0.143)
α	−3.680	0.146	−0.400	−0.202	0.584	0.593	0.319	2.544	−0.299	−0.005
	(2.612)	(0.265)	(0.696)	(0.618)	(0.674)	(1.820)	(0.245)	(2.803)	(0.448)	(0.963)

Notes: $\Delta \ln RE_t = \alpha + \beta_{1,s_t}\Delta \ln RE_{t-1} + \beta_{2,s_t}\Delta \ln ST_t + \beta_{3,s_t}\Delta TB_t + \beta_{4,s_t}\Delta BO_t + \beta_{5,s_t}\Delta \ln FX_t + u_{t,s_t}$; $S_t = 1$ indicates market state of low volatility and high return, and $S_t = 0$ indicates market state of high volatility and low return. P_{11} indicates the transition probability of being in upside market state (State 1), and P_{00} is the transition probability of being in downside market state (State 2). The statistics in the brackets are standard errors for the estimated coefficients. ***, ** and * indicate significance level at 1%, 5% and 10%, respectively.

Table 4. Wald test of the null hypothesis of no switch in the coefficients.

$H_0 : \beta_{i,1} = \beta_{i,0}$	ST_t	TB_t	BO_t	FX_t
AU	21.548***	1.714	2.067*	0.536
HK	1.157	1.546	0.357	1.441
JP	0.086	0.370	0.470	0.719
SG	4.294**	3.288*	1.056*	4.416**
FR	181.78***	0.049	0.045	2.267**
GR	20.651***	1.786	0.194	1.230
SW	42.392***	0.030	0.029	0.014
UK	3.057*	0.715	0.989	12.451***
CA	42.845***	2.186*	0.456	7.914***
US	271.826***	0.055	0.001	1.615*

Notes: The statistics reported are for Wald test which is asymptotically$\chi^2(2)$.
***, ** and * indicate significance level at 1%, 5% and 10%, respectively.

Table 5. Log-likelihood ratio test of single-regime vs. switching-regime models.

Market	Single-regime Model log-likelihood	Switching-regime model log-likelihood	Log-likelihood ratio statistics
AU	−2026.72	−1806.14	441.16***
HK	−1822.80	−1692.12	261.36***
JP	−2527.90	−2389.33	277.14***
SG	−2162.30	−1987.20	350.20***
FR	−2140.83	−1960.22	361.22***
GR	−2517.49	−2310.37	414.24***
SW	−1796.67	−1645.74	301.86***
UK	−2263.37	−2063.09	400.56***
CA	−2128.71	−1992.50	272.42***
US	−2278.89	−2014.04	529.70***

Notes: The log-likelihood ratio test is computed as:$LR = -2L_{null} + 2L_{alternative}$, where L_{null} represents the log-likelihood value for the null model (single-regime) and $L_{alternative}$for the alternative model (switching-regime model). The statistics are assumed to follow a $\chi^2(df2 - df1)$ distribution. In our setting, df is the free parameters of two models and$df2 = 12$, $df1 = 6$;*** indicates significance level at 1%, **indicates significance level at 5%.,and * indicates significance level 10%.

market condition with high return and low volatility (boom), while State 0 is represented by S_0 which refers to the down-SRE market condition with low return and high volatility (bust).

One clear observation from Table 6 is that significant responses of SRE market volatilities on the financial market performance risk factors are evident when the markets are in high-volatility regime (State 0). Moreover, the magnitude of the response, measured by the absolute value of the coefficient, is much larger during the bust-market period in many instances. It implies that financial market risk factors are more effective in influencing the SRE markets when the markets are highly turbulent. During high SRE market volatility periods, Panel B of Table 4 reveals that the sign of the ST volatility factor is consistently and negatively related to SRE market volatility, indicating a decrease in stock market volatility during market recession would lead to an increase in SRE market risk. Moreover, this negative response is consistent in all 10 SRE markets and is statistically significant for 70% (7 cases) of SRE markets. Since SRE

Table 6. Results of MS-GARCH model with exogenous variable: October 1994–March 2014.

	AU	HK	JP	SG	FR	GE	SW	UK	CA	US
Panel A: Low-volatility regime (State 1)										
$\Delta \ln ST_t$	1.523**	0.423	0.250	−0.419	−1.468*	0.774	0.026	−0.843	−0.004	−0.050
	(0.754)	(0.630)	(0.207)	(0.270)	(0.201)	(0.756)	(0.092)	(0.784)	(0.094)	(0.251)
ΔTB_t	−0.915	−0.102	−0.763	0.488	−0.049***	1.573	−0.202	−0.300***	0.179**	0.003
	(0.964)	(0.386)	(0.499)	(1.938)	(0.016)	(5.794)	(0.128)	(0.076)	(0.086)	(0.244)
ΔBO_t	0.214**	0.967***	−0.232	2.863*	1.242	1.097	−0.058	0.208	0.287	−0.886*
	(0.103)	(0.306)	(0.330)	(1.707)	(1.499)	(1.348)	(0.066)	(0.129)	(0.236)	(0.483)
$\Delta \ln FX_t$	0.790	−1.884*	0.878	−0.175	−0.956	2.740	0.052	0.714	0.031	−0.385
	(2.328)	(1.098)	(2.604)	(0.489)	(2.311)	(2.191)	(0.371)	(1.163)	(0.133)	(0.853)
Panel B: High-volatility regime (State 0)										
$\Delta \ln ST_t$	−1.644**	−3.873***	−2.120***	−0.500**	−0.716	−1.188	−0.625***	−1.110	−1.001***	−1.208**
	(0.723)	(0.898)	(0.580)	(0.241)	(1.229)	(1.370)	(0.149)	(0.849)	(0.186)	(0.483)
ΔTB_t	1.004*	2.208	9.413*	1.362	0.216***	9.944	1.036***	0.339***	−0.026	1.203**
	(0.538)	(1.734)	(4.910)	(7.191)	(0.022)	(16.961)	(0.248)	(0.085)	(0.578)	(0.556)
ΔBO_t	−0.233*	−1.062**	8.143***	−3.961**	−3.207*	−1.642	0.115	−0.418***	−0.273	−2.780**
	(0.138)	(0.497)	(3.049)	(1.369)	(1.665)	(2.363)	(0.330)	(0.139)	(1.400)	(1.153)
$\Delta \ln FX_t$	−2.225	−3.265***	−15.473**	−2.619**	2.244	−8.087	−0.568	1.143	−2.646***	−4.194
	(1.934)	(1.030)	(6.555)	(1.321)	(2.747)	(5.394)	(0.566)	(2.923)	(0.315)	(3.734)

Notes: This table reports the coefficient $z_t(S_t = j)$ from the following regression:

$\Delta \ln RE_t = \mu_t + \varepsilon_t$

$h_t^{(j)} = \gamma + \frac{\alpha}{g(S_{t-1}=j)}\left(\varepsilon_{t-1}^{(j)}\right)^2 + \beta \hat{h}_{t-1} + \lambda \times z_t(S_{t-1} = j) \times X_t^{(j)}$

where $X_t^{(j)}$ represents stock market return ($\Delta \ln ST_t$), 3-month Treasury bill rate (TB_t), 10-year government bond rate (BO_t) and foreign exchange rate ($\Delta \ln FX_t$). $S_t = 1$ indicates market state of low volatility and high return and $S_t = 0$ indicates market state of high volatility and low return. The statistics in the brackets are standard errors for the estimated coefficients. ***, ** and * indicate significance level at 1%, 5% and 10% respectively.

markets are riskier than the corresponding local stock markets during high-volatility periods due to the added risk from stock market, a reweighting from real estate to stock may be considered, which is broadly consistent of strong evidence of a flight to quality – from stocks to Treasury bonds, during high-volatility period (Chan et al., 2011). Second, the TB indicator imposes a significant and positive impact on 60% (six cases) of the markets, which is broadly in line with our expectation that during high-volatility periods, a positive relationship exists between SRE market and money markets. For the BO indicator, its significant and negative sensitivity is similar with the ST finding. During periods of high SRE market uncertainty, the SRE market risk and bond market risk are negatively correlated as investors rebalance their portfolio and shift to the less risky bond markets. Consequently, the bond market yield will fall during market turbulent time. Finally, the FX market is either negatively or positively linked to SRE market in bust state. However, it is difficult to generalize conclusively as the responses (in the signs, significances and sizes of the estimated betas) are quite heterogeneous among various SRE markets.

Table 7 presents the test results for the equality of state-dependent coefficients. As can be seen, the null hypothesis of no regime shifts in the volatility beta coefficients is rejected for ST (six markets), TB (five markets), BO (three markets) and FX (five markets). Of the 10 SRE markets, JP and HK have registered regime-dependent risk linkages to changes in stock market risk, bond risk and currency risk. For the US and AU real estate markets, changes to the stock market risk, money market risk and bond market risk significantly affect the regime-dependent dynamics of **their** SRE market risk. Moreover, the influences of the financial market risk indicators on the SRE market risk in terms of direction and significance do vary across other economies studied. These heterogeneous responses among the various SRE markets may be due to different financial market conditions, as well as the differential progress made in real estate market securitization in the respective countries.

Finally, Figure 2 graphs the estimated probability plots of the SRE markets being in the low-volatility state from the univariate MRS-regression model and the MRS-GARCH models. These probabilities allow us to make statistical inferences about the regime in which the SRE markets stay at each point in time of the complete data set. In

Table 7. Test of the null hypothesis of no switch in the coefficients: SWGARCH model.

$H_0: \beta_{i,1} = \beta_{i,0}$	ST_t	TB_t	BO_t	FX_t
AU	121.548***	1.714	2.067	1.020
HK	18.592***	1.268	12.787***	29.756***
JP	10.238***	3.772*	7.192***	4.487**
SG	0.031	0.009	1.362	2.953*
FR	0.191	58.588***	1.991	0.619
GR	1.935	0.358	0.572	3.973**
SW	17.72***	13.904***	0.197	0.774
UK	0.030	21.412***	8.091***	0.012
CA	27.485***	0.110	0.146	46.374***
US	3.642*	2.837*	1.592	1.376

Notes: the statistics reported are for Wald test which is asymptotically$\chi^2(2)$.
***, ** and * indicate significance level at 1%, 5% and 10%, respectively.

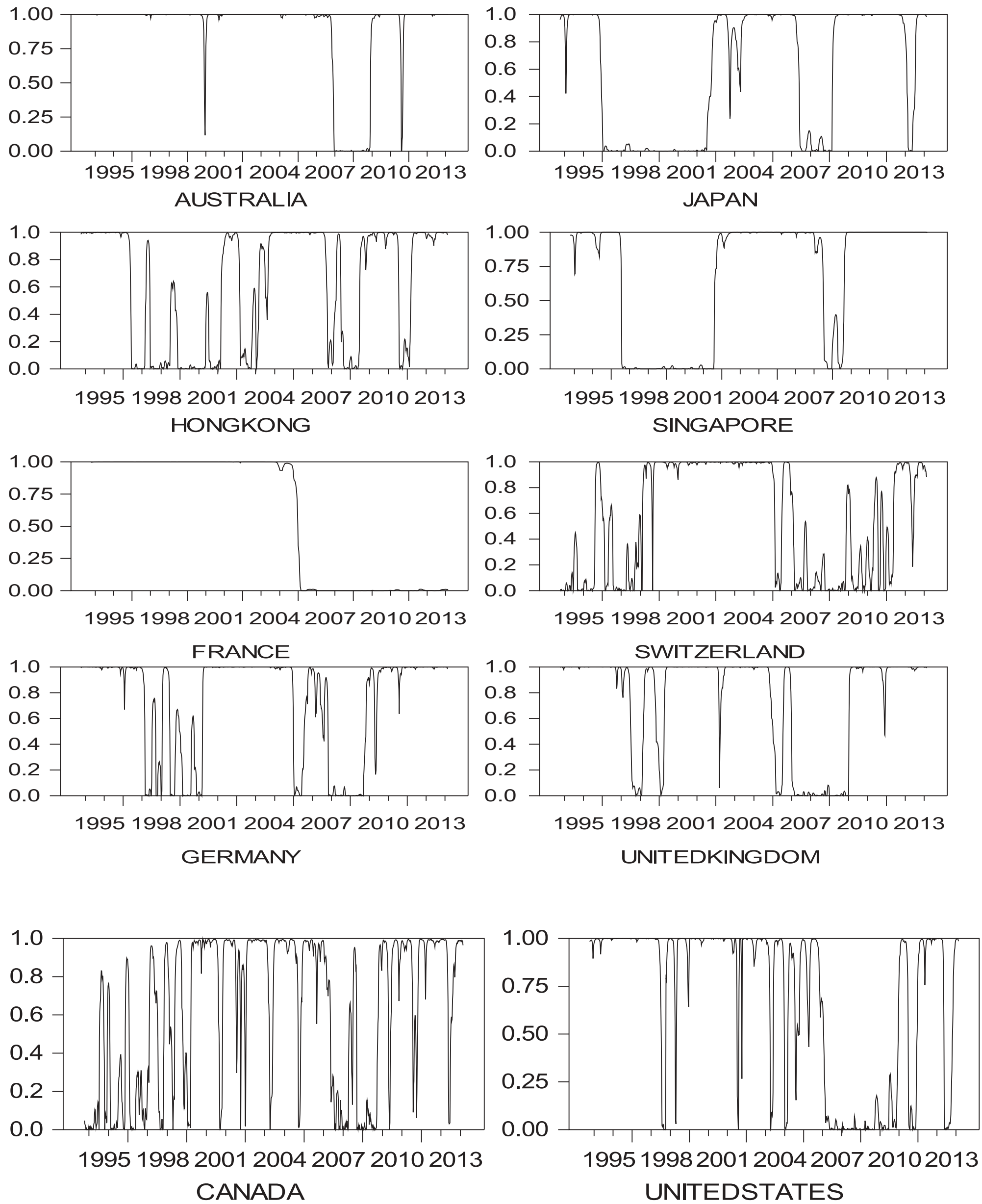

Figure 2. Estimated smoothed probability plots of the SRE markets being in the low-volatility state.
Note: All references to the vertical axis are "Probability level".

general, we observe various SRE markets' switches to the high-volatility regime caused by major crises happened during the study period, notably the subprime/GFC happened from June/July 2007 and the European debt crisis (EDC) from January 2010. **Additionally, there are numerous switching that can be observed across selected SRE markets; for examples, in the US and Canada, numerous switching happened mostly around 2007–2010 and reflects mainly the impact of the global/regional systematic**

risk factors due to the 2008–2009 GFC and 2010–2011 EDC, as well as due to close geographical proximity between the two countries. In the case of Hong Kong, the switching happened around the 1998–2001 period (global risk factors mainly due to the Asian and emerging market financial crisis), 2003–2004 period (local/regional factors), 2007–2009 period (GFC) and 2011–2012 period (EDC). Our regime-switching models are thus adequate to reflect the bust and boom stage, i.e. two regimes, of the SRE markets.

In **summary**, although the asymmetric regime-dependent response of SRE market volatilities to changes in the four financial market risks does not present uniformly in all markets, there is adequate evidence from this study to alarm investors and policy-makers on the relevance and importance of regime-dependent asymmetrical response of SRE market volatilities to changes of major financial market risk, such as stock, money, bond and foreign exchange markets in the domestic economy. During periods of high SRE market uncertainty, various financial markets are more correlated. Consequently, negative news from the SRE markets will cause a larger decline in returns than an equal magnitude of good news. Moreover, the variance appears to be more volatile when bad news impacts the financial markets than when good news does. As such, the absolute magnitude of such regime-dependent asymmetrical linkage impact among the SRE and other financial markets could be much larger during the downside market. Consequently, investors and policymakers should be alerted of the risk of increased exposure of securitized property markets to financial markets during high-volatility market conditions.

Conclusion

In this paper, we employ two-state MRS non-linear econometrics to explore the asymmetrical regime-dependent linkage between SRE market and stock, money, bond and exchange markets in 10 developed economies. By classifying the SRE markets into two different states (i.e. low volatility/high return and high volatility/low return), **we find that the regime-dependent asymmetrical response of the SRE market prices to the financial market factors are heterogeneous among the markets examined, with the absolute magnitude of the linkage impacts much larger among the SRE and other financial markets**. In general, during high-volatility state, SRE market returns are linked positively to ST returns and changes to FX rates. Moreover, SRE market risks appear to inversely link to ST market risk and bond market risk in some economies, implying appropriate hedging strategies may be adopted by investors to reduce overall portfolio risk. Overall, the findings of this study help explain the limited or even contrasting evidence gathered from earlier literature under regime-invariant context.

Despite the heterogeneous asymmetrical linkage response finding, we observe three similar regime-dependent asset market linkage patterns along two regional lines and one cross-continental line. In Asian markets, both SG and HK SRE volatilities are impacted significantly by negative stock market risk, negative bond market risk and negative currency market risk, during high-volatility state. For the two European countries of the UK and FR, their SRE market volatilities are influenced significantly by positive money market risk and negative bond market risk. Finally, for the cross-continental line which comprises the US and AU markets, their SRE market volatilities are influenced significantly by three joint domestic risk factors: negative stock market risk, positive money market risk and negative bond market risk, in high-volatility state. This extra and specific information will provide investors with in-depth implication in their pursuits for portfolio diversification, rebalancing and hedging; as well as for policymakers in promoting financial market growth and managing financial stress in the respective domestic economies.

The findings of this study are indicative. From the academic perspective, one of the major challenges is a switch from linear to non-linear viewpoint of the economic and financial market risk on SRE market subject to single/multiple structural breaks. The practical implications of the findings cannot be ignored too. For investors, the results may indicate pockets of diversification opportunities as the various asymmetrical regime-dependent effects are heterogeneous. The regime-dependent relationship between SRE market risk and financial market risk may also provide useful information for policymakers in regulating the relevant economic and financial market variables, given that market volatility and the co-movement of macroeconomic and financial market performance indicators display large variation between bust and boom periods.

Notes

1. Securitized real estate (SRE) is also referred as "public real estate". Its two investment vehicles are real estate stocks and real estate investment trusts (REITs). Property stocks are different from REITs in their organization form, tax status, institutional framework and risk-return performance. From this point onward, the terms "securitized real estate" will be used as abbreviation "SRE" throughout the paper, unless otherwise indicated.
2. Since the present study commences from October 1994 and majority of the sample countries only established a REIT-like market structure after Year 2000, we do not have sufficiently long time series for a separate multi-country study using REIT data alone. As such, REITs and real estate stocks are evaluated together in this study.
3. Weekly format data (Thursday–Thursday) are used given that daily data suffers from non-synchronous trading hours and weekend effect while monthly data cannot fully capture sudden jumps and structural breaks in financial returns.
4. **The stock market series can either reflect total returns or price returns. We can also replace the total return with price return series to ensure consistency across both stock and real estate series. We wish to thank a reviewer for offering this suggestion.**
5. **We have graphed both index series (SR, RE and FX) and rate series (TB and BO) on the same chart to reveal the nature of the five original series. However, as noted by one reviewer, the index series and rate series are not strictly comparable with the rate series. He suggested that we may recast the index series in terms of log differences or percentage changes. This will assist in identifying co-movements between the reported series. Many thanks to this suggestion which we fully agree as another useful method of representing the time-series fluctuations.**
6. As in Edwards and Susmel (2001), since our interest is on asset market linkages and three states (k = 3) considerably complicate the estimation, we focus our attention on a two-state system (k = 2), although we recognize that in some public real estate markets, a three-state SWARCH model may be more appropriate (Liow & Ye, 2014). Ramchand and Susmel (1998) also find a two-state (k = 2) formulation is a parsimonious way to capture the shift in return and variance, *"In fact a two*-state formulation is able to capture in a statistical and economic sense, the changes in variance regimes, while a three-state regime is rejected (page 399)." Finally, there are two states/regimes which are widely discussed and analyzed

in the literature: bullish and bearish. A bullish market corresponds to a state of high return and low volatility, while a bearish market indicates low return and high volatility.

7. **While the strong statistical significance of the ST indicator in both models is revealed, the results also highlight the low level and lack of significance across other indicators across the 10 economies/ countries. This might simply reflect a lack of explanatory power with some of the indicators or associated with other model misspecifications. One reviewer suggested to consider re-estimate the model with either TB or BO omitted as a visual inspection of the rate series suggests a high degree of co-movement, although they do tend to diverge at the onset of the GFC. We wish to thank the reviewer in offering this useful and kind suggestion.**

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References

Ahmad, W., Bhanumurthy, N. R., & Sehgal, S. (2015). Regime dependent dynamics and European stock markets: Is asset allocation really possible? *Empirica*, *42*, 77–107.

Anderson, R. I., Boney, V., & Guirguis, H. (2012). The impact of switching regimes and monetary shocks: An empirical analysis of REITs. *Journal of Real Estate Research*, *34*, 157–181.

Ang, A., & Bekaert, G. (2002). International asset allocation with regime shifts. *Review of Financial Studies*, *15*, 1137–1187.

Ang, A., & Chen, J. (2002). Asymmetric correlations of equity portfolios. *Journal of Financial Economics*, *63*, 443–494.

Barsky, R. B. (1989). Why don't the prices of stocks and bonds move together? *The American Economic Review*, *79*(5), 1132–1145.

Baur, D. G. (2010). Stock-bond co-movements and cross-country linkages. *International Journal of Banking, Accounting and Finance*, *2*(2), 111–129.

Baur, D. G., & Lucey, B. M. (2009). Flights and contagion: An empirical analysis of stock–Bond correlations. *Journal of Financial Stability*, *5*(4), 339–352.

Bredin, D., O'Reilly, G., & Stevenson, S. (2007). Monetary shocks and REIT returns. *The Journal of Real Estate Finance and Economics*, *35*, 315–331.

Chan, K. F, Treepongkaruna, S, Brooks, R, & Gray, S. (2011). Asset market linkages: evidence from financial, commodity and real estate assets. *Journal Of Banking & Finance*, *35*(6), 1415-1426.

Chan, K. F., Treepongkaruna, S., Brooks, R., & Gray, S. (2011). Asset market linkages: Evidence from financial, commodity and real estate assets. *Journal of Banking & Finance*, *35*(6), 1415–1426.

Chen, N.-F., Roll, R., & Ross, S. A. (1986). Economic forces and the stock market. *Journal of Business*, *59*, 383.

Chen, S. J., Hsieh, C. H., & Jordan, B. D. (1997). Real estate and the arbitrage pricing theory: Macrovariables vs. Derived Factors. *Real Estate Economics*, *25*, 506–523.
Chen, S.-J., Hsieh, C., Vines, T. W., & Chiou, S.-N. (1998). Macroeconomic variables, firm-specific variables and returns to REITs. *Journal of Real Estate Research*, *16*, 269–278.
Chou, Y.-H., & Chen, Y.-C. (2014). Is the response of REIT returns to monetary policy asymmetric? *Journal of Real Estate Research*, *36*, 109–135.
Cotter, J., & Stevenson, S. (2006). Multivariate modeling of daily REIT volatility. *The Journal of Real Estate Finance and Economics*, *32*, 305–325.
Devaney, M. (2001). Time varying risk premia for real estate investment trusts: A GARCH-M model. *The Quarterly Review of Economics and Finance*, *41*, 335–346.
Edwards, S., & Susmel, R. (2001). Volatility dependence and contagion in emerging equity markets. *Journal of Development Economics*, *66*, 505–532.
Ewing, B. T., & Payne, J. E. (2005). The response of real estate investment trust returns to macroeconomic shocks. *Journal of Business Research*, *58*, 293–300.
Fleming, J., Kirby, C., & Ostdiek, B. (1998). Information and volatility linkages in the stock, bond, and money markets. *Journal of Financial Economics*, *49*(1), 111–137.
Guidolin, M., & Timmermann, A. (2007). Asset allocation under multivariate regime switching. *Journal of Economic Dynamics and Control*, *31*(11), 3503–3544.
Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica: Journal of the Econometric Society*, *57*, 357–384.
Hamilton, J. D. (1990). Analysis of time series subject to changes in regime. *Journal of Econometrics*, *45*, 39–70.
Hamilton, J. D. (1994). *Time series analysis*. Chapter 22. Princeton: Princeton University Press.
Hamilton, J. D. (1996). Specification testing in markov-switching time-series models. *Journal of Econometrics*, *70*, 127–157.
Hamilton, J. D., & Susmel, R. (1994). Autoregressive conditional heteroskedasticity and changes in regime. *Journal of Econometrics*, *64*, 307–333.
Harvey, C. R. (1989). Time-varying conditional covariances in tests of asset pricing models. *Journal of Financial Economics*, *24*, 289–317.
Henry, O. T. (2009). Regime switching in the relationship between equity returns and short-term interest rates in the UK. *Journal of Banking & Finance*, *33*(2), 405–414.
Kal, S. H., Arslaner, F., & Arslaner, N. (2015). The dynamic relationship between stock, bond and foreign exchange markets. *Economic Systems*, *39*(4), 592–607.
Lamoureux, C. G., & Lastrapes, W. D. (1990). Heteroskedasticity in stock return data: Volume versus GARCH effects. *The Journal of Finance*, *45*(1), 221–229.
Ling, D. C, & Naranjo, A. (1999). The integration of commercial real estate markets and stock markets. *Real Estate Economics*, *27*(3), 483-515.
Liow, K. H., & Ye, Q. (2014). Switching volatility and cross-market linkages in public property markets. *Journal of Property Research*, *31*(4), 287–314.
Liow, K. H., Zhu, H., Ho, D. K., & Addae-Dapaah, K. (2005). Regime changes in international securitized property markets. *Journal of Real Estate Portfolio Management*, *11*, 147–165.
Liu, C. H, Hartzell, D. J, Grissom, T. V, & Greig, W. (1990). The composition of the market portfolio and real estate investment performance. *Real Estate Economics*, *18*(1), 49-75.
Liu, C. H., & Mei, J. (1992). The predictability of returns on equity REITs and their co-movement with other assets. *The Journal of Real Estate Finance and Economics*, *5*, 401–418.
Lizieri, C., & Satchell, S. (1997). Interactions between property and equity markets: An investigation of linkages in the United Kingdom 1972–1992. *The Journal of Real Estate Finance and Economics*, *15*(1), 11–26.
Longin, F., & Solnik, B. (2001). Extreme correlation of international equity markets. *The Journal of Finance*, *56*, 649–676.
McCue, T. E. A., & Kling, J. L. (1994). Real estate returns and the macroeconomy: Some empirical evidence from real estate investment trust data, 1972–1991. *Journal of Real Estate Research*, *9*, 277–287.

Naranjo, A., & Ling, D. C. (1997). Economic risk factors and commercial real estate returns. *The Journal of Real Estate Finance and Economics*, *14*, 283–307.

Nishiyama, K. (1998). Some evidence on regime shifts in international stock markets. *Managerial Finance*, *24*(4), 30–55.

Nneji, O., Brooks, C., & Ward, C. W. (2013). House price dynamics and their reaction to macroeconomic changes. *Economic Modelling*, *32*, 172–178.

Panchenko, V., & Wu, E. (2009). Time-varying market integration and stock and bond return concordance in emerging markets. *Journal of Banking & Finance*, *33*(6), 1014–1021.

Peterson, J. D., & Hsieh, C. H. (1997). Do common risk factors in the returns on stocks and bonds explain returns on REITs? *Real Estate Economics*, *25*, 321–345.

Quan, D. C., & Titman, S. (1999). Do real estate prices and stock prices move together? An international analysis. *Real Estate Economics*, *27*, 183–207.

Ramchand, L., & Susmel, R. (1998). Volatility and cross correlation across major stock markets. *Journal of Empirical Finance*, *5*, 397–416.

Schaller, H., & Van Norden, S. (1997). Regime switching in stock market returns. *Applied Financial Economics*, *7*, 177–191.