Asymmetric Response of Real Estate Securities to Macroeconomic Risk Factors under Switching Regimes

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Abstract This study is to investigate the effect of financial and economic factors on international real estate securities markets from a volatility regime switching perspective. Using weekly data from October 1994 to March 2014, the macro risk factors examined in this study include stock market returns, 3-month Treasury bill yield, 10-year government bond yield and foreign exchange returns. Under the framework of Markov regime-switching models, we contribute to the literature by analyzing this regime-dependent effect at levels of both real estate securities return and conditional volatility. Regime switching models are found to fit statistically better than linear regression and traditional GARCH model in characterizing the linkages between public traded property market and macro risk factors. Result shows that regime-switching response of real estate securities to the risk factors is evident at both return and volatility levels. In both tranquil and crisis period, stock market returns and foreign exchange returns impose significant impact on real estate securities market return. Moreover, the magnitude of impact is much higher in the downside market. During the crisis period, stock market returns, Treasury bill yield and foreign exchange risk are found to contribute to the increase of real estate securities market volatility, while government bond yield rate plays the contrary role. The result highlights the risk of intensified exposure of international real estate securities markets to macroeconomic conditions during extreme market conditions which the investors and policy makers should be alert to.

Keywords Real estate securities, regime switching, macroeconomic factors

1. Introduction

It is widely recognized that macroeconomic developments play an important role in stock market performance. Since the work of Chen *et al.* (1986), researches have shown ample evidence that stock market returns are influenced by macroeconomic variables. However,

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fewer researchers have come down to investigate real estate stocks, which constitute an important sector of broader equity market, especially in Asia. Based on statistics from FTSE, real estate stocks account for 5 to 22 percent of total stock market capitalization in Asia, while the figure is 3 percent in Europe and North America. In fact, the expansions of market capitalizations of Asian property companies are accelerated by the prosperity and stability of economy, implying strong linkages between real estate securities market and macroeconomic conditions. Moreover, the relationship between real estate securities and broader economy cannot be simply replicated from that of general equity market. Unlike general equities, the underlying asset of real estate securities is physical property, whose future cash flow is 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 real estate industry is highly cash flow dependent and capital intensive, macroeconomic variables are critical for valuation and development of real estate companies as well as their stock returns.

Furthermore, recent researches have shown that such impact from macroeconomic risk is nonlinear and depend on the state of the market (Boyd *et al.* 2005; Basistha & Kurov 2008), which suggests that traditional time- and state-invariant studies are not sufficient to yield valid effect. However, compared the broader equities market literature, researches on the asymmetric effect in the real estate sector is relatively scant, with few exceptions such Anderson *et al.* (2012) and Chou and Chen (2014). They both apply a Markov-switching model to investigate the asymmetric impact of monetary policy on REIT returns. The results from the two papers are, however, inconsistent, with the former showing that the impact is only significant during high volatility regimes and the latter suggesting the contrary. So far, no empirical literature has tested the relationship between various macro risk factors and real estate securities during "boom" and "bust" regimes. Given the sensitivity of real estate securities to economic conditions and its cyclical nature, it is worth a separate study in the real estate field.

This study differs from prior work by examining various risk factors for international real estate securities market in a regime-switching framework. This asymmetric response of real estate securities is measured at the level of both market return and conditional volatility. Though several researchers have found significant impact of macro variables on the volatility of real estate securities (Devaney 2001; Cotter & Stevenson 2006), based on the author's knowledge, no studies seek to examine the question from a regime-switching perspective[3]. This study contributes to this aspect by specifically examining the a wide set of macro risk variables that influence both returns and volatility of real estate securities market in a relatively longer sample period that covers the global financial crisis. Given that market volatility[4] and comovement of macro variables both display large variation between bust and boom period, we expect the asymmetric response of real estate securities to macro variables is evident on not only market returns, but also conditional volatility.

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[3] Bredin *et al.* (2007) find significant effect of interest rates on both REIT's returns and their volatility, but they fail to find any asymmetric evidence with respect to a positive or negative unanticipated change in the interest rate.

[4] There are several theoretical explanations to support this asymmetric volatility effect. The first is the well-known leverage effect hypothesis by Black (1976) and Christie (1982), who argue that the drop in the stock price increases financial leverage, and leads to the increase in stock risk and its volatility. An alternative explanation would be the time-varying risk premia, which documents that equity risk premia is higher at market troughs than it is at peaks (Harvey 1989)

In particular, the macro determinants investigated in this study includes stock market returns, 3-month Treasury bill yield, 10-year government bond yield and foreign exchange rate to US dollars in ten developed real estate securities markets. All of these variables are found to exert an impact on the performance of real estate securities market in earlier literature. More importantly, the frequency of these variables is reported on a daily basis, which enables us to estimate their impact on the market volatility in a GARCH framework.

To distinguish the state of real estate securities markets into boom and bust period, the Markov switching regime models are employed in this paper, which have been suggested in literature to characterize the dynamics in financial data (Ang & Bekaert 2002). Specifically, we apply Markov switching regime regression and Markov switching regime GARCH model (MS-GARCH thereafter) to model the impact of macro risk factors on both return and volatility of real estate securities markets subjected to regime changes. The Markov regime-switching models endogenously distinguish the market returns into high and low volatility so that we can assess the linkages with macroeconomic conditions in different periods.

To preview our results, asymmetric effect of macroeconomic and financial variables on real estate securities market is evident at both return and volatility levels. This effect is not consistently priced across all markets and behaves differently in periods of crisis and tranquil markets. There is, however, some similarity in the behavior of some macro risk factors. Among the factors examined, stock market risk and foreign exchange rate is in positive relation to real estate securities market returns. US dollar is an exception as the exchange rate is negatively linked to real estate securities return. It is also found that during the financial turbulent period, stock market returns, Treasury bill rate and foreign exchange rate will contribute to the volatility of the real estate securities markets, while long-term government bond rate plays a negative role. Overall, the findings of this study help explain the limited or even contrasting evidence yield from earlier literature under constant coefficient context.

We contribute to the literature in the following ways. First, unlike previous studies which distinguish market performance by positivity or negativity of returns, in this study the market states are generated by the Markov regime switching models in an endogenous way. It helps avoids the problem of subjectivity. Second, while earlier researches mostly focused on REITs in the United States, our study extensively analyzed general real estate stocks in ten developed markets in the world. The S&P securitized real estate index used in this study covers the investable universe of both REITs and property companies and is relatively more liquid and volatile than pure REITs. Thirdly, we find the asymmetric effect of various macroeconomic shocks on real estate securities is significant at both return and volatility level. It contributes to the literature by providing new evidence that macroeconomic risks may affect real estate securities returns at second conditional moments in an asymmetric way.

The remainder of this paper is structured as follows. Section 2 briefly discusses the related literature. Section 3 presents the sample data and various macro risk factors used.

Section 4 describes the settings of Markov regime-switching regression and MS-GARCH models. Section 5 presents the empirical results and conclusion follows in Section 6.

2. Literature review

Earlier works have established the link between macroeconomic variables and real estate securitized market (Chen *et al.* 1986; McCue & Kling 1994; Chen *et al.* 1997; Chen *et al.* 1998; Chandrashekaran 1999). In these works, macroeconomic variables are treated as factors in the Asset Pricing Theory context. These works successfully identify a number of state variables for real estate securities returns and their relative importance. For example, Naranjo and Ling (1997) find real per capita consumption and real Treasury bill rate are priced consistently across different real estate portfolio groups. The result also suggests that the term structure of interest rate and unexpected inflation rate are not priced constantly, but vary over time.

The old question of how stock market volatility are related to business cycles has received extensive discussion since the seminal work of Schwert (1989). In the recent finance literature, some researchers have attempted to investigate different responses of financial returns to macroeconomic news. de Goeij and Marquering (2006) conduct an analysis in the bond market and find that a negative shock from the macroeconomic variable has a greater impact on the bond volatility than a positive shock. Corradi *et al.* (2013) suggest similar findings in the stock market, where the overall volatility can be largely explained by macroeconomic factors. To seek for theoretical explanation, Mele (2007) finds that countercyclical stock volatility takes place when risk premia increases more in bad times than in good times. Therefore, investors may take different attitudes toward discounting future cash flows, resulting in asymmetric fluctuations in asset prices.

Researchers have also found that the business cycle of whether the economy is in growth or recession relates to the real estate securities market performance. When there is signal of economic contraction, the real estate market may respond negatively in face of increasing credit constraint. Ewing and Payne (2005) find that the unanticipated changes in macroeconomic factors are associated with price falls in REITs. For example, if there is suddenly a tightening monetary policy raising interest rates in the short term, it would adversely affect real estate market activity. Bredin *et al.* (2007) attempt to find if there is any asymmetric effect of unexpected monetary policy on both REIT return and volatility. The positive and negative unexpected changes are distinguished in their model, but no evidence of asymmetry emerges. To improve from this study, we condition the effect of macroeconomic variables on the performance of real estate securities markets and determine the market states by its volatility in an endogenous way.

To study the interaction of macroeconomic variables and real estate returns during market boom and bust, some real estate researchers have already employed the Markov regime switching model. As in Hamilton and Susmel (1994), low and high variance regimes estimated from Markov regime switching models usually correspond to periods of tranquil and turmoil markets, respectively. Anderson *et al.* (2012) are among the first to examine this issue using Markov regime switching model with error correction term. Their result demonstrates significant difference in the effects of unanticipated monetary policy on REIT returns between high- and low-variance regimes. Later Chou and Chen (2014) use Markov-switching regressions to identify the REIT return regimes and employ different monetary proxies. They also apply the same analysis to Australia, Japan and the UK REIT markets, where similar conclusions are found.

In this study, we improve from earlier literature in the following ways: (1) we develop Markov regime switching GARCH model with exogenous variable to examine the effect of macroeconomic variables on real estate securities returns and volatility; (2) besides interest rate, we use various other macroeconomic variables such as government bond and foreign exchange rate and study whether asymmetric effects exist; (3) we extensively study ten developed real estate securities markets around the world and examine the cross-country variation.

3. Sample Data

3.1 Overview of sample market

The sample markets include ten developed real estate securities markets globally: Australia, Hong Kong, Japan, Singapore, France, Germany, Switzerland, United Kingdom, Canada and United States. The total market capitalization of these real estate securities markets constitutes around 84 percent of real estate securities market capitalization in the world according to FTSE. The developed financial markets enable us to investigate a long range of financial and economic data. More importantly, stock markets in developed countries tend to be more responsive to changes in its fundamental economic variables, whereas the financial systems in emerging markets are subject to structural breaks due to the economic development and reform. Table 1 gives a quick glimpse of economic and financial market conditions of the sample markets.

[Insert Table 1]

To briefly discuss the sample markets in this study, the US market has the longest history of real estate securities investment as well as the most mature market structure. European real estate market is also well developed. France, Germany and the UK are the "big three" in Europe real estate markets, which are among the top five countries targets for commercial real estate investment in 2011 according to media report on REIT.com[5]. Switzerland is famous 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, Japan has a long tradition of listed real estate and plays a dominant role in Asian financial market. In Singapore and Hong Kong, the size of real estate securities markets develops rapidly in recent years and yields better performance due to favorable economic environment. Similar with the US, Australia is one of the two most matured public real estate markets, with its listed property trusts regarded as a highly successful indirect real estate investment vehicle.

[5] http://www.reit.com/news/articles/why-global-investment-us-commercial-real-estate-rising

3.2 Real estate securities market returns

To obtain empirical data for the analysis, we download financial market index and macroeconomic data from Datastream over the period of October 1994 to March 2014. Weekly format data (Thursday to next Wednesday) 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.

The real estate securities market data consists of weekly property market total return index in local currency from Standard and Poors (S&P) Index Database. 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 total return index at time t. The S&P indices have been popularly used as the benchmark of global real estate securities for investment and researches. The property price index covers a diversified universe of both REITs and global public-traded property companies that involved in real estate ownership, development or management. Compared to other measurements of global public-traded real estate securities such as FTSE EPRA/NAREIT Global Real Estate Index, S&P Global Property Index has less strict requirement of company size, which enables a wider coverage of property companies (around 40% more)[6]. As many Asian property companies are of small- or mid-cap size and are often more profitable than counterparts of larger size, this criterion makes them eligible for the index and creates large

[6] This is based on Global Real Estate Securities Benchmarks:2013 Update from PREI.

differences. Table 2 below gives a brief description of real estate securities market returns data in this study.

[Insert Table 2]

3.3 Macroeconomic risk factors

In this study, we use weekly real estate securities data in order to obtain appropriate estimation of time-varying market volatility. To be consistent, we follow earlier literature (Naranjo & Ling 1997; de Goeij & Marquering 2006) to consider macroeconomic variables such as 3-month Treasury bill yield (TB_t)[7], 10 years government bond yield (GB_t), foreign exchange rate ($\Delta \ln FX_t$) and stock market returns ($\Delta \ln ST_t$), which are available up to daily basis. Table 3 summarizes the explanatory variables, expected coefficient signs in regressions of real estate securities returns and proxies. The details of the data for each country are reported in Table A.1 in the appendix. Figure 1 plots the time series trend of the sample data for each market over time, with the total return indices of stock market and property stock market in natural logarithm to facilitate the comparison with other explanatory variables. Note from the graphs that there was a drop in the indices of real estate securities market from mid-2007 to the end of 2009, coinciding with the onset of the global financial crisis. Following the trough of real estate securities markets, the 3-month Treasury bill rate also falls substantially to almost zero level in certain markets such as Japan and United Kingdom while long-term government

[7] For some markets that are lack of 3-month Treasury bill rate data, we use the 3 month interbank rate as a proxy.

bond rate falls to a lesser extent. The foreign exchange rate generally goes in the same direction with real estate securities market, with the exception of Hong Kong which performs a linked exchange rate system. France and Germany officially switched to euro currency on 1 January 1999.

[Insert Table 3]

[Insert Figure 1]

Following prior literature, the variables considered in this study have been found to impose effects on the stock performance of real estate companies: (1) Both short-term and long-term interest rates constitute risk factors for real estate companies as they are used to discount the underlying property portfolio. They are also used as monetary policy instrument by the central banks to influence the financial market (Naranjo & Ling 1997; Peterson & Hsieh 1997). (2) Aggregate stock market movement is important signal and driver for the real estate securities market (McCue & Kling 1994; Anderson *et al.* 2012). (3) And foreign exchange risk has been of increasing concern for property companies as many of them are expanding their business abroad ((Ferson & Harvey 1994; Dumas & Solnik 1995).

4. Methodology

Theoretically, real estate securities price are the discounted present value of its future cash flows. Any factors that affect the discount rates are likely to change the present value of the real estate securities. The seminal work by Chen *et al.* (1986) gives us guidance of the possible risk factors which might exert an impact on the financial market returns. Building up on their work, we identify possible risk factors for the real estate securities market. But this has to be compromised with the weekly frequency format.

To detect the underlying changes of market regimes, it calls for the application of regime switching models proposed by Hamilton and Susmel (1994). It has been updated to a regime switching GARCH model by Gray (1996) and Dueker (1997), which this study is going to follow. In such a model, boom and bust market returns are distinguished and characterized by discrete conditional distributions so as to better capture the shifts and jumps in the volatility process.

To examine the relationship of macroeconomic variables with real estate securities market return and volatility, our empirical analysis consists of two steps: (1) a Markov regime switching regression to study the risk factors that influence real estate securities returns; (2) a Markov regime switching GARCH model with exogenous variable (MS-GARCH-X) to estimate the impact of various variables on the conditional volatility of real estate securities. In both models, the coefficients of the risk factors to real estate securities markets are allowed to be time-dependent and switch between regimes. We repeat the above two steps for the ten sample markets. Below we briefly introduce the settings of the two methodologies.

4.1 Markov regime switching regression of real estate securities market return

Our empirical analysis starts by studying the influence of macroeconomic variables on real estate securities at the return level. We first test whether real estate securities return respond to stock market return, 3-month Treasury bill rate and 10-year government bond rate in a linear setting:

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

where $\Delta \ln RE_t$ is the real estate securities market return calculated as the first difference of the natural logarithm of the price index at week t . α is the constant and β_i is the parameter for the factor loading of each of the explanatory variables. We choose the following risk factors that influence real estate securities market returns:

$\Delta \ln ST_t$: the lagged stock market returns at week t;

TB_t : 3-month Treasury bill rate at week t;

BO_t : 10-years government bond rate at week t;

$\Delta \ln FX_t$: logarithm differential in the foreign exchange rate at week t.

Following the work of and , we estimate the first difference of Treasury bill rate and government bond yield as the shock from these variables to real estate securities market.

Next we consider a Markov regime switching regression of real estate securities returns:

$$\Delta \ln RE_t = \alpha_{s_t} + \beta_{1,s_t} \Delta \ln RE_{t-1} + \beta_{2,s_t} \Delta \ln ST_t + \beta_{3,s_t} TB_t + \beta_{4,s_t} BO_t + \beta_{5,s_t} \Delta \ln FX_t + u_{t,s_t} \quad (2)$$

where u_{t,s_t} follows the distribution of $N\left(0, \sigma_{S_t}^2\right)$. s_t is a Markov chain with 2 states and transition probability matrix P. So in this regime switching model, each regime is characterized by a distinct conditional normal distribution:

$$\Delta \ln RE_t = \begin{cases} \mu_0 + \Sigma_0 \varepsilon_t & \text{if } s_t = 0 \\ \mu_1 + \Sigma_1 \varepsilon_t & \text{if } s_t = 1 \end{cases} \quad (3)$$

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

$$P = \begin{bmatrix} P_{00} & 1 - P_{11} \\ 1 - P_{00} & P_{11} \end{bmatrix} \quad (4)$$

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

$$\beta_{i,S_t} = \beta_{i,0} \left(1 - S_t\right) + \beta_{i,1} S_t \quad (5)$$

The unobserved state variable S_t takes the value of either 0 or 1, which indicates bust and boom stage of real estate securities market. α_{S_t} and σ_{S_t} is the state-dependent mean and standard deviation of $\Delta \ln RE_t$, respectively.

Overall, this model tests hypothesis that real estate securities return responds different to the risk factors depending on the state of the real estate securities markets.

4.2 Markov regime switching GARCH model with exogenous variables

In order to model the state-dependent effect of macroeconomic variables on real estate securities volatility, we employ a switching regime GARCH model with exogenous variable in the variance equation. A Markov switching model governs the change between different variance regimes so that in each regime, the variance is expressed by a unique GARCH process. In order to examine the influence of external variables on the conditional variance, we follow the traditional GARCH-X model and introduce an exogenous variable in the variance equation to control for the effect. In our switching regime context, however, the effect is not constant over the sample period, but conditioning on the current stage of the market. This methodology is designed to capture the asymmetric response of real estate securities performance to economic market condition changes. The following of this section will start by explicitly explaining the setup of the MS-GARCH model:

The difference between MS-GARCH model and GARCH model is that, while GARCH model assumes an ARMA process of volatility, the MS-GARCH model keeps same structure for volatility, but allows the possibility of sudden jumps between two market states. It is recently becoming popular in finance literature because it can well deal with volatility persistency and determines the market states endogenously. A simple illustration of the model is as follows:

$$\Delta \ln RE_t = \mu_t + \varepsilon_t \tag{6}$$

where ε_t ~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 μ_t is allowed to switch according to a Markov process governed by a state variable S_t, indicating good time when $S_t = 1$ and bad times when $S_t = 0$.

$$\mu_t = \mu_l + \mu_h (1 - S_t) \tag{7}$$

$$h_t^{(j)} = \gamma + \frac{\alpha}{g(S_{t-1} = j)} (\varepsilon_{t-1}^{(j)})^2 + \beta \hat{h}_{t-1} + \lambda \times z_t (S_{t-1} = j) \times X_t^{(j)} \tag{8}$$

The regime-dependent conditional variance is given by equation (4), 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 $\lambda \bullet z_t$, the latter of which is allowed to switch between different states. We replace the exogenous variable $X_t^{(j)}$ with $\Delta \ln ST_t$, TB_t, BO_t and $\Delta \ln FX_t$ to examine their respective effect on the conditional variance h_t.

The initial probability of being in regime i is given by $\Pr(S_1 = i) = p_i$ where S_1 is the first regime in the Markov chain. The transition probability between state 1 and 0 is given by:

$$P = \begin{bmatrix} P_{00} & 1 - P_{11} \\ 1 - P_{00} & P_{11} \end{bmatrix} \quad (9)$$

To emphasize, the probability of being in state j is determined by the time-varying performance of the dependent variable, but not the exogenous ones, which distinguish this study from many previous ones.

5. Empirical result

To study the response of real estate securities return to external shocks, we include in our study changes in stock market, term structure and foreign exchange rate as possible risk factors. The initial result, reported in Table 4, is from a single regime (linear) perspective, while Table 5 reports the estimated results from a regime-switching regression of equation (1). The reported coefficient corresponds to the β_{i,S_t} s in equation (1) of the state variables. Comparing the result of the two tables, we have the following observations:

(1) The stock market returns affect real estate securities returns significantly in both good and bad market states. The magnitude of impact is much larger during the downside market, with Hong Kong and Japan as an exception where the coefficients are fairly close between two regimes. The Wald test with null hypothesis $H_0 : \beta_{i,1} = \beta_{i,0}$ is significantly rejected for all markets except Hong Kong and Japan. It implies that when real estate securities market is turmoil, stock market return will impose a higher impact on the real estate securities market ($\beta_{2,0} > \beta_{2,1}$).

(2) The 3-month Treasury bill rate is not consistently priced in our ten sample markets. The negative signs of the estimated coefficients β_3 of Australia, Germany and Canada in Table 4 show that an increase in the 3-month Treasury bill rate will lead to falls in real estate securities returns. However, in the regime-switching setting, the statistical significance of 3-month Treasury bill rate disappears in Australia, while in Germany and Canada the significant impact only holds in the high volatility regime and the magnitude (in absolute value) much larger than linear estimation.

(3) As for the 10-year government bond, the response of real estate securities is only significant in Australia and Germany in the linear specification with a positive sign. This is consistent with general expectation that stock market, including real estate securities market, displays a negative relationship with bond price, and thus is positively related to bond yield. In the regime-switching regressions, however, we find that the impact of government bond yield remains silent for all markets during periods of market turbulence (high volatility regime). This result is supported by earlier literature which does not find statistical significant relationship between the two asset returns (Liu & Mei 1992; Naranjo & Ling 1997).

(4) The sensitivity of real estate securities return to foreign exchange risk also varies between good and bad states. The sign of the estimated coefficients is consistent with our expectations, as the positive exchange risk (currency appreciation) will lead to the inflow of capital, and thus contribute to the boom of the financial

market. The US market is an exception where the coefficient is significantly negative in the whole sample period and in low volatility regime. For the US market, this finding is not surprising as the US dollar is considered as "safe-haven" currencies for investors, which displays a negative relation with the stock market. Therefore, when the stock market turns risker, the US dollar will appreciate.

[Insert Table 4]

[Insert Table 5]

To ascertain that the coefficients between two regimes reported in Table 5 are significantly different from each other, we use the Wald test statistics to test if there is any switch in the beta coefficients. The null hypothesis is strongly rejected for the stock market factor for most markets, which suggests that the effect of stock market changes on these real estate securities markets is not equal across regimes. However, as shown in the result, the reaction to Treasury bill rate and government bond rate shows almost non-variation across regimes. Overall, the result is in favor of inequality in return reaction to financial variables (stock and foreign exchange rate changes) during different volatility regimes, though the extent varies in different markets. In this regard, previous literature which overlooked the market condition might result in biased conclusion on the response of real estate securities market to the risk factors.

[Insert Table 6]

The log-likelihood ratio test is also applied to compare if the switching-regime model fits significantly better than the single-regime model. The log-likelihood value along with the test statistics are reported in In Table 7. As can be seen, the statistics all reject the null model in favor of the alternative regime switching one at 1% significance level. Though the LR test does not exactly follow a χ^2 distribution, the large test statistics still reveal that rejection of the null hypothesis is highly significant[8].

[Insert Table 7]

Next we estimated the response of real estate securities market to changes of economic and financial variables at the volatility level. Table 8 reports the estimated state-dependent coefficient of the exogenous variable *m* in the regime switching GARCH model in equation (8)[9]. The variable is replaced with stock market return ($\Delta \ln ST_t$), 3-month Treasury bill rate (TB_t), 10-year government bond rate ΔBO_t and foreign exchange change ($\Delta \ln FX_t$) in the respective market. Similar with previous analysis, S_1 indicates the up real estate securities market with high return and low volatility, while S_0 refers to the down real estate securities market with low return and high volatility.

Based on the result, the significant response of real estate securities is more evident when the real estate securities market is in the high volatility regime. And the magnitude of the response, measured by the absolute value of the coefficient, is much larger during the

[8] As suggested by Gray (1996) and Garcia (1998), the parameters in the switching-regime model are not identified under the null hypothesis, so the asymptotic distribution of the likelihood ratio test is non-standard.

[9] To keep brevity, we do not report the result from standard GARCH-X model, but is available upon request.

bust-market period. It implies that macro risk factors are more effective to influence the real estate securities market when it is highly turbulent. Another interested question raised would be if these state variables contribute to the volatility of the real estate securities market, especially during the high volatility regime? For the stock market returns reported on the first row of Panel B, the negative signs suggest that during market recessions, a drop in the stock market return would increase the real estate securities markets volatility. Second, the result of 3-month Treasury bill rate indicates a significant positive impact on the conditional volatility of real estate securities market, which is also in line with our expectations that an increase in the short-term interest rate would lead to high market volatility. Moreover, the negative signs observed in 10-year government bond rate in relation to property stock market volatility is consistent with theory. As explained in the "flight-to-quality" phenomenon, during periods of stock market uncertainty, the stock price and bond price (opposite to bond yield) display negative relationships as investors will rebalance their portfolio and shift to less risky bond markets. As a result, the government bond yield will fall during market turbulent times. Finally, the foreign exchange rate is also found to contribute to real estate securities market volatility during bust market period. As the foreign exchange rate in Hong Kong is strictly regulated and there remains slight variations over the years, the estimated result does not truly unveil its self-adjustment to real estate securities market changes.

[Insert Table 8]

Similar with previous analysis, Table 9 presents the test statistics for the equality of state-dependent coefficients. As shown in the result, the asymmetric response to real estate securities volatility does not exist constantly across all markets, but it is more evident than the result at return level, especially for the interest rate variables.

[Insert Table 9]

6. Conclusion

Real estate securities price equilibrium is often exposed to economic conditions that cause non-diversifiable risk for investors. Although macroeconomic factors are theoretically important drivers for real estate securities market returns, empirical works often found scarce or contrasting evidence of real estate securities market responses to economic risk factors. Some researchers have pointed out that these risk factors may exert different impact on real estate securities market between market bust and boom period. Therefore it could lead to biased result by examining overall sample period under a constant coefficient modelling. In this article we seek to identify the asymmetric response of real estate securities to a number of macroeconomic and financial risk factors by examining simultaneously the impact of these factors on level and conditional volatility of weekly returns. To distinguish the performance of real estate securities market into good and bad market states, we employ different types of Markov regime switching models. In this way we identify possible risk factors that may either affect returns or conditional volatility in different market states.

To summarize our result, we show that risk factors indeed exert an asymmetric impact on real estate securities at both return and volatility level. However, they are not consistently priced across all the sample markets. An increase in returns of stock market and foreign exchange rate leads to higher returns and conditional volatility in real estate securities markets, and for most sample markets this positive relation is magnified in volatile period. In contrary, the Treasury bill and government bond rate show almost no significant impact on real estate securities market at the return level. Notwithstanding their silence for the market returns, they are positively and negatively related to conditional volatility of real estate securities market in high volatility regime, respectively. The foreign exchange risk is also found to contribute to real estate securities volatility in the bust market period.

The findings of this study suggest new direction for researches on the interaction between real estate securities and market risk factors. Previous linear perspective might be no longer effective to detect such relation as it might vary as the market regime changes. This research also gives guidance for both investors and policy makers. For investors, it may indicate good diversification values to allocate their assets. The investors should pay special attention to a factor if it is priced in the current market stage. For policy makers, this study offers implication for them to control for market risk and make policies in accordance with the market performance.

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Table 1 Overview of sample market conditions in year 2011

	AU	HK	JP	SG	FR	GR	SW	UK	CA	US
Panel A. Main economic indicators										
GDP per capita	67556	36796	46720	51709	39772	41863	78925	39093	52219	51749
Inflation	1.8	4.1	-0.0	4.5	2.0	2.0	-0.7	2.8	1.5	2.1
Unemployment	5.2	3.3	4.3	2.8	9.9	5.4	4.2	7.9	7.2	8.1
Real interest rate	4.7	1.1	2.3	3.2	-2.0	-1.4	2.6	-1.2	1.3	1.5
Panel B. Main financial Indicators										
Market capitalization of list companies (Billion$)	1286	1108	3681	414	1823	1486	1079	3019	2016	18668
Money and quasi money growth (YoY%)	7.1	7.8	2.2	7.2	1.1	-0.9	13.0	0.8	4.8	4.9
S&P global equity indices (YoY%)	15	22.6	18	28.9	15.2	27	18.1	5.8	6.0	13.4

Notes: data is sourced from World Bank Database

Table 2 **Summary statistics for real estate securities market returns**

	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***
GR	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	12721.59***
US	0.18	3.25	30.11	-39.50	-1.72	38.90	56896.97***

Notes: All price returns are taken logarithm differentials and in local currency. ***, ** and * indicates significance level at 1%, 5% and 10%.

Table 3 **Explanatory variables in the model**

Variable	**Expected sign**	**Proxy**
$\Delta \ln ST_t$	+	Weekly change of S&P BMI total return index (%)
TB_t	-	3-month Treasury bill yield (%)
BO_t	-	10-year Government bond yield (%)
$\Delta \ln FX_t$	+/-	Weekly change of foreign exchange rate with US (%)

Table 4 **Single regime regression result**

	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:

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

The statistics in the brackets are standard errors for the estimated coefficients. ***, ** and * indicates significance level at 1%, 5% and 10%.

Table 5 **Markov regime switching regression result**

	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_0	-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: The coefficients reported are based on the following regression:

$$\Delta \ln RE_t = \alpha_{S_t} + \beta_{1,S_t} \Delta \ln RE_t + \beta_{2,S_t} \Delta \ln ST_t + \beta_{3,S_t} TB_t + \beta_{4,S_t} BO_t + \beta_{5,S_t} \Delta \ln FX_t + u_{t,S_t}$$

$S_t = 1$ indicates market state of low volatility and high return, and $S_t = 0$ indicates market state of high volatility and low return. P_{11} represents 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 * indicates significance level at 1%, 5% and 10%.

Table 6 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 * indicates significance level at 1%, 5% and 10%.

Table 7 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 $\chi^2\left(df2 - df1\right)$ distribution. In our setting, df is the free parameters of two models and $df2 = 12$, $df1 = 6$.
***, ** and * indicates significance level at 1%, 5% and 10%.

Table 8 Markov regime switching GARCH model with exogenous variable

	AU	HK	JP	SG	FR	GE	SW	UK	CA	US
Panel A: Low volatility regime with high return										
$\Delta \ln ST_t$	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)
TB_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)
BO_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 with low return										
$\Delta \ln ST_t$	-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)
TB_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)
BO_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)	(4.369)	(1.665)	(2.363)	(0.330)	(0.139)	(1.400)	(1.153)
$\Delta \ln FX_t$	-2.225	7.265***	-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 $z_t\left(S_t = j\right)$ from the following regression:

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

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

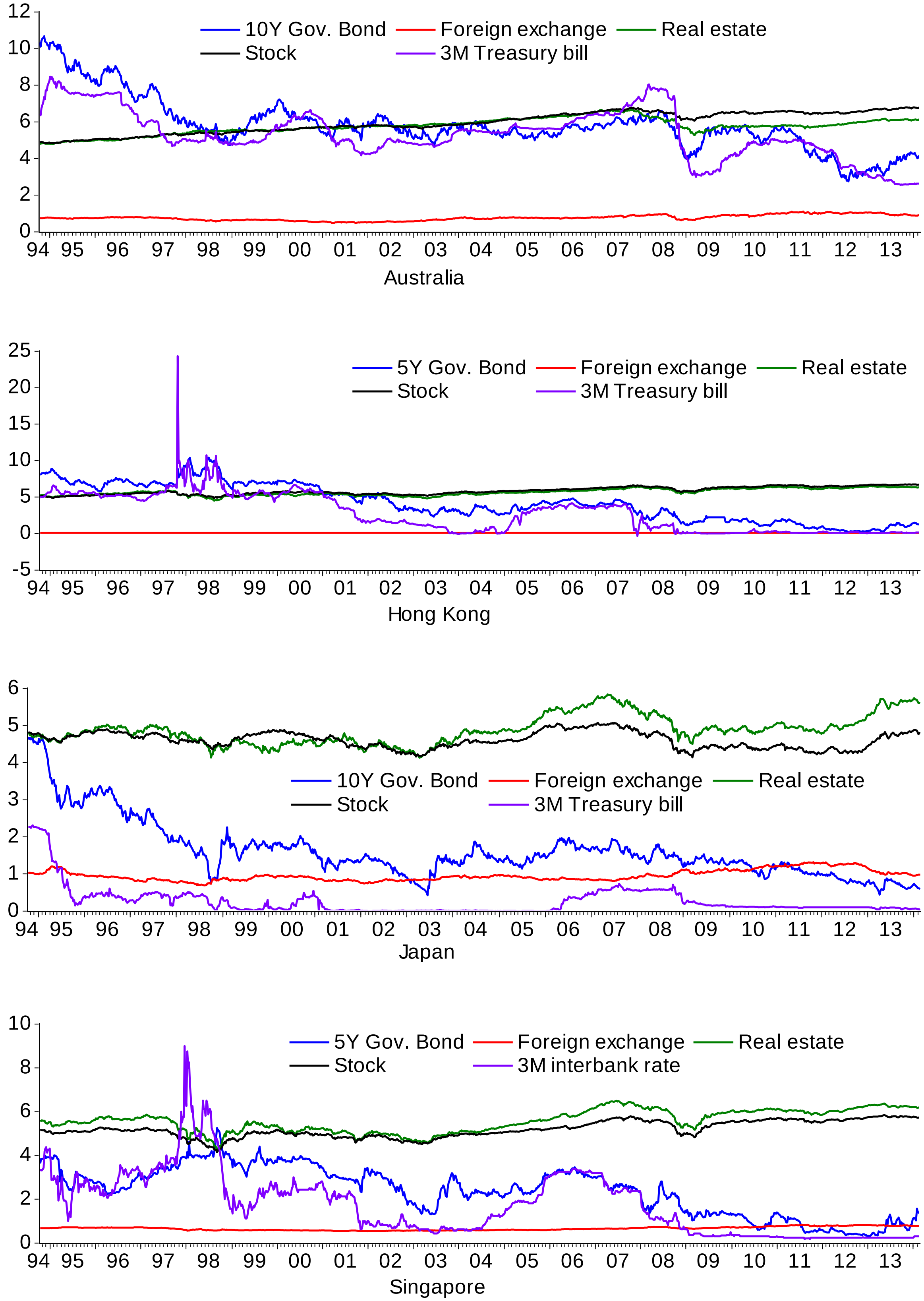
where $X_t^{(j)}$ represents stock market return ($\Delta \ln ST_t$), 3-month Treasury bill rate (TB_t), 10-year government bond rate (BO_t) and foreign exchange rate ($\Delta \ln FX_t$). $S_t = 1$ indicates market state of low volatility and high return, and $S_t = 0$ indicates market state of high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

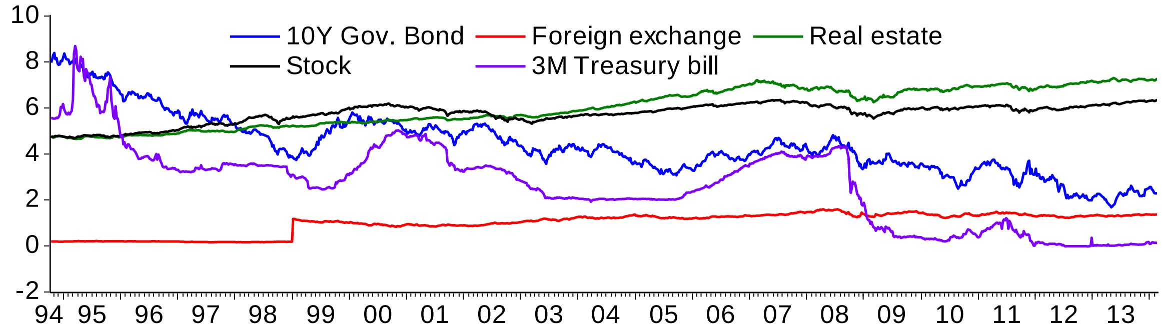
Table 9 Test of the null hypothesis of no switch in the coefficients

$H_0 : \beta_{i,1} = \beta_{i,0}$	ST_t	TB_t	BO_t	FX_t
AU	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

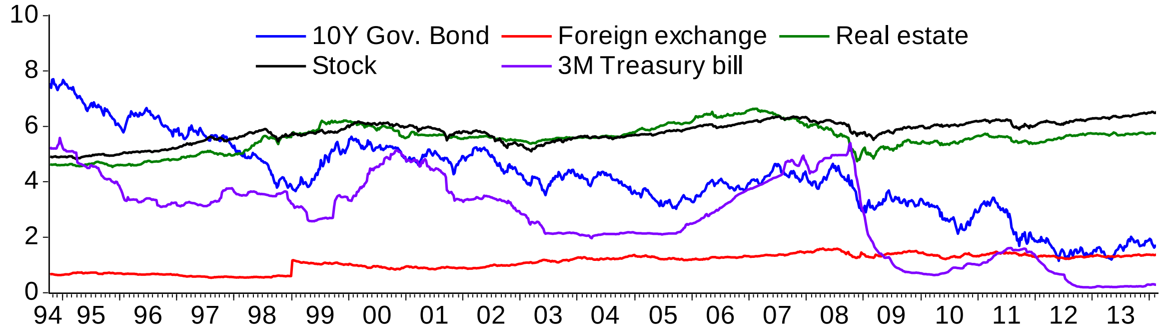
Notes: the statistics reported are for Wald test which is asymptotically $\chi^2(2)$.
***, ** and * indicates significance level at 1%, 5% and 10%.

Figure 1 Time series plot of sample data

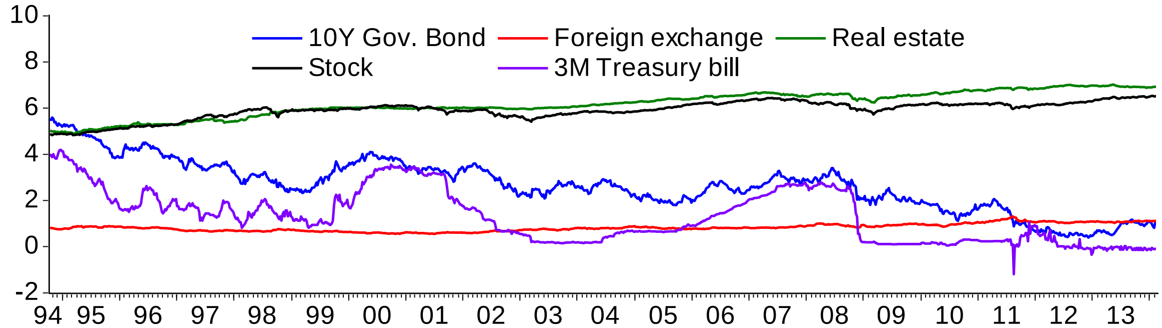




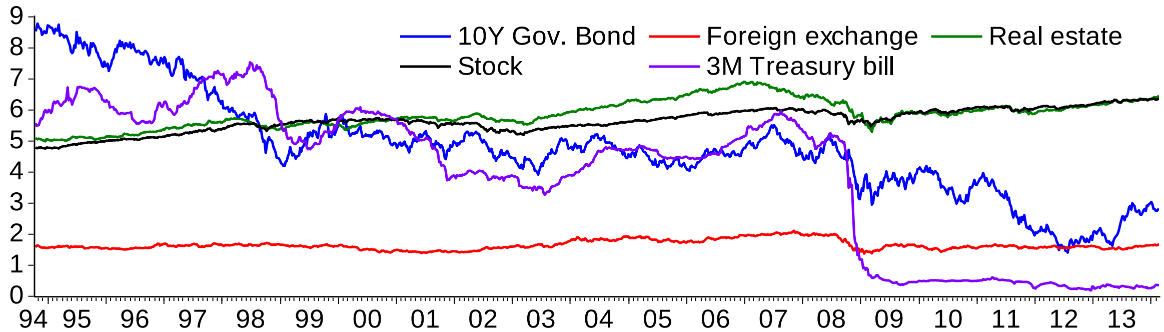
France



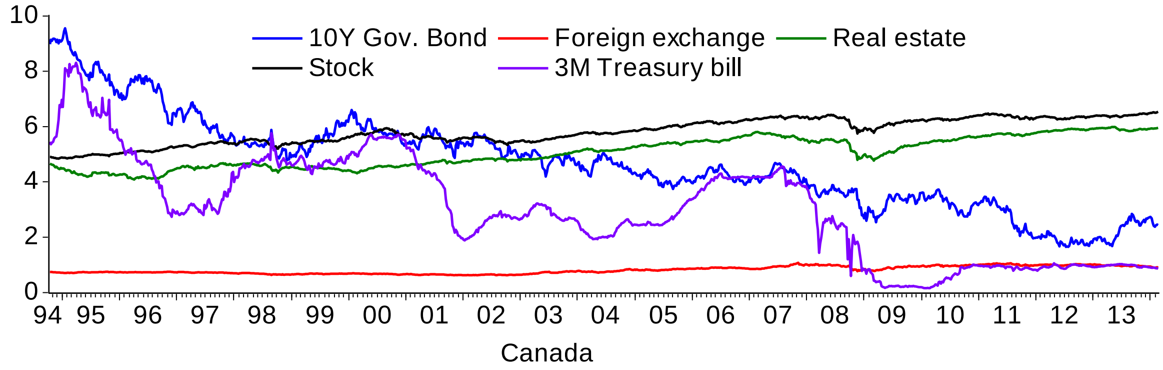
Germany

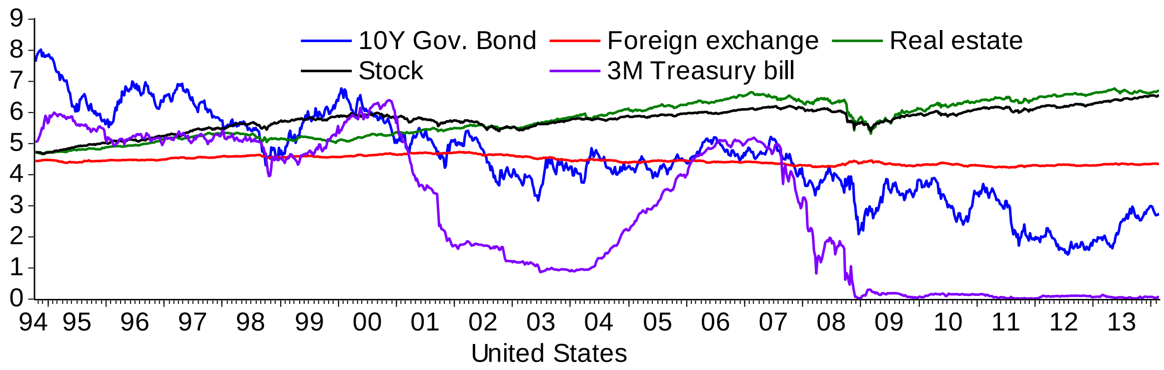


Switzerland



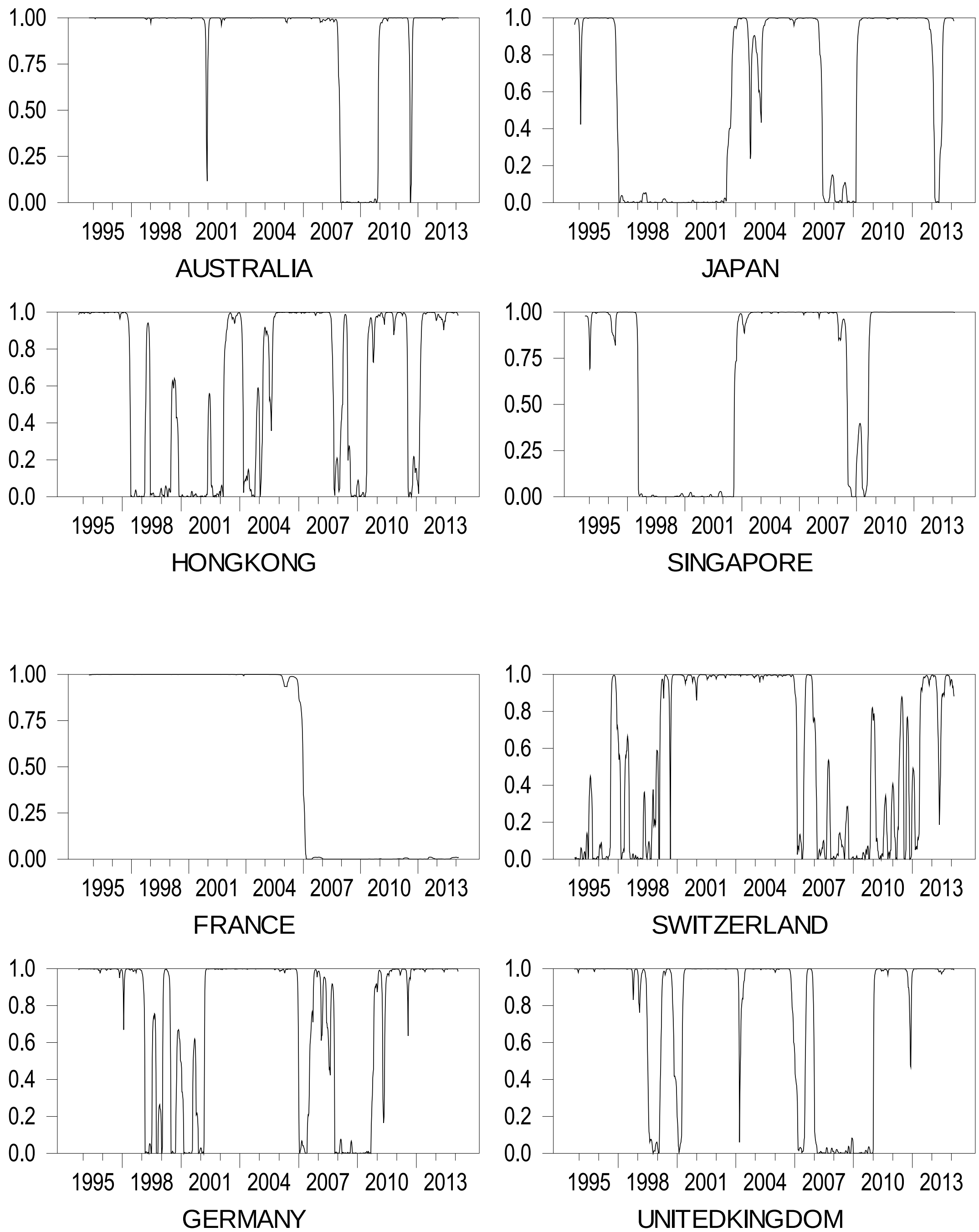
United Kingdom

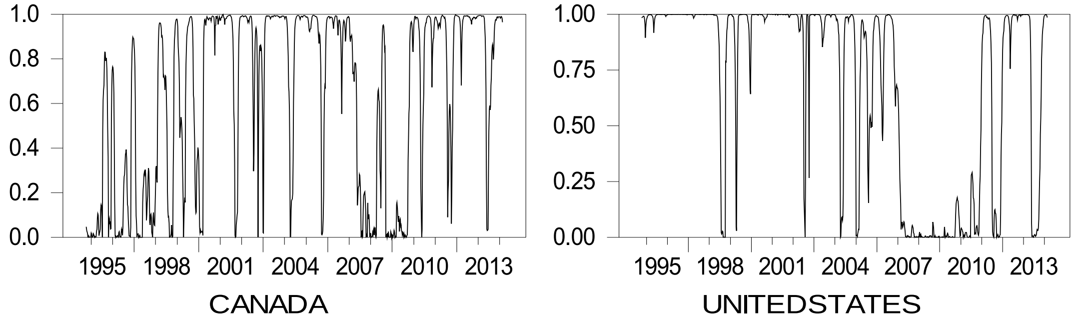




Notes: The total return indices of stock market and real estate securities market are in natural logarithm form.

Figure 2 Smoothed probability of regime switching regressions




1.0
0.8
0.6
0.4
0.2
0.0
1995 1998 2001 2004 2007 2010 2013
CANADA
1.00
0.75
0.50
0.25
0.00
1995 1998 2001 2004 2007 2010 2013
UNITEDSTATES

Appendix

Table A-1 Description of financial market returns and economic variables

Market	Definition
	Property returns
All markets	S&P PROPERTY - TOT RETURN INDEX
	Stock returns
All markets	S&P BMI - TOT RETURN INDEX
	3-month Treasury bill rate
Australia	AUSTRALIA DEALER BILL 90 D - MIDDLE RATE
Hong Kong	HONG KONG EXCHANGE FUND BILL 3 MTH - RED. YIELD
Japan	JAPAN FINANCING BILL 3 MONTH - RED. YIELD
Singapore	SINGAPORE T-BILL 3 MONTH - MIDDLE RATE
France	FRANCE TREASURY BILL 3 MONTHS - BID RATE
Germany	GERMANY INTERBANK 3 MONTH - OFFERED RATE
Switzerland	SWISS INTERBANK 3M (ZRC:SNB) - BID RATE
United Kingdom	UK TREASURY BILL TENDER 3M - MIDDLE RATE
Canada	CANADA TREASURY BILL 3 MTH. (BOC) - MIDDLE RATE
United States	US TREASURY BILL 3M (FT) (DISC) - MIDDLE RATE
	10 year Government bond rate
Australia	AUSTRALIA BENCHMARK BOND 10 YR (DS) - RED. YIELD
Hong Kong	HONG KONG EXCHANGE FUND NOTE 10 YR - RED. YIELD
Japan	JAPAN BENCHMARK BOND -RYLD.10 YR (DS) - RED. YIELD
Singapore	SINGAPORE T-BOND YIELD 10 YEAR - MIDDLE RATE
France	FRANCE BENCHMARK BOND 10 YR (DS) - RED. YIELD

Germany	GERMANY BENCHMARK BOND 10 YR (DS) - RED. YIELD
Switzerland	SWITZERLAND BNCHMRK. BOND 10 YR (DS) - RED. YIELD
United Kingdom	UK BENCHMARK BOND 10 YR (DS) - RED. YIELD
Canada	CANADA BENCHMARK BOND 10 YR (DS) - RED. YIELD
United States	US TREAS.BENCHMARK BOND 10 YR (DS) - RED. YIELD
	Foreign exchange rate
Australia	US $ TO AUSTRALIAN $ (WMR) - EXCHANGE RATE
Hong Kong	US $ TO HONG KONG $ (GTIS/TR) - EXCHANGE RATE
Japan	US $ TO 100 JAPANESE YEN (GTIS/TR) - EXCHANGE RATE
Singapore	US $ TO SINGAPORE $ (GTIS/TR) - EXCHANGE RATE
France	US $ TO FRENCH FRANC (GTI'DEAD' - EXCHANGE RATE
Germany	US $ TO GERMAN MARK (GTIS'DEAD' - EXCHANGE RATE
Switzerland	US $ TO SWISS FRANC (GTIS/TR) - EXCHANGE RATE
United Kingdom	US $ TO UK £(WMR) - EXCHANGE RATE
Canada	US $ TO CANADIAN $ (GTIS/TR) - EXCHANGE RATE
United States	US $ MAJOR CURRENCY MAR 73=100 (FED) - EXCHANGE INDEX

Notes: Weekly data are obtained from the Datastream.