The Dynamics of Housing Returns in Singapore: How Important are the International Transmission Mechanisms?

Kuang Liang Chang and Nan Kuang Chen and Charles Ka Yui Leung

National Chiayi University, National Taiwan University, City University of Hong Kong

2011

The Dynamics of Housing Returns in Singapore: How Important are the International Transmission Mechanisms?*

Kuang-Liang Chang, Nan-Kuang Chen, and Charles Ka Yui Leung †

This version: March 2011

Abstract

This paper studies the dynamics of housing returns in Singapore. We first extract the movements of Singapore's economic aggregates that are free from foreign (U.S. and rest of the world) factors, and then examine the determinants of its housing returns. We find that both the domestic variables (such as GDP growth rate, volume of international trade, and exchange rate) and U.S. variables (such as the Federal Fund Rate and the External Finance Premium) are important during the

*Acknowledgement: We are grateful to Yongheng Deng, Min Hwang, Fred Kwan, Sau Kim Lim, Dan McMillen, John Quigley, Isabel Yan, Matthew Yiu for discussion in different occasions, seminar participants at the Bank of International Settlements, City University of Hong Kong, National University of Singapore, for many useful comments and suggestions, and the National Science Council (Chen) for financial support. Edward Tang provides excellent research assistance. The work described in this paper was partially supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China [Project No. CityU 144709]. The usual disclaimer applies.

†Chang: Department of Applied Economics, National Chiayi University, 580 Sinmin Road, Chiayi City 60054, Taiwan. TEL: 886-5-2732852, E-mail: klchang@mail.ncyu.edu.tw. Chen: Department of Economics, National Taiwan University, 21 Shuchow Road, Taipei 10021, Taiwan. TEL: 886-2-2351-9641 ext. 471, E-mail: nankuang@ntu.edu.tw. Leung: Department of Economics and Finance, City University of Hong Kong, Kowloon Tong, Hong Kong. TEL: 852-2788–9604; Fax: 852-2788-8806; E-mail: kycleung@cityu.edu.hk.

boom regime. The bust regime is very different. Directions for future research are discussed.

Key words: house price, international transmission mechanism, regime-switching, regime-dependent response, two-stage procedure.

JEL classification: E30, F40, G10

1 Introduction

Real estate markets played important role in recent crises, including the Asian financial crisis (AFC hereafter) in the late 1990s and the global financial crisis of 2007-09 (GFC hereafter).[1] Academics and policy makers are thus very eager to answer the following questions. (1) What determines the real estate prices? (2) How can the real estate cycles be predicted? (3) What and can government policies do to "stabilize" real estate cycles, and how can they do it? To address these questions is clearly a non-trivial task for large economies such as the United States.[2] It may be even more difficult for small economies, as they are subject to shocks from the domestic economy as well as from the rest of the world.

This paper attempts to shed light on these questions by studying the Singaporean housing market. Several justifications are in order. First, Singapore experienced the AFC and resumed economic growth soon after.[3] This enables us to study the "mean-reversion" behavior of the economy and the asset markets. Second, consistent with casual observations, previous studies have confirmed that the Singaporean economy is significantly affected by external shocks.[4] Third, some recent studies suggest that there is a "balance sheet channel" for a shock to propagate in the Singaporean macro-economy, as well as those of other Asian countries.[5]

In addition, the specific approach of this paper will complement existing studies on

[1]The literature on the cause of the AFC is too large to be reviewed here. Among others, see the review of Burnside, Eichenbaum and Rebelo (2001), Corsetti, Pesenti and Roubini (1998), Mera and Renaud (2000) and the reference therein.

[2]Clearly, it is beyond the scope of this paper to review that literature. Among others, see Bossaerts and Hillion (1999), David and Fagan (1997), Estrella (2005), Estrella and Hardouvelis (1991), Estrella and Mishkin (1997), Menzly, Santos and Veronesi (2004).

[3]Among others, see Tse and Leung (2002), Devereux (2003).

[4]Among others, see Abeysinghe (1998), Cheung and Yuen (2002), Mackowiak (2007), Meng (2003).

[5]"Balance sheet channel" includes "maturity mismatch risk," "currency mismatch risk," "capital strcture mismatch risk," etc. The theoretical analysis of "balance sheet channel" can be found in Aghion et al (2004), Bernanke and Gertler (1989), Bernanke, Gertler and Gilchrist (1999), Kiyotaki and Moore (2002), among others.

Several studies emphasize the validity of the balance sheet channel in the Asian economies. Among others, see Allen et al (2002), Chen et al (2006), Krugman (1999).

Singapore. Existing studies on the Singaporean macro-economy typically ignore real estate market and existing studies on the Singaporean real estate market tend to take a micro-approach.[6] As a result, the dynamic interactions between the real estate market and the aggregate economy are under-explored. This paper joins this emerging literature by taking a macro-econometric approach. In particular, it takes a regime-switching structural vector-regressive (RS-SVAR) approach. Our choice of econometric modeling reflects our vision on how U.S. and other external factors and the Singapore macroeconomy may have complicated interactions within the Singaporean housing market. Figure 1 provides an oversight of that vision. First, the U.S. factors are expected to affect the Singaporean macro-economy, as confirmed by several previous studies. The macro-economic variables may have some complicated interactions among themselves. They will then affect the housing market. This is the indirect channel. The direct channel would clearly be the U.S. factors directly affecting the Singaporean housing market.

To implement these complicated interactions, this paper will take a two-stage approach. The first stage is to estimate how the U.S. factors and the world oil price affect the Singaporean macro-economy. The second stage is to estimate how the Singaporean macro-economy and other external factors affect housing returns in Singapore. We will provide more details in the next section.

(Figure 1 about here)

It should be noted that our empirical approach is in line with recent studies of the housing market and financial markets. First, the regime-switching nature of our econometric model is clearly inspired by a series of papers, including those of Amisano and Tristani (2009), Chen and Leung (2008), Maheu and McCurdy (2000), Sargent, Williams and Zha (2006). Sims and Zha (2006), among others. As we do not know a priori *which part of the model* will displace regime-switching, we consider several specifications and examine their performance. Our choice of using the VAR approach is motivated by the

[6] It is beyond the scope of this paper to review that literature. Among others, see Ong (2008).

fact that the reduced form of a dynamic, stochastic general equilibrium model (DSGE) can typically be represented by a VAR model,[7]. Third, there is increasing evidence of non-trivial dynamics among the macroeconomic variables, real estate variables and financial variables.[8] Our empirical model thus includes both macroeconomic variables and financial variables and studies how they affect the housing market.

Our paper also complements a recent study by Hwang and Lum (2009) (HL hereafter). HL extends the GMM approach advocated by Hansen (1982), and estimates the codependent dynamics of housing and stock market returns in Singapore. As the GMM approach begins with the dynamic optimization of a representative agent, it enables HL to provide a nice structural interpretation of the parameters. This paper, in contrast, takes a structural VAR approach, interpreting that as the reduced form dynamics of a DSGE model. In particular, the regime-switching approach of this paper allows for the possibility of a regime-dependent response of housing returns to the stock market return and other macroeconomic variables, which is confirmed in our estimation. The approach of this paper also allows us to separate the direct impact from the impact of U.S. factors on the Singaporean housing market, and from their indirect counterparts that translate through the Singaporean macro-economy. Clearly, the two papers have very different foci and should be interpreted as complementary.

The structure of this paper is simple. The next section explains in detail the estimation strategies and the empirical models, and is followed by a section that describes the data. The results are then presented. The final section concludes the paper.

[7]Among others, King, Plosser and Rebelo (2002), Lubik and Schorfheide (2003, 2004), Smets and Wouters,(2007) show that the reduced form of a DSGE model can be *approximated by VAR models in general*. With *additional assumptions*, Kan et al (2004), Leung (2007) show that the reduced form of a DSGE model with asset markets can be *exactly represented by a VAR*.

[8]Among others, see Chang, Chen and Leung (2010a, b), Christiano, Motto and Rostagno (2007), Davis (2010), Goodhart and Hofmann (2007), Jaccard (2009), Leung (2004), Sims (1980a, b), Tsatsaronis and Zhu (2004) and Yosihda (2008).

2 Estimation Strategies and the Empirical Models

2.1 Stage One: Extracting Economic Aggregates Free from Foreign Effects

Our empirical investigation has two stages. As we want to separate the influence of external and internal factors on the Singaporean housing market, our first task is to extract the movements of Singaporean aggregate variables net of the effects from the U.S. and the rest of the world. Specifically, we obtain the residuals $\widetilde{X}_t^s$ by estimating the following $VAR(m)$ model:

$$X_t^s = A_0 + \sum_{i=1}^{m} A_{1i} X_{t-i}^{us} + \sum_{j=1}^{m} A_{2j} x_{t-j}^{w} + \widetilde{X}_t^s, \ \ i, j = 1, 2, 3, \tag{1}$$

where $X_t^s = [x_{1t}^s, x_{2t}^s, x_{3t}^s, x_{4t}^s]'$ is the vector of Singapore's growth rate of real GDP, real stock return, growth rate of real amount of trade, and growth rate of nominal exchange rate; $X_t^{us} = [x_{1t}^{us}, x_{2t}^{us}, x_{3t}^{us}, x_{4t}^{us}, x_{5t}^{us}]'$ is the vector of the U.S. growth rate of real GDP, real stock return, federal funds rate (FFR), the external finance premium (EFP), and the TED spread; x_t^w represents the effects from the rest of the world: change rate of oil price; $\widetilde{X}_t^s$ is the vector of residuals; and A_0 is a 4×1 vector, A_{1i} is a 4×5 vector, and A_{2j} is a 4×1 vector:

$$A_0 = \begin{bmatrix} a_{01} \\ a_{02} \\ a_{03} \\ a_{04} \end{bmatrix}, A_{1i} = \begin{bmatrix} a_{1i,11} & a_{1i,12} & a_{1i,13} & a_{1i,14} & a_{1i,15} \\ a_{1i,21} & a_{1i,22} & a_{1i,23} & a_{1i,24} & a_{1i,25} \\ a_{1i,31} & a_{1i,32} & a_{1i,33} & a_{1i,34} & a_{1i,35} \\ a_{1i,41} & a_{1i,42} & a_{1i,43} & a_{1i,44} & a_{1i,45} \end{bmatrix}, A_{2j} = \begin{bmatrix} a_{2i,11} & a_{2i,12} & a_{2j,1} \\ a_{2i,21} & a_{2i,22} & a_{2j,2} \\ a_{2i,31} & a_{2i,32} & a_{2j,3} \\ a_{2i,41} & a_{2i,42} & a_{2j,4} \end{bmatrix}.$$

According to Chang, Chen and Leung (2010b), this set of U.S. variables performs well in predicting the joint dynamics of the U.S. housing and stock returns. Limited by data availability, we can only allow the length of lag in X_t^{us} and x_t^w to be $m = 3$. Note that the resulting measure of Singapore's economic aggregates, $\widetilde{X}_t^s$, should be orthogonal to X_{t-i}^{us} and x_{t-j}^w. We can then proceed to stage two.

2.2 Stage Two: The Dynamics of Singapore's Housing Returns

In stage two, we estimate how housing returns are influenced by the domestic aggregate variables ($\widetilde{X}_t^s$), the U.S. factors (X_t^{us}), the oil price (x_t^w), and its own lag (h_{t-k}^s, $k = 1, 2, ...$). Specifically, we estimate the following dynamic equation,

$$h_t^s = B_0(\omega_t) + B_1'(\omega_t)\widetilde{X}_t^s + B_2'(\omega_t) X_t^{us} + b_3(\omega_t) x_t^w + \sum_{k=1}^{p} d_k(\omega_t) h_{t-k}^s + \varepsilon_t, \tag{2}$$

where $\varepsilon_t \sim N(0, \sigma^2)$, $B_1'(\omega_t)$ is a 1×4 vector, and $B_2'(\omega_t)$ is a 1×4 vector. The Markov switching process relates the probability that regime j prevails in t to the prevailing regime i in $t-1$, $Pr(\omega_t = j \mid \omega_{t-1} = i) = P_{ij}$. The transition probabilities are assumed to be fixed and the transition matrix of the Singaporean economy is given by:

$$P = \begin{pmatrix} P_{11} & 1 - P_{22} \\ 1 - P_{11} & P_{22} \end{pmatrix} = \begin{pmatrix} \frac{\exp(a_1)}{1+\exp(a_1)} & \frac{1}{1+\exp(a_2)} \\ \frac{1}{1+\exp(a_1)} & \frac{\exp(a_2)}{1+\exp(a_2)} \end{pmatrix},$$

where a_1 and a_2 are parameters to be estimated.

As the state of the economy is *unobservable*, we identify the regime for given a time period by the Hamilton (1994) smoothed probability approach, in which the probability of being state ω_t at time t is given by $\pi(\omega_t \mid \Omega_T)$. Given that we assume the state of nature shifts between two regimes in both economies, i.e., $\omega_t \in S = \{1, 2\}$, we identify the economy most likely to be in state j if $\pi(\omega_t = j \mid \Omega_T) > 0.5$, $j = 1, 2$.

A merit of the regime-switching model is that within each regime the model is linear, which is consistent with the evidence of short-run predictability. On the other hand, the stochastic switching among regimes would make long-run profitability difficult, which is consistent with the evidence of (long-run) market efficiency.[9] Another merit of the model is that the volatility of shocks, the "responsiveness" of the system to the shocks, the persistence of variables, among others, can be time-varying. Thus, the regime-switching model does allow for a more flexible structure. In this paper, we take a further step by allowing various combinations of coefficients of the regime-switching model to be regime-dependent. Depending on whether a coefficient or a group of coefficients are subject to regime switching, we consider a total of nine specifications of models, labeled Model 1 to

[9]Among others, see Chang, Chen and Leung (2010a) for more discussion on this point.

Model 9, as listed in the appendix. Model 1 is a single-regime model:

$$h_t^s = B_0 + B_1' \widetilde{X}_t^s + B_2' X_t^{us} + b_3 x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{3}$$

in which all coefficients are constants. On the other hand, the model (2), labeled as Model 9, is the most general specification, in which all coefficients are regime-dependent.

2.3 Data

The empirical analysis of this paper is based on Singaporean and the U.S. data covering the period $1984Q1 - 2010Q2$, the longest time series for both countries accessible to the authors. To be compatible with the house price index that is available quarterly, variables that were originally available monthly are transformed into quarterly variables. The definitions and sources of data are summarized in Table 1.

[Table 1 about here]

The data from Singapore were taken from the Singaporean Department of Statistics. The amount of trade is defined as the sum of total exports and imports. There is a major residential property price index and other five sub-indices available. As shown in Figure 2a and Table 2, they exhibit the same pattern of dynamics and their pairwise correlations are extremely high. In the following, we use the aggregate residential property price index (HP_1) as our measure of Singapore's housing price index. Real GDP, real stock index, and real amount of trade are deflated by CPI. We compute stock and housing returns by taking the growth rates of the stock price index and housing price index respectively.

[Figure 2a, Table 2 about here]

For the U.S. data, real GDP was taken from the Department of Commerce, Bureau of Economic Analysis. The federal funds rate was taken from H.15 statistical release ("Selected Interest Rates") issued by the Federal Reserve Board of Governors. The S&P 500 stock price index is obtained from DataStream. There are a number of available series that have been used as the measure external finance premium. Here we choose corporate bond spread (Baa-Aaa) as our measure of the external finance premium. The TED spread is the difference between the interest rate for three-month U.S. T-bills and the three-month Eurodollars contract, represented by the London Interbank Offering Rate (LIBOR).[10] Both the corporate bond spread and the 3-month Eurodollar deposit rate are from the H.15 statistical release ("Selected Interest Rates") issued by the Federal Reserve Board of Governors.

Figure 2 and 3 plot the economic aggregates for Singapore, the U.S., and the rest of the world. Table 3 gives a statistical description of Singapore's housing returns, which shows that the volatility of housing returns is extremely large. With a mean growth rate of 3.916%, it oscillates between the maximum and the minimum (35.143%, −40.194%) during its sample periods.

[Table 2b, 3; Figure 2-3 about here]

3 Baseline Results

We first extract residuals of Singapore's economic aggregates by estimating the model (1), and then proceed to estimate the dynamics of Singapore's housing returns from Model 1 to Model 9.

The estimation results of the model (1) are listed in Table A-1 of the appendix. We then plot the residuals from the estimation, i.e., Singapore's GDP, stock return, total amount of trade, and the nominal exchange rate after controlling for the effects of the U.S. and the rest of the world, in the dotted lines of Figure 2.

[10]The widely-used BBA LIBOR, compiled by the British Bankers' Association, started only from January 1986. Therefore, we replace the 3-month LIBOR rate by 3-month Eurodollar deposit rate. These two series are highly correlated.

3.1 Determinants of the Dynamics of Housing Returns

The residuals from estimating the model (1) are plugged into the Singapore's housing return equation. We then estimate Model 1 to 9. The estimation results are shown in Table A-2 of the appendix .

The regime-dependent means of housing returns for Models 2 to 9 are listed in Table 4. Clearly, the mean of housing returns in regime 2 is much lower than that of regime 1 for all models. In fact, in six out of eight regime-switching models the mean returns are negative. Hence, we label regime 2 as the *bust* regime and regime 1 as the *boom* regime. The transition probabilities for Models 2 and 9, as shown in Table 5, vary widely across models.

Given the estimated parameters, transition probabilities, and variance-covariance matrix, we compute the smoothed probabilities of the bust regime for Models 2 to 9, as shown in Figure 4 and Table 6. With different model specifications, the identified bust periods are very much different across models. In particular, in Models 8 and 9, where almost all parameters are assumed to be subject to regime switching, the shifts of regimes are very frequent. It is evident from Table 5 that the transition probabilities of these two models are much lower than others. From these results, we gain a glimpse of possible errors if a model is mis-specified.

[Table 4-6]

[Figure 4]

How do we choose a winner from among these nine models? A criterion is to compare the performances of their in-sample forecasts. We compute two widely-used measures for forecasting housing returns h_t^s: mean square errors (MSE) and mean absolute errors (MAE), which are defined respectively as

$$\begin{aligned} RMSE(k) &= \frac{1}{T-k}\sum_{t=1}^{T-k}\left(h_{t+k}^s - \widehat{h}_{t+k|t}^s\right)^2, \\ MAE(k) &= \frac{1}{T-k}\sum_{t=1}^{T-k}\left|h_{t+k}^s - \widehat{h}_{t+k|t}^s\right|, \end{aligned}$$

where $\widehat{h}^s_{t+k|t} \equiv E\left(h^s_{t+k} \mid \Omega_t\right)$. Clearly, MSE tends to penalize "big mistakes" more than the MAE. As will be clear, our main conclusions do not depend on whether MSE or MAE is used.

We compute both the *MSE* and *MAE* of in-sample k-step ahead forecasts, $k = 1, ..., 4$, across all models, and the results are displayed in Table 9. Several interesting observations are in order. First, we find that, regardless of whether *MSE* or *MAE* are used, Model 5 has the best in-sample forecasting performance among these eight regime-switching models, followed by Model 6. Specifically, Model 5 is specified as

$$h^s_t = B_0(\omega_t) + B_1'(\omega_t)\widetilde{X}^s_t + B_2'(\omega_t) X^{us}_t + b_3 x^w_t + \sum_{k=1}^{p} d_k h^s_{t-k} + \varepsilon_t, \quad (4)$$

i.e., only the intercepts and coefficients of Singapore's "net" economic aggregates and of the U.S. macroeconomic variables are regime-dependent. Figure 5 plots the movements of housing returns in Singapore and its predicted values under Model 5. We can see that Model 5 is able to capture the dynamics of the housing returns closely.

Second, most regime-switching models have higher *MSE* and *MAE* than the linear model (Model 1). This suggests that taking account of regime switching may yield worse results than a linear model if the model is mis-specified.

[Table 9]

[Figure 5]

Given that Model 5 has the best in-sample forecasting, Table 10 displays its estimation results. There are several notable findings. First, Singapore's GDP has a significantly negative effect on its housing return in the boom regime, while the GDP of U.S. has a positive effect on Singapore's housing return in boom regime and a negative effect in bust regime.[11] To understand this result, we first plot the movements of the housing returns

[11]Notice that our econometric model is a two-stage procedure. As it is shown in Wooldrige (2010), Chong, Lam and Yan (2011), Chong and Yan (2011), among others, the standard error tends to be larger than the OLS counterparts. Thus, while our model yields unbiased estimates of the coefficients, we tend to under-evaluate the statistical significance of those coefficients. Since correcting for the standard error estimation is very difficult in a regime-switching structural VAR context, and the coefficients that we identify as statistically significant would only improve should the correction is made, we only acknowledge this issue and proceed.

of both countries in Figure 6. Note that the dynamics of Singapore's housing returns are much more volatile than those of the U.S., and the patterns of housing return movements are also very different in the two economies. For example, in the last ten years Singapore's housing returns rose to almost 30% and did not decline until late 2007. The decline in housing returns following the subprime crisis was very deep, but starting in early 2009 the housing market rebounded at an astonishing pace, while the U.S. housing market was still staggering.

That a positive shock can lead to a negative response in the housing return may sound counter-intuitive, but we attempt to provide an explanation here. A good shock of GDP growth at time t leads to an immediate appreciation of house prices, as the housing supply is fixed in the short run. Over time, however, the supply can respond. It may be even more pronounced in Singapore as the Singaporean government is often pro-active. Thus, as the shock dies down, the future increase in house price will not be as much. Therefore, the time t increase in house price could be larger than those in subsequent periods, leading to time t housing returns $h(t)$ being higher than time $t+1$ returns $h(t+1)$. Moreover, according to the regime-classification provided by our regime-switching model*, when the Singapore's housing returns are in the boom regime, the U.S. housing market stays in the bust regime.* This is consistent with the notion that U.S. investors tend to diversify their portfolios internationally.[12]

Second, stock market fluctuations in Singapore will affect the housing market, but only in the bust regime. This indicates that the spillover effect of the financial market strengthens in a bear market. Third, a rise in the total amount of trade and an appreciation in exchange rate leads to higher housing returns. This is intuitive because Singapore has been running trade surpluses, and larger trade surpluses lead to an appreciation in the exchange rate. These two effects together bring in more foreign capital, leading to domestic asset prices rises.

Fourth, more importantly, U.S. monetary policy and the EFP both have significantly negative effects on Singapore's housing returns. This indicates that the international transmission channels of Singapore's housing returns work through the monetary policy

[12] Among others, see Curcuru et al (2010) for more discussion on this.

and risk premium of the U.S., especially in the boom regime. Finally, the U.S. stock market and the oil price do not have significant effects on Singapore's housing market. Figure 7 shows the impulse responses of the Singapore housing returns to innovation in equation (2) across different models. Interestingly, they all show a large initial response that diminishes almost completely within two years.

[Table 10 about here]

[Figure 6, 7 about here]

3.2 Diebold and Mariano Test

On top of the MAE and MSE statistics, we can also directly measure whether one model predicts statistically significantly better than an alternative. Following the literature, we adopt the Diebold-Mariano test to assess the "relative performance" of different models.[13] Let $\{y_t\}$ denote the series to be forecast and let $y^i_{t+h|t}$ be the model i's k-step forecast of y_{t+h} based on the information at time t, $k > 0$, $i = 1, 2$. Let $e^i_{t+k|t}$ be the model i forecast error, $e^i_{t+k|t} \equiv y_{t+k} - y^i_{t+k|t}$. The Diebold-Mariano (henceforth *DM*) test is based on the loss differential,

$$d_t = L\left(e^1_{t+k|t}\right) - L\left(e^2_{t+k|t}\right),$$

where $L(\cdot)$ is a loss function. Clearly, if the two models have roughly the same predictive power, the expectation of the loss differential will be zero, $E[d_t] = 0$. If, instead, Model 1 predicts better (*worse*) model 2, the expected value of the loss differential will be positive (*negative*).[14] The results are not very satisfactory. Model 5 statistically out-performs

[13] The Diebold and Mariano test has been widely used in the literature. See Hordahl, Tristani and Vestin (2006) for a review of the literature.

[14] The DM statistics will depend $\overline{d}$, which is an average value of d_t, for different period t, and the co-variance of d_t and d_{t-j}, $j = 1, 2, 3, ...$ As shown by Zivot (2004), other things being equal, if model 1 which consistently over-predict in some sub-period and then consistently under-predict in other sub-period, it is more likely to get not only a lower value of d_t in different period t, but also a higher value of co-variance d_t and d_{t-j}, $j = 1, 2, 3, ...$ As a result, model 1 is would be classified as under-perform the alternative model. See Zivot (2004) for more details.

Models 9 and 10, but not the others. One possible explanation is that the time series is relatively short. Data availability constrains us from considering a more sophisticated model.

[Table 11 about here]

4 Robustness Checks

4.1 Single Stage Estimation

As a direct comparison with Model 5, we estimate it again using Singapore's economic aggregates *without* controlling for foreign effects. That is, we estimate the following Model 5A:

$$h_t^s = B_0(\omega_t) + B_1'(\omega_t) X_t^s + B_2'(\omega_t) X_t^{us} + b_3 x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t. \quad (5)$$

Note that the difference between this model and Model 5 is that the term $\widetilde{X}_t^s$ in (4) is now replaced by X_t^s which is the vector of Singapore's economic aggregates that contain noises from the U.S. and the rest of the world. By doing so, we forego the stage one estimation and proceed to Stage two directly.

Table 12 and 13 summarize the statistical properties of Model 5A, together with Model 5. Table 14 and Figure 8 clearly shows that, without accounting for noises from the U.S. and the rest of the world, the regimes identified according to the Markov process switch much more frequently.

Table 15 shows that Model 5A performs marginally better than Model 5 in terms of MSE, but Model 5A performs far worse than Model 5 in terms of MAE.

Table 16 compares the estimation results of these two models. Distinct features are evident in accounting for the dynamic properties of Singapore's housing returns between these two models. Importantly, this shows exactly why our two-stage approach matters. For example, the U.S. stock price and the oil price do not affect Singapore's housing returns after accounting for the interactions of macroeconomic variables between Singapore, the U.S., and the rest of the world (Model 5). However, the U.S. stock price and the oil price appear to have significant effects on those housing returns under Model 5A. In other words, the U.S. stock price and the oil price in the world market only affect the Singaporean housing market by affecting the domestic aggregate variables, an *indirect* effect. The drawback of a single stage approach such as Model 5A is that it does not help the reader to separate direct and indirect effects. In contrast, our two-stage approach is able to disentangle the complicated interaction effects and clearly identify the sources of fluctuation in Singapore's housing returns.

[Table 12-16 about here]

4.2 An Alternative Modeling Strategy

In this subsection, we estimate an alternative model that makes two important changes to the benchmark model. First, in the benchmark model, we include only four of Singapore's macroeconomic variables in the stage one estimation, i.e., $X_t^s = [x_{1t}^s, x_{2t}^s, x_{3t}^s, x_{4t}^s]'$ includes the growth rate of real GDP, real stock return, growth rate of real amount of trade, and growth rate of nominal exchange rate. We now *expand* the set of variables by including a fifth element, Singapore's housing returns, so that $X_t^s = [x_{1t}^s, x_{2t}^s, x_{3t}^s, x_{4t}^s, x_{5t}^s]'$ is a 5×1 vector. We obtain the residuals $\widetilde{X_t^s}$ from the estimation. Second, in the stage two estimation, we consider the following model

$$\widetilde{X_t^s} = B_0(\omega_t) + \sum_{k=1}^{p} B_j'(\omega_t)\widetilde{X_{t-k}^s} + \varepsilon_t, \qquad (6)$$

where $B_j(\omega_t)$ is a 5×5 matrix. As compared to (4), the stage two estimation includes no macroeconomic variables of the U.S. and the rest of the world.

We label this specification the "Alternative Model." There are two objectives in specifying this model. First, by adding housing returns to the stage one estimation, we allow them to interact with other macroeconomic variables, which will in turn have an impact on the residuals in $\widetilde{X_t^s}$. Second, in stage two, we include only the lagged terms of $\widetilde{X_t^s}$, as the effects of the U.S. and the rest of world have been filtered in stage one. Clearly, a drawback of this model is that the results obtained here are not directly comparable to the previous results. Previously, our stage two model maximized the matching between the model and the raw housing return data. Under the Alternative Model, stage two (6) attempts to maximize the matching between the model and the "filtered data," not only the housing return, but the whole vector of the filtered data (i.e. including the Singaporean GDP growth rate, stock return, etc.). Nonetheless, some of our colleagues insist us to estimate the Alternative Model because it may be statistically more general.

Table 12 and 13 compare the statistical properties of the Alternative Model to the other models. Table 15 compares the MSE and MAE between Model 5 and this Alternative Model. Clearly, Model 5 performs better than the Alternative Model based on either one of the criteria. Again, it should be recalled that the Alternative Model needs to balance the matching between the model and a whole vector of the Singaporean variables, while Model 5 focuses on matching the data of housing return only. For completeness, Table 17 lists the stage two estimation results for housing returns.

[Table 17 about here]

5 Concluding Remarks

Given the increasing interdependence of economies in recent decades, the potential significance of the international transmission of fluctuations in economic activity and financial markets has gained attention. In many Asian countries, it is a very important concern for both academics and policy makers. On the one hand, most Asian countries are still developing, and openness to international trade and capital flows can be vital to continued economic growth. On the other hand, international exposure in trade and financial services may imply higher volatility in economic growth, and even social conflict in some cases.[15]

Tselichtchev and Debroux (2009, pp.189-192) summarize the Singaporean experience as follows,

[15] Obviously, it is beyond the scope of this paper to review that literature. Among others, see Acemoglu et al (2003), Imbs (2004), Rijckeghem and Weder (2001).

“On the financial front, heavy investment, by both foreign and local capital, in property and stock in the first half of the decade led to a surge of asset prices, resulting in a financial bubble. Stock and property prices peaked in 1996 and had begun to decline before the Asian crisis... Generally, the influence of the Asian crisis on the national economy was marginal. Still, in 1998, GDP fell by 1.4 percent and stock prices plunged by over 60 percent from their peak.... In 2008, in the wake of the global financial turmoil, the Singapore economy slowed down, first and foremost because of a slump in exports.... In the fourth quarter it shrank dramatically 17.0 percent on a quarter-to-quarter and 3.7 percent on a year-to-year basis. The growth rate for the whole of 2008 was only 1.2 percent. Signs of deflation appeared. The key Straits Times Index (STI) fell almost 55 percent between the beginning of the year and the end of October....”

This quotation highlights a few facts. First, Singapore has experienced financial crises and its economy is still growing. Second, while GDP can fall a few percentage points on an annual basis during a crisis, the stock price can lose half of its value. As other authors have studied the dynamics between the Singaporean economy and its stock market, this paper focuses on Singapore’s housing market dynamics. We investigate how external shocks (for instance, from the U.S.) as well as internally generated shocks are transmitted to the housing market. Our principal finding that the responses of housing returns significantly differ across regimes is important. From the best model we can identify (Model 5), we find that during the boom regime, the housing return responds negatively to the GDP growth rate and the exchange rate fluctuations in Singapore dollars, and to the Federal Fund rate and the External Finance Premium of the U.S. Perhaps more interestingly, the responses of Singaporean housing returns to these factors are not statistically significant during the bust regime. One interpretation is that during the boom regime, these factors will stimulate the current period housing price more than the subsequent period price, which will tend to depress returns. Why would the housing price of the current period respond differently to those factors from the subsequent periods during the boom regime? One possible explanation is that during the current period, the supply is fixed and the current period price tends to respond sharply. Yet the same sharp increase in price also stimulates the housing supply in subsequent periods, which tends to suppress future price growth. The question is then why this mechanism fails to operate during the bust regime. One explanation is that during the bust regime, both households and developers are very cautious, or process information very differently, which may affect the equilibrium responses in house price and the housing supply. If this is indeed the case, this paper provides indirect support to theories that emphasize different attitudes of households and firms across regimes. Those differences can be caused by financial constraints, beliefs, behavioral factors, allocation of attention or other factors.[16] Future research should explore how to identify the reasons behind the different responses.

An alternative explanation is that the government behaves very differently across regimes. However, this is not easy to verify in the current framework. In fact, this paper takes a somewhat reduced-form approach. Limited by the data availability and the sample size, we can *only estimate the overall response* of the Singaporean economy to different shocks. We cannot separate the response of the private sector from that of the government sector. According to Tselichtchev and Debroux (2009, pp.192-195), government intervention can be a significant component:

"The government's S\$20.5 billion Resilience Package for 2009 consists of five components: job creation; stimulation of bank lending (the government is to extend capital to share risks with banks); enhance business cash-flow and competitiveness (through tax measures and grants); supporting families; and building a home for the future (infrastructure spending and expanded provisions for education and healthcare).... For Singapore, city-making has a special meaning. It is not just about solving the problems of a big city or addressing the challenges it faces. It is an "aggressive" policy of making it..."

Future research should take a more "structural approach" to separately identifying the response from the private sector versus the public sector. That will enable us to evaluate the effectiveness of different government policies, which could lead to very important research results for both policy makers and academic researchers in Asia.

[16]It is beyond the scope of this paper to review this emerging literature, among others, see Brunnermeier and Sannikov (2010), Kacperczyk, Nieuwerburgh and Veldkamp (2010), and the reference therein.

References

[1] Abeysinghe, T., 1998, Forecasting Singapore's quarterly GDP with monthly external trade, International Journal of Forecasting 14, 505–513.

[2] Aghion, P., P. Bacchetta, and A. Banerjee, 2004, A corporate balance-sheet approach to currency crises, Journal of Economic Theory 119, 6–30.

[3] Allen, M., C. Rosenberg, C. Keller, B. Setser, and N. Roubini. 2002. A balance sheet approach to financial crises, IMF Working Paper.

[4] Amisano, G. and O. Tristani, 2009, A DSGE model of the term structure with regime shifts, European Central Bank, mimeo.

[5] Bernanke, B. and M. Gertler, 1989, Agency costs, net worth, and business fluctuations, American Economic Review 79, 14–31.

[6] Bernanke, B., M. Gertler and S. Gilchrist, 1999, The Financial Accelerator in A Quantitative Business Cycle Framework, in J. Taylor and M. Woodford (ed.), Handbook of Macroeconomics, Vol. 1, New York: Elsevier.

[7] Bossaerts, P. and P. Hillion,1999, Implementing statistical criteria to select return forecasting models: what do we learn?, Review of Financial Studies 12, 405–428.

[8] Brunnermeier, M. and Y. Sannikov, 2010, A Macroeconomic Model with a Financial Sector, paper presented at the Econometric Society World Congress.

[9] Burnside; C., M. Eichenbaum and S. Rebelo, 2001, Prospective Deficits and the Asian Currency Crisis, Journal of Political Economy, 109(6), 1155-1197.

[10] Chami, R., T. F. Cosimano and C. Fullenkamp, 1999, The stock market channel of monetary policy, IMF Working Paper 99/22.

[11] Chang, K. L.; N. K. Chen and C. K. Y. Leung, 2010a, Monetary Policy, Term Structure and Real Estate Return: Comparing REIT, housing and stock, forthcoming in Journal of Real Estate Finance and Economics.

[12] Chang, K. L.; N. K. Chen and C. K. Y. Leung, 2010b, Would some model please give me some hints? In search of some stylized facts of the Monetary Policy and Asset Return Dynamics, paper presented at the European Real Estate Society meeting.

[13] Chen, N. K., Chu, H. L., Liu, J. T. and Wang, K. H. 2006, Collateral Value, Firm Borrowing, and Forbearance Lending: An Empirical Study of Taiwan, Japan and the World Economy, 18, 49-71.

[14] Chen, N. K. and C. K. Y. Leung, 2008, Asset price spillover, collateral and crises: with an application to property market policy, Journal of Real Estate Finance and Economics, 37, 351-385.

[15] Cheung, Y. W. and J. Yuen, 2002, Effects of U.S. Inflation on Hong Kong and Singapore, Journal of Comparative Economics, 30, 603-619.

[16] Chong, T. T. L., T. H. Lam and I. K. M. Yan, 2011, Is the Chinese Stock Market Really Inefficient, City University of Hong Kong, mimeo.

[17] Chong, T. T. L., and I. K. M. Yan, 2011, Threshold Models with Multiple Threshold Variables and the Prediction of Financial Crises, City University of Hong Kong, mimeo.

[18] Christiano, L., R. Motto and M. Rostagno, 2007, Financial factors in business cycles, Northwestern University, mimeo.

[19] Corsetti, G., P. A. Pesenti and N. Roubini, 1998, What Caused the Asian Currency and Financial Crisis? Part I: a Macroeconomic Overview, NBER Working Paper 6833.

[20] Curcuru, S., C. Thomas, F. Warnock, and J. Wongswan, 2010, U.S. international equity investment and past and prospective returns, UVA, mimeo.

[21] Cozzi, G. and J. Toporowski, 2006, The balance sheet approach to financial crises in emerging markets, University of London, mimeo.

[22] David, E. P. and G. Fagan, 1997, Are financial spreads useful indicators of future inflation and output growth in EU countries? Journal of Applied Econometrics, 12, 701-714.

[23] Davis, S., 2010, The Adverse Feedback Loop and the Real Effects of Financial Sector Uncertainty, Vanderbilt University, mimeo.

[24] Devereux, M., 2003, A Tale of Two Currencies: the Asian Crisis and the Exchange Rate Regimes of Hong Kong and Singapore, Review of International Economics, 11, 38-54.

[25] Diebold, F. and R. Mariano, 1995, Comparing predictive accuracy, Journal of Business & Economic Statistics, 13, 253-263.

[26] Estrella, A., 2005, Why does the yield curve predict output and inflation?, Economic Journal 115, 722-44.

[27] Estrella, A. and G. Hardouvelis, 1991, The term structure as a predictor of real economic activity, Journal of Finance 46, 555-76.

[28] Estrella, A. and F. Mishkin, 1997, The predictive power of the term structure of interest rates in Europe and the United States: implications for the European Central Bank, European Economic Review 41, 1375-1401.

[29] Francq, C. and J. M. Zakoian, 2001, Stationary of multivariate Markov-switching ARMA models, Journal of Econometrics 10, 339-364.

[30] Goodhart, C. and B. Hofmann, 2007, House Prices and the Macroeconomy: Implications for Banking and Price Stability (Oxford University Press).

[31] Hamilton, J., 1994, Time series analysis (Princeton University Press).

[32] Hansen, L. P., 1982, Large Sample Properties of Generalized Method of Moments Estimators, Econometrica, 50(4), 1029-54.

[33] Hordahl, P., O. Tristani and D. Vestin, 2006, A joint econometric model of macroeconomic and term-structure dynamics, Journal of Econometrics, 131, 405-444.

[34] Hwang, M. and S. K. Lum, 2009, A Test of HCCAPM: Housing Market and Government in Asset Pricing context, George Washington University and National University of Singapore, mimeo.

[35] Jaccard, I., 2009, House Prices, Real Estate Returns and the Business Cycle, European Central Bank, mimeo.

[36] Kacperczyk, M., S. V. Nieuwerburgh and L. Veldkamp, 2010, Attention Allocation Over the Business Cycle, New York University, mimeo.

[37] Kan, K.; S. K. S. Kwong and C. K. Y. Leung, 2004, The dynamics and volatility of commercial and residential property prices: theory and evidence, Journal of Regional Science, 44(1), 95-123.

[38] King, R., C. Plosser and S. Rebelo, 2002, Production, Growth and Business Cycles: Technical Appendix, Computational Economics, 20, 87–116.

[39] Kiyotaki, N. and J. Moore, 2002, Balance-Sheet Contagion, American Economic Review, 92, 46-50.

[40] Krugman, P., 1999, Balance Sheets, the Transfer Problem, and Financial Crises, International Tax and Public Finance 6, 459-472.

[41] Leung, C., 2004,) Macroeconomics and Housing: a review of the literature, Journal of Housing Economics 13, 249-267.

[42] Leung, C. K. Y., 2007, Equilibrium correlations of asset price and return, Journal of Real Estate Finance and Economics 34, 233-256.

[43] Lubik, T., and F. Schorfheide, 2003, Computing sunspot equilibria in linear rational expectations models, Journal of Economic Dynamics & Control 28, 273–285.

[44] Lubik, T., and F. Schorfheide, 2004, Testing for Indeterminacy: An Application to U.S. Monetary Policy, American Economic Review 94(1), 190-217.

[45] Lustig, H. and S. Van Nieuwerburgh, 2005, Housing collateral, consumption insurance and risk premia: An empirical perspective, Journal of Finance 60, 1167–1219.

[46] Mackowiak, B., 2007, External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets, Journal of Monetary Economics 54, 2512–2520.

[47] Maheu, J. and T. McCurdy, 2000, Identifying bull and bear markets in stock returns. Journal of Business and Economic Statistics 18, 100–112.

[48] Meng, C. K., 2003, Singapore business cycles: A supply-side analysis, ASEAN Economic Bulletin 20, 1-10.

[49] Menzly, L., T. Santos and P. Veronesi, 2004, Understanding predictability, Journal of Political Economy 112, 1–47.

[50] Mera, K. and B. Renaud ed., 2000, Asian Financial Crisis and the Role of Real Estate, NY: M. E. Sharpe.

[51] Ong, S. E., 2008, Mortgage market in Singapore, in D. Ben-Shahar, C. Leung, S. E. Ong ed., Mortgage Markets Worldwide, New York: Wiley-Blackwell.

[52] Piazzesi, M., M. Schneider and S. Tuzel, 2007, Housing, consumption, and asset pricing, Journal of Financial Economics 83, 531-569.

[53] Sargent, T., N. Williams and T. Zha, 2006, Shocks and government beliefs: The rise and fall of American inflation, American Economic Review 96, 1193-1224.

[54] Sims, C., 1980a, Comparison of interwar and Postwar business cycles: Monetarism reconsidered, American Economic Review, 250-257.

[55] Sims, C.,1980b, Macroeconomics and reality, Econometrica 48, 1-48.

[56] Sims, C. and T. Zha, 2006, Were there regime switches in U.S. monetary policy?, American Economic Review 96, 54-81.

[57] Smets, F. and R. Wouters, 2007, Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach, American Economic Review, 97(3), 586–606.

[58] Tsatsaronis, K. and H. Zhu, 2004, What dirves housing price dynamics: cross-country evidence, BIS Quarterly Review, March, 65-78.

[59] Tselichtchev, I. and P. Debroux, 2009, Asia's Turning Point: an introduction to Asia's Dynamic economies at the Dawn of the new century, New York: John Wiley & Sons.

[60] Tse, C. Y. and C. K. Y. Leung, 2002, Increasing Wealth and Increasing Instability: The Role of Collateral, Review of International Economics, 10(1), 45-52.

[61] Wooldridge, J., 2010, Econometric Analysis of Cross Section and Panel Data, Cambridge: MIT press, 2nd edition.

[62] Yoshida, J., 2008, Technology shocks and asset price dynamics: The role of housing in general equilibrium, University of Tokyo, mimeo.

[63] Zivot, E., 2004, Notes on Forecasting, University of Washington at Seattle, mimeo.

Figure 1: How the USA factors and the Singapore macro-economy may affect the Singapore housing market

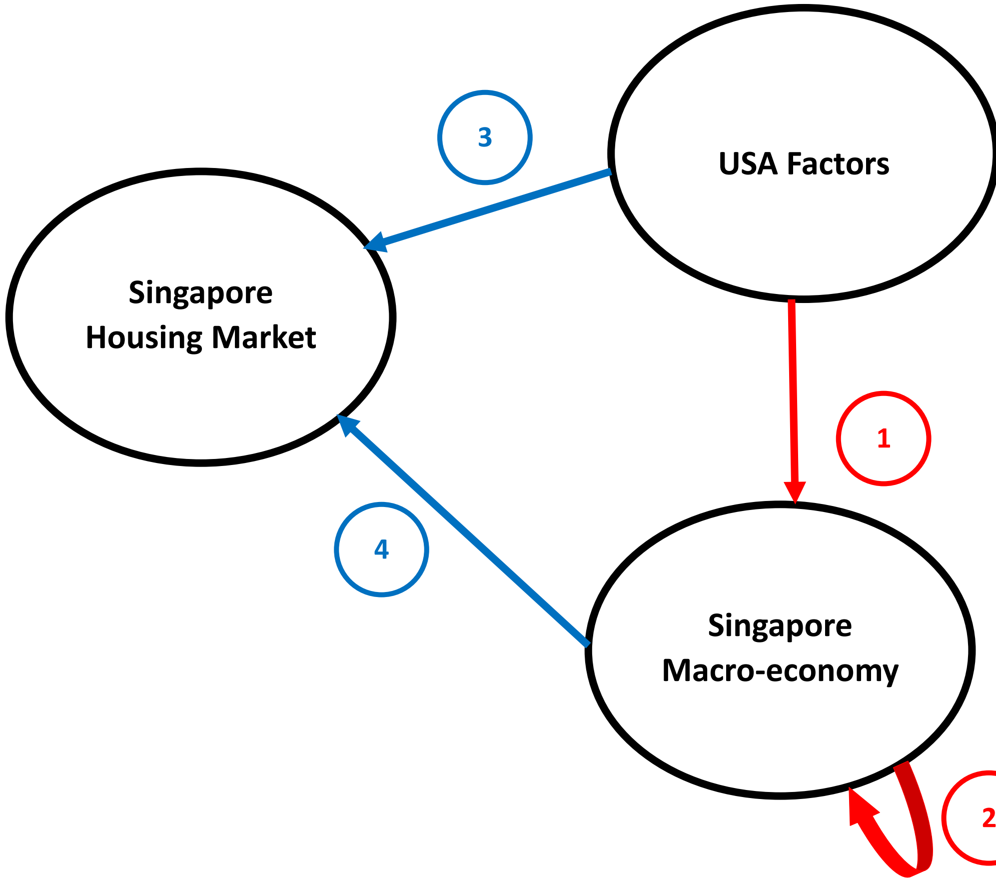


Figure 2a House Price Indices in Singapore (See Table 2 for Definitions)

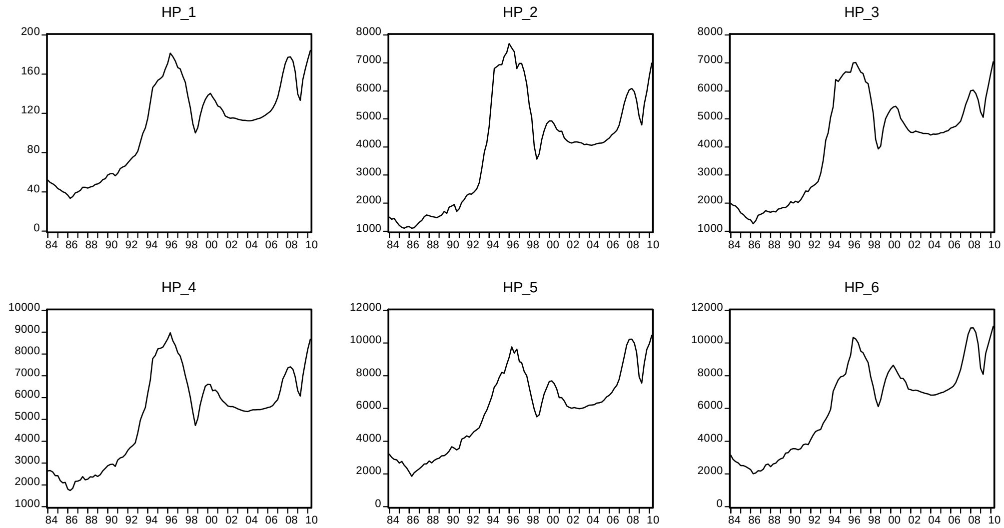
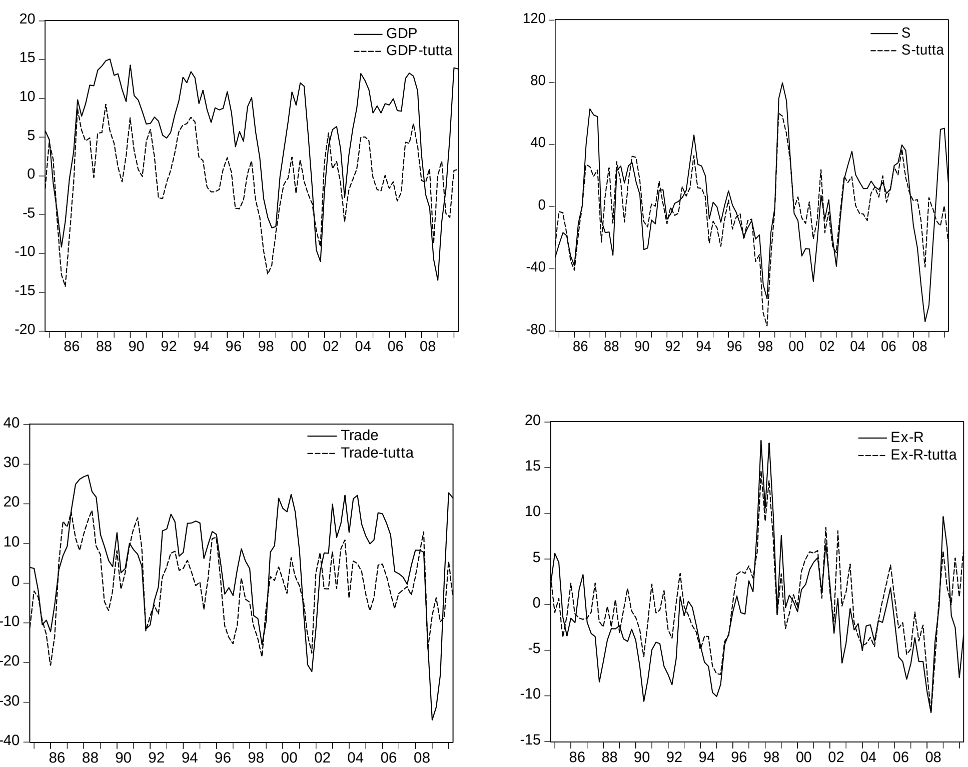
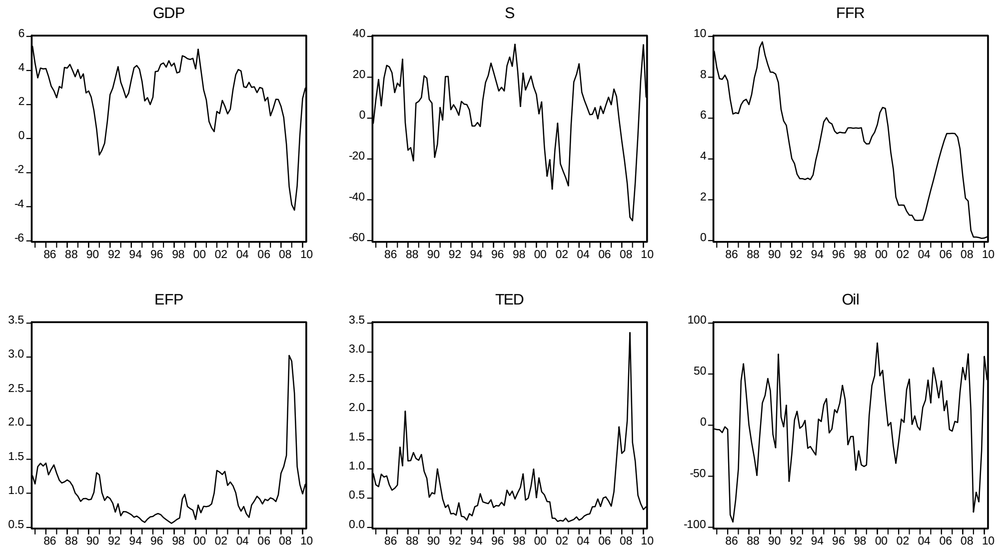


Figure 2b Economic Aggregates of Singapore Before and After Extracting the Effects from the Rest of the World



Note: “GDP” refers to GDP growth. “S” refers to the stock returns. “Trade” refers to growth rate of real amount of international trade. “Ex-R” refers to growth rate of exchange rate. “X-tutta” refers to the X variable after controlling for US and world variables.

Figure 3 Variables of the U.S. and the Rest of the World



Note: “GDP” refers to GDP growth. “S” refers to the stock returns. “FFR” refers to federal fund rate. “EFP” refers to the external finance premium. “TED” refers to TED spread. “Oil” refers to oil price change.

Figure 4 Smoothed Probabilities of Regime 2 (Bust Regime)

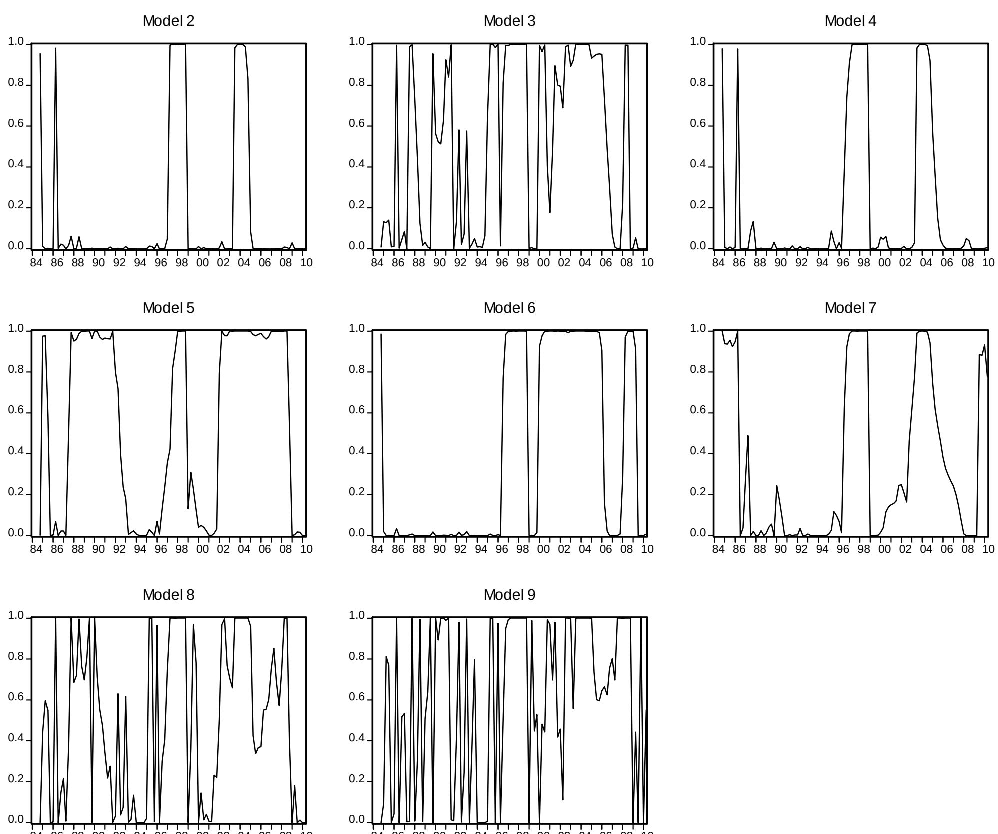


Figure 5 Singapore's Housing Returns and the Predicted Housing Returns by Model 5

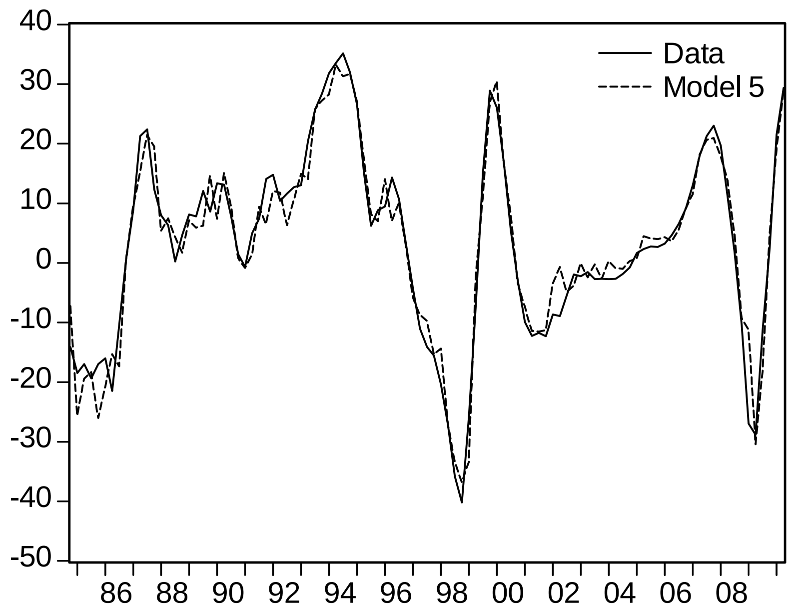


Figure 6 The Housing Returns of Singapore and the U.S.

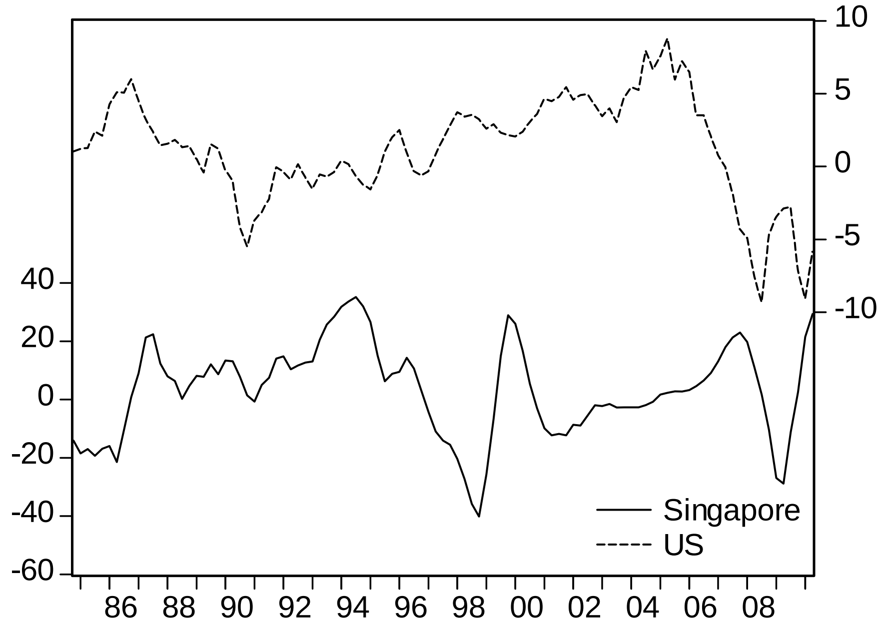


Figure 7 Impulse Response of Housing Return to a Standard Deviation of Innovation

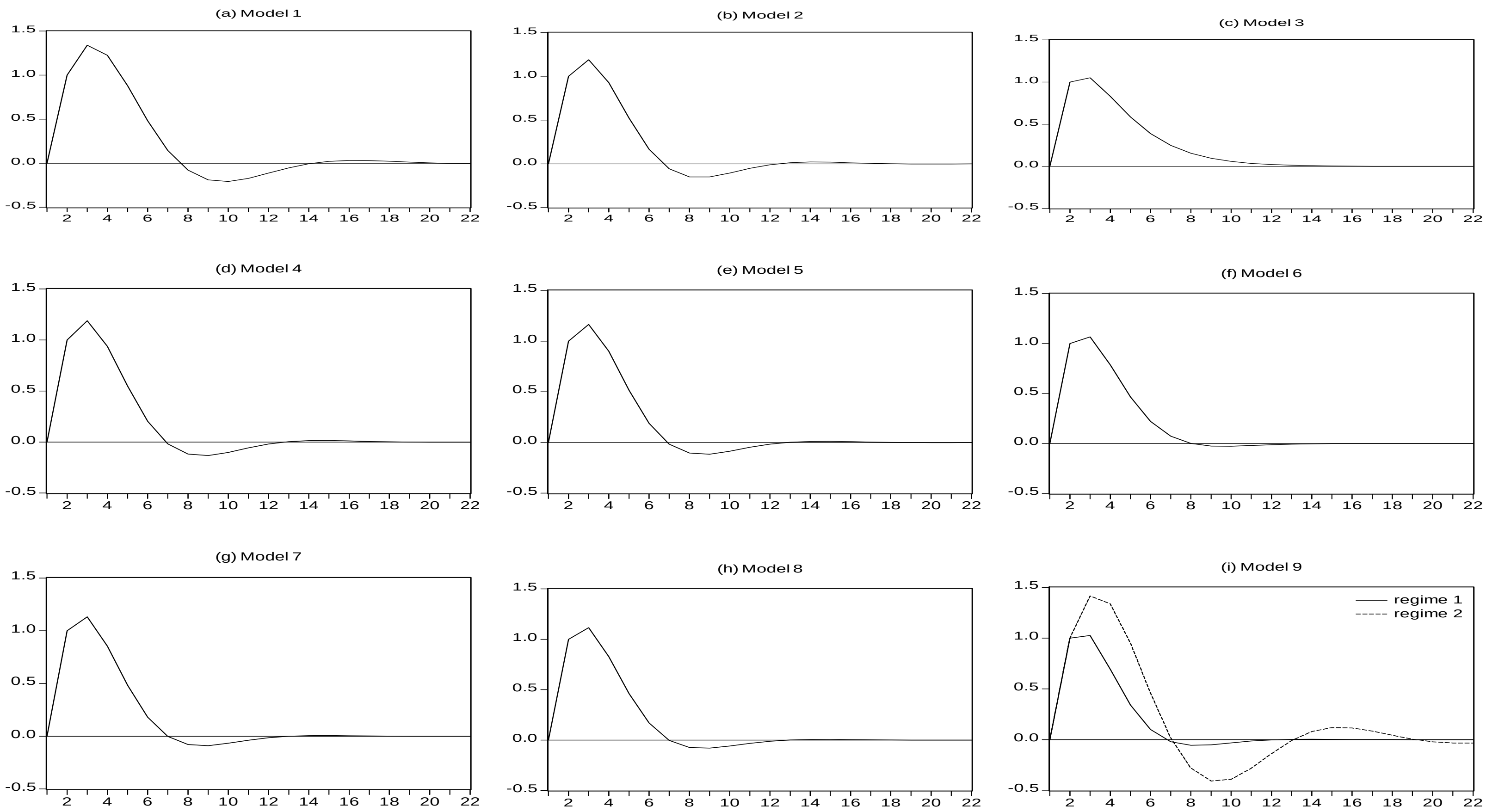


Figure 8 Smoothed Probabilities of Regime 2 for Model 5 and 5A

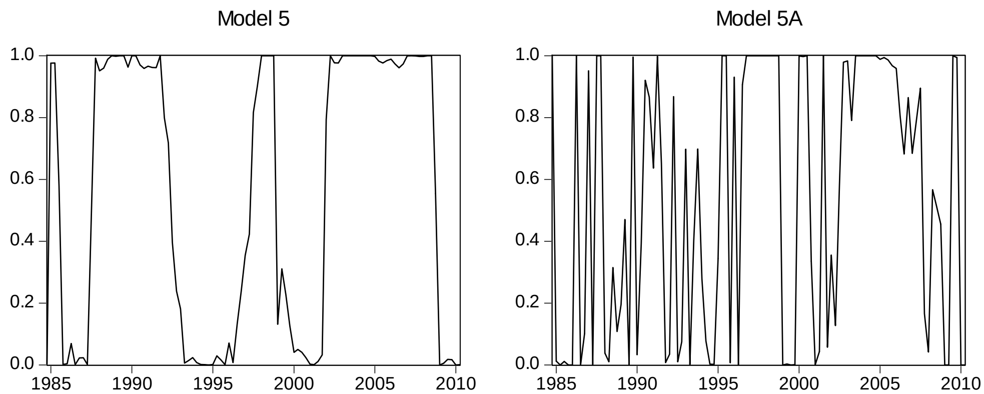


Figure 9 The Data for the Filtered Housing Returns and the Forecasting Returns

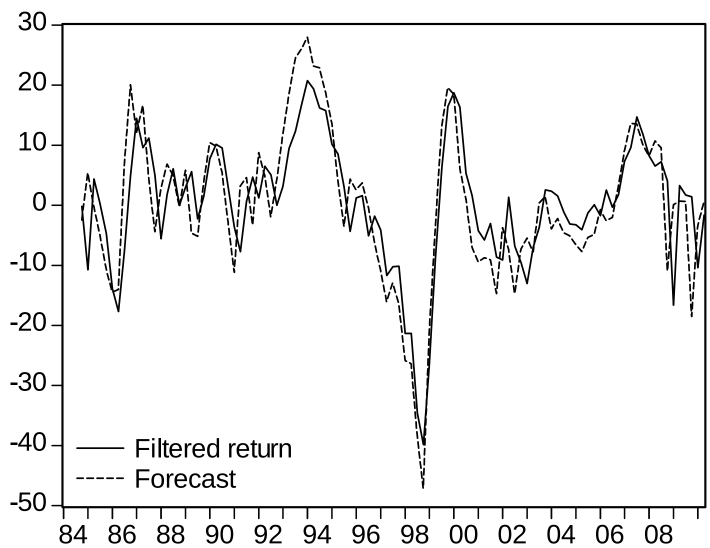


Table 1 Definitions and Sources of Data (1984Q1-2010Q2)

	Variables	Definition
Singapore	Housing price index	The Aggregate Residential Property Price Index
	GDP	SP GDP AT MARKET PRICES CURA (SP$, seasonally adjusted)
	Stock price index	MSCI SINGAPORE-PRICE INDEX (SP$)
	CPI	SP CPI NADJ (SP$)
	Exchange rate	SP SINGAPORE DOLLARS TO US $
	Import	SP IMPORTS CURA (SP$)
	Export	SP EXPORTS CURA (SP$)
U.S.	GDP	Real Gross Domestic Product (seasonally adjusted)
	Stock price index	S&P500 index
	FFR	Federal funds rate
	EFP	External finance premium: corporate bond spread (Baa-Aaa)
	TED spread	3-month Eurodollar deposit rate - 3-month T-bill rate
World	Oil price	OPEC Oil Basket Price U$/Bbl

Note: The Singapore data are taken form Singapore Department of Statistics, and the U.S. data are respectively from Bureau of Economic Analysis, Federal Reserve Board of Governors, and DataStream.

Table 2 Correlation coefficient Among Six Property Price Indices

	HP_1	HP_2	HP_3	HP_4	HP_5	HP_6
HP_1	1.000	0.978	0.987	0.985	0.993	0.990
HP_2		1.000	0.991	0.993	0.954	0.942
HP_3			1.000	0.995	0.965	0.962
HP_4				1.000	0.965	0.955
HP_5					1.000	0.991
HP_6						1.000

Note: The six property price indices are respectively HP_1: Aggregate residential property price index, HP_2: Median Housing price (landed; detached, SGD/ sq m), HP_3: Median Housing price (landed; semi-detached, SGD/ sq m), HP_4: Median Housing price (landed; terrace, SGD/ sq m), HP_5: Median Housing price (non-landed; apartment, SGD/ sq m), HP_6: Median Housing price (non-landed; condominium, SGD/ sq m).

Table 3 Descriptive statistics of Singapore's Housing Return (%)

Mean	3.196
Median	4.629
Maximum	35.143
Minimum	-40.194
Std. Dev.	15.846
Skewness	-0.284
Kourtosis	2.835
Jarque-Bera	1.160
	[0.560]

Note: Value in square brackets is P-value

Table 4 Regime-Dependent Mean of Housing Returns (%)

Model	Regime 1	Regime 2
1	3.610	3.610
2	8.365	-22.782
3	17.473	-7.804
4	9.173	-19.499
5	7.453	0.487
6	15.182	-15.761
7	9.160	1.646
8	10.752	-0.458
9	12.147	-0.766

Table 5 Transition probabilities for Model 2 to Model 9

Model	P_{11}	P_{22}
2	0.953	0.759
3	0.780	0.777
4	0.948	0.791
5	0.900	0.906
6	0.939	0.912
7	0.920	0.869
8	0.715	0.694
9	0.483	0.664

Table 6 Periods of Identified as Regime 2 (Bust Regime)

Model	Bust Periods
2	1984Q4 1986Q2 1997Q2-1998Q4 2003Q3-2004Q4
3	1986Q2 1987Q3-1988Q1 1989Q4-1991Q3 1992Q2 1993Q1 1995Q1-1996Q1 1996Q3-1998Q4 2000Q1-2000Q3 2001Q3-2006Q2 2008Q2-2008Q3
4	1984Q4 1986Q2 1996Q4-1998Q4 2003Q3-2005Q1
5	1985Q1-1985Q3 1987Q3-1992Q2 1997Q3-1998Q4 2002Q1-2008Q4
6	1984Q4 1996Q3-1998Q4 2000Q1-2006Q1 2008Q2-2009Q2
7	1984Q4-1986Q2 1996Q3-1998Q4 2003Q1-2005Q3 2009Q3-2010Q2
8	1985Q2-1985Q3 1986Q2 1987Q4-1989Q3 1990Q1-1990Q3 1992Q2 1993Q1 1995Q2-1995Q3 1996Q1 1997Q1-1998Q4 1999Q3-1999Q4 2002Q1-2005Q1 2006Q2-2008Q3
9	1985Q2-1985Q3 1986Q2 1986Q4-1987Q1 1987Q4 1988Q3 1989Q1-1989Q3 1990Q1-1991Q2 1992Q2 1993Q1 1993Q4 1995Q2-1995Q3 1996Q1 1996Q3-1998Q4 1999Q2 1999Q4 2000Q4-2001Q3 2002Q3-2008Q4 2009Q4 2010Q2

Table 7 The Summary Statistics of Housing Returns (%): Data and Models (1984Q4-2010Q2)

Correl.	Data	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Mean	3.196	3.196	3.136	3.349	3.120	3.184	2.962	3.392	3.540	3.610
Median	4.629	4.199	5.181	4.714	4.753	4.468	4.273	4.908	5.232	4.397
Maximun	35.143	33.226	30.287	32.577	31.006	33.298	32.994	30.984	32.231	33.085
Minimun	-40.194	-36.099	-37.243	-36.548	-37.529	-36.772	-38.380	-40.228	-33.961	-33.632
Std. Dev.	15.846	15.354	15.322	15.579	15.493	15.381	15.938	15.664	15.056	15.212
Skewness	-0.284	-0.391	-0.458	-0.354	-0.447	-0.382	-0.429	-0.483	-0.365	-0.308
Kurtosis	2.835	2.854	2.971	2.751	2.925	2.998	2.849	2.982	2.801	2.702

Table 8 Correlation Between Housing Returns and Other Macroeconomic Variables

Correl.	Data	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
(H,GDP)	0.679	0.683	0.682	0.695	0.673	0.670	0.664	0.677	0.686	0.673
(H,S)	0.576	0.563	0.560	0.553	0.558	0.542	0.526	0.543	0.543	0.565
(H,Trade)	0.566	0.582	0.579	0.609	0.568	0.577	0.580	0.570	0.596	0.574
(H,EX-R)	-0.626	-0.614	-0.612	-0.616	-0.611	-0.612	-0.611	-0.622	-0.618	-0.602

Key: “Correl” refers to Correlation; “(H,GDP)” refers to (House Return, GDP growth); “(H,S)” refers to (House Return, Stock Price Change); “(H,Trade)” refers to (House Return, Real Amount of International growth rate); “(H,EX-R)” refers to (House Return, Exchange Rate Change)

Table 9 In-Sample Forecasting Performance

Model	MSE	MAE
1	15.203	3.076
2	15.942	3.137
3	15.381	3.091
4	17.306	3.173
5	**14.625**	**2.793**
6	14.777	2.965
7	15.134	2.945
8	16.226	3.151
9	18.837	3.544

Table 10 The Estimation results of Model 5

	Regime 1 (boom regime)	Regime 2 (bust regime)
GDP growth rate (Singapore)	-0.606**	0.323
Stock return (Singapore)	0.014	0.162***
Change rate of amount of Trade (Singapore)	0.581***	-0.139
Change rate of exchange rate (Singapore)	-0.481**	0.115
GDP growth rate (US)	0.960*	-0.883**
Stock return (US)	0.036	-0.084
FFR(US)	-2.313***	0.005
EFP(US)	-4.601**	-5.854
TED	1.737	1.140
Oil price growth rate	-0.011	

Note: *** significant at 1%, ** significant at 5%, * significant at 1%.

Table 11 A Summary of Diebold and Mariano (1995) Statistics

Model	MSE	MAE
1	-0.252	-1.446
2	-0.442	-1.509
3	-0.254	-1.149
4	-0.739	-1.545
5	benchmark	benchmark
6	-0.049	-0.747
7	-0.161	-0.628
8	-0.642	-1.793*
9	-1.660*	-3.341***

Note:*** Statistically significant at 1% level. * Statistically significant at 10% level.

Table 12 The Summary Statistics of Housing Returns (%): Data, Model 5, 5A, and the Alternative Model (1984Q4-2010Q2) [Charles: is Filtered Data out of place]

Correl.	Data	Model 5	Model 5A	Filtered Data	Alternative Model
Mean	3.196	3.184	3.294	0.000	0.183
Median	4.629	4.468	4.630	-0.297	1.420
Maximun	35.143	33.298	31.853	27.946	20.759
Minimun	-40.194	-36.772	-35.437	-47.087	-39.848
Std. Dev.	15.846	15.381	15.375	12.593	10.547
Skewness	-0.284	-0.382	-0.332	-0.523	-0.922
Kurtosis	2.835	2.998	2.828	4.631	5.054

Key: Notice that the Alternative model tries to match the "filtered data" and the other models in the text attempt to match the raw data. Hence they are not directly comparable. Nevertheless, we put the corresponding figures together in a table for reference.

Table 13 Correlation Between Housing Returns and Other Macroeconomic Variables

Correl.	Data	Model 5	Model 5A	Filtered Data	Alternative Model
(H,GDP)	0.679	0.670	0.697	0.670	0.564
(H,S)	0.576	0.542	0.570	0.621	0.504
(H,Trade)	0.566	0.577	0.576	0.529	0.394
(H,EX-R)	-0.626	-0.612	-0.598	-0.558	-0.499

Key: "Correl" refers to Correlation; "(H,GDP)" refers to (House Return, GDP growth); "(H,S)" refers to (House Return, Stock Price Change); "(H,Trade)" refers to (House Return, Real Amount of International growth rate); "(H,EX-R)" refers to (House Return, Exchange Rate Change). For the alternative specification, we report the correlation between filtered housing returns and other filtered macroeconomic variables. For the alternative model, we calculate the correlations between Filtered housing returns and other filtered macroeconomic variables.

Table 14 Periods of being in State 2 for Model 5, 5A, and the Alternative Model

Model	Bust Periods
5	1985Q1-1985Q3 1987Q3-1992Q2 1997Q3-1998Q4 2002Q1-2008Q4
5A	1984Q4 1986Q2 1987Q1 1987Q3-1987Q4 1989Q4 1990Q3-1991Q3 1992Q2 1993Q1 1993Q4 1995Q2-1995Q3 1996Q1 1996Q3-1998Q4 2000Q1-2000Q3 2001Q3 2002Q3-2007Q3 2008Q2-2008Q3 2009Q3-2009Q4
Alternative Model	1984Q2 1985Q2-1986Q1 1996Q2-1999Q1 2001Q3-2001Q4 2002Q3-2002Q4 2008Q4 2010Q2

Table 15 In-Sample Forecasting Performance: Model 5,5A, and the Alternative Model

Model	MSE	MAE
5	**14.625**	**2.793**
5A	14.540	3.064
Alternative	43.212	5.348

Table 16 The Estimation Results of Model 5 and 5A

	Model 5		Nodel 5A	
	Regime 1 (boom regime)	Regime 2 (bust regime)	Regime 1 (boom regime)	Regime 2 (bust regime)
GDP growth rate (Singapore)	-0.606**	0.323	0.071	0.131
Stock return (Singapore)	0.014	0.162***	0.115***	0.167***
Change rate of amount of Trade (Singapore)	0.581***	-0.139	0.039	-0.005
Change rate of exchange rate (Singapore)	-0.481**	0.115	-0.024	0.095
GDP growth rate (US)	0.960*	-0.883**	0.253	-1.730***
Stock return (US)	0.036	-0.084	0.149***	-0.141***
FFR(US)	-2.313***	0.005	-0.981***	-0.237
EFP(US)	-4.601**	-5.854	-3.004	-6.417***
TED(US)	1.737	1.140	2.624	0.572
Oil price growth rate	-0.011		-0.020*	

Note: *** significant at 1%, ** significant at 5%, * significant at 1%.

Table 17 Stage Two Estimation Results of Housing Return under the Alternative Model

	Regime 1 (boom regime)	Regime 2 (bust regime)
GDP-tutta (Singapore)	-0.012	-0.242
S-tutta (Singapore)	0.092	0.446
Trade-tutta (Singapore)	-0.162	0.008
Ex-R-tutta (Singapore)	0.038	-0.264
H-tutta (Singapore)	0.665***	0.226

Note: *** significant at 1%, ** significant at 5%, * significant at 1%.

Table 18 The Unconditional Means for Filtered Data under the Alternative Model

	Regime 1 (boom regime)	Regime 2 (bust regime)
GDP-tutta (Singapore)	1.974	-8.464
S-tutta (Singapore)	7.007	-22.069
Trade-tutta (Singapore)	4.224	-15.360
Ex-R-tutta (Singapore)	-1.415	2.518
H-tutta (Singapore)	4.426	-14.856

Table 19 A Summary of Diebold and Mariano (1995) Statistics

Model	MSE	MAE
5	benchmark	benchmark
5A	0.035	-1.259

Note:*** Statistically significant at 1% level. * Statistically significant at 10% level.

Key: Notice that the Model 5 is to forecast the future housing return, while Alternative model is to forecast the future “filtered” housing return. Thus, a direct comparison of the forecasting ability of Model 5A and Alternative is inappropriate.

APPENDIX

A Nine specifications of Models

Model 1

$$h_t^s = B_0 + B_1' \widetilde{X}_t^s + B_2' X_t^{us} + b_3 x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{7}$$

Model 2

$$h_t^s = B_0 (\omega_t) + B_1' (\omega_t) \widetilde{X}_t^s + B_2' X_t^{us} + b_3 x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{8}$$

Model 3

$$h_t^s = B_0 (\omega_t) + B_1' \widetilde{X}_t^s + B_2' (\omega_t) X_t^{us} + b_3 x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{9}$$

Model 4

$$h_t^s = B_0 (\omega_t) + B_1' \widetilde{X}_t^s + B_2' X_t^{us} + b_3 (\omega_t) x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{10}$$

Model 5

$$h_t^s = B_0 (\omega_t) + B_1' (\omega_t) \widetilde{X}_t^s + B_2' (\omega_t) X_t^{us} + b_3 x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{11}$$

Model 6

$$h_t^s = B_0 (\omega_t) + B_1' (\omega_t) \widetilde{X}_t^s + B_2' X_t^{us} + b_3 (\omega_t) x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{12}$$

Model 7

$$h_t^s = B_0 (\omega_t) + B_1' \widetilde{X}_t^s + B_2' (\omega_t) X_t^{us} + b_3 (\omega_t) x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{13}$$

Model 8

$$h_t^s = B_0 (\omega_t) + B_1' (\omega_t) \widetilde{X}_t^s + B_2' (\omega_t) X_t^{us} + b_3 (\omega_t) x_t^w + \sum_{k=1}^{p} d_k h_{t-k}^s + \varepsilon_t, \tag{14}$$

Model 9

$$h_t^s = B_0 (\omega_t) + B_1' (\omega_t) \widetilde{X}_t^s + B_2' (\omega_t) X_t^{us} + b_3 (\omega_t) x_t^w + \sum_{k=1}^{p} d_k (\omega_t) h_{t-k}^s + \varepsilon_t, \tag{15}$$

Appendix B

This appendix provides details of the regression results discussed in the text.

Table B-1 Stage One Estimation for the Benchmark Model

Parameter	GDP	Stock Return	Amount of Trade	Exchange Rate
Constant	7.388**	14.971	1.463	-1.440
	(2.955)	(13.667)	(5.363)	(2.642)
GDP(-1)	-0.095	-0.540	2.214	-0.289
	(0.946)	(4.377)	(1.718)	(0.846)
Stock(-1)	0.006	0.357	-0.105	0.105**
	(0.058)	(0.269)	(0.106)	(0.052)
FFR(-1)	3.926***	9.892*	3.924*	-2.600**
	(1.297)	(5.998)	(2.353)	(1.160)
EFP(-1)	-3.241	-11.444	-10.402	-0.537
	(4.027)	(18.629)	(7.310)	(3.602)
TED(-1)	-2.928	-7.408	-1.449	1.638
	(2.579)	(11.929)	(4.681)	(2.306)
Oil(-1)	0.006	0.020	0.081**	-0.031
	(0.022)	(0.101)	(0.040)	(0.019)
GDP(-2)	0.822	-7.040	1.867	-0.093
	(1.380)	(6.383)	(2.505)	(1.234)
Stock(-2)	0.075	0.228	0.174	-0.024
	(0.074)	(0.342)	(0.134)	(0.066)
FFR(-2)	-0.218	-6.493	-2.008	1.193
	(2.189)	(10.126)	(3.973)	(1.958)
EFP(-2)	-0.670	10.868	1.749	0.503
	(5.219)	(24.142)	(9.473)	(4.667)
TED(-2)	1.443	1.117	3.798	0.590
	(2.603)	(12.041)	(4.725)	(2.328)
Oil(-2)	0.010	-0.148	0.028	-0.018
	(0.028)	(0.127)	(0.050)	(0.025)
GDP(-3)	-1.578*	6.068	-1.905	2.015**
	(0.896)	(4.143)	(1.626)	(0.801)
Stock(-3)	-0.013	-0.103	-0.111	-0.030
	(0.058)	(0.266)	(0.104)	(0.051)
FFR(-3)	-3.143**	-4.973	-2.379	0.295
	(1.330)	(6.151)	(2.414)	(1.189)
EFP(-3)	3.613	5.762	11.336*	-2.232
	(3.555)	(16.444)	(6.453)	(3.179)
TED(-3)	-0.101	-3.388	-3.759	1.501
	(2.254)	(10.428)	(4.092)	(2.016)

Oil(-3)	0.018	-0.196**	-0.012	0.024
	(0.023)	(0.105)	(0.041)	(0.020)

Note:*** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level. Values in parentheses represent the standard deviations.

Table B-2 Stage Two Estimation for the Benchmark Model

parameter	Model 1		Model 2		Model 3	
	State 1	State 2	State1	State 2	State 1	State 2
b_0	8.334***		11.572***	2.258	16.123***	3.104
	(2.199)		(2.018)	(4.299)	(1.980)	(3.405)
d_1	1.339***		1.190***		1.050***	
	(0.079)		(0.074)		(0.077)	
d_2	-0.568***		-0.489***		-0.272***	
	(0.080)		(0.064)		(0.070)	
b_{11}	0.061		0.148	0.437	-0.080	
	(0.174)		(0.167)	(0.927)	(0.141)	
b_{12}	0.084***		0.039*	0.007	0.071***	
	(0.027)		(0.022)	(0.294)	(0.020)	
b_{13}	0.100		0.096	0.193	0.216***	
	(0.078)		(0.074)	(0.682)	(0.069)	
b_{14}	-0.144		-0.144	-0.156	-0.116	
	(0.124)		(0.108)	(0.524)	(0.105)	
b_{21}	-0.685**		-0.072		-0.751**	-0.292
	(0.296)		(0.270)		(0.318)	(0.488)
b_{22}	0.047		0.112***		0.246***	-0.042
	(0.034)		(0.029)		(0.045)	(0.035)
b_{23}	-0.347		-0.935***		-1.244***	0.244
	(0.213)		(0.205)		(0.275)	(0.327)
b_{24}	-4.627***		-6.654***		-7.855***	-2.480

	(1.796)	(1.803)		(1.779)	(2.509)
b_{25}	0.754	2.886**		3.888***	-4.026*
	(1.526)	(1.254)		(1.445)	(2.079)
b_3	-0.019	-0.034***		-0.006	
	(0.013)	(0.011)		(0.013)	
σ^2	15.203***	8.735***		5.960***	
	(2.818)	(1.669)		(1.408)	
a		3.011***	1.148	1.266***	1.251**
		(0.652)	(0.710)	(0.452)	(0.500)
lnL	-286.309	-279.627		-274.167	

Note:*** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level. Values in parentheses represent the standard deviations.

Table B-2 Stage Two Estimation for the Benchmark Model (Continued)

parameter	Model 4		Model 5		Model 6	
	State 1	State 2	State1	State 2	State 1	State 2
b_0	11.639***	3.067	13.892***	8.0068*	14.703***	5.710**
	(1.944)	(2.400)	(2.329)	(4.357)	(2.440)	(2.493)
d_1	1.189***		1.165***		1.065***	
	(0.071)		(0.078)		(0.084)	
d_2	-0.477***		-0.457***		-0.349***	
	(0.061)		(0.071)		(0.078)	
b_{11}	0.143		-0.606**	0.323	-0.027	0.077
	(0.163)		(0.244)	(0.249)	(0.185)	(0.280)
b_{12}	0.040*		0.014	0.162***	0.100***	0.086*
	(0.021)		(0.042)	(0.041)	(0.025)	(0.051)
b_{13}	0.066		0.581***	-0.139	0.103	-0.015
	(0.070)		(0.117)	(0.097)	(0.076)	(0.170)
b_{14}	-0.110		-0.481**	0.115	0.180	0.167
	(0.100)		(0.193)	(0.193)	(0.145)	(0.217)
b_{21}	-0.063		0.960*	-0.883**	-0.158	
	(0.266)		(0.514)	(0.391)	(0.277)	
b_{22}	0.118***		0.036	-0.084	-0.005	
	(0.028)		(0.056)	(0.061)	(0.033)	
b_{23}	-0.911***		-2.313***	0.005	-1.150***	
	(0.200)		(0.491)	(0.285)	(0.218)	
b_{24}	-6.718***		-4.601**	-5.854	-4.847**	
	(1.667)		(2.303)	(3.612)	(2.131)	
b_{25}	2.837**		1.737	1.140	0.549	
	(1.251)		(2.449)	(1.642)	(1.434)	

b_3	-0.034***	0.056**	-0.011		-0.002	0.056**
	(0.011)	(0.028)	(0.013)		(0.013)	(0.029)
σ^2	8.599***		7.062***		7.955***	
	(1.579)		(1.183)		(1.383)	
a	2.906***	1.333*	2.193***	2.262***	2.740***	2.340***
	(0.717)	(0.721)	(0.619)	(0.690)	(0.827)	(0.622)
lnL	-277.483		-268.035		-275.794	

Note:*** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level. Values in parentheses represent the standard deviations.

Table B-2 Stage Two Estimation for the Benchmark Model (Continued)

parameter	Model 7		Model 8		Model 9	
	State 1	State 2	State1	State 2	State 1	State 2
b_0	10.527***	7.086*	17.902***	5.832	21.738***	4.719**
	(3.153)	(4.162)	(2.202)	(4.408)	(4.762)	(2.193)
d_1	1.132***		1.115***		1.026***	1.415***
	(0.073)		(0.059)		(0.098)	(0.082)
d_2	-0.427***		-0.415***		-0.360***	-0.664***
	(0.064)		(0.049)		(0.116)	(0.075)
b_{11}	0.194		-0.053	0.231	0.104	0.375***
	(0.158)		(0.187)	(0.244)	(0.205)	(0.134)
b_{12}	0.040*		-0.025	0.170***	0.018	0.098***
	(0.023)		(0.038)	(0.036)	(0.044)	(0.025)
b_{13}	0.025		0.285***	-0.061	0.079	-0.086
	(0.072)		(0.085)	(0.081)	(0.135)	(0.064)
b_{14}	-0.106		-0.437***	0.126	-0.555***	0.095

	(0.098)		(0.140)	(0.154)	(0.184)	(0.090)
b_{21}	0.241	-3.580***	-0.125	-0.746	0.399	-1.061***
	(0.345)	(1.116)	(0.369)	(0.549)	(0.534)	(0.327)
b_{22}	0.112***	0.180**	0.152***	-0.058	0.234***	0.009
	(0.041)	(0.075)	(0.035)	(0.058)	(0.066)	(0.030)
b_{23}	-0.865***	-0.002	-1.711***	0.237	-2.853***	0.094
	(0.253)	(0.668)	(0.269)	(0.274)	(0.482)	(0.163)
b_{24}	-6.510**	-0.243	-10.443***	-5.390	-14.904***	-2.616
	(2.546)	(3.759)	(2.429)	(3.345)	(4.083)	(1.922)
b_{25}	2.779**	3.531	5.872***	0.765	14.053***	0.004
	(1.380)	(4.333)	(2.144)	(1.460)	(4.164)	(1.120)
b_3	-0.036***	0.096**	-0.047***	0.030	-0.063***	0.026*
	(0.012)	(0.045)	(0.015)	(0.021)	(0.020)	(0.013)
σ^2	7.713***		4.881***		3.400***	
	(1.478)		(1.109)		(0.788)	
a	2.441***	1.894**	0.922**	0.820	-0.067	0.682**
	(0.749)	(0.745)	(0.455)	(0.509)	(0.528)	(0.347)
lnL	-269.506		-262.722		-254.905	

Note:*** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level. Values in parentheses represent the standard deviations.

Table B3 Stage One Estimation of the Alternative Model

Parameter	GDP	Stock Return	Amount of Trade	Exchange Rate	Housing Return
Constant	7.388** (2.955)	14.971 (13.667)	1.463 (5.363)	-1.440 (2.642)	25.205*** (7.715)
GDP(-1)	-0.095 (0.946)	-0.540 (4.377)	2.214 (1.718)	-0.289 (0.846)	-0.138 (2.471)
Stock(-1)	0.006 (0.058)	0.357 (0.269)	-0.105 (0.106)	0.105** (0.052)	-0.112 (0.152)
FFR(-1)	3.926*** (1.297)	9.892* (5.998)	3.924* (2.353)	-2.600** (1.160)	6.307* (3.385)
EFP(-1)	-3.241 (4.027)	-11.444 (18.629)	-10.402 (7.310)	-0.537 (3.602)	-17.250 (10.515)
TED(-1)	-2.928 (2.579)	-7.408 (11.929)	-1.449 (4.681)	1.638 (2.306)	1.998 (6.734)
Oil(-1)	0.006 (0.022)	0.020 (0.101)	0.081** (0.040)	-0.031 (0.019)	0.095* (0.057)
GDP(-2)	0.822 (1.380)	-7.040 (6.383)	1.867 (2.505)	-0.093 (1.234)	-0.723 (3.603)
Stock(-2)	0.075 (0.074)	0.228 (0.342)	0.174 (0.134)	-0.024 (0.066)	0.038 (0.193)
FFR(-2)	-0.218 (2.189)	-6.493 (10.126)	-2.008 (3.973)	1.193 (1.958)	-4.070 (5.715)
EFP(-2)	-0.670 (5.219)	10.868 (24.142)	1.749 (9.473)	0.503 (4.667)	-0.500 (13.627)
TED(-2)	1.443 (2.603)	1.117 (12.041)	3.798 (4.725)	0.590 (2.328)	2.475 (6.797)
Oil(-2)	0.010 (0.028)	-0.148 (0.127)	0.028 (0.050)	-0.018 (0.025)	-0.000 (0.072)
GDP(-3)	-1.578* (0.896)	6.068 (4.143)	-1.905 (1.626)	2.015** (0.801)	-2.964 (2.338)
Stock(-3)	-0.013 (0.058)	-0.103 (0.266)	-0.111 (0.104)	-0.030 (0.051)	0.019 (0.150)
FFR(-3)	-3.143** (1.330)	-4.973 (6.151)	-2.379 (2.414)	0.295 (1.189)	-1.319 (3.472)
EFP(-3)	3.613 (3.555)	5.762 (16.444)	11.336* (6.453)	-2.232 (3.179)	2.408 (9.282)
TED(-3)	-0.101 (2.254)	-3.388 (10.428)	-3.759 (4.092)	1.501 (2.016)	-3.209 (5.886)

Oil(-3)	0.018 (0.023)	-0.196** (0.105)	-0.012 (0.041)	0.024 (0.020)	-0.097 (0.059)

Note: *** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level. Values in parentheses represent the standard deviations.

Table B4 Stage Two Estimation Results for Alternative Model (GDP-dutta, S-dutta, Trade-dutta, Ex-R-dutta, H-dutta)

	Regime 1		Regime 2	
Parameter	Estimate	S.E.	Estimate	S.E.
$b_0^{(1)}$	0.956	0.590	-3.139	35.286
$b_1^{(11)}$	0.505	0.411	1.069	28.177
$b_1^{(12)}$	0.020	0.045	0.076	12.379
$b_1^{(13)}$	-0.006	0.113	-0.212	4.173
$b_1^{(14)}$	0.013	0.215	0.055	23.642
$b_1^{(15)}$	-0.019	0.141	-0.135	21.047
σ_1^2	8.226***	3.084	8.226***	3.084
λ_1	1.000	(---)	0.893	10.165
$b_0^{(2)}$	4.977	4.282	-16.842	725.426
$b_1^{(21)}$	-1.086	1.653	2.995	125.038
$b_1^{(22)}$	0.528**	0.262	0.204	20.229
$b_1^{(23)}$	0.400	0.606	-1.645	72.015
$b_1^{(24)}$	0.393	1.206	-1.755	135.029
$b_1^{(25)}$	-0.149	0.479	-0.253	34.995
σ_2^2	217.105***	58.591	217.105***	58.591
λ_2	1.000	(---)	0.958	28.468
$b_0^{(3)}$	2.167	1.481	-8.616	112.234
$b_1^{(31)}$	-0.122	0.562	1.219	27.021
$b_1^{(32)}$	-0.005	0.111	0.094	10.710

$b_1^{(33)}$	0.628***	0.230	0.024	5.665
$b_1^{(34)}$	-0.015	0.465	0.065	12.110
$b_1^{(35)}$	-0.077	0.284	-0.394	22.560
σ_3^2	31.891**	13.190	31.891**	13.190
λ_3	1.000	(---)	0.558	8.904

Table B4 Stage Two Estimation Results for Alternative Model (GDP-dutta, S-dutta, Trade-dutta, Ex-R-dutta, H-dutta (Continued)

	Regime 1		Regime 2	
Parameter	Estimate	S.E.	Estimate	S.E.
$b_0^{(4)}$	-0.515	0.643	3.185	494.029
$b_1^{(41)}$	0.017	0.338	0.073	152.406
$b_1^{(42)}$	-0.025	0.041	0.026	17.868
$b_1^{(43)}$	0.040	0.101	0.133	93.804
$b_1^{(44)}$	0.624***	0.169	0.353	23.879
$b_1^{(45)}$	-0.010	0.079	-0.113	37.179
σ_4^2	6.526**	3.159	6.526**	3.159
λ_4	1.000	(---)	1.515	29.549
$b_0^{(5)}$	1.600	1.927	-2.916	277.036
$b_1^{(51)}$	-0.012	0.776	-0.242	99.172
$b_1^{(52)}$	0.092	0.107	0.446	6.147
$b_1^{(53)}$	-0.162	0.269	0.008	37.686
$b_1^{(54)}$	0.038	0.583	-0.264	41.165
$b_1^{(55)}$	0.665***	0.231	0.226	11.116
σ_5^2	39.552***	10.796	39.552***	10.796
λ_5	1.000	(---)	0.646	5.408

r_{12}	0.353	0.215		
r_{13}	0.597***	0.211		
r_{14}	-0.117	0.295		
r_{15}	0.468*	0.244		
r_{23}	0.136	0.269		
r_{24}	-0.026	0.300		
r_{25}	0.489**	0.204		
r_{34}	-0.148	0.310		
r_{35}	0.504**	0.201		
r_{45}	-0.324	0.307		
P_{ii}	0.914***	0.124	0.704**	0.350
lnL		1529.157		

Note: *** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level.