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On the Linkages between Exchange Rate Movements Stock, Bond and Interest Rate Market in a Regime-Switching Model: Evidence for ASEAN and East Asia

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Abstract : This study analyzes the relationship among exchange rate (against US dollar), interest rate, government bond and the stock market in three ASEAN countries consisting of Thailand, Malaysia, Singapore and three East Asia countries comprising Japan, Korea, and China. The paper analyzes the question whether there exist a correlation between these variables in both high growth and low growth economy and whether there exist a similar market pattern in these countries. In this study, we estimate the correlations between these variables using the MS-VECM approach. In addition, the obtained regime probabilities allow us to detect and identify the factor or event affecting the movement of the financial markets.

Keywords : MS-VECM; Bayesian; the relationship of financial markets; regime probabilities.

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1 Introduction

With the development of international financial markets, the stock index, exchange rate, government bond yield and interest rate can grow more interacting through trade flow and capital flow. Volatility affecting one market may be transmitted rapidly to another by contagion effects. Estimating and understanding the dynamic linkages have important implications for asset allocation, portfolio diversification, currency risk hedging, stock and currency market return predictability. In this article, we examine whether the spill-over effects exist and take place across exchange rate (against US dollar), interest rate, government bond and the stock markets.

Why we consider these four markets in our study?

There are many approaches and evidences that confirm the relationship between those four variables. For the stock and exchange market. There are two potential theories expressing the relationship between stock prices and exchange rate (foreign exchange market: FX). The first is the flow-oriented model, which argues that the currency exchange will impact the international competitiveness and trade balance. For instance, domestic currency depreciation improves the competiveness of local firms, resulting in an upward movement of stock prices in response to the increase in expected in-coming cash flows. The second is the stock-oriented model which shows that exchange rates are affected by stock prices movements and the persistent upward trend in stock prices will attract money inflow and lead to an appreciation of the currency, or vice versa. Numerous researches have investigated the linkages between stock index and FX market and provided interesting empirical results. Diamandis and Drakos [1] used VECM model and found that the stock index and FX was positively related in Brazil, Argentina, Chile, and Mexico. Tsai [2] found that the relationship between the stock index and FX was negative in Malaysia, Singapore, South Korea, the Philippines, Taiwan, and Thailand. Tudor and Popescu-Dutaa [3] used VAR model and found the causality relationship was from FX to stock index in Brazil and Russia and no relationship between FX and stock index in China. The causality-in-variance was found to be from the stock returns to exchange rate changes in the US, in the opposite direction in the Euro area and Japan, and of bidirectional feedback in Switzerland and Canada, in the study by Caporale, Hunter, and Ali [4] who used bivariate DCC-GARCH model to study the banking crisis between 2007 and 2010. Many research papers have also been undertaken on the relationship between stock and bond markets such as those by Yang et al.[5], Andersen et al. [6], Baele [7] which commonly found positive significant relationship to exist between stock and bond markets. Another strand of the literature has brought attention to the dependency between FX and interest rates as well. The relationship between FX and interest rate is positive under the flexible prices approach [8] but under the Keynesian approach, the relationship is negative. Bautista [9] suggested a strong positive correlation between interest rate and FX during the turbulent periods in the Philippines from his dynamic conditional correlation (DCC) analysis. Conversely, Sanchez [10] found that the correlation between exchange rates and interest rates, given risk premium as condition, is negative for economic expansion and positive for economic contraction. Furthermore, we also found some evidences that stock market can be influenced by interest rate movement. There are also different views in terms of the relationship between interest rates and stock prices. For example, higher interest rates increase the opportunity cost of money, thus decreasing the return and stock prices of companies. On the other hand, lower interest rates do not have the opposite impact on stock prices. The Markov-switching vector autoregressive (MS-VAR) model, is utilized by Kal, Arslaner, and Arslaner [8] for investigating whether the deviation of a currency from its fundamentally determined rate of return affects the relationship between interest rates and stock market yields. From some evidences cited above motivated us to explore to explore the relationship between the four financial variables of our interest. Our study will cover six East and Southeast Asian countries because financial markets in Asia have become more attractive for foreign capital investment and these countries in particular have grown more export-dominant in recent decades. Hence, the goal of this paper is aimed at examining profoundly the various relationships between these four financial variables and providing the explanation for the different economic condiction. To achieve our purpose, the Markov Switching Vector error correction model (MS-VECM), which was introduced in Krolzig, Marcellino, and Mizon [11], is employed in this study. The model has an ability to estimate the cointegrated structure of variables and capture the long-run relationship of the variables in the financial model and it can also explain the non-linearity embedded in the relationship of financial markets in each country. To estimate the parameters in the model, we select a Bayesian estimation technique because the computation in the conventional maximum likelihood method may be difficult in our case where we have a large number of unknown parameters in the model. Moreover with the Bayesian prior for our estimated parameter, it is possible to reduce the estimation uncertainty and to obtain accurately the inference[12] . The rest of the paper is organized as follows. Section 2 discusses the MS-VECM model and the Bayesian prior and posterior estimation. The data description and the estimation results are presented in Sections 3 and 4. Finally, Section 5 summarizes and concludes the paper.

2 Methodology

2.1 Markov Vector Error Correction Model

To understand our approach, consider the following Markov-switching VECM (MS-VECM):

$$\Delta y_t = c_{S_t} + \sum_{i=1}^{p} \beta_{i,S_t} \Delta y_{t-i} + \Pi_{S_t} \Delta y_{t-1} + u_{t,S_t} \tag{2.1}$$

where Δy_t denotes a k-dimensional vector of differenced variables of interest, c_{S_t} is a vector of state dependent intercept term, β_{i,S_t} is state dependent autoregressive parameter matrices of vector Δy_{t-i}, Π_{S_t} are the state dependent error correction terms defined by the r k matrix of co-integrating vectors and is u_{t,S_t} error variance which is allowed to change across the regimes with normally distributed,$u_{t,S_t} \sim N\left(0, \Sigma_{S_t}\right)$. S_t denotes the unobserved state variable which evolves according to a H-state and thus, allowing intercept term, co-integrating term, autoregressive term and variance-covariance matrix to switch across regimes. In this study the state variable is assumed to follow the first-order Markov switching process with the transition probabilities,$P_{ij}\left(S_t = i | S_{t-1} = j\right), \quad i, j = 1, ..., H$

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{H1} \\ p_{12} & p_{22} & \cdots & p_{H2} \\ \vdots & \vdots & \ddots & \vdots \\ p_{1H} & p_{2H} & \cdots & p_{HH} \end{bmatrix} \tag{2.2}$$

where P_{ij} is the probability change from regime i to regime j. In this study, the two-regimes MS-VECM is assumed, following the popular practice in many studies. Consequently, we can extend Eq. (2.1) as follows:

$$\Delta y_t = \begin{cases} c_{(S_t=1)} + \beta_{1(S_t=1)}\Delta y_{t-1} + ... + \beta_{i(S_t=1)}\Delta y_{t-p} + \Pi_{(S_t=1)}\Delta y_{t-1} + u_{t,(S_t=1)} \\ c_{(S_t=2)} + \beta_{1(S_t=2)}\Delta y_{t-1} + ... + \beta_{i(S_t=2)}\Delta y_{t-p} + \Pi_{(S_t=2)}\Delta y_{t-1} + u_{t,(S_t=2)} \end{cases} \tag{2.3}$$

2.2 Prior Distributions and Likelihood

In this study, we choose a prior density for our parameters following the estimation by Doan in RATS software. The selected Flat prior density is applied in the estimation of MS-VECM model where intercept term (c_{S_t}), autoregressive term (β_{i,S_t}), co-integrating vector (Π_{S_t}) are assumed to have informative prior, flat prior, variance-covariance matrix (Σ_{S_t}) to have Inverted Wishart prior, and Beta prior for the transition probabilities (P_{ij}).

Let $\theta = \{c, \beta, \Pi\}$,have the least informative priors, i.e., flat prior, where the prior is simply a constant. Thus, the posterior is constant times the likelihood,

$$P\left(\theta_{S_t}, \Sigma_{S_t}, P_{ij} | \Delta y_t\right) = pr\left(\theta_{S_t}\right) \bullet 1\left(\theta_{S_t}, \Sigma_{S_t}, P_{ij} | \Delta y_t\right) \tag{2.4}$$

where $pr\left(\theta_{S_t}\right)$ is a flat prior with uniform distribution $(-\infty, +\infty)$. Thus, the likelihood of the model will generate more effect on the posterior distribution. For Σ_{S_t}, the inverted Wishart priors are used.

$$\Sigma_{S_t} \sim IW\left(\Phi_{S_t}, v_{S_t}\right) \tag{2.5}$$

where $\Phi_{S_t} \in R^{n \times n}$ is the prior error variance for variance-covariance parameters for both two regimes and v_{S_t} is the degree of freedom of the Wishart densities. As prior for transition probabilities p_{ij} ; $i = 1, 2; j = 1, 2$, we define the prior for the P_{ij}, to be P_{ij} : $\beta\left(m_{ij}+1, m_{ii}+1\right)$ where m_{ij} is the number of prior transitions. Summarizing, the likelihood function for c_{S_t}, Π_{S_t}, β_{S_t}, Σ_{S_t}, P_{ij} and S_t is given by,

$$L\left(c_{S_t}, \beta_{S_t}, \Sigma_{S_t}, P_{ij}, S_t|\Delta y_t\right) \propto$$
$$\prod_{i=1}^{n}\left\{\sum_{S_t=1}^{H=2}\left((2\pi)^{-\frac{1}{2}}|\Sigma_{S_t}|^{-\frac{1}{2}}\right)exp\left(-\frac{1}{2}tr\left[\left\{vec(u_{S_t})'\left(\Sigma_{S_t}\bigotimes I\right)(vec(u_{S_t}))\right\}\right]\right)\right\} \tag{2.6}$$

where $u_{S_t} = \Delta y_t - c_{S_t} - \beta_{1,S_t}\Delta y_{t-1} - ... - \beta_{i,S_t}\Delta y_{t-p} - \Pi_{S_t}\Delta y_{t-1}$.

2.3 Posterior Estimation

The posterior densities were obtained from the priors times the likelihood functions. Katsuhiro [13] proposed two steps of posterior estimation via Gibb sampling. First, using Hamiltons filter method to estimate the state variable $S_t = \{s_1, ..., s_t\}$, $S_t \in (1, 2)$, then we estimate the posterior densities for the intercept term, co-integrating term, autoregressive term and variance-covariance matrix.

To sample the state (or regime) variable (S_t), Hamiltons filter [14] is used to filter the state variable S_t from the following conditional distribution

$$P\left(S_t|S_{t+1}, \Theta, \Delta y\right) = \frac{P\left(S_{t+1}|S_t, \Theta, \Delta y\right)P\left(S_t|\Theta, \Delta y\right)}{P\left(S_{t+1}|\Theta, \Delta y\right)} \tag{2.7}$$

where $\Theta = \{c_{S_t}, \beta_{S_t}, \Sigma_{S_t}, \Pi_{S_t}, p_{11}, p_{22}, p_{12}, p_{21}\}$. After drawing the$S_t$, we then, generate the transition probabilities, $P = \{p_{11}, p_{12}, p_{21}, p_{22}\}$which are also derived from the previous estimation algorithm. Note that they are drawn from posteriors formed from beta-conjugate distributions. Then, to estimate$\Theta$the Multi-move Gibbs sampling can be used to generate sample draws which involve the repeated generation of variates from their full conditional densities, as follows:

1) Specify the staring values for P^0,${c_{S_t}}^0$,${\Pi_{S_t}}^0$,${\beta_{S_t}}^0$ and ${\Sigma_{S_t}}^0$.
2) Generate ${S_t}^j = \left\{{s_1}^j, {s_2}^j ..., {s_t}^j\right\}'$ from $P\left(S_t|\Theta^0, \Delta y\right)$.
3) Generate the transition probabilities P^j from $P\left(P_{11}, P_{12}, P_{21}, P_{22}|{S_t}^j, \Theta^0, \Delta y\right)$.
4) Generate ${c_{S_t}}^j$ from $P\left(c_{S_t}|{\beta_{S_t}}^0, {c_{S_t}}^0, {\Sigma_{S_t}}^0{S_t}^j\Delta y\right)$.
5) Generate ${\beta_{S_t}}^j$ from $P\left(\beta_{S_t}|{\beta_{S_t}}^0, {c_{S_t}}^j, {\Sigma_{S_t}}^0{S_t}^j\Delta y\right)$.
6) Generate ${\Sigma_{S_t}}^j$ from $P\left(\Sigma_{S_t}|{\beta_{S_t}}^j, {c_{S_t}}^j, {\Sigma_{S_t}}^0{S_t}^j\Delta y\right)$.
7) Repeating step 2-6 to generate P^{j+1},${\beta_{S_t}}^{j+1}$,${\Sigma_{S_t}}^{j+1}$, and ${S_t}^{j+1}$.

In this study, 10,000 iterations samples were generated using the MCMC Gibbs sampling estimation procedure as described in the steps above. The first 1,000 samples were discarded and the remaining 9,000 samples were used to describe the joint parameter density. As a result, we can obtain the posterior means and standard deviations of these remaining samples.

3 Dataset

In this study to analyze the relationship between the stock index, exchange rate, government bond yield and interest rate. The data were collected from Thomson DataStream; the selected variables consist of exchange rate, stock price, interest rate and bond yield from Thai, Malaysian, Singapore, Japanese, South Korean, and Chinese financial markets. The data are weekly time series for the period from March 2009 to February 2016, covering totally 362 observations. we transformed these variables into logarithms before computing in the model.

4 Empirical Results

4.1 The Results of Unit Roots Test

Prior to conducting the Markov-switching with co-integration analysis, it is important to determine the order of integration for all variables in order to ensure that there are not integrated at the zero order. In this study, we employed the Bayes factor unit root test of Wang and Ghosh [15] to identify the order of integration of our variables.

In this study, we specify the null hypothesis of unit root as $H_0 = P\left(\phi = 1|\Delta y_t\right)$ and the alternative hypothesis as $H_a = P\left(0 < \phi < 1|\Delta y_t\right)$. The null hypothesis can be determined as the marginal likelihood of AR(1) model $\Delta y_t = a + \left(\phi - 1\right)\Delta y_{t-1} + \varepsilon_t$ where $\phi = 1$ while $0 < \phi < 1$ for an alternative marginal likelihood of AR(1) model. In this test, Bayes factor is the posterior odd ration $P\left(\phi = 1|\Delta y_t\right)/P\left(0 < \phi < 1|\Delta y_t\right)$ and the null hypothesis is rejected if Bayes factor is less than 1. The results of the Bayes factor are presented in Table 1, which showed that the logarithm of all variables are I(1) and I(2).

4.2 Lag Length Selection

In this section, we have to specify the lag length for the MS-VECM model in order to choose the shortest lags which produce serially uncorrelated residuals. We employed the vector error correction lag length criteria to find the best number of lag lengths. For the VECM lag length criteria based on BIC, the results are reported in Table 2 and revealed that the BIC values for lag=1 are the lowest. Therefore, in this study, we chose the appropriate lag length p=1 to estimate our model.

4.3 Test for Number of Co-Integration

To determine the rank or the number of co-integration vectors, Bayesian information criteria (BIC) is conducted and the results are shown in Table 3.

Table 1: Bayes factor unit root test

Variable	Bayes factor	Integrated order
SET	0.9969	I(2)
THB	0.7862	I(2)
THI	0.9978	I(2)
THBY	0.9979	I(2)
KLSE	0.9997	I(1)
MYR	0.1926	I(1)
MYI	0.9993	I(1)
MYBY	0.9972	I(1)
STI	0.9979	I(1)
SGD	0.9999	I(1)
SGI	0.9976	I(2)
SGY	0.9945	I(2)
Nikkei	0.9993	I(1)
JPY	0.9934	I(2)
JPI	0.9999	I(2)
JPBY	0.999	I(1)
KOSPI	0.9978	I(1)
KWR	0.2799	I(2)
KI	0.9986	I(1)
KBY	0.9583	I(1)
SSE	0.5438	I(1)
CHY	0.9343	I(2)
CHI	0.9996	I(1)
CHBY	0.9994	I(1)

Source: Calculation Note: SET, KLSE, STI, Nikkei, KOSPI, and SSE denote as a stock market of Thailand, Malaysia, Singapore, Korea, and China, respectively. THB, MYR, JPY, KWR, CHY denote as currency of Thailand, Malaysia, Singapore, Korea, and China, respectively. THI, MYI, SGI, JPI, KI, and CHI denote as interest rate of Thailand, Malaysia, Singapore, Korea, and China, respectively. THBY, MYBY, SGY, JPBY, KBY, and CHBY denote as interest rate of Thailand, Malaysia, Singapore, Korea, and China, respectively.

We select the rank of the long-run relationship using BIC which was obtained from VECM with a conjugate prior. In this study, we specified a tightness parameter, a decay parameter, and a parameter for the lags of the variables as 0.10, 0.10, and 0.50, respectively. Based on the results of co-integration selection shown in Table 3, the result show that models of Thailand, Malaysia, Japan, and Korea present the lowest value of BIC at one co-integrating vector, while Singapore and China has two and zero number of cointregration, respectively. Therefore, the study chose r = 1 for Thailand, Malaysia, Japan, and Korea, r=2 for Singapore, and r=0 for China (MS-VAR).

Table 2: VECM Lag length criteria

Country	Lag	BIC
Thailand	1	4.668841*
	2	4.868588
	3	5.09762
	4	5.342994
Malaysia	1	-1.674580*
	2	-1.44877
	3	-1.23569
	4	-1.00201
Singapore	1	1.165207*
	2	1.315242
	3	1.459583
	4	1.576193
Japan	1	14.02791*
	2	14.08883
	3	14.21729
	4	14.35055
Korea	1	12.88807*
	2	13.1272
	3	13.33543
	4	13.50933
China	1	1.954617*
	2	2.147083
	3	2.334305
	4	2.51713

Source: Calculation

Table 3: Co-integration rank selection

BIC	r=0	r=1	r=2	r=3
Thailand	-20.3081	-20.3634	-20.3571	-20.3337
Malaysia	-23.5417	-23.5848	-23.5785	-23.5663
Singapore	-12.9893	-13.0257	-13.3597	-12.8657
Japan	-11.6093	-11.6653	-11.6005	-11.5077
Korea	-20.5098	-20.5454	-20.5446	-20.5218
China	-23.9792	-23.922	-23.8084	-23.6927

Source: Calculation Note : r = Cointegration rank

Table 4: Estimated MS(2)-VECM(1) : Thailand

	SET	THB	THI	THBY
		Regime-dependent intercepts		
R1	$-9.751(2.53)^a$	$-0.084(2.19)$	21.962(17.78)	5.077(2.88)
R2	$-11.696(2.55)^a$	$3.602(1.67)^a$	$-11.494(10.69)$	$-0.462(2.34)$
		Regime-dependent Autoregressive Lag 1		
		Regime 1		
SET	0.022(0.46)	-260(0.23)	1.467(0.96)	0.661(0.67)
THB	-1.632(2.16)	0.218(0.59)	1.778(2.74)	0.561(1.90)
THI	-0.460(0.75)	-0.161(0.13)	1.275(0.77)	0.530(0.55)
THBY	-0.389(0.28)	-0.202(0.14)	0.865(0.74)	$0.847(0.36)^a$
ECT(1)	$-0.187(0.02)^a$	-0.039(0.02)	0.234(0.19)	0.043(0.03)
		Regime 2		
SET	-0.428(0.72)	0.087(0.21)	-0.049(0.89)	-0.063(0.38)
THB	-1.763(2.94)	0.583(0.67)	-0.256(3.38)	-0.147(1.25)
THI	0.751(0.81)	-0.236(0.15)	0.990(0.74)	-0.092(0.33)
THBY	-0.272(0.44)	-0.068(0.11)	-0.081(0.54)	0.365(0.30)
ECT(1)	$-0.208(0.02)^a$	0.002(0.01)	-0.136(0.11)	-0.020(0.02)
	p1	p2	Duration	Observations
R1	0.982	0.02	55.55	186
R2	0.018	0.98	50	175

Source: Calculation () is standard deviation and a is Bayesian statistic significant R1 and R2 are regime 1 and regime 2, respectively

4.4 Model Estimation Result

In this section, the estimated results of six financial markets in six countries are presented in Table 4-9. The result contain the estimated parameters in the model and the transition matrix.

The estimated parameters of MS(2)-VECM(1) model, in the case of Thailand is shown in Table 4. Apparently, the estimated intercept parameters seem to have a statistically significant economic interpretation. The values of the intercept term in regime 1 are mostly higher than those in regime 2 and thus we can interpret regime 1 as high growth economic state and regime 2 as low growth economic state. The four error correction terms (ECT(1)) are shown in both regimes. The first important feature of these estimates is that there are exist a weakly exogenous. Consider regime 1, in all four equation, there is only SET that will adjust significantly if the index deviates from the long-run price equilibrium. For all other equations, no significant adjustments are observed in case of a short-run deviation from their equilibrium, which suggests that these variables are weakly exogenous. Thus, we can say that SET index has the long run relationship and short-run adjustment dynamics, so that the deviation of SET index from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. Similar to regime 1, there is only SET that has a statistically significant long run relationship and short-run adjustment dynamics. However, the results show that SET index adjusted more rapidly in the low growth markets since the speed of adjustment to long-run equilibrium of ECT(1) in regime 2 is larger than regime 1. The results furthermore show that THBY is significantly affected by its own lag in regime 1.

Consider the matrix of transition probability parameters, which are also presented in Table 4. The result shows that the probabilities of switching between regime 1 and regime 2 are less than 2%, while those of remaining in their own regime are more than 98%, meaning that the two regimes are persistent. Moreover, the expected number of months that the economy stays in high growth and low growth are 55.55 and 50 weeks, respectively. This means that the Thai economy stays in high growth state slightly longer than in low growth one.

Table 5: Estimated MS(2)-VECM(1) : Malaysia

	KLSE	MYR	MYI	MYBY
	Regime-dependent intercepts			
R1	$4.895(0.23)^a$	$0.417(0.083)^a$	$0.518(0.134)^a$	$-1.336(0.11)^a$
R2	$2.225(0.11)^a$	$0.153(0.203)^a$	$-4.715(0.203)^a$	$1.811(0.09)^a$
	Regime-dependent Autoregressive Lag 1			
	Regime 1			
KLSE	0.455(0.45)	0.260(0.15)	-0.108(0.25)	0.006(0.22)
MYR	0.469(0.63)	$0.758(0.22)^a$	0.543(0.36)	0.104(0.31)
MYI	-0.441(0.63)	-0.423(0.23)	0.272(0.35)	-0.222(0.33)
MYBY	-0.074(0.30)	-0.030(0.10)	-0.295(0.17)	0.229(0.15)
ECT(1)	0.068(0.001)a	0.002(0.00)	$0.015(0.00)^a$	$0.072(0.003)^a$
	Regime 2			
KLSE	-0.073(0.31)	0.589(0.54)	0.724(0.54)	-0.151(0.23)
MYR	-0.610(0.40)	0.782(0.69)	0.722(0.68)	0.128(0.29)
MYI	$(-0.935(0.27)^a$	-0.898(0.45)	-0.452(0.47)	-0.030(0.20)
MYBY	-0.883(0.21)	-0.174(0.36)	$-0.942(0.37)^a$	$0.374(0.15)^a$
ECT(1)	$0.140(0.00)^a$	0.031(0.00)	$0.157(0.01)^a$	$-0.011(0.00)^a$
	p1	p2	Duration	Observations
R1	0.987	0.021	47.619	135
R2	0.013	0.979	76.923	226

Source: Calculation () is standard deviation and a is Bayesian statistic significant R1 and R2 are regime 1 and regime 2, respectively

Table 5 presents the estimated results of Malaysia financial market. Regimes 1 and 2 are also interpreted as high and low growth economic states, respectively. Consider regime 1, we found that MYR has a positive significant effect from its own lag. In addition, the error correction term (ECT(1)) of KLSE, MYI, and

MYBY show a significant adjustment in the short-run deviation. However, the values of the ECT(1) of these equations are all positive, meaning they diverge from the long run equilibrium. For regime 2, we can see that the coefficients of KLSE and MYI equations demonstrate that the lagged MYI and MYBY seem to significantly influence KLSE and MYI, respectively. Consider the ECT(1) of this regime, the similar result is obtained except for the ECT(1) of MYBY equation. The error correction term of MYBY is statistically significant negative and lies between 0 and -1, meaning only Malaysian bond yield is co-integrated with Kuala Lumpur Stock Exchange, Malaysia ringgit and interest rate, respectively.

Table 6: Estimated MS(2)-VECM(1) : Singapore

	STI	SGD	SGI	SGBY
		Regime-dependent intercepts		
R1	$0.984(0.26)^a$	$-1.386(0.85)$	$-40.196(12.15)^a$	$-9.906(2.24)^a$
R2	0.267(0.21)	$3.116(0.82)^a$	16.740(11.40)	$-1.006(1.64)$
		Regime-dependent Autoregressive Lag 1		
		Regime 1		
STI	0.228(0.12)	0.066(0.18)	0.700(3.78)	-1.601(0.86)
SGD	-0.066(0.23)	0.447(0.36)	-0.627(7.41)	-1.192(1.64)
SGI	0.002(0.003)	0.005(0.005)	0.106(0.10)	-0.003(0.02)
SGBY	-0.024(0.03)	-0.002(0.05)	-0.073(1.19)	0.313(0.26)
ECT(1)	0.002(0.002)	-0.003(0.002)	-0.027(0.04)	-0.001(0.01)
ECT(2)	$0.087(0.003)^a$	0.016(0.01)	$0.419(0.12)^a$	$0.124(0.02)^a$
		Regime 2		
STI	-0.047(0.09)	-0.046(0.13)	-1.873(2.73)	-0.547(0.34)
SGD	-0.325(0.26)	0.767(0.43)	7.029(8.75)	0.226(0.84)
SGI	0.004(0.003)	0.002(0.005)	0.042(0.09)	$0.019(0.010)^a$
SGBY	-0.044(0.04)	0.032(0.066)	1.512(1.36)	$0.464(0.127)^a$
ECT(1)	0.001(0.001)	-0.002(0.002)	0.040(0.04)	$-0.009(0.004)^a$
ECT(2)	$0.095(0.002)^a$	$-0.036(0.01)^a$	-0.183(0.11)	0.013(0.020)
	p1	p2	Duration	Observations
R1	0.968	0.023	43.478	215
R2	0.032	0.977	31.25	146

Source: Calculation () is standard deviation and a is Bayesian statistic significant R1 and R2 are regime 1 and regime 2, respectively

Consider the matrix of transition probability parameters, which are also presented in Table 5. The result shows that regime 1 and regime 2 are persistent since the probabilities of switching between these two regimes are around 1.3-2.1% while remaining in their own regime has approximately 98% probability. Whereas the high growth regime has duration of approximately 76.923 weeks, the low growth regime has duration of 47.619 weeks. This means that the Malaysian economy stays mostly in high growth state rather than in low growth situation.

Table 7: Estimated MS(2)-VECM(1) : Japan

	Nikkei	JPY	JPI	JPBY
Regime-dependent intercepts				
R1	$9.217(0.01)^a$	$4.334(0.01)^a$	$-2.300(0.001)^a$	0.027(0.041)
R2	9.623(0.04)	$4.605(0.02)^a$	$-2.100(0.001)^a$	0.149(0.081)
Regime-dependent Autoregressive Lag 1				
Regime 1				
Nikkei	0.367(0.22)	$0.396(0.19)^a$	0.001(0.001)	0.285(0.616)
JPY	0.036(0.41)	-0.490(0.36)	-0.001(0.001)	-1.240(1.170)
JPI	0.001(0.00)	0.001(0.001)	0.001(0.001)	0.001(0.001)
JPBY	0.086(0.14)	0.101(0.13)	0.001(0.001)	$0.911(0.412)^a$
ECT(1)	$0.019(0.001)^a$	$-0.037(0.00)^a$	-0.001(0.001)	-0.025(0.014)
Regime 2				
Nikkei	0.282(0.67)	0.161(0.37)	0.001(0.001)	-0.624(1.256)
JPY	-1.289(1.46)	-0.584(0.82)	-0.001(0.001)	$6.260(2.755)^a$
JPI	0.001(0.001)	0.001(0.001)	0.001(0.001)	0.001(0.001)
JPBY	0.076(0.11)	0.048(0.06)	0.001(0.001)	-0.355(0.209)
ECT(1)	-0.020(0.01)	$-0.032(0.01)^a$	-0.001(0.001)	$0.371(0.032)^a$
	p1	p2	Duration	Observations
R 1	0.985	0.011	66.667	167
R 2	0.015	0.989	90.909	194

Source: Calculation () is standard deviation and a is Bayesian statistic significant R1 and R2 are regime 1 and regime 2, respectively

Table 6 presents the estimated results of Singapore financial market. The values of the intercept term in regime 1 are mostly lower than regime 2 thus we can interpret regime 1 as low growth economy and regime 2 as high growth economy. Consider regime 1, for all equations, there are no significant adjustment to be observed in case of a short-run deviation from their equilibrium thus suggesting that these variables are weakly exogenous. In addition, the error correction term (ECT(2)) of STI, SGI, and SGBY show a significant adjustment in the short-run deviation; however, the values of the ECT(2) of these equations are positive, meaning they diverge from the long run equilibrium. For regime 2, we can see that the coefficients of SGBY equation demonstrate that SGI seems to significantly influence SGBY. Consider the ECT(1) of this regime, the error correction term of SGBY is statistically significant negative and lies between 0 and -1, meaning only Singapore bond yield is co-integrated with SingaporeStraits Times Index, Singapore dollar and interest rate. Consider the ECT(2) of regime 2, the error correction term of SGD is negative at statistically significant level and lies between 0 and -1, meaning only Singapore dollar is co-integrated with SingaporeStraits

Times Index, Singapore bond yield and interest rate. The results, furthermore, show that SGBY is significantly affected by its own lag in regime 2.

Consider the matrix of transition probability parameters, which are also presented in Table 6. The result shows that regime 1 and regime 2 are persistent since the probabilities of switching between these two regimes are around 2.3-3.2% while remaining in their own regime is approximately 97%, meaning that the two regimes are persistent. While the high growth regime has duration of approximately 31.25 weeks, the low growth regime has duration of 43.478 weeks. This means that Singapore economy stays in low growth economy longer than in high growth economy.

Table 8: Estimated MS(2)-VECM(1) : Korea

	KOSPI	KRW	KI	KBY
Regime-dependent intercepts				
R1	9.701(1.741)^a	0.624(1.283)	6.076(6.405)	−27.490(5.770)^a
R2	−12.609(2.658)	11.435(1.275)^a	−5.812(4.888)	2.753(3.208)
Regime-dependent Autoregressive Lag 1				
Regime 1				
KOSPI	0.380(0.172)^a	-0.224(0.184)	0.610(1.010)	-0.518(0.820)
KRW	0.326(0.272)	0.436(0.304)	-2.597(1.744)	−3.541(1.423)^a
KI	0.011(0.115)	-0.013(0.129)	0.620(0.746)	0.533(0.608)
KBY	0.141(0.095)	−0.242(0.101)^a	0.680(0.568)	0.577(0.461)
ECT(1)	-0.008(0.007)	0.024(0.005)^a	-0.020(0.024)	0.109(0.022)^a
Regime 2				
KOSPI	-0.778(0.421)	0.539(0.200)^a	-1.022(0.888)	-0.029(0.531)
KRW	-0.540(0.707)	0.556(0.331)	0.220(1.507)	-1.028(0.917)
KI	-0.013(0.537)	0.011(0.251)	0.420(1.147)	-0.097(0.692)
KBY	-0.492(0.405)	0.197(0.191)	-0.482(0.871)	0.707(0.520)
ECT(1)	0.076(0.010)^a	−0.017(0.005)^a	0.026(0.019)	0.016(0.012)
	p1	p2	Duration	Observations
R1	0.986	0.024	71.428	157
R2	0.014	0.976	41.667	204

Source: Calculation () is standard deviation and a is Bayesian statistic significant R1 and R2 are regime 1 and regime 2, respectively

Table 7 presents the estimated result of Japan. The values of the intercept term in regime 1 are mostly lower than regime 2 thus we can interpret regime 1 as low growth economy and regime 2 as high growth economy. Consider regime 1, we can see that the coefficients of JPY equations demonstrate that Nikkei seems to significantly influence the lagged values of JPY. In addition, the error correction term (ECT(1)) of JPY shows that the error correction term of JPY is statistically significant negative and lies between 0 and -1, meaning only JapaneseYen is co-integrated with Nikkei index, Japan bond yield and interest rate. Consider the error correction term (ECT(1)) of Nikkei, a significant adjustment takes place when there is a short-run deviation; however, the value of the ECT(1) of Nikkei is positive, meaning they diverge from the long run equilibrium. For regime 2, we can see that the coefficients of JPBY equation demonstrate that JPY seems to significantly influence the lagged JPBY. Similar to regime 1, there is only JPY that has a statistically significant long run relationship and short-run adjustment dynamics. However, the results show that JPY adjusts more rapidly in the low growth markets since the speed of adjustment to long-run equilibrium of ECT(1) in regime 1 is faster than in regime 2. Consider the error correction term (ECT(1)) of JPBY, there is a significant adjustment in the short-run deviation; however, the value of the ECT(1) of JPBY is positive, meaning they diverge from the long run equilibrium. The results furthermore show that JPBY is significantly affected by its own lag in regime 1.

Consider the matrix of transition probability parameters, the result shows that regime 1 and regime 2 are persistent since the probabilities of switching between these two regimes are around 1.1-1.5% while that of remaining in their own regime is approximately 99%. Since the high growth regime has duration of approximately 90.909 weeks while the low growth regime has duration of 66.667 weeks, we can say that the Japanese economy stays in high growth economy longer than in low growth economy.

Table 8 presents the estimated results of Korea. It is difficult to identify the regime for Korea case. However, we can look at the sign of the intercept term and it shows that the negative signs mostly take place in regime 2. Thus, we can interpret regime 2 as low growth economic state and regime 1 as high growth one. Consider regime 1, we can see that the coefficients of KRW and KBY equations demonstrate that the lagged KBY and KRW seem to have significant bidirectional influence (KRW and KBY, respectively) In addition, the error correction term (ECT(1)) of KRW and KBY shows a significant adjustment after the short-run deviation; however, the values of the ECT(1) of these equations are positive, meaning they diverge from the long run equilibrium. For regime 2, we can see that the coefficients of KRW equation demonstrate that KOSPI seems to significantly influence KRW. Consider the ECT(1) of this regime, the error correction term of KRW is statistically significant negative and lies between 0 and -1, meaning only Korean Won is co-integrated with South Korea KOSPI Index, Korean bond yield and interest rate. In addition, the error correction term (ECT(1)) of KOSPI indicates a significant adjustment in the short-run deviation; however, the value of the ECT(1) of KOSPI is positive, meaning they diverge from the long run equilibrium. The results furthermore show that KOSPI is significantly affected by its own lag in regime 1.

Consider the matrix of transition probability parameters in Table 8. The result shows that both regime 1 and regime 2 are persistent since the probabilities of staying in their regimes are approximately 98%. Whereas the high growth regime has duration of approximately 71.428 weeks, the low growth regime has duration of 41.667 weeks meaning that Korea economy mostly stays in high growth economy more than in low growth economy.

Table 9: Estimated MS(2)-VAR(2): CHINA

	SSE	CHY	CHI	CHBY
Regime-dependent intercepts				
R1	0.0005(0.005)	0.0052(0.023)	0.0246(0.026)	0.0231(0.032)
R2	−0.0007(0.005)	−0.0029(0.024)	0.0377(0.026)	0.001(0.032)
Regime-dependent Autoregressive Lag 1				
Regime 1				
SSE	1.002(0.004)[a]	0.0001(0.017)	-0.0132(0.019)	−0.444(0.224)[a]
CHY	-0.012(0.017)	0.9084(0.077)[a]	0.0024(0.086)	-1.218(0.765)
CHI	0.017(0.015)	0.085(0.071)	1.107(0.078)[a]	0.332(0.205)
CHBY	-0.014(0.019)	0.005(0.081)	-0.081(0.090)	0.571(0.180)[a]
Regime 2				
SSE	0.9943(0.004)[a]	0.025(0.017)	-0.0318(0.019)	0.007(0.023)
CHY	0.0379(0.019)[a]	0.8433(0.074)[a]	0.0496(0.085)	0.0004(0.106)
CHI	0.002(0.017)	0.074(0.069)	1.036(0.078)[a]	0.091(0.098)
CHBY	-0.0217(0.019)	-0.043(0.081)	0.0412(0.091)	0.828(0.118)[a]
	p1t	p2t	Duration	Observations
R1	0.9703	0.0298	33.67	290
R2	0.0297	0.9702	33.557	71

Source: Calculation () is standard deviation and a is Bayesian statistic significant R1 and R2 are regime 1 and regime 2, respectively

Table 9 presents the estimated results of MS(2)-VAR(1) model which is different from the other cases since there is no cointegration term in this model. Table 9 provides a result of China financial market for two regimes and found that the values of the intercept term in regime 1 are mostly higher than in regime 2 thus we can interpret regime 1 as high growth state and regime 2 as low growth state. Consider regime 1, we can see that the coefficients of CHBY equations demonstrate that SSE seem to significantly influence CHBY. For regime 2, we can see that the coefficients of SSE equation demonstrate that CHY seems to significantly influence SSE. The results furthermore show that all these four variables are significantly affected by their own lag in both regime 1 and regime 2.

Consider the matrix of transition probability parameters. The similar result is obtained from the MS(2)-VAR(1) model. the probabilities switching between these two regimes are around 2.97-2.98% while remaining in their own regime approximately 97%, this means that the two regimes are persistent. Whereas the high growth regime has duration of approximately 33.67 weeks, the low growth regime has duration of 33.557 weeks. This signifies that Chinas economy stays in low growth economy and high growth economy for virtually equal length of time.

4.5 Regime Probabilities

The estimated MS-VECM model also produces smoothed probabilities, which can be understood as the optimal inference on the regime using the full-sample information. We plot the regime probabilities for the six countries, in Figures 1-6. Each Figure shows the smooth probability, which is the probability of staying in either regime 1 or regime 2, during the period of 2009 - 2016.

Figure 1 shows that the model is consistent with the hypothesis that high growth and low growth represent different financial outcomes. Regime 1 of the model is plotted in Figure 1. We interpreted this regime as the era of the expansion. According to this result, we can observe that from the late 2011 to 2012, the Thai economy stayed in low growth regime. Apparently at that period of time, Thailand was in trouble with the flood crisis. Word Bank estimated damages to have reached THB 1,440 billion due to the closure of multiple factories. The economy continued to be in a delicate position as the flood impact had reduced investors and insurance companies confidence, which would ultimately lead to an increase in unemployment and poor economy. Tourism, another substantial revenue generator in the economy, suffered a loss of THB 3.71 billion and a fall of 3.2 million tourists according to the Tourism Ministry. We can see this flooding resulted in the low growth regime from late of 2011 to middle of 2012. In addition, Domestic political crisis which gave rise to a period of political instability in Thailand from the late 2013 onward also became another factor causing the Thai economy to slow down. Subsequently, anti-government protests took place between November 2013 and May 2014; and the Royal Thai Armed Forces staged a coup d'tat unseating the government on 22 May 2014. Some country urged tourists to cancel trips and halted non-essential visits by its governmental officers. The Ministry of Tourism and Sports said on 27 May 2014 that the arrival of "foreign tourists dropped by 20%" resulting in a low growth regime after November 2013.

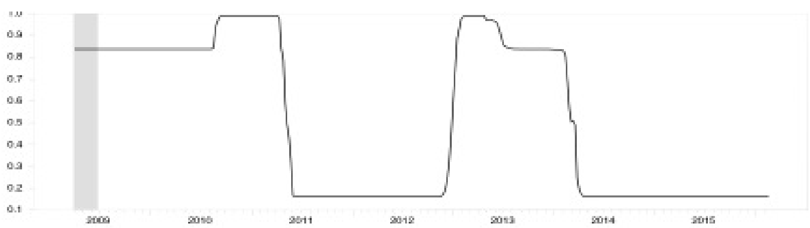

Figure 1: Regime 1 probabilities of Thailand's Market

Figure 2 presents the probabilities for the MS-VECM of Malaysia, which is a single MS chain of two regimes. Malaysia is a highly open, upper-middle income economy. In 2010, Malaysia launched the New Economic Model (NEM), which aims for the country to reach high income status by 2020. The Economic Transformation Program is an initiative by the Malaysian government to turn Malaysia into a high income economy by the year 2020, launched on September 25, 2010. There are some costs for the Economic Transformation Program, and also some risk for these programs, such as declining in oil price and the volatility in capital flows from the normalization of US monetary policy. In Figure 2, we can see all of these risks resulting in the low growth regime from early of 2010 to middle of 2014.

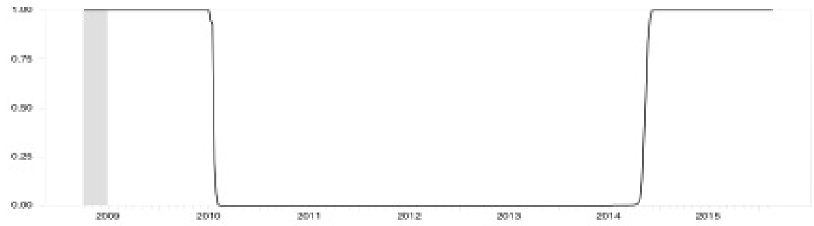

Figure 2: Regime 1 probabilities of Malaysia's Market

The regime probabilities of Singapore for regime 1 are presented in Figure 3. From the estimated results of Singapore, we interpret regime 1 as low growth economy and regime 2 as high growth economy. Singapore has become the largest foreign exchange trading center in Asia and ranks second in interest rate derivatives trading. Singapore is a leading global financial center in the world, particularly in Southeast Asia. Singapore is highly vulnerable to the global economic environment given its open economy. Therefore the world economic crisis can bring a huge impact on Singapores economy. As we can observe from Figure 3, the low growth regime was during 2009-2016. Over that period, there were severe crises in United States of America (USA) and Euro zone called hamburger crisis and European debt crisis, respectively. We expect that Singapores economy would be influenced by those crises from aboard and probably slowed down an economic growth along our sample period. There are some economic reports that could reflect the four recession periods in the graph. In the first period, 2009-2010, we found that it was corresponding to the hamburger crisis in the USA. The second period in 2011 was corresponding to the beginning of European (EU) debt crisis. In the third period, between 2013 and 2014, the government reported that Singapore's unemployment rate was around 1.9% and the country's economy had a lowered growth rate, when compared with the year 2010. Finally, the last period was corresponding to the announcement of the tightened policy and constrained exports of EU that contracted the export of Singapore. Overall, Singapores economy stays in low growth economy more than in high growth economy.

The MS-VECM of Japan provides regime 1 probabilities in Figure 4. Similar to Singapore, from the estimated results of Japan, we interpret regime 1 as low growth economy and regime 2 as high growth economy. In Figure 4, we can see the low growth regime exhibit in the middle of 2012. In those period, Japan's economy contracted since the first quarter of 2012, due to the slowing global growth and tensions with China. Moreover, the high pressure of deflation in Japans economy

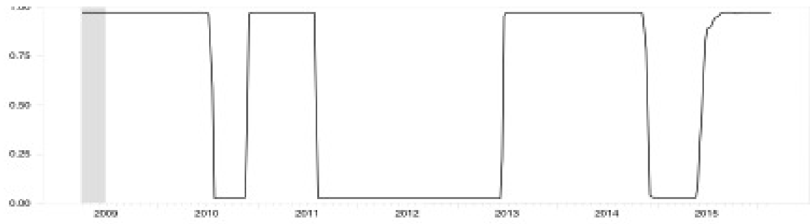

Figure 3: Regime 1 probabilities of Singapore's Market

and the high debt to GDP are also the factor that are generate the negative effect to Japans economy. Thus, these brought the world's third-largest economy into recession. As we observed in the Figure 3, the smoothed probabilities of low regime is mostly took place along our sample periods.

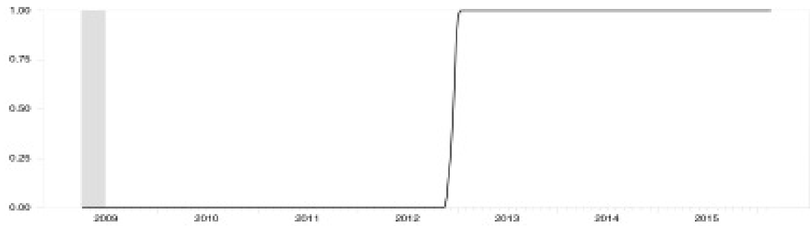

Figure 4: Regime 1 probabilities of Japan's Market

The regime probabilities of Koreas economy are illustrated in Figure 5. From the estimated results of Korea, we can interpret regime 1 as high growth economic state and regime 2 as low growth one. The economy of South Korea is the global leader of consumer electronics, Mobile Broadband and Smartphone. South Korea was one of the few developed countries that were able to avoid a recession during the global financial crisis. The International Monetary Fund complimented the resilience of the South Korean economy against various economic crises, citing low state debt, and high fiscal reserves. In Figure 5, we can see the high growth regime to present from 2009 to 2011.

Despite its economy's high growth potential and apparent structural stability, South Korea has suffered perpetual damage to its credit rating in the stock market due to the belligerence of North Korea in times of deep military crises, which has an adverse effect on the financial markets of South Korean economy. North Korea has continued to test weapons systems since 2012, including the launch of the long-range Unha-3 rocket in December 2012 and a nuclear test in February 2013. Pyongyang threatened a fourth test in November 2014, following the adoption of a resolution by the UN General Assembly condemning North Korean human rights abuses. In addition, the slowdown in the world economy during these times also the factor that pushed the high pressure on the Korean economy and resulting in the low growth regime since 2012.

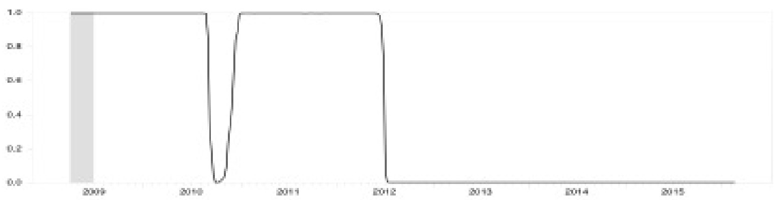

Figure 5: Regime 1 probabilities of Korea's Market

The regime probabilities of Chinese economy are illustrated in Figure 6. From the estimated results of China, we can interpret regime 1 as high growth state and regime 2 as low growth one. We can observe that the Chinas economy is likely to stay in high growth regime during 2009-2011. We found that the State Council unveiled a CNY 4.0 trillion (USD 585 billion) stimulus package in an attempt to shield the country from the worst effects of the financial crisis during that time. Apparently, China exited the financial crisis in good shape, with low inflation and a sound fiscal position. According to the International Monetary Fund, the Chinese economy grew more than 9% per year between 2009-2011. However, the global downturn and the subsequent slowdown in demand did severely affect the Chinese economy. In Figure 5, we can see the low growth regime taking place during 2011. The fifth generation came to power in 2012, when President Xi Jinping and Premier Li Keqiang took the reins of the country. The new Xi-Li administration unveiled an ambitious reform agenda in an attempt to change the countrys economic fundamentals and ensure a sustainable growth model. In Figure 5, we can see the high growth regime occurring from 2012 to the middle of 2015. However, we observe that the Chinese economy tended to switch to low growth regime after the mid-2015. This corresponds to the speech of Premier Li Keqiang delivered at the opening of the National Peoples parliament in China. He mentioned that the government had cut its growth target for that year to a range of 6.5% to 7%, down from 7%. China's financial system had a high debt levels at both banks and local authorities and the concern over Yuan devaluation in the previous year has caused the high negative pressure on Chinese economy until present day.

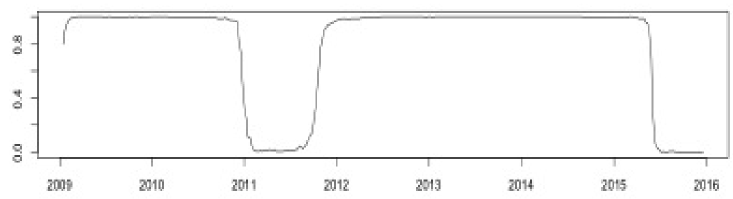

Figure 6: Regime 1 probabilities of China's Market

5 Conclusion

In this paper, we analyze the relationship between the stock index, exchange rate (against US dollar), government bond yield and interest rate of six Asian countries in the Markov-Switching VECM framework. The study conducted a Bayesian estimation technique to estimate the mean of parameters of the model. Based on the results of co-integration test, the models of Thailand, Malaysia, Japan, and Korea have one co-integrating vector, while Singapore has two and China has zero co-integrating. The results of this study show that in Malaysias low growth regime, its interest rate and government bond yield seem to significantly influence its stock market and interest rate, respectively; in Singapores high growth regime, its interest rate seems to significantly influence its government bond yield; in Japans low growth regime, Nikkei seems to significantly influence its exchange rate movement, and in Japans high growth economy regime, its exchange rate movement seems to significantly influence its government bond yield; in Koreas high growth economy regime, its government bond yield and its exchange rate movement seem to significantly influence mutually, and in Koreas low growth economic regime, its stock market KOSPI seems to significantly influence its exchange rate movement; in Chinas high growth economic regime, its stock market SSE seems to significantly influence it government bond yield, and in Chinas low growth economy regime, its exchange rate movement seems to significantly influence its stock market SSE. We also find evidence that the smooth probability, which is the probability of staying in either regime 1 or regime 2, is different in each country. This can be attributed to global capital inflows and outflows among other possible sources. Investors, fund and portfolio managers, and policy-makers should thus give heed to these regime-specific interactions when they make capital budgeting decisions and implement regulation policies.

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