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RESEARCH ARTICLE

Regime-Switching Business Cycle Synchronization in the ASEAN

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Abstract: This paper investigates patterns of business cycle synchronization and analyzes the underlying common factors in six ASEAN countries, that is, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. Two important findings result. First, according to resulting regime probabilities calculated from the Markov-switching model, Singapore is not synchronized with other ASEAN members, while Indonesia, Malaysia, and the Philippines are highly correlated. Second, according to the principal component analysis, we find that the world's import value growth, the output growth of China, and the capital flow of Singapore are most likely to account for 88% of variation in probabilities of the ASEAN being in the contraction regime.

Keywords: Business cycle synchronization, Regime-switching model, Principal component analysis, ASEAN.

JEL Classification: C34, C38, E32, F44

Synchronization of business cycles is the important condition for implementation of the monetary union under the theory of optimum currency areas. In the case of Southeast Asia, the agreement of the ASEAN Free Trade Area (AFTA) in 1992 set off economic collaboration in the region. Recently, the ASEAN Economic Community (AEC) has enhanced economic partnership over capital and labor mobility as an important step towards the goal of single market.[1]

Thus, business cycle synchronization in the ASEAN has drawn substantial attentions from economists in the empirical field. Most pioneer studies in this area focus on identifying patterns of synchronization in key macroeconomic variables. Kim et al. (2003) and Plummer and Wignaraja (2006) show that the degree of comovement in macroeconomic variables among Asian countries is high and is rising after the Asian financial crisis. Later studies further examine factors that affect these comovement patterns. Rana (2007) shows that trade intensity within the region is a key factor that tightens the economic linkage in Asia. This result is also supported by Gochoco-Bautista (2008), who found that the trade linkage is an importantfactor that explains the output comovement in East Asia. In addition, global shocks have important effects on the regional business cycles through demand for exports. Later, Moneta and Ruffer (2009) find that the demand for export, oil price, and exchange rate play an important role in business cycle synchronization. Sethapramote (2015) finds that key macroeconomic variables, that is, GDP, inflation,

export, and exchange rate, are highly correlated within the ASEAN, but supporting evidences of economic policy linkages are found only in few cases. In addition, the monetary policy linkage provides contribution to the comovement in output growths among ASEAN countries.

In the literature, the early focus is mainly on examining the timing of cycles using pairwise comparison between countries. That is, correlation coefficients were calculated with an extension of several data filtering, for example, spectral analysis, and/or time-series techniques, for example, vector autoregression, to provide additional insight of the comovement pattern.[2] However, it lacks the essence of how the business cycle fluctuates between expansion and contraction regimes. Hamilton (1989) and Kim and Nelson (1998) fill this empirical gap by proposing the Markov-switching model (MSM) and using it to estimate regime probabilities of business cycles in the US.

Later, several papers emphasize the importance of assessing potential changes in those patterns. Camacho and Perez-Quiros (2006) propose a novel method to analyze business cycle synchronization based on the comparison of Markov-switching unobserved variables that refer to the business cycle dynamic of each country. Specifically, real output is modeled as a regime-switching process in order to indicate whether the economy is in a period of expansion or contraction. Afterwards, Leiva-Leon (2014) extends Camacho and Perez-Quiros (2006) to analyze business cycle synchronization by calculating latent variables from multivariate MSMs. The business cycle comovement is then identified by two economies experiencing expansion and contraction regimes synchronously.

In East Asia, the MSM has been applied in several studies on business cycle comovement. Girardin (2004) focuses on the linkage between growth cycles in Japan and other East Asian countries. The regime-dependent correlations in growth cycles show that Hong Kong, Indonesia, and Thailand are highly correlated with Japan, while the other countries are not. Girardin (2005) extends his previous paper and estimates the cross-country correlation among East Asian countries by means of the regime probabilities of growth cycles. The results show that correlations of recession probabilities between Northeast and Southeast Asian countries increased after the 1990s. Moreover, the correlation is high in the case of China and Southeast Asian countries, while the correlations with Japan are relatively lower than those with China. Recently, Dufrénot and Keddad (2014) provide supportive evidences that the external demand is a key factor driving business cycle synchronization among the ASEAN-5 countries. However, the study shows that the regional cycles can predict the business cycle regime in the ASEAN-5 countries only when they are in the expansion regime

Even though the MSM has been applied in several studies of business cycle synchronization in the ASEAN, there is still a lack of papers that identify underlying common factors. Therefore, the principal component analysis (PCA) is then applied to decompose the common factors that affect the comovement in key variables and explain the factors that affect each component. Graham (2014) uses the PCA technique to analyze the international business cycles and finds that the Asian countries are the most connected to international business cycles compared to other regions. Moreover, the results from the PCA show that global component explains around 26% of variance in all countries' business cycles.

Henceforth, we extend the results from previous studies in two aspects. First, the MSMs are used to calculate the regime probabilities of recession (or slow growth) in each of the ASEAN countries. Second, we conduct the PCA to analyze the factors that commonly affect regime-transition probabilities in MSMs.

The remainder of this paper is organized as follows. Section 2 explains the data and characteristics of business cycles in ASEAN. Section 3 explains research methodology. In Section 4, regime-switching models for each of the ASEAN countries are estimated to analyze comovement in the regime probabilities. In Section 5, the PCA of regime probabilities is analyzed for the common factors underlying regime-switching synchronization. Lastly, conclusion and policy implications are discussed in Section 6.

Characteristics of Business Cycles Among ASEAN Countries

To analyze business cycles synchronization, we use the real GDP data for the six ASEAN countries, that is, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. The quarterly data from 1994 to 2014 are obtained from the CEIC database. The

annualized real output growth is computed based on the year-over-year basis.

We first compute the descriptive statistics of the real output growth in each country to check for stylized facts of the growth cycles in the ASEAN. The results are presented in Table 1. In addition, the time-series plots of real output growth are plotted in Figure 1.

The results from Table 1 show that Vietnam, Singapore, and Malaysia are among the countries with high rates of growth. Thailand has the lowest growth rate in the region during the period of study. Regarding economic stability, Vietnam has the lowest standard deviation in real output growth. From Figure 1, real output growth in Vietnam is positive, which means no recession throughout the period. In addition, Indonesia and the Philippines also have positive growth rates with an exception of the period during the Asian financial crisis (1997 to 1999). Therefore, in this study, we follow Giradin (2004) to characterize the business cycles in terms of growth that consists of the expansion regime and contraction regime. Finally, the degree of economic fluctuation is high in the case of Singapore, Indonesia, and Thailand.

Next, we calculate the cross-country correlation coefficients for the real output growth between all pairs of the six ASEAN countries. We consider the results from the full sample period (1994 to 2014). Specifically, the two subsamples ranging from 1994 to 2004 and 2005 to 2014 are used to represent the period before and after the global financial crisis, respectively. The results are displayed in Table 2.

Table 2 shows that the correlation coefficients are high in most cases. Malaysia, Singapore, and Indonesia have high degrees of correlation approximately ranging from 0.4 to 0.7. For Thailand and the Philippines, the correlation coefficients are approximately 0.4 to 0.6. Vietnam has the lowest degree of correlation among the ASEAN-6 countries with a correlation coefficient around 0.2 to 0.4.

Comparing the two subsamples, the correlations in the first subsample (1994 to 2004) are generally slightly higher than those of the second subsample (2005 to 2014). These results can be explained by a simultaneous decrease in output growth during the Asian financial crisis and the recovery period after the crisis. These results are similar to those of the previous studies, for example, Sethapramote (2015). To further investigate the pattern of synchronization within the region, the regime-switching model will be applied to provide additional information for the business cycle synchronization. The research methodology and empirical results are discussed in Sections 3 and 4.

Research Methodology

In this study, the main research methods consist of the MSM and the PCA. The brief details of each model are explained as follows.

MSM

Hamilton (1989)[3] introduces the MSM and provides the empirical application in calculating probabilities of regime switching in business cycles. Since then, the MSM has become a popular approach in estimating the regime switching in business cycles. The regime-switching model in business cycles can be estimated from the Markov-switching autoregressive model of output growth. Specifically, a two-state MSM, in

Table 1. *Descriptive Statistics for Output Growth in ASEAN-6 Countries*

	ID	MY	PH	SG	TH	VN
Mean	4.549786	5.355119	4.690226	5.877726	3.760318	6.869941
Standard Deviation	4.622613	4.360340	2.074406	4.940898	4.469424	1.517893
Maximum	10.79700	11.93200	8.494000	18.52900	15.17160	9.593938
Minimum	−17.95000	−11.03000	−2.774000	−9.046000	−12.20230	3.788000
Skewness	−3.308990	−1.591257	−0.946850	−0.411839	−1.012340	0.046653
Kurtosis	15.04372	6.327900	4.439673	3.672660	5.091272	2.060378

Source: Authors' calculation. The real GDP data are collected from CEIC database. ID, Indonesia; MY, Malaysia; PH, Philippines; SP, Singapore; TH, Thailand; VN, Vietnam.

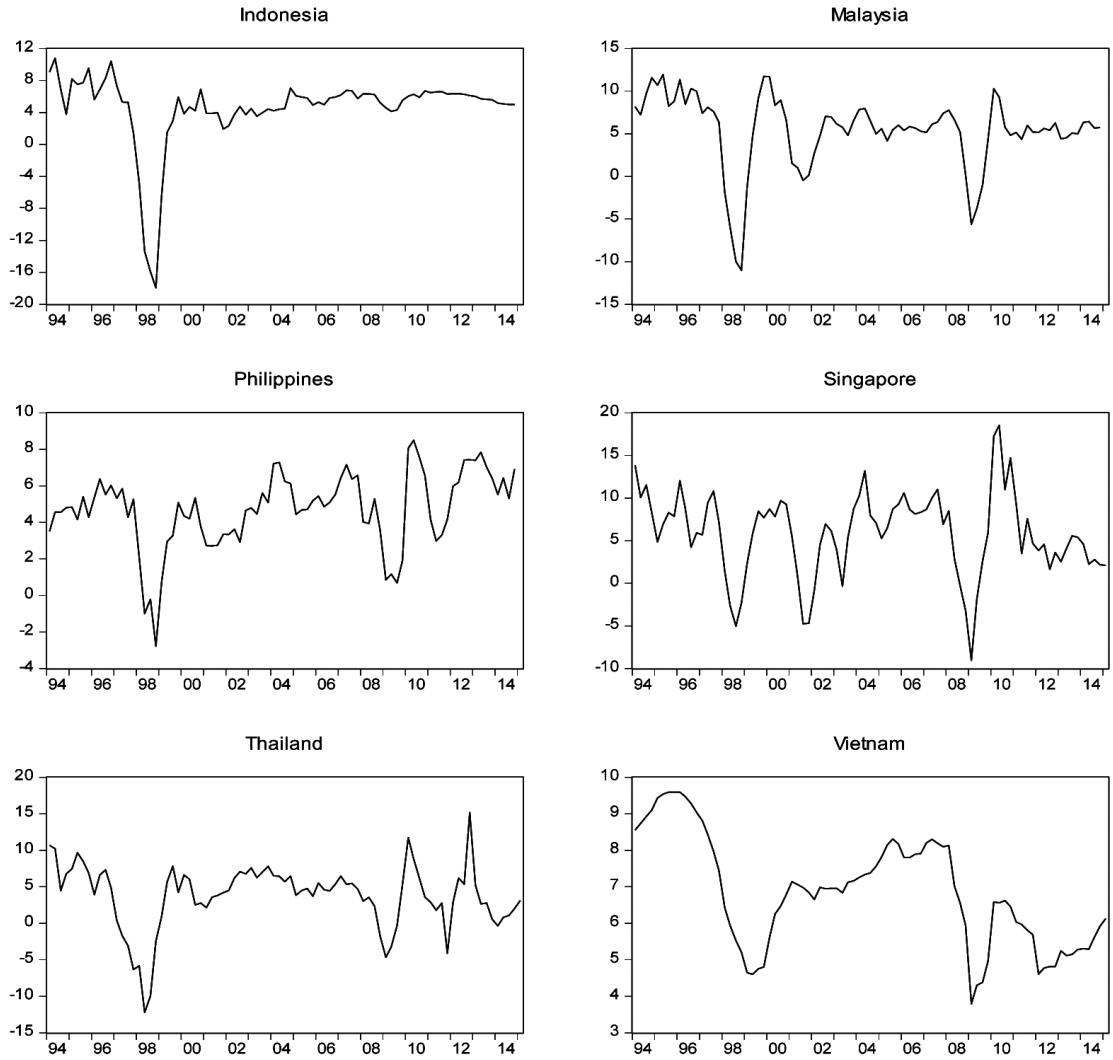


Figure 1. Quarterly output growth (YoY) in ASEAN-6 countries. Source: CIEC.

which the mean growth rate of the gross domestic product (GDP) is subject to regime switching and the errors follow a regime-invariant AR(4) process, can be written as follows:

$$Y_t = \propto_{s_t} + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} + \beta_4 Y_{t-4} + \varepsilon_t, \quad (1)$$

where Y_t followings AR(4) process represents the real output growth at a given country, $s = 1,2$ identifies each of the two regimes, and $\propto_{s_t} = \begin{cases} \alpha_1 \text{ if } s_t = 1 \\ \alpha_2 \text{ if } s_t = 2 \end{cases}$ denotes the conditional output growth rate in expansion and contraction regimes in business cycles.

In the Markov-switching framework, the different regimes are driven by an unobserved Markov chain. Hence, the changing process between the unobservable state variables, s_t, is set to follow the first-order Markov chain process as follows:

$$p[s_t = 1|s_{t-1} = 1] = p$$

$$p[s_t = 2|s_{t-1} = 1] = 1 - p$$

$$p[s_t = 2|s_{t-1} = 2] = q$$

$$p[s_t = 1|s_{t-1} = 2] = 1 - q$$

where $p[s_t = j|s_{t-1} = i]$ is the probability that state i will be followed by state j.

Table 2, *The Cross-Country Correlation Coefficients for the Real Output Growth*

Panel A. Full Sample: 1994 to 2014

	ID	MY	PH	SG	TH	VN
ID	1.000000	0.740866	0.652148	0.458893	0.590237	0.348222
MY	0.740866	1.000000	0.688307	0.713829	0.650313	0.487872
PH	0.652148	0.688307	1.000000	0.559360	0.527874	0.246346
SG	0.458893	0.713829	0.559360	1.000000	0.511993	0.445276
TH	0.590237	0.650313	0.527874	0.511993	1.000000	0.329703
VN	0.348222	0.487872	0.246346	0.445276	0.329703	1.000000

Panel B. First Subsample: 1994 to 2004

	ID	MY	PH	SG	TH	VN
ID	1.000000	0.865966	0.815636	0.631408	0.734440	0.616907
MY	0.865966	1.000000	0.816315	0.775011	0.657320	0.515388
PH	0.815636	0.816315	1.000000	0.658426	0.549589	0.531814
SG	0.631408	0.775011	0.658426	1.000000	0.454069	0.395214
TH	0.734440	0.657320	0.549589	0.454069	1.000000	0.333722
VN	0.616907	0.515388	0.531814	0.395214	0.333722	1.000000

Panel C. Second Subsample: 2005 to 2014

	ID	MY	PH	SG	TH	VN
ID	1.000000	0.362771	0.256122	0.273637	0.309339	0.206440
MY	0.362771	1.000000	0.713183	0.735483	0.658252	0.498318
PH	0.256122	0.713183	1.000000	0.529934	0.628843	0.242945
SG	0.273637	0.735483	0.529934	1.000000	0.630351	0.580486
TH	0.309339	0.658252	0.628843	0.630351	1.000000	0.369371
VN	0.206440	0.498318	0.242945	0.580486	0.369371	1.000000

Source: Authors' calculation using real output growth data in the six ASEAN countries.

The estimation of the equation (1) can be performed using the maximum likelihood estimator.

PCA

The PCA method is a technique to reduce variables of interest by generating a set of new variables as a linear function of the original ones. The new variables are generated in order to include the variation of original variables. We call the new variables as the *i*th-order principal components (PC_i). The process of generating principal component is outlined as follows.

First, is calculated as a linear function of the original *p* variables, written as follows:

$$\mathrm{PC}_1 = w_{11}X_1 + w_{12}X_2 + \cdots + w_{1p}X_p \text{ or } \mathrm{PC}_1 = w_1'x \quad (2)$$

$$w = [w_{11}\ w_{12} \ldots w_{1p}]\ , x = [X_1\ X_2 \ldots X_p]$$

where *x* is input data and *w* is weight matrix.

The first principal component includes the variation of these *p* variables. Therefore, we calculate the weight matrix under the condition that maximizes $Var(w_1'x)$ with the constraint that $w_1'w_1 = 1$.

Similarly, we generate PC_2 as a linear function of

the original p variables incorporating the remaining variation from the set of p variables. Theoretically, PC_2 is orthogonal to and as a result, they are not correlated.

$$PC_2 = w_{21}X_1 + w_{22}X_2 + \cdots + w_{2p}X_p$$

$$\text{or } PC_2 = w_2'x$$

w_2 is calculated to maximize $\text{Var}(w_2'x)$ with $w_2'w_2 = 1$, $w_1'w_2 = 0$, and $\text{Cov}(w_1'x, w_2'x) = 0$.

Next, we construct PC_2, PC_4,..., $PC_{p\text{-}1}$, and PC_p using the same procedure as PC_2.

Business Cycle Synchronization: The Markov-Switching Approach

We first estimate the MSM for each individual country and extract time-varying transition probabilities as time series. The estimation results are shown in Table 3.

The results from the likelihood ratio (LR) test reject the null hypothesis of no regime switching in every case, which shows that the MSM can be applied to estimate the regime of expansion and contraction in the growth cycles. The estimated output growth rates during the high growth regime (α_1) range between 4.88% (Indonesia) and 7.05% (Vietnam). The contraction period consists of a recession period with a negative growth rate in the case of Indonesia (−4.17%), Thailand (−2.83%), and Malaysia (−1.21%).

In other countries, the contraction regime consists of a relatively low positive growth rate, that is, Vietnam (5.56%), Singapore (1.17%), and the Philippines (1.11%). Thailand and Singapore possess high growth volatility, while the growths of Vietnam and the Philippines are the steadiest.

Next, we denote regimes 1 and 2 as the expansion and contraction regimes, respectively. The probabilities of transition between regimes are computed in Table

Table 3. *Results of the MSMs for Each of ASEAN6 Countries*

(1994Q1–2015Q1)	ID	MY	PH	SG	TH	VN
α_1	4.88	5.50	5.13	6.04	5.11	7.05
	(5.30)	(10.10)	(16.27)	(7.93)	(4.05)	(20.38)
α_2	−4.17	−1.21	1.11	1.77	−2.83	5.56
	(−2.38)	(−0.67)	(1.65)	(1.77)	(−1.86)	(15.24)
β_1	0.92	1.13	0.64	1.26	1.22	1.29
	(6.90)	(8.61)	(3.98)	(7.97)	(9.52)	(11.07)
β_2	−0.03	−0.38	0.24	−0.46	−0.36	−0.15
	(−0.21)	(−1.73)	(1.27)	(−1.82)	(−1.93)	(−0.81)
β_3	0.07	−0.01	−0.00	−0.12	−0.01	−0.08
	(0.43)	(−0.06)	(−0.04)	(−0.83)	(−0.07)	(−0.39)
β_4	−0.17	−0.12	−0.27	—	−0.03	−0.15
	(−1.52)	(−0.97)	(−2.44)	—	(−0.30)	(−1.25)
σ	1.66	1.70	1.00	2.12	1.99	0.25
D_1	78.48	72.21	37.19	9.44	23.94	38.72
D_2	2.97	3.86	3.66	1.00	6.37	12.94
Log-likelihood	−161.25	−164.16	−126.54	−198.29	−188.14	−17.30
LR	21.69	99.19	247.14	12.94	13.42	34.11
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Note. The estimation results are based on Equation (1) The figures in parenthesis are t-statistics. D_1 and D_2 are denoted as the durations of the expansion regime and contraction regime, respectively. LR is the likelihood ratio test statistics for linearity, and the figures in the brackets are p-values of the LR test.

Table 4. *Probabilities of Transition Between Regimes*

	Indonesia		Malaysia		Philippines		Singapore		Thailand		Vietnam	
Initial Regime	**R.1**	**R.2**	**R.1**	**R.2**	**R.1**	**R.2**	**R.1**	**R.2**	**R.1**	**R.2**	**R.1**	**R.2**
R.1	0.99	0.01	0.99	0.01	0.97	0.03	0.89	0.11	0.96	0.04	0.97	0.03
R.2	0.34	0.66	0.26	0.74	0.27	0.73	1.00	0.00	0.16	0.84	0.08	0.92

Source: Authors' calculation from the regression results of the two-regime MSMs specified in equation (1). R.1 and R.2 are the expansion and contraction regimes, respectively.

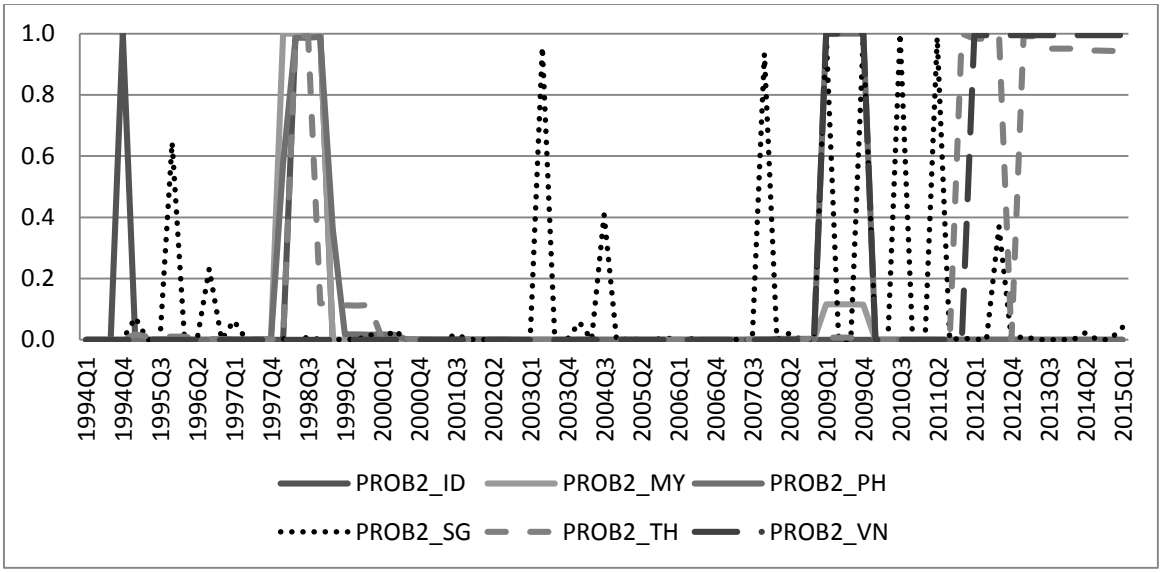


Figure 2. Smoothed probabilities of being in the contraction regime. Source: Authors' calculation from the regression results of the two-regime MSMs specified in Equation (1).

4, and the smoothed probabilities of being in the contraction regime are displayed in Figure 2.

Figure 2 provides some important characteristics worth being discussed. First, the contractions in the GDP growth simultaneously occur during 1997:4 to 1999:1, which represents the Asian financial crisis that originally happened in the ASEAN and severely affected all of the countries in the region. Second, these smoothed probabilities generally increased since 2007:3, although the timing of each country is slightly different. Singapore quickly fell into recession during 2007:3 to 2008:1, while for Vietnam and the Philippines, the contraction came during 2008:3 to 2009:4. Notably, the output growth rates in Thailand and Vietnam significantly decreased after 2011:2. After 2007:3, the world economy suffered from the global financial crisis originating from the US and the debt crisis in the eurozone. Moreover, the growth rate of China also encountered a significant slowdown after 2011. These external shocks directly hit each ASEAN country with different timings of contraction. Interestingly, Singapore and Indonesia faced the contraction in other periods, which separate them from any other ASEAN countries.

Next, we use time-series data of transition probabilities to empirically analyze the relationship between expansion/contraction probabilities among groups of countries to provide additional information about synchronization from the comovement indicators among the output growth. The results of the cross-correlations of the smoothed probabilities of the contraction regime are displayed in Table 5.

The results from cross-correlations in regime probabilities provide additional information to those from the cross-correlations in output growths. In particular, Singapore has the lowest correlation with

Table 5. *Cross-Correlations of the Smoothed Probabilities of Being in the Contraction Regime*

Panel A. Full Sample: 1994–2014

	ID	MY	PH	SG	TH	VN
ID	1.000000	0.854677	0.610283	−0.070317	0.281265	−0.098700
MY	0.854677	1.000000	0.710275	−0.042302	0.204772	−0.061417
PH	0.610283	0.710275	1.000000	0.196817	0.085878	0.262693
SG	−0.070317	−0.042302	0.196817	1.000000	−0.122370	0.096677
TH	0.281265	0.204772	0.085878	−0.122370	1.000000	0.663531
VN	−0.098700	−0.061417	0.262693	0.096677	0.663531	1.000000

Panel B. First Subsample: 1994–2004

	ID	MY	PH	SG	TH	VN
ID	1.000000	0.854306	0.923978	−0.091144	0.838358	0.286699
MY	0.854306	1.000000	0.956731	−0.106770	0.711182	0.336027
PH	0.923978	0.956731	1.000000	−0.117186	0.788572	0.360801
SG	−0.091144	−0.106770	−0.117186	1.000000	−0.091099	−0.064278
TH	0.838358	0.711182	0.788572	−0.091099	1.000000	0.305848
VN	0.286699	0.336027	0.360801	−0.064278	0.305848	1.000000

Panel C. Second Subsample: 2005–2014

	ID	MY	PH	SG	TH	VN
ID	1.000000	−0.099849	−0.100078	−0.119949	0.443022	0.368446
MY	−0.099849	1.000000	0.999987	0.370949	−0.213942	0.410387
PH	−0.100078	0.999987	1.000000	0.371494	−0.214198	0.410134
SG	−0.119949	0.370949	0.371494	1.000000	−0.196406	0.040963
TH	0.443022	−0.213942	−0.214198	−0.196406	1.000000	0.687802
VN	0.368446	0.410387	0.410134	0.040963	0.687802	1.000000

Source: Authors' calculation using data from smoothed probabilities of being in contraction regime in Figure 2.

other countries. This implies that probabilities of recession in Singapore are not related to other countries in the ASEAN-6. Interestingly, the correlations of Vietnam and other ASEAN countries in the case of regime probabilities are higher than those of the output growths. The Philippines, Indonesia, and Malaysia are the core countries that have the highest correlation degree of being in the contraction regime.

Our remarks are supported by the literature. Moneta and Ruffer (2009) find that there are two common factors underlying ASEAN business cycle synchronization; the first one connects all ASEAN members together, but the second one strongly connects Singapore with Hong Kong and Taiwan. This second factor is to be the connection among advanced financial markets as evidently shown in Gong and Kim (2013). The paper shows that the trade and financial integration within Asian economies provided an important role in business cycle comovements of Asian countries. However, the strength of these two linkages is different among the ASEAN members. For Singapore, the financial linkages provide the important channel for economic integration. The status of Singapore as the regional financial center and the role of capital flows are much bigger than those of the other countries. For the trade linkages, Malaysia, Indonesia, and the Philippines have the biggest share of intraregional percentage of total trade. Therefore, these stylized facts explain the pattern of comovement found in our results.

In the comparison of the two subsamples, the degree of correlation is high during the first subsample, when

the Asian financial crisis played an important role in leading the ASEAN-6 countries into recession. However, Vietnam had a higher degree of correlation with other countries in the second period. This result emphasizes the increasing role of Vietnam in the movement of the ASEAN business cycle.

In the next section, we analyze factors influencing the regime switching in MSMs among the group of countries to find factors that commonly affect transition probabilities in MSMs.

PCA of Regime Probabilities in the ASEAN

In this section, we calculate the principal components for the set of series that consist of the smoothed probabilities of being in the contraction regime for each of the ASEAN-6 countries. The eigenvectors are used to generate the weight for each of the principal components (w_1, w_2,…, w_6). The results are shown in Table 6. In addition, the percentage of variation explained by each principal component is shown in Table 7.

The results from Table 7 show that the first principal component (PC_1) can explain almost a half (43%) of variables in the group of regime probabilities in the group of ASEAN-6 countries. The second and third principal components (PC_2, PC_3) can explain the 27% and 19% of total variation, respectively. In sum, all three principal components can explain the majority of total variation (88%). Moreover, eigenvalues are greater than 1 for the first three principal components. Therefore, we focus on the first three principal components. The weights in Table 6 for PC_1, PC_2, and PC_3 are applied to compute the series. The results are shown in Figure 3.

Subsequently, we analyze factors influencing the regime switching in MSMs among the group of countries to find factors that commonly affect transition probabilities in MSMs. The three important factors are used in this paper, that is, the world's import value growth (MGW_G), the real output growth rate of China (GDPG_CN), and Singapore's inward foreign portfolio investment (FPI_IN). The results of cross-correlation between these variables are shown in Table 8. Moreover, we plot for PC_1, PC_2, and PC_3 with their related factors in Figures 4 to 6.

The results from Table 6 show that there are high degrees of correlation between these variables. The correlation coefficients between PC_1 and the growth of the world's import value, and PC_2 and the output growth rate of China are −0.514 and −0.461, respectively. In case of PC_3 and Singapore's inward foreign portfolio investment, the correlation is 0.03.

Table 6. *Eigenvectors of Each Principal Component*

Variable	ID	MY	PH	SG	TH	VN
PC_1	0.556942	−0.202066	−0.158525	0.323480	−0.634272	0.341929
PC_2	0.572499	−0.220050	−0.076599	0.063945	0.748822	0.230503
PC_3	0.520487	−0.057972	0.314563	−0.572843	−0.174456	−0.517879
PC_4	0.013194	0.009887	0.884008	0.465211	0.036698	0.022158
PC_5	0.265115	0.621170	−0.250414	0.473649	0.068354	−0.502134
PC_6	0.143856	0.722106	0.160860	−0.349796	−0.022604	0.555990

Source: Authors' calculation from the PCA.

Table 7. *Eigenvalues and Percentages of Variation Explained by Principal Components*

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	Total
Eigenvalue	2.56	1.60	1.14	0.50	0.13	0.07	6.00
proportion	42.59%	26.62%	18.98%	8.43%	2.15%	1.231%	100.00%

Source: Authors' calculation from the PCA.

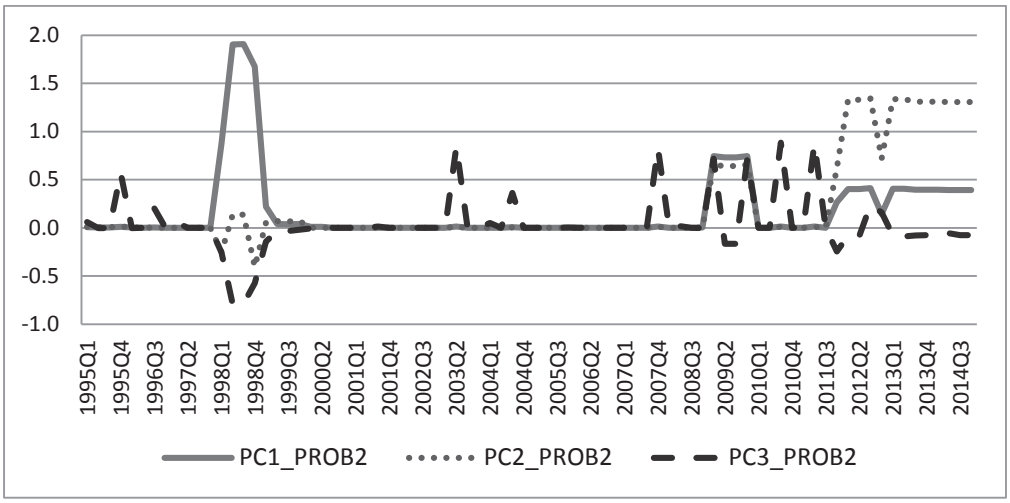


Figure 3. The first, second, and third principle components. Source: Authors' calculation using eigenvectors of principal components displayed in Table 7.

Table 8. *Cross-Correlations Among Three Principal Components and the Key Determinant Factors*

	MGW_G	GDPG_CN	FPI_SG
PC1_PROB2	−0.723	−0.356	−0.114
PC2_PROB2	−0.489	−0.461	−0.102
PC3_PROB2	0.096	0.084	0.032

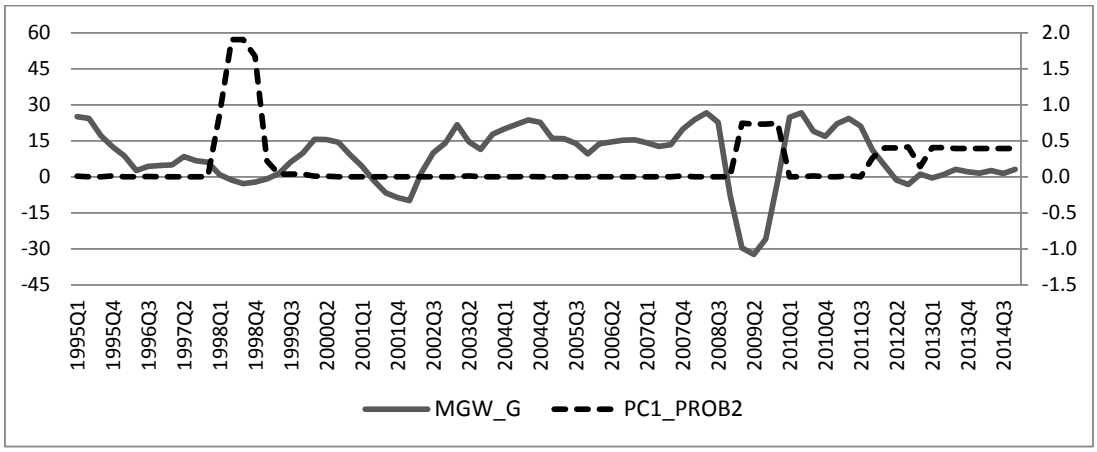
Source: Authors' calculation. The three principle components are based on the results from Figure 3. The world's import value growth (MGW_G), real output growth rate of China (GDPG_CN), and Singapore's inward portfolio investment are collected from the CEIC database.

This number is not indicated the relationship between the two variables. However, Figure 6 shows that the capital outflow (negative inward portfolio investment) is considerably high during 2008 to 2012, when PC_3 concurrently increased. The correlation coefficient is 0.21 during the period.

As we can see from Figure 4, PC_1 increases significantly during 1997:3 to 1998:3, 2008:3 to 2009:1, and 2011:3 to 2014:4. This period covers the period of the Asian financial crisis, global financial crisis, and eurozone's debt crisis. During those periods, the decreases in the world's import value were observed. However, during the period of 2001, the shrinkage in the world's import value due to the dot-com bubble crisis was not associated with the increase in PC_1. The reason for this pattern is that the US economy quickly recovered after the dot-com crisis. The impact was limited to the US and developed countries. Therefore, these results show that PC_1 can be explained by the major shock in global economy associated with the decline in the world's import value.

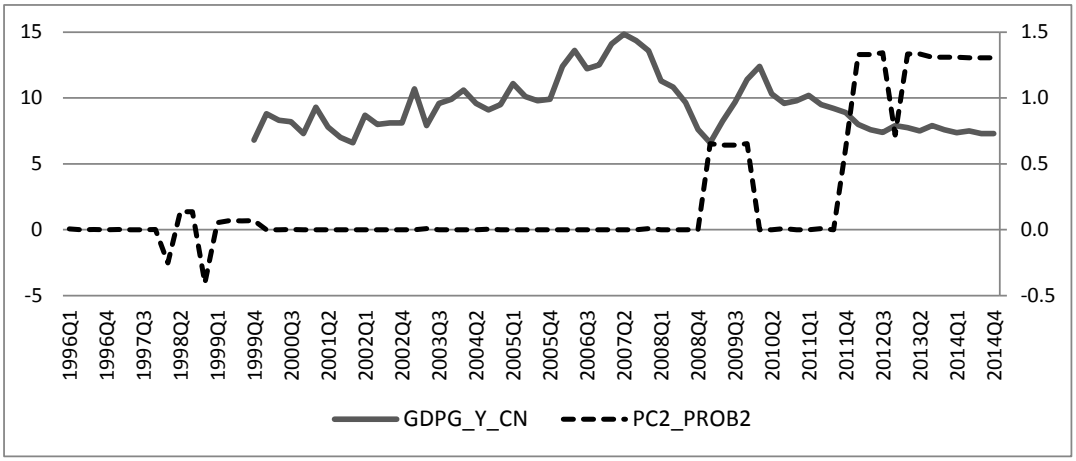
Next, Figure 5 shows the time-series plot of PC_2 and the real GDP growth of China. The results show that the timing of increase in PC_2 corresponds to the period of decline in China's real quarterly GDP growth rate.

Therefore, the results from the PCA show that the main components of the common probabilities for the ASEAN-6 countries to be in the contraction regime are explained by the external factors, that is, the growth in the world's import value, the output growth of China, and the country-specific factor, that is, Singapore's inward foreign portfolio investment. Interestingly, the



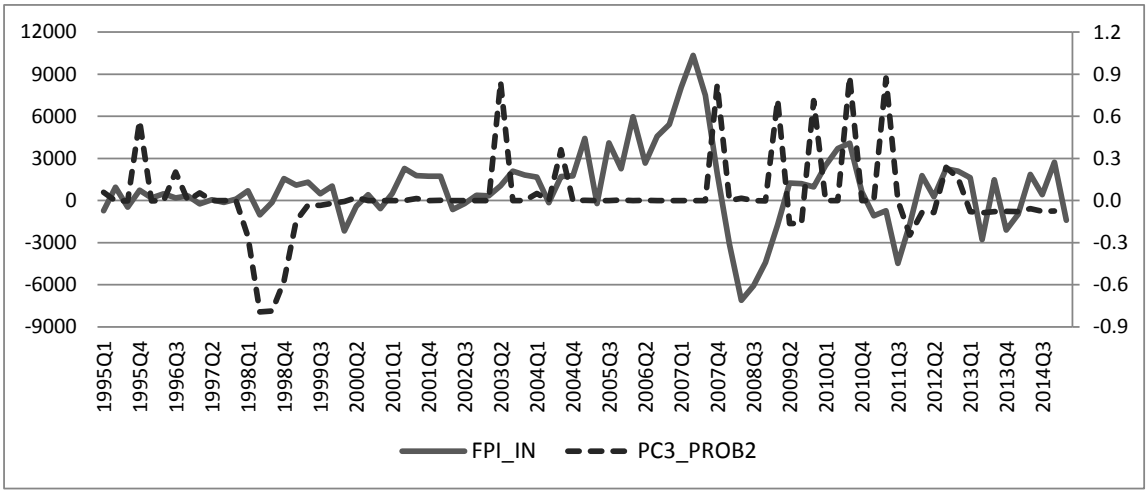
Source: Authors' calculation. The world's import value (MGW) is collected from the CEIC database.

Figure 4. PC_1 and the world's import value.



Source: Authors' calculation.

Figure 5. PC_2 and the real GDP growth of China.



Source: Authors' calculation. The inward foreign portfolio investment of Singapore is collected from the CEIC database.

Figure 6. PC_3 and Singapore's inward foreign portfolio investment.

output growth of China can explain more variation of the recession's probabilities than that of the US. These results provide an important implication for countries in the ASEAN to develop the countermeasure to precisely handle major external factors that potentially lead the region into contraction. In sum, these results explain the factors that affect the comovement of regime probabilities of business cycles in the ASEAN.

Conclusion

In this paper, we investigated the pattern of business cycle synchronization in the ASEAN using the regime-switching approach. The MSM is applied to identify the expansion and contraction regimes in the six ASEAN countries. The results show that these countries expand at the growth rate of around 4% to 7% per annum during the expansion period. However, in the contraction period, some countries drop into recession with the negative growth rate (Indonesia, Thailand, and Malaysia), while the remaining countries have a positive, but low, growth (Vietnam, Singapore, and the Philippines). However, there are differences in some characteristics of business cycles among the six ASEAN countries. The degree of correlations in both output growth and regime probabilities is generally high. Singapore has the lowest correlation with other countries. These results imply that probabilities of recession in Singapore are not related to other countries in the ASEAN. Interestingly, the correlations of Vietnam and other ASEAN countries in the case of regime probabilities are higher than those of the output growth. The Philippines, Indonesia, and Malaysia are the core countries that have the highest correlation degree of being in the contraction regime.

Next, the PCA is applied to find the main components in the comovement of regime probabilities. There are three main components explained by the growth in the world's import value, the output growth of China, and the inward foreign portfolio investment of Singapore. These results provide an important implication for countries in the ASEAN to develop the countermeasure to precisely handle major external factors that potentially lead the region into contraction.

NOTES

[1] Labor mobility is limited to skilled labor.

[2] See Camacho et al. (2006) for details on the applications of spectral analysis and vector autoregression in estimating business cycle synchronization in European countries.

[3] See Hamilton (1994) for the detailed properties of the Markov-switching model. In addition, Guidolin (2012) and Ang and Timmermann (2011) summarize the variation of MSMs and their applications to empirical researches.

References

Camacho, M., & Perez-Quiros, G. (2006). A new framework to analyze business cycle synchronization. *Nonlinear Time Series Analysis of Business Cycles*, Elsevier's Contributions to Economic Analysis series, Chapter 5, *276*, 133–149.

Camacho, M., Perez-Quiros, G., & Saiz, L. (2006). Are European business cycles close enough to be just one? *Journal of Economic Dynamics and Control*, *30*, 1687–1706.

Dufrénot, G., & Keddad, B. (2014). Business cycles synchronization in East Asia: A Markov-switching approach, *Economic Modelling*, *42*, 186–197.

Girardin, E. (2004). Regime-dependent synchronization of growth cycles between Japan and East Asia. *Asian Economic Paper*, *3*, 147–176.

Girardin, E. (2005). Growth-cycle features of East Asian countries: Are they similar? *International Journal of Finance and Economics*, *10*, 143–156.

Gochoco-Bautista, M. S. (2008). Output movements in East Asia: Is there a regional factor? *The World Economy,* 738–762.

Graham, J. (2014). *'N Sync: How do countries' economies move together?* (Working Paper, Reserve Bank of New Zealand, AN2014/04).

Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica, 57*(2), 357–384.

Kim, C.-J., & Nelson, C. R. (1998). "Business cycle turning points, a new coincident index, and tests of duration dependence based on a dynamic factor model with regime switching." *The Review of Economics and Statistics,* 188–201.

Kim, S. H., Kose, M. A., & Plummer, M. G. (2003). Dynamics of business cycles in Asia: Differences and similarities. *Review of Development Economics*, *7*, 462–477.

Leiva-Leon, D. (2014). A new approach to infer changes in the synchronization of business cycle phases (Working Paper, Bank of Canada, 2014-38.

Moneta, F., & Ruffer, R. (2009). Business cycle synchronization in East Asia. *Journal of Asian Economics*, *20*, 1–12.

Nellis, J. G. (1982) A principal components analysis of international financial integration under fixed and floating exchange rate regimes. *Applied Economics*, *14*(4), 339–354s.

Plummer, M. G., & Wignaraja, G. (2006). The post crisis sequencing of economic integration in Asia: Trade as a complement to a monetary future. *Economie Intérnationale*, *107*, 59–85.

Rana, P. (2007). Economic integration and synchronization of business cycles in East Asia. *Journal of Asian Economics*, *18*(5), 711–725.

Sethapramote, Y. (2015). Synchronization of business cycles and economic policy linkages in ASEAN. *Journal of Asian Economics*, *39*, 126–136.