International Journal of Economic Research

ISSN : 0972-9380

available at http: www.serialsjournal.com

Volume 14 • Number 6 • 2017

Economic Growth and Business Cycle: The Case of Thailand

Paravee Maneejuk*, Pathairat Pastpipatkul and Songsak Sriboonchitta

Faculty of Economics, Chiang Mai University, Chiang Mai, Thailand
E-mail: mparavee@gmail.com, ppthairat@hotmail.com

Abstract: This study is aimed at analyzing business cycle in Thailand using a Markov-switching Vector Autoregressive approach with a special concern about structural changes. Our specific interests are to examine the cyclical movements among economic activities, and to detect the nonlinear economic growth through the context of business cycle. Empirical results show that all parameters are statistically significant and differ across economic stages. These significant results can, in turn, support the aspects of comovement of different economic activities over the business cycle and also the existence of distinct relationships among these variables across different economic regimes. Additionally, the economic growth as measured by growth rate of real GDP, is affected by changes in the economic activities in which magnitude of effects are differ across regimes. This result reasonably supports the persistence of nonlinear economic growth path as being due to the fluctuation in economic activities associated with business cycle.

Keywords: Business cycle; Economic growth; Comovement; Markov-switching model; Structural change

1. INTRODUCTION

There is no doubt about the importance of economic growth for nations. As in any country's economic policy, the focus is often on economic growth and on a way to make the economy grows sustainably. The term economic growth is usually quantified by the percent rate of increase in real gross domestic product (real GDP), which is a measure of the values of goods and services produced within a country irrespective of who owns the factors of production, so that the economic growth refers to the increase in national output.

However, no economy can enjoy any growth at the same constant level through time (Lucas, 2000). The economic growth as measured by the growth rate of real GDP moves either upward or downward around its long-term growth trend due to the fluctuations that economy experiences (Burn and Mitchell, 1946). To a large extent, the economy moves following a certain pattern. That is, as a country develops, there exists a period of expansion where the growth rate is above-average growth, continues until it reaches a maximum growth rate or peak. But after the peak, the expansion will turn into a period of recession and eventually reaches a minimum growth rate or trough. However, the trough will not exist eternally because the economy will somehow recover. As such, the trough is then followed by another expansion, peak, contraction and trough again. This cyclical movement is considered to be a consequence of fluctuations in the economy associated with business cycle, which is a basic for explaining the economic behavior.

Actually, the business cycle is associated with many economic activities or economic organizations regarding a country's economic growth. One of the most influential works on business cycle, Burn and Mitchell (1946) indicated that the expansion phase occurs at about the same time in many economic activities, such as production, consumption, investment, and employment, as illustrated by the increases in index numbers of economic activity, such as indexes of production, price, national aggregate of income, and employment. These expansions are then followed by similarly general recessions where those indexes are decreased. However the contractions are followed later by revivals, which in turns merge into new expansion phase of the next cycle. Similarly, the 1995 Nobel Prize winner in Economics, Robert Lucas emphasizes the coordination of activity among various economic sectors in which their outputs should move together. This aspect of cyclical movements of different economic activities has become a key fact on business cycle measurement that researchers should take into account.

Motivated by this reasoning, this study aims to examine this nonlinearity in economic behavior associated with the business cycle. However, we do focus particularly on the business cycle in developing country. This is because, the economic fluctuations associated with the business cycle is based on important assumption that individuals must have a truly economic freedom. What do we mean by economic freedom? This can be viewed as a freedom to produce, trade, and consume any goods and services at the market prices without the government intervention. The government can play important role as a stabilizing force but only when the economy severely contracts (Cooley and Prescott, 1995). Therefore the major force that drives the economy and essentially brings about the country's economic pattern is considered to come from a public sector. Unlike a truly free country like the United States, the economic growth path and business cycle in developing countries, particularly Thailand are something else. The ability of the Thai people to undertake economic actions or so-called the economic freedom is relatively less. Although, the Thai government does not take control of all economic activities as happened in Nazi Germany or Soviet Russia, but sometimes the freedom of enterprise is limited by governmental controls, such as price controls and wage controls, which in turn make the business cycle fade out. Moreover, the political instability in Thailand that occurs over the past few decades could ruin the economy, undermine the investment, and hold other economic activities far below the potential levels. This raises a question whether the business cycle in Thailand still follows that certain pattern suggested by the traditional theory of business cycle. Are the economic stages as in the common business cycle still persistence? Or they fade out? And importantly, is there the consistent pattern of comovement among economic activities over the business cycle?

To address these questions, we will employ an effective tool for examining the business cycle characteristics that will be described thoroughly in Section 2. Later, all included variables as well as a model specification will be explained through Section 3. In Section 4, we will discuss about estimated characteristics of the business cycle in Thailand as well as the impact of included variables on Thailand's economic growth that may be inconstant across different stages of the business cycle.

2. METHODOLOGY

To analyze the business cycle, we consider an application of Hamilton's model that is a Markov-switching vector autoregressive (MS-VAR) model generalized by Krolzig (1997). For the statistical measurement of economic fluctuations, the Markov-switching model has become popular since Hamilton (1989) proposed the Markov-switching autoregressive (MS-AR) model and applied to the business cycle measurement in the US. Since then, there have been a lot of extensions in which one of the influential works is an application of Krolzig (1997). He generalized the idea of MS-AR model to the MS-VAR model since he emphasized the co-movement of important macroeconomic variables or the economic activities, and then applied this technique to measure the European business cycle. This tool has spread various studies on economic fluctuations associated with business cycle. We also realize its potential and employ this MS-VAR model to analyze the business cycle for our work.

2.1. Markov-switching Vector Autoregressive (MS-VAR) Model

The MS-VAR model is well-known that it provides a synthesis of the dynamic factor structures and nonlinear approach which is useful for modeling fluctuations of the economy associated with business cycle. This model refers to an unobserved regime, denoted by S_t, driven by the Markov process, and the regime here can imply a phase of the business cycle. The MS-VAR model can be viewed as the VAR model with regime changes. However, following the originator of this model, Krozig (1997), together with Perlin (2015), the structure of the MS-VAR model is as follows:

$$Y_t = I_{S_t} + \sum_{i=1}^{p} A_{S_t}^{i} Y_{t-1} + E_{t,S_t} . \tag{1}$$

From Eq.(1), Y_t is a $(K \times 1)$ vector of endogenous variables –or our time series variables- that follows the autoregressive form. I_{S_t} is a $(K \times 1)$ vector of regime-dependent intercepts and $A_{S_t}^{i}$ is a $(K \times K)$ vector of regime-dependent coefficients of past lags of Y_t, for lag $i = 1,.., p$. $E_{t,S_t} \sim \text{NID}(0, \Sigma_{S_t})$ in which Σ_{S_t} is referred to as the non-negative variance of the residuals in each regime. In the general specification of MS-VAR model, all the parameters are conditional on the regime (S_t), meaning they can vary across the regimes. Suppose we have M regimes in the MS-VAR model; therefore,

$$Y_t = \begin{cases} I_{S_t=1,t} + A_{S_t=1}^{1} Y_{t-1} + \ldots + A_{S_t=1}^{p} Y_{t-p} + \sigma_{S_t=1}^{1} \varepsilon_{1,t} \\ \vdots \\ I_{S_t=1,t} + A_{S_t=2}^{1} Y_{t-1} + \ldots + A_{S_t=M}^{p} Y_{t-p} + \sigma_{S_t=M}^{M} \varepsilon_{\mathrm{M},t} \end{cases} \tag{2}$$

The regime variable S_t in the MS-VAR model, is generally governed by the first order Markov process, which is defined by the transition probability as follows:

$$p_{ij} = \Pr(S_{t+1} = j \mid S_t = i) \text{ and } \sum_{j=1}^{M} p_{ij} = 1 \quad i, j = 1, \ldots, M , \tag{3}$$

where p_{ij} is probability of the transition from regime i to regime j. We can collect all the transition probabilities for M regimes in the transition matrix P

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1M} \\ p_{21} & p_{22} & \cdots & p_{2M} \\ \vdots & \vdots & \cdots & \vdots \\ p_{M1} & p_{M2} & \cdots & p_{MM} \end{bmatrix} . \tag{4}$$

Here we assume that the Markov chain is stationary so the MS-VAR process is also stationary, thereby ergodic (Cavicchioli, 2015). Moreover, for the estimation technique implemented for MS-VAR model, we consider the maximum likelihood estimator (MLE), which is designed to estimate the parameters of the model where the observed time series depends on the unobserved or hidden stochastic variable S_t (Perlin, 2015). We consequently need the likelihood function to be maximized. We assume a normal distribution for the errors, so the log likelihood can be written as:

$$\begin{aligned} \ell(\Theta) = & -\frac{K}{2}\log_e(2\pi) - \frac{1}{2}\log_e\left|\Sigma'\Sigma\right| \\ & -\frac{1}{2}(\mathrm{Y}_t - I_{S_t} + \sum_{i=1}^{p} A^i_{S_t} Y_{t-1})' \left(\Sigma'\Sigma\right)^{-1} (\mathrm{Y}_t - I_{S_t} + \sum_{i=1}^{p} A^i_{S_t} Y_{t-1}) \text{'} \end{aligned} \tag{5}$$

in which $\Theta = \left\{ I_{S_t}, A^i_{S_t}, \Sigma \right\}$. Following Krolzig (1997), the expected log likelihood function for Eq. (5) is approximated by

$$L(\widehat{\Theta}) = \sum_{S_t=1}^{M} \sum_{t=1}^{T} \ell(\Theta_{S_t}) \cdot (\mathrm{E}_{S_t} \mid Y_t) , \tag{6}$$

where $(\mathrm{E}_{S_t} \mid Y_t)$ are the filtered probabilities, which in turn is calculated by Hamilton's filter (Hamilton, 1994). This specific filter of Hamilton can be determined using the following algorithm.

1. Giving an initial guess for transition matrix P as in Eq. (4)
2. Updating the transition probabilities with the past information including the parameters in the model, Θ_{S_t}, and P for calculating the likelihood function in each regime at time t as in Eq. (6). The probability of each regime is updated by the following formula:

$$(\mathrm{E}_{S_t} \mid Y_t) = \Pr(S_t = m \mid \Theta_{S_t}) = \frac{f_m(\mathrm{Y}_t \mid S_t = m, \Theta_{S_{t-1}}) \Pr(S_t = m \mid \Theta_{S_{t-1}})}{\sum_{m=1}^{M} f_m(\mathrm{Y}_t \mid S_t = m, \Theta_{S_{t-1}}) \Pr(S_t = m \mid \Theta_{S_{t-1}})} . \tag{7}$$

Note that we assume M regimes for this MS-VAR model in which $m=1,..,M$. The term $f_m(\mathrm{Y}_t | S_t = m, \Theta_{S_{t-1}})$ is referred as the likelihood function of regime m and $\Pr(S_t = m | \Theta_{S_{t-1}})$ is referred as the filtered probabilities at time $t-1$.

3. Iterating Step 1 and Step 2 for t = 1, ..., T.

However, for empirical applications, it might be more helpful to use a model where only some parameters are conditional on the regime of the Markov chain, while the other parameters are regime-invariant. Krolzig (1997) emphasized this and invented a common notation to provide simplicity in expressing those models. Following Krolzig (1997), we consider particularly intercepts (*I*), autoregressive parameters (*A*), and heteroskedasticity (*H*) to vary across different regimes. And hence, we have got eight alternative specifications of the MS-VAR model as shown in Table 1. In a case that all the parameters are conditional on the regime, Krolzig considered this as a general specification of the MS-VAR model. However, to select the best one among these competing models, the Akaike information criterion (AIC) is used, in which the model with lowest value of AIC is preferred.

Table 1
Types of MS-VAR Models

		I varying	*I invariant*
A	*H* invariant	MSI-VAR	VAR (linear)
invariant	*H* varying	MSIH-VAR	MSH-VAR
A	*H* invariant	MSIA-VAR	MSA-VAR
varying	*H* varying	MSIAH-VAR	MSAH-VAR

Source: Krolzig (1997)

Importantly, we have to make clear that this study considers, in particular, MSI-VAR models (with intercept) rather than MSM-VAR models (with mean) because the MSI-VAR models adjust more smoothly after the regime shift. In addition, the estimation procedure of the MSM-VAR models may face to a problem of nonlinear optimization if the endogenous variable does not depend on the unobserved variable (S_t) (Krolzig, 2003).

2.2. Likelihood Ratio Test

This part is conducted since we concern about a number of stages really occur in or fit to the Real-world, particularly Thailand's, business cycle. As such, this study employs a likelihood ratio (LR) test to examine number of regimes for the MS-VAR model. The LR test is a statistical test used for comparing the goodness of fit of two models: null and alternative models. Roughly, the LR statistic is simply twice the difference in the log likelihoods, which can be illustrated as follows:

$$LR = 2(L_1(\hat{\Theta}_{S_t}) - L_0(\hat{\Theta}_{S_t})). \tag{8}$$

From Eq.(8), $L_0(\hat{\Theta})$ is the log likelihood for the null model and $L_1(\hat{\Theta})$ is the log likelihood for the alternative model. In case, the null hypothesis is the model with no regime switching, or equivalently a linear VAR model, while the alternative hypothesis is the one with regime switching. The rejection is equivalent to the rejection of linear VAR in favor of the MS-VAR model. The probability distribution of the test statistic is approximately a chi-squared distribution with degrees of freedom equal to $df_{L_1(\hat{\Theta})} - df_{L_0(\hat{\Theta})}$. The *p*-value is computed by $P(\chi^2_{df_{L_1(\hat{\Theta})} - df_{L_0(\hat{\Theta})}} \geq LR)$. For instance, if we consider one regime against two regimes for the MS-VAR model, we then have

$$L_0(\hat{\Theta}) = \sum_{t=1}^{T} \ell(\Theta), \tag{9}$$

and

$$L(\hat{\Theta}) = \sum_{S_t=1}^{2} \sum_{t=1}^{T} \ell(\Theta) \cdot (\mathrm{E}_{S_t} |Y_t) \tag{10}$$

3. DATA AND MODEL SPECIFICATION

In this section, we present the dataset and introduce the considerable variables to identify the business cycle. To measure the cycle, the basic variable is real GDP since it is the best measure to track a country's economic performance, and with a growth rate form the real GDP can indicate the growth in economic output. Although the economic movement in regards to business cycle is based on the output, we also consider the coordination of activity among various economic sectors as highlighted by Robert Lucas. In particular, we consider the growths of number of unemployed people (*UNP*), industrial production (*IPI*), retail sales (*Retail*), and gross disposable household income (*Income*) over the business cycle. The variables we use are of quarterly frequency, spanning from 1995:Q1 to 2016:Q4, with the description is given in Table 2. These variables specified in the MS-VAR model can take the form as

$$y_t = v_{s_t} + y_{t-1} \cdot \beta_{1_{S_t}} + \ldots + y_{t-q} \cdot \beta_{q_{s_t}} + u_t$$

$$\begin{bmatrix} GDP_t \\ UNP_t \\ IPI_t \\ Retail_t \\ Income_t \end{bmatrix} = \begin{bmatrix} v_{GDP_t}(s_t) \\ v_{UNP_t}(s_t) \\ v_{IPI_t}(s_t) \\ v_{Retail_t}(s_t) \\ v_{Income_t}(s_t) \end{bmatrix} + \begin{bmatrix} GDP_{t-1} & \cdots & GDP_{t-q} \\ UNP_{t-1} & \cdots & UNP_{t-q} \\ IPI_{t-1} & \cdots & IPI_{t-q} \\ Retail_{t-1} & \cdots & Retail_{t-q} \\ Income_{t-1} & \cdots & Income_{t-q} \end{bmatrix} \cdot \begin{bmatrix} \beta^{GDP}_{1,s_t} & \cdots & \beta^{GDP}_{q,s_t} \\ \beta^{UNP}_{1,s_t} & \cdots & \beta^{UNP}_{q,s_t} \\ \beta^{IPI}_{1,s_t} & \cdots & \beta^{IPI}_{q,s_t} \\ \beta^{Retail}_{1,s_t} & \cdots & \beta^{Retail}_{q,s_t} \\ \beta^{Income}_{1,s_t} & \cdots & \beta^{Income}_{q,s_t} \end{bmatrix} + \begin{bmatrix} u_{GDP_t} \\ u_{UNP_t} \\ u_{IPI_t} \\ u_{Retail_t} \\ u_{Income_t} \end{bmatrix}.$$

The model comprises 5 variables that are *GDP, UNP, IPI, Retail*, and *Income* modeled as MS-VAR in which s_t represents regime or state and q is the lag term. To decide the number of regimes, we follow the traditional theory of business cycle. That is, the cycle has basically 4 states namely expansion, recession, depression, and recovery, therefore $s_t = 1, \ldots, 4$. However, the exact number of regimes occur in this experiment have to be investigated by the LR test, so that number of stages may not follow the theory; It can be one, two, or three regimes over the cycle. But prior to the testing regime, the characteristics of each stage can briefly explained as follows.

In the expansion phase, the demand for goods and services increase. There are the increases in sales and profit which in turn induce companies to invest in more production facilities and inventories. Moreover, this strong demand also pushes the need for more workers, which spurs an increase in employment levels. Mopping up of resources in the economy leaves no room for expansion; inputs become expensive, signaling that the economy is at its peak.

In the recession phase, the economy slows down, and the level of sales and production orders start declining. Production facilities become underutilized, and companies respond by reducing the work rate. Workers who had been hired on casual basis are laid off, and this reduces their disposable income. Idle capacity of production facilities reduces the output, and most companies are forced to reduce prices of products in an attempt to increase demand.

Table 2
Descriptive Statistic

	Δ Retail	*Δ IPI*	*Δ Income*	*Δ GDP*	*Δ UNP*
Mean	0.016	0.011	-0.338	0.015	0.029
Median	0.014	0.012	-0.244	0.014	-0.028
Maximum	0.444	0.239	8.164	0.107	1.274
Minimum	-0.236	-0.227	-7.717	-0.083	-0.374
Std. Dev.	0.076	0.049	1.936	0.024	0.300
Skewness	1.661	-0.368	0.471	-0.609	1.679
Kurtosis	14.299	12.934	9.763	7.682	7.011
Jarque-Bera	502.861***	359.707***	169.027***	84.866***	99.234***
ADF-test	-8.343***	-10.576***	-8.541***	-10.266***	-3.599***

Note: "***" denote rejections of the null hypothesis at 1% significance levels.

In the depression phase, a protracted period of recession ushers in a depression. Demand for products and services decrease, forcing companies to shut down some production facilities. Closing of production means a company cannot sustain its work force, and it is forced to lay them off. Unemployment leaves the consumers with very little disposable income needed to buy necessities. The gross domestic production declines and standard of living of the people also declines.

In the recovery phase, this stage is characterized by an increase in consumers' confidence of the market. The bank lending rates are low, and companies can afford to finance projects. There is an increase in productivity due to the increased aggregate demand in the economy. Increase in production allows companies to start employing, which in turn, increases the income of consumers who can now afford to purchase goods. Profit margins of companies starts rising, and the gross domestic product also start to increase.

Additionally, to avoid the phenomenon of false regression caused by the regression analysis of non-stationary time series, the variables should be taken as Augmented Dickey Fuller (ADF) unit root test before estimating the MS-VAR model. We do not provide the result of the ADF test, but it suggests that the null hypothesis of the unit root test can be rejected and that all series are stationary at the 1%, 5%, and 10% confidence levels. This means that we can use these variables as endogenous variables in the MS-VAR model for the purpose of estimating the business cycle characteristics.

4. EMPIRICAL RESULT

In this section, we present the estimated results sequentially starting with lag length selection for VAR model followed by the likelihood ratio test for determining the number of stages or regimes, and selecting appropriate structure for the MS-VAR model, respectively. After these core ingredients for the MS-VAR model with the structural change are defined, we are then able to estimate Thailand's business cycle characteristics in which the estimated parameters at different stages and the probabilities of staying in, particularly smoothed and filtered probabilities, will be shown at the end of this section.

4.1. Lag Length Selection

We begin this section by lag length selection for determining the vector autoregressive lag length. We employ the AIC and BIC to choose an appropriate lag term for the VAR model. Table 3 shows the AIC and BIC values of each model at lags 1 to 5. We found that the appropriate lag for the VAR model using this data set, is lag 1 since it has the lowest values of AIC and BIC.

Table 3
Lag Length Selection

	VAR	
Lag	*AIC*	*BIC*
1	-585.6269	-511.9965
2	-578.7729	-444.4271
3	-578.7685	-384.3032
4	-566.8678	-312.8895
5	-571.9103	-259.0368

Source: Calculation.

4.2. Likelihood Ratio Test for Determining the Number of Markov Regimes

The likelihood ratio (LR) test is conducted in this part to determine the number of Markov regimes under this data set, which reflect the number of stages in the business cycle. Following formula for the LR test statistic, as shown in Eq. (8), it is measured by twice difference in the log likelihood values between null model and alternative model. In this study, both null and alternative models are in the form of MS-VAR model but with different number of regimes. For example, the first roll of Table 4 is the result of LR test in which the null model is the MS-VAR model with 1 regime –this particular model is equivalent to the linear VAR model- and the alternative model is the MS-VAR model with 2 regimes. L(Ho) stands for log likelihood of the null model and L(Ha) is of the alternative model. LR test statistic measured following that formula is shown in the fourth column.

Table 4
Results of the LR Test

Model	*L(Ho)*	*L(Ha)*	*LR test*	*P-value*
1 VS 2	322.813	436.699	227.773	0.0000
1 VS 3	322.813	410.521	175.416	0.0000
2 VS 3	436.699	410.521	52.357	0.3087

Source: Calculation.

Note: If we compute the LR statistic for the third test through the common formula as in Eq.(8), we will get a negative value. Hence, this LR statistic is particularly measured by $LR = -2(L_0(\tilde{\Theta}_{s_t}) - L_1(\tilde{\Theta}_{s_t}))$ (Pastpipatkul *et al.,* 2016).

Table 4 shows the results of three LR tests. Result of the first LR test indicates that there exists a rejection of the MS(1)-VAR model in favor of the MS(2)-VAR model. However, the second LR test also exists to reject the MS(1)-VAR model, but, in favor of the MS(3)-VAR model. As the model with 2 and 3 regimes are both preferable to the linear VAR model, we then perform the third LR test to settle this issue. It is found that we cannot reject the null model which is the MS(2)-VAR at 10% significance level, so the appropriate model for this data set is considered to be the MS(2)-VAR model.

4.3. Selecting Appropriate Structure for the MS-VAR Model

This part is about structural selection based on MS(2)-VAR(1) model since we concern about structural change to measure in detail the characteristics of Thailand's business cycle. In particular, the structural change refers to changes in intercepts (*I*), autoregressive parameters (*A*), and heteroskedasticity (*H*); therefore, we have eight different types of models as shown in Table 1 and here Table 5 provides the empirical result.

Table 5
MS Structural Specification based on AIC

MS Specification		*I varying*	*I invariant*
A invariant	*H* invariant	-634.023	-585.626
A invariant	*H* varying	-639.015	-641.000
A varying	*H* invariant	-586.716	-607.709
A varying	*H* varying	-679.399	-616.604

Source: Calculation.

With a given set of models, we then employ the AIC to choose the best model among all candidates. Table 5 shows relative quality of each model through the AIC values. It is found that the MS(2)-VAR(1) model with varying *A*, *I*, and *H* has the lowest value of AIC that is equal to -679.399. Hence, the appropriate model for explaining the characteristics of Thailand's business cycle under this data set, is considered to be the MSIAH(2)-VAR(1).

4.4. Estimates of the MS-VAR Model with the Structural Change

The estimates of the MSIAH(2)-VAR(1) model is illustrated in Table 6. This empirical results indicate that the nonlinearity in economic growth as well as the fluctuation of economic activities associated with the business cycle, appear in terms of changes in the whole process of economic growth. The economic activities, i.e. retail sales, industrial production, gross disposable household income, (un)employment, as well as the economic growth, behave differently across regimes. As shown in Table 6, the estimated parameters of each variable are significantly different across regimes, in which some economic activities change in the same direction as the change of real GDP growth, while some of them move inversely. In terms of the modelling structural change, it is found that the MSIAH-VAR model is preferred. This means changes in the whole process of economic growth can be explained by changes in the structures i.e. intercepts, autoregressive parameters, and heteroskedasticity across different regimes.

Table 6
Estimates of MSIAH(2)-VAR(1)

	Δ Retail	*Δ IPI*	*Δ Income*	*Δ GDP*	*Δ UNP*
Regime-dependent Intercepts					
Regime 1	0.0011	0.0020	-0.3830	**0.0159**	**0.0439**
Regime 2	0.0005	0.0010	0.0010	**0.0015**	**0.0014**
Regime-dependent Autoregressive Parameters at Lag 1					
Regime 1					
Δ Retail	0.1425	0.0344	-6.0193	**0.0351**	**1.1144**
Δ IPI	0.1161	0.2494	31.1725	**0.0332**	**-3.9193**
Δ Income	0.0036	0.0014	0.1219	**0.0006**	**0.0232**
Δ GDP	0.3135	0.2650	-16.8342	**0.0445**	**3.7941**
Δ UNP	-0.0921	-0.0294	38.4588	**-0.0116**	**0.3241**
Regime 2					
Δ Retail	-0.0340	-0.7305	15.6703	**-0.0143**	**0.5397**
Δ IPI	0.5456	-0.4144	-18.2938	**-0.3830**	**-0.9749**
Δ Income	-0.0005	0.0054	0.0050	**0.0011**	**-0.0119**
Δ GDP	-0.2100	-0.9468	38.4588	**-0.0675**	**-0.3024**
Δ UNP	0.3241	-0.0143	-0.1810	**-0.0101**	**-0.4888**

Log-likelihood	3073.402	**AIC**	-679.3995	**BIC**	-284.0910

	Transition Prob. p_{1t}	p_{2t}	**Duration**	**Observation**
Regime 1	0.94	0.35	17.73	81
Regime 2	0.06	0.75	1.54	5

Source: Calculation.

Note: Surprisingly, all estimated parameters are statistically significant at the 1% significance levels.

Table 6 shows that intercepts of some growth variables in regime 1, says retail sales, industrial production, and real GDP, are greater than the ones in regime 2, while intercept of growth rate of gross disposable household income in regime 1 is less than the one in regime 2. Additionally, intercept of growth rate of unemployment in regime 1 is much greater than the one in regime 2. Due to these distinct results, we cannot conclude confidently that which regime is expansion (or recession). However, the probabilities shown in Figure 1 just provide helpful information. Basically, the probabilities show the chance of staying in some certain regime. Figure 1 is illustrating the probabilities of staying in regime 1 in which there are two periods of time that the cycle is dragged down. Let's look at the historical information related to this figure. It is well known that Thailand and many countries in East Asia went through the great financial crisis in 1997-98, and again in 2011-12 due to the global economic crisis. We emphasize that these two crises cause Thailand's business cycle to go down to the recession during 1997 continuing to 1999 and again during 2011-12. Hence, regime 1 is supposed to be the expansion since Figure 1 shows that the probabilities of staying in this regime is almost zero during that period of time. Consequently, regime 2 is supposed to be the recession.

To a large extent, Table 6 shows that in each cycle the length of staying in the expansion is approximately 18 quarters. The probability of changing from expansion (regime1) to recession (regime2) is equal to 0.06 but the chance of remaining in the expansion is equal to 0.94. On the other hand, it is about 5 quarters for the length of staying in the recession. The probability that Thailand's business cycle will stay in the recession is about 0.75 while the rest 0.35 is the probability of changing from the recession to the expansion. The estimated autoregressive parameters are conditional on the regime. For instance during the expansion phase, a 1% increase in the growth rate of industrial production (Δ*IPI*) leads to a rise in the growth of retail sales (Δ*Retail*), industrial production (Δ*IPI*) itself, disposable household income (Δ*Income*), and the real GDP (Δ*GDP*) about 0.034%, 0.249%, 0.0014%, and 0.265%, respectively. In addition, a rise in industrial production just 1% can cause a decrease in the growth rate of unemployment (Δ*UNP*) by 0.029%. On the contrary, the increase in the growth rate of industrial production during the recession brings about the negative impacts mostly on other sectors. It causes a decrease in retail sales, industrial production itself, and the real GDP about 0.731%, 0.414%, and 0.947%, respectively. Although it still causes the reduction in unemployment, but the rate is double lower; that is about 0.029% in the expansion but 0.014% in the recession.

As also presented in Table 6, the changes in considerable economic activities result in distinct impact on economic growth measured by the real GDP. In the expansion, increases in the growth rates of those economic activities by 1% lead to an increase in economic growth, for instance, by 0.313% (by retail sales) and 0.265% (by industrial production). However, these impacts become negative during the recession phase. This indicates that the impacts of changes in the economic activities on the real GDP growth are unequal through regimes, which in turn support the persistence of nonlinear economic growth path as being due to the fluctuation in economic activities associated with business cycle.

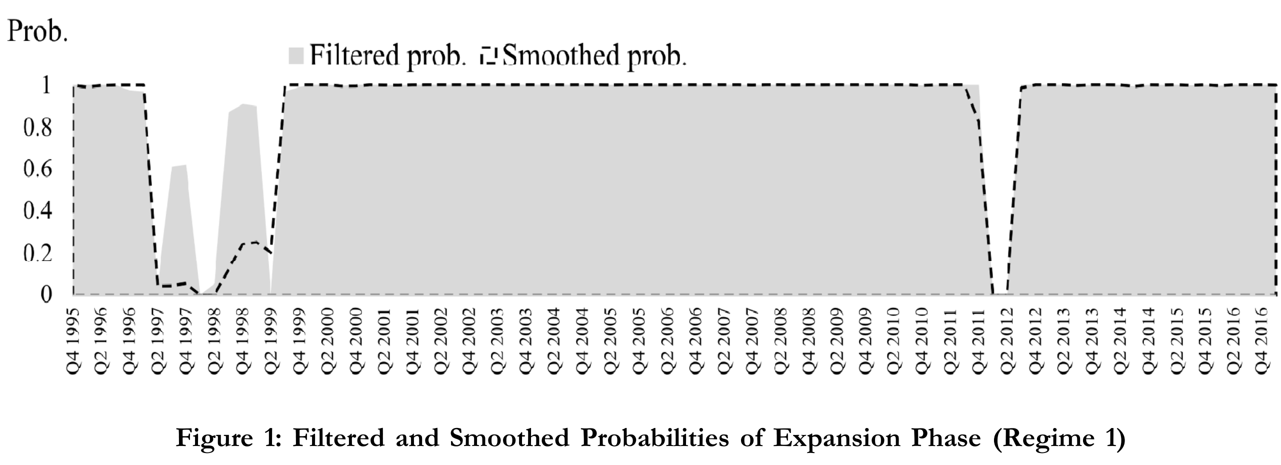

Figure 1: Filtered and Smoothed Probabilities of Expansion Phase (Regime 1)

5. CONCLUSION

This study is on the analysis of business cycle particularly in Thailand using a Markov-switching vector autoregressive approach (MS-VAR) with structural changes. This study yields two important purposes: to examine the simultaneous cyclical movements among economic variables, and to detect the nonlinear economic growth through the context of business cycle. This study builds the business cycle by using the real GDP, unemployment, industrial production, retail sales, and gross disposable household income. As a sequence of modelling, The LR test is used for determining the number of Markov regimes, which refers to the stages of business cycle, and the AIC is used for both lag length and structural selections. Hence, this study came up with the MSIAH(2)-VAR(1) model to reflect the characteristic of Thailand's business cycle.

The overall results show that the relationships among economic activities during the recession phase tend to be negative, but are more likely to be positive during the expansion. These significant results can reasonably support the aspects of comovement of different economic activities over the business cycle as suggested by many traditional theories of business cycle, and also the existence of distinct relationships among these variables across different economic regimes. Moreover, the impacts of changes in the economic activities on the real GDP growth are unequal through regimes. This supports the persistence of nonlinear economic growth path as being due to the fluctuation in economic activities associated with business cycle. To be more specific, the smoothed probabilities show that Thailand's business cycle mostly takes place in the expansion, except for the periods of great depression during 1997-98 and the global economic crisis during 2011-12.

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