TWO-STATE MARKOV SWITCHING ANALYSIS USING COINCIDENT AND LEADING ECONOMIC INDICATORS: MALAYSIAN CASE

Izani Ibrahim
Ahmad Raflis Che Omar
Finance Department
National University of Malaysia
Bangi, Malaysia

Abstract

In this paper we have analyzed the Malaysian Coincident and the Leading Economic Indicator using the Markov-Switching Model developed by Hamilton (1996). Coincident and Leading Economic Indicators spanning from January 1981 to August 2001 were used in this study. The results show that for the Malaysian economy, the average number of months the economy is in expansionary and recession is 34 months and 10 months respectively (using the Leading Indicator data) and 40 months and 8 months (using the Coincident Indicator data). The Malaysian economy has a must higher probability to be in expansionary state than in recession. The results of this study also show that the leading indicators are not very reliable in forecast the state of the economy and the coincident does not match very well with recessions and expansion of the Malaysian economy.

1. Introduction

Economic indicators are usually used to forecast changing business cycle in an economy as they are descriptive and ex-ante time series data for forecasting economic or business conditions. Economic indicators are usually categorized into Leading, Coincident and Lagging indicators. Leading indicators by its construction should lead the overall economic situation and reach their trough or peak before the business cycle turns, while Coincident economic indicator should coincide with the condition of the aggregate economy.

The origins of the current leading indexes for most countries go back to the late 1930s. Burns and Mitchell (1946) drew up a list of 71 statistical series that they considered to be reliable indicators of economic recoveries. Since business cycles are defined as broad-based contractions and expansions, combinations of indicators or composite indexes are generally better at tracking the cycles than any single indicator (Moore, 1950). Moore and Shiskin (1967) developed an explicit scoring system to gauge the value of the individual series as indicators of the business cycle and apply weights the indicators in constructing composite indexes.

In spite of long development in construction of economic indicate, the record of the traditional leading index has not been perfect, but it has been helpful in predicting recessions. Although the same methodology is used to construct the traditional coincident and leading indexes, no statistical technique is employed to ensure that the leading index actually "leads" the coincident index (Green and Beckman, 1993). Economic indicators system, however has been recognized as essential tool for monitoring and tracking the country's economic cycle. However, it is unable to measure or predict the magnitude of change that will occur in the economy. In cases where there are more than one turning point happening in a short period, human judgment is also needed to identify which is the correct turning point.

Stock and Watson (1989) provide a particularly strong challenge to the traditional leading index approach by applying modern time series techniques to the selection and weighting of the leading index components. While their research was convincing, in the first out-of-sample experiment the Stock and Watson (1989) Leading Index failed to predict, or even acknowledge, the recession that occurred from July 1990 to March 1991.

The purpose of this study is to examine the accuracy of time series forecasts of recessions and expansions of the Malaysian economy, using coincident and leading economic indicators, produced by the Malaysian Statistics Department. We will also look at some information that can be extracted from the indicators with respect to the lag indicators. In this case, we apply Markov-switching model by assuming a two-state regime of recessions and expansions and test the hypothesis that the coincident and the leading indicators serve as a useful input to a time series model to forecast recessions and expansions in Malaysia.

Many authors have built Markov-switching model based on the seminal work of Hamilton (1989) who developed the model in his study of US interest rate and business cycle. As noted by Stekler (1991), the process of predicting turning points of regimes is different from making quantitative prediction; consequently, forecasting methods designed exclusively to predict regime changes have to be developed. The regime-switch approach adopted by Lahiri and Wang (1994) and Layton (1996) avoids these pitfalls, since it uses a Markov-switch model to generate ex-ante forecast for points of transition between the regimes of recession and expansion. In another paper, Hamilton (1990) used Ergodic Markov algorithm with no Bayesian priors to estimate the Markov regime-switching model.

Ang and Bekaert (1998) use the Markov-switching model to study econometric performance of interest rates for the US, Germany and the UK. Here, the regime-switching model is found to forecast better than univariate models and the regimes in interest rates correspond reasonably well with business cycle. Ivanova, Lahiri and Seitz (2000) found that the Markov-switching model allows the dynamic behavior of the economic to vary between expansions and recessions in term of duration and volatility, and confirm the usefulness of yields spreads for forecasting inflation cycles and economic downturns.

2. Data

The data used in the analysis for the Markov-Switching model are the Malaysian economic coincident and the leading indicators published by the Malaysian Statistic Department (2001) which are calculated using the methods employed by Moore and Shiskin (1967). The data are the monthly data spanning from January 1981 to August 2001. All data are seasonally adjusted and the growth rates are expressed as compound annual rates based on the ratio of the current month's index to the average index during the preceding 12 months. The data are 6-month smoothed changes at annual rates. For comparison purposes, we also assumed Malaysian economy experience periods of recessions and contraction as defined by the Malaysian Statistic Department (2001)

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3. Theory

Time series data often experience episodes of behavior changes or structural breaks. These breaks can be a dramatic one and consequently change parameters over time driven by Markov state variable that is assumed to be unobserved to the econometrician. Importantly, Regime Switching Model can accommodate regime-dependent mean reversion in time series (Ang and Bekaert, 1998). In regime switching model the unobserved breaks during changes in regimes are incorporated in analysis as parameters that need to be estimated. In this paper we assumed the Coincident Indicator (CI) and the Leading Indicator (LI) experienced episodes of economic contractions and expansions and they are unobservable.

If the states economic contractions and expansions are observable, then we can consider the following equations for estimations;

$$y_t - \mu_1 = \phi_1(y_{t-1} - \mu_1) + \varepsilon_t \qquad \text{for expansionary period}$$
$$y_t - \mu_2 = \phi_2(y_{t-1} - \mu_2) + \varepsilon_t \qquad \text{for contractionary period,}$$

or

$$y_t - \mu_s = \phi_1(y_{t-1} - \mu_s) + \varepsilon_t$$

where s = 1 for expansionary and s = 2 for contractionary.

When the states of the economy are unobservable, we need a description of the time series process for the unobservable state variables. Following the methodology adopted by Hamilton (1989), the simplest time series model for discrete-valued random variable is a Markov chain. In a two-state Markov-chain, we assume that the probability that state at time t (s_t) equal to some value j depends on the past only through the most recent (s_{t-1}). Thus, we can write the conditional probability as;

$$\Pr\{s_t = j \mid s_{t-1} = i, s_{t-2} = k, \ldots\} = \Pr\{s_t \mid s_{t-1} = i\} = p_{ij} \quad \text{for } i, j = 1, 2.$$

Thus p_{ij}, referred to as the transition probability, is the probability of state j in time t given state in time t-1 is i. For the two state model, the transition probabilities is collected into a **P** matrix known as the transition matrix;

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix} = \begin{bmatrix} p_{11} & 1-p_{22} \\ 1-p_{11} & p_{22} \end{bmatrix}$$

The probability density of y_t conditional on the random variable s_t taking on the value j is;

$$f(y_t \mid s_t = j; \theta) = \frac{1}{\sqrt{2\pi}\sigma_i} \exp\left\{\frac{-(y_t - \mu_j)^2}{2\sigma_j^2}\right\}.$$

Here, the unobserved regime $\{s_t\}$ is presumed to have been generated by some probability distribution; where the unconditional probability that s_t takes on the value j is denoted by π_j:

$$\Pr\{s_t = j; \theta\} = \pi_j \qquad \text{for } j = 1, 2.$$

The probabilities π_1 and π_2 are included in θ; that is θ is given by

$$\theta = (\mu_1, \mu_2, \sigma_1^2, \sigma_2^2, \pi_1, \pi_2)'.$$

We will skip the derivation of the likelihood function. Those who are interested can refer to Hamilton (1989) or Hamilton (1994, Chapter 22). It can be shown that the unconditional density of y_t, summing over all possible values for j, denoted by $f(y_t; \theta)$ is;

$$f(y_t;\theta) = \sum_{j=1}^{2} p(y_t, s_t = j; \theta)$$

$$= \frac{\pi_1}{\sqrt{2\pi}\sigma_1} \exp\left\{ \frac{-(y_t - \mu_1)^2}{2\sigma_1^2} \right\} + \frac{\pi_2}{\sqrt{2\pi}\sigma_2} \exp\left\{ \frac{-(y_t - \mu_2)^2}{2\sigma_2^2} \right\}.$$

Thus the log likelihood for the observed data can be calculated as

$$L(\theta) = \sum_{t=1}^{2} \log f(y_t; \theta).$$

The maximum likelihood estimates of θ is obtained by maximizing the log likelihood subject to the constraints that $\pi_1 + \pi_2 = 1$ and $\pi_j \geq 0$ for j = 1, 2. This can be done using numerical methods or using the Ergodic Markov (EM) algorithm.

Following Hamilton's (1994) AR(4) Markov-Switching method for a two state regime, the switching model fitted to the data by maximum likelihood is;

$$\begin{aligned} y_t - \mu_{s_t} &= \phi_1(y_{t-1} - \mu_{s_{t-1}}) + \phi_2(y_{t-2} - \mu_{s_{t-2}}) \\ &\quad + \phi_3(y_{t-3} - \mu_{s_{t-3}}) + \phi_4(y_{t-4} - \mu_{s_{t-4}}) + \varepsilon_t \end{aligned} \qquad (1)$$

with $\varepsilon_t \sim$ i.i.d. $N(0, \sigma^2)$ and with s_t presumed to follow a two-state Markov chain with transition probability p_{ij}. We will define state 1 as expansion and state 2 as recession.

In the process of obtaining the values of the parameters in $\theta = (\mu_1, \mu_2, \sigma_1^2, \sigma_2^2, \pi_1, \pi_2)'$, the transition matrix **P** that maximization of the likelihood function is simultaneously identified. We can extract some useful information from the transition matrix, **P**. These include the average time the economy will stay in a particular regime and the probability of the economy stays in a particular regime. We are also able to construct an m-period-ahead transition matrix for our ergodic two-state Markov chain.

Our interest in this paper include the average time the economy will stay in a particular regime, say state s_1, which is given by $1/(1 - p_{11})$ and for state s_2, it is given by $1/(1 - p_{22})$. The probability the regime will be in state s_1, $Pr\{s_t = 1\}$, is given by $(1 - p_{22})/(2 - p_{11} - p_{22})$, and the probability the regime will be in state s_2, $Pr\{s_t = 1\}$, is given by $(1 - p_{11})/(2 - p_{11} - p_{22})$.

4. Empirical Results

Table 1 shows the results for the two-regime switching analysis using the Coincident Indicator (CI). State 1 is the expansion state while state 2 is when the state is in recession. As we would expect the mean of the growth of CI is higher during the expansion period than in the during recession (that is $\mu_1 = 0.629$ and $\mu_2 = -0.246$). The value of the coefficients for equation (1) show that for ϕ_1, ϕ_3 are ϕ_4 are significant at 5% level. Probability of state is in expansion given last period's state is expansion, p_{11} is 0.975 while the probability of state is recession given last period's state is recession, p_{22} is 0.880. Using the formula given earlier, the average number of months the economy will state in expansion is 40.31 months and the average number of months the economy stays in recession is 8.35 months. Further, the probability of the economy is in expansionary state, pr{ s = 1}, is 0.828 and the probability for recession, pr{ s = 2} is 0.1712. Similarly, the results for Leading Indicator (LI) is given in Table 2.

From Tables 1 and 2, the mean growth rates for CI and LI when the economy is in expansion are about the same, which is 0.6 percent. However, the means when the economy is in recession are significantly different. On the average, the results show that the Malaysian economy favors periods of expansionary than recession. This is consistent with the average periods for both state of economy.

Table 1: Maximum Likelihood Estimates of Parameters for Markov-Switching Model of Malaysian Coincident Economic Indicator

Variable	Coeff	Std Error	T-Stat	Signif
μ_1	0.62910	0.05542	11.35079	0.00000
μ_2	-0.24571	0.14909	-1.64805	0.09934
ϕ_1	-0.58650	0.06842	-8.57189	0.00000
ϕ_2	-0.03353	0.08005	-0.41884	0.67534
ϕ_3	0.34375	0.08209	4.18736	0.00003
ϕ_4	0.20184	0.06939	2.90855	0.00363
p_{11}	0.97519	0.01524	63.97250	0.00000
p_{22}	0.88028	0.07406	11.88628	0.00000
σ	0.76014	0.03960	19.19723	0.00000

Average months in expansion	40.306
Average months in recession	8.353
Pr{ state = expansion}	0.828
Pr{ state = recession}	0.172

Table 2: Maximum Likelihood Estimates of Parameters for Markov-Switching Model of Malaysian Leading Economic Indicator

Variable	Coeff	Std Error	T-Stat	Signif

μ_1	0.64809	0.09709	6.67550	0.00000
μ_2	-0.00603	0.22158	-0.02720	0.97830
ϕ_1	-0.24547	0.06932	-3.54087	0.00040
ϕ_2	0.12152	0.07580	1.60312	0.10891
ϕ_3	-0.01090	0.07630	-0.14283	0.88643
ϕ_4	-0.07124	0.07876	-0.90450	0.36573
p_{11}	0.97053	0.02821	34.39850	0.00000
p_{22}	0.90352	0.07203	12.54316	0.00000
σ	0.93494	0.04831	19.35493	0.00000

Average months in expansion	33.933
Average months in recession	10.365
Pr{ state = expansion}	0.766
Pr{ state = recession}	0.234

We also have Graphs 1 and 2 which show the plots of the CI's monthly growth rate and the plot of the probability being in contraction using the CI data respectively. The shaded areas represent the recession periods determined to begin and end according by the Malaysian Statistic Department (2001), however they are not used in anyway to estimate the parameters in the model. We include the periods in our graphs for the purpose of comparisons with the results obtained from the Markov-Switching Model. Similar graphs are plotted for the LI in Graphs 3 and 4.

From the graphs, it appear that both the CI and the LI did not do very well in tracking periods of recessions and expansions for the Malaysian economy, with respect to the periods determined by the Malaysian Statistic Department, especially when the economy is in recession. The CI by construction is supposed to coincident with the performance of the economy. However, it fails, in particular during the recession period from March 1996 to November 1999 and August 2000. The LI on the other hand, seems to track better for the expansion period. This can be observed by the sharp drop in Graph 2 when the economy is beginning to experience an expansion.

The LI seems to do a little better compared to the CI. By construction, the LI is supposed to lead the economy. Clearly, from Graph 4, the LI is unable to give the lead regarding the appearing recession in the economy. On the other hand, the LI do comparative well in predicting an expansionary economy. This can be seen by the reducing probability of contraction before expansionary periods. However this result is not conclusive.

Although the Markov-Switching Model is unable to "perfectly" match the periods of and expansions according to the Malaysian Statistic Department, we cannot be too quick in rejecting the model. The imperfect match may be due to inaccurate determination of the periods of recessions or expansions that is determined by the Statistic Department.

5. Conclusion

In this paper we have analyzed the Malaysian Coincident and the Leading Economic Indicator using the Markov-Switching Model developed by Hamilton (1996). In this model

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we assumed two states of recession and expansion in economy look at the transition probability of a particular state given last period's state. The results show that for the Malaysian economy, the average number of months the economy is in expansionary and recession is 34 months and 10 months respectively (using the Leading Indicator data) and 40 months and 8 months (using the Coincident Indicator data). The results also show that the Malaysian economy has a must higher probability to be in expansion than in recession.

With respect to forecasting using the model, we found that the results from the model are unable to match very well with the predetermined period of recession and expansion, in particular with the recession periods. However this could be due to inaccurate definition of recession and expansion. This will need further research and investigation regarding how the period of recession and expansion are determined.

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Figure 1: Monthly rate of growth of Malaysian Coincident Indicator

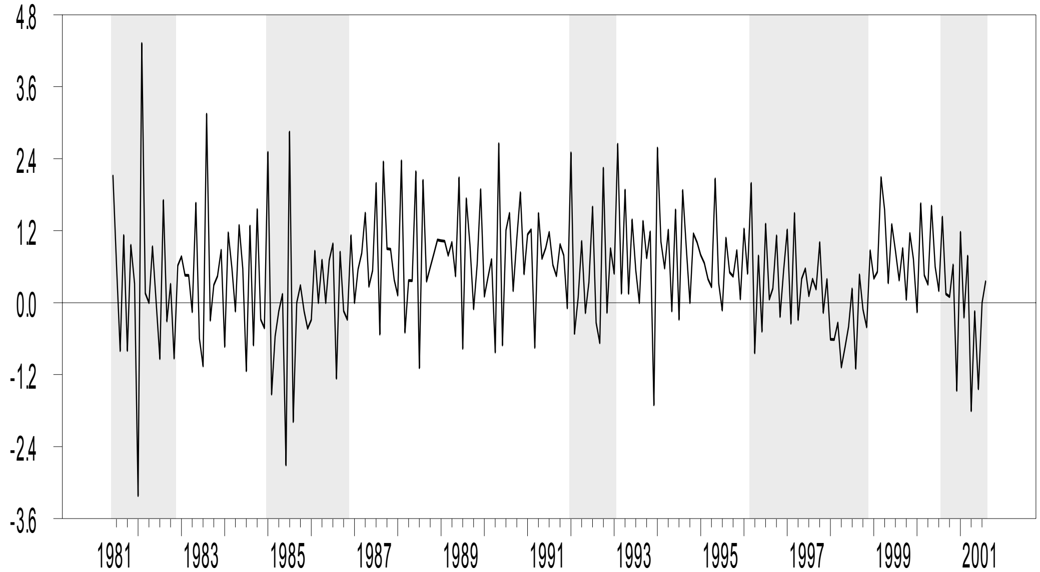

Figure 2: Probability that economy is in contraction state, or $\Pr\{s_t = 2 \mid , y_{t-1}, y_{t-2}, \ldots; \theta\}$ using Coincident Indicator data

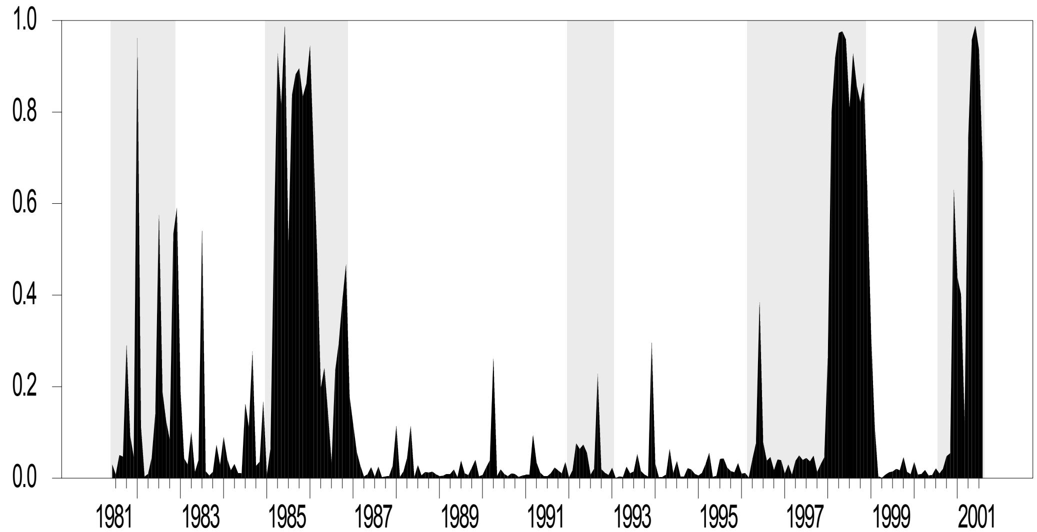

Figure 3: Monthly rate of growth of Malaysian Leading Indicator

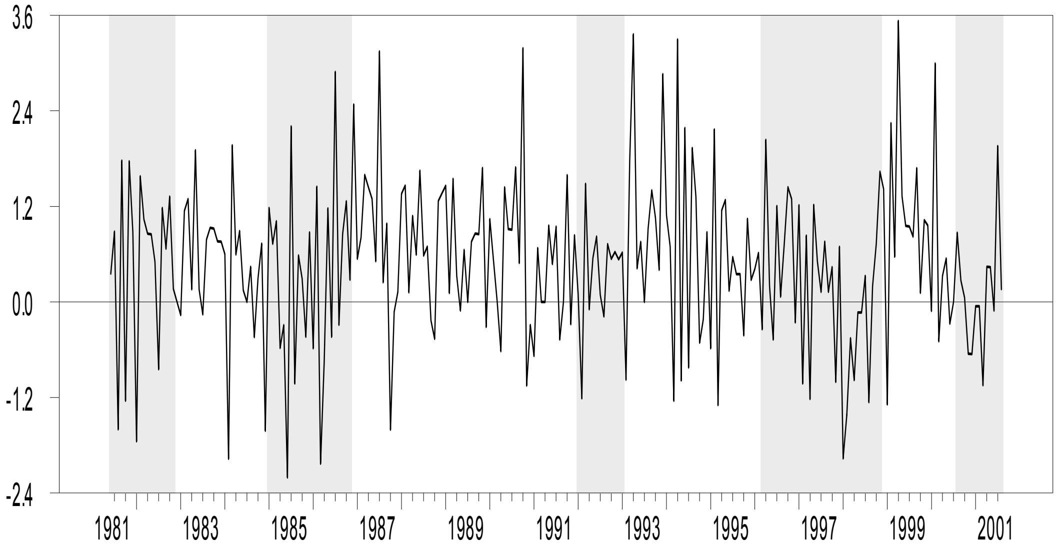

Figure 4: Probability that economy is in contraction state, or $\Pr\{s_t = 2 \mid y_{t-1}, y_{t-2},\ldots; \theta\}$ using Leading Indicator data