The Journal of Social Sciences Research
ISSN(e): 2411-9458, ISSN(p): 2413-6670
Special Issue. 6, pp: 423-428, 2018
URL: https://arpgweb.com/journal/journal/7/special_issue
DOI: https://doi.org/10.32861/jssr.spi6.423.428

Academic Research Publishing Group

Original Research Open Access

Asymmetric Effects of the Effect of Oil Price on Stock Markets in Four Asian Countries: Markov Switching Analysis

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Abstract

The Markov switching vector autoregressive model is a dynamic stochastic system with stochastic autoregressive parameters. This model able to measure a time varying problem when the variables undergoing regime switching. Structural change or shock is an ordinary fact in time series data. Some shocks have an important role under specific regimes in examining the business cycle contraction. Excluding changes in regime for the measurement of variance decomposition may produce biased results. Moreover, the parameters in the time series model might also have a structural change. Therefore, linear models are no longer suitable to be used in analyzing the financial model; and nonlinear time series models that are Markov switching models are proposed to solve these kinds of problems. A two regimes Markov switching vector autoregressive model is used in this study to analysis the time series data. The regime is dependent heterogeneous with varying the variance to detect every change of the business cycle. The correlations between oil price, Malaysia, Singapore, Thailand and Indonesia stock price are examining using Markov switching model. The result shows that the regimes dependent models suitable to employ in study the asymmetric business cycle; and oil price have a negative relationship with the changes of the four selected Asian stock markets.

Keywords: Regime dependent; Markov switching vector autoregressive; Variance decomposition; Structural change.

1.Introduction

Markov switching vector autoregressive (MS-VAR) model is an extension of Hamilton's model (Hamilton, 1989) which able to measure the phase shifting by estimating the transition probabilities of a data point to another. The Markov switching model can estimate multivariate linear or non-linear time series models. Moreover, the MS-VAR model also can examine the different values of parameter in economic shocks and forecast the economic variables, such as depression and inflation(Krolzig, 1997). The MS-VAR model is able to give a systematic approach by computing the past regime switching information of the data. Besides, it is also estimated consistently and efficiently on the variables in the model, detects the changes and corrects the vector autoregressive model at the times when regimes are altering.

The business cycle is a broad term in describing the fluctuations in economic activities such as economic expansion and contraction (Morley and Piger, 2012). Shock is a common fact in the time series variables (Phoong S. Y. and Phoong, 2018). Some shocks acts an important role under specific regimes when examines the business cycle contraction. Exclude the changes in regime when measuring the variance decomposition might result a biased output. Besides, overstated will be resulted if ruled out the specific shock during the shift in regime (Francesco, 2012). Thus, regime dependent MS-VAR model is employed in this study to examine the asymmetric effect of the business cycle.

The main objective of the Markov switching models used in this study is to capture the turning points, jumps as well as breaks in the series, thus the switching behavior or breaks that might exist in the series are concerned. The 1997 Asian financial crisis, also known as the Asian contagion, is one of the events that have affected the switching behavior in the series. This crisis greatly impacted the shares and currency markets of Indonesia, Malaysia, the Philippines and Thailand. The causes of the debacle are many and disputed, including economic bubble fueled by hot money in Thailand, the devaluation of the Chinese Renminbi, inflation and appreciation of the real exchange rate. This issue triggered most of the Asian countries' economy, causing a recession on stock market and currency in Malaysia, Thailand, Indonesia and other Asian countries. Malaysian Ringgit, Thai Baht, Indonesian Rupiah and Philippine Peso sharply declined in the early period of the Asian financial crisis. Then, the downward pressures hit the South Korean Won, Singaporean Dollar, Taiwanese Dollar and Hong Kong Dollar (Nanto, 1998).

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The paper is organized as follows. The next section reveals the previous studies that related to this paper. Section 3 gives a description of the data and samples. Section 4 discusses the methodology and the estimation method. Section 5 reports the empirical results. Finally, Section 6 presents conclusions.

2. Literature Review

The past literature has come to various conclusions regarding the relationship of oil price and macroeconomic variables. Bohi (1991) found that the oil price do not have any significant macroeconomic effects. However, other researches recognize the impact of oil price increase, but with different conditions and explanations. Lee *et al.* (1995) concluded that the consequences of the increase in oil price are a function of the size relative their current variability degree. One of the reasons given by Hooker (2002) of the difficulty in identifying the relationship between oil price and macroeconomic is the lack of dominant theoretical mechanism. For instance, there were different arguments regarding the ways in which the oil price primarily impacts the macroeconomic.

The multivariate Markov switching models are generally applied in examining the changes of the financial time series, and then predict the future movement. According to Diebold and Rudebusch (1996), there are two approaches of Markov switching models: jointly dynamic factor model and regime shifting model in analysis the time series data. Hondroyiannis and Papapetrou (2006) using three regimes mean adjusted heteroskedasticity MS-VAR (MSMH-VAR) model in estimating the correlation between inflation and stock price in Greece. The results showed that MSMH-VAR can provide a more accuracy results than Ordinary Least Square and linear vector autoregressive model.

In financial field, there are several studies that used MS-VAR model in the research, for example Guo *et al.* (2011) employed a two regimes MS-VAR model in the research of the contagion effects among stock returns, real estate market, credit default market and energy market during the financial crisis period.

3. Sample and Data

The monthly data used in this paper are oil return, and stock returns of Indonesia (Jakarta Stock Exchange Composite Index or JCI), Malaysia (Kuala Lumpur Composite Index or KLCI), Singapore (Straits Times Index or STI) and Thailand (The Stock Exchange of Thailand or SETI). The duration of the sample is taken from December 1989 to May 2012. The stock indices are denominated in local currency per U.S. dollar and the data are not seasonally adjusted, but taking natural logarithm to reduce variability in the data.

4. Methodology

The MS-VAR model is able to capture the changes in regimes. The general idea of the model is that the *M*-dimensional time series vector, $\mathbf{y_t} = (\mathbf{y_{1t}}, \ldots, \mathbf{y_{mt}})$ is subjected to an unobserved regime variable, $s_t \in \{1, \ldots, n\}$ which represents the probability of being in a particular state of the switching mechanism in various states. Two regime switching models are used in the present paper to estimate the financial relationship model ($i, j = 1, 2$).

There are variety specifications of the Markov switching model. Intercept adjusted heterogeneousMS-VAR model is used since this specification able to capture the smooth transition of the data series from one state to another. The general equation of MSIH(n)-VAR(p) model is as follows:

$$y_t = \Omega(s_t) + A_1(y_{t-1}) + \ldots + A_n(y_{t-n}) + u_t \quad (1)$$

$$s_{t+1} = \beta s_t + \Omega_{t+1} \quad (2)$$

where Ω is an intercept term and A_i is parameter shift function with $i = 1, 2, \ldots, n$. While β is a transition matrix and u_t is identically independent with $(0, \Sigma s_t)$.

Generally, Markov process allows any order of visiting the regimes and also allows for visit of more than once. The transition probabilities, p_{ij} of the Markov chain are allowed to be practically determined by lagged values of the series (Phoong S. W. *et al.*, 2015).

The observed regime depends on the observed vector $\mathbf{y_t} = (\mathbf{y_{1t}}, \ldots, \mathbf{y_{mt}})$, then for a two-regimes case, the transition probabilities is a (2×1) vector, $\hat{\xi}_{t|t}$ is as follows:

$$\hat{\xi}_{t|t} = \begin{bmatrix} P(s_t = 1 | \mathbf{Y_t}; \lambda) \\ P(s_t = 2 | \mathbf{Y_t}; \lambda) \end{bmatrix} \quad (3)$$

where the summation of the two probabilities is equal to one. The $\mathbf{Y_t} = \{\mathbf{y_t}, \mathbf{y_{t-1}}, \ldots, \mathbf{y_1}, \mathbf{y_0}\}$ are the past values for every observed time series and $\lambda = (\theta_1, \theta_2, p_{11}, p_{22}, \sum_1, \sum_2)$ where λ is set of model parameters, θ is the coefficient, p is the parameter, $\sum_1$ and $\sum_2$ represent the variance.

The MS-VAR model is suit to the large change of the market volatility since it is economical representations of state space model. In this case, Markov switching model is able to let the expectations, variance as well as the dynamics series depend on the realization on a finite number of discrete states.

5. Results and Discussion

The results of descriptive statistics are reported as follows.

Table-1. Descriptive Statistics of the Series

	OP	KLCI	STI	SETI	JCI
Mean	0.006	0.003	0.005	0.0001	0.002
Standard Deviation	0.085	0.080	0.077	0.104	0.118
Skewness	-0.275	-0.125	-0.430	-0.430	-0.834
Kurtosis	5.544	7.014	5.344	4.712	6.955
Jarque-Bera	75.945***	181.297***	69.872***	41.170***	206.540***

*** the *p*-value significant at the 1% level.

Summary statistics for the series of OP, KLCI, STI, SETI and JCI is recorded in Table 1. The return on oil is on average higher than the mean stock returns. As described by modern portfolio theory, volatility creates risk that is associated with the degree of dispersion of return around the average. In other words, the higher the chance of a lower-than expected return, the riskier the investment. Therefore, STI returns are reasonable to have a small standard deviation since it is a developing country with stable economic condition.

Skewness is used to measure the symmetry of the time series. It is important in investment. By knowing the skewed, one can better estimate whether a given (or future) data point will more or less than the mean. All series that reported in Table 1 are skewed to the left. Kurtosis is used to estimate the flatteness of the distribution. The normal distribution has a kurtosis value equal to 3. However, Taylor (2008) revealed that the sample estimates of the kurtosis are always far greater than 3 for financial time series. Based on the findings in Table 1, all series have a positive coefficient of excess kurtosis. Excess kurtosis implies that the return distribution have large kurtosis coefficient, which are greater than 3. This is important when examining the historical returns from a stock index, since bigger the coefficient of the kurtosis above the "normal level", the more likely that the future returns will be either extremely high or extremely small. Furthermore, this is supported by the highly significance Jarque-Bera test that rejects normality.

The impact of oil price on the four selected Asian stock index is analysis by using a two regimes MS-VAR model. The output is summarized in Table 2.

Table-2. Outputs of using MSIH-VAR model

	Oil_t	$Malaysia_t$
Constant (R.1)	0.006776	-0.009678
Constant (R.2)	-0.001183	0.012151
Oil_{t-1}	0.214255	-0.086859
$Malaysia_{t-1}$	0.019684	0.042602
σ (R.1)	0.094876	0.116116
σ (R.2)	0.022279	0.050542

	Oil_t	$Thailand_t$
Constant (R.1)	0.006506	0.004071
Constant (R.2)	-0.001136	-0.002425
Oil_{t-1}	0.246525	-0.029421
$Thailand_{t-1}$	0.001803	0.120576
σ (R.1)	0.094169	0.093442
σ (R.2)	0.020525	0.109953

	Oil_t	$Singapore_t$
Constant (R.1)	0.006102	-0.014017
Constant (R.2)	-0.000333	0.016050
Oil_{t-1}	0.213946	-0.125763
$Singapore_{t-1}$	0.013504	-0.021394
σ (R.1)	0.098724	0.110997
σ (R.2)	0.023303	0.044673

	Oil_t	$Indonesia_t$
Constant (R.1)	0.005770	-0.009263
Constant (R.2)	-0.000899	0.009300
Oil_{t-1}	0.225561	0.064013
$Indonesia_{t-1}$	0.022722	0.230144
σ (R.1)	0.091556	0.146114
σ (R.2)	0.021475	0.078793

Based on the findings that recorded in Table 2, oil price has a negative impact on stock index. A decreasing on oil return impact a rising of the four selected Asian stock market. This can related with the capital market theory that increasing of the oil price will disturb the trade and fiscal balance sheets of oil importing countries and oil exporting countries (Sauter and Awebuch, 2003).

The sample countries selected in this paper are neighboring countries and they have interrelations among themselves. For instance, Malaysia and Singapore have a close and unique relation due to the closer geographical position, trade, economy, transport, politics, culture and ethnicity. Malaysia and Singapore is major trading partner and most of the oil products are exported to Singapore. According to Ministry of International Trade and Industry Malaysia 2011 (2011) the top five export destination for Malaysia products are Singapore, China, Japan, United State and Thailand in 2010. Furthermore, Singapore is the largest Asian trading partner followed by Thailand, Indonesia, Phillippines and Vietnam. Therefore, these markets are correlated and having the same direction with the changes of the oil price. Moreover, the small volatility, σ^2 of the parameters that recorded in Table 2 illustrated that the regime dependent heterogeneous model fit the data well and able to give significance and reliable findings.

The computed transition probability of the business cycle of oil price effect on the flows of Malaysia stock price reported that p_{12} =Prob ($s_t = 1|s_t = 2$) = 0.2580, meaning that the probability transition from crisis region (regime 1) to growth regime (regime 2) is 0.258. In addition, p_{12} is higher than the transition probability from regime 2 to regime 1, p_{21} =Prob ($s_t = 2|s_t = 1$) = 0.1748 when analysis the changes of the business cycle. This indicated that recover need longer time than stagnant in the stock market. The p_{11} and p_{22} have a high value, thus rejected the null hypothesis of no shifts in the regime.

The others three economic models also presented the same conclusion with the oil price effect on Malaysia stock market model that is the market decline is faster than the economic recovery. Besides, the business cycle is proved as an asymmetric cycle since around 60% of the data is classified in growth state for all the economic models. The regime classification of the data for every change is detected and summarized in Table 3.

Table-3. Regime Classification

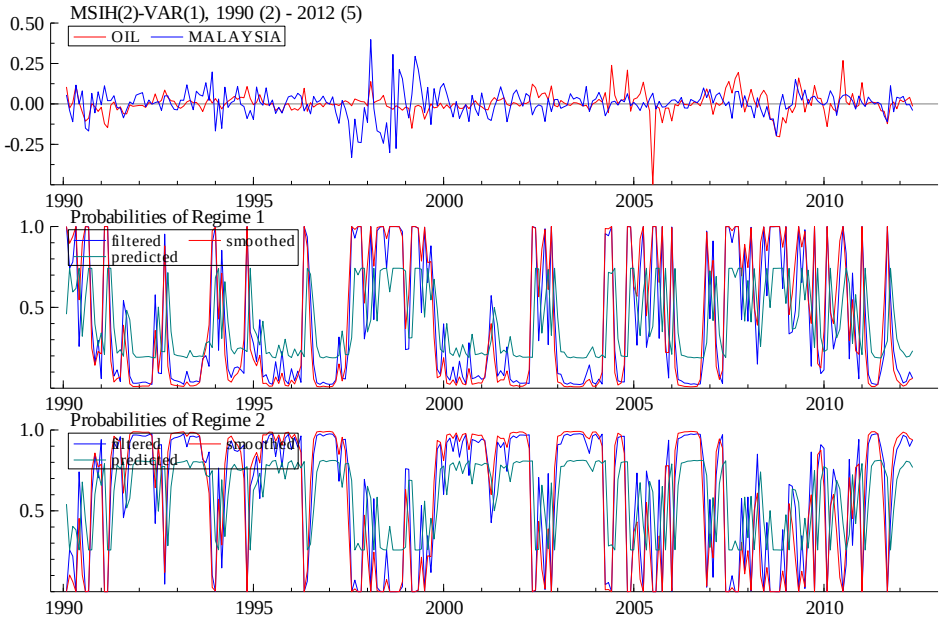
Regime 1 (Recession State)	Regime 2 (Growth State)
1990:2 - 1990:9	1990:10 - 1991:1
1991:2 - 1991:3	1991:4 - 1992:8
1992:9 - 1992:9	1992:10 - 1993:11
1993:12 - 1994:1	1994:2 - 1994:2
1994:3 - 1994:3	1994:4 - 1994:10
1994:11 - 1994:11	1994:12 - 1996:4
1996:5 - 1996:6	1996:7 - 1997:6
1997:7 - 1998:12	1999:1 - 1999:1
1999:2 - 1999:9	1999:10 - 2002:4
2002:5 - 2002:11	2002:12 - 2004:3
2004:4 - 2004:6	2004:7 - 2004:10
2004:11 - 2005:4	2005:5 - 2005:5
2005:6 - 2005:10	2005:11 - 2005:12
2006:1 - 2006:1	2006:2 - 2006:11
2006:12 - 2007:2	2007:3 - 2007:5
2007:6 - 2008:2	2008:3 - 2008:4
2008:5 - 2009:1	2009:2 - 2009:2
2009:3 - 2009:8	2009:9 - 2009:9
2009:10 - 2009:10	2009:11 - 2010:1
2010:2 - 2010:2	2010:3 - 2010:4
2010:5 - 2010:8	2010:9 - 2010:9
2010:10 - 2010:10	2010:11 - 2010:12
2011:1 - 2011:1	2011:2 - 2011:7
2011:8 - 2011:9	2011:10 - 2012:5

Remark: 1990:2 is February 1990

Based on the findings in Table 3, there are long recession period during the year 2007 until 2009. A total of 24 months of stock market index are recorded in recession state during the range from June 2007 until August 2009. Only 3 months during that period are reported in growth state. This indicated that Malaysia stock market faced a long depression period during global financial crisis 2007/2008 and the influence continued in the year 2009.

A probabilities sketched of regimes when $s_t = 1, 2$ and when s_t is increased is sketched and reported in Figure 1 to identify the number of states that should be encounter to examine the data in this study. Filtered probabilities and smoothed probabilities are also sketched to present the time series data, since filtered probability sketched the optimal inference of the state variables in the specific time *t*; while smoothed probability is sketched the optimal inference of turning points passing the time (Phoong S. W. *et al.*, 2014). Figure 1 shown that the Markov switching models are able to capture the transition probability of the data when $s_t = 1$ and 2. Therefore, a two regimes MSIH-VAR model is used to estimate the data. This is supported by Doornik (2013) that the number of regimes affects the flexibility of the model examined since increasing the number of regime might indicate too much flexibility of the model examined and may result in a biased output.

Figure-1. Probability Sketched of MSIH(2)-VAR(1) model



Information criterion tests are used to examine the significance of the regime dependent heterogeneous model in analysis the asymmetric business cycle. Table 4 recorded the outputs of information criterion tests.

Table-4. Outputs of Information Criterion Tests

Information Criterion Tests	Statistical value
AIC	-5.3950
HQ	-5.3088
SIC	-5.1806
Log-likelihood	738.9234
Likelihood Linearity	186.4709 Chi(5) =[0.0000]* DAVIES=[0.0000]*

*the p-value is significant at 5% significance levels

Based on the findings in Table 4, higher log-likelihood statistics with small information criterion tests outputs indicated the MSIH-VAR model fit the data well and able to provide significance results. In addition, the likelihood ratio tests indicating that the model has no misspecification problem due to the findings of the χ^2 (5) = 0 and DAVIES = 0.

6. Conclusion

This paper examines the oil price effect on four selected Asian stock index by using regime dependent heterogeneous model. A two regime dependent heterogeneous Markov switching model with varying variance is suitable to detect the transition probabilities of the variables series since increasing the number of regime leads to too much flexibility to the examined model. This result coincides with the results reported by Hunjra *et al.* (2011) that the changes of the oil price have a negative relationship with the changes of the stocks. This is same with the conclusion of Sauter and Awebuch (2003), and Basnet and Upadhyaya (2015). The present study is contribute in enhance the understanding on the effect of oil in stock returns by taking into account the effect of the regime shifts, asymmetric effect and the turning point of the series.

Acknowledgment

The authors greatly acknowledge financial support provided by University Malaya Research Fund Assistance (BKP) under project no. BK010-2017.

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