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A Markov Switching Vector Error Correction Model on Oil Price and Gold Price Effect on Stock Market Returns

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Abstract: Stock market index represent a country growth and always as an interest for economist and statisticians. In this paper, the effect of oil price and gold price on stock market index on Malaysia, Singapore, Thailand and Indonesia are investigated and a two-regime Markov Switching Vector Error Correction model is used to examine the nonlinear properties model. Moreover, a two regime mean adjusted Markov Switching Vector Error Correction model is used in the study to capture the filtered and smoothed probabilities of the time series sequence in the economic model. Results found that the oil price and gold price affect the movement of the Malaysia, Singapore, Thailand and Indonesia stock market index and there is an asymmetric cycle since 97% of the total sample size is recorded in the growth state.

Keywords: *Mean adjusted, regime, MS-VECM, commodity price, stock market*

1. Introduction

Commodity prices such as gold and oil always relate to the movement of the stock market prices and exchange rates. Historical evidence had shown that when the global economy was in the recession period, the demand of oil and gold would be increased. Although oil and gold are limited reservation but oil belongs to a basic of energy sources, which affect the country's economy as states by Sauter and Awerbuch (2003) and gold, is a popular investment. Both of these two commodity prices implies on the country's stock market prices. Labys and Granger (1971) were the first authors studied the behaviour and the implication of the commodity prices in their book. In statistics field, there are common to employ various time series model in study the economic and financial behaviour. Linear model such as autoregressive model, moving average models and mixed ARMA models are no longer suitable to estimate the economic and financial data if the data exhibits nonlinear properties such as the asymmetry and volatility clustering in economic activity over the business data, interest rates, stock prices and unemployment rates. According to Krolzig (1997), Markov Switching Vector Autoregressive (MS-VAR) model have become increasingly prominent in applications since it able to detect the classical business cycle phases and detect the difference in terms of average growth rates of the economy. MS-VAR model also can increase the reliability of analysis of the business cycle, and provide useful information in the study of economic relationship because of its properties on detection the high-level regime. Therefore, the perception of the current state of economy can be improving (Anas et al., 2004). While in the MS-VAR model approach, an exploration on the correlated markov chain can be used to analysis the relationship between multiple time series variables and provided useful information for the long-run economic relationship. Thus, Markov Switching Vector Error Correction model (MS-VECM) is important to be included in the study to provide a better understanding of the nature of non-stationary among the components in the model (Anas et al., 2004).

Besides that, MS-VECM is more flexible in estimate the long-run relationship of the restricted model framework since it is estimated in its unrestricted structure. MS-VECM also can be estimate regarding to the number of the regimes, lags, Markov Switching intercept, variance and autoregressive parameters. However, Greene (2003) describes that intercept and coefficient of the slope in long-run equilibrium cannot measure directly but can retrieve indirectly from the parameters of the MS-VECM. Furthermore, MS-VECM is more flexible to the market's mood because of the time-variant dynamic properties and able to estimate the endogenously and exogenously variables. A number of studies that used MS-VECM in estimated the economic and financial relationship such as Gotz et al. (2013) describe that MS-VECM able to discriminate the different between price transmission regimes even if the state variable is unobservable or incompletely observed variable; and Hamilton and Raj (2002) used MS-VECM in study the dynamic characteristics in different market of the series and detect the existence of sudden shocks in the data. The motivation of this paper is to investigate the oil price and gold price effect on four selected Asia countries' stock market returns by using the nonlinear time series model, Markov Switching Vector

Error Correction Model. Malaysia, Singapore, Thailand and Indonesia are selected because Thailand is the first country faced the financial collapse when Asian Financial Crisis 1997. In addition, Thailand, Malaysia, Singapore and Indonesia are the most affected countries by the Asian Financial Crisis 1997. The rest of this paper proceeds as follows. Section 2 reveals the previous studies that related to this study. Section 3 presents the sample and data. Section 4 introduces the economic methodology employed in this study. Section 5 reports the results and discussions. Section 6 presents the conclusions of the study and the final section is further recommendation that can be study.

2. Literature Review

Commonly, many nonstationary variables also present a long-run pattern although some of them may behave separately in the short-run economic model. These variables were then included in a long-run equilibrium, in the sense that a linear combination of their levels behaves as an attractor in long-run equilibrium (Engle and Ganger, 1987). However, the system is out of equilibrium in most of the time. Therefore, numerous economists start study the economic forces such as market mechanisms and government interventions to correct these equilibrium errors and vector error correction model (VECM). However, there were numerous economists and statisticians adopt different statistical methods to study and predict the economic growth in the world. While Markov Switching models, which can modelling the nonlinearities of the data and capturing each points in the regime, shift were introduced and then was widely applied in analysis the economic fluctuation in the world. According to Mishra et al. (2010), increasing of the gold price may affect the decreasing of the stock market returns and Mishra et al. (2010) concluded that the gold might be the primarily traded on the New York Commodities Exchange in the future. While, Liao and Chen (2008) was the first authors in investigated the effects of oil and gold prices on individual industries by using GARCH and TGARCH model and concluded that the volatility of oil price returns has the same effect with the volatility of the gold price returns. Besides that, multivariate Mrkov Switching models are commonly used in the economic field to capture the moving of the economic time series data. Diebold and Rudebusch (1996) were proposed two main approaches in the Markov Switching models that are jointly dynamic factor models and regime switching models in examine the of the business cycle and concluded that regime switching models perform better than jointly dynamic factor models.

Moreover, Sarno and Valente (2006) also applied the MS-VECM in studying the weekly data of Tokyo, United State and United Kingdom stock market. Results found that the one-step-ahead forecast of out-sample MS-VECM model do not improve mean absolute error and root mean squared error on the standard linear VECM. Furthermore, MS-VECM is found that able to perform better than linear VECM model in examine the relative market timing test since MS-VECM also able measure the mixtures of multivariate normal distributions with weights by predicting the probability of the regime and given a closer value to the true density stock returns changes for an outside-sample density than linear-VECM. While in financial field, Kanas and Kouretas (2007) was applied MS-VECM in study the changes of exchange rate in United States. A two regime multivariate MS-VECM includes the high volatility and low volatility regime is adopted in examine the short-run and long-run relationship of United State dollars exchange rate in Greece. According to Kanas and Kouretas (2007), Markov switching model was choosing to apply in the study is because the model is able to capture the structural breaks and cluster regime. Moreover, they found that the regime was independent when consider the official rate but when consider the opposite direction, a dependent regime was shown. In addition, the estimation of the different pattern of adjustment of the premium in the two regimes by using MS-VECM can provide an accurate result since the estimated model are able to capture all the nonlinear features in the premium. Besides that, Kanas and Kouretas (2007) also found that the time path of the parallel exchange rate was varying across the regime but with the same convergence speed to the steady state.

Sample and Data: The monthly index data in this study is taken from Bursa Malaysia Kuala Lumpur and DATASTREAM and then transform into the natural logarithms to examine the economic relationship between oil price and gold price effect on the selected countries. The sample size of the study is 270 observations that are start from December 1989 until May 2012.

3. Methodology

The study structure was a quantitative approach and several steps are undergo before applied MS-VECM on examine the economic relationship model. First step is identified the variables in the economic model

and after that the stationary test was applied to detect whether the time series data have a constant mean, variance and auto covariance or not; since extreme changes always happen in real world data. Economic data always exhibit non-stationary behaviour such as regime switching and jumps. Therefore, Augmented Dickey-Fuller (ADF) test and Kwiatkowski-Philips-Schmidt-Shin (KPSS) test are important as preliminary step in the study to check the existence of the random walk or unit root problem in the time series data. Third step is co integration test where Johansen test is used to check whether the data are stationary linear combination and share a common stochastic drift or not. The presence of cointegration in the series must take account the method to test the occurrence of the unit roots in the variables. If the variables have cointegrating relationship then MS-VECM is used to examine the commodity prices effect on stock market returns in Malaysia, Singapore, Thailand and Indonesia. The MS-VECM that proposed by Krolzig (1997) act as an error correction mechanism in each disequilibrium regime, since the regimes are generated by stationary, irreducible Markov chain. Errors arising from regime shifts can be corrected towards the stationary distribution of the regimes by MS-VECM. In MS-VECM framework, the MS-VECM allows for the shocks to each variable in the model to affect the transition probabilities of the phase shifting. While the model also account for the temporary periods that diverges from the long run relationship. Thus, MS-VECM pays an important role on capturing the long-run properties of the system.

A MS-VECM is allowed for state dependence of both intercept and the error variance-covariance matrix. The MSM(n)-VECM(p) equation is

$\Delta y_t = \mu(s_t) + \prod y_{t-p} + [\sum_{k=1} A_k(y_{t-k}) - \mu(s_{t-k}) + u_t]$

Where $u_t \sim NID(0, \sum(s_t))$. While the transition matrix is

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

If $0 < r < n$ cointegration relationship among variables, $\prod(1)$ is a reduced rank, r and can be expressed as a two (m x r) matrices product and $\prod(1) = \alpha\beta'$, where $\beta' y_t$ is a cointegrating vectors that are stationary linear combinations of the I(1) variables and α is the factor loading matrix. While the unobserved state of ξ with $I(s_t = i)$ is $s_t = i$ and zero otherwise system can be present by the following matrix:

$$\xi_1 = \begin{bmatrix} I(s_t = 1) \\ I(s_t = 2) \end{bmatrix}$$

The MS-VECM equation can be denote as $\Delta y_t = N\xi_t + \prod^*(L)\Delta y_{t-1} + \alpha z_{t-1} + \varepsilon_t$; where $N = [v_1\ v_2]$ and $z_t = \beta' y_t$. While the Expectation-Maximization (EM) algorithm also used to estimate the MS-VECM including log-likelihood results.

4. Results and Discussion

Stationary Test: ADF test and KPSS test that discuss in the previous section are applied in the time series sample to check the existence of the unit root and the stationary behaviour of the variables in the time series model. If the statistical value is greater than then the ADF critical value, then the series is prove to have a unit root and the series is known as non-stationary series. Unlike ADF test, the KPSS test has stationary as the null hypothesis and has a unit root as alternative hypothesis. Furthermore, the KPSS test is difference with ADF test in allowing for drift but not trend in the regression equation. Akaike Information Criterion (AIC) is used to determine the lag length in ADF test while Least Square method is applied in the ADF test and KPSS test. ADF test and KPSS test are employed to estimate the stationarity of the series at level and first difference of each variable. In addition, the tests have been implementing in three forms that are without constant and trend, with constant, and with constant and trend. In conclusion, ADF test and KPSS test as the first step in the testing procedure in this study is because want to check the stationarity of the series. If the series is non-stationary then a differencing estimator is taken to generate stationarity of the series. Furthermore, if the series has the same order of integration then the next step is to test whether the series have a cointegrating relation. Since all the series that discuss in the previous section are I (1), thus the cointegrated relations between the series are tested by using Johansen's test.

Cointegration Test: There are two types Johansen Cointegration Test that are Johansen Trace Test and Johansen Maximum Eigenvalue Test. According to Johansen (1991), these two tests have different hypothesis where the hypothesis of the trace statistic test in this study are

H_0: There is at most r cointegrating relations

H_1: There are m cointegrating relations

While the hypothesis of maximum eigenvalue statistic test in this study are
H_0: There is at most r cointegrating relations
H_1: There are r + 1 cointegrating relations

Where cointegration order, r = 0, 1, 2, 3, 4 and m is the total of cointegrating relations that may exist in the test. The following sections are the description of the cointegrated relations of oil price, gold price and stock index.

Table 1: Johansen Test Output

Series	Hypothesis on no. of CE	Eigenvalue	Trace statistic	Maximum-Eigen statistic
OP, GP, KLCI, STI, SETI and JCI	None	0.199733	136.2312* (0.0000)	58.59890* (0.0000)
	At most 1	0.146872	77.63227* (0.0008)	41.77642* (0.0013)
	At most 2	0.077311	35.85586 (0.1273)	21.16182 (0.1210)
	At most 3	0.040511	14.69403 (0.4800)	10.87633 (0.3973)
	At most 4	0.013663	3.817706 (0.7370)	3.618207 (0.6896)
	At most 5	0.000758	0.199500 (0.7107)	0.199500 (0.7107)

	0.05 Critical value					
	None	At most 1	At most 2	At most 3	At most 4	At most 5
Trace Statistic	83.93712	60.06141	40.17493	24.27596	12.32090	4.129906
Maximum-Eigen Statistic	36.63019	30.43961	24.15921	17.79730	11.22480	4.129906

The value in () is represent to the p-value
* denotes rejection of the hypothesis at the 0.05 level

Mackinnon et al., (1999) p-value is used in the Johansen Trace Test and Johansen Maximum Eigenvalue Test. Results show that there are at most one cointegrated vector exists in the model since the trace statistic values and maximum-eigen statistic values greater than 0.05 critical values. In addition, p-values of trace test and maximum eigenvalue test in the hypothesis testing on at most one cointegrating equation are less than 0.05, thus it can be concluded that there are at most one cointegrating relations between the variables in the economic model at 95% significant level and MS-VECM is used to capture the transition properties of the series to examine the oil price (OP) and gold price (GP) effect on Malaysia stock market index (KLCI), Singapore stock market index (STI), Thailand stock exchange index (SETI) and Indonesia stock exchange index (JCI).

Evaluate Oil Price and Gold Price effect on stock market growth by using mean adjusted MS-VECM: All variables including OP, GP, KLCI, STI, SETI and JCI are as endogenous variables in estimate the economic model by using MS-VECM. The following table is the findings of two regimes mean adjusted Markov Switching Vector Error Correction Model with first integrated order, MSM(2)-VECM(2).

Table 2: MSM(2)-VECM(1) for OP, GP, KLCI, STI, SETI and JCI

Log Likelihood	**2163.1113**					
AIC	**-15.6128**					
HQ	**-15.2307**					
SC	**-14.6614**					
	OP	GP	KLCI	STI	SETI	JCI
μ (s_t = 1)	-0.014	-0.030	-0.196	-0.152	-0.203	-0.336
μ (s_t = 2)	0.003	0.006	0.010	0.010	0.007	0.013
OP_{t-1}	0.301	-0.042	-0.073	-0.020	-0.002	0.075
GP_{t-1}	0.077	-0.163	-0.075	-0.105	-0.014	0.235
$KLCI_{t-1}$	-0.015	0.048	-0.147	-0.020	0.090	0.167
STI_{t-1}	0.045	-0.045	0.082	0.078	0.081	0.244
$SETI_{t-1}$	0.032	0.011	0.096	0.036	0.041	-0.006

JCI_{t-1}	0.006	-0.003	0.026	-0.051	-0.080	0.015
σ	0.062	0.043	0.076	0.072	0.097	0.096

Matrix Of Transition Probabilities, p_{ij}

	$s_t = 1$	$s_t = 2$
$s_t = 1$	0.6169	0.3831
$s_t = 2$	0.0121	0.9879

Regime Properties

	No. of Observations	Probability	Duration
$s_t = 1$	9.1	0.0306	2.61
$s_t = 2$	258.9	0.9694	82.73

LR = Likelihood Ratio linearity test
** indicates that the p-value is significant at 5% level

First regime ($s_t = 1$) in MSM(2)-VECM(1) is represented to the recession state or "Bear" market and the second regime ($s_t = 2$) is represent to the growth state or "Bull" market. All coefficients in the first regime in MSM-VECM are negative but with a lower coefficient value for the variables in the model. Moreover, OP is decreasing with an average of 1.3592% and GP is decreasing in average of 3.0194% when the business cycle under the recession state. Besides that, the growth state for this model report that all index of variables are recover especially Indonesia stock market index. The transition probabilities of the MSM(2)-VECM(1) is

$$P = \begin{bmatrix} 0.6169 & 0.3831 \\ 0.0121 & 0.9879 \end{bmatrix}$$

Where the second regime is more prevalent than first regime. Events like Asian Financial Crisis in 1997, '9-11' and Global Economy 2008 may as the factors that indicates the structural change of the market index. Figure 1 is the MSM(2)-VECM(1) probabilities figure which is sketch to support the interpretation of these two regimes model and provide a briefly explanation about the specification model in explaining the economic model.

Figure 1: Probabilities graph of MSM(2)-VECM(1)

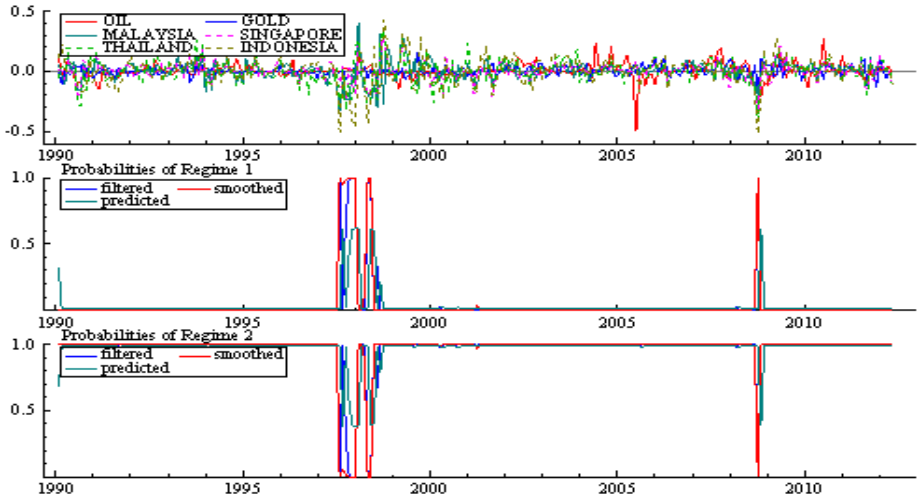

Figure above show the findings of MSM(2)-VECM(1). Three panels are sketch in the figure to explain the probability of the regime 1 and 2. First panel in the figure are sketching to explain how the inferred regime probabilities switch into the mean growth rate; while the second panel are sketch based on the filtered and smoothed probabilities of regime 1 and third panel are present the filtered and smoothed probabilities of regime 2. Moreover, the filtered probability and smoothed probability of the optimal inference on the turning point and state variables at time for the variables in the recession state and growth state are included to explain the variables of the economic model. While the probabilities sketch in MSM(2)-VECM(1) showed an economic depression from August 1997 until October 1998 and a depression on October 2008. This can be related with the Asian Financial Crisis at 1997/98 and Global Economy Crisis 2008, which causes the rapid downturn of the economic trend. Therefore, it can be concluded that oil price and gold price affect the stock exchange of Malaysia, Singapore, Thailand and Indonesia.

5. Conclusion

In conclusion, the economic model between OP, FP, KLCI, STI, SETI and JCI have nonlinear properties and a differencing process are used to transform the series in the economic model to become stationary. Moreover, the variables are proved to have cointegrating relations MS-VECM is applied to examine the economic relationship model. Two regimes MS-VECM is used where regime 1 represent the recession state and regime 2 is represented to growth state in analysis the economic time series data. Results showed that oil price and gold price would affect the stock market returns for the four selected Asia countries and there is an asymmetric business cycle since 97% of observations from the total sample size are recorded in the growth state.

Recommendations: This paper investigated market mood on the oil price and gold price effect on Malaysia, Singapore, Thailand and Indonesia stock exchange. This would benefit the economists and investors to study the commodity price effect on stock returns. Further research might explore the others factors, which may affect the market mood and more countries, can be involved in the further study.

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