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Nonlinear Monetary Policy Reaction Function in Malaysia: Evidence using a Markov Switching Vector Autoregression

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ABSTRACT

Monetary policy reaction function or the so called feedback rule explains how the monetary authority accommodates economic developments and business cycles by altering its policy rule. This monetary policy reaction function plays an important role in macroeconomic analysis by the virtue of stabilization policy as well as growth strategy tools. However, there is a possibility that this feedback rule responses actively or passively towards economic activity. Hence, this study empirically estimates a monetary policy reaction function for Malaysia during the period 1971 – 2015. Hence, a Markov Switching Vector Autoregression is utilised by taking into account active and passive regime policies' rules. The results verify the pertinence of Taylor rule in the monetary feedback rule for Malaysia. They also show that inflation, output gap and exchange rate affect the policy rate for the establishment of optimal policy rate. Using economic validation, we prove that our model is robust and coincide with the real data.

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INTRODUCTION

In the last decade, Malaysia underwent various monetary policy developments, with the changes in the monetary policy structure being largely influenced by the need to maintain the effectiveness of monetary policy in a changing economic and financial environment. This evolution can be characterized by four main developments. The first evolution was monetary targeting where narrow money, M1, was used as policy targeting up to mid 1980s, subsequently broad money, M2 and M3 was used up to the early 1990s (see Habibullah et al., 2002). The second evolution was that the interest rate targeting which occurred from the mid-1990s to September 1998 based on the base lending rate (BLR) framework. The third evolution was the fixed exchange rate from September 1998 until July 2005 by using interest rate targeting. Under this policy, the capital controls were implemented, BLR was linked to the intervention rate and the exchange rate was pegged to the US$ at RM 3.80/US$. The fourth evolution was the floating exchange rate using interest rate targeting that was implemented in July 2005 and is in operation until now. This policy was based on the current interest rate framework by using the Overnight Policy Rate (OPR) as to signify the monetary policy's decision (BNM).

The empirical estimation of monetary policy reaction function is frequently applied to appraise the central bank's actions and policies as its responses to economic conditions. However, central bank behavior on monetary policy decisions is yet to be fully understood by non-policymakers. Starting with a policy rule proposed by Taylor (1993), significant number of literature had emphasized on the analysis of monetary policy reaction functions with Taylor rules being utilized as simple estimates for best monetary policies worldwide. The Taylor rule proposed by Taylor (1993) demonstrates a simple linear relationship between inflation, interest rate and output gap. According to this rule, the monetary authorities will usually indicate their current facts regarding the inflation and output gap prior to the determination of optimal policy rates. Most studies prefer to model the monetary policy reaction by focusing on function of interest rate type rule. This is due to its simplicity and the capacity to monitor the real data and high accuracy when it comes to the description of the behavior of monetary authorities. Besides, the theory had clearly defined the association between monetary aggregates, interest rate and exchange rate (Ramayandi, 2007).

In recent years, economists are beginning to concentrate on the prospect that policy rule may respond asymmetrically to inflation and economic activity. Leeper (1991) was the first economist who classified fiscal and monetary policies as active and/or passive according to their behaviour. An active authority is free to go after its objective and is unconstrained by the state of government debt while a passive authority is restricted to the active authority as well as to the private sector's behavior. In the Malaysian context, monetary authority can actively stabilize the inflation dynamics by adjusting the policy variable if it is not restrained by fiscal authority or the government budget constraint. Moreover, many empirical studies have proven that policies are drawn based on both active and passive regimes. This fact has been proven by Clarida et al. (1998), Woodford (1999) and Favero and Monacelli (2003) for U.S country that find the switching of monetary and fiscal policies between active and passive regimes depends upon prevailing economic cycles and shocks. Tan and Habibullah (2007) also contribute to this debate on nonlinearity or asymmetry in monetary policy. Based on studies' results and facts, in representing policy rule, a single regime model is less significant than switching regime model which permits coefficients switching between active and passive regimes. However, empirical work for developing countries is sparse, existing studies in this area are mostly concentrated on the experience of developed economies and not much information is known about the result of the same practice in the case of developing countries. Given the different institutional structure and shocks faced by central banks in developing economies, it would be interesting to conduct the same study on these countries.

This study chooses the Bank Negara Malaysia (The Central Bank of Malaysia) as the case study for three reasons. Firstly, Malaysia is classified as a small open economy with a history of a low and stable inflation rate. Secondly, among the developing countries, Malaysia has underwent and completed deregulation process of its financial system relatively early. Deregulation of the banking system began in the early 1970's and banking institutions' interest rate was deregulated in 1978. Finally, this study is motivated due to the decision made by BNM in November 1995 whereby the nation's monetary policy strategy was switched from monetary targeting to interest rate targeting (Karim and Karim, 2014). Therefore, a further comprehension in regard to the designing of optimal policy rate by BNM is highly imperative. This is due to the fact that BNM will usually decide on current policy rate through the monitoring of several macroeconomics indicators; for examples. prevailing output gap and inflation rate (Khalid et al., 2014).

Studies regarding monetary policy reaction function (MPRF) are still lacking for Malaysia. Empirical studies based on linear MPRF undertaken by Umezaki (2007), Ramayandi (2007), Gan and Kwek (2010), Zaidi and Fisher (2010) and Islam (2011), Ramayandi (2007) and Umezaki (2007) show that Taylor Rule, a policy on feedback rule to inflation and output gap, is used by for Malaysia's monetary policy. Zaidi and Fisher (2010) had utilised a structural VAR model in an open-economy condition to estimate the reaction of monetary policy in Malaysia. In their study, several external variables such as foreign monetary policy, foreign income, and oil prices have been used to ascertain the monetary policy reaction function. In addition, utilising Structural VAR with impulse response function analysis, Gan and Kwek (2010) discovered that BNM policy rates are more responsive to inflation shock than output gap shock. Meanwhile, Islam (2011) estimated Taylor rule based policy reaction function and discovered that BNM disregarded Taylor rule and the calculated coefficient and expected value were significantly different.

Despite the consistency in results with significant evidence of a linear MPRF, the majority of empirical studies have not confirmed about the possibility of asymmetric or non-linear effects of Malaysia's monetary policy. The most recent study by Khalid and Marwan (2013) estimated Taylor rule based monetary policy reaction function by using

Markov Switching Regression for the case of Malaysia from 1991-2014. They found that when nonlinearity is considered in the model, the Taylor rule holds for Malaysia's monetary policy reaction function; and Bank Negara Malaysia (BNM) formulates its policy rates in accordance to output level and inflation rates. Moreover, the exchange rate was also included in their feedback rule function. This gives the impression that the measurement of linear monetary policy feedback rules has neglected the nonlinearity that emerges from inflation level, output gap and monetary policy stance. In contrast to Khalid and Marwan (2013) that used Markov Switching (MS) regression in their study, our study uses a Markov Switching Vector Autoregression (MS-VAR) which allows the consideration of more dynamic information in the model. Past studies have utilised numerous methods that range from Ordinary Least Squares (Islam 2011), Structural VAR (Gan and Kwek, 2010; Zaidi and Fisher, 2010; and Karim and Karim, 2014), Generalized Methods of Moments (Ramayandi, 2007; and Umezaki, 2007) and MS Regression (Khalid and Fakhzan 2013).

Following this, it is the aim of this paper to empirically estimate Malaysia's monetary policy reaction function. To do so, we use Malaysia's dataset of yearly data from 1971 to 2015. First, the regime switching changes are characterized through entire sample period. This is performed by employing Markov Switching Vector Autoregressive (MS-VAR) method to estimate monetary rules for Malaysia.

[2] Following Leeper (1991), we assume that monetary policy reaction function is switching between two regimes, i.e., passive monetary and active monetary regimes. The active and passive states are categorised based on interest rates' feedback coefficients of inflation rate. The model specification used in this study is similar to Doi et al. (2011) model in estimating the policy rules for Japan. In their study, they employed a modified Davig and Leeper (2007) specification by considering open-economy. Under the circumstances, the specification includes the real interest rate's departure from its trend. This paper differs from the previous studies as it uses MS-VAR model which estimates the timing of the regimes switch without any prior assumptions of when this switch takes place. It is the model's assumption, ruled by Markov Chain, that the regime takes place in two situations, i.e. passive and active; and they are recognised as a random set. Henceforth, the changes in the regime will be identified as random set. This allows the recognition of the switch's identity and the comprehension of the probability of the series remaining or moving between regimes.

This paper will proceed as follows: Section 2 describes the methodology employed. Section 3 gives description of data. Section 4 provides the empirical results as well as the economic validation of the results; and finally Section 5 concludes the paper.

[2] The literature on the Markov-switching model can primarily be found in Hamilton (1994), Krolzig (1998) and Kim and Nelson (1999).

METHODOLOGY

Monetary Policy Reaction Function

According to Taylor (1993), the interest rate (r_t) is targeted by the central bank to be the function of real interest rate equilibrium (r_t^*), prevailing interest rate (π_t), percentage difference between real GDP and its potential value estimate (y_t), and the difference between actual inflation and the central bank's targeted inflation (π^*). Hence, it is mathematically written as follows:

$$r_t = \pi_t + r_t^* + 0.5y_y + 0.5(\pi_t - \pi^*) \quad (1)$$

Noted that $y_t = 100(Y - Y^*)/Y^*$, where Y is the real GDP and Y^* is the real GDP of previous period. The equation above is called as Taylor rule whereby if there is positive output gap, there will be upward pressure on wages and prices due to GDP surpassing its potential rate under full employment. Hence, there will be an increase in the targeted interest rate by the central bank to reduce inflation pressure. However, if there is a negative GDP gap, the targeted interest rate will be lowered. Similarly, should the inflation rate is more than the targeted rate, the interest rate will be increased by the central bank.

Next, this study extends this Taylor rule's framework by using Doi et al. (2011) version of monetary policy reaction function to analyse the regime switching change[3]:

$$r_t = v(s_t^m) + \beta(s_t^m)\pi_t + \delta(s_t^m)y_t + \gamma(s_t^m)e_t + \sigma(s_t^m)u_t \quad (2)$$

Where interest rate (r_t) reacts to inflation (π_t), output gap (y_t) and real exchange rate's deviation from its trend (e_t). In monetary policy reaction function, interest rate utilised as monetary policy variable as in (2) for Malaysia is deemed as reasonable as interest rate targeting is used as its operating target and as policy variable to reflect the stance of monetary policy. Typically, the terms "active" and "passive" are classified based on the coefficient of β, if the values greater than or less than one, respectively. In view that feedback rule is based on real term, not nominal, hence the threshold value for Taylor coefficient is zero, not unity. Therefore, should the inflation rate's coefficient exceeds zero, then the policy is called 'active'; which implies a stronger movement in policy to stabilize the economy, and vice versa.

Markov Switching Vector Autoreggresive (MS-VAR)

The modelling of non-linearities and regime shifts/structural breaks is using the increasingly popular Markov switching model. Goldfeld and Quandt (1973) were the first who attempted to develop Markov Switching regression models. On the other

[3] Equation (2) is written in the form of switching regression which allows the policy to switch between active and passive regimes.

hand, Hamilton (1989) and Krolzig (1998) significantly contribute in the development of MS-Var which combines switching models with vector autoregression. MS-VAR is extremely efficient in characterising the fluctuations of macroeconomic with the occurrence of structural breaks or regime shifts. By applying the Markov-switching framework to the monetary policy reaction function, the framework allows “active” and “passive” models as switching regimes to the stochastic process, thus, generating interest rate’s growth. Various types of specifications can be accommodated by the MS-VAR model. It allows non-linearity with heteroscedasticity, occasional shifts, reversing trends and forecasts (Krolzig 1998). There are three types of models being examined: MSI(m)-VAR(p) (Markov switching intercept), where only the intercept terms are regime-dependent, MSIH(m)-VAR(p) (Markov switching intercept heteroskedasticity) where both the intercept terms and the covariance matrix are regime-dependent, and MSIAH(m)-VAR(p) (Markov switching intercept autoregressive heteroskedastic) where the vector autoregressive parameters are regime-dependent. Based on finite order VAR process, the basic model, MSI(m)-VAR(p) can be represented by:

$$y_t = \begin{cases} v_1 + A_{11}y_{t-1} + \cdots + A_{p1}y_{t-p} + B_1e_t & if\ s_t = 1 \\ \vdots & \\ v_m + A_{1m}y_{t-1} + \cdots + A_{pm}y_{t-p} + B_me_t & if s_t = m \end{cases} \quad (3)$$

where $e_t -$ NID (0; I_K) with K endogenous variables y_t, t = 1, ..., T ; which are the functions of intercepts v_i ; A_i (.) is the matrix and presents the lagged values’ coefficients for different regimes’ variables; autoregressive terms with lag order p and residuals B_ie_t. The assumptions of the regime generating process (s_t) is required to carry out the process of data generation. The Markov switching approach stipulates that the various possible situations are divided into m situations, denoted s_t , t = 1, . . . , m, refers to m regimes. A hidden m-state Markov-chain is assumed to govern state s_t. The probability of p_{ij} being in regime j next period on the condition of being in regime i in current period is presumed to be exogenous and constant. Having assumed a two regime Markov process for monetary policy, specifically p_{ij} = Pr (s_t = i|s_{t-1} = j) where i, j = 1, 2. Is defined in the 2 x 2 transition matrix P below.

$$P = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} \quad (4)$$

Where p_{11} denotes the probability to be in regime 1, provided that during the previous period the system was in regime 1. Meanwhile, p_{22} denotes the probability to be in regime 2, provided during the previous period the system was in regime 2. Therefore, 1− p_{11} is the probability that y_t will shift to state 2 in period t from state 1 in period $t - 1$; while 1 − p_{22} is the probability of a change during times $t - 1$ and t, from state 2 to state 1.

DATA

This study utilizes annual data ranges from 1971 to 2015. The period is chosen to cover major crises experienced by Malaysia. The real interest rate, which is the policy instrument, is measured based on the average of lending and deposit rates, and where inflation is subtracted. In view that potential output cannot be measured, the calculation of output gap is a challenge. Malaysia's economy may differ from other advanced countries and has experienced many significant disturbances, particularly the late 1990s crisis. Nonetheless, we should remember that there is a possibility that output gap has a large margin of error due to the challenge in calculating capacity output. To calculate the estimated potential output, output will first be detrended and the residuals are then utilised as output gap estimates. The calculation of potential output involves the technique suggested by Hodrick and Prescott (1997) filter. In employing this filter, in view that this study employs annual data, we set lambda = 100.
[4] This consideration is regarded as appropriate in view that Kydland and Prescott (1990) proposed that the lambda for annual data to be at 400 and lambda for quarterly data to be at 1600. As for inflation rate, it is calculated based on the yearly change of the Consumer Price Index (2000 = 100). Lastly, the real exchange rate's deviation from its trend is the real exchange rate gap. The data are primarily from World Bank databank. Apart from the World Bank databank, the data were also collected from the International Government Statistics Yearbook by IMF as well as from the Asian Development Bank's data sets.

EMPIRICAL RESULTS

Data Analysis

The analysis starts with the plotting of the series' graph. Figure 1 presents the results. From the plots, we observed that the series are stationary. To test the series' stationarity, the ADF and KPSS test have been utilised. As per Table 1, the Jarque–Bera test statistics indicate that Output Gap (y) and Exchange Rate Gap (e) series are normally distributed but Real Interest Rate (r) and Inflation Rate (p) series are not. Based on Table 2, the Augmented Dickey and Fuller (ADF) shows that all the series are stationary at 1% significance level except for the case p, y and e which stationary at 5% level of significance. Kwiatkowski et al. (KPSS) is also consistent with the results of ADF test.

[4] The smoothess of trend companent is ascertained by the Lambda parameter. A higher lambda value will cause the penalty in the second term to be higher and result in smoother trend component, the cyclical component considers more data, larger gap and displays longer 'cycles'.

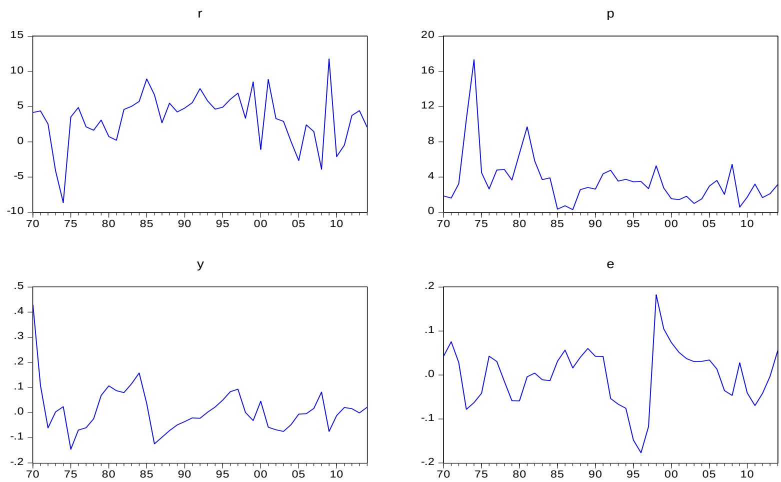

Figure 1 Trend of all variables in the model from 1971-2015

Table 1 Descriptive Statistics

	Real Interest Rate (r)	Inflation Rate (p)	Output Gap (y)	Exchange Rate Gap (e)
Mean	3.2622	3.5970	0.0112	-0.0015
Maximum	11.7820	17.3289	0.4293	0.1823
Minimum	-8.6390	0.2900	-0.1460	-0.1769
Std. Dev.	3.8061	2.9695	0.0930	0.0667
Skewness	-0.6894	2.6324	1.9736	-0.2223
Kurtosis	4.1484	11.955	10.214	3.7028
Jarque-Bera	6.0376	202.3596	126.8027	1.2967
Probability	0.0488**	0.0000***	0.0000***	0.5228

Notes: Jarque-Bera normality test. The null hypothesis is of normality. ***, **, * indicates significant at 1%, 5% and 10% level.

Table 2 Unit Root Tests

	ADF		KPSS	
	Without Trend	With Trend	Without Trend	With Trend
r	-5.6633***	-5.6065***	0.18847	0.1868
Δr	-7.8148***	-7.7108***	0.1418	0.1411
p	-2.9205**	-2.9592	0.4809	0.0693
Δp	-5.7681***	-5.6658***	0.2381	0.2179 [a]
y	-6.4566***	-6.1283**	0.1519	0.0572
Δy	-7.1932***	-7.0392***	0.2249	0.0909
e	-3.4352**	-3.3842**	0.0488	0.0489
Δe	-6.1445***	-6.1067***	0.2790	0.2215 [a]

Notes: Automatic lag length selection based on Schwarz Information Criteria for ADF while for KPSS is based on Newey-West Bandwith. KPSS denotes the Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992) unit root test. The null hypothesis is that of series trend is stationarity. [a] Denotes rejection of the null.***, **, * indicates significant at 1%, 5% and 10% level.

Markov Switching Model Specification

The order of the VAR specification needs to be determined prior to the estimation of the MS-VAR model. Therefore, the VAR lag order selection criteria was employed; and Table 3 presents the result. When small sample is involved (i.e. 60 and less observations), the Akaike's information criterion (AIC) and final prediction error (FPE) will be used. This is because they reduce under-estimation possibility while enhance the possibility of getting true lag length (Liew, 2004). According to the result shown in Table 3, the best lag length is 1 where the results reveal that FPE and AIC criteria were significant.

Table 3 VAR lag order selection criteria

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	-94.0975	NA	0.0014	4.7852	4.9524	4.8461
1	-55.9885	66.9232*	0.0005*	3.7068*	4.5426*	4.0111*
2	-42.5048	21.0476	0.0006	3.8295	5.3341	4.3774
3	-28.3411	19.3455	0.0006	3.9190	6.0924	4.7105
4	-19.2811	10.6069	0.0010	4.2576	7.0996	5.2925

Notes: * indicates lag order selected by the criterion.

As stated in the previous section, there are two regimes in this study which are classified as active and passive monetary policies. For the selection of model, as suggested by Krolzig's (1998) we adopted an intuitive approach. The best model is selected based on Information Criteria (IC). The various MS specifications (such as MSI, MSIA, MSIAH) were then compared and a model that dominates in terms of IC (such as Akaike Information Criterion (AIC) test, Schwarz Information Criterion (SC) test, Hannan-Quinn Information Criterion (HQ) Test was chosen. To test the goodness of fit for the estimated statistical model, the AIC test was employed. It is a measurement test for selection of model in estimating the parametric model's efficiency; and to estimate the order of the model, the HQ test was employed (Phoong, 2014). Moreover, the performance comparison between the linear and non-linear models in the data fit was examined through the log-likelihood test. Therefore, we estimate MSI (2)-VAR(1), MSIA(2)-VAR(1) and MSIAH(2)-VAR(1) models.[5] The results are given in Table 4.

Table 4 Diagnostic checking on VAR(1) to VAR(4)

Model	Autocorrelation Prob.	Normality	Stability	AIC	SIC
VAR(1)	0.5581	2.9103	Stable	5.6451	5.8478
VAR(2)	0.6518	1.2595	Stable	5.6212	5.9898
VAR(3)	0.4198	1.5567	Stable	5.5425	6.0803
VAR(4)	0.6964	1.7165	Stable	5.6475	6.3580

Notes: ***, **, * indicates significant at 1%, 5% and 10% level. Autocorrelation LM Test reports the LM test statistics. Normality Test reports the Jarque-Bera normality test. Stability Test is using CUSUM test (Brown, Durbin and Evans, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines.

Table 5 Comparison between various MS-VAR specification

	MSI(2)-VAR(1)	MSIA(2)-VAR(1)	MSIAH(2)-VAR(1)
AIC	4.1375	3.7948*	4.1530
SIC	5.6269*	5.9462	6.7182
HQ	4.6835	4.5834*	5.0933

Notes: * indicates better performance for the model.

[5] To estimate the models, the MSVAR class of codes for OX by Krolzig (1998) is utilised.

Table 6 Comparison between VAR(1) and MSIAH(2)-VAR(1) model

	VAR(1)	MSIA(2)-VAR(1)
AIC	4.3543	3.7948*
SIC	5.5955*	5.9462
HQ	4.8092	4.5834*
Log-likelihood	-61.4398	-50.8879*

Notes: * indicates better performance for the model.

Based on Information Criteria (IC) it is determined that the most adequate model in this study is MSIA(2)-VAR(1) where based on AIC and HQ it outperforms other MS-VAR specifications. Meanwhile, in comparison between linear and non-linear model based on AIC, HQ and Log-likelihood test, MSIA(2)-VAR(1) outperforms the VAR(1).

Two-State Markov Switching VAR of Monetary Policy Reaction Function

The monetary policy regimes, i.e., active and passive, are classified in accordance to Taylor Rule, that is based on the feedback of real interest rates on inflation rates. As stated in methodology, zero is the threshold value of Taylor coefficient and not unity because the feedback rule is expressed in real term and not nominal. Hence, should the coefficient of inflation rate exceeds zero, then it is 'active' policy; and if it smaller than zero, then is it 'passive'.

Table 7 MSIA(2)-VAR(1) outputs

Likelihood Ratio linearity test	Chi(20) =[0.0000] ** Chi(22)=[0.0000] ** DAVIES=[0.0000] **			
	Regime 1			
Dependent / Independent	r	p	y	e
Constant	1.5962	**2.1513**	0.0129	0.0021
r_{t-1}	0.2229	-0.0453	-0.0023	-0.0027
p_{t-1}	**0.3031**	0.0741	**-0.0131**	-0.0005
y_{t-1}	**21.2557**	-2.7918	0.0413	-0.0675
e_{t-1}	-8.1326	-8.7854	-0.8253	**0.7841**
SE	2.9261	1.6032	0.0404	0.0456
	Regime 2			
Dependent / Independent	r	p	y	e
Constant	**5.5861**	**3.3201**	**-0.0451**	0.0214
r_{t-1}	-0.0115	**-0.3084**	**0.0057**	**0.0059**
p_{t-1}	**-0.7859**	**0.7865**	**0.0098**	**-0.0072**
y_{t-1}	**37.2766**	**20.8039**	**0.4311**	**0.2194**
e_{t-1}	**36.7031**	**-27.974**	-0.1665	0.1782
SE	2.9261	1.6032	0.0405	0.0456

Notes: Bold characters mean rejection of the null hypothesis of zero coefficients at the 95% confidence level or higher

Table 8 Transition probabilities and Regime Properties of the MSIAH(2)-VAR(2)

Regime	Transition Probabilities		Regime Properties		
	Active	Passive	N.Observation	Probabilities	Duration
Active	0.8000	0.2000	20.9	0.4928	5.00
Passive	0.1943	0.8057	21.1	0.5072	5.15

To test for linearity, the Likelihood Ratio linearity test statistics (χ^2 (46), χ^2 (48), and Davies) is employed. Here it is assumed that the null hypothesis is a linear model, while the alternative hypothesis is a MS model.[6] The support for non-linearity of the data and rejection of the linear model favouring regime switching model of two regime model is appropriate. From Table 7, it can be observed that p_{t-1}(0.3031) has positive effect in regime 1, which implies regime 1 is the active regime while the effect of p_{t-1}(-0.7859) is negative in regime 2 which then implies that regime 2 is the passive regime.[7] Since inflation rate, output gap and exchange rate gap are significant, this specification proves that Taylor rule holds in the case of Malaysian monetary policy. Table 8 presents the Transition probabilities and regime durations for MSIA(2)-VAR(1).

Based on the findings, both regimes contain persistency. While the probability to stay in active regime is 0.8000 at the period following active regime, to stay at passive regime at the period following passive regime was calculated as 0.8057. Based on Transition probabilities, the transition from passive regime to active regime has fairly low probability; with transition probabilities from active regime to passive regime and from passive regime to active regime are 0.2000 and 0.1943, respectively. The probabilities of being in the active regime and passive regime are almost the same. In this case, the Passive regime is more prominent than the active regime. Additionally, passive regime is the model's dominant state; with 50.72% of the time series data being disclosed in the passive regime. Durations show that the active regime and passive regime are persistent where both regimes last 5 years on average. Thereafter, the estimations for both filtered and smoothed probabilities are done and the graphics are presented in Figure 2. The regime graphics indicate that there are moderately rapid transitions with high number of phases. In addition, the graphics indicate that the model stays at the active regime longer than in the passive regime. This shows when there is a crisis, the passive regime will shift to active regime and Malaysia's economy needs a long time to recover after experiencing an impact from the crisis.

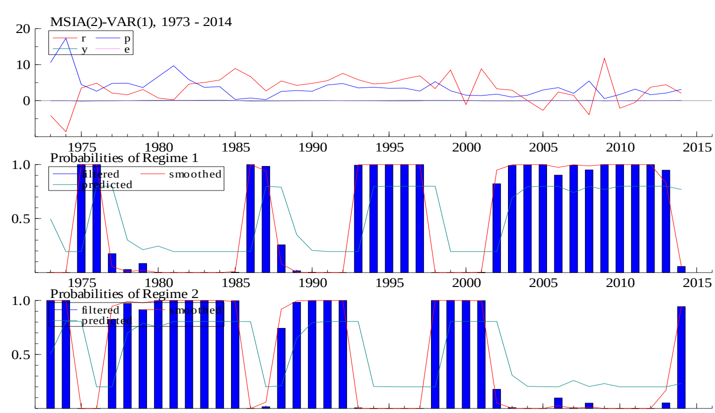

Figure 2 MSIA(2)-VAR(1) probabilities sketched

[6] The embedded likelihood ratio in MSVAR can be employed to decide on regime's optimal number. The test also allows the models be compared with with equal number of regimes such as MSIA(2)-VAR(3) and MSIAH(2)-VAR(3) only. However, comparison of MSIA(2)-VAR(3) with MSIAH(3)-VAR(3) cannot be undertaken (Fallahi, F. 2011)

[7] Refers to the first row where real interest rate (r) is the dependent variable.

Economic validation

A growing body of empirical and theoretical research has demonstrated that central banks respond aggressively to financial crisis, causing them to deviate from simple monetary policy rules and it is well-documented in the literature that central banks will mostly implement expansionary or contractionary monetary policy following an exogenous financial shock. Hence, it is imperative that the examination of the estimated regimes be economically relevant and supports real business cycle in Malaysia. Based on the result of Table 9, the classification of regime will be discussed in this section. Based on the sample in this study, Malaysia has undergone five major crises: “the first oil crisis” of 1973-1974, “the commodity or second oil crisis” of 1980-1981, “the electronic/commodity crisis” of 1985-1986, “the financial crisis” of 1997-1998 and ”global financial crisis” of 2007-2009.

Table 9 Classification of Monetary Policy Regimes

Year	Regimes	Year	Regimes
1973	Passive*	1994	Active
1974	Passive	1995	Active
1975	Active	1996	Active
1976	Active	1997	Active*
1977	Passive	1998	Passive*
1978	Passive	1999	Passive
1979	Passive	2000	Passive
1980	Passive*	2001	Passive
1981	Passive*	2002	Passive
1982	Passive	2003	Active
1983	Passive	2004	Active
1984	Passive	2005	Active
1985	Passive*	2006	Active
1986	Active*	2007	Active*
1987	Active	2008	Active*
1988	Passive	2009	Active*
1989	Passive	2010	Active
1990	Passive	2011	Active
1991	Passive	2012	Active
1992	Passive	2013	Active
1993	Active	2014	Passive

Note : * indicates crisis on the current year.

The first oil crisis in 1973-1974 shows an immediate economic effects which caused world currencies to heavily fluctuate and international finance not stable. Restrictive monetary policy was in place to curtail unnecessary credit creation and increase in inflation. Monetary policy was classified as passive, since the existing monetary policy was retained although there was major oil crisis. In 1975, monetary policy was in the active regime when BNM somewhat reversed the policy to encourage more credits and decided to curtail unemployment. Early 1980s, the second oil crisis hit and resulted in a massive collapse of world’s commodity trade. Due to constant stagflation problem in industrial nations, and international trade had slowed down, Malaysia needed to encourage domestic consumption, therefore expansionary policy was retained for a longer period. During 1980–1984 the average annual growth rate was at 7%, and the third commodity crisis of 1985-1986 resulted in negative growth rate (-1%) in 1985 which was the first in the history of Malaysia. This compelled BNM to activate the monetary policy by reducing interest rates. Thereafter, Malaysian economy registered a high growth phase in the post-independence era that the country had ever seen.

Early 1990s, BNM retained low interest rates and monetary policy was in passive state. However, Malaysia was hit by Asian financial crisis in 1997 which caused Ringgit and the Kuala Lumpur Composite Index (KLCI) to fall sharply. At the end of 1998 interest rates were sharply raised by BNM and expected to fix the exchange rate and recession. A sudden reversal of BNM from contraction to expansion policy at 1999 was where when interest rates were reduced to the maximum policy to spur economic growth. Finally, the global financial crisis of 2008-2009 caused collapse in exports and a slowdown in foreign direct investment (FDI) and led to expansionary monetary policy; which acted as a cushion to the financial system against capital outflows and share market collapse. In 2009, Malaysian economy recovered but the world economy was still sluggish. BNM had retained the interest rate low as to ensure economic growth. From another standpoint, Table 9 also illustrates that models of the two regimes are more appropriate rather than a single regime model.

CONCLUSION

Utilizing Malaysia's annual data between 1971 and 2015, this study has examined empirically the country's non-linear monetary policy reaction functions. For Malaysia, to formulate its monetary policy, the interest rate targeting method is utilised; and hence the factors that would impact the policy rate need to be appraised. Based on the results of nonlinear model show that MS-VAR of MPRF provides good in-sample data fits and outperformed the linear VAR. In view that the determination of policy rate is significantly based on exchange rate, the monetary policy reaction function for Malaysia has to include exchange rate as part of its specification to obtain the best model. The results indicate that the estimated regime shift appears to be related to the inflation and business cycle. This shows that in determining an optimal policy rate, regime shift or non-linearity in reaction functions has important economical and statistical effects. In terms of policy implication, this study could assist the government and other relevant agencies to develop policies during crisis as well as reduce the impact of the crisis. Moreover, this study also benefits various economic sectors, in particular the financial sector to have better prediction on how central bank responds to prevailing economic environment. Therefore, it provides the basis to the analysis of past policies and to forecast future policy rate. It is also for the impact evaluation of other policy actions, i.e. fiscal policy and economic shocks. Meanwhile for the central banks, it is for their evaluation of policy choices and communication purposes.

REFERENCES

Brown, R. L., Durbin, J. and Evans, J. M. (1975), “Techniques for testing the constancy of regression relationships over time”, *Journal of the Royal Statistical Society*. Series B (Methodological), pp. 149-192.

Clarida, R., Galı, J. and Gertler, M. (1998), “Monetary policy rules in practice: some international evidence”, *European Economic Review*, Vol. 42 No 6, pp. 1033-1067.

Davig, T. and Leeper, E.M. (2007), “Fluctuating macro policies and the fiscal theory”, *In NBER Macroeconomics Annual 2006*, Vol. 21, pp. 247-316. MIT Press.

Doi, T., Hoshi, T. and Okimoto, T. (2011), “Japanese government debt and sustainability of fiscal policy”, *Journal of the Japanese And International Economies*, Vol. 25 No. 4, pp. 414-433.

Fallahi, F. (2011), “Causal relationship between energy consumption (EC) and GDP: a Markov-switching (MS) causality”, *Energy*, Vol. 36 No. 7, pp. 4165-4170.

Favero, C. A. and Monacelli, T. (2003), “Monetary-fiscal mix and inflation performance: Evidence from the US”, *Discussion Paper Series- Centre for Economic Policy Research London, 2003.*

Gan, P. T. and Kwek, K. T. (2010), “The monetary policy reaction function: Evidence from ASEAN-3”, *Asian Academy of Management Journal of Accounting and Finance*, Vol. 6 No. 1, pp. 1-24.

Goldfeld, S. M. and Quandt, R. E. (1973), “A Markov model for switching regressions”, *Journal of Econometrics*, Vol. 1 No. 1, pp. 3-15.

Habibullah, M. S., Puah, C. H. and Azali, M. (2002), “Testing long-run neutrality of money in a developing economy”, *Savings and Development*, Vol. 26 No. 2, pp. 165-181.

Hamilton, J. D. (1989), “A new approach to the economic analysis of nonstationary time series and the business cycle”, *Econometrica: Journal of the Econometric Society*, Vol. 57 No 2. pp. 357-384.

Hodrick, R. J. and Prescott, E. C. (1997), “Postwar US business cycles: an empirical investigation”, *Journal of Money, Credit, and Banking*, Vol. 29 No. 1, pp. 1-16.

Islam, M. S. (2011), “Taylor Rule-based Monetary Policy for Developing Economies-A case Study with Malaysia”, *International Review of Business Research Papers*, Vol. 7 No. 1, pp. 134-149.

Karim, Z. A. and Karim, B. A. (2014), “Interest rates targeting of monetary policy: An open economy SVAR study of Malaysia”, G*adjah Mada International Journal of Business*, Vol. 16 No. 1, pp. 1-22.

Khalid, N. and Fakhzan, N. (2013), “The effect of regime switching policy rules on economic growth”, *Jurnal Ekonomi Malaysia*, Vol. 47 No. 2, pp. 93-109.

Khalid, N., Karim, Z. A. and Yussof, I. (2014), “Testing a non-linear model of monetary policy reaction function: evidence from Malaysia”, *Jurnal Ekonomi Malaysia*, Vol. 48 No. 2, pp. 19-27.

Krolzig, H. M. (1998), “Econometric modelling of Markov-switching vector autoregressions using MSVAR for Ox”, available at: fmwww.bc.edu/ec-p/software/ox/Msvardoc.pdf

Kwiatkowski, D., Phillips, P. C., Schmidt, P. and Shin, Y. (1992), "Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?", *Journal of Econometrics*, Vol. 54 No. 1, pp. 159-178.

Kydland, F. E. and Prescott, E. C. (1990), "Business cycles: Real facts and a monetary myth", *Real business cycles: A reader*, pp. 383.

Leeper, E. M. (1991), "Equilibria under 'active'and 'passive'monetary and fiscal policies", *Journal of Monetary Economics*, Vol. 27 No. 1, pp. 129-147.

Liew, V. K. S. (2004), "Which lag length selection criteria should we employ?", *Economics Bulletin*, Vol. 3 No. 33, pp. 1-9.

Phoong, S. W., Ismail, M. T. and Sek, S. K. (2014), "Linear Vector Error Correction Model versus Markov Switching Vector Error Correction Model to Investigate Stock Market Behaviour", *Asian Academy of Management Journal of Accounting and Finance*, Vol. 10 No. 1, pp. 133-149.

Ramayandi, A. (2007), "Approximating Monetary Policy: Case Study for the ASEAN-5 (No. 200707)", *Department of Economics*, Padjadjaran University.

Tan, Siow-Hooi and Habibullah, Muzafar Shah, (2007), "Business Cycles and Monetary Policy Asymmetry: An Investigation Using Markov-Switching Models," *Physica A: Statistical Mechanics and its Applications*, Vol. 380 No. C, pp. 297-306.

Taylor, J. B. (1993), "Discretion versus policy rules in practice", in *Carnegie-Rochester conference series on public policy in North-Holland*, pp. 195-214

Umezaki, S. (2007), "Monetary policy in a small open economy: The case of Malaysia", *The Developing Economies*, Vol. 45 No. 4, pp. 437-464.

Woodford, M. (2001), "The Taylor rule and optimal monetary policy", *The American Economic Review*, Vol. 91 No. 2, pp. 232-237.

Zaidi, M. A. S. and Fisher, L. A. (2010), "Monetary policy and foreign shocks: A SVAR analysis for Malaysia", *Korea and the World Economy*, Vol. 11 No. 3, pp. 527-550.