PROSIDING PERKEM ke-9 (2014) 257 - 268
ISSN: 2231-962X

Testing Monetary Policy Reaction Function: Non Linear Evidence from Malaysia

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ABSTRACT

This paper examines the validity of Fisher hypothesis and estimates the Taylor's rule of monetary policy reaction function for the case of Malaysia. Using a sample period of 1990-2014, and estimation procedure namely the *Autoregressive Distributed Lag (ARDL)* model, the evidence supports the existence of long run Fisher effect with the coefficient value of one, suggesting that nominal interest rates adjust one-for-one with respect to the changes in the expected inflation. In addition, using a non-linear estimation model, the finding also support the relevance of Taylor rule in which the Bank Negara Malaysia (BNM) sets the policy rates based on both inflation and output growth. This finding signal that inflation has not affected the real sector and will be absorbed by nominal interest rates, hence the argument of the neutrality of money is supported for the case of Malaysia.

Key Words: Monetary Policy; Interest Rate; Inflation; Taylor Rule; Fisher Effect.

INTRODUCTION

Most economists have agreed that monetary policy has a real effect at least in the short run (Taylor, 1997). Therefore, choosing the proper operating target of monetary policy (interest rates or monetary aggregates) is pivotal for the monetary authority to stimulate effectively the real sector's activity, and to maintain price stability. Poole (1970) used a Hicksian IS-LM model to show that interest rate targeting is superior to money stock targeting if the money market shocks (influencing the LM curve) are relatively smaller than the shocks arising in the commodity market (influencing the IS curve). Since the 1990s, most central banks around the world have shifted their monetary policy stance from targeting monetary aggregates towards targeting interest rates. The main reason is the instability in the relationship between monetary aggregates and aggregate expenditures due to financial innovations, and changes in the payments technology occurring in the 1990s (Handa, 2009).

In Malaysia's experience, the Bank Negara Malaysia (BNM) has switched the monetary policy strategy from monetary targeting towards interest rate targeting in November 1995. During interest rate targeting, monetary policy has operated through short-term interest rates to attain the ultimate target that is a sustainable long-run economic growth, accompanied with price and financial stability [1]. The BNM believed that a change in the interest rates policy has a predominant effect on the

[1] During the interest rate targeting, monetary policy in Malaysia can be categorized into three main evolutions. Firstly, from November 1995 up to September 1998, the BNM has introduced a new Base Lending Rate (BLR) framework, which takes into account the 3-month interbank rate in the BLR formula. Secondly, since September 1998, the BNM has employed interest rate targeting with a fixed exchange rate, and modified the BLR framework

domestic economy through monetary policy channel. For example, a change in the BNM policy rate will have a direct effect on interest rates (lending rate, deposit rate, and money market rate), in which will affect the cost of funds and liquidity in the banking system. This, in turn, will affect the private sector, particularly firms' balance sheet conditions in terms of their financial assets (for example, equity returns), investment spending, and liabilities position, which subsequently influences aggregate expenditure and inflation. Thus, the main question is how does the BNM set their policy rates? Is that the standard monetary policy reaction function, namely a Taylor's rule exist for the Malaysian? Therefore, understanding this two questions are pivotal to the BNM in designing their optimal policy rules, in order to achieve the target level of inflation rate, and to sustain a long run economic growth.

There are many studies that have been conducted to test the validity of the Taylor rule, such as Castro, 2008, Molotsova et. al., 2008 in the United States, Castro, 2008 in United Kingdom, Molotsova et. al., 2008 in German and Ncube and Tshuma, 2010 in South Africa. Yet the results have shown the failure to get agreeableness about one robust long run relationship between inflation, nominal interest rates and output gap. Previous studies have shown that the outcomes were very sensitive to the sample used (country selected), period of study as well as the methodology. Furthermore, the economic variables keep changing overtime and this would affect the relationship between interest rates and inflation. Hence, it is crucial to determine the validity of Taylor rule for the sake of monetary policy implications.

Furthermore, inflation and controlled short-term interest rates alter the long term interest rates. Thus, the term structure of interest rates may also change. All these factors will have different impacts on the real economy as compared to those under monetary targeting. Interest rate cannot be controlled for a longer duration because in the long run, interest rate is determined by real factors in the economy and thus cannot be manipulated by the central bank. Thus, the success of any long run intermediate rate target must be accompanied by a stable expected rate of inflation.

The interest among economists in estimating monetary policy reaction functions has increased dramatically. The reaction function can be used to evaluate the actions and policy of central bank in response to the economic environments. In spite of large number of studies to estimate the reaction functions from various countries and samples, researchers have not been successful in providing an accurate representation of the central bank behaviour. For instance, Khoury (1990) surveys 42 such empirical reaction functions from various studies, but she found that there is little consistency in the significance of regressors in the reaction functions.

The focal point of this study is to investigate the validity of the Fisher hypothesis and to estimate the BNM monetary policy reaction function using a standard Taylor rule. Therefore, this study contributes to the existing on Fisher effect and Taylor rule in three aspects. First, by testing the Fisher effect, one can identify the relationship between nominal interest rate and inflation in a small-open economy (i.e., Malaysia) for both short and long run. Second, this study also test the validity of BNM monetary policy reaction function that follows Taylor rule in formulating their policy interest rate in order to achieve price stability and sustainable economic growth in the long run. By testing the validity of the Fisher effect and monetary policy reaction function, it can suggest to the BNM to design an optimal monetary policy by setting the ideal level of policy rates that can promote price stability (inflation) and generate long run economic growth. Third, this study uses the most recent econometric method namely ARDL model in investigating the Fisher hypothesis, and a non-linear estimation model in estimating the BNM monetary policy reaction function using a standard Taylor rule. Using a standard Taylor rule, it can identify how the BNM set the current policy rates after observing the current level of inflation and output.

The plan of the paper is as follows. Section 2, briefly discusses the literature review, whereas Section 3 discusses the theoretical framework relating to Fisher hypothesis and Taylor rule. Section 4 explains a model specifications and the econometric model. The result of the empirical estimation is illustrated in section 5. Finally, section 6 concludes the paper.

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taking into account the Intervention Rate in the determination of BLR formula. At the same time, due to the currency crisis that occurred in the East Asian region, the BNM implemented capital controls to stabilize the economy. Thirdly, since April 2004, the BNM has introduced a new interest rates framework, the Overnight Policy Rate (OPR) to signal the monetary policy stance. During this period, the BNM has gradually liberalized capital control, and has eliminated the pegging with the US dollar since July 2005.

LITERATURE REVIEW

The debate that exists in monetary economics always concern about the appropriate target of monetary policy whether monetary authority should use money growth rules or interest rate rules to control output and price. Keynes (1936) was the first to highlight the appropriateness of using the interest rate as an intermediate target of monetary policy due to the instability of money demand. Poole (1970) addresses this question by using an aggregate demand framework (IS-LM). He showed that an interest rate rule is preferable if the money demand shocks are more numerous than the IS shock, while a money growth rule is preferable in the opposite case. However, Poole's analysis ignores other important factors such as inflation and aggregate supply disturbances. Following that, the interest of economists in examining interest rate targeting has been increased dramatically. Charles and Timothy (1997) analysed the cost and benefit of interest rate targeting using both, the partial equilibrium model and the monetary general equilibrium model with sluggish portfolio adjustment. According to them, if the interest rate is pegged, the firm's demand for loans is supplied by the monetary authority rather than by the private sector. Barro (1989) evaluated both the monetary targeting and interest rate targeting instruments through their success in minimizing the discrepancies between expected and actual price levels. According to Barro, the interest rate targeting is always superior to the monetary targeting because the central bank can target nominal interest rates without endangering its control on the price level. William T. Gavin et al. (2005) examined the effects of alternative monetary policy rules (money growth or interest rate rules) on inflation persistence using a dynamic stochastic general equilibrium framework. The empirical results showed that the interest rate rules rather than the money growth rules can capture the degree of inflation persistence and the relative volatility of the price level. Hence, given these previous studies, we may conclude that most of monetary economists agreed that interest targeting has become superior to monetary targeting as its characteristics that predictable and easier to observe by the policy makers as well as its ability to have an immediate effect on individual's consumption and investment behaviour.

Most of Central Bank now employing interest rate targeting in line with Taylor rule although some countries have generalized Taylor rule by adding more targeting variables. According to the Taylor rule, the central bank has an inflation target, and it raises nominal interest rates when inflation is above target and lowers them when it is below target. Taylor (1993) shows that since 1987, U.S. monetary policy is based on a simple rule that the central bank sets the short term nominal interest rate as a measure of inflation and output gap with coefficients of 1.5 and 0.5 respectively. Given the various coefficients of inflation, interest rate rules can be distinguished into two distinctive styles. If a feedback rule has the inflation coefficient greater than unity which satisfies the Taylor principle, it is accepted as an *active* interest rate rule. In contrast, a *passive* rule involves an inflation coefficient of less than unity.

Studies by Meltzer (1987), Clarida, Gali and Gertler (1998), Judd and Rudebusch (1998) and Taylor (1999) for U.S. countries emphasized the implementation of inflation alone or price stability for monetary policy. Their results show that the coefficient reaction on inflation was larger in the 1980s and 1990s. For instance, Taylor (1999) found the estimate of this reaction function on inflation to be about 0.8 for the early period and about 1.5 for the later period, which is nearly double. Rudebusch and Svensson (1998) examined the effectiveness of policy rule whenever the central bank changes its interest rate in response to the forecast of future inflation rather than to current inflation and real output. The results show that for the forecast inflation rule with a 6 quarters forecast horizon, the standard deviation of output is 0.9 percent while the standard deviation of inflation is 1.3 percent.

In contrast to a standard Taylor's reaction function, another approach for the monetary policy targeted by the central bank has been implemented as well. For instance, McCallum (1981) and McCallum and Nelson (1999) emphasized the implementation of the nominal income growth and the nominal income targeting respectively. Specifically, these authors take into account the response of policy rate to the expected nominal income growth rather than to the expected inflation. McCallum and Nelson (1999) have compared the findings by Clarida, Gali and Gertler (2000) for the U.S according to the Taylor's rule that is based on the nominal income growth target. The results show that the U.S. policy rule is largely influenced by the expected nominal income growth since 1979. Therefore, the authors conclude that the U.S. monetary policy was designed to stabilize the nominal income growth.

However, apart from the inflation and output gap, the role of the exchange rate on the policy rate is undeniable. Ball (1999) found that the macroeconomic performance in a small open economy has increased by adding the exchange rate to the reaction function. In his analysis he uses a monetary condition index which is a weighted average of the interest rate and the exchange rate in place of the interest rate alone as an instrument. Ball added the lagged exchange rate as a variable to the policy rate.

The findings show that the output variability could be reduced by 17 percent by adding the exchange rate to the policy rule by the same amount of inflation variability.

In the Malaysian context, existing study relating to the Taylor rule and monetary policy reaction function are still limited in the literature. Pei-Tha and Kwek (2010), Ramayandi (2007) and Hsing (2009) found that Malaysia monetary policy follows the Taylor Rule with inflation and output gap as the determinant of policy reaction function. Furthermore, Pei-Tha and Kwek (2010) conducted a Structural VAR and Impulse Response Function analysis and found that the BNM respond to the shock from inflation faster compared to the shock from the output gap. BNM respond to the shock from inflation immediately after the first quarter while BNM only respond to the shock from output gap at the third quarter. Both of the shocks die out at the third year.

On the other hand, Islam (2011) conducted a linear Taylor rule empirical study on Malaysia and found that BNM did not comply with the Taylor rule and the coefficients obtained were far from the expected value. Consequently, the author showed that using a counterfactual historical simulation, if BNM had been using the Taylor rule as the monetary policy reaction function, there will be a lower social cost to the economy and Malaysia would have a better overall macroeconomic performance. Another noteworthy paper is by Pei-Tha and Han (2009) where it was found that the Islamic Monetary Policy in Malaysia also follows the Taylor rule. Instead of using interest rate or the profit sharing ratio, Pei-Tha and Han (2009) used the Islamic interbank rate as the proxy for interest rate policy. The paper concluded that the Islamic monetary policy applied to the Taylor rule is superior and predicts better without riba in the economy.

MODEL SPECIFICATION AND ESTIMATION PROCEDURE

Bound Testing Approach to Analyse the Fisher Hypothesis

In this paper, the ARDL model or the so-called bound testing approach is used to examine the existence of the Fisher hypothesis in Malaysia. Pesaran (1997) introduced the ARDL model and has numerous advantages. The main advantage of this approach is that the long run relationship between the nominal interest rate and inflation can be tested irrespective of whether the underlying regressors are purely I(0), purely I(1) or mutually co integrated. Since the inflation rate is measured by the change in the consumer price index, so this variable tends to integrate at level and therefore ARDL approach can be the best alternative for the co integration test. Apart from that, a dynamic error correction model (ECM) can be generated from the ARDL model through the simple linear transformation (Banerjee et al., 1993).

In order to illustrate the ARDL modelling approach, the model specification that represents the relationship between the nominal interest rate and inflation is considered, which is as follows:

$$i_t = \alpha + \beta\pi_t + \varepsilon_t \quad (4)$$

where i_t and π_t are the time series for the nominal interest rates and the inflation rates respectively. ε_t is a vector of stochastic error terms while α and β are the parameters. Based on equation (4), the error correction version of the ARDL model is given by:

$$\Delta i_t = \alpha_0 + \lambda_1 i_{t-1} + \lambda_2 \pi_{t-1} + \gamma\Delta\pi_t + \Sigma_{i=1}^{p}\beta_i \Delta i_{t-1} + \Sigma_{i=1}^{q}\delta_i \Delta\pi_{t-1} + \xi_t \quad (5)$$

From equation (5), β and δ represent the short run dynamic of the model while λ represents the long run relationship. The null hypothesis in this equation is $\lambda_1 = \lambda_2 = 0$, means the non-existence of the long run relationship. Equation (5) is the econometric model that will be estimated by using the ARDL bound test approach. The ARDL regression yields an F statistic, which can be compared with the critical values tabulated by Narayan (2004). If the test statistic is above the upper critical value, the null hypothesis of no long run relationship can be rejected regardless of whether the order of integration of inflation and the nominal interest rate are I(0) or I(1). In contrast, if the test statistic is below a lower critical value, the null hypothesis cannot be rejected. However, the result is inconclusive if the test statistic falls between these two bounds.

Non-Linear Estimation of the Taylor Rule Reaction Function

Based on the Taylor's (1993) original work, the central bank targets the nominal interest rate, which is proxied by federal fund rate (i_t). The central bank targets its interest rate as a function of the equilibrium real interest rate (r_t^*), the current inflation rate (π_t), the percentage deviation of the real GDP from an estimate of its potential level (y_t) and the deviation of actual inflation from the rate of inflation targeted by the central bank (π^*). In functional form, Taylor rule is given by:

$$i_t = \pi_t + r_t^* + 0.5y_t + 0.5(\pi_t - \pi^*) \tag{6}$$

Where y_t = 100 (Y-Y*)/Y* and Y is the real GDP. Taylor did not estimate this equation econometrically. However, he assumed that the weights on deviation of the real GDP and inflation from their potential level were both equal to 0.5. The intuition behind this monetary rule is straightforward. If the output gap is positive, it means GDP exceeds its potential level under full employment and this will put an upward pressure on wages and prices. In order to reduce the inflation pressure, the central bank will increase the targeted level of interest rates. In contrast, if the GDP gap is negative, the central bank will lower its targeted level of interest rate. Likewise, if inflation is greater than the targeted level, the central bank will increase the interest rate.

Judd and Rudebusch (1998) examined the alternatives to Taylor's simple specification by estimating the reaction function weights econometrically rather than simply choosing parameters equal to 0.5 as Taylor did. They considered the dynamic specification in estimating reaction function base on the Taylor rule. In specification, they replaced equation (6) with:

$$i_t^* = \pi_t + r_t^* + \lambda_1(\pi_t - \pi^*) + \lambda_2 y_t + \lambda_3 y_{t-1} \tag{7}$$

Where i_t^* is the recommended interest rate that can be achieved through gradual adjustment. Equation (7) includes an additional lagged gap term along with the contemporaneous gap. This general specification would allow the central bank to respond with different variables proposed as effective monetary policy targets, including inflation alone, nominal GDP growth as well as both inflation and the GDP gap in level form.

The central bank may not be able to immediately reach its targeted level of interest rate. Now by taking into account the dynamics of adjustment of the actual level of interest rate, assume that the central bank's adjustment mechanism is:

$$\Delta i_t = \gamma(i_t^* - i_{t-1}) + \rho\Delta i_{t-1} \tag{8}$$

where γ is the speed of adjustment in the interest rate at time t and ρ reflects the persistence of the monetary policy that the central bank follows. After substituting equation (7) into equation (8), the following equation is obtained:

$$\Delta i_t = \gamma\alpha - \gamma i_{t-1} + \gamma(1 + \lambda_1)\pi_t + \gamma\lambda_2 y_t + \gamma\lambda_3 y_{t-1} + \rho\Delta i_{t-1} \tag{9}$$

By adding an error term, Equation (9) can also be written in econometric form, which is as follows:

$$\Delta i_t = \beta_0 - \beta_1 i_{t-1} + \beta_2\pi_t + \beta_3 y_t + \beta_4 y_{t-1} + \beta_5\Delta i_{t-1} + \epsilon_t \tag{10}$$

Where:

$$\begin{aligned}
\beta_0 &= \gamma\alpha = \gamma(i_t - \beta_2\pi_t^*) \\
\beta_1 &= \gamma \\
\beta_2 &= \gamma(1 + \lambda_1) = -\beta_2(1 + \lambda_1) \\
\beta_3 &= \gamma\lambda_2 = -\beta_2\lambda_2 \\
\beta_4 &= \gamma\lambda_3 = -\beta_2\lambda_3 \\
\beta_5 &= \rho
\end{aligned}$$

Equation (10) is named as specification A in this study or so called Judd and Rudebusch's model that will be estimated.

Unlike Judd and Rudebusch (1998), we take a step further by considering an open economy version of the Taylor rule. Denote E_t as the percentage change in the exchange rate and substituting this variable into equation (7), equation (11) is obtained:

$$i_t^* = \pi_t + r_t^* + \lambda_1(\pi_t - \pi^*) + \lambda_2 y_t + \lambda_3 y_{t-1} + \lambda_4 E_t \tag{11}$$

Again substituting equation (11) into equation (8), the following equation is obtained:

$$\Delta i_t = \gamma\alpha - \gamma i_{t-1} + \gamma(1+\lambda_1)\pi_t + \gamma\lambda_2 y_t + \gamma\lambda_3 y_{t-1} + \gamma\lambda_4 E_t + \rho\Delta i_{t-1} \quad (12)$$

By adding an error term, Equation (12) can also be written in econometric model form which is as follows:

$$\Delta i_t = \beta_0 - \beta_1 i_{t-1} + \beta_2\pi_t + \beta_3 y_t + \beta_4 y_{t-1} + \beta_5 E_t + \beta_6\Delta i_{t-1} + \epsilon_t \quad (13)$$

Where:

$$\beta_0 = \gamma\alpha = \gamma(i_t - \beta_2\pi_t^*)$$
$$\beta_1 = \gamma$$
$$\beta_2 = \gamma(1+\lambda_1) = -\beta_2(1+\lambda_1)$$
$$\beta_3 = \gamma\lambda_2 = -\beta_2\lambda_2$$
$$\beta_4 = \gamma\lambda_3 = -\beta_2\lambda_3$$
$$\beta_5 = \gamma\lambda_4 = -\beta_2\lambda_4$$
$$\beta_6 = \rho$$

Equation (13) is the econometric model that will be estimated and named as specification B. Hence, in this study, two model specifications of Taylor rule are considered namely specification A and B.

In order to estimate the parameters of Taylor reaction function for Malaysia as in equations (9) and (12), the nonlinear regression is used. This method can estimate the parameters of reaction function separately as they appear in equation (9) and (12). Based on all the parameters we can proceed with the hypothesis testing to examine the behaviour of the central bank. There are three possibilities about how the central bank sets its interest rate targeting. First, the central bank might respond by setting the interest rate according to the inflation alone (as in Meltzer 1987, Clarida, Gali and Gertler 1998 and Judd and Rudenbusch 1998), which is Ho: $\lambda_2 = \lambda_3 = \lambda_4 = 0$. Second if the central bank changes the interest rate based on the nominal output growth (as in McCallum 1981 and McCallum and Nelson 1999), the null hypothesis Ho: $\lambda_1 = \lambda_2 = -\lambda_3$, cannot be rejected. Finally if the Central bank reacts to inflation and output gap (as in Taylor 1993), the null hypothesis Ho: $\lambda_1 = \lambda_2 = \lambda_3 = 0$ will be rejected.

Description of the Data

This study has covered the period of 1990-2014 by using quarterly frequency data. The three-month Treasury bill (nomint) is used as the nominal interest rate for the Fisher model and the Taylor model. The real effective exchange rate is used as the proxy for the exchange rate. All the quarterly time series data for Gross Domestic Product (GDP), Consumer Price Index (CPI), three-month Treasury bill and the exchange rate were obtained from the International Financial Statistics by the International Monetary Fund (IMF). However, there is no data available for estimated output gap in Malaysia. Therefore, the potential GDP was estimated by applying a Hodrick-Prescott (1997) filter to the Malaysia's real GDP series. This technique was used by Taylor to estimate the potential GDP in his empirical studies of the monetary rule in U.S. This technique can generate a smooth estimate of the long term trend component in a GDP series and can be used as a potential GDP.

RESULTS

Fisher Model

Figure 1 shows the trend of nominal interest rate and inflation rate in Malaysia from 1990:1 to 2014:1. As can be seen, the nominal interest rate is higher than the inflation rate most of the time, suggesting that the real rate of interest is positive throughout the majority of the study. Both the variables are volatile from year to year. The inflation rate measured by the change in the consumer price index has values between -2.3 to 8.4 percent, with the highest being achieved in the year 2008:3. In average, the mean of inflation rate is 2.82 percent for the whole period of study, while the mean for nominal interest rate is 4.05 percent. The standard deviation for the nominal interest rate is 1.84 which is higher than the standard deviation of the inflation rate, which is 1.52, suggesting that the nominal interest rate is more volatile than the inflation rate.

Unit Root Test

To determine the order of integration for each variable, time series data for inflation and nominal interest rates are tested by means of *Augmented Dickey Fuller (ADF)* method. The optimal lag structure is determined using the AIC introduced by Akaike (1977). Table 1 summarizes result for unit root test for both inflation (INF) and the nominal interest rate (NOMINT). As shown in panel A Table 1, the null hypothesis of no stationary could not be rejected for both variables at level, indicating that the inflation and nominal interest rate are not stationary at level. However, both variables are stationary at I(1). As the ARDL Bound test approach can be applied irrespective of whether the variables are I(0) or I(1) (Pesaran et al., 2001).

ARDL Bound Test

We then test for the existence of long run relationship between the series of the variables. The null hypothesis, that there is no long run relationship between the nominal interest rate and inflation, against the alternative, that there exists a long run relationship between nominal interest rate and inflation rate, is tested using the F statistic. Table 2 provides the results of the F-statistics to various lag orders. The critical value is also reported in Table 2 based on the critical value suggested by Narayan (2004) for a small sample size between 30 and 80. As can be seen from Table 2, the computed F-statistics are significant at least at 0.95 levels for all order of lags (lag 1 to lag 4). This implies that the null hypothesis of no cointegration is rejected and therefore there is a long run relationship among the variables. In this case, the ECM version of the ARDL model is an efficient way in determining the long run relationship among the variables. Consequently, there is a tendency for the variables to move together towards a long-run equilibrium.

Having found a long run relationship, we then estimate the ARDL model from equation (5). The results of the ARDL (p, q) bound test are summarized in Table 3. In this study, the ARDL (2, 2) was chosen and selected by AIC as it has a lower prediction error than the SBC model. In the long run, inflation coefficient is significant and has positive effect on the nominal interest rates. This evidence supports the existence of a long run Fisher effect with the coefficient value of 1.0788, which is close to one. According to Crowder and Hoffman (1996), this long run coefficient is about 1.4 for the U.S and according to Crowder (1997); this coefficient is between 1.52 and 1.95 in Canada. Because the long run coefficient elasticity between the nominal interest rate and inflation is unity, we can then interpret that these results are consistent with the Fisher effect. As a result, the nominal interest rates adjust one-for-one with respect to changes in the expected inflation. This implies that the real interest rate will not be affected by changes in expected inflation. Therefore, changes in the real interest rates may be caused by real economic variables.

The results of the ECM-ARDL for the short run analysis are reported in Table 4. The error correction term (ECT_{t-1}) is significant at 1 percent significant level and has the negative sign. The coefficient of ECT equal to 0.1581 suggests that more than 16 percent of disequilibrium caused by previous years shock will be corrected in the current year and converges back to long run equilibrium. In order to obtain an accurate and adequate model for Fisher hypothesis, the adequacy of the models are examined by running the diagnostic tests and the stability test. Overall, the Jarque-Bera normality test suggests that the errors are not normally distributed. However, the results show no evidence of serial correlation and heteroscedasticity effect in the disturbances.

Taylor Reaction Function

In this subsection, we discuss the results obtained for nonlinear estimation of specifications A and B, which appear in previous equations (9) and (12) respectively. Table 5 summarizes the results for Taylor reaction function using different alternative specifications, namely specification A and specification B. The parameters $\lambda_1, \lambda_2, \lambda_3$ *and* λ_4 respectively represent the reaction coefficient on inflation, GDP gap, lagged GDP gap and the exchange rate. α and γ are constants and significantly different from zero for both specifications. The reaction coefficient on inflation, λ_1 is significant at 1 percent significant level with a negative coefficient of 0.79. This coefficient is relatively small compared to the findings by Taylor (1993, 1999) where the coefficient on inflation was equal to 1.5 for U.S. However the estimated weights on the GDP gap and on the lagged GDP gap are not significant for both the specifications. These finding are different from the past literatures, for instances Judd Rudebusch (1998), Rudebusch and Svensson (1999) and Taylor (1993, 1999) where the output gap is found to be important in determining how the central bank changes the interest rate.

It can also be seen that the exchange rate is important in determining the interest rate, targeted by the central bank. Thus, we can conclude that the specification 'A' with the exchange rate performs better than the other specifications and can be regarded as the best reaction function model. In addition, the coefficient on the lagged interest rate (ρ), which is a measure of the speed of adjustment of the interest rate to its targeted level, is not statistically significant for both specifications. The R^2 is very low for both the specifications with less than 20 percent variation in the dependent variable being explained by the independent variables in the model. The diagnostic test shows that the residuals of the models are normally distributed and there is no ARCH effect. However the residuals have serial correlation. This is because the financial data is sensitive to the economic environment and hence the residuals tend to be correlated.

The main question of this study on the Taylor reaction function is to examine what is the benchmark variable that will enable the central bank to determine the interest rate. The first hypothesis is to test whether the central bank reacts based on inflation alone or not ($Ho: \lambda_2 = \lambda_3 = \lambda_4 = 0$) cannot be rejected, suggesting that the inflation is the only variable that determines the policy rate. The same goes for the nominal output growth, where the hypothesis testing is not significant, only for specification B. Therefore the central bank does not set its interest rate based on the nominal output growth. However for the hypothesis whether the central bank determines the interest rate on the basis of both the inflation and output gap, only specification A is significantly different from zero while specification B is not significant. Therefore, for specification A (i.e., specification model with exchange rate) the central bank responds on the basis of both the inflation and output gap. This finding is similar to the results found by Taylor (1993).

CONCLUSIONS AND POLICY IMPLICATIONS

This study has examined the empirical validity of the Fisher effect and the Taylor reaction function for Malaysia using quarterly data from 1990 to 2014. In Malaysia, the interest rate targeting has been implemented to formulate the monetary policy and hence it is crucial to determine what factors would affect the policy rate. The Fisher effect was investigated by applying the ARDL bound test. Results based on the ARDL approach rejects the null hypothesis of no long run relationship between nominal interest rate and inflation. Hence, there exist a long run relationship between inflation and nominal interest rates. Furthermore, the long run coefficient elasticity is unity, and hence consistent with the Fisher hypothesis, where the nominal interest rate adjusts one-for-one with respect to changes in the expected inflation. Hence, for Malaysia, inflation has not effects on the real sector and will be absorbed by nominal interest rates. For policy implications, this finding suggests that Malaysia, which is a low inflation country, would tend to have stable real interest rates. Overall, this result also suggests that in an environment with deregulation, the real interest rate is not affected by nominal shocks, indicating the neutrality of monetary policy in Malaysia.

Secondly, the Taylor reaction function, which is the response of central bank to the economic developments, has been investigated using the nonlinear regression techniques for different alternative specifications. However, because the exchange rate is significant in determining the policy rate, the specification that includes the exchange rate, is the best model to reflect the monetary policy reaction function in Malaysia. The findings show that only inflation affect the policy rate while output gap is found not be an important variable in the determination of the policy rate. Using the Wald test to test the hypothesis, we found that the central bank sets its interest rate based on either inflation alone or both inflation and output gap. However, the central bank does not set its interest rate according to nominal output growth. For the policy implication, this suggests that the central bank of Malaysia dampens inflationary pressure by changing its policy rate. The central bank follows the Taylor rule in formulating interest rates targeting to achieve the inflation target (price stability) and both inflation and output gap.

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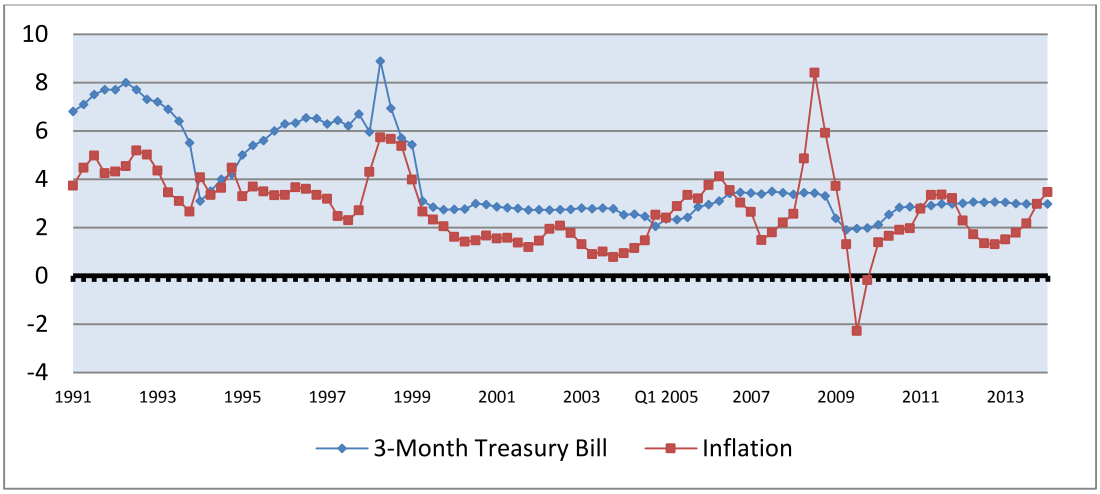
FIGURE 1: The Trend of Inflation and Nominal Interest Rates (1990:1 - 2014:1)



(Units: percentage)
Source: IMF International Financial Statistics

TABLE 1: Unit Root Results (*Augmented Dickey Fuller* (ADF))

	Constant	Constant and Trend
A. At Level I(0)		
INF	-2.2531(4)	-2.1043 (4)
NOMINT	-2.1485(1)	-2.5460 (1)
B. First Differences I(1)		
INF	-5.1706* (3)	-5.2322* (3)
NOMINT	-6.5646* (0)	-6.5716* (0)

Note: (*), (**) and (***) Significant at 1%, 5% and 10%.
The number of optimum lags in parentheses using the AIC

TABLE 2: F-statistics for Testing the Existence of a Long run Equation

F- statistics	Lag	Significance Level	Bound Critical Values* (restricted intercept and no trend)	
			I(0)	I(1)
7.2046* 6.8560* 5.7624* 3.5755***	1 2 3 4	1 %	4.458	5.410
		5 %	3.253	4.065
		10 %	2.725	3.455

*Note: * Bound critical values are based on Narayan (2004)*

TABLE 3: Estimation of the Long Run Coefficients, ARDL (2, 2) Test

Dependent variable: Nomint	
Inflation	1.0788*
	(0.3185)
Constant	0.8418
	(0.8892)

Note: (*), (**) and (***) indicate significant at 1%, 5% and 10% significance level respectively. Numbers in parentheses are standard errors.

TABLE 4: Estimation of the Short Run (VECM) Model, ARDL (2, 2) Test

Panel A: Estimated Model	
Dependent variable: D(Nomint)	
$D(Nomint)_{t-1}$	0.3290*
	(0.1079)
$D(Inflation)_{t}$	-0.0779
	(0.1069)
$D(Inflation)_{t-1}$	-0.1596
	(0.1061)
Constant	0.1331
	(0.1453)
ECT_{t-1}	-0.1581*
	(0.0439)
Panel B: Diagnostic Testing	
Serial Correlation [a]	1.5769
	[0.209]
Functional Form [b]	3.0364***
	[0.081]
Normality [c]	228.5505*
	[0.000]
Heterocedasticity [d]	12.3348*
	[0.000]

Note: ARDL (1,0,0) lag for each variable is selected based on AIC. (*), (**) and (***) indicate significant at 1%, 5% and 10% significance level respectively. [a] Lagrange multiplier test of residual serial correlation; [b] Ramsey's RESET test using the square of the fitted values; [c] Based on a test of skewness and kurtosis of residuals; [d] Based on the regression of squared residuals on squared fitted values.

TABLE 5: Taylor Rule Reaction Functions – Alternative Specifications

	Specification A	Specification B
Parameters:		
γ	0.1623* (3.0525)	0.0807*** (1.9344)
α	-8.2121** (-2.3368)	2.7421 (1.5766)
λ_1	-0.7900* (-2.6691)	-0.7483 (-1.2442)
λ_2	0.1826 (1.5441)	0.4078 (1.3713)
λ_3	0.0284 (0.2795)	0.0207 (0.0990)
λ_4	0.1097* (3.0669)	
ρ	-0.0537 (-0.5121)	-0.0771 (-0.7199)
R^2	0.1709	0.1150
Adjusted R^2	0.1117	0.0630
Diagnostic Testing:		
Serial Correlation LM Test *Ho: No serial correlation*	0.6321 [0.5341]	1.0227 [0.3641]
Jarque-Bera Normality Test *Ho: Normal*	2.8846 [0.2364]	2.8846 [0.2364]
ARCH Test *Ho: No ARCH*	0.1459 [0.7034]	1.7446 [0.1900]
Hypothesis Testing (Wald Test) F-Statistic *The central bank responds based on:*		
Inflation alone *Ho:* $\lambda_2 = \lambda_3 = \lambda_4 = 0$	3.7454** [0.0141]	1.0215 [0.3644]
Nominal Output Growth *Ho:* $\lambda_1 = \lambda_2 = -\lambda_3$	4.0827** [0.0203]	1.2053 [0.3047]
Both Inflation and Output Gap *Ho:* $\lambda_1 = \lambda_2 = \lambda_3 = 0$	2.732163* [0.0488]	0.849696 [0.4706]

*, **, *** = *Significant at 1%, 5% and 10%*
The number in ( ) and [ ] indicates the t-statistic and the probability respectively.