The Economic Research Guardian – Vol. 8(1)2018
Semi-annual Online Journal, www.ecrg.ro
ISSN: 2247-8531, ISSN-L: 2247-8531
Econ Res Guard 8(1): 11-24

How Does the Policy Rate Respond to Output and Prices in Thailand?

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Abstract
This paper empirically investigates how the policy rate as a monetary policy stance reacts to output and price level in Thailand during 2005 and 2016. An empirical relationship that characterizes the way the Bank of Thailand adjusts its policy rate to output growth and inflation is identified. The results from Johansen cointegration test show that there exists a long-run relationship of the policy rate with real GDP and prices. This long-run equation differs from the empirical Taylor-type rule. However, the result from short-run dynamics captures the short-run interest rate equation. The partial adjustment coefficient in the estimated interest rate equation is negative and highly significant, which indicates that any deviation of the policy rate from its equilibrium value is corrected by monetary policy actions. Furthermore, there is long-run causality running from inflation and economic growth to a change in the policy rate. In the short run, economic growth does not negatively cause a change in the policy rate while inflation positively causes a change in the policy rate. Also, impulse response analysis from an unrestricted VAR model indicates that a shock to inflation has a stronger impact on the fluctuations in the policy rate a shock to output growth does.

Keywords: Policy rate, Output, Prices, Error correction mechanism, Impulse responses

JEL classification: C22, C32, E52

1. Introduction

The Taylor rule proposed by Taylor (1993) is the simple rule that explains how the central bank of the United States adjusts the federal fund rate by using the current values of output gap and inflation in relation to their target values. In earlier empirical studies, researchers estimate monetary policy reaction functions for advanced countries. By pursuing monetary policy rule, the central banks conduct a sluggish partial adjustment of short-term policy interest rate. Clarida et al. (1998) estimate monetary reaction functions for Germany, Japan, the United States, France, Italy and the United Kingdom. They find that the success of monetary policy in Germany, Japan and the United States stems from an implicit adoption of inflation targeting. The central banks in these three countries respond to anticipated inflation rather than lagged inflation. For the other three countries, the central banks are heavily dominated by German monetary policy rule. Using the German central bank policy as a benchmark, they find that interest rate in these countries are higher than macroeconomic conditions when the European Monetary System collapse.

There are some arguments in the literature pertaining to the choice of interest rate and the functional form of estimated equation. Minford et al. (2003) argue that an interest rate relation with output and inflation does not identify a central bank reaction function because the central bank may follow different monetary policy rules. Mehra (2001) indicates that the United States Federal Reserve (Fed) reacts to long-term inflationary expectations in the post-1979 period. Therefore, the behavior of the long-term bond rate is more responsive to actual or expected inflation than the federal fund rate. Kim et al. (2005) investigate the nature of nonlinearity in the monetary policy rule of the Fed using the flexible approach to nonlinear inference. They find evidence of nonlinearity for the period to 1979, but little evidence for the subsequent period. Possible asymmetries in the Fed's reactions to inflation deviations from target and output gap occur in the 1960s and 1970s, but do not capture the entire nature of nonlinearity. Due to some problems with estimation of the Taylor rule, such as misspecification and inconsistency in time series analysis, Eleftheriou (2009) estimates the interest rate rule for Germany and finds evidence of a stable interest rate rule, which is similar to the Taylor rule. The long-run relationship of the policy rate with output and inflation is found. Fernandez et al. (2010) find that The Fed's partial adjustment of the federal fund rate toward an equilibrium rate depends on the unemployment rate and forward-looking inflation measures. Seip and McNown (2013) examine monetary policy in the United States for six periods. They find that the Fed changes interest rate in accordance with economic instability, i.e., movements in inflation and unemployment. Baxa et al. (2013) use recently developed monetary policy rule estimation methodology to be applied to the data of the United States, the United Kingdom, Australia, Canada and Sweden. They find that the central banks in these countries often change policy rates during the 2008-2009 global financial crisis. Most central banks respond to both stock-market stress and bank stress while they respond to exchange-rate stress when their economies are more open.

In theory, monetary policy can affect both real activity and price level. In conducting monetary policy, a central bank simply changes the size of money supply. The simple tool exercised by most central banks is open market operations. If cent banks buy securities from the public, the size of money supply will increase, and thus output and price level should increase. On the contrary, when central banks sell securities to the public, the size of money supply will be reduced, and thus output and price level should fall. The efficacy of monetary policy can be enhanced by an implementation of inflation targeting. Clarida et al. (1998) give evidence indicating that some form of inflation targeting can be a nominal anchor for monetary policy rather than fixing exchange rates. The Bank of Thailand is also associated with the concept of inflation targeting. However, its policy operationally involves the adjustment of policy rate. According to International Monetary Fund, the policy rate is the rate used by the central bank to implement or signal its monetary policy stance. In Thailand, the decisions on the policy rate are taken by the Bank of Thailand monetary policy committee. The committee will lower the policy rate when the growth rate of the country is low and inflation tends to fall. The committee will leave the policy rate unchanged when it considers that the current monetary policy is appropriate to support the economic recovery and does not pose risks to financial stability. The adjustment of policy rate is shown in Figure 1.

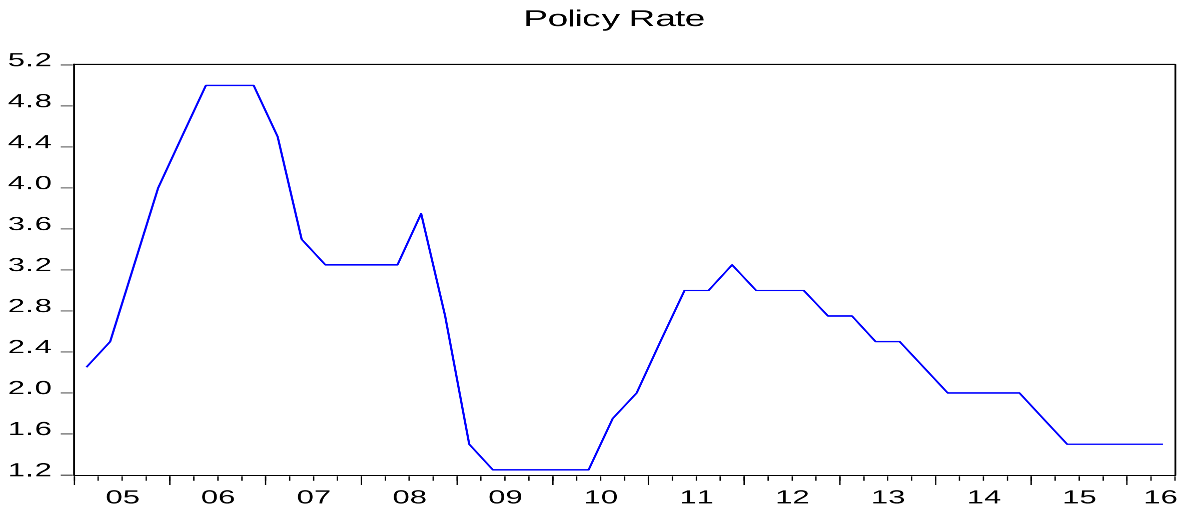

Figure 1 - Movements in the Policy Rate.

The plot of the policy rate as monetary policy stance of the bank of Thailand shows fluctuations in the rate. This rate increased from the first quarter of 2005 and decreased by the fourth quarter of 2006. The policy rate was lowest in the second quarter of 2009 and remained the same until the second quarter of 2010. The sharp drop of the policy rate was due to the impact of the global economic recession when the central banks worldwide cut policy rates sharply. Even though this rate increased from the third quarter of 2010, it started decreasing thereafter.

This paper contributes to the literature in that it extends an analysis of interest rate equation to an Asian emerging market economy and provides evidence on how the policy rate responds to output growth and the inflation rate when the Bank of Thailand adjusts the policy rate in accordance with macroeconomic conditions. The remainder of the paper is organized as follows: Section 2 describes the data, empirical model and estimations used in the analysis, Section 3 presents empirical results, and the last section draws conclusion.

2. Data and Methodology

2.1. Data

The dataset used in the analysis is quarterly time series. This dataset is retrieved from various sources. The policy rate as a measure of monetary policy stance and the long-term rate measured by 10-year government bond yield are retrieved from the Bank of Thailand website. Real GDP series is obtained from the Office of National Economic and Social Development Board while the consumer price index series is obtained from the website of Ministry of Commerce. The period of investigation is during 2005Q1 and 2016Q2, which is period of implementing inflation targeting. The number of observation is 46 because the policy rate series is available from 2005Q1 to 2016Q2, and thus the number of observations is limited by this series. All series are seasonally adjusted before being transformed to logarithmic series.

The stochastic properties of the series need to be well understood in order to obtain a consistent model. These properties may depend on the sample length and frequency of the data. The unit root tests with constant only are used to test for the order of integration in all series, which are expressed in logarithmic series. The results of unit root tests are reported in Table 1.

Table 1 - Results of Unit Root Test

Variable	ADF test	PP test	Zivot-Andrews test
A.Level			
rp (policy rate)	-2.132	-1.671	-3.754
y (real GDP)	-1.218	-1.224	-3.040
p (price level)	-2.216	-2.619*	-2.986
r (long-term rate)	-1.222	-1.118	-2.846
B. First Difference			
Δrp	-3.461**	-3.461**	-4.701**
Δy	-8.759***	-9.775***	-9.482***
Δp	-5.311***	-5.180***	-7.498***
Δr	-7.748***	-8.519***	-10.429***

Note: The optimal lag length for ADF and Zivot-Andrews tests is determined by Schwarz Information Criterion (SIC) and the optimal bandwidth of PP tests is determined by Newey-West automatic selection using Bartlett kernel. For Zivot-Andrews tests, the optimal lag is determined by SIC. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

The unit root tests for all variables used in the analysis are concerning with the optimal lag order. Besides the conventional tests, ADF and PP tests, the ADF-type of tests proposed by Zivot and Andrews (1992), which take into account of unknown structural breaks, are also employed.[1] The ADF tests show that all variables are integrated of order 1 or they are I(1) series because they contain unit root in level, but contain no unit root in first differences. However, the PP tests indicate that all variables are I(1), except for the price level that is integrated of order zero, or I(0) series because the series does not contain unit root in level. However, the level of significance of the test is only 1%. The Zivot-Andrews tests show that all variables are I(1) series. Since only one variable shows less definitive result for unit root test at low level of significance, all series are treated as I(1) in the following analysis. The time series properties of the data enable the conduct of cointegration test.

[1] The asymptotic one-sided p-values of the tests are provided by Vogelsang (1993).

2.2. Methodology

2.2.1. Cointegration Analysis

The equation representing the Taylor rule of Taylor (1993) is expressed as:

$$i_t = i^* + \alpha(\pi_t - \pi^*) + \beta y_t \quad (1)$$

where i_t is nominal short-term interest rate, r* is the targeted interest rate, π_t is inflation rate and π^* is the targeted inflation rate and y_t is real GDP. This rule is believed to be an accurate description of how the US Federal Reserve takes monetary policy decisions. This rule is also used by other central banks. Since the properties of time series are important in newly developed econometric framework, the equation to be estimated can be different from the Taylor rule. An empirical model that identifies long-run relationship among the policy rate, real GDP and price level is expressed as:

$$rp_t = a + b_1 y_t + b_2 p_t + e_t \quad (2)$$

where *r* is the log of policy rate, *y* is the log of real GDP, and *p* is the log of price level measured by CPI. For a robustness check, the four-variable model is also estimated. This model is expressed as:

$$rp_t = a + b_1 y_t + b_2 p_t + + b_3 r_t + e_t \quad (3)$$

where r_t is the log of long-term rate (10-year government bond yield).

If the variables are found to be integrated of order one, Johansen cointegration tests proposed by Johansen and Juselius (1990) and Johansen (1991) can be used. The tests employ the maximum likelihood procedure to determine the existence of cointegrating equations in nonstationary time series as a VAR model. The reduced form VAR model of order *p* is expressed as:

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \dots\dots\dots\dots\dots + \Gamma_{p-1} \Delta x_{t-p-1} + \alpha\beta' x_{t-1} + e_t \quad (4)$$

where *x* is a vector of first differences of nonstationary variables, Γ_i is the matrix of short-run parameters, and $\alpha\beta'$ is the information coefficient matrix between the levels of nonstationary series. The relevant elements of the matrix *a* are adjusted coefficients while the matrix β contains cointetrating equations. There are two likelihood ratio test statistics for the number of cointegrating equations, i.e., trace and maximum eigenvalue statistics. If the two test statistics are greater than the critical values at the 5% level of significance, cointegrating equation(s) will exist.

2.2.2. Short-Run Dynamics

The existence of cointegration allows for an analysis of short-run dynamics. The ECM based on equation (2) is expressed as:

$$\Delta rp_t = \mu + \sum_{i=1}^{k}[\beta_i \Delta r_{t-i} + \gamma \Delta y_{t-i} + \delta_i \Delta p_{t-i}] + \lambda e_{t-1} + u_t \qquad (5)$$

The coefficient of the error-correction term (e_{t-1}) captures the short-run adjustment while the short-run dynamics are depicted by the coefficients of the lagged values of first differences of all series. The optimal lag for the ECM model, *k*, can be selected by various criteria. However, the ECM model should pass diagnostic tests, specifically serial correlation test, heteroscedasticity and normality tests of the residuals. The ECM based on equation (3) is expressed as:

$$\Delta rp_t = \mu + \sum_{i=1}^{k}[\beta_i \Delta r_{t-i} + \gamma \Delta y_{t-i} + \delta_i \Delta p_{t-i} + \varphi_i \Delta r_{t-i}] + \lambda e_{t-1} + u_t \qquad (6)$$

Equations (5) and (6) can be used to perform short-run and long-run causality analysis.

It should be noted that equation (2) does not represent the Taylor-type rule. However, partial adjustment can be perfectly captured by the dynamics of the model in equation (4) when only one cointegrating relation is found. In other words, equation (3) is the short-run interest rate equation (Eleftheriou, 2009).

3. Empirical Results

In this section, the results of cointegration tests, short-run dynamics, causality tests and impulse response analysis are presented. The results of unit root test with unknown structural shifts of Zivot and Andrews indicate that the breakpoint of key variables (real GDP and price level) is 2008Q3, which is during the 2008-2009 global financial crisis (see Baxa et al., 2013). Therefore, the dummy variable (D_t) is used as an exogenous variable in Johansen cointegration tests.[2]

3.1. Three-Variable Model

Since all variables are I(1) series as shown by the results of unit root test reported in Table 1, Johansen cointegration tests without deterministic trend are performed with the lag of 2 determined by Schwarz Information Criterion (SIC).[3] The simple model with three variables [r_t, y_t, p_t] of equation

[2] Even though the critical values might not be altered by including an exogenous variable, the estimated coefficients can be affected.

[3] Due to a relative small sample in the analysis, Akaike information criterion (AIC) is not used because this criterion usually selects a larger optimal lag length.

(2) is estimated and the 2008 global economic crisis dummy variable is treated as an exogenous variable. The results are reported in Table 2.

The results in Table 2 show that there is a cointegrating relationship among the log of policy rate, the log of real GDP, and the log of price level.

Table 2 - Results of Cointegration Tests

A: Trace Test			
Coint. Rank	Trace statistic	5% Critical value	p-value
None*	48.450	24.276	0.000
Almost 1*	27.543	12.321	0.000
Almost 2*	6.833	4.130	0.011
B: Max Eigenvalue Test			
Coint. Rank	Max-Eigen statistic	5% Critical value	p-value
None*	27.187	17.797	0.015
Almost 1*	20.430	11.225	0.001
Almost 2*	6.833	4.130	0.011

Note: * denotes rejection of the hull hypothesis of no cointegration at the 5% level and p-values are provided by MacKinnon et al. (1999).

The estimated long-run relationship between the policy rate and the other two macroeconomic variables is reported in Table 3.

Table 3 - Results of Long-Run Relationship

Dependent Variable: rp_t

Variable	Coefficient	Standard Error	t-Statistic
y_t	10.901**	4.467	2.452
p_t	-14.498**	5.919	-2.449

Note: ** indicates significance at the 5 percent level.

The long-run relationship between the policy rate and the two indicators (output and price level) does not bear a resemblance to a Taylor-type rule for the interest rate. The estimated long-run equilibrium equation shows that real GDP (y) is positively related to the policy rate (rp). Equation (4) cannot be interpreted as an IS curve because output is not negatively related to interest rate. The estimated coefficient is large, which indicates that a 1 percent increase in real GDP causes the policy rate to increase by 10.90 percent. Therefore, this positive relationship is consistent with the policy stance of the Bank of Thailand. Regarding the impact of price level, the price level is negatively related to the policy rate, i.e., a 1 percent increase in price level causes the policy rate to decrease by 14.50 percent. This phenomenon indicates the lack of the Fisher effect since nominal interest rate will not be positively adjusted to the rate of inflation

It should be noted that the positive relationship between real GDP and the policy rate might seem reasonable. As a matter of fact, the policy rate is used by the Bank of Thailand to signal its monetary

stance. This rate is adjusted to accommodate economic growth. In other words, this rate is raised when the growth rate is high and vice versa. Therefore, the positive relationship between the two variables is observed. However, the relationship between the policy rate and price level is significantly negative. The rationale for this relationship is that an increase in price level may be associated with an increase in real GDP, and thus the Bank of Thailand tends to adjust the policy rate downward and vice versa.
The finding of one cointegrating equation enables an estimation of short-run dynamics from the ECM framework. The partial adjustment that is captured by the dynamics of the estimated model representing the short-run interest rate equation is reported in Table 4.

Table 4 - Results of Short-Run Dynamics

Dependent Variable: Δrp_t

Variable	Coefficient	Standard Error	t-Statistic
e_{t-1}	-0.129***	0.034	-3.842
Δrp_{r-1}	0.244*	0.186	1.952
Δrp_{r-2}	0.186	0.121	1.532
Δy_{r-1}	-3.325	0.717	-0.453
Δy_{r-2}	-0.703	0.639	-1.099
Δp_{r-1}	7.461***	1.343	5.555
Δp_{r-2}	1.701	1.717	0.991
Intercept	-0.057**	0.020	-2.842

Adjusted R^2 = 0.634, F = 13.375
Diagnostic Tests:
Serial Correlation: LM Statistic = 7.341 (p-value = 0.602)
Heteroskedasticity: $\chi^2_{(1)}$ = 97.033 (p-value = 0.444)
Normalilty: Jarque-Bera Statistic = 0.858 (p-value = 0.651)

Note: ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively.

Since there exists a cointegrating relation between the policy rate and the two macroeconomic variables (real GDP and price level, only one ECM model can be analyzed. As mentioned in Section 2, various criteria can be used to select the optimal lag order of the ECM model. Since the sample size is relatively small, the lag order of 2 determined by SIC is used, and necessary diagnostic tests are performed. The estimated ECM passes diagnostic tests for serial correlation because the LM statistic shows that the null hypothesis of no serial correlation cannot be rejected. The Chi-square statistic also reveals that the null hypothesis of no heteroskedasticity is accepted and thus the estimated model contains constant variances. In addition, the Jarque-Bera statistic indicates the absence of non-normality in the residuals.

The estimated coefficient of the error-correction term (e_{t-1}) in the interest rate equation captures the adjustment to the long-run equilibrium relationship. This coefficient is negative and significant at the 1% level. This coefficient has the absolute value of less than one, which indicating that any deviation from the long-run equilibrium will be corrected by monetary policy actions. Specifically, a negative 1 percent deviation from the equilibrium causes the policy rate to increase by 13 basis points in the next period. The significance of the estimated coefficient of the error-correction term also implies that the long-run relationship is stable. This finding is in line with the finding by Eleftheriou (2009) for the case of Germany.

3.2. Four-Variable Model

The results of cointegration tests of equation (3), which includes the dummy variable are reported in Table 5.

Table 5 - Results of Cointegration Tests

A: Trace Test			
Coint. Rank	Trace statistic	5% Critical value	p-value
None*	64.961	54.079	0.004
Almost 1*	35.452	35.193	0.047
Almost 2	15.840	20.262	0.182
Almost 3	5.790	9.165	0.208
B: Max Eigenvalue Test			
Coint. Rank	Max-Eigen statistic	5% Critical value	p-value
None*	29.509	28.588	0.038
Almost 1	19.509	22.299	0.114
Almost 2	10.051	15.892	0.329
Almost 3	5.790	9.165	0.208

Note: * denotes rejection of the hull hypothesis of no cointegration at the 5% level and p-values are provided by MacKinnon et al. (1999).

The results of cointegration tests show that there are two cointegrating equations. Since the main focus is on the first cointegrating equation, the second cointegrating equation is not analyzed.
The long-run relationship between the policy rate and other three explanatory variables are presented in Table 6.

Table 6 - Results of Long-Run Relationship of the four-variable model

Dependent Variable: rp_t

Variable	Coefficient	Standard Error	t-Statistic
y_t	10.933**	4.477	2.442
p_t	-14.428**	5.804	-2.469
r_t	0.075	0.826	-0.094

Note: ** indicates significance at the 5 percent level.

The long-run relationship seems to be similar to that of the three-variable model but the coefficient of the long-term interest rate is not significant. The short-run dynamics of the four-variable model are reported in Table 7.

The Economic Research Guardian – Vol. 8(1)2018
Semi-annual Online Journal, www.ecrg.ro
ISSN: 2247-8531, ISSN-L: 2247-8531
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Table 7 - Results of Short-Run Dynamics of the four-variable model

Dependent Variable: Δrp_t

Variable	Coefficient	Standard Error	t-Statistic
e_{t-1}	-0.131***	0.034	-3.877
Δrp_{r-1}	0.334*	0.162	2.065
Δrp_{r-2}	0.192	0.140	1.374
Δy_{r-1}	-0.405	0.730	-1.554
Δy_{r-2}	-0.552	0.053	-0.844
Δp_{r-1}	5.177**	2.201	2.532
Δp_{r-2}	1.852	2.368	0.782
Δr_{r-1}	0.228	0.165	1.380
Δr_{r-2}	0.003	0.191	0.016
Intercept	-0.040	0.024	-1.617
Adjusted $R^2 = 0.632$, F = 9.005			
Diagnostic Tests:			
Serial Correlation: LM Statistic = 18.168 (p-value = 0.314)			
Heteroskedasticity: $\chi^2_{(1)}$ = 182.332 (p-value = 0.437)			
Normalilty: Jarque-Bera Statistic = 1.589 (p-value = 0.437)			

Note: ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively.

The results presented in Table 7 are similar to the results of short-run dynamics of the three-variable model. The estimated ECM passes all diagnostic tests. The sign of the error correction term is significantly negative with the absolute value of less than one. This implies that any deviation from the long-run equilibrium will be corrected. As appeared in the three-variable model, at least one coefficient of lagged inflation is significant at the 5% level while no lagged output growth is significant. However, the coefficients of the lagged long-term rate are not significant. This finding is consistent with the finding that there is no positive long-run relationship between the policy rate and long-term interest rate. According to Bernanke and Blinder (1992), the long-term bond rate should be added to the model because of the role of the yield curve is important in recent monetary policy analysis. However, most emerging bond markets are not well-developed. Therefore, there is no response of the policy rate to the long-term bond yield.

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3.3. Causal Relationships

The results of causality tests are reported in Table 8.

Table 8 - Results of Causality tests

Null Hypothesis	Wald F-statistic	p-value
Growth and inflation does not cause the policy rate.	14.244***	0.001
Growth does not cause the policy rate.	1.787	0.190
Inflation does not cause the policy rate.	28.539***	0.000

Note: *** and ** indicate significance of the 1 and 5 percent level, respectively.

There are causal relationships between output growth, inflation and the movement of policy rate. Since the results in Table 4 allow for causality tests in both long-run and short-run causations.

The results in Table 8 are obtained from Wald coefficient restriction tests on the coefficient of the error-correction terms and the coefficients of lagged independent variables (output growth and inflation). There is a long-run causality running from growth and inflation to the policy rate adjustment. In the short run, output growth does not cause the policy rate to fall while inflation causes the policy rate to rise. It can be concluded that the short-run adjustment seems to be different from the long-run adjustment.

3.4. Impulse Responses

In performing the estimation of the unrestricted VAR model, all variables in their first differences are used. The results of the analysis of impulse responses are shown in Figure 2.

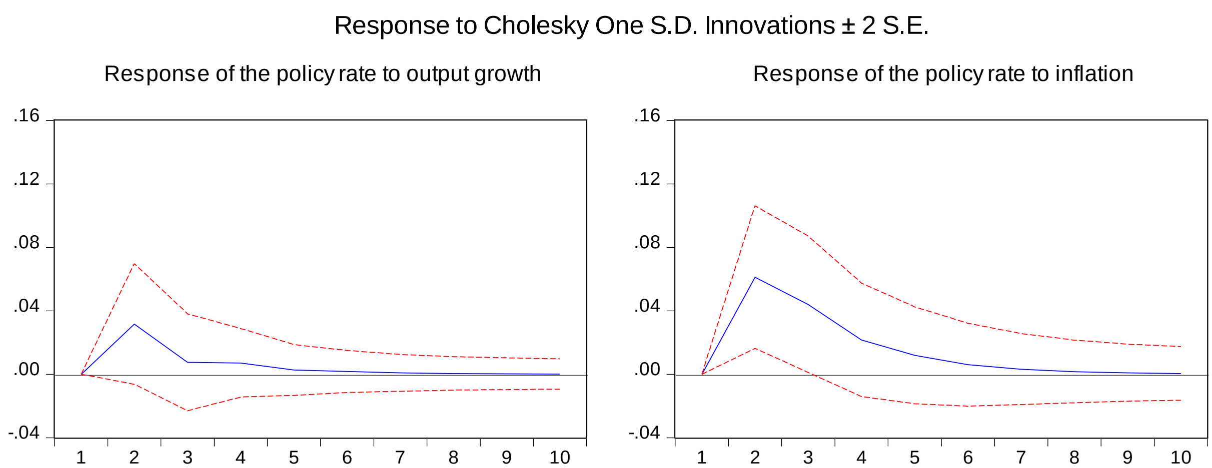

Figure 2 - Impulse Responses of Policy Rate to Output Growth and Inflation

In Figure 2, the solid lines are point estimates of the impulse responses of the policy rate due to a one standard deviation of output growth and inflation. The dashed lines contain the 95% error bands. The response horizon is in quarters. The response of the policy rate due to a positive output shock shows that the policy rate increases with a lag of about one quarter. The rising of the policy rate does not last long enough because the policy rate starts falling in just one quarter. After the second quarter, the policy rate starts falling and dissipates in the sixth quarter. The output shock seems to cause fluctuation in the policy rate. The response of the policy rate due to a positive inflation shock shows that the policy rate also increases with a lag of about a quarter. The policy rate starts to decline within two quarters and dissipates within eight quarters. It should be noted that the impact of an inflation shock on the policy rate adjustment is stronger than the impact of a shock to output growth. It should be noted that the implementation of inflation targeting by the Thai monetary authority might not be a nominal anchor for monetary policy as mentioned by Clarida et al. (1998) because the impact of an inflation shock seems to be more severe than the impact of a shock to growth shock.

3.5. Discussion

This paper shows that the estimated interest rate equation explains the importance of economic growth and inflation on the adjustment of the policy rate quite well. Therefore, nonlinear models as investigated by Kim et al. (2005) might not be needed. However, the exchange rate and foreign interest rate are cannot included in this study due to a relatively small sample size. Furthermore, stock market stress mentioned by Baxa et al. (2013) is not included in the model. Therefore this study has some limitations. A larger model for estimation is left for future research.

4. Conclusion

The econometric properties of the data are important in estimating the Taylor-type rule of monetary policy. Without taking into account of stationarity of the data, the models can be mis- specified and the results are inconsistent. This paper employs cointegration technique and VAR model to investigate the impact of output and price level on the policy rate in Thailand during the period that inflation targeting has been implementing. The results show that there exists a long-run relationship of the policy rate with real GDP and price level. The estimated short-run interest rate equation is obtained from short-run dynamics. The estimated long-run equation seems to be stable because the coefficient of the error correction term has a negative sign with the absolute value of less than one. In addition, there is long-run causality running from output growth and inflation to the policy rate adjustment. In the short-run, only the inflation rate causes the policy rate while output growth does not cause it. The impulse responses generated in this paper indicate that a shock to inflation rate has a stronger impact on fluctuations in the policy rate than a shock to output growth does. Without inflation targeting, the variations of the policy rate might be larger. Therefore, policymakers should maintain the inflation targeting scheme for the success of monetary policy.

Acknowledgements

This research paper is partially funded by National Institute of Development Administration, Bangkok, Thailand.
The author would like to thank anonymous referee for helpful comments and suggestions.

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