

## MONETARY POLICY SHOCK ON INFLATION, OUTPUT, AND EXCHANGE RATE

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### **Abstract**

*This study aims to estimate the impact of monetary policy shocks on inflation, output, and exchange rates during the inflation-targeting period. The data analyzed are quarterly data covering the period 2005Q3 - 2020Q1. The analysis tool used is the Vector Error Correction model with the cointegration relationships between variables. The results show that there are variations in the impact of the monetary policy shock on the response of the variables in the model. Monetary policy shocks can explain the forecast error variance of policy interest rates, inflation, exchange rates, and output, respectively, with the largest to the smallest contribution. The characteristics of shocks are unexpected and unpredictable, resulting in variability and volatility of the variable responses. Therefore, reducing the monetary policy shock can improve the effectiveness of the monetary policy. Improving the effectiveness of monetary policy can be done with the support of the central bank's credibility.*

**Keywords:** *monetary policy shocks; Vector Error Correction model; forecast error variance; policy interest rates; central bank credibility*

### INTRODUCTION

The effectiveness of monetary policy is a long-standing question that is still an interesting issue to be discussed in the literature on monetary economics and central banking, especially in the era of inflation targeting. Inflation targeting by central banks can be used as a strategy to reduce fluctuations in the business cycle. Inflation targeting has a positive effect on the synchronization of the business cycle (Flood & Rose, 2010). The success in reducing fluctuations in the business cycle is an indication of the effectiveness of monetary policy in stabilizing the economy, especially output and prices. A study conducted by Cho and Rhee (2015) found evidence of the success of inflation targeting in stabilizing fluctuations in the business cycle.

The effectiveness of monetary policy can be affected by a monetary policy shock. Monetary policy shock is one type of shock in the economy. Shocks in economics are defined as unpredictable or unexpected events that affect the economy. These shocks can affect both positively and negatively. Technically, shocks are unpredictable changes in exogenous factors. Unpredictable exogenous factors are factors that cannot be explained by economic models, but they can affect endogenous economic variables. However, according to Sims (1980), the shock is claimed to be atheoretical. The response of economic variables, such as output and employment, at the time of shock and the next time, is measured by the impulse response function (Lütkepohl, 2008). In the context of monetary policy, shocks occur when the central bank changes the pattern of interest rates or controls the money supply, without sufficient early warning, to control inflation or maintain price stability. However, monetary policy shock is relatively important in explaining fluctuations in the business cycle as stated by Rossi and Zubairy (2011).

Ramey (2016) reviewed the many recent innovations for identifying shocks and there are three main shocks, namely monetary, fiscal, and technology. Monetary policy shock can have a large impact, however, likely, monetary shocks will no longer be an important source of macro instability. Regarding policy shocks, for example, Bernanke and Blinder (1992) identify federal funds rate shocks as monetary policy shocks and use this type of identification.

Monetary policy, which tends to be carried out more systematically at present, causes monetary policy shocks which are rare nowadays. Its identification as a real monetary policy shock is largely the effect of better information on the part of the central bank, the foresight of agents, and noise. While this is bad news for econometric identification, it is good news for economic policy. Uhlig (2005) states that contractionary monetary policy shock does not have a clear effect on real output. Meanwhile, prices move gradually in response to monetary policy shocks. These results conclude that monetary policy shock has an ambiguous real effect.

However, according to Kim and Lim (2018), research-based model construction for a small open economy and in the inflation-targeting period as long as the policy is consistent, so the results of the study will provide results that do not lead to the puzzle. However, according to Kim and Lim (2018), research is based on model construction for a small open economy and in the inflation target period as long as the policy is consistent, the results of the study will not lead to a puzzle. This contrasts with previous findings of some puzzles, such as price, output, and exchange rate puzzles.

At the academic level and among policymakers, the question of why and to what extent monetary policy has a real effect on macroeconomic variables, especially output, inflation, and exchange rates is still the main motivation in carrying out their studies. From previous studies, there has been a broad consensus that monetary shocks do have a real effect on output. The extensive empirical literature has documented the delayed and persistent effects of monetary policy shocks on output (Olivei & Tenreyro, 2007). In addition, the output response is generally persistent and common with considerable delays. A typical impulse response represents output that peaked six to eight quarters after a monetary policy shock.

Murgia (2020) investigates how the impact of European Central Bank (ECB) monetary policy shocks on output and inflation. The results show that industrial production has decreased by more than 0.5% due to an unpredictable positive monetary policy shock of 100 basis points. Meanwhile, inflation responded weakly with a very small drop of only 0.05%. Kim (2014) states that contractionary monetary policy shocks, which increase interest rates, appreciate local currencies. The local currency appreciates significantly in the short run as predicted by most theories.

So far, research results show that there are variations in the effects of monetary policy shocks on the economy. However, the real effect of policy shock is consistently found in various approaches (Coibion, 2012). He suggests that the measurement of alternative monetary policy shocks from the Taylor rule estimate has a moderate real effect. It also shows that the historical contribution of monetary policy shocks to real fluctuations especially during the 1970s and early 1980s is significant. Monetary policy shock may cause reduced effectiveness in stabilization because it has an impact on macroeconomic volatility as found by Salisu and Gupta (2020), in addition to having an impact on response variability as found by Ahmad and Ranagaraju (2020) and Singh and Di Crestvolant (2020).

There is a close relationship between the level of credibility of the central bank and monetary policy shock. The more credible the central bank is, the more capable it will be to implement monetary policy effectively in achieving price stability. The smaller the shock effect that works due to the high credibility of the central bank, the more effective monetary policy will be in influencing macroeconomic variables, especially output, inflation, and exchange rates. The results of a study conducted by Moreira (2012) explained that the higher the level of credibility, the lower the sensibility to observed deviations. As a consequence, the flexibility of the central bank will be higher in stimulating the economy without expressive unstable results.

The motivation of this study is that the results are still ambiguous and varied regarding the impact of the monetary policy shock from previous studies. Although inflation targeting is expected to increase the effectiveness of the monetary policy, monetary policy shocks due to uncertainty are expected to continue to impact macroeconomic variables, especially inflation, output, and the exchange rate. This study aims to estimate the impact of monetary policy shocks on inflation, output, and the exchange rate during the inflation-targeting period in Indonesia. Monetary policy shocks are associated with policy interest rate shocks. The policy interest rate is the right instrument for measuring the effectiveness of monetary policy as in some arguments by Kutu and Ngawala (2016), and Arwatchanakarn (2019).

## METHODS

The definition of shock applied in this study is the definition according to Sims (1980). The term shock in question is innovation, which is the residual of the analyzed reduced form VAR model. The VAR model developed involves variables that represent the main targets of monetary policy through policy interest rates, namely inflation, exchange rates, and output. The term monetary policy shock in this case is a policy interest rate shock. The policy interest rate used by the central bank in Indonesia during the inflation-targeting period is the BI rate/BI seven days repo rate (BI7DRR). Therefore, the measure of monetary policy shock, in this case,

is the BI rate/BI7DRR shock. In the reduced form VAR model, this shock is innovation, which is the residual of the monetary policy equation.

In this study, the variables involved in the model are considered as variables that are closely related to the impact of monetary policy as targets to be achieved, namely output, inflation, and exchange rates, in addition to policy interest rates. Including many other variables in the VAR model to assess the importance of monetary policy shock would be misleading. This thinking is in line with the arguments of Lovcha and Perez-Laborda (2018).

Inflation is measured by the percentage change in the consumer price index (CPI) year on year. Output is represented by real gross domestic product with the base year of 2000. Meanwhile, the exchange rate is measured in US dollars per rupiah and expressed in natural logarithms. Output is real GDP (2000 = 100) in billion rupiahs expressed in natural logarithms. The variables of the policy interest rate, inflation, output, and exchange rate are denoted by PIR, INF, OUTPUT, and ER, respectively. The data analyzed are quarterly data covering the period 2005Q3-2020Q1. Data for all variables are accessed online from Bank Indonesia. The analysis period covered is the period of targeting inflation in Indonesia, where the policy interest rate is set as the monetary policy stance in response to inflation in particular and macroeconomic conditions in general.

The model presented in this analysis is the Vector Error Correction Model (VECM), which is an extension of the standard Vector Autoregression (VAR) model by including cointegration between variables in the model. The theoretical basis can be used in this model which is reflected in the relationship between variables in the cointegration equation. If there is cointegration in the VAR model, the model can be developed into a VECM in studies involving shocks (Zou, 2018). The VECM is a special case of VAR for variables that are stationary at the first difference (i.e., I(1)). The form of the VAR model is as follows:

$$\Delta INF_t = \sum_{i=1}^k \alpha_{1i} \Delta INF_{t-i} + \sum_{i=1}^k \beta_{1i} \Delta LNOUTPUT_{t-i} + \sum_{i=1}^k \gamma_{1i} \Delta LNER_{t-i} + \sum_{i=1}^k \lambda_{1i} \Delta PIR_{t-i} + u_t^{\Delta INF} \dots\dots\dots(1)$$

$$\Delta LNOUTPUT_t = \sum_{i=1}^k \alpha_{2i} \Delta INF_{t-i} + \sum_{i=1}^k \beta_{2i} \Delta LNOUTPUT_{t-i} + \sum_{i=1}^k \gamma_{2i} \Delta LNER_{t-i} + \sum_{i=1}^k \lambda_{2i} \Delta PIR_{t-i} + u_t^{\Delta LNOUTPUT} \dots\dots(2)$$

$$\Delta LNER_t = \sum_{i=1}^k \alpha_{3i} \Delta INF_{t-i} + \sum_{i=1}^k \beta_{3i} \Delta LNOUTPUT_{t-i} + \sum_{i=1}^k \gamma_{3i} \Delta LNER_{t-i} + \sum_{i=1}^k \lambda_{3i} \Delta PIR_{t-i} + u_t^{\Delta LNER} \dots\dots\dots(3)$$

$$\Delta PIR_t = \sum_{i=1}^k \alpha_{4i} \Delta INF_{t-i} + \sum_{i=1}^k \beta_{4i} \Delta LNOUTPUT_{t-i} + \sum_{i=1}^k \gamma_{4i} \Delta LNER_{t-i} + \sum_{i=1}^k \lambda_{4i} \Delta PIR_{t-i} + u_t^{\Delta PIR} \dots\dots\dots(4)$$

If INF, LNOUTPUT, LNER, and PIR are I(1) and cointegrated, the system of equations can be modified by allowing cointegrating relationships between I(1) variables. This model was later referred to as the VECM. Therefore, in this analysis, a unit root test is needed to determine whether the data series are I(1) or not. Furthermore, the cointegration test is carried out to determine the cointegrating relation between variables. Regarding the results of the analysis, the interpretation of the estimation results of the VECM that must be interpreted is the impulse response function and variance decomposition. The impulse response function is utilized to determine the response of the variable in focus to the shock that occurs within a certain time horizon. Meanwhile, variance decomposition is used to determine the contribution of shocks which can explain the forecast error variance of the variable in focus, so that it can be seen that shock is the dominant external shock that explains the forecast error variance of a variable.

## RESULTS

The first step in the model analysis is to perform the unit root test. The results of the unit-roots test using the Augmented Dickey-Fuller (ADF) test are reported in Table 1, which shows that all variables are I (1).

Table 1. Unit Root Test of Variables

Variables	ADF test	
	Level	First Difference
PIR	-1.0558	-4.1366***
INF	-2.2258	-7.0174***
LNOUTPUT	-0.9836	-8.4569***
LNER	-0.0571	-6.0485***

\*\*\* p-value < 0.01

Furthermore, the results of the cointegration test presented in Table 2 show that there are two cointegration relations. Therefore, the standard VAR model can be developed into a VECM. Two cointegration equations that can be identified and involved in the model can be presented in the following equation (5).

Table 2. The Result of Cointegration Test

H <sub>0</sub>	H <sub>1</sub>	Trace Statistic	0.05 Critical value	Prob.	Max-Eigen Statistic	0.05 Critical value	Prob.
r = 0	r = 1	73.2614*	47.8561	0.0000	37.1453*	27.5843	0.0022
r < 1	r = 2	36.1161*	29.7971	0.0082	24.2562*	21.1316	0.0175
r < 2	r = 3	11.8599	15.4947	0.1638	8.3352	14.2646	0.3457
r < 3	r = 4	3.5247	3.8415	0.0605	3.5247	3.8415	0.0605

\* significant at the critical value of 0.05, indicating 2 cointegrating equations

The first cointegration equation shows the relationship between inflation to the exchange rate and policy interest rates. The second cointegration equation shows the relationship between output to the exchange rate and the policy interest rate. Inflation has a positive relationship with the exchange rate and policy interest rates. Meanwhile, output has a negative relationship with the exchange rate and policy interest rates. The cointegration relationship in the output equation shows a relationship that is following the theory's expectations. Furthermore, equation (6) is a system of equations that shows the estimation results of the VECM parameters. The VECM estimation is based on the results of the best model selection that takes into account the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), and diagnostic checks.

$$\begin{bmatrix} 1.7181 & 1.4339 \\ -0.7565 & -0.0777 \end{bmatrix} \begin{bmatrix} LNER \\ PIR \end{bmatrix} + \begin{bmatrix} 11.9610 \\ 6.8951 \end{bmatrix} [C] = \begin{bmatrix} INF \\ LNOUTPUT \end{bmatrix} \dots\dots\dots (5)$$

$$\begin{bmatrix} -1.0131 & -4.7627 \\ -0.0013 & -0.0000 \\ -0.0235 & -0.2717 \\ -0.0549 & -3.8543 \end{bmatrix} \begin{bmatrix} CE_1 \\ CE_2 \end{bmatrix} + \begin{bmatrix} 0.3053 & 0.5153 & 0.5055 & -0.0102 \\ 0.0006 & 0.0005 & 0.0006 & 0.0010 \\ 0.0157 & -0.0004 & 0.0023 & 0.0132 \\ -0.0067 & 0.1060 & 0.0195 & -0.0423 \end{bmatrix} \begin{bmatrix} \Delta INF_{t-1} \\ \Delta INF_{t-2} \\ \Delta INF_{t-3} \\ \Delta INF_{t-4} \end{bmatrix} +$$

$$\begin{bmatrix} 2.3970 & -7.1759 & 0.1365 & 3.3348 \\ -0.2714 & -0.3408 & -0.3080 & 0.7087 \\ -0.1751 & 0.0268 & -0.3718 & -0.3396 \\ 23.4755 & 15.7641 & 20.1464 & 18.7459 \end{bmatrix} \begin{bmatrix} \Delta LNOUTPUT_{t-1} \\ \Delta LNOUTPUT_{t-2} \\ \Delta LNOUTPUT_{t-3} \\ \Delta LNOUTPUT_{t-4} \end{bmatrix} +$$

$$\begin{bmatrix} 0.3912 & -1.0989 & 1.4249 & -6.3273 \\ 0.0026 & 0.0089 & 0.0246 & -0.0140 \\ 0.1863 & -0.2879 & 0.0638 & -0.0767 \\ -0.6295 & -0.1561 & -0.7466 & -1.6159 \end{bmatrix} \begin{bmatrix} \Delta LNER_{t-1} \\ \Delta LNER_{t-2} \\ \Delta LNER_{t-3} \\ \Delta LNER_{t-4} \end{bmatrix} +$$

$$\begin{bmatrix} 0.9307 & -0.5382 & -0.6823 & -0.3770 \\ -0.0012 & 0.0007 & -0.0027 & -0.0008 \\ -0.0389 & 0.0340 & 0.0109 & -0.0052 \\ 0.7013 & -0.0950 & -0.2048 & 0.2840 \end{bmatrix} \begin{bmatrix} \Delta PIR_{t-1} \\ \Delta PIR_{t-2} \\ \Delta PIR_{t-3} \\ \Delta PIR_{t-4} \end{bmatrix} + \begin{bmatrix} -0.0152 \\ 0.0160 \\ 0.0040 \\ -1.0979 \end{bmatrix} [C] = \begin{bmatrix} \Delta INF \\ \Delta LNOUTPUT \\ \Delta LNER \\ \Delta PIR \end{bmatrix} \dots\dots\dots (6)$$

Furthermore, the estimation results of the VECM equation system in equation (6) provide meaningful information from the impulse response function and variance decomposition. Diagnostic checks on the VECM estimation results are given in Table 3. The results show that the model estimation has passed the problems of non-normality, serial correlation, and heteroscedasticity.

Table 3. ECM Model Diagnostic Checks

Diagnostic Elements	Equation			
	ΔINF	ΔLNOUTPUT	ΔLNER	ΔPIR
R <sup>2</sup>	0.5900	0.9503	0.5374	0.6234
Adjusted R <sup>2</sup>	0.4055	0.9280	0.3293	0.4539
F-Stat	3.1980	42.5360	2.5820	3.6783
AIC	3.9834	-7.0689	-3.2783	1.7218
SIC	4.6525	-6.3999	-2.6093	2.3909
JB Stat			1.2514	
SC LM test			22.5837	
Chi-sq Het test			345.3379	

## DISCUSSIONS

The impulse response functions are presented in Figure 1. The inflation response to monetary policy shock was quite quick in the first three quarters, then declined through 8 quarters. However, the inflation response shows up and down. The existence of monetary policy shock with a magnitude of one standard deviation is responded to by inflation by rising and then falling. Over an observed time horizon of 20 quarters, the inflation response is volatile. Unexpected changes in the policy rate every 25 basis points have an impact on the pattern of the up and down inflation response and do not show a fading effect after 20 quarters. These results indicate that the effect of the monetary policy shock is permanent with an up and down pattern but with a diminishing shock effect. This condition has an impact on the effectiveness of the monetary policy, which uses policy interest rates to stabilize prices. However monetary policy shock is not the dominant shock that affects inflation. There is also an exchange rate shock that has an impact on inflation with almost the same effect but in the opposite direction.

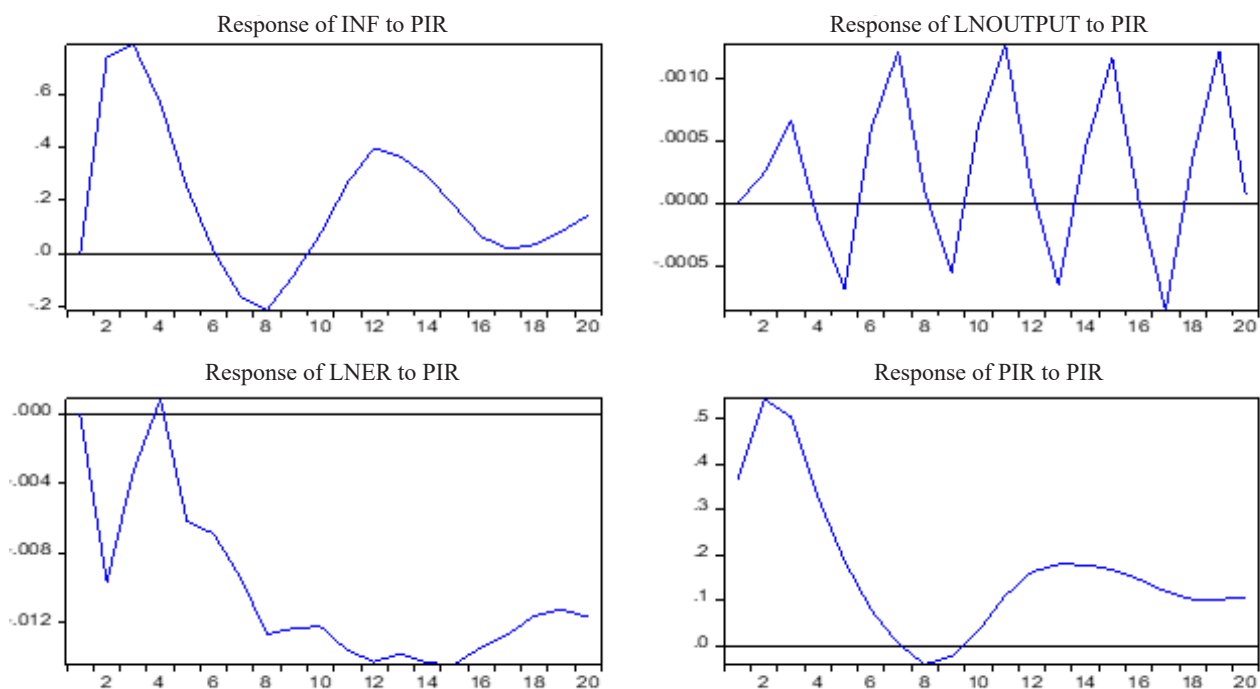


Figure 1. Response of Inflation, Output, Exchange Rate, and Policy Interest Rate to Monetary Policy Shock

Output responds to monetary policy shocks with fluctuating rising and falling patterns. This output response pattern follows the pattern of economic fluctuations as measured by quarterly real GDP. There is a permanent response that fluctuates over a 20-quarter time horizon. The existence of a permanent fluctuating response from output to monetary policy shock causes obstacles to achieving the effectiveness of monetary policy in stabilizing output. The effect of unpredicted factors on changes in real output determines the quarterly movement of fluctuating output. The movement pattern of real output is largely determined by short-run aggregate demand. This condition poses a challenge for the central bank in implementing effective monetary policy in stabilizing output through changes in policy interest rates.

Based on the variance decomposition in Figure 2, in the first five quarters, the forecast error variance of inflation can be explained by the policy interest rate shock with a larger proportion than the exchange rate shock. However, after the fifth quarter, the condition reversed where the exchange rate shock was able to explain with a larger proportion than the policy interest rate shock. This result is in line with the findings in a previous study conducted by Arintoko and Insukindro (2017), that exchange rate shock has an important impact on macroeconomic variables including output and inflation. In an economy that applies inflation targeting, the role of the exchange rate in efforts to stabilize prices and output is very important.

However, in particular, when viewed from the variance decomposition, forecast error variance of output is explained more by inflation shocks than monetary policy shocks. Meanwhile, policy interest rate shocks as monetary policy shocks have a very small contribution in determining the forecast error variance of output to macroeconomic shocks.

The forecast error variance of the exchange rate is also explained by the monetary policy shock. The exchange rate responds to monetary policy shocks by falling and rising during the first four quarters and then tending to fall within a 20-quarter time horizon. Overall, the forecast error variance of the exchange rate is caused more by inflation shock than by interest rate shock and output shock.

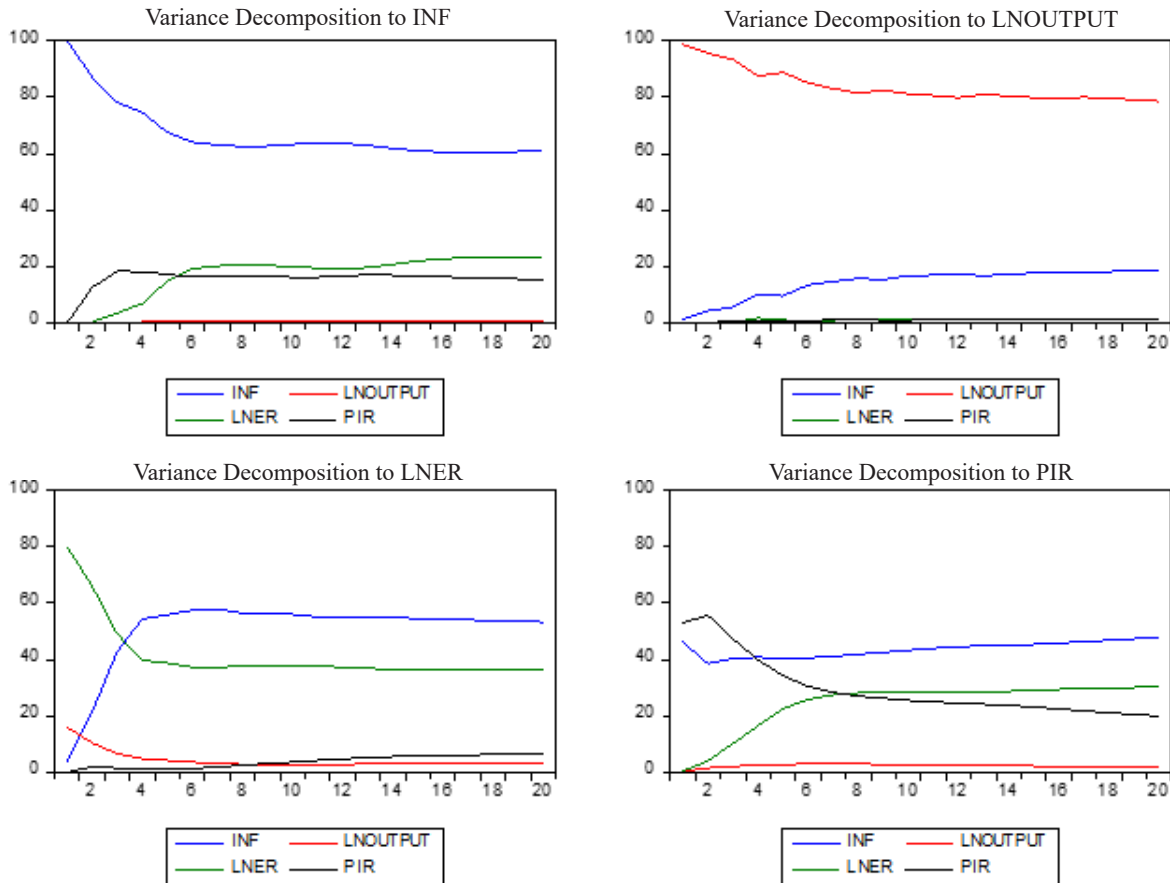


Figure 2. Variance Decomposition of Inflation, Output, Exchange Rate, and Policy Interest Rate

Based on the variance decomposition, monetary policy shocks do not become the dominant shocks as exogenous shocks which explain the forecast error variance of inflation, output, and exchange rates. The contribution to explaining, in general, is very small, although there is a permanent contribution, especially to forecast error variance in inflation and exchange rates. This result is a positive indication of the achievement of monetary policy effectiveness because the strong effect of shock will hinder the effectiveness of monetary policy through changes in policy interest rate. The shock when working to affect macroeconomic variables can run counter to theoretical logic because shock reflects behavior that was not predicted and expected.

Overall, monetary policy shocks explain the forecast error variance of the policy interest rate with the largest proportion. For the second-largest proportion, monetary policy shocks explain the forecast error variance of inflation. Meanwhile, the forecast error variance of exchange rate and output is explained by monetary policy shocks with a smaller proportion.

However, the effectiveness of monetary policy can be achieved optimally if the presence of monetary policy shocks is minimized. The smaller the impact of monetary policy shock on inflation, exchange rate, and output variables, the more effective monetary policy within the inflation targeting framework will be. To improve the effectiveness of monetary policy by targeting inflation through changes in policy interest rates, it is necessary to support transparency and good communication between the central bank and the public. In this condition, the credibility of the central bank needs to be improved to reduce the impact of the monetary policy shock, as argued by Montes and Curi (2016). One of the efforts to increase credibility is through improved reputation (Montes & Batos, 2014) and increased transparency (Baeriswyl & Cornand, 2010). In the implementation of inflation targeting, increasing the credibility of the central bank is a key factor in achieving the effectiveness of monetary policy for controlling inflation as stated by Kurihara (2019).

## CONCLUSIONS

Monetary policy shocks, which are proxied by policy interest rate shocks, are generally able to explain the forecast error variance of inflation, output, and exchange rates. However, monetary policy shocks are better able to explain the forecast error variance of inflation than the forecast error variance of exchange rates and output. Because they are unpredictable and unexpected, the presence of shocks will certainly affect the effectiveness of monetary policy through changes in policy interest rates. With the support of transparency and good communication, the effectiveness of monetary policy through changes in policy interest rates will increase. The effectiveness of this monetary policy cannot be separated from the credibility of the central bank. Central bank credibility is influenced by transparency and reputation.

This research can still be developed further. The use of output measures can be developed into the output gap, while inflation can be measured by the inflation deviation between actual and target inflation. In addition, modeling can be developed especially in structural models by applying restrictions following the theoretical development being carried out.

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