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Does Monetary Policy Respond to Macroeconomic Shocks? Evidence from Indonesia

Arintoko and Nunik Kadarwati

Abstract: The activist policy is believed by policymakers and economists that monetary policy can respond to macroeconomic shocks to stabilize the economy. This study aims to find evidence and discuss the response of monetary policy to macroeconomic shocks. For this reason, the effects of GDP shocks, inflation shocks, and exchange rate shocks on policy interest rates in the implementation of monetary policy are discussed through vector error correction model (VECM) analysis along with policy interest rate responses involving the long-run relationships. The study period 2001Q1 – 2020Q1 is used as the policy implementation period using the policy interest rate. The results of the analysis show that based on the magnitude of the impact and its contribution, inflation shock and exchange rate shock are the most important macroeconomic variable shocks in influencing the monetary policy stance in Indonesia. Inflation shocks and exchange rate shocks need to be a priority focus for monetary policymakers in an economic environment where uncertainty is increasing and rapidly changing. In addition to the interests of the domestic economy, monetary policy also needs to remain focused on considering and adapting to increasingly dynamic global economic and financial developments.

Keywords: Monetary Policy; Macroeconomic Shocks; Vector Error Correction Model; Policy Interest Rates; Monetary Policy Stance
JEL Classification: E30; E40; E52

AFFILIATION:
Department of Economics and Development Studies, Faculty of Economics and Business, Universitas Jenderal Soedirman, Central Java, Indonesia

***CORRESPONDENCE:**
arintoko@unsoed.ac.id

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Introduction

Monetary policy for a country is vital to be implemented if stabilizations of output and prices are the final goal. In implementing monetary policy, the central bank is given a mandate with both single and multiple objectives. In conducting monetary policy, the central bank can implement it by responding to shocks (Baeriswyl & Cornand, 2010). Macroeconomic shocks are shocks that are generally encountered in a dynamic macroeconomic environment. Macroeconomic shocks faced by policymakers include shocks to inflation, output, and exchange rates. The implementation of monetary policy can be carried out with expansionary or contractionary policies in response to shocks. Active monetary policy is believed to be able to respond to shocks for economic stabilization (Mankiw, 2016). Various structural shocks that drive high inflation such as inflation shocks, output shocks, and exchange rate shocks are of greater concern to the central bank

in implementing inflation targeting. Inflation control as a monetary policy target makes monetary policy more focused on how to respond to various shocks that affect inflation.

In inflation-targeting countries, the monetary authority also considers output stabilization in the long run. Stabilization of both is possible when there is no trade-off between inflation and output. Lothian (2014) states that based on experience in the United States, the United Kingdom, and the Euro there is no trade-off between inflation and output volatility. They both move together when there is a rise and fall in economic trends. However, in countries that adopt inflation targeting, inflation stabilization needs to be the main focus in implementing monetary policy. According to Smets (2014), when implementing a new macroprudential policy framework, countries should aim for financial stability with a primary focus on price stability.

In many studies, monetary policy has an impact that includes the impact on output, inflation, and exchange rates. This empirical evidence is provided in studies conducted by, among others, Nyumuah (2018), Abbasinejad et al. (2018), Sethi et al. (2019), Mandel et al. (2019), and Tai Nguyen et al. (2022). The results of a study by Arintoko (2021) imply the important role of monetary policy in stabilizing output and inflation in the short run and stabilizing inflation in the long run. The interest rate channel is a key channel in stabilizing output and inflation.

Monetary policy is generally carried out in response to changes in macroeconomic variables. As long as macroeconomic changes can be predicted according to expectations, monetary policy can be carried out with more certainty based on rules. Forward-looking monetary policy in stable macroeconomic conditions can adopt a monetary policy based on the rules for setting interest rates. Mayandy (2019) found evidence that macroeconomic stability supports the ability of monetary policy to enforce rules-based policies. The minimum macroeconomic shocks were able to condition a relatively stable macroeconomic policy and environment. However, unexpected macroeconomic changes will pose a challenge for the central bank in implementing monetary policy effectively.

On the other hand, in the realm of academics and research, the issue of monetary policy is still dominated by discussions and studies on how monetary policy shocks affect the macroeconomy. This research has been carried out with various models. Blank and Dovern (2010) prove the impact of monetary policy shock on the banking sector. Meanwhile, Coibion (2012) discusses the small effect of monetary policy shocks from the standard VAR model and the large effect of monetary policy shocks with Romer and Romer (2004). Another study is by Abeygunawardana et al. (2017) who studies the macroeconomic effects of monetary policy shocks on the money market, government securities market, real sector, and prices. Furthermore, studies conducted by Kim and Lim (2018) and Kim et al. (2020) prove the impact of monetary policy shock on the exchange rate in a small open economy. Recent research by Salisu and Gupta (2020) estimates the dynamic effects of monetary policy shocks on macroeconomic volatility. Likewise, Zhang (2021) with the concept of the new shock also analyzed the impact of monetary policy shocks on output and total factor productivity. On the other hand, monetary policy shock

increases when the inflation trend is increasing, as the results of research conducted by Le and Finch (2021).

However, in the current implementation of monetary policy, the debate for decision-makers that arises is how monetary policy responds to shocks. Supply shocks are one of the issues that have been widely discussed at the empirical level about how these shocks affect inflation and economic growth. Regarding monetary policy, supply shocks are also a factor that monetary policy will respond to. In measuring output shocks, supply shocks and demand shocks will determine the output shocks.

Setting an inflation target within a predetermined range provides flexibility in responding to supply and demand shocks that occur for the central bank (Mishkin & Serletis, 2011). The advantage of implementing inflation targeting is its ability to reduce the effects of inflationary shocks. The central bank not only responds to rising inflation but also to negative shocks on aggregate demand. So, in implementing monetary policy to reduce inflation, the central bank responds to supply shocks and demand shocks, especially negative shocks from both. Experience from the crisis has shown that the shocks that occur affect the ability of monetary policy to control inflation and stimulate economic activities (Jannsen et al., 2019). Unexpected changes in exchange rates and inflation can cause demand and supply shocks, while output shocks can affect inflation because they can be caused by demand shocks or supply shocks. The unexpected decline in the rupiah exchange rate and an unexpected increase in inflation can cause negative demand shocks. Meanwhile, negative supply shocks and positive demand shocks can trigger inflationary shocks. Therefore, the inflation-targeting monetary policy aimed at stabilizing inflation will always pay attention to macroeconomic shocks that occur.

In this study, inflation shocks, output shocks, and exchange rate shocks are expected to have impacts on monetary policy responses. Output is measured by gross domestic product (GDP) as usual. The response to shocks is the stance of monetary policy between expansionary and contractionary monetary policies. Inflationary shocks caused by unexpected changes in inflation, output, and exchange rates will be responded to by contractionary monetary policy, and vice versa. Through changes in policy interest rates, the central bank is able to respond to significant changes in inflation and output (Li et al., 2021). Therefore, monetary policy through changes in policy interest rates has flexibility in responding to macroeconomic shocks.

Regarding inflation, Filis and Chatziantoniou (2013) state that the inflation rate in both oil-importing and oil-exporting countries is influenced by oil price shocks. Therefore, changes in domestic inflation can be affected by shocks in world oil prices. Oil price shocks will affect inflation through cost pushes. In this view, unexpected domestic inflation can be affected by shocks in world oil prices. In the transmission of monetary policy, changes in policy interest rates will affect macroeconomic variables, namely exchange rates, inflation, and output. In addition, in the transmission of monetary policy, how the policy responds to changes in macroeconomic variables, namely exchange rates, inflation, and output, will provide feedback on the target variables for changes in monetary policy. Onder and Villamizar-Villegas (2018) in their study examine how monetary policy

responds to dynamically changing macroeconomic variables. Monetary policy consistently responds to inflation and exchange rate behavior. The effectiveness of monetary policy in practice can be seen in how policy responds to shocks. Unexpected changes in exchange rates, inflation, and output become consequences of the monetary policy response. Therefore, exchange rate shocks, inflation shocks, and output shocks will be responded to by monetary policy. In the monetary policy stance, feedback from shocks will determine the monetary policy response. The central bank in Indonesia is mandated to implement monetary policy to stabilize the value of the rupiah as reflected in inflation and exchange rates, in addition to having the ultimate goal of real output.

So far, many kinds of research on monetary policy have been carried out related to how the shock of monetary policy affects macroeconomic variables. These studies focus more on the impact of monetary policy shocks. In the increasingly dynamic and uncertain global macroeconomic environment, the effects of macroeconomic shocks are no less important in influencing the monetary policy stance for the benefit of the domestic economy. Therefore, how policy responds to these shocks becomes more important to study. The implementation of monetary policy through the determination of interest rates cannot avoid the effects of economic shocks. Implementation of the determination of policy interest rates by decision-makers will certainly respond to shocks. Economic shocks are unpredicted and unexpected changes in the macroeconomy that also affect the implementation of monetary policy. Unexpected changes in foreign interest rates, world oil and food prices, climate change, and non-economic factors can cause macroeconomic shocks.

Moreover, the study of how the monetary policy response is generally associated with a supply shock or a demand shock separately. Research conducted by Al Hajj et al. (2015) distinguishes between supply shock, demand shock, and fiscal shock in analyzing the three shocks to monetary policy. Research conducted by Natal (2012) relates the response of monetary policy to oil price shocks. Since supply shocks and demand shocks can occur together which determines the output shocks, this study is motivated to analyze how the monetary policy response responds to the output shock. In targeting inflation, monetary policy in Indonesia is primarily important in responding to inflation shocks and exchange rate shocks. Unexpected changes in prices and exchange rates are important parts of how the monetary policy stance is affected. The exchange rate in the study of how monetary policy responds is an important issue. Research conducted by Syarifuddin et al. (2014) analyzed the response of monetary policy to the volatility of the exchange rate. Meanwhile, Yagmur (2016) conducted a study to analyze the role of the exchange rate in the implementation of monetary policy. The level and variability of the exchange rate significantly affect the implementation of monetary policy.

The existing research gap is related to how monetary policy responds to macroeconomic shocks, which has not been considered in previous studies. This research gap will be filled with this research in the context of the monetary policy stance within the inflation-targeting framework. This study aims to analyze how monetary policy responds to output (GDP) shocks, inflation shocks, and exchange rate shocks in the application of inflation targeting in which inflation and exchange rate stability are the focus to achieve output

stabilization. Through inflation targeting, it is expected that monetary policy will be effective through changes in policy interest rates. To capture information on how monetary policy responds to GDP shock, inflation shock, and exchange rate shock, this study applies a vector error correction model with policy interest rates as the response variable in a long-run relationship.

This study is suitable to be implemented in Indonesia. Indonesia is one of the emerging countries that has adopted an inflation targeting framework (ITF) in implementing monetary policy as a mandate given to Bank Indonesia to maintain rupiah stability. The mandate was given by the central bank in Indonesia according to the Law of the Republic of Indonesia Number 23 of 1999 that efforts to achieve price stabilization have two objectives, namely stabilizing inflation and stabilizing the exchange rate.

The stability of the rupiah has two meanings, namely the stability of the prices of goods and services as reflected in inflation, and the stability of the rupiah currency exchange rate against foreign currencies. Exchange rate stability is an important condition needed for price stability and the financial system in the free-floating exchange rate regime implemented in Indonesia. In inflation stabilization, the exchange rate channel has an important role in monetary transmission in Indonesia as studied by Kusuma and Kassim (2013). In monetary transmission, apart from the exchange rate, interest rates also have a key role in influencing inflation as studied by Lelo et al. (2018). Furthermore, studies related to monetary transmission have expanded and enriched empirical findings with the development of studies in the context of monetary transmission by the behavior of non-conventional banks through the behavior of Islamic banks, one of which is a recent study conducted by Johari et al. (2022).

The implementation of the ITF involves replacing the monetary base with the interest rate as a target in the implementation of monetary policy to achieve inflation and exchange rate stability. The increasingly flexible application of the ITF seeks to deal with an increasingly dynamic macroeconomic environment (Agung et al., 2011). This policy was adapted to deal with macroeconomic shocks that could weaken the stability of the financial sector. Therefore, active monetary policy is more trusted as an effective monetary policy when the economy is always faced with macroeconomic shocks that can affect domestic inflation. In implementing the ITF, Bank Indonesia needs to respond to macroeconomic shocks as a monetary policy stance to achieve its target.

This study contributes to the enrichment of empirical evidence on how the active policy model applied in the flexible ITF responds to macroeconomic shocks. In a period of flexible exchange rates, exchange rate dynamics and other macroeconomic indicators such as GDP and inflation allow their shocks to be responded to by the monetary policy stance. The results of this study will also contribute to the policy of how each type of shock is relatively responded to by monetary policy.

Research Method

The variables involved in the model used in this study are macroeconomic variables whose changes are usually responded to by policy interest rates. The selected variables are limited to the core variables because including many other variables in the model will obscure the main purpose of the analysis. Meanwhile, the data analyzed according to the selected variables are quarterly data and cover the period 2001Q1 - 2020Q1. The time period under study considers that the use of the policy interest rate variable as a reference begins in this period. While the limitation of the end of the period is to isolate the influence of the Covid-19 era which is not included in this part of the study to avoid biased results. The explanations of the individual variables can be seen in Table 1.

Table 1 Definition of Variables

Variable	Term	Indicator	Source
Policy interest rate	PIR	BI rate/BI seven days repo rate (BI7DRR) in percent per annum.	Bank Indonesia
GDP	LNGDP	Real Gross Domestic Product (2010 = 100) in billion rupiahs expressed in natural logarithms	BPS-Statistics Indonesia
Inflation	INF	Percentage change in consumer price index (CPI), year on year (yoy)	Bank Indonesia
Exchange rate	LNER	US dollar per rupiah and expressed in natural logarithms.	Bank Indonesia

The policy interest rate is used as a proxy for monetary instruments in the implementation of monetary policy by Bank Indonesia. The policy interest rate becomes a more likely instrument to influence market interest rates which in turn can affect consumption and investment so that it will determine aggregate demand. In addition, policy interest rates are more flexible in responding to changes in the dynamic macroeconomic environment in the implementation of monetary policy with inflation targeting. Indications in monetary policy response are more reflected in policy interest rate decisions than other instruments. The use of policy interest rates is also in line with the inflation targeting period which began in 2001.

The research model in this study is a Vector Autoregression (VAR) model. With the selected variables, this model is applied for multivariate time series as in equations (1) to (4). From many time series, linear interdependence can be identified through the stochastic process in the VAR model.

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

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

$$\Delta INF_t = \sum_{i=1}^{k} \alpha_{3i} \Delta PIR_{t-i} + \sum_{i=1}^{k} \beta_{3i} \Delta LNGDP_{t-i} + \sum_{i=1}^{k} \gamma_{3i} \Delta INF_{t-i} + \sum_{i=1}^{k} \lambda_{3i} \Delta LNER_{t-i} + u_t^{\Delta INF} \quad (3)$$

$$\Delta LNER_t = \sum_{i=1}^{k} \alpha_{4i} \Delta PIR_{t-i} + \sum_{i=1}^{k} \beta_{4i} \Delta LNGDP_{t-i} + \sum_{i=1}^{k} \gamma_{4i} \Delta INF_{t-i} + \sum_{i=1}^{k} \lambda_{4i} \Delta LNER_{t-i} + u_t^{\Delta LNER} \quad (4)$$

The VAR model is a model that can be used for forecasting and can be a robust forecasting tool, including in the study conducted by Khamis et al. (2018). The use of the VAR model can lead to the Vector Error Correction (VECM) model if there is cointegration in the VAR model (Zou, 2018). Similarly, in a study conducted by Usman et al. (2017), the application of VECM as a VAR model is due to the non-stationary data and cointegration between variables.

Before estimating the VAR model, unit root tests are performed to determine whether the data series are stationary at the level, I(0), or at the first difference, I(1). The VAR model requires data stationarity of the same order. If all variables in the model are I(1) and are co-integrated, then the application model is a Vector Error Correction model. Detection of the existence of a cointegration relationship between variables is carried out through the cointegration test with the Johansen test. In the analysis of the VAR model as well as VECM so that the analysis of impulse response and variance decomposition are effective, the VAR or ECM model must be stable (Lu, 2018). The stability test required in this study is the detection of the inverse roots of AR characteristic polynomials. The VAR model is stable or stationary if all roots have a modulus of less than one, and located inside the unit circle (Dan et al., 2014). If the estimated model is VECM then the roots must be equal to unity. Based on the model that has passed the diagnostic check including model stability, the VEC model performs impulse response analysis and variance decomposition. Impulse response analysis was conducted to analyze the response of one variable to the shock of another variable. Meanwhile, the variance decomposition shows the contribution of each shock that affects the forecast error variance.

Result and Discussion

The results of the unit root test are carried out on variables in the level and variables in the first difference. As reported in Table 2, the variables in the level based on both the augmented Dickey-Fuller (ADF) and Dickey-Fuller Generalized Least Squares (DF-GLS) tests conclude that all variables are not I(0). Furthermore, the test results on the variables in the first difference resulted in the second test statistic which concluded that the data series of the variables studied was I(1).

Table 2 Unit Root Test of Variables

Variables	Unit Root Test	
	ADF	DF-GLS
PIR	-2.0826	0.0155
LNGDP	-0.6449	2.2125
INF	-2.4073	-1.8670*
LNER	-0.2132	-0.2913
∆PIR	-4.4492***	-2.9970***
∆LNGDP	-10.4927***	-10.4686***
∆INF	-8.1015***	-6.7741***
∆LNER	-8.7220***	-4.6572***

*** p-value < 0.01, * p-value < 0.10

After conducting a unit root test to identify the cointegration relationship between variables in the model studied, a cointegration test was carried out with the results reported in Table 3. The cointegration test results by applying the Johansen test showed that there were two cointegration relationships. The trace statistic concludes that there are cointegration relationships with a p-value of 0.05.

Table 3 The Result of Cointegration Test

H_0	H_1	Trace Statistic	0.05 Critical value	Prob.	Max-Eigen Statistic	0.05 Critical value	Prob.
r = 0	r = 1	57.5151*	47.8561	0.0048	23.6509	27.5843	0.1474
r < 1	r = 2	33.8641*	29.7971	0.0161	19.8423	21.1316	0.0749
r < 2	r = 3	14.0219	15.4947	0.0823	9.7375	14.2646	0.2297
r < 3	r = 4	4.2843*	3.8415	0.0385	4.2843*	3.8415	0.0385

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

The existence of two cointegration relationships indicates that the application of the VAR model as in equations (1) – (4) will result in the VECM model in this study. The results of the diagnostic checks against the estimation results of the VECM model are presented in Table 4. Overall, the results of the diagnostic checks show that the VECM model is the best model with passes for non-normality, serial correlation, and heteroscedasticity. The test results reject each null hypothesis with a p-value greater than 0.05 for the statistical values presented at the bottom of the table.

Table 4 VECM Model Diagnostic Checks

Diagnostic Elements	Equation			
	ΔPIR	ΔLNGDP	ΔINF	ΔLNER
R^2	0.6304	0.9413	0.5312	0.3650
Adjusted R^2	0.5049	0.9213	0.3720	0.1494
F-Stat	5.0228	47.203	3.3370	1.6927
AIC	1.7738	-6.9841	3.9119	-3.1032
SIC	2.3746	-6.3833	4.5127	-2.5025
JB Stat		15.2200		
SC LM test		9.2197		
Chi-sq Het test		330.7979		

The results of detecting the stability of the model as shown in Figure 1 show that all the roots lie inside and on the unit circle. In the stability test of the VAR model, the model is stable if all the roots are less than one or the dots are inside the circle. However, because the model being tested is the VECM model which has cointegration relations, then some roots are equal to one (Lütkepohl, 1991; Vymyatnina, 2005; Forest, 2014). These results conclude that the VECM model is stable to ensure that the analysis of the impulse response and variance decomposition is effective.

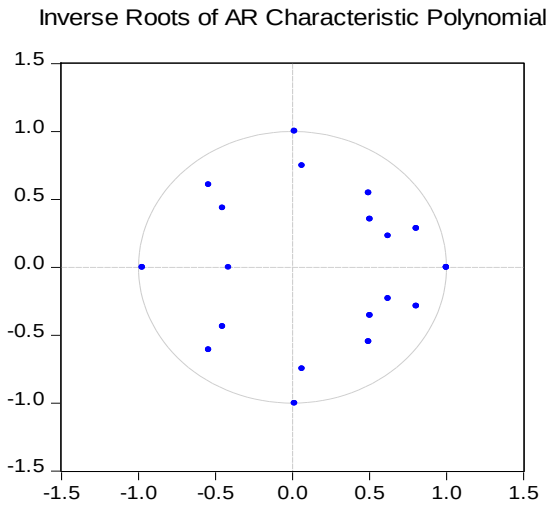


Figure 1 Inverse Roots of AR Characteristic Polynomial

The estimated parameters of the VECM model based on the VAR model in equations (1) – (4) are presented in Table 5 and Table 6. Table 5 shows the cointegration relationship indicated in this model. Meanwhile, the overall estimation of the VECM model produces the estimated parameters presented in Table 6.

Table 5 Cointegrating Equations

	Cointegrating Equations (CEs)	
	Cointegrating Equation 1	Cointegrating Equation 2
PIR_{t-1}	1	0
$LNGDP_{t-1}$	0	1
INF_{t-1}	-0.7327***	0.0681***
$LNER_{t-1}$	-0.4119	0.6607
C	-6.7149	-7.638

*** p-value < 0.01

The two cointegration relationships indicated in this model are the inflation and exchange rate relations with policy interest rates and GDP, respectively. In particular, the issue studied is that inflation and exchange rates have a positive relationship with policy interest rates. Policy interest rates increase when inflation and exchange rates rise. Meanwhile, GDP increases when inflation and exchange rates fall or depreciate. In Table 6, both cointegration relationships have significant negative coefficients, which is reflected in their error-correction term (ECT), on policy interest rates adjustment in the short run. However, only ECT 1 is as expected because it is between -1 and 0. The optimal lag in the model was determined based on the minimum Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) values, in addition to being based on the highest values of R^2 and adjusted R^2. The criteria for selecting the best model include R^2, adjusted R^2, AIC, and SIC (Gujarati & Porter, 2009). The model is chosen if R^2 and adjusted R^2 are the highest among the tested models. Meanwhile, based on AIC and SIC, the chosen model is a model that has a minimum AIC and SIC. From the test results of models with lags, the 4-lag model competes with the 3-lag model to be chosen as the best model. The

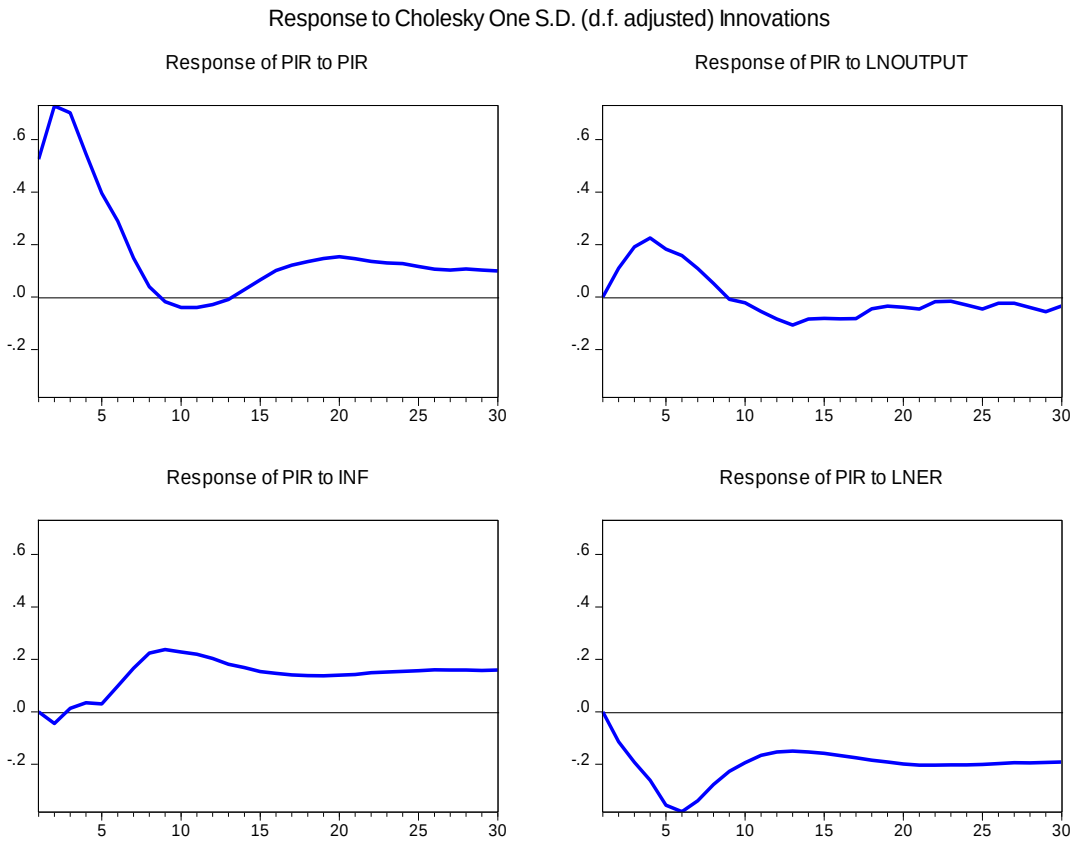
4-lag model has AIC and SIC values of -4.8028 and -2.1467. Meanwhile, the 3-lag model has AIC and SIC values of -4.6186 and -2.4850. However, the 4-lag model has higher R^2 and adjusted R^2 values for each equation in the model than the 3-lag model, in addition to having a lower AIC than the 3-lag model. The 4-lag model has R^2 values in each equation of 0.6304, 0.9413, 0.5312, and 0.3650, and has adjusted R^2 values of 0.5049, 0.9213, 0.3720, and 0.1494, as reported in Table 4 and Table 6. Meanwhile, the 3-lag model has R^2 values in each equation of 0.5234, 0.9288, 0.4911, and 0.3059, and has adjusted R^2 values of 0.4083, 0.9116, 0.3683, and 0.1383. The 4-lag model, therefore, has more information than the 3-lag model. Thus, the 4-lag model was chosen as the best model for the VECM model. So, the model with four lags is the model chosen as the fittest model supported by data.

Table 6 Vector Error Correction Estimates

	Equation			
	ΔPIR	ΔLNGDP	ΔINF	ΔLNER
ECT 1	-0.1715**	-0.0008	0.2755	0.0099
ECT 2	-2.3618***	-0.0075	-4.4339**	-0.0876
ΔPIR_{t-1}	0.6360***	0.0007	1.3525	-0.0214
ΔPIR_{t-2}	-0.1369	0.0017	0.0914	0.0340**
ΔPIR_{t-3}	0.0670	-0.0021	0.2412	-0.0015
ΔPIR_{t-4}	0.1506	0.0018	-0.3481	0.0117
$\Delta LNGDP_{t-1}$	24.2412**	-0.2842**	48.6314*	0.2016
$\Delta LNGDP_{t-2}$	15.8438*	-0.3466***	36.2857	0.4696
$\Delta LNGDP_{t-3}$	19.6120**	-0.3396***	42.4056	0.2285
$\Delta LNGDP_{t-4}$	16.9447*	0.6617***	40.9457	0.2816
ΔINF_{t-1}	-0.0097	-0.0002	-0.0619	0.0069
ΔINF_{t-2}	0.0630	0.0000	0.1283	-0.0046
ΔINF_{t-3}	-0.0191	-0.0003	0.1627	-0.0026
ΔINF_{t-4}	-0.0302	0.0003	-0.1793	0.0059
$\Delta LNER_{t-1}$	-1.1109	0.0238	0.6716	0.0842
$\Delta LNER_{t-2}$	0.4472	0.0034	5.9550	-0.2598**
$\Delta LNER_{t-3}$	-0.7626	0.0191	-1.2037	0.0806
$\Delta LNER_{t-4}$	-1.8765	0.0077	-1.4172	-0.0776
C	-1.0691	0.0176	-2.0844	-0.0199
R^2	0.6304	0.9413	0.5312	0.3650
Adjusted R^2	0.5049	0.9213	0.3720	0.1494

*** p-value < 0.01, ** p-value < 0.05, * p-value < 0.1

Figure 2 on the top left shows a positive policy rate response to the interest rate shock itself. Policy interest rates respond positively to unexpected changes in the policy interest rate itself in a quarter. After two quarters of its implementation, the policy rate response declined for seven quarters. Therefore, the policy interest rate shock will affect the policy interest rate for eight quarters. After the first eight quarters, the positive effect of the shock tends to be persistent over a 30 period time horizon. So, persistently the effect of interest rate shock was responded to positively by interest rate policy through monetary policy carried out by the central bank.



Note: OUTPUT = GDP

Figure 2 Policy Interest Rate Response to Policy Interest Rate Shock, output (GDP) Shock, Inflation Shock, and Exchange Rate Shock

Unexpected changes in policy interest rates that have occurred will then be responded to by the monetary policy stance as a response to adjustments in conducting monetary policy to achieve the stated goals. Interest rate shocks can occur because they are triggered by external shocks, for example by sudden changes in foreign interest rates. Bank Indonesia usually adjusts its interest rates to US interest rates in anticipation of capital flight out of Indonesia, although adjustments, especially in sudden interest rate hikes, are undesired and expected decisions.

Figure 2 on the top right shows the response of policy interest rates to GDP shock. The GDP shocks affect changes in policy interest rates. Policy interest rates respond positively to unexpected changes in GDP. The positive policy interest rate response to the GDP shock lasted for three quarters with a smaller effect than the interest rate shock itself. The positive effect of the GDP shock is neutral after eight quarters. In a time horizon of 30 quarters, the GDP shock eventually has a persistent negative effect on policy interest rates. So, persistently unexpected changes in GDP respond to a persistent decline in the policy interest rate but with a fairly small effect.

The results of the impulse response analysis show that there is a monetary policy response to GDP shocks. Monetary policy is also mandated to stabilize output, in addition to stabilizing inflation. Therefore, monetary policy will respond to GDP shocks through flexible monetary policy. GDP shocks can cause inflation due to demand shocks or supply shocks.

The lower left of Figure 2 shows the policy rate response to inflation shock. Initially, inflation shock was responded negatively in one period by policy interest rates, but the effect was small. However, overall, unexpected changes in inflation were responded positively by policy interest rates. The positive effect of inflation shock occurs persistently over a 30 period time horizon. The unexpected increase in inflation was responded to by persistent increases in the policy interest rate with a larger response size than the response due to the interest rate shock itself.

Regarding changes in inflation that are responded to by policy interest rates, these empirical results are in line with the results of a study conducted by Onder and Villamizar-Villegas (2018). The difference is that in the previous study the policy interest rate response was to the inflation level, while in this study the policy interest rate response was to inflation shock. The results of this study provide more valuable information than the unexpected changes in inflation to the policy interest rate response. This information is important because monetary policy is implemented within the framework of targeting inflation in an increasingly uncertain economic environment.

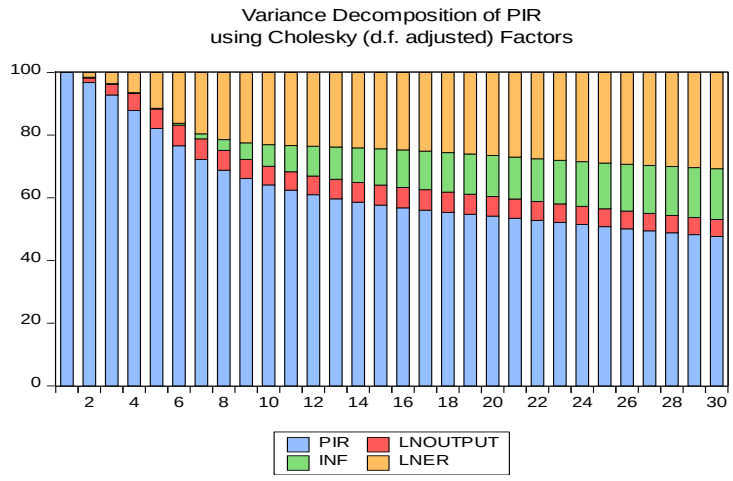
The positive response of monetary policy through the adjustment of policy interest rates to inflation shocks indicates that the monetary policy stance is in line with the efforts of the central bank to maintain inflation stability by directing inflation according to its target. Inflation shock is an important concern for policymakers because of the potential for unexpected sources of inflation such as cost-push inflation and volatile food inflation due to changes in world oil and food prices, as well as the effects of global climate change.

The bottom right of Figure 2 shows the response of policy interest rates to the exchange rate. Exchange rate shock responded negatively by policy interest rates in 5 quarters. Overall, the negative policy interest rate response to exchange rate shock was persistent over a 30 period time horizon. A persistently negative response means that unexpected changes in the exchange rate are responded negatively by the BI7DRR interest rate as the policy interest rate. Shock in the event of an unexpected increase in the exchange rate (unexpected appreciation) was responded to by a decrease in the policy interest rate. With symmetric assumptions, unexpected depreciation is responded to by an increase in policy interest rates. The important role of exchange rate changes in this study is in line with the results of research by Yagmur (2016) that exchange rate variability has a significant effect on the implementation of monetary policy. Likewise, the empirical results are in line with the results of research conducted by Syarifuddin et al. (2014) that exchange rate volatility is responded to by monetary policy. The difference between the changes in the exchange rate from the two previous studies is the variability and volatility, while in this study the change in the exchange rate is the shock. Exchange rate shocks reflect conditions of uncertainty and a volatile environment rather than the dynamics of

exchange rates as measured by their variability and volatility. The study by Leiva-Leon et al. (2022) states that exogenous exchange rate shocks play a major role in unanticipated nominal exchange rate movements.

The increase in interest rates is aimed at controlling further depreciation and controlling inflation beyond its target. Changes in the exchange rate have a major contribution to inflation through imported inflation and the exchange rate pass-through of domestic prices in Indonesia. In addition, the monetary policy implemented following the main task of the central bank is to maintain inflation and exchange rate stability. Therefore, these empirical results indicate the implementation of monetary policy that is responsive to unexpected changes in the exchange rate. These empirical results prove that the behavior of monetary policy in Indonesia is following Bank Indonesia's commitment to maintaining inflation and exchange rate stability. From the description of the impulse response function, the overall effect of shocks on the response to declining policy interest rates tends to end with a smaller but persistent effect. Concerning exchange rates and inflation, policy interest rates respond positively to inflation shocks rather than exchange rate shocks. These results prove that inflation is the main concern and consideration in the monetary policy stance in Indonesia, especially in the context of implementing inflation targeting. This is relevant to the monetary policy framework that sets the inflation target, rather than the exchange rate. The exchange rate by the central bank is not targeted at a certain level but is more concerned with volatility that supports exchange rate stability.

If measured by forecast error variance, the policy interest rate responses are influenced by the policy interest rate shock itself, GDP shock, inflation shock, and exchange rate shock, each of which can be shown in the variance decomposition in Figure 3. The effect of the policy interest rate shock itself is dominant in affecting the forecast error variance of policy interest rates but with a diminishing contribution in a time horizon of 30 quarters. The reduced contribution of the policy interest rate shock itself was accompanied by an increase in the contribution of other shocks, especially exchange rate and inflation shocks in influencing the forecast error variance of policy interest rates.



Note: OUTPUT = GDP

Figure 3 Variance Decomposition of Policy Interest Rate

Exchange rate shock has the largest contribution to the forecast error variance of policy interest rates in a way that it excludes the influence of the policy interest rate shock itself. In a free-floating exchange rate, the more likely an unexpected change in the exchange rate will occur. The relationship between the forecast error variance of policy interest rates on exchange rate shocks indicates that the implementation of monetary policy to achieve inflation that is on target has the main concern on exchange rate fluctuations. An increase in the contribution of exchange rate shocks will cause a forecast error in the variance of policy interest rates, in this case, the BI7DRR interest rate, which will be relatively larger determined by exchange rate shocks rather than mainly inflation shocks and GDP shocks as the contribution of interest rate shocks decreases. Exchange rate shocks can cause an increase in the forecast error variance of policy interest rates, which will also affect policy effectiveness. The higher the forecast error variance, the less effective the policy for setting interest rates will be. The results of this study complement the repertoire of research on the relationship between monetary policy and exchange rates. If in the study of Kim and Lim (2018) and Kim et al. (2020) monetary policy shock affects the exchange rate, the results of this study provide evidence that the exchange rate shock is also responded to by changes in policy interest rates in the implementation of monetary policy.

With symmetric assumptions, unexpected depreciation and appreciation of the exchange rate can increase the forecast error variance of the BI7DRR interest rate so that the implementation of monetary policy through setting interest rates creates a gap between the actual interest rate and the expected interest rate. The determination of the policy interest rate to be higher or lower than it should be when the exchange rate shock works. Apart from the interest rate shock itself, the inflation shock has the second-largest contribution after the exchange rate shock in influencing the monetary policy response. Unexpected changes in inflation also determine the forecast error variance of policy interest rates. Meanwhile, GDP shock also contributed to the forecast error variance of policy interest rates. The results of this study complement the results of empirical studies on the effect of monetary policy shock on output and inflation from the opposite side. In a study conducted by Mumtaz and Zanetti (2013), Kandil (2014), and Olayiwola (2018) monetary policy shock affects output and inflation, then in this study inflation and output or GDP shocks are also responded to by monetary policy. However, the contribution of GDP shock in a time horizon of 30 quarters shows the magnitude of the contribution that tends to be constant. This means that the GDP shock plays a relatively small role in the forecast error variance compared to exchange rate and inflation shocks.

Overall, the estimation results of the model, which were observed through impulse response and variance decomposition, show that monetary policy in Indonesia responds to exchange rate shocks, inflation shocks, and GDP shocks. Flexible inflation targeting policy can respond to macroeconomic shocks by stabilizing inflation through changes in policy interest rates. This finding is following the explanations proposed by Mishkin and Serletis (2011) and Mankiw (2016). In addition, this finding proves that monetary policy is active in responding to inflationary shocks, especially those from exchange rate shocks. The response to exchange rate shocks contributed the greatest impact because unexpected changes in the exchange rate could cause supply shocks and demand shocks.

Unexpected exchange rate changes are very influential on the monetary policy response and are in line with the findings by Yagmur (2016) and Syarifuddin et al. (2014) on the important role of the exchange rate in the monetary policy response. Inflationary shocks and GDP shocks were also responded to by monetary policy because they were inflationary shocks. This finding corroborates the results of a study conducted by Li et al. (2021). Unexpected changes in inflation and output can be responded to flexibly by policy interest rates. The overall results conclude that monetary policy in Indonesia responds to macroeconomic shocks and this finding is in line with the conclusions of the discussions by Baeriswyl and Cornand (2010) and Onder and Villamizar-Villegas (2018) from their study results.

Conclusion

This study provides empirical results that changes in policy interest rates as a reflection of the monetary policy stance respond to the effects of inflation shock, exchange rate shock, and GDP shock in addition to the policy interest rate shock itself. From the impulse response function, the policy interest rate responds positively to the inflation shock with a persistent final impact and a smaller effect size. Exchange rate shocks were responded negatively by changes in policy interest rates. The final impact is persistent with a smaller effect, exchange rate shock has a negative effect on policy interest rates. Meanwhile, the GDP shock, which was initially responded to positively but in the end, was persistently responded negatively with a relatively small effect by policy interest rates.

Inflation shock, exchange rate shock, and GDP shock, having persistent impacts, have a relative contribution to the forecast error variance of policy interest rates, which in turn affects policy effectiveness. The policy is effective if the actual policy interest rate is closer to the expected interest rate in the monetary policy stance. Exchange rate shock has the largest contribution apart from interest rate shock itself in determining the forecast error variance of policy interest rates. Inflation shock has a smaller contribution than exchange rate shock in determining the forecast error variance of policy interest rates. Meanwhile, GDP shock has the smallest contribution to determining the forecast error variance of policy interest rates. Forecast error variance in general can determine the effectiveness of monetary policy which in turn affects the credibility of the policy. Inflation and exchange rate shocks based on the magnitude of their impact and contribution are the most important macroeconomic shocks in influencing the monetary policy stance in Indonesia. These two shocks need to be a priority focus for policymakers in implementing inflation-targeting monetary policy in an increasingly uncertain and rapidly changing macroeconomic environment. In addition to the interests of the domestic economy, monetary policy also needs to remain focused on considering and adapting to dynamic global economic and financial developments.

However, this research is limited to the study period gathered during the pre-pandemic era in Indonesia, so the number of observations was also relatively limited. The applied model does not include structural changes that may occur when the effects of the pandemic impact structural changes in the observation period. Therefore, future research

is needed by developing and applying a VAR model that can provide model stability when there are structural changes during the study period.

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