-RESEARCH ARTICLE-

RESPONSE OF EXCHANGE RATE TO MONETARY POLICY SHOCKS: AN EVIDENCE FROM INDONESIA

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─**Abstract**─

The exchange rate is a significant determinant in shaping the direction of monetary policy. This study examines the exchange rate reactions to monetary policy shocks in Indonesia from 2005 to 2021 using a vector autoregression model to capture the influence of monetary policy on the exchange rate. The results demonstrate that the exchange rate responds positively to interest rate, money supply, and inflation shocks. In contrast, exchange rates respond negatively to reserve shocks. Since we employ structural vector autoregressive, our findings are consistent with the actual result. In addition, we incorporate the actual exchange rate as opposed to the nominal exchange rate used in the baseline model. The outcome is still comparable to that of the baseline model. The consequence is that a rise in interest rate, money supply, and inflation results in a depreciation of the exchange rate, whereas an increase in reserves results in an appreciation.

Keywords: Exchange Rate, Interest Rate, Money Supply, Inflation, Foreign Exchange Reserve, Indonesia, Vector Autoregressive

JEL Classification: E31, E58, E61

1. INTRODUCTION

Globalization of economic activities significantly impacts the macroeconomic stability of small, open economies (de Mendonca & Nascimento, 2020; Feng, Li, & Wu, 2021; Mishkin, 2009). The globalization process interconnects economic activity among the

worldwide community of producers and consumers. The proportion of a country's total imports and exports to its gross domestic product is a measure of its degree of globalization exposure. The value of a nation's currency in the worldwide market for exchange rates is an additional indicator of its economic strength (Anwar, 2021a; Calderón & Kubota, 2018). Due to the increased level of integration, the shock or shocks affecting a group of countries can readily be communicated to other countries with tight economic ties or trading partners. If their currencies are freely exchanged, external shocks can harm each economy through exchange rate swings, depending on the fundamentals. Each nation undertakes policies to stabilize its foreign currency to prevent economic volatility from spreading to other sectors of the economy (S. Kim & Lim, 2018). The level of exchange rate volatility is an important indicator of macroeconomic stability, influencing a nation's terms of trade. Therefore, exchange rate variations are one of the most important factors in determining the volume and direction of international trade (Ramasamy & Abar, 2015). To reap the benefits of international commerce, developing nations must pay particular attention to their exchange rate variations, which are an indicator of the economy's response to exogenous shocks and have consequences for macroeconomic stability (Anwar & Nicholas, 2020; Habib, Mileva, & Stracca, 2017). In 1997, some Asian nations, including Indonesia, Thailand, and South Korea, experienced a financial crisis due to a significant devaluation in their exchange currencies. The experience of the crisis prompted these nations to modify their policy frameworks to strengthen the credibility and independence of their central banks and make price stability and financial sector stability their primary priority.

Moreover, the currency rate contributes significantly to the stability of the macroeconomy by influencing export and import prices (Latief & Lefen, 2018). Exchange rate variations affect the prices of imported goods and their export competitiveness. Depending on the extent of transmission to domestic prices, changes in the exchange rate can cause spikes in domestic inflation, especially in small open economies, thereby influencing public consumption and investment (Kandil, 2015). The exchange rate is the price of a country's currency in other countries or international currencies. International commercial activities necessitate currency exchange between nations through the foreign exchange procedure (Aslam, Aziz, Nguyen, Mughal, & Khan, 2020; Miciuła, 2015). The exchange rate is an indicator that impacts the financial market and money market activity by influencing investors' choices. In open economies with freely floating exchange rates, the rates are influenced by the dynamics of supply and demand, which depend on risk and expectations.

The international Fisher effect suggests a relationship between currency and interest rates (Fisher, 1930). According to the international Fisher effect theory, the movement of a country's currency exchange rate relative to other nations can be explained by the difference in nominal interest rates between the nations. According to the expectations and neutrality of money theory given by Lucas Jr (1972), a rise in the money supply results in a depreciation of the exchange rate. The link between inflation and exchange

rate can be described using Balmaseda's Purchasing Power Parity (PPP) hypothesis. The concept of PPP theory is guided by the law of one price, which states that the price of an item or service in two nations using the same currency should be identical. In actuality, however, the current inflation rate and capital outflows decrease the foreign exchange. This is compatible with the purchasing power parity theory, which states that an increase in the price of products or services causes a rise in foreign exchange demand.

Foreign currency reserves are frequently used as a type of official intervention in foreign exchange markets to reduce excessive volatility. According to Calvo and Reinhart (2002), monetary authorities around the world have limited swings in their exchange rates by buying and selling foreign currency. Calvo and Reinhart (2002) investigated whether countries claiming to be afloat are, in fact, afloat. They discovered that most countries that profess to let their exchange rates float do not, and they confirmed that widespread "fear of floating" exists, such as a concern of big currency fluctuations. They imply that floating anxiety is widespread in developing market nations, regardless of geography or level of development. Murtala, Raja, Fajri, and Muhammad (2017) and Lee and Yoon (2020) have proven a negative link between foreign exchange reserves and the exchange rate based on their examinations of this relationship.

Indonesia is an excellent opportunity to examine the relationship between monetary policy and exchange rate stability. Literature implies that monetary policy is more effective in stabilizing exchange rate shocks in developing nations such as Indonesia than in their equivalents in advanced or industrialized nations (Aizenman, Chinn, & Ito, 2016; Aleem & Lahiani, 2014). The selection of Indonesia is based in part on the country's adoption of monetary and exchange rate policies that resemble those of industrialized countries but are customized to local realities. As a result of the 1997-1998 Asian financial crisis, Indonesia adopted inflation targeting with the policy interest rate as the primary monetary policy instrument. Additionally, Indonesia implemented a regime with a variable exchange rate. Therefore, Indonesia's monetary and exchange rate policy framework is identical to that of the developed nations. Are the effects of monetary policy on the exchange rate on Indonesia's real economy comparable to those observed in industrialized nations after moving to the current monetary and exchange rate regime? Are the effects in Indonesia generally in line with theory and comparable to those in industrialized nations, given that they have implemented comparable frameworks?

In Indonesia, the demand for foreign currencies affects the Rupiah's value, and the selection of foreign currencies for international payments affects fluctuations in exchange rates. This is because a rise in the value of foreign currencies is communicated to domestic customers through higher pricing of essential goods and the rupiah exchange rate. In addition, disparities in exchange rates influence movements in the currency market, such that a depreciation of the local exchange rate improves export demand, but

wages and prices rise. Therefore, the economy must respond to eliminate the misalignment in exchange rates (Anwar, 2021b).

Among the elements contributing to the fluctuation of the Indonesian currency exchange rate are monetary policy, global economic development or the external sector, political stability, and capital mobility. Exchange rate variations significantly impact macroeconomic stability and performance (Nor, Masron, & Alabdullah, 2020). Therefore, a stable exchange rate is necessary to achieve and sustain pricing and external sector stability. A free-floating exchange rate is utilized in developing economies such as Indonesia, where the domestic currency is traded on the money market at rates determined by market procedures. According to Barbosa, Jayme Jr, and Missio (2018), floating exchange rates reveal genuine currency based on market price without government involvement. Consequently, in this regime, the native currency reveals the exchange rate based on market supply and demand, so any mismatch is remedied by market fundamentals (Hosni, 2021).

Through the portfolio adjustment channel, a central bank's policy interest rate affects the exchange rate's level and dynamics (Suhendra & Anwar, 2020). Under this route, the policy rate increases domestic currency demand by attracting foreign investors through the rates on debt instruments. Suppose the monetary authority raises its monetary policy interest rate over the long term. In that case, the exchange rate of its currency tends to climb against other currencies, and this process continues until the relative yield in other economies also rises. A decrease in the policy rate causes depreciation via portfolio flight. In developing countries with inefficient financial markets, the impact of the central bank's policy interest rate on the currency exchange rate is uneven. Previous studies, such as those conducted by Murtala et al. (2017); Pham (2019); Ramasamy and Abar (2015); Saraç and Karagöz (2016), indicate a positive link between interest rate and exchange rate. However, Ali, Mahmood, and Bashir (2015); Jeelani, Tomar, Das, and Das (2019); My and Sayim (2016) imply that the policy rate and exchange rate have an inverse link.

Figure 1 shows that Indonesia's central bank policy interest rate was high from 2003-to 2007, around 13%. However, it decreased to 9.50% and 6.75% in 2008 and 2009, respectively. The policy rate was stable until mid-2014 but increased to 7.75% in November 2014. In April 2016, the policy rate was 5.50%, declining to 4.25% in December 2017. In 2020, Indonesia's central bank policy interest rate reached the lowest of 3.75% as a response to maintaining economic recovery in the COVID-19 era. The bilateral exchange rate of the Indonesia Rupiah to the US Dollar tends to depreciate from Rp. 9,480/US $ in 2005 to Rp. 10,240/US $ in September 2008. At the end of 2008, the Indonesian exchange rate reached Rp. 12,151/US $. The rate of Rupiah to US$ remained stable from 2009 to 2014 at around Rp. 12,000/US $. However, there was a

depreciation of the Rupiah in 2015, which reached Rp. 14,657/ US $. In 2018, the Rupiah exchange rate was Rp. 15,227/ US $. In April 2020, the Rupiah exchange rate reached Rp. 16,741/ US $.
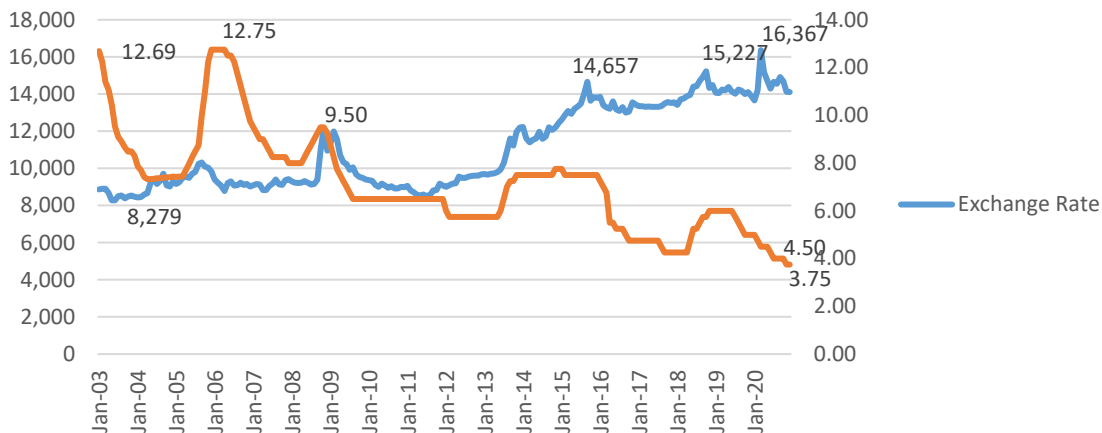

Figure 1: Interest Rate and Exchange Rate Indonesia
Data Source: Indonesia Central Bank

2. LITERATURE REVIEW

The exchange rate is the price of a country's currency in other countries or international currencies. International commercial activities necessitate currency exchange between nations through the foreign exchange procedure (Aslam et al., 2020; Miciuła, 2015). The exchange rate is an indicator that impacts the financial market and money market activity by influencing investors' choices. In open economies with freely floating exchange rates, the rates are influenced by the dynamics of supply and demand, which depend on risk and expectations.

Using OLS estimates, Ramasamy and Abar (2015) evaluated the impact of macroeconomic variables on the exchange rate. They discovered that inflation greatly impacted the exchange rate, whereas the interest rate had no meaningful impact. Using VECM estimation, Benoit (2011) investigated the impact of the interest rate on the Turkish exchange rate. Their findings indicate that the interest rate substantially affects the exchange rate. Using VECM calculations, Ali et al. (2015) investigated the effect of interest rate, inflation, and money supply on Pakistan's currency rate. The results indicate that inflation positively affects the exchange rate, whereas money supply and interest rates have a negative effect. Murtala et al. (2017) utilized Auto-Regressive Distrusted Lag Model to examine the determinants of the Indonesian exchange rate (ARDL). Short-term results, interest rates, and money supply have a positive and substantial effect on

the exchange rate, whereas long-term results are negative. In the short and long run, foreign exchange reserves negatively and considerably impact the exchange rate.

My and Sayim (2016) used Stepwise Multiple Regression to analyze the impact of economic factors on the foreign exchange rates between the US Dollar and four emerging economies: China, India, Brazil, and Mexico. The conclusion indicates that inflation substantially impacts the US$/CNY (China) and US$/INR exchange rates (India). The influence of interest rates on the USD/MXN (Mexico) exchange rate is substantial. Using vector autoregression model (VAR) estimates, Pham (2019) studied the effects of monetary policy on the Vietnamese exchange rate. The outcome demonstrates that interest rates and money supply have substantial and favorable effects on the exchange rate. Raza and Afshan (2017) examined the determinants of the Pakistani exchange rate using the structural break test and the ARDL approach. The conclusion indicates that money supply and inflation have a positive and considerable effect on the exchange rate over the long run. Using the Ordinary Least Square (OLS) model, Jeelani et al. (2019) investigated the structural break in the link between exchange rate and macroeconomic factors. They discovered that inflation greatly impacted the exchange rate, whereas interest rates had no meaningful impact. Using the Vector Error Correction Model (VECM) technique, Suidarma, Sanica, Ayu, and Darma (2018) analyzed the overshooting of the Indonesian Rupiah exchange rate against the US Dollar. The finding indicates that money supply and interest rate negatively affect the exchange rate over the long term, while no relationship exists over the short term. This paper extends the empirical research to investigate the relationship between exchange rate fluctuations and monetary policy innovations.

Utilizing a vector auto regression technique, Ito and Sato (2008b) study the effects of exchange rate variations on East Asian domestic prices. In the case of crisis-stricken economies, the study indicates that the exchange rate price of imported goods is extremely high. In addition, the impulse response of monetary policy variables to exchange rate shocks and CPI to monetary policy shocks was positive, substantial, and statistically significant. Using data from 2006 to 2018, Prabheesh and Rahman (2009) examine the relationship between monetary policy and credit cards in Indonesia. The results of the SVAR approach indicate that transmission of monetary policy through the loan channel is poor, with exchange rates playing a more prominent role in the transmission process. Ridhwan, Groot, Rietveld, and Nijkamp (2011) provide evidence that the varied geographical effects of monetary policy are highly related to sectoral composition, hence demonstrating the significance of the interest rate channel of monetary policy and using the VAR model to examine Indonesia.

Using the TGARCH model, Syarifuddin, Achsani, Hakim, and Bakhtiar (2014) studied the monetary policy response to exchange rate volatility in Indonesia. The results demonstrate that USD/IDR volatility in Indonesia is persistent, and the Central Bank's policy reaction is effective. In addition, Central Bank foreign exchange sale actions

result in a small USD/IDR depreciation. Caporale, Cipollini, and Demetriades (2005) examine the influence of monetary policy on the exchange rate during a financial crisis. Using a bivariate VECM model of four Asian nations. During calm periods, the tight monetary policy helped defend the exchange rate, but during the Asian crisis, it had a reverse impact. J. Kim, Kim, and Park (2020) use the VAR model to examine the effects of monetary policy shocks on the exchange rate of Asian nations. In select countries, such as Malaysia, the People's Republic of China, and the Republic of Korea, contractionary monetary policy shocks lead to large exchange rate appreciation, according to a study. However, India, Indonesia, the Philippines, and Thailand demonstrate a considerable depreciation or no effect. Based on their findings, researchers conclude that an increase or drop in interest rates may not protect Asian countries from currency rate depreciation or appreciation pressures following an increase or fall in US interest rates. Except for Indonesia, the inflation rate is low in all other nations. Yang and Zhang (2021) analyze the impact of monetary policy on the exchange rate using a time-varying VAR model. According to the findings, during both conventional and unconventional monetary policy periods in the United States, a contractionary monetary policy shock results in a rise in the exchange rate. In reaction to exchange rate shocks, Eichenbaum, Johannsen, and Rebelo (2021) study the monetary policy regime and its effect on inflation and exchange rate. The application of the DSGE model reveals that the dynamics of currency rates and their correlation with inflation are disruptive to the foreign demand for dollar-denominated bonds.

The selection of Indonesia is based in part on the country's adoption of monetary and exchange rate policies that resemble those of industrialized countries but are customized to local realities.
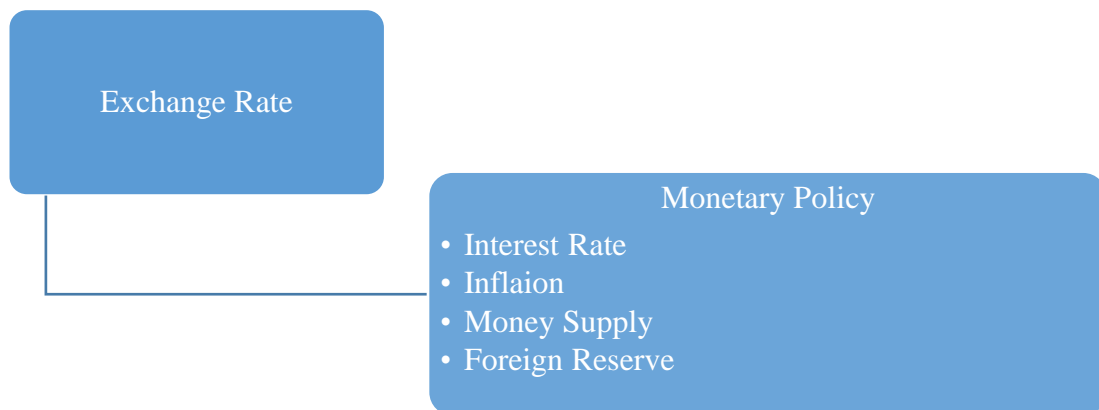
Exchange Rate

Monetary Policy
- Interest Rate
- Inflaion
- Money Supply
- Foreign Reserve

Figure 2. Conceptual Framework

As a result of the 1997-1998 Asian financial crisis, Indonesia adopted inflation targeting with the policy interest rate as the primary monetary policy instrument. Additionally, Indonesia implemented a regime with a variable exchange rate. Therefore, Indonesia's monetary and exchange rate policy framework is identical to that of the developed nations. For these reasons, the researcher wishes to examine evidence from Indonesia about the currency rate's response to monetary policy shocks. Based on the existing literature, researchers developed the conceptual framework depicted in Figure 2.

3. DATA AND ECONOMETRIC METHODOLOGY

3.1 Data

The Indonesian macroeconomic variables used to calculate the impact of a monetary policy rate shock on exchange rate fluctuations include the exchange rate, interest rate, money supply, inflation, and foreign reserve assets. It comprises monthly data sets spanning the years 2005m1 through 2021m12, with the period of each variable dependent on the availability of data. The data was obtained from the International Financial Statistics (IMF) and the World Development Indicator of the World Bank. The specifics of all variables are provided in Table 1.

The central bank interest rate is the interest rate determined by Indonesia's central bank to implement its monetary policy stance. We include a few control variables that, according to

Table 1: **Description of the Variables**

Symbol	Variable Name	Measurement	Source	References
ER	Exchange Rate	Bilateral currency IDR-US$	IMF	Prabheesh and Rahman (2009)
IR	Interest Rate	Central bank policy interest rate	IMF	J. Kim et al. (2020)
MS	Money Supply	M2/GDP	WDI	Ali et al. (2015)
Inflation	Inflation	percentage change in the index consumer price	WDI	Ito and Sato (2008a)
Reserve	Foreign Exchange Reserve	foreign-currency deposits held by monetary authorities	WDI	Syarifuddin et al. (2014)

3.2   Econometric Methodology

This study makes considerable use of the VAR methodology for econometric research to describe the interactions between macroeconomic variables and the dynamic impact of random shocks on the system of variables. Our decision regarding which variables to include in the VAR model was guided by economic theory and past research, such as (Abouwafia & Chambers, 2015; Aizenman et al., 2016; Caporale et al., 2005; Ito & Sato, 2008b; J. Kim et al., 2020; Syarifuddin et al., 2014). We utilized a logarithmic approximation due to the varying amplitude of the error term to avoid heteroscedasticity (Benoit, 2011).

Our baseline model is as follows:

$$ER_t = \beta_0 + \beta_1 IR_t + \beta_2 MS_t + \beta_3 Inf_t + \beta_4 Res_t + \varepsilon_t \qquad (1)$$

ER denotes exchange rate; IR is central bank policy interest rate; MS is money supply; Inf is inflation, and Res is foreign exchange reserve. The central bank rate is expected to positively affect the exchange rate by following the overshooting hypothesis (Dornbusch, 1976). The expectations and neutrality of the money theory proposed by Lucas Jr (1972) suggest that the policy interest rate positively affects the money supply on the exchange rate. According to PPP theory (Balassa, 1964), inflation positively affects the exchange rate. Lastly, the effect of foreign reserve assets on the exchange rate is emphasized by Calvo and Reinhart (2002).

Several previous research, such as Murtala et al. (2017); Pham (2019); Ramasamy and Abar (2015); Saraç and Karagöz (2016) have shown that there is a positive link between interest rate and the exchange rate. However, Ali et al. (2015); Jeelani et al. (2019); My and Sayim (2016) suggest that the correlation between interest rate and the exchange rate is negative. The link between inflation and the domestic currency has been studied by research such as by Murtala et al. (2017); Raza and Afshan (2017) have shown the positive connection between money supply and the exchange rate. However, Ali et al. (2015); Suidarma et al. (2018) have shown a negative link between the supply of money and the exchange rate. The connection between foreign exchange reserve and the exchange rate has been studied by previous research such as by Lee and Yoon (2020); (Murtala et al., 2017) have shown the negative correlation between foreign exchange reserve and the exchange rate. This paper extends the empirical study to examine the link between exchange rate fluctuations in monetary policy innovations.

The unit root test is the first step in determining whether a time series is stationary. Standard unit root tests, such as the Augmented Dickey-Fuller test and Phillip Peron tests, and Kwiatkowski, Phillips, Schmidt, and Shin are used for this purpose (KPSS). If each variable is non-stationary, the cointegrating relationship between variables is examined using the Johansen-Juselius method Søren Johansen (1988); Soren Johansen and Juselius (1992) to avoid the problem of spurious association and inaccurate findings.

Without cointegration, VAR models can be estimated in first-difference by eliminating the error-correction term for Granger causality with a short-term interaction feedback relationship. Then, here are our VAR models:

$$
\begin{aligned}
ER_t = \alpha_1 + {}& + \sum_{j=1}^{k} a_{1,j}\, ER_{t-j} + \sum_{j=1}^{k} b_{1,j}\, IR_{t-j} + \sum_{j=1}^{k} c_{1,j}\, MS_{t-j} \\
& + \sum_{j=1}^{k} d_{1,j}\, Inf_{t-j} + \sum_{j=1}^{k} e_{1,j}\, Res_{t-j} \\
& + U_{1,t}
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
IR_t = \alpha_2 + {}& + \sum_{j=1}^{k} a_{2,j}\, ER_{t-j} + \sum_{j=1}^{k} b_{2,j}\, IR_{t-j} + \sum_{j=1}^{k} c_{2,j}\, MS_{t-j} + \sum_{j=1}^{k} d_{2,j}\, Inf_{t-j} \\
& + \sum_{j=1}^{k} e_{2,j}\, Res_{t-j} \\
& + U_{2,t}
\end{aligned}
\tag{3}
$$

$$
\begin{aligned}
MS_t = \alpha_3 + {}& + \sum_{j=1}^{k} a_{3,j}\, ER_{t-j} + \sum_{j=1}^{k} b_{3,j}\, IR_{t-j} + \sum_{j=1}^{k} c_{3,j}\, MS_{t-j} \\
& + \sum_{j=1}^{k} d_{3,j}\, Inf_{t-j} + \sum_{j=1}^{k} e_{3,j}\, Res_{t-j} \\
& + U_{3,t}
\end{aligned}
\tag{4}
$$

$$
\begin{aligned}
Inf_t = \alpha_4 + {}& + \sum_{j=1}^{k} a_{4,j}\, ER_{t-j} + \sum_{j=1}^{k} b_{4,j}\, IR_{t-j} + \sum_{j=1}^{k} c_{4,j}\, MS_{t-j} \\
& + \sum_{j=1}^{k} d_{4,j}\, Inf_{t-j} + \sum_{j=1}^{k} e_{4,j}\, Res_{t-j} \\
& + U_{4,t}
\end{aligned}
\tag{5}
$$

$$Res_t = \alpha_5 + + \sum_{j=1}^{k} a_{5,j}\, ER_{t-j} + \sum_{j=1}^{k} b_{5,j}\, IR_{t-j} + \sum_{j=1}^{k} c_{5,j}\, MS_{t-j}$$

$$+ \sum_{j=1}^{k} d_{5,j}\, Inf_{t-j} + \sum_{j=1}^{k} e_{5,j}\, Res_{t-j}$$

$$+ U_{5,t} \tag{6}$$

By calculating impulse responses and variance decompositions, the influence of innovations on the model's macroeconomic variables can be determined (Caporale et al., 2005; Ito & Sato, 2008b). Impulse responses and variance decomposition are utilized in VAR models to give a framework for explaining the dynamic variables following a unit shock. Common methods of presenting VAR models include variance decomposition and impulse responses (which measure the impact of various shocks on the variable of interest). The variance decomposition of a cointegrated system is used to estimate the relative significance of long-term and short-term shocks and convergence to the steady-state. Variance The predicting performance of autoregressive models, as determined by forecast error variance decompositions (FEVDs), is the subject of research (Fikri, Alwi, & Muda, 2021)

4.   EMPIRICAL RESULTS

4.1   Unit Root Tests

Table 2: **Unit Root Tests**

Variable	ADF	PP	KPSS
Level			
ER	-2.2448	-2.4224	0.1804
IR	-2.7289	-2.4888	0.1939
MS	-1.5297	-1.9501	0.2808
Inflation	-3.3503*	-3.0528	0.1735
Reserve	-1.8173	-2.0352	0.2247
First Different			
D(ER)	-12.2776***	-12.2641***	0.0689***
D(IR)	-4.7928***	-7.3425***	0.0641***
D(MS)	-16.7332***	-19.5998***	0.0828***
D(Inflation)	-4.0457***	-8.4140***	0.0302***
D(Reserve)	-11.5478***	-11.6226***	0.0731***

Notes: symbols *, **, *** denote statistical significance at the 10%, 5% and 1% level.

Table 2 summarizes the results of the unit root tests. The table presents Augmented Dicky-Fuller (ADF), Philips and Perion (PP), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests statistics for each variable at the level and first difference with the trend but no constant. All five variables were non-stationary at level, but all were stationary at their first difference.

4.2 Result of VAR

First, the model was estimated to examine the interrelationship between exchange rate, interest rate, money supply, inflation, and foreign exchange reserve by applying VAR. Lag 2 was selected as the optimal lag based on the Akaike information criterion. The results are presented in Table 3.

Table 3: Result of VAR Estimation

	D(ER)	D(IR)	D(MS)	D(INF)	D(RES)
D(ER(-1))	-0.1075 (0.0883)	-0.2347 (0.5014)	0.0703 (0.0445)	0.5707 (1.7519)	0.0478 (0.0958)
D(ER(-2))	-0.3411*** (0.0889)	-0.0096 (0.5048)	-0.0300 (0.0448)	-0.2847 (1.7640)	0.1139 (0.0964)
D(IR(-1))	-0.0021 (0.0143)	0.3563*** (0.0810)	0.0107 (0.0072)	0.4955* (0.2833)	0.0104 (0.0155)
D(IR(-2))	0.0403*** (0.0136)	0.1555** (0.0771)	-0.0081 (0.0068)	-0.0561 (0.2695)	-0.0447*** (0.0147)
D(MS(-1))	0.0749 (0.1626)	0.0511 (0.9233)	-0.3018*** (0.0819)	1.5873 (3.2263)	-0.0203 (0.1764)
D(MS(-2))	0.3795*** (0.1607)	0.4621 (0.9125)	-0.1313 (0.0809)	1.5115 (3.1883)	-0.3543** (0.1743)
D(INF(-1))	0.0019 (0.0039)	0.0565*** (0.0223)	0.0001 (0.0001)	0.3744*** (0.0779)	-0.0009 (0.0042)
D(INF(-2))	0.0010 (0.0040)	0.0056 (0.0227)	0.0001 (0.0002)	-0.1270 (0.0079)	0.0065 (0.0044)
D(RES(-1))	-0.1752** (0.0812)	-0.6866 (0.4610)	-0.0429 (0.0409)	-0.8101 (1.6110)	0.1435* (0.0880)
D(RES(-2))	-0.1130 (0.0082)	0.0053 (0.4648)	0.0088 (0.0412)	1.0281 (1.6243)	0.0283 (0.0888)
C	0.0031 (0.0033)	-0.0138 (0.0192)	0.0140*** (0.0017)	-0.0403 (0.0670)	0.0076** (0.0036)

Notes: Symbols *, **, *** denote statistical significance at the 10%, 5% and 1% level. Standard errors are in parentheses.

The exchange rate is negatively affected by its first lag, but this effect is not statistically significant, as shown in Table 3. However, the second lag has a negative and statistically significant influence on the exchange rate, as measured by the coefficient -0.3411. This indicates that the exchange rate over the preceding two quarters has drastically depreciated. The first interest rate lag harms the exchange rate, while the second interest rate lag has a positive and large impact on the exchange rate, with a coefficient of around 0.0403. This suggests that inflation during the previous two quarters causes a large exchange rate depreciation. Money supply lag one has a positive but minor effect on the exchange rate, while money supply lag two has a positive and significant effect on the exchange rate with a coefficient of 0.3795. Inflation lags one and two have a marginally beneficial effect on the currency rate. The influence of foreign exchange reserve lag one on the exchange rate is substantial at 1 percent. This means that the preceding quarter's foreign exchange reserves result in a large exchange rate appreciation.

4.3   Result of Impulse Response Function

Figure 3 illustrates the connections between exchange rate, central bank interest rate, money supply, inflation, and reserve, as the impulse response function suggests. First, we examine the exchange rate's impulse response to an interest rate shock. Regarding the one standard deviation shock associated with the central bank's interest rate, the exchange rate responds positively until period twenty. This data confirms our hypothesis that central bank interest rates erode exchange rates. The positive response of the exchange rate to a shock to the money supply peaks at approximately 0.005 in period 3.

Regarding inflation, a one standard deviation increase in inflation increases exchange rates across all periods. Shock the foreign exchange reserve by one standard deviation, and the exchange rate will be negative until period twenty, with a minimum of 0.008 at period 3. This conclusion confirms our hypothesis that increasing foreign exchange reserves will strengthen the exchange rate.
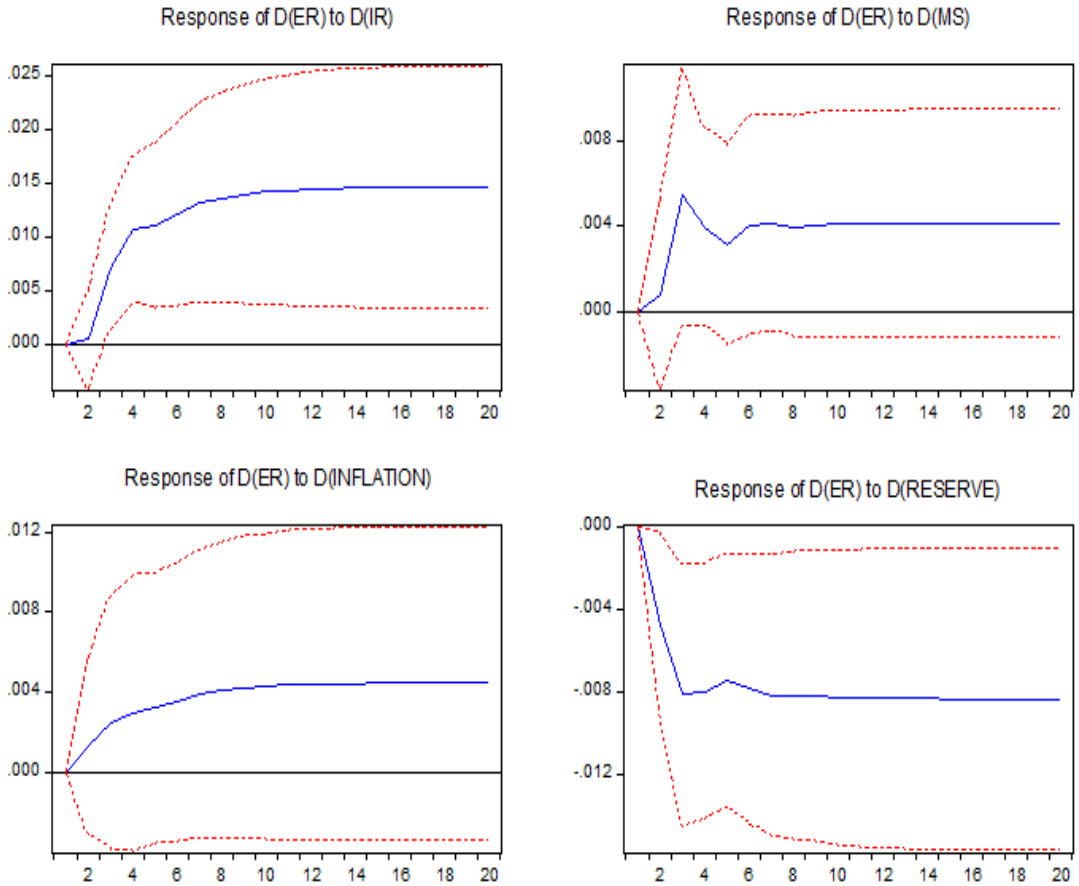

Figure 3: Impulse Response Function of Exchange Rate

Table 4 presents the findings of the forecast error variance decompositions, which reveal the contributions of the factors to the variation of a single variable. Panel 1 of Table 4 demonstrates that, at a 2-quarter horizon, innovations to the exchange rate accounted for roughly 96.6 percent of the variance in predicting errors; at a 10-quarter horizon, the contribution of innovations to the exchange rate decreased to approximately 86.2 percent.

4.4   Result of Variance Decomposition

Table 4: Variance Decomposition of Exchange Rate

Period	D(ER)	D(IR)	D(MS)	D(INF)	D(RES)
Forecasting D(ER)					
2	96.6344	0.0606	0.0646	0.0908	3.1490
4	86.6454	6.5722	2.4946	0.2988	3.9887
6	86.3463	6.6509	2.6521	0.3293	40212
8	86.2114	6.7650	2.6517	0.3468	4.0248
10	86.2003	6.7743	2.6527	0.3479	4.0246
Forecasting D(IR)					
2	0.6361	94.9306	0.0010	3.4507	0.9814
4	1.0256	91.8569	0.1996	5.7898	1.1278
6	1.0382	91.6746	0.2178	5.9275	1.1416
8	1.0440	91.6355	0.2195	5.9577	1.1431
10	1.0447	91.6282	0.2201	5.9632	1.1436
Forecasting D(MS)					
2	12.0280	2.4217	85.0054	0.0577	0.4870
4	13.1993	3.4847	82.5839	0.2516	0.4802
6	13.2613	3.5126	82.4863	0.2543	0.4852
8	13.2608	3.5192	82.4786	0.2544	0.4868
10	13.2606	3.5203	82.4775	0.2541	0.4870
Forecasting D(INF)					
2	1.3526	7.2052	0.3001	90.9750	0.1669
4	1.3695	8.0985	0.4838	89.8864	0.1816
6	1.3704	8.1566	0.4905	89.8006	0.1817
8	1.3712	8.1700	0.4912	89.7851	0.1823
10	1.3712	8.1724	0.4913	89.7826	0.1824
Forecasting D(RES)					
2	19.6098	1.4442	0.2407	0.5328	78.1723
4	18.4145	4.4296	2.5549	1.4777	73.1273
6	18.3634	4.5616	2.6191	1.5608	72.8949
8	18.3503	4.6270	2.6169	1.5711	72.8344
10	18.3481	4.6374	2.6173	1.5721	72.8249

The second highest contributor to the forecast error variance of the exchange rate at the 10-quarter horizon was the interest rate, which contributed almost 6,7 percent. Modifications to the money supply, inflation, and reserve made a negligible contribution to forecasting error variance.

In panel 2 of Table 4, there is evidence that the interest rate explains almost 95% of the forecast error variance of the interest rate at a 2-quarter horizon. However, the contribution gradually decreased to around 91% over a 10-quarter horizon. In panel 3 of Table 4, there is evidence that the money supply explains around 85 percent of the forecast error variance of the money supply at the two-quarter horizon. However, the contribution gradually decreased to approximately 82 percent at the ten-quarter horizon.

In panel 4 of Table 4, there is evidence that inflation explains almost 91 percent of the forecast error variance of inflation at the two-quarter horizon. This contribution gradually decreased to approximately 89.7 percent at the ten-quarter horizon. The final panel of Table 4 explains that the significance of foreign exchange reserves decreases as the prediction horizon lengthens. Approximately 78 percent of the variation of the error in estimating the foreign exchange reserve at the 2-quarter horizon was attributable to the foreign exchange reserve. This proportion decreased to approximately 72.8 percent at the 10-quarter horizon.

4.5 Robustness Checks

To ensure the accuracy of the findings, we develop the initial model in various ways. To begin, we employ VAR to examine the exchange rate's reaction to monetary policy shocks and quantify the impact on real exchange rate changes. The findings are summarized in Figure 4. The findings are similar to those of the baseline model, except that the exchange rate reaction to a money supply shock is negative, implying that the exchange rate and the money supply move in opposite directions.

Second, instead of using the nominal exchange rate, we add the real exchange rate to examine how the real exchange rate responds to monetary policy shocks and quantify the impact of monetary policy shocks on real exchange rate changes. Figure 5 illustrates the findings quite similar to the baseline model. These results demonstrate the robustness of our model.

5. DISCUSSION

A unit shock to the central bank's policy rate raises the exchange rate for all periods. This conclusion implies that an increase in the central bank's policy rate causes the currency rate to depreciate. This result is consistent with the global fisher effect theory. The central bank's contractionary monetary policy results in higher yields on domestic securities.
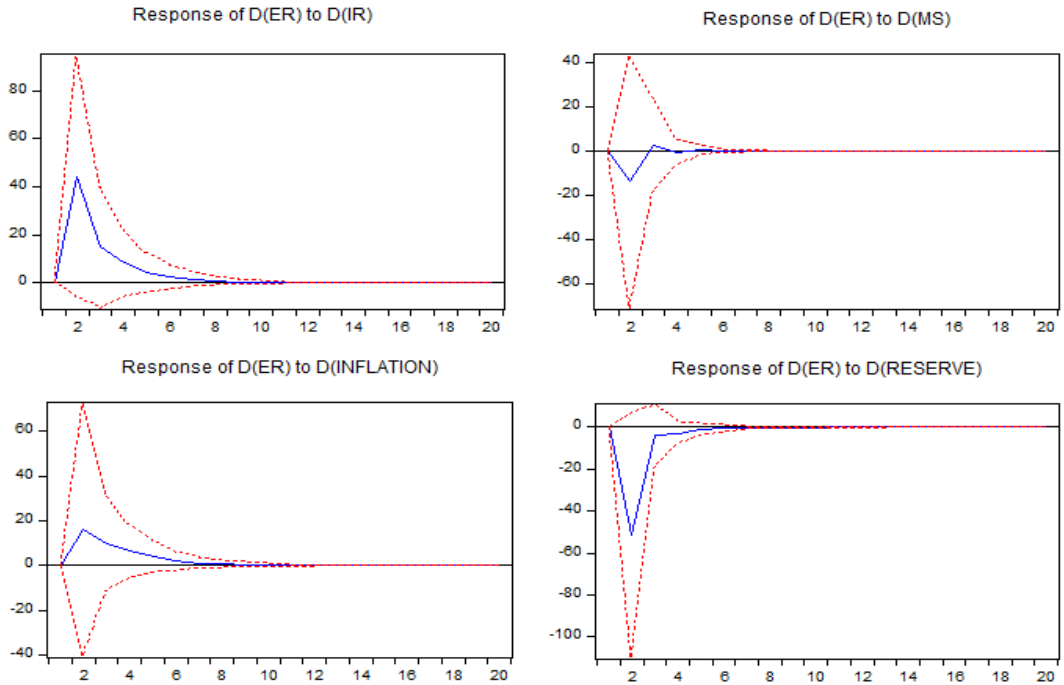
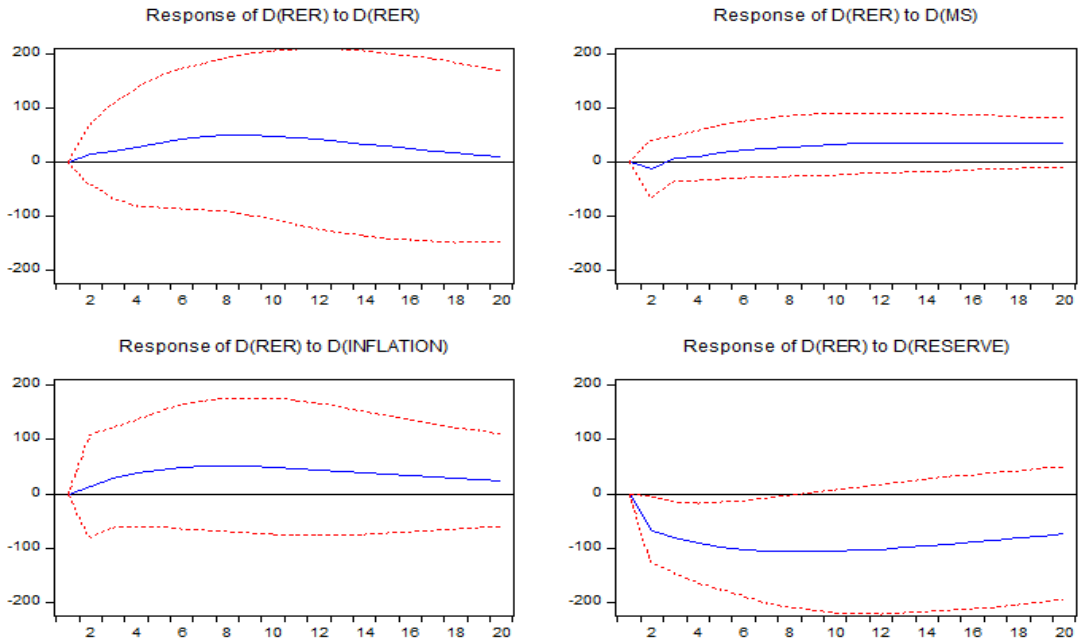**Figure 4:** Impulse Response Function of Exchange Rate (Structural VAR model)

Figure 5: Impulse Response Function of Real Exchange Rate

This stimulates foreign portfolio investments in rupiah-denominated assets such as bonds and stocks, along with a matching inflow of foreign cash. The results reveal that the interest rate positively affects the exchange rate. When interest rates rise, the exchange rate tends to depreciate, which is consistent with the exchange rate problem. This result aligns with those of (Grilli & Roubini, 1995). According to J. Kim et al. (2020), the exchange rate paradox occurs in countries with a high level of capital restriction, which permits monetary policy shocks to impact the exchange rate directly. This study confirms the findings of Murtala et al. (2017); Pham (2019); Ramasamy and Abar (2015); Saraç and Karagöz (2016) that interest rates have a favorable effect on the native currency.

Our findings, however, contradict Dornbusch (1976) theory, which predicts that the exchange rate should first overshoot in response to long-term monetary policy shocks. As a result, there was no exchange rate overshoot in Indonesia. Previous empirical studies, such as those by Ali et al. (2015); Jeelani et al. (2019); My and Sayim (2016), have proved the sensitivity of the exchange rate appreciation to monetary policy shocks.

A shock to the money supply per unit increases the exchange rate for all periods. Consistent with the principle of supply and demand in currency and money markets, this result shows that an increase in money supply depreciates the native currency. The supply hypothesis indicates that a country's money supply will cause its currency's exchange rate to decline if it is not matched by sufficient demand (Suidarma et al., 2018). Our research reveals that the money supply has a positive relationship with the exchange rate, such that a rise in the domestic money supply causes the Rupiah to depreciate. Because the money supply must be conveyed into the banking system, then to the business sector for investment, and then to the home sector for consumption, the public's rise in the money supply is immediately utilized by the business and household sectors. Thus, a rise in the money supply increases people's purchasing power for goods and services but decreases the rate of return. If domestic goods and services are insufficient, imports must be increased, which causes a depreciation due to a greater demand for foreign currency. The relationship between money supply and exchange rates is consistent with those of Murtala et al. (2017); Raza and Afshan (2017). They established that an increase in the money supply leads to a depreciation in exchange rates. In contrast, Ali et al. (2015); Suidarma et al. (2018) propose a negative link between the two variables.

A unit shock to inflation depreciates the exchange rate over all periods. This outcome conforms to the PPP theory. PPP theory concludes that one unit of a given currency must be able to purchase the same quantity of commodities across all nations. According to the findings of this study, the inflation variable harms the exchange rate, meaning that if a country's inflation rises, the demand for that country's currency will decrease as exports fall (due to higher prices). In addition, consumers and businesses in that country tend to increase imports, which can reduce a country's inflation rate.

Moreover, growing inflation exerts pressure on the value of the local currency, causing some international investors to hesitate to engage in local stocks. The outcomes of this investigation are also consistent with prior research. Ali et al. (2015); Jeelani et al. (2019); Pham (2019); Ramasamy and Abar (2015); (Raza & Afshan, 2017) have demonstrated that inflation and the currency rate are positively correlated. Our findings, however, contradict those of My and Sayim (2016), who demonstrate a negative link between inflation and exchange rate.

One standard deviation of foreign currency reserve shock decreases the exchange rate across periods. This conclusion indicates that a rise in foreign exchange reserves causes the exchange rate to depreciate. This outcome is consistent with Keynes's hypothesis. Foreign exchange reserves are regularly used for official currency market intervention. According to Calvo and Reinhart (2002), monetary authorities worldwide have regulated the level or volatility of their currency prices through the purchase and sale of foreign currencies. The more a nation's foreign exchange reserves, the greater its ability to perform international economic and financial transactions and the greater the value of its currency (Mishkin, 2009). According to the findings of this study, the variable reserve harms the exchange rate. The majority of Bank Indonesia's foreign exchange reserves support international transaction activities, such as import financing and foreign debt.

Furthermore, foreign exchange reserves are utilized to stabilize the exchange rate. Market players feel that the growth in reserves implies that the Indonesian economy is improving, which will lead to a rise in demand for the exchange rate and a subsequent appreciation of the Rupiah. This is because the country's foreign exchange reserves are substantial but underutilized; they should be used not only for international transaction activities but also to stabilize the exchange rate. In addition, the findings of this analysis support the claims of Lee and Yoon (2020); Murtala et al. (2017) that foreign exchange reserves positively affect the exchange rate.

6. CONCLUSION

This study presents a vector autoregression-based empirical examination of Indonesia's exchange rate, interest rate, money supply, inflation, and reserve from 2005 to 2020. We established the positive responses of the exchange rate to shocks in the interest rate, money supply, and inflation; nevertheless, the exchange rate has a negative response to a shock in foreign exchange reserves. These findings suggest that an increase in interest rate, money supply, and inflation causes a depreciation in the exchange rate, whereas an increase in reserves causes an appreciation. Our findings are reliable; first, structural vector autoregressive reveals that our results are comparable to the baseline. In addition, for the baseline model, we incorporate the real exchange rate rather than the nominal exchange rate, with the same outcome.

To ensure the stability of the Rupiah exchange rate, officials must maintain a constant and low central bank interest rate. Therefore, to prevent a significant change in the

domestic currency over the long run, authorities must employ prudent monetary policy management. Additional research indicates that it may be prudent to utilize alternative bilateral exchange rates for the Rupiah, such as the Euro, the British Pound, the Japanese Yen, the Singapore Dollar, and the Australian Dollar. In addition, future research could broaden the scope of this publication by sampling different nations and comparing the results to those of this study.

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