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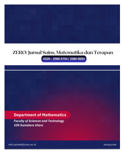

# Forecasting Macroeconomic Variables in Indonesia Using the Vector Autoregressive Method

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**ABSTRACT**

This study aims to analyze the dynamic relationship and predict inflation, the rupiah exchange rate, oil and gas exports, and BI interest rates in Indonesia. The Vector Autoregressive (VAR) method was used with monthly data from January 2015 to September 2025, the best model obtained was VAR (2). The Granger causality test results show that most variables are dominated by their own lag effects. Impulse response analysis shows that shocks are temporary and subside in the medium term. Forecast results for October 2025–September 2026 shows relatively stable inflation in the range of 2.42–2.70%. The rupiah exchange rate is expected to depreciate moderately by around 1.4%. Meanwhile, oil and gas exports declined significantly by 3.9%, and the BI interest rate is expected to fall by 12.8% to 4.14%. These findings indicate that Indonesia's macroeconomic stability is dominated by internal dynamics, so monetary policy focuses on inflation and the exchange rate.



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## 1. INTRODUCTION

Inflation, exchange rates, export performance, and policy interest rates are macroeconomic indicators that are often used to reflect the level of economic stability in a country. In the context of Indonesia as a developing country with a relatively high level of economic openness, movements in these indicators are becoming increasingly important because the domestic economy tends to be sensitive to external shocks, such as commodity price fluctuations and changes in global financial conditions [1]. Inflationary pressures have a direct impact on people's purchasing power and welfare [2], while exchange rate dynamics have broad implications for financial sector stability and international trade performance [3]. Meanwhile, oil and gas exports still play a role as one of the main sources of foreign exchange, and Bank Indonesia's benchmark interest rate is used as a monetary policy instrument to maintain price and exchange rate stability [4].

Theoretically, these four indicators do not stand alone but interact with each other in a simultaneous system. Interest rate policy affects inflation through the aggregate demand channel, while also impacting the exchange rate through the interest rate differential and international capital flow mechanisms [5]. On the other hand, changes in the exchange rate can be passed on to domestic price levels through the exchange rate pass-through mechanism and affect the competitiveness of exports in the global market [6]. This pattern of interaction shows a reciprocal relationship between variables, so that macroeconomic dynamics are better understood in the framework of an endogenous open economy system [7].

In an empirical context, various studies in Indonesia have used the VAR and VECM approaches to examine the relationship between macroeconomic variables, particularly inflation, exchange rates, and interest rates. A number of studies have found short-term and long-term relationships between inflation and exchange rates, as well as the response of inflation to monetary policy [8][9]. However, most of these studies still focus on analyzing dynamic relationships and causality, while the simultaneous forecasting of several key indicators has received relatively little attention. In addition, the role of oil and gas exports is still rarely explicitly included in the same systemic framework [10].

The research gap lies in the limited number of studies that specifically use VAR models to simultaneously forecast inflation, exchange rates, oil and gas exports, and policy interest rates in an integrated system. Many previous studies also included global factors as exogenous variables, such as world oil prices or the Fed interest rate. In contrast to this approach, this study treats all indicators as endogenous variables with reference to the open macroeconomic theoretical framework, in which domestic interactions between variables are considered capable of representing the transmission of external shocks through historical data dynamics [11].

Based on this background, this study aims to analyze the dynamic relationship and predict the movement of key macroeconomic indicators in Indonesia using a Vector Autoregressive (VAR) model. The main contribution of this study lies in its emphasis on simultaneous forecasting in a single endogenous system, which is expected to provide a more comprehensive empirical basis for the formulation of monetary policy and efforts to maintain national macroeconomic stability [12].

## 2. RESEARCH METHOD

This study uses the VAR model because it is capable of analyzing the dynamic relationships between variables simultaneously without structural limitations based on theory. All variables are made stationary through differentiation, so that the analysis focuses on short-term dynamics rather than long-term relationships as in VECM, and does not aim to identify structural shocks as in SVAR. Because it uses data in the form of first differentiation, the results of the analysis and forecasting reflect temporary responses and transitional dynamics, so that the resulting policy implications are short-term.

Although VAR is effective in capturing dynamic relationships, this method has limitations such as potential multicollinearity and linearity assumptions, whereas economic dynamics are often nonlinear. Therefore, the research results are understood as a linear approach to a complex economic system.

The data used is monthly data for the period January 2015–September 2025 sourced from Bank Indonesia and BPS. The details are summarized in Table 1.

**Table 1.** Research Variable

| Variable | Description | Unit |
|---|---|---|
| $Y_1$ | Inflation | Percent (%) |
| $Y_2$ | Rupiah Exchange Rate | Rupiah/USD |
| $Y_3$ | Oil and Gas Exports | Million USD |
| $Y_4$ | BI Rate | Percent (%) |

The data used in this study was secondary monthly time series data for the period January 2015 to September 2025 with a total of 129 observations. Inflation was represented by the Consumer Price Index (CPI) inflation rate in annual percentage (year-on-year), while the exchange rate was measured using the middle value of the rupiah against the US dollar based on the Jakarta Interbank Spot Dollar Rate (JISDOR), both sourced from Bank Indonesia. Meanwhile, oil and gas export performance was expressed in millions of US dollars, and the policy interest rate was represented by the BI Rate in percentage, obtained from the Central Statistics Agency (BPS).

All indicators were transformed into first differences to achieve stationarity before being estimated in the VAR model, without applying logarithmic transformation. The COVID-19 pandemic period (2020–2021) was retained in the sample as it was considered to reflect relevant economic shocks and was important for capturing the macroeconomic system's response to extreme events.

The stages of analysis in this study were as follows.

### 2.1 Stationarity Test

In time series analysis, data must be stationary so that the forecasting results are not biased [13]. Stationarity was tested using the Augmented Dickey–Fuller (ADF) test with the equation:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + \varepsilon_t \tag{1}$$

Where:

$\Delta Y_t$ : first difference variable Y
$\beta t$ : deterministic trend component
$\gamma$ : unit root coefficient
$Y_{t-1}$ : one-period lag variable
$\varepsilon_t$ : error term

In the ADF test, if the ADF value is smaller than the critical value, it was concluded that there is no unit root or, in other words, the data were stationary [14]. However, if the data does not meet stationarity, differencing was performed [15].

### 2.2 Determining the Optimal Lag

The selection of lags or orders in the VAR model was conducted using the Akaike Information Criterion (AIC). The lag with the lowest AIC was selected as the optimal lag for the VAR model [16].

### 2.3 VAR Model Parameter Estimation

Parameter estimation was performed by constructing a VAR model for each variable analyzed simultaneously. A VAR model with order p describes that the value of a variable at a given time is influenced by the value of that variable and other variables in the system in the previous periods up to lag p, as well as by the error component. The VAR(p) model can be written as [11]:

$$Y_t = C + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \cdots + \Phi_p Y_{t-p} + + \varepsilon_t \tag{2}$$

$$Y_t = \begin{bmatrix} Y_{1,t} \\ Y_{2,t} \\ \vdots \\ Y_{m,t} \end{bmatrix} \quad \Phi_p = \begin{bmatrix} \Phi_{11}(p) & \Phi_{12}(p) & \cdots & \Phi_{1m}(p) \\ \Phi_{21}(p) & \Phi_{22}(p) & \cdots & \Phi_{2m}(p) \\ \vdots & \vdots & \ddots & \vdots \\ \Phi_{m1}(p) & \Phi_{m2}(p) & \cdots & \Phi_{mm}(p) \end{bmatrix} \quad \varepsilon_t = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \vdots \\ \varepsilon_{m,t} \end{bmatrix}$$

Where:

$C$ : constant vector
$\Phi_p$ : VAR parameter matrix
$Y_{t-1}, Y_{t-2}, \dots, Y_{t-p}$ : observation vector of endogenous variables in the previous period
$\varepsilon_t$ : error vector
$m$ : number of endogenous variables

Equation (2) represented the $p$-th order Vector Autoregression (VAR) model, which was used to model the dynamic relationships between several endogenous variables simultaneously in a time series framework. The vector $Y_t$ was an $m \times 1$ vector that contained all endogenous variables in period $t$, while the constant $C$ reflects the deterministic component in the system. The coefficient matrix $\Phi_1, \Phi_2, \dots, \Phi_p$ describes the influence of past values of all variables in the system on the current value up to lag $p$, so that each variable is influenced not only by its own historical values, but also by the historical values of other variables. Meanwhile, the vector $\varepsilon_t$ represents random disturbances (shocks) that are assumed to be white noise and reflect unexpected innovations that affect the system in period $t$. Thus, the VAR model allowed for a comprehensive analysis of the interaction and transmission of dynamics between macroeconomic variables without establishing a priori structural causal relationships.

### 2.4 Model Stability Test

Model stability tests were conducted to show that any shocks occurring in the system will be temporary and will subside over time [11]. Mathematically, VAR model stability tests are based on the following characteristic equation:

$$\det\left(I_k - A_1 z - A_2 z^2 - \cdots - A_p z^p\right) = 0 \tag{3}$$

where $I_k$ denotes the $k \times k$ identity matrix, $A_1, A_2, \dots, A_p$ are the VAR coefficient matrices up to lag $p$, and $z$ is the root of the characteristic polynomial. The VAR model was considered stable if the value $|z| < 1$ or, in other words, when all roots of the characteristic polynomial have a modulus value less than one [11]

### 2.5 White Noise Residual Test

The white noise residual test is used to ensure that the residuals are random and unpatterned, indicating that the VAR model has been able to capture the main dynamics of the data. In macroeconomic analysis, VAR residuals are often not normally distributed, but this does not reduce the validity of VAR as a forecasting tool because its main focus is to project future values, not to make parameter inferences based on the assumption of normality [17]. Although the non-normality of residuals can affect the validity of statistical tests and confidence intervals, approaches such as bootstrapping can be used as a more reliable alternative. For short-term forecasting purposes, VAR models remain relevant as long as the residuals satisfy the characteristics of white noise, namely having a zero mean, constant variance, and no autocorrelation [18]. Mathematically, this is written as:

$$E(\varepsilon_t) = 0$$
$$Var(\varepsilon_t) = \sigma^2$$
$$Cov(\varepsilon_t, \varepsilon_{t-k}) = 0, \ \ \forall k \neq 0$$

Diagnostic tests of residuals in VAR models include tests for autocorrelation, heteroscedasticity, and normality. The autocorrelation test is performed using the Portmanteau method to assess whether the residuals still contain serial correlation over time, because residuals that satisfy the white noise property should not be correlated with each other [18]. The heteroscedasticity test is performed using the Autoregressive Conditional Heteroscedasticity–Lagrange Multiplier (ARCH-LM) method to test whether there is conditional heteroscedasticity in the estimated residuals [19]. Constant residual variance indicates that the residuals do not meet the white noise characteristic [20]. In addition, the residuals from the VAR model are also expected to be normally distributed, and if this assumption is not met, data transformation is required, with normality testing performed using the Jarque–Bera test [21].

### 2.6 Parameter Significance Test

The endogenous parameter significance test aimed to determine whether the lag of endogenous variables in the VAR model has a significant effect on variables in the current period [22].

Test hypothesis:

$H_0 : \Phi_{ks} = 0$ (endogenous parameters have no significant effect)

$H_1 : \Phi_{ks} \neq 0$ (endogenous parameters have a significant effect)

The test statistic was specified as follows:

$$t_{statistic} = \frac{\widehat{\Phi}_{ks}}{SE(\widehat{\Phi}_{ks})} \tag{4}$$

Where:

$k$ = 1, 2, ..., $m$ ($m$ : number of lagged endogenous variables)

$s$ = 1, 2, ..., $v$ ($v$ : number of equations (number of endogenous variables))

$\widehat{\Phi}_{ks}$ : estimate of the $k$-th endogenous parameter estimates

If the test statistic value was greater than the critical value or the probability value is less than the significance level, then $H_0$ is rejected and the endogenous parameter is proven to have a significant effect.

### 2.7 Granger Causality Test

The Granger causality test was conducted to identify temporal causality between time series variables. A variable was considered to Granger-causes another variable if the past information of that variable can improve the predictive ability of another variable [23].

Test hypothesis:

$H_0 : \beta_1 = \beta_2 = \cdots = \beta_s = 0$ (variable $X$ does not Granger-causes variable $Y$)

$H_1$ : at least one $\beta_j \neq 0$ (variable $X$ Granger-causes variable $Y$)

The test statistic was specified as follows:

$$y_t = c + \sum_{i=1}^{p} \Phi_i y_{t-i} + +\varepsilon_t \tag{5}$$

The test was conducted using Wald test statistics, with the decision criterion that $H_0$ is rejected if the p-value is smaller than the significance level.

### 2.8 Impulse Response Function (IRF) Analysis

The Impulse Response Function (IRF) was used to observe and analyze how a shock to one variable affects other variables (and itself) over time [24]. IRF was defined as the response of the endogenous variable at horizon $j$ due to a one-unit shock to the innovation in period $t$.

# 3. RESULT AND ANALYSIS

## 3.1 Descriptive Statistics

Descriptive statistics for each research variable were presented in Table 2.

**Table 2.** Descriptive Statistics of Research Variables for the Period January 2015–September 2025

| Variable | Mean | Min | Max | Standard Deviation |
|---|---|---|---|---|
| Inflation | 3.25 | -0.09 | 7.26 | 1.51 |
| Rupiah Exchange Rate | 14476 | 12579 | 16827 | 1005.36 |
| Oil and Gas Export | 1199.30 | 560.90 | 1988.90 | 283.36 |
| BI Rate | 5.26 | 3.50 | 7.75 | 1.20 |

Based on Table 2, inflation averaged 3.25% with a range of −0.09% to 7.26% and a standard deviation of 1.51, indicating price fluctuations including periods of deflation with relatively moderate volatility. The average rupiah exchange rate was 14476 rupiah/USD, with a range of 12579 to 16827 and a standard deviation of 1,005.36, reflecting fairly high exchange rate volatility. Average oil and gas exports reached USD 1199.3 million with significant variation, as reflected in the minimum value of USD 560.9 million, maximum of USD 1988.9 million, and standard deviation of 283.36, indicating sensitivity to global economic conditions and energy prices. Meanwhile, the BI Rate averaged 5.26% with a standard deviation of 1.2, indicating its relatively stable movement as a monetary policy instrument.

Figure 1 visualized the time series plot of the four research variables from January 2015 to September 2025.

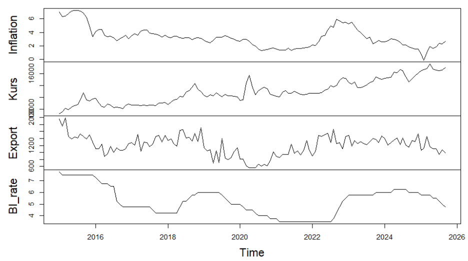



**Figure 1.** Time Series Plot of Inflation, Rupiah Exchange Rate, Oil and Gas Export Value, and BI Rate for the Period January 2015–September 2025

Figure 1 shows that inflation fluctuated throughout the observation period, with a downward trend at the beginning of the period until around 2020, then increasing sharply in the 2021–2022 period before declining again until the end of the observation period. The rupiah exchange rate showed a gradual upward trend. The value of oil and gas exports fluctuated quite sharply, with a significant decline around 2020, followed by a recovery in the following period, although it declined again towards the end of the observation period. Meanwhile, BI interest rates moved relatively steadily and gradually, with a sharp decline in certain periods and an increase again after 2022. This reflects Bank Indonesia's moderate policy response in maintaining economic stability. Overall, this graph shows different dynamics and volatility in each variable, requiring further time series analysis to capture the dynamic relationship between these variables.

## 3.2 Stationarity Test

Stationarity testing was performed using the ADF test. The results of the ADF test at the level for each variable are summarized in Table 3.

**Table 3.** Data Stationarity Test at the Level

| Variable | Dickey–Fuller | Critical Value | Description |
|---|---|---|---|
| Inflation | -2.4068 | -2.88 | Not Stationary |
| Rupiah Exchange Rate | -1.6961 | -2.88 | Not Stationary |
| Oil and Gas Export | -3.3761 | -2.88 | Stationary |
| BI Rate | -1.948 | -2.88 | Not Stationary |

Based on Table 3, only the oil and gas export value variable had an ADF value < critical value, so only this variable is stationary at the level, while the inflation, rupiah exchange rate, and BI rate variables do not meet the stationarity assumption. Therefore, to equalize the level of stationarity between variables, all research variables were differenced before further analysis.

The variables that have undergone the differencing process are then retested for stationarity. The results of the ADF test on variables that have undergone one differencing are summarized in Table 4.

**Table 4.** Data Stationarity Test at the First Difference Level

| Variable | Dickey–Fuller | Critical Value | Description |
|---|---|---|---|
| Inflation | -7.6613 | -2.88 | Stationary |
| Rupiah Exchange Rate | -10.7979 | -2.88 | Stationary |
| Oil and Gas Export | -11.4281 | -2.88 | Stationary |
| BI Rate | -4.6567 | -2.88 | Stationary |

Based on Table 4, it was concluded that after performing a single differencing, all variables meet stationarity so that the next stage of analysis can be carried out.

### 3.3 Determining the Optimal Lag and VAR Model Estimation

The selection of the optimal lag was based on the lowest Akaike Information Criterion (AIC) value. Table 5 presented a summary of AIC values for several alternative lags tested.

**Table 5.** AIC Values for Several Lags

| Lag | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| AIC | 16.570 | 16.421 | 16.520 | 16.666 | 16.739 |

Based on Table 5, the lowest AIC value was found in lag 2 at 16.421. Therefore, the optimal lag length used for VAR model estimation was lag 2, corresponsing to the VAR (2) specification.
Table 6 summarized the results of VAR (2) model parameter estimation.

**Table 6.** VAR Model Parameter Estimation

| Parameter | Inflation | Rupiah Exchange Rate | Oil and Gas Export | BI Rate |
|---|---|---|---|---|
| $\alpha$ | -0.03179 | 37.10719 | -10.87200 | -0.01348 |
| $Y_{1,t-1}$ | 0.19720 | 25.07813 | 1.88602 | 0.00823 |
| $Y_{1,t-2}$ | -0.08171 | 36.30039 | 43.68045 | 0.04924 |
| $Y_{2,t-1}$ | 0.00001 | 0.20307 | -0.09546 | 0.00014 |
| $Y_{2,t-2}$ | 0.00015 | -0.40730 | 0.07886 | 0.00001 |
| $Y_{3,t-1}$ | 0.00024 | -0.12316 | -0.54141 | 0.00009 |
| $Y_{3,t-2}$ | -0.00007 | -0.10341 | -0.18400 | -0.00010 |
| $Y_{4,t-2}$ | 0.03524 | 52.47724 | 38.31716 | 0.33150 |
| $Y_{4,t-2}$ | -0.11730 | 89.51371 | -67.92053 | 0.21380 |

### 3.4 Model Stability Test

Table 7 presented the root modulus values used as the basis for tasting the stability of the VAR model.

**Table 7.** VAR Model Stability Test

| No | Root Modulus Value |
|---|---|
| 1 | 0.6666333 |
| 2 | 0.6444661 |
| 3 | 0.6444661 |
| 4 | 0.4728466 |
| 5 | 0.4728466 |
| 6 | 0.3869546 |
| 7 | 0.2721701 |
| 8 | 0.2721701 |

Based on Table 7, it was seen that all characteristic root modulus values were less than one. This indicated that all roots were within the unit circle, meaning that the VAR model met the stability condition. Thus, the VAR model used was suitable for further analysis.

### 3.5 White Noise Residual Test

The white noise residual test was conducted through three stages, namely the residual autocorrelation test, residual heteroscedasticity test, and residual normality test.

**Table 8.** White Noise Residual Test

| Whaite Noise Residual Test | Test Statistics | Chi-Square | P-value |
|---|---|---|---|
| Residual Autocorrelation | Portmanteau | 163.31 | 0.4126 |
| Residual Heteroscedasticity Test | ARCH-LM | 1140 | 0.891 |
| Residual Normality Test | Jarque-Bera | 1789.4 | <2.2e-16 |

Based on Table 8, the results of the white noise residual test show that the VAR model meets the assumptions of no residual autocorrelation and homoscedasticity. Although the normality test for residuals is not satisfied, this condition does not necessarily indicate that the model is unsuitable. Asymptotic theory in dynamic models still applies to some non-normal residual distributions [11]. Therefore, as long as the assumptions of autocorrelation and variance stability are met, the VAR model can still be used for forecasting purposes.

### 3.6 Parameter Significance Test

Significance tests were conducted to determine the effect of endogenous variable lags on the prediction variables. Tables 9, 10, 11, and 12 summarize the results of the VAR model significance tests for the variables of inflation ($Y_{1,t}$), rupiah exchange rate ($Y_{2,t}$), oil and gas export value ($Y_{3,t}$), and BI interest rate ($Y_{4,t}$).

(a) VAR Model for Inflation Variables.

**Table 9.** Significance Test of VAR Model Parameters for Inflation Variables

| Parameter | Estimate | Standard Deviation | P-value |
|---|---|---|---|
| $\alpha$ | -0.03179 | 0.03796 | 0.4040 |
| $Y_{1,t-1}$ | 0.19720 | 0.09199 | 0.0341 |
| $Y_{1,t-2}$ | -0.08171 | 0.09064 | 0.3692 |
| $Y_{2,t-1}$ | 0.00001 | 0.00014 | 0.9430 |
| $Y_{2,t-2}$ | 0.00015 | 0.00014 | 0.3000 |
| $Y_{3,t-1}$ | 0.00024 | 0.00020 | 0.2354 |
| $Y_{3,t-2}$ | -0.00007 | 0.00020 | 0.7399 |
| $Y_{4,t-2}$ | 0.03524 | 0.22320 | 0.8748 |
| $Y_{4,t-2}$ | -0.11730 | 0.21360 | 0.5840 |

VAR model for inflation variables:

$$Y_{1,t} = -0.03179 + 0.19720Y_{1,t-1} - 0.08171Y_{1,t-2} + 0.00001Y_{2,t-1} + 0.00015Y_{2,t-2} + 0.00024Y_{3,t-1} - 0.00007Y_{3,t-2} + 0.03524Y_{4,t-1} - 0.11730Y_{4,t-2}$$

The estimation results in Table 9 showed that inflation in the current period was significantly influenced by the first lag of inflation itself ($Y_{1,t-1}$), with a positive constant of 0.19720, indicating the persistence of inflation. Conversely, the second lag of inflation, as well as all other lags of variables, including the rupiah exchange rate, oil and gas exports, and BI interest rates, did not show a significant effect at a 5 percent significance level. This pattern indicated that short-term inflation movements tended to be driven by their own internal dynamics, while the cross-variable effect was relatively limited.

(b) VAR Model for Rupiah Exchange Rate Variables

**Table 10.** Significance Test of VAR Model Parameters for Rupiah Exchange Rate Variables

| Parameter | Estimate | Standard Deviation | P-value |
|---|---|---|---|
| $\alpha$ | 37.10719 | 23.85164 | 0.1225 |
| $Y_{1,t-1}$ | 25.07813 | 57.79915 | 0.6652 |
| $Y_{1,t-2}$ | 36.30039 | 56.94851 | 0.5251 |
| $Y_{2,t-1}$ | 0.20307 | 0.08549 | 0.0192 |
| $Y_{2,t-2}$ | -0.40730 | 0.08759 | 8.8e-06 |
| $Y_{3,t-1}$ | -0.12316 | 0.12443 | 0.3243 |
| $Y_{3,t-2}$ | -0.10341 | 0.12652 | 0.4154 |
| $Y_{4,t-2}$ | 52.47724 | 140.23965 | 0.7089 |
| $Y_{4,t-2}$ | 89.51371 | 134.22496 | 0.5062 |

VAR model for rupiah exchange rate variables:

$$Y_{2,t} = 37.10719 + 25.07813Y_{1,t-1} + 36.30039Y_{1,t-2} + 0.20307Y_{2,t-1} - 0.40730Y_{2,t-2} - 0.12316Y_{3,t-1} - 0.10341Y_{3,t-2} + 52.47724Y_{4,t-1} + 89.5137Y_{4,t-2}$$

For the rupiah exchange rate equation (Table 10), the estimation results showed that both exchange rate lags ($Y_{2,t-1}$ and $Y_{2,t-2}$) had a significant effect on the exchange rate in the current period. The positive coefficient on the first lag and the negative coefficient on the second lag reflected the existence of a short-term adjustment mechanism, whereby previous exchange rate movements triggered opposite responses in the following period. Meanwhile, other variables in the system did not contribute significantly, so that exchange rate dynamics reflected internal adjustment processes rather than direct transmission from other macroeconomic indicators.

(c) VAR Model for Oil and Gas Export Variables

**Table 11.** Significance Test of VAR Model Parameters for Oil and Gas Export Variables

| Parameter | Estimate | Standard Deviation | P-value |
|---|---|---|---|
| $\alpha$ | -10.87200 | 17.19649 | 0.528 |
| $Y_{1,t-1}$ | 1.88602 | 41.67188 | 0.964 |
| $Y_{1,t-2}$ | 43.68045 | 41.05859 | 0.290 |
| $Y_{2,t-1}$ | -0.09546 | 0.06164 | 0.124 |
| $Y_{2,t-2}$ | 0.07886 | 0.06315 | 0.214 |
| $Y_{3,t-1}$ | -0.54141 | 0.08971 | 1.92e-08 |
| $Y_{3,t-2}$ | -0.18400 | 0.09122 | 0.046 |
| $Y_{4,t-1}$ | 38.31716 | 101.10962 | 0.705 |
| $Y_{4,t-2}$ | -67.92053 | 96.77316 | 0.484 |

VAR model for oil and gas export variables:

$$Y_{2,t} = -10.87200 + 1.88602Y_{1,t-1} + 43.68045Y_{1,t-2} - 0.09546Y_{2,t-1} + 0.07886Y_{2,t-2} - 0.54141Y_{3,t-1} - 0.18400Y_{3,t-2} + 38.31716Y_{4,t-1} - 67.92053Y_{4,t-2}$$

Based on Table 11, oil and gas export values also showed a strong dependence on their own historical values, as reflected in the significance of both lags ($Y_{3,t-1}$ and $Y_{3,t-2}$). The negative coefficients on both lags indicated a correction pattern, where an increase in exports in the previous period tended to be followed by a decline in the subsequent period. These findings indicated an internal adjustment process in oil and gas export performance, while the role of other variables in the system was relatively insignificant in the short term.

(d) VAR Model for BI Rate Variables

**Table 12.** Significance Test of VAR Model Parameters for BI Rate Variables

| Parameter | Estimate | Standard Deviation | P-value |
|---|---|---|---|
| $\alpha$ | -0.01348 | 0.01525 | 0.379 |
| $Y_{1,t-1}$ | 0.00823 | 0.03695 | 0.824 |
| $Y_{1,t-2}$ | 0.04924 | 0.03641 | 0.179 |
| $Y_{2,t-1}$ | 0.00014 | 0.00005 | 0.013 |
| $Y_{2,t-2}$ | 0.00001 | 0.00006 | 0.845 |
| $Y_{3,t-1}$ | 0.00009 | 0.00008 | 0.242 |
| $Y_{3,t-2}$ | -0.00010 | 0.00008 | 0.223 |
| $Y_{4,t-1}$ | 0.33150 | 0.08965 | 0.0003 |
| $Y_{4,t-2}$ | 0.21380 | 0.01525 | 0.014 |

VAR model for BI rate variables:

$$Y_{2,t} = -0.01348 + 0.00823Y_{1,t-1} + 0.04924Y_{1,t-2} + 0.00014Y_{2,t-1} + 0.00001Y_{2,t-2} + 0.00009Y_{3,t-1} - 0.00010Y_{3,t-2} + 0.33150Y_{4,t-1} + 0.21380Y_{4,t-2}$$

Meanwhile, the estimation results in Table 12 showed that BI interest rate dynamics were mainly influenced by previous interest rate policies, as reflected in the significance of the first and second lags of the BI Rate ($Y_{4,t-1}$ and $Y_{4,t-2}$). The positive coefficients on both lags indicated the persistence of monetary policy. In addition, the rupiah exchange rate in the first lag ($Y_{2,t-1}$) also had a significant effect on the BI Rate, indicating that exchange rate movements were one of the considerations in adjusting the benchmark interest rate. Conversely, inflation and oil and gas exports did not show a significant effect, so that the short-term monetary policy response was more related to internal interest rate dynamics and exchange rate stability.

## 3.7 Granger Causality Test

Table 13 summarized the results of the Granger causality test for these four variables.

**Table 13.** Granger Causality Test

| Variable | P-value |
|---|---|
| Inflation with Rupiah Exchange Rate | 0.666 |
| Rupiah Exchange Rate with Inflation | 0.631 |
| Inflation with Oil and Gas Export Value | 0.536 |
| Oil and Gas Export Value with Inflation | 0.326 |

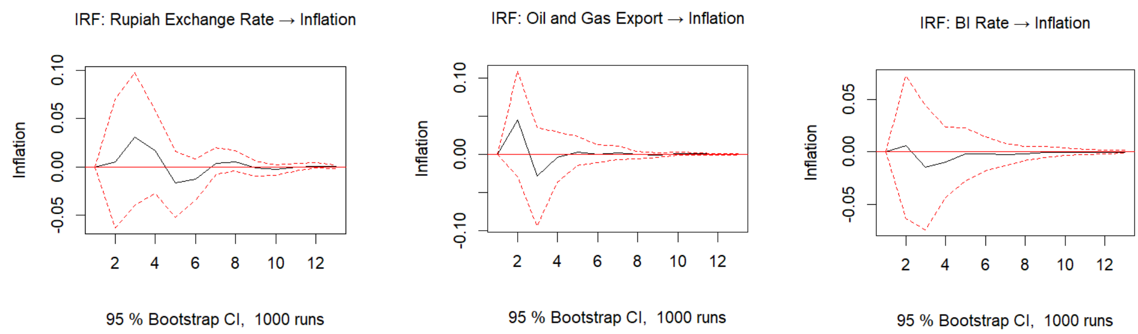
| | |
|---|---|
| Inflation with BI Rate | 0.320 |
| BI Rate with Inflation | 0.868 |
| Rupiah Exchange Rate with Oil and Gas Export Value | 0.171 |
| Oil and Gas Export Value with Rupiah Exchange Rate | 0.597 |
| Rupiah Exchange Rate with BI Rate | 0.028 |
| BI Rate with Rupiah Exchange Rate | 0.606 |
| Oil and Gas Export Value with BI Rate | 0.055 |
| BI Rate with Oil and Gas Export Value | 0.845 |

Based on Table 13, most variable pairs do not show a significant causal relationship because the p-value is greater than 5 percent. A significant relationship was only found between the rupiah exchange rate and the BI Rate with a p-value of 0.028, indicating that movements in the exchange rate in the previous period played a role in influencing interest rate policy. Meanwhile, the relationship between oil and gas exports and the BI Rate has a p-value of 0.055, indicating weak causality around the significance threshold.

Overall, the causality structure in the model is limited and tends to point to the BI Rate as the main policy variable. The lack of reciprocal relationships between other variables indicates that the dynamics of the system are more likely to occur through monetary policy channels than through direct interactions between macroeconomic indicators.

### 3.8 Impulse Response Function (IRF) Analysis

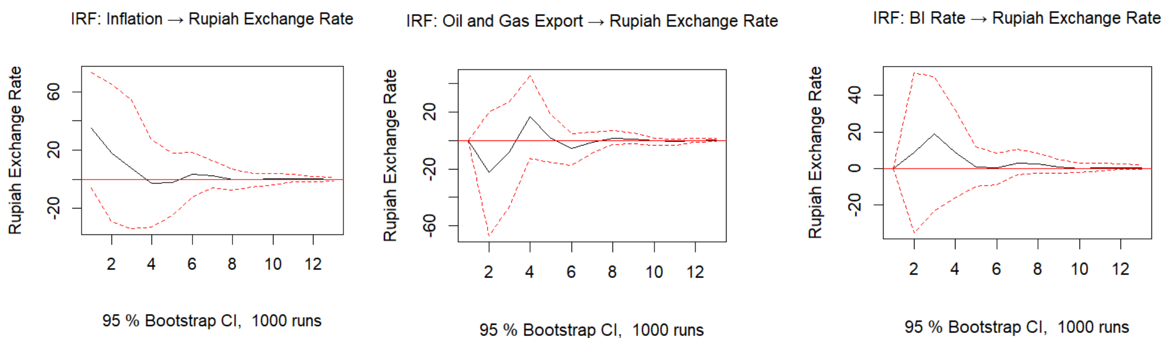
Figure 2 showed the response of inflation to shocks of one standard deviation in the rupiah exchange rate, oil and gas export values, and the BI rate.




(a) (b) (c)

**Figure 2.** Orthogonal Impulse Response Function Graph of Inflation Variables

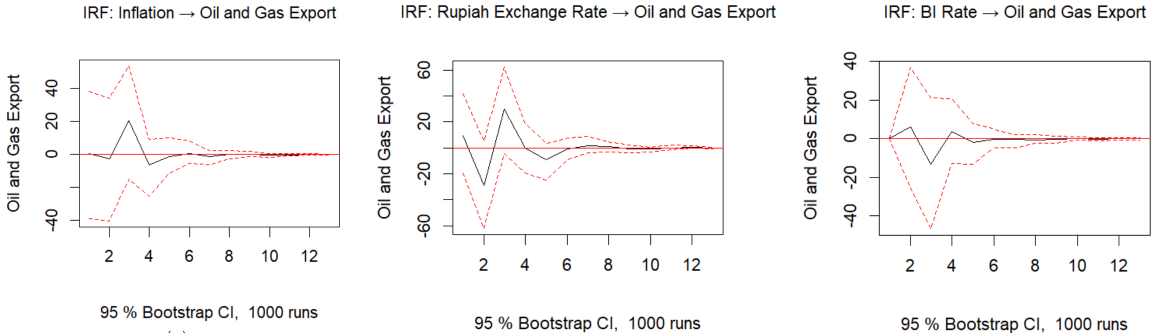
The results of the impulse response analysis in Figure 2 show that inflation responds to shocks from the rupiah exchange rate, oil and gas exports, and BI interest rates temporarily and tends to subside within a few periods. The response of inflation to exchange rate shocks is relatively small and fluctuates around zero, indicating that the transmission mechanism from the exchange rate to inflation during the observation period is not very strong. On the other hand, oil and gas export shocks trigger inflation volatility in the early period, but their effects quickly weaken, indicating that the external sector's influence on inflation is limited. Meanwhile, BI interest rate shocks produce a clearer inflation response at the beginning of the horizon, but remain non-persistent, reflecting the effectiveness of interest rate policy in dampening inflationary pressures without causing long-term imbalances.




(a) (b) (c)

**Figure 3.** Orthogonal Impulse Response Function Graph of Rupiah Exchange Rate Variables

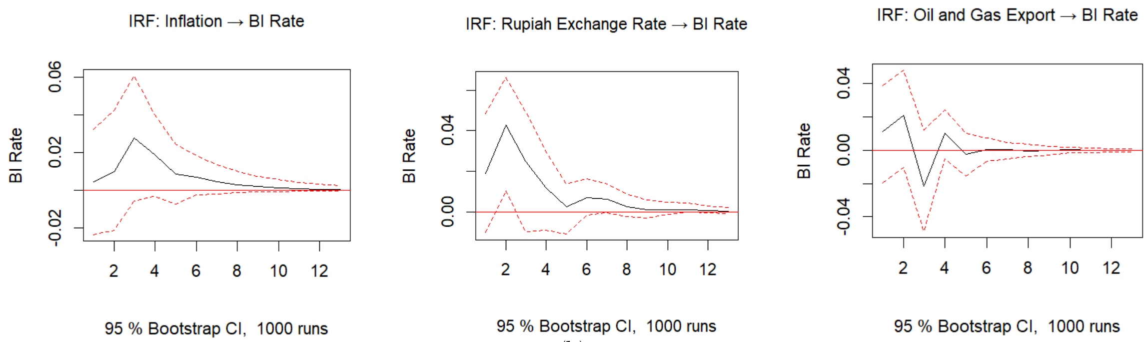
Unlike inflation, the rupiah exchange rate in Figure 3 shows sharper fluctuations in the early period, mainly in response to BI interest rate shocks and inflation. The response to inflation shocks reflects the foreign exchange market's adjustment to domestic price changes and inflation expectations, but the weakening response in the following period indicates that inflationary pressures do not always translate into persistent exchange rate changes. Shocks to oil and gas exports also triggered initial volatility in the exchange rate, but the effect quickly faded, indicating that changes in export performance only had a temporary impact. Among all variables, BI interest rate shocks elicited the strongest response, confirming the high sensitivity of the exchange rate to interest rate policy through capital flow mechanisms and interest rate differentials.




(a) (b) (c)

**Figure 4.** Orthogonal Impulse Response Function Graph of Gas and Oil Export Value Variables

For oil and gas export performance in Figure 4, the response to shocks in inflation, exchange rates, and the BI Rate showed relatively high initial fluctuations, but these did not persist in the medium term. The response to inflation shocks tended to oscillate around zero, indicating that domestic price changes did not directly determine oil and gas exports, which were more influenced by global prices and medium-term contracts. The response to exchange rate shocks was more apparent at the beginning of the horizon, reflecting the impact of changes in price competitiveness, but this effect was not persistent. BI Rate shocks also triggered a fairly clear initial response, which could be attributed to changes in funding costs and liquidity conditions, but the impact weakened over time.




(a) (b) (c)

**Figure 5.** Orthogonal Impulse Response Function Graph of BI Rate Variables

Meanwhile, the BI Rate response in Figure 5 showed a relatively quick adjustment pattern to inflation and exchange rate shocks. Inflation shocks were responded to positively at the beginning of the horizon, reflecting the monetary policy reaction in maintaining price stability. However, this response was not maintained in the long term, indicating the flexibility of monetary authorities in adjusting policy as inflationary pressures eased. The response to exchange rate shocks was also quite strong at the beginning of the period, confirming the role of interest rates as an instrument of external stabilization. In contrast, oil and gas export shocks only generated a small and quickly fading response, indicating that this sector was not a major determinant in interest rate policy setting.

### 3.9 Forecasting

Using the VAR (2) model, forecasts were obtained for inflation, the rupiah exchange rate, oil and gas export values, and the BI rate for the next 12 months, which were summarized in Table 14.

**Table 14.** Forecast Results

| Period | Inflation | Rupiah Exchange Rate | Oil and Gas Export | BI Rate |
|---|---|---|---|---|
| October 2025 | 2.69 | 16561.14 | 987.66 | 4.61 |
| November 2025 | 2.70 | 16511.14 | 1034.56 | 4.53 |
| December 2025 | 2.69 | 16502.22 | 1015.39 | 4.46 |
| January 2026 | 2.65 | 16544.58 | 1006.36 | 4.40 |

| | | | | |
|---|---|---|---|---|
| February 2026 | 2.62 | 16586.33 | 1001.33 | 4.35 |
| March 2026 | 2.59 | 16606.04 | 994.92 | 4.32 |
| April 2026 | 2.57 | 16623.83 | 989.77 | 4.28 |
| May 2026 | 2.54 | 16651.30 | 982.84 | 4.25 |
| June 2026 | 2.51 | 16681.86 | 975.41 | 4.22 |
| July 2026 | 2.48 | 16709.50 | 968.75 | 4.20 |
| August 2026 | 2.45 | 16735.52 | 962.12 | 4.17 |
| September 2026 | 2.42 | 16762.59 | 955.22 | 4.14 |

These forecast results could be visualized in Figures 6.

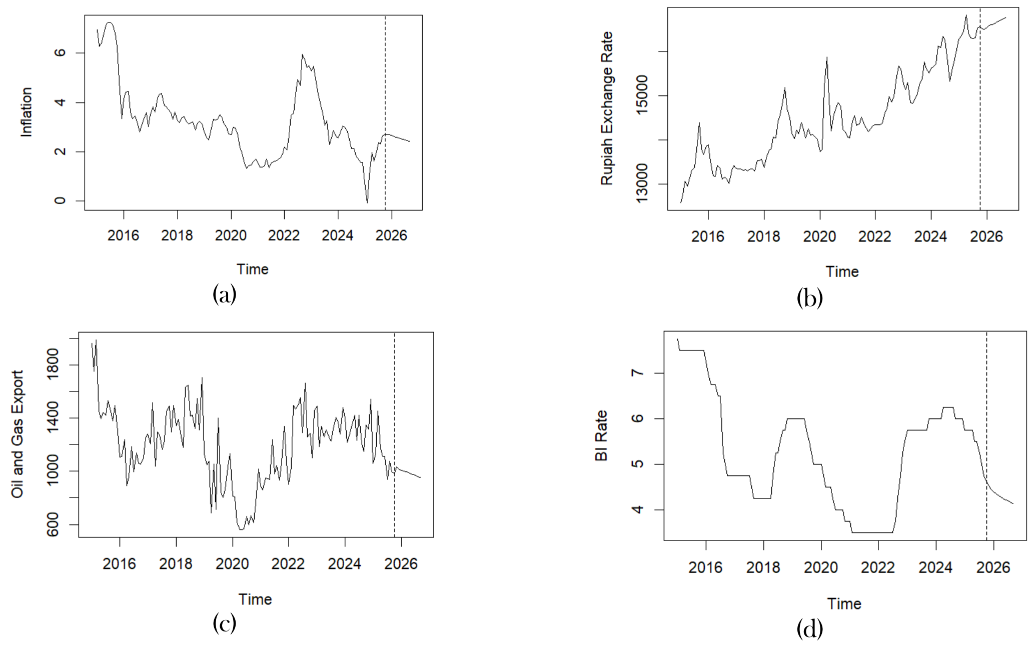



**Figure 6.** Actual Data and Forecast Results for Indonesia's Macroeconomic Variables

In general, a comparison between actual data and forecast results showed that although macroeconomic variables fluctuated in the short term, their movements tended to lead to more stable conditions in the coming period. This pattern indicated the existence of an adjustment mechanism in the economic system that allowed shocks to be temporary and not develop into long-term instability. This finding was important in the context of policy because it showed that macroeconomic dynamics were still on a path that could be managed through existing policy instruments.

Based on Figure 6(a), inflation showed quite sharp fluctuations with significant spikes in certain periods before declining again, reflecting the response of inflation to temporary shocks from both the demand and supply sides. Forecast results indicated that inflation will move relatively steadily at a moderate level going forward. This condition suggested that inflationary pressures were expected to remain under control, providing room for monetary authorities to maintain price stability without the need for excessive policy tightening in the short term.

Figure 6(b) showed that historically, the rupiah exchange rate had experienced a long-term depreciation trend accompanied by volatility, reflecting the influence of external factors and global financial market dynamics. However, the forecast results indicated that future exchange rate movements were likely to be more stable, despite continuing gradual weakening. This indicated a relatively controlled adjustment process towards external equilibrium, thereby minimizing the risk of sudden exchange rate pressure.

Furthermore, Figure (c) showed that oil and gas export values experienced high volatility and a sharp decline during the crisis period, reflecting the sensitivity of the oil and gas sector to global shocks and fluctuations in world energy prices. The forecast results showed a moderate downward trend accompanied by stabilization, indicating that oil and gas export performance in the future was not expected to face extreme pressure, although it remained vulnerable to changes in external conditions. These findings reinforced the importance of diversification strategies and anticipation of external risks in the management of the oil and gas sector.

Meanwhile, Figure 6(d) showed that the BI Rate moved adaptively in line with inflation dynamics and economic stability, reflecting its role as the main instrument of monetary policy. In the forecast period, the BI Rate was expected to decline gradually, indicating a direction of monetary policy easing in line with more controlled inflation and relatively stable macroeconomic conditions. Overall, these forecast results confirmed that monetary policy and market mechanisms played an important role in reducing short-term volatility and maintaining macroeconomic stability in the medium term.

Forecast results indicate stable inflation and gradual depreciation of the exchange rate, in line with the dominant role of monetary policy and external factors in developing economies [25]. The impact of oil and gas exports is relatively weaker due to their dependence on global energy prices and their declining contribution as a result of export diversification, so that their impact on macroeconomic variables is smaller in the short term, although they remain important for external balance.

## 4. CONCLUSION

The estimation results show that all variables have reached a stationary state after one differentiation, and the VAR (2) model was selected as the best model because it meets the AIC criteria and most of the diagnostic and system stability tests. The Granger causality test shows a significant relationship between the rupiah exchange rate and BI interest rates at a 5 percent significance level, and between oil and gas exports and BI interest rates at a 10 percent level. The impulse response analysis indicates that the shocks between variables are temporary and tend to subside within a certain period of time.

The forecasting results indicate that inflation is expected to be relatively stable, the rupiah exchange rate is likely to depreciate, oil and gas export performance will decline, and BI interest rates will show a downward trend during the projection period. Overall, these findings prove that the VAR model is capable of simultaneously representing the dynamics of the macroeconomic system based on data, while also illustrating the short-term adjustment mechanism and system stability.

From a policy perspective, these results can be used as an initial reference for monetary authorities in designing interest rate policies that are more responsive to exchange rate dynamics and external pressures. Forecasting information can also serve as an early warning system in maintaining inflation and exchange rate stability. The weakening role of oil and gas exports underscores the importance of export diversification strategies and strengthening the non-oil and gas sector to enhance the economy's external resilience.

However, this study has limitations because the VAR model used is unable to identify structural causal relationships and does not capture long-term relationships due to the use of first differentiation. In addition, global variables have not been included, so external influences are only reflected indirectly. Therefore, these findings should be understood as short-term empirical indications and need to be supplemented with further analysis and the development of more comprehensive models.

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