

## ANALYSIS OF THE IMPACT OF OIL PRICES AND EXCHANGE RATES ON INDONESIA'S FOREIGN EXCHANGE RESERVES USING THE STRUCTURAL VECTOR AUTOREGRESSION (SVAR) MODEL

Eqfal Rizki Andika<sup>1</sup>, Frederico Mego Sundoro<sup>2</sup>, Rohman Wahyu Hidayat<sup>3</sup>, Amabel Theifur Rasendriya<sup>4</sup>

<sup>1,2,3,4</sup>Semarang State University

\*Email correspondence: [eqfalrizki@students.unnes.ac.id](mailto:eqfalrizki@students.unnes.ac.id)

### ABSTRACT

Foreign exchange reserves play a strategic role in maintaining macroeconomic stability, exchange rate stability, especially in supporting the external resilience sector. Indonesia's economic resilience is highly determined by the Foreign Exchange Reserve which functions as a *Buffer* when there is a *shock* external. Two variables that affect the position of Foreign Exchange Reserves are fluctuations in global energy commodity prices, especially oil, and the volatility of the rupiah exchange rate against the US dollar. This study aims to analyze the effect of global oil prices and the USD exchange rate against the Rupiah on Indonesia's Foreign Exchange Reserves both in the short and long term through a quantitative approach with a model *Structural Vector Autoregression* (SVAR). Oil price fluctuations and the movement of the Rupiah exchange rate against the US Dollar are relevant issues due to geopolitical uncertainty, as well as international trade dynamics. The results of Bibliometrix analysis with vosViewer and Biblioshiny tools on Scopus indexed articles in 2021-2026, foreign exchange reserves, exchange rates, and oil prices show a strong relationship with contemporary international economic issues. The data used in the study is secondary data for the monthly time series for the period 2006-2025 obtained from Federal Reserve Economic Data (FRED). The results of the analysis show that the shock of world oil prices has a significant positive effect on short-term foreign exchange reserves, but the effect subsides after the implementation of monetary policy in stabilization. On the other hand, the depreciation of the rupiah has proven to exert negative pressure on the accumulation of foreign exchange reserves, especially when Bank Indonesia intervenes in the foreign exchange market to maintain exchange rate stabilization. This study concludes that exchange rate stability and controlling the external impact of oil price volatility are important factors in maintaining the resilience of national foreign exchange reserves. Therefore, the government and monetary authorities need to strengthen fiscal and monetary policy coordination, increase diversification of foreign exchange sources, and strengthen external sector stability to minimize the risk of global pressure on the Indonesian economy.

**Keywords:** Oil price, Exchange rate, Indonesian Foreign Exchange Reserves, SVAR

## 1. INTRODUCTION

The majority of the economies of countries in the world experience fluctuations from external shocks as an implication of the globalized economy. The source of external shocks is different and the impact on the country is also different because each country has different economic characteristics and structures. One indicator to see how the economic condition in a country is can be seen through the State Foreign Exchange Reserve. In this context, foreign exchange reserves are influenced by several factors, including the shock of Global Oil Prices (*Oil Prices*) and Exchange Rates (*Exchange Rates*). The higher the exchange rate, the stronger the country, so it can obtain more foreign exchange reserves. In Indonesia, the characteristics of the economy are *small-open economy*, which means that when there is an external shock, it is very difficult to avoid the impact of the external *shock* itself. This small open economy is highly susceptible to external dynamics, including fluctuations in world oil prices and the movement of the Rupiah exchange rate against the US Dollar. Both are variables that interact with each other and directly or indirectly affect the position of national foreign exchange reserves. Therefore, external shocks are the focus of attention in economic policy-making and economists in various countries around the world, including Indonesia.

According to Gandhi (2006), foreign exchange reserves have two important functions, namely to finance the balance of payments imbalance, usually to finance imports and pay foreign obligations, as well as to maintain monetary stability or to maintain currency exchange rates. The exchange rate is the number of currency units that must be submitted to obtain foreign currency units (S.Alam, 2007). The exchange rate can also be interpreted as a means of payment for conducting international transactions and usually already has an official exchange rate at the Central Bank (Sonia and Setiawina, 2016).



Based on the view *main information* From the results of the Bibliometrix analysis, by using Scopus database data with the keyword "Exchange Rate", it can be interpreted that the development of research related to the topics analyzed in the period 2021–2026 shows quite complex dynamics with a total of 1,881 documents originating from 401 sources and involving 3,913 authors, thus reflecting a relatively high level of scientific productivity and collaboration. Nonetheless, the *annual growth rate* of -22.08% indicates a decrease in the number of publications in the last period, which could reflect a consolidation phase or a decrease in the intensity of research on this topic. The international collaboration rate of 29.88% and an average of 2.57 authors per document show that research is dominated by cooperation between

researchers, both on a national and global scale. On the other hand, the number of *author's keywords* A considerable number of references (4,159) indicates the diversity of study focuses, while the high total references (79,153) indicate the depth of the literature used. The average document age of 2.9 years indicates that the analyzed research is relatively up-to-date, supported by an average citation per document of 7,839 which shows a fairly good level of academic influence in the scientific community. Overall, this data illustrates that despite the decline in publication trends, the quality, collaboration, and diversity of research topics are still well maintained.

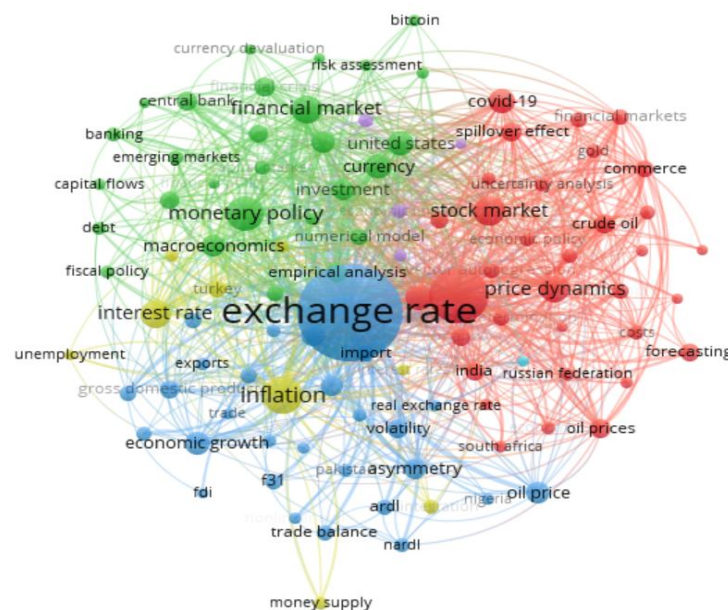


**Figure 1. Results of Bibliometric Analysis on the keyword "exchange rate"**  
**Source: Researcher, processed using Vos Viewer**

The result of the network visualization co-occurrence of the Scopus database data with the keyword explaining that *exchange rate* (exchange rate) is the main center of studies with wide relevance to various economic topics. The dominance of this central position indicates that the exchange rate plays a key role as a key variable that connects the macroeconomic, financial market, and real sector dimensions. From the results (Figure 1), it can be seen that there is a grouping of research themes into several clusters, where macroeconomic and monetary policy clusters highlight the exchange rate relationship with *monetary policy*, *financial market*, and the role of central banks; financial market clusters emphasize the linkage with *stock market*, *price dynamics*, as well as the impact of global shocks such as oil price fluctuations. While the real sector cluster shows a close relationship with *inflation*, *economic growth*, and international trade. In addition, the existence of methodological variables such as ARDL and the concept of asymmetry indicates the empirical approach used in analyzing related dynamics. Overall, the density and complexity of the network indicate that exchange rates are not only influenced by domestic factors, but are also highly integrated with global dynamics, thus making them a strategic indicator in understanding the transmission of economic policies and financial system stability.

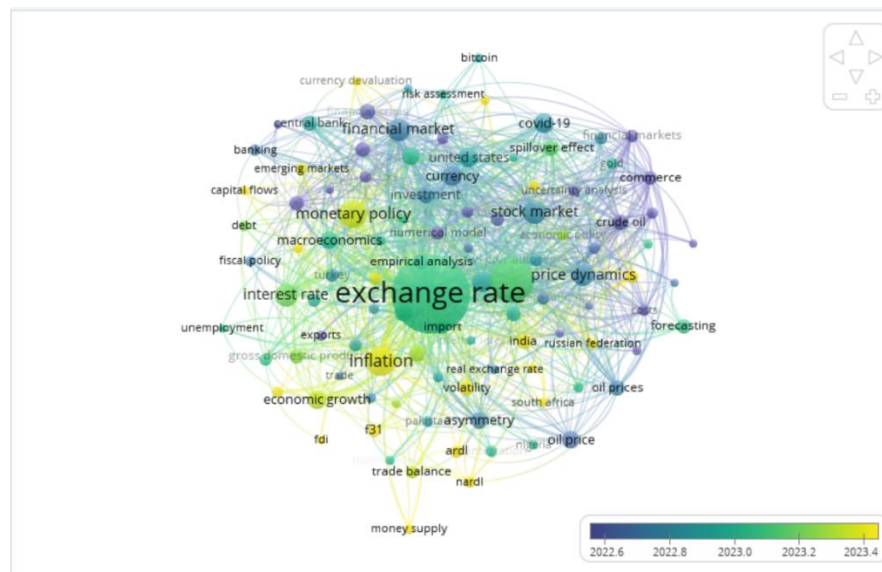


**Figure 2. Overlay Visualization Results for the keyword "Exchange Rate"**  
Source: Researcher, processed using Vos Viewer

Visualization *overlay* from the VosViewer shows the dynamics of the development of related research topics *exchange rate* based on the average year of publication, in which color becomes a temporal indicator (blue = older, yellow = newer). It can be seen that *exchange rate* remains a stable and dominant center of study, but there has been a shift in research focus from traditional issues such as *monetary policy*, *financial market*, and *interest rate* (which tends to be darker/bluer) towards more contemporary issues such as *inflation*, *economic growth*, *uncertainty analysis*, as well as methodological approaches such as *ARDL* and *asymmetry* (which is lighter in color/yellow). In addition, the emergence of topics such as *COVID-19*, *spillover effect*, and *oil prices* It shows that the latest literature is increasingly highlighting the impact of global shocks and uncertainty on exchange rates. The high density of the network indicates that despite the evolution of the theme, the interlinkages between variables are still very strong, so the research on exchange rates is moving in a more integrative direction by combining macroeconomic, financial market, and global external factors analysis in a more comprehensive framework.

This issue has strong relevance both nationally and internationally. From an international perspective, the volatility of world crude oil prices is influenced by decisions from OPEC (*Organizing of the Petroleum Exporting Countries*), geopolitical instability in the Middle East region, and economic recovery after the Covid-19 pandemic. Which, from the existing conditions, has created significant uncertainty for oil-importing and exporting countries (Baumeister, C., & Hamilton, J. D. 2019). In addition, the International Monetary Fund (IMF, 2023) also stated that global energy commodity price volatility is one of the main risks to the macroeconomic stability of developing countries, in this case, including Indonesia's foreign exchange reserves accompanied by exchange rates. In addition, the Fed's *aggressive interest* rate hikes since 2022 have exacerbated depreciative pressure on developing countries'

currencies, including the Rupiah, which has a direct impact on the use of Indonesia's foreign exchange reserves as a stabilization instrument (BIS, 2022).

Nationally, Indonesia recorded the country's foreign exchange reserves of USD 144.0 billion in January 2025. This figure is equivalent to 6.5 months of import financing. That according to (Bank Indonesia, 2025) this figure is still a very safe figure and is still above the international adequacy standard of three months of imports. However, the pressure stemming from the volatility of world crude oil prices and the strengthening of the rupiah exchange rate against the United States dollar has repeatedly forced Bank Indonesia to intervene in the foreign exchange market, which in turn will have an impact on depleting Indonesia's foreign exchange reserves in the short term. A clear example occurred in October 2023 when Indonesia's foreign exchange reserve position decreased from US\$134.9 billion in September 2023 to US\$133.1 billion. The decline was influenced by, among other things, the government's external debt payments and the need for Bank Indonesia to stabilize the rupiah exchange rate as an anticipatory measure against increasing uncertainty in the global financial market. In the same period, the rupiah exchange rate experienced depreciation pressure due to the strengthening of the US dollar and high volatility in the international financial market, prompting Bank Indonesia to intervene in the foreign exchange market to maintain exchange rate stability (Bank Indonesia, 2024).

Research on the relationship between oil prices, exchange rates (*exchange rates*) and Indonesia's foreign exchange reserves generally uses a quantitative approach based on secondary *time-series data*. The common and commonly used types of data are data with monthly or quarterly data coverage for international/global oil price variables (Brent Crude Oil), nominal exchange rates, and official foreign exchange reserves reported by the monetary authorities of each country. The main data source used is *Federal Reserve Economic Data (FRED)*. This quantitative approach was chosen because it allows dynamic analysis of relationships between variables in the time dimension, including the identification of causality relationships, *impulse responses*, and decomposition of variances. Where, all of them are the main capabilities of the Structural Vector Autoregression (SVAR) model. The use of the SVAR model in particular provides advantages in identifying structural shocks that have richer interpretations than conventional VAR models (Kilian & Lütkepohl, 2017).

There are several economic policies that are closely related to the dynamics of the variables used in the focus of this research. First, the monetary policy carried out by Bank Indonesia (BI) in maintaining exchange rate stability through open market operations (OPT) and interventions in the foreign exchange market which directly implicates the position of Indonesia's foreign exchange reserves. In this case, the sale of foreign exchange by Bank Indonesia (BI) to reduce the excessive depreciation of the rupiah exchange rate will reduce the stock of Indonesia's foreign exchange reserves itself in the short term. Second, the subsidized fuel price policy by the Indonesian government is indirectly related to global oil price variables. During the surge in global oil prices, the burden of fuel subsidies increased significantly, which would result in widening the fiscal deficit and depressing the exchange rate through increased fuel imports.

Third, the foreign exchange policy that regulates the obligation of exporters to place foreign exchange from export proceeds (DHE) in the country. As stipulated in Government Regulation Number 36 of 2023 which is a strategic instrument to strengthen the country's foreign exchange reserves and maintain Indonesia's external stability (Ministry of Finance, 2023). Fourth, at the international level, OPEC (*Organization of the Petroleum Exporting Countries*) *production policy and the Fed's* (Federal Reserved) *interest rate policy* are external factors that indirectly and significantly affect global oil prices and capital outflows or inflows from Indonesia.

Based on the above background description, this study seeks to answer all research questions including the following: (1) How does global oil price shocks affect Indonesia's foreign exchange reserves in the short and long term? (2) How does the shock of the Rupiah exchange rate affect the US dollar on the position of Indonesia's foreign exchange reserves? (3) How can the dynamic interaction between oil prices, exchange rates, and Indonesia's foreign exchange reserves be identified through the SWAR model?

The purpose of this study is to prove and answer the influence of global oil prices and exchange rates on Indonesia's foreign exchange reserves analytically and indefinitely by using the Structural Vector Analysis Regression (SVAR) model with monthly data for the period of 2006-2025. The benefits of this research are expected to contribute academically to the development of open macroeconomic literature in Indonesia, as well as provide relevant policy implications for Bank Indonesia, the Indonesian Ministry of Finance and the Government of Indonesia in formulating a strategy for managing the country's foreign exchange reserves that are more resilient and anticipatory to external shocks.

## 2. LITERATURE REVIEW

A number of previous research studies have explored and deepened the relationship between global oil prices and exchange rates against countries' foreign exchange reserves. Research on variables in the study is growing rapidly. Especially after the economic crisis in 2008-2009 which made many developing countries aware of the importance of an adequate buffer of foreign exchange reserves. In this case, the collection of journals relevant to the study in the period 2019-2025 which is the empirical and methodological basis in this research through various approach methods and country contexts. The results and outputs of previous research become the empirical and theoretical foundation for the research being developed.

In the context of the relationship between oil prices and exchange rates (*exchange rates*), Salisu et al. (2021) used the VAR panel for 20 oil-importing countries over the period (2010-2020) and found that the increase in oil prices consistently led to the depreciation of the exchange rates of importing countries through the path of deterioration of the trade balance. Its transmission mechanism works through an increase in the value of energy imports that drive increased demand against the US Dollar and depreciating pressure on the domestic currency. This study states that for a net oil importer such as Indonesia, the oil price shock is basically a negative term of trade shock that has the potential to weaken the overall external position.

Aizenman et al. (2020) in their comprehensive study on the determinants of accumulated foreign exchange reserves in emerging market countries found that the precautionary motive is the desire to have a buffer against sudden stop capital flow reversals. That is, it remains the main determinant of the accumulation of foreign exchange reserves, although the intensity varies depending on the level of financial openness and the depth of trade integration. The study also found that exchange rate volatility statistically significantly increases the country's foreign exchange reserve needs optimally, confirming the relevance of the exchange rate as a critical determinant of the country's foreign exchange reserves.

In the Indonesian context, Purba, Tiawon, and Beatris (2023) analyzed the determinants of Indonesia's foreign exchange reserves using the Error Correction Model (ECM) approach. The results of the study show that the exchange rate is one of the variables that has a significant influence on the dynamics of Indonesia's foreign exchange reserves both in the short and long term. These findings indicate that exchange rate stability has an important role in maintaining the adequacy of foreign exchange reserves as an instrument for stabilizing the external sector. However, the use of the ECM approach in the study still has limitations because it is only able to identify short-term and long-term relationships without explaining the mechanism of shock transmission dynamically through impulse response or forecast error variance decomposition as can be done by the SVAR model.

The SVAR approach has advantages over conventional linear econometric models because it is able to identify structural shocks and analyze dynamic responses between variables through impulse response function (IRF) and forecast error variance decomposition (FEVD). According to Kilian and Lütkepohl (2017), this ability allows researchers to distinguish the sources of economic shocks and trace their transmission mechanisms more comprehensively than the ECM and reduced VAR approaches.

### Foreign Exchange Reserves

Foreign exchange reserves are foreign exchange reserves reserved by the Central Bank (Bank Indonesia) for financing and foreign obligations, including import financing or other payments to foreign parties (Hady, 2001). Foreign exchange reserves, often referred to as *International Reserves and Foreign Currency Liquidity* (IRFCL) or *official reserve assets*, are defined as all foreign assets controlled by monetary authorities and can be used at any time, to finance balance of payments imbalances or in the context of monetary stability by intervening in the foreign exchange market and for other purposes.

According to Gandhi (2006), the components of foreign exchange reserves can be in the form of monetary gold, *Special Drawing Rights* (SDR), *Reserve Position in the Fund* (RPF), foreign exchange, and other bills. Meanwhile, the recording of the value of foreign exchange reserves in statistics is generally according to the market price, namely the market rate that affects the time of the transaction. The market price for bills such as participation and the SDR rate is determined by the IMF. Monetary gold transactions are valued according to the market

price of the underlying transaction, while for the valuation of the position of foreign exchange reserves, market prices are used which have an effect at the end of the period.

### **World Oil Prices**

World oil prices play an important role because they determine energy costs, especially in developing countries that depend on energy imports, such as Indonesia. The three types of oil that are commonly traded are European Brent Oil, Middle East Dubai Oil, and US West Texas Intermediate Oil (Nurfitriyani, 2023). The world oil price is calculated as the amount of money needed to produce 1 barrel of US oil. API levels and sulfur content determine the price of oil (American Petroleum Institute). This study highlights WTI crude oil as a standard for oil prices around the world that is used to see the impact of changes in oil prices on production costs and people's purchasing power. High oil prices tend to increase production costs in energy-dependent sectors, such as transportation and manufacturing, thereby reducing people's ability to buy goods. This can lead to a decrease in domestic consumption and investment which can ultimately slow down Indonesia's economic growth, according to Mundell-Fleming's theory (Purba, 2019).

The factors that affect oil prices are basically seen in the movement of commodity prices and are based on the supply and demand of commodities. Of these two things, they are influenced by several factors that have an impact on global oil prices in the short and long term. Because markets are global and volatile, these components are not easy to measure. However, we can estimate it by looking at the latest trends. In addition, keep in mind that speculators and price manipulation can affect this type of market (Sultan & Soesilo, 2017).

### **Exchange Rate (Exchange Rate)**

The exchange rate or exchange rate is the price of a country's currency that will be measured and expressed in the currency of another country or in a foreign language known as *the exchange rate*. A foreign currency price is expressed in terms of the exchange rate at which, if an increase occurs in the exchange rate of a currency within the country, it will be called the appreciation of the currency (the currency of another country is much lower, meaning that the value of our domestic foreign currency will increase).

There is a transaction of buying and selling goods and services with other countries, there is a comparison of the value or price between the two currencies and an exchange rate or exchange rate is created consisting of the selling rate, the buying rate, and the middle rate (Hadi, 2015). The foreign exchange rate or exchange rate indicates the price or value of a country's currency expressed in the value of another country's currency. The foreign exchange rate can also be defined as the amount of domestic money needed, namely the amount of rupiah needed to obtain one unit of foreign currency (Sukirno, 2013).

The Uncovered Interest Parity (UIP) theory explains that exchange rate movements in an open economy are influenced by differences in the rate of return of financial assets between countries which is reflected in interest rate differential. In the period of monetary tightening of

the United States in 2022–2024, the Federal Reserve's high interest rates increase the attractiveness of US dollar-denominated assets and reinforce depreciation pressure on emerging currencies, including the Rupiah. This condition encourages monetary authorities in various developing countries to carry out stabilization policies through interest rate instruments and foreign exchange market intervention using foreign exchange reserves (IMF, 2024).

The relationship between the exchange rate and foreign exchange reserves is dynamic and interdependent. Exchange rate depreciation pressures may prompt central banks to use foreign exchange reserves to dampen foreign exchange market volatility, while the adequacy of foreign exchange reserves contributes to market confidence in the ability of monetary authorities to maintain external stability. The characteristics of such simultaneous relationships indicate that exchange rates and foreign exchange reserves cannot be treated as completely exogenous variables. Therefore, the Structural Vector Autoregression (SVAR) approach is relevant because it is able to model dynamic interactions between variables endogenously while identifying shock transmission mechanisms through Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) analysis.

### Theoretical Framework and Research Hypothesis

Based on the literature review above, a theoretical framework can be formulated that connects the three variables in this study. **First**, through trade channels and balance of payments, the hypothesis: Oil prices rise → oil and gas imports increase → trade balance deficit widens → demand USD increases → KURS weakens (depreciation) → Bank Indonesia's intervention → CDI decreases. **Second**, through the expectation and capital flow channels, the hypothesis is that OIL volatility will increase → global uncertainty increases → capital outflows from Indonesia → KURS depreciate → Bank Indonesia's intervention → CDI decreases. Based on this theoretical framework, the research hypothesis is: (H1) Positive shock of oil prices has a negative effect on foreign exchange reserves in the medium term; (H2) Exchange rate depreciation shocks have a negative effect on foreign exchange reserves; (H3) Exchange rate shocks contribute more to foreign exchange reserve variations than oil price shocks.

## 3. METHODS

### Research Approach

This study uses a quantitative approach with a multivariate *time-series data analysis design*. The methodology of this quantitative approach was chosen because the research question is causal-dynamic and requires quantification of the relationship between variables in the time dimension. The entire procedure in analyzing model regression estimation is carried out using the STATA 17 application device which provides a variety of complete and tested modules including VAR, SVAR, IRF and FEVD estimations. The internal validity of the study is maintained through systematic diagnostic testing of each hold and analysis procedure.

The selection of the Structural Vector Autoregression (SVAR) model as the main analysis tool in this study is based on its ability to identify dynamic relationships between variables while distinguishing the sources of economic shocks that occur in the system. The SVAR model is an extension of the Vector Autoregression (VAR) approach introduced by Sims (1980), by adding structural constraints based on economic theory so that each shock identified has a clearer and more meaningful economic interpretation. In contrast to the reduced VAR model which only describes the statistical relationships between variables, the SVAR model allows researchers to identify the mechanism of shock transmission in more depth through Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) analysis. Therefore, the SVAR model is considered more suitable for analyzing the interaction between world oil prices, exchange rates, and foreign exchange reserves that theoretically influence each other in an open economic system (Sims, 1980; Kilian & Lütkepohl, 2017). SVAR makes it possible to identify shocks in depth so that the results of IRF and FEVD can be interpreted in causally clear economic language. SVAR treats all variables as endogenous, thus avoiding the bias that arises from the use of OLS that assumes one variable to be exogenous. In addition, SVAR is also able to capture the contemporaneous relationship between variables through matrix A, which is highly relevant to global oil prices, exchange rates, and foreign exchange reserves can affect each other almost simultaneously in a single monthly period.

### Research Variable Data

The data used in this study is secondary data of monthly data over time spans (*time-series*) from the period of January 2006 to December 2025. With an output of 240 initial observations and after lag and differentiation determination, there are 237 active observations left in the period April 2006 – December 2025. The selection of this period was chosen because it includes various cycles and economic dynamics that are representative for analyzing the impact of oil prices and exchange rates, including the economic crisis in the year (2008-2009), the commodity super-cycle (2010-2014), the episode of the oil price plummeting period (2014-2016), the Covid-19 pandemic for the period (2020-2021) and the post-Covid-19 pandemic recovery in the period (2021-2022) and the high interest rate of the Fed (*Federal Reserve*) and geopolitical uncertainty for the year period (2022-2024).

**Table. 1 Variables, Indicators, and Data Sources**

| Yes | Variable                              | Stata Code | Units            | Data Source |
|-----|---------------------------------------|------------|------------------|-------------|
| 1.  | Indonesia's Foreign Exchange Reserves | CDI        | Million USD      | FRED        |
| 2.  | Crude Oil Price                       | OILPRICE   | USD per barrel   | FRED        |
| 3.  | IDR/USD exchange rate                 | KURS       | Rupiah for 1 USD | FRED        |

Source: FRED, Processed Author (2025)

The dependent variable used is Indonesia's foreign exchange reserves (FER) which is measured in million United States Dollars (USD). Foreign exchange reserves are chosen because they reflect a country's ability to meet international obligations, maintain exchange rate stability, and become the central bank's main instrument in the face of external pressures. In the

Indonesian context, foreign exchange reserves also play an important role as a tool for foreign exchange market intervention when there is excessive exchange rate volatility.

The first independent variable is the world oil price (Oil Price) which is represented by the price of Brent or West Texas Intermediate (WTI) crude oil in United States Dollars per barrel. Oil prices are chosen because they are one of the strategic indicators of the global economy that affect a country's production costs, inflation, trade balance, and foreign exchange flows. Oil price fluctuations also have the potential to affect the position of foreign exchange reserves through changes in the value of energy imports and foreign exchange receipts from international trade activities.

The second independent variable is the exchange rate of the Rupiah against the United States Dollar (USD-IDR) which is measured based on the amount of Rupiah per one US Dollar. This variable is used because the exchange rate is one of the main indicators of the external stability of the economy. Exchange rate movements are closely related to foreign exchange reserves, especially as Bank Indonesia actively uses foreign exchange reserves as a stabilization instrument in times of depreciation pressure and high volatility in the foreign exchange market.

All data was obtained through Federal Reserve Economic Data (FRED). This database was chosen because it provides standardized, easily accessible, and widely used macroeconomic data in international academic research. In addition, FRED integrates data from various official institutions such as the International Monetary Fund (IMF), the World Bank, the Bank for International Settlements (BIS), and national statistical authorities so that the credibility and consistency of the data can be accounted for academically.

The variable CDI (Indonesian Foreign Exchange Reserve) is used in USD million units according to the reporting format obtained from FRED. OILPRICE uses USD units per barrel obtained from FRED which is consistently in frequency every month which serves as a proxy for world oil prices as well as its high correlation with Brent and Indonesian Curd Price (ICP) prices as relevant price references for Indonesia. The KURS reflects the amount of rupiah needed to buy one US dollar, so the increase in the value of this variable indicates the depreciation of the rupiah exchange rate.

All variables are estimated in the form of first difference (dCDI, dOILPRICE, dKURS) after the stationerity test confirms that all three are I(1). Unlike the previous version, the variables in this study were not transformed into natural logarithms because the CDI variable had a large enough unit (million USD) and the SVAR scheme was applied using data at the first difference level to maintain an interpretive unit.

## Model ANSWER

As the foundation of the SVAR model, the reduced-form VAR model is first estimated. A VAR(p) model with three endogenous variables can be written as:

$$Y_t = c + A1Y_{t-1} + A2Y_{t-2} + \dots + ApY_{t-p} + ut \dots (1)$$

where  $Y_t = [dCDI, dOILPRICE, dKURS]'$  is a vector ( $3 \times 1$ ) of the endogenous variable;  $c$  is the vector of the constant ( $3 \times 1$ );  $A_i$  is the coefficient matrix ( $3 \times 3$ ) at lag  $i$ ; and  $ut$  is a distributed reduced-form residual vector i.i.d. with a variance-covariance matrix  $\Sigma u$ .

The SVAR model is then constructed by identifying the structural relationships between variables through restrictions on two matrices: matrix  $A$  which captures the contemporary relationship between endogenous variables, and matrix  $B$  which captures the contemporary relationship between endogenous variables and structural shocks. Common representations of the SVAR model are:

$$A ut = B \epsilon t \dots (2)$$

where  $\epsilon t$  is a vector of structural shocks that are assumed to be orthogonal with  $E(\epsilon t \epsilon t') = I$ . Equation (2) implies that structural shocks are connected to residual reduced-form through:  $ut = A^{-1}B \epsilon t$ . The identification restrictions applied use a recursive approach (Cholesky) so that matrix  $A$  is lower triangular with a diagonal one, and matrix  $B$  is diagonal.

Specifically, based on the SVAR syntax used in STATA — `svar dCDI dOILPRICE KURS, aeq(A) beq(B)` — matrix  $A$  and  $B$  are specified as follows:

$$A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} B = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The sequence of  $dCDI \rightarrow dOILPRICE \rightarrow dKURS$  variables in the system reflects causal assumptions based on economic theory: (1) foreign exchange reserves ( $dCDI$ ) are placed first because on a monthly frequency it is a policy variable that moves slower and does not directly respond to other variables in a contemporary way — changes in foreign exchange reserves are the result of policy decisions that require execution time; (2) oil prices ( $dOILPRICE$ ) respond contemporaneously to foreign exchange reserve conditions but faster than exchange rates in the context of market transmission; (3) the exchange rate ( $dKURS/KURS$ ) as the most responsive market variable, moving contemporaneously against the other two variables in a single monthly period.

### Empirical Analysis Procedure

This study uses the Structural Vector Autoregression (SVAR) approach to analyze the dynamic relationship between world oil prices, the exchange rate of the Rupiah against the United States Dollar, and Indonesia's foreign exchange reserves. This approach was chosen because it is able to identify the relationships between variables simultaneously and trace the transmission mechanism of economic shocks through the identification of structural shocks that have a clearer economic interpretation than conventional VAR models (Kilian & Lütkepohl, 2017). The stages of empirical analysis are carried out in stages as explained below.

### Uji Stasioneritas ( Augmented Dickey-Fuller Test)

The initial stage of analysis was carried out through a stationarity test using the Augmented Dickey-Fuller (ADF) Test. This test aims to ensure that the data does not contain root units that can cause the estimation results to be invalid or result in pseudo-spurious regression. The test was carried out at the level and first difference level for all research variables, namely foreign exchange reserves, world oil prices, and the exchange rate of the Rupiah against the United States Dollar. The zero hypothesis in the ADF test states that the variable contains root units or is not stationary, while the alternative hypothesis states that the data is stationary. The test decision was based on a comparison between the ADF statistical value and the MacKinnon critical value at a certain level of significance. Variables that are not stationary at the level will be transformed to the first difference until they meet the assumption of stationarity (Enders, 2015).

### **Determination of Optimal Lag**

Once the data is declared stationary, the next step is to determine the optimal lag length to use in the model. Lag selection is important because too little lag has the potential to eliminate dynamic information between variables, while too much lag can reduce the efficiency of estimation. The optimal lag determination was carried out using the Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz Bayesian Information Criterion (SBIC). The selected lag is the lag that produces the smallest information criterion value and is supported by the results of the residual diagnostic test. Next, a Lagrange Multiplier (LM) test is performed to ensure that the residual model does not contain autocorrelation so that the estimated model meets the basic assumptions of VAR and SVAR analysis (Lütkepohl, 2005).

### **SVAR Model Estimation and Structural Identification**

After the optimal lag is obtained, the estimation begins by forming a reduced form VAR model as the basis for identifying relationships between variables. Furthermore, Structural Vector Autoregression (SVAR) estimation is carried out by applying structural restrictions based on economic theory and transmission mechanisms that are relevant to the relationship between oil prices, exchange rates, and foreign exchange reserves.

Through these restrictions, the model is able to separate the structural shocks originating from each variable so that the resulting economic interpretation becomes stronger. Parameter estimation is carried out using the Maximum Likelihood approach which aims to obtain parameters that are most suitable for the characteristics of the data. The success of the estimation process is demonstrated by the convergence of the model and the fulfillment of structural identification conditions (Kilian & Lütkepohl, 2017).

### **Analisis Impulse Response Function (IRF) Struktural**

After the SVAR model is estimated, an Impulse Response Function (IRF) analysis is performed to see how a variable responds to shocks originating from other variables in the

system. This analysis allows researchers to observe the direction, magnitude, and duration of the response that occurs after the emergence of a certain economic shock.

In this study, the observation horizon was set for the next ten periods to capture short- to medium-term adjustment patterns. The results of the IRF are used to explain how changes in world oil prices and exchange rates affect the dynamics of Indonesia's foreign exchange reserves over time. Because it comes from a structurally identified SVAR model, the resulting response has a stronger economic interpretation than the impulse response in a regular VAR model.

### Forecast Error Variance Decomposition (FEVD)

The final stage of analysis was carried out using Forecast Error Variance Decomposition (FEVD). This analysis aims to measure how much each structural shock contributes in explaining the variation or uncertainty of a variable's prediction over a given period.

Through FEVD, it can be known which variables have a dominant role in influencing changes in Indonesia's foreign exchange reserves. For example, if exchange rate shocks contribute the greatest to the variation in foreign exchange reserves, it can be concluded that exchange rate stability is a relatively more important factor than other factors in determining the dynamics of Indonesia's foreign exchange reserves. Thus, the results of FEVD are complementary to the IRF analysis in understanding the structural relationships between the variables studied.

## 4. RESULTS AND DISCUSSION

### Augmented Dickey-Fuller Test

The results of the stationery test were carried out to determine the variables that were studied whether they were stationary or non-stationary using the Augmented Dickey-Fuller Test (ADF) test method, the specific results were obtained as follows:

**Table. 2 Hasil Uji Stationeritas (Augmented Dickey-Fuller Test)**

| Variable           | ADF Level       | ADF 1st Diff     | p-value   | Conclusion |
|--------------------|-----------------|------------------|-----------|------------|
| Permanent contract | $Z(t) = -1.913$ | $Z(t) = -13.103$ | 0.0000*** | I(1)       |
| OILPRICE           | $Z(t) = -2.057$ | $Z(t) = -10.341$ | 0.0000*** | I(1)       |
| COURSE             | -               | $Z(t) = -12.422$ | 0.0000*** | I(1)       |

Source: STATA 17 output, author-processed (2025)

\*Note: significant at  $\alpha = 1\%$ . MacKinnon's critical value = 1%=-3.464; 5% = -2.881; 10% = -2.571. Obs = 239 (level), 238 (1st diff). Specification = Random Walk Whitout Drift.

In the information of the table presented, that the table is the result of a test for stationery testing using the Augemnted Dickey-Fuller Test (ADF) shows that the CDI variable at that level has a statistic ADF  $Z(t) = -1.913$  with a p-value of 0.3261, which is far above the critical value of 5% (-2.881%), thus failing to reject the hypothesis of zero ( $H_0$ ) of the existence of the root

unit implies that the CDI variable is in a non-stationary state at the level. Similarly, in the independent variable, namely OILPRICE with  $Z(t) = -2.057$  ( $p\text{-value} = 0.2623$ ) and KURS which is also in a non-stationary position at the level. However, after first differencing ( $d.CDI$ ,  $d.OILPRICE$ ,  $d.KURS$ ), all variables showed statistics of Augmented Dickey-Fuller (ADF) test results that far exceeded the critical value at the 1% confidence level.  $Z(t) = -13.103$ ,  $-10.341$ , and  $-12.422$ , respectively with a  $p\text{-value}$  of  $0.0000$ . Thus, the root unit hypothesis is rejected and it is concluded that the three variables, namely CDI, OILPRICE, and KURS are integrated of order one,  $I(1)$ , and stationary at the first difference.

### Optimal Lag Determination and VAR Estimation

Based on the lag results using AIC, HQIC, and SBIC information criteria, the lag selected and optimal in this study estimate was lag 2 ( $p = 2$ ). The value of the information criteria from the VAR(2) estimation results was  $AIC = 38.91071$ ,  $HQIC = 39.03457$ , and  $SBIC = 39.218$ . In the results of the information presented, these three conditions are consistent and show that var(2) is the most parsimony specification with an adequate fit. The VAR(2) estimation was carried out on the three variables, namely  $d.CDI$ ,  $d.OILPRICE$ , and  $d.KURS$  using samples in the period April 2006 to December 2025 (237 active observations).

**Table. 3 VAR Estimation Result(2) – Equation Summary**

| Equations  | RMSE    | R-Squared | Chi <sup>2</sup> | P > Chi <sup>2</sup> |
|------------|---------|-----------|------------------|----------------------|
| d.CDI      | 2793.86 | 0.0328    | 8.027            | 0.2361               |
| d.OILPRICE | 5.79033 | 0.1556    | 43.664           | 0.0000               |
| d.COURSE   | 258.338 | 0.9903    | 24183.93         | 0.0000               |

Source: STATA 17 output, processed by the author (2025), Sample: 2006m4 – 2025m12, N=237

From the summary of the VAR(2) equation above, it can be seen that the KURS equation has  $R^2 = 0.9903$ , which indicates that 99.03% of the variation in exchange rate changes can be explained by the lag-lag variable in this system. This condition is natural, considering that the exchange rate is very resistant and is greatly influenced by its own value in the previous period (L.1 KURS has a coefficient of 1.1054 with  $Z = 15.91$ ,  $p = 0.0000$ ). The dCDI equation yields an  $R^2$  value of 0.0328 which indicates that only a small fraction of the variation in foreign exchange reserve changes can be explained by the variable dynamics in the model. These results indicate that the movement of Indonesia's foreign exchange reserves is also influenced by various other factors outside the research model, such as government transactions with the external sector, issuance of debt securities in foreign exchange, payment of foreign obligations, foreign exchange market intervention activities by Bank Indonesia, and changes in the composition of reserve assets. Thus, the low value of  $R^2$  does not necessarily indicate the weakness of the model, but rather reflects the complexity of the determinants of foreign exchange reserves derived from various sources of external transactions and macroeconomic policies.

From the individual coefficients of VAR(2), the highlights are: (1) the L1 coefficient d.CDI of the d.CDI equation is 0.1753 ( $p = 0.010$ ), at a significance level of  $\alpha = 5\%$ , where the value ( $p = 0.010$ ) indicates that there is a positive autocorrelation in the change in foreign exchange

reserves; (2) L1 coefficient. The KURS in the KURS equation is 1.1054 ( $z=15.91$ ,  $p = 0.0000$ ). From the test results, it is confirmed that the persistence of the exchange rate is very high; and (3) the L.dCDI coefficient in the KURS equation of -0.0264 ( $z = -4.17$ ,  $p = 0.0000$ ), this figure shows that this condition is strong, where the increase in foreign exchange reserves in the previous period statistically significantly underestimated the pressure on the exchange rate (rupiah appreciation).

### SVAR Model Estimation Results

The SVAR model estimation was carried out using the SVAR syntax test dCDI, dOILPRICE, and dKURS. aeq (A) and beq (B) with the matrices A and B specified as the lower triangle and diagonal respectively. The Maximum Likelihood iteration process successfully converged after 47 iterations with a final likelihood log of -4589,919 that was exactly the same as the reduced-form VAR likelihood log, confirming that the model was exactly identified. The following SVAR estimation results are presented in the table. 4

**Table. 4 Results of Matrix Coefficient Estimation A & B (SVAR)**

| Parameter | Coefficin  | Std. Error | z-stat | P >  z | 95% Conf. Int.     |
|-----------|------------|------------|--------|--------|--------------------|
| /A: [2,1] | -0.0083794 | 0.0001323  | -2.87  | 0.004  | [-0.0087; -0.0001] |
| /A: [3,1] | 0.0246983  | 0.0056756  | 4.35   | 0.000  | [0.0136; 0.0358]   |
| /A: [3,2] | 9.458985   | 2.738491   | 3.45   | 0.001  | [4.092; 14.826]    |
| /B: [1,1] | 2752.289   | 126.4168   | 21.77  | 0.000  | [2504.5; 3000.1]   |
| /B: [2,2] | 5.607767   | 0.2575733  | 21.77  | 0.000  | [5.103; 6.113]     |
| /B: [3,3] | 236.4153   | 10.85891   | 21.77  | 0.000  | [215.1; 257.7]     |

Source: Output of STATA 17, processed by the author (2025). Model exactly identified, Log Likelihood = -4589.919,  $N = 237$ .

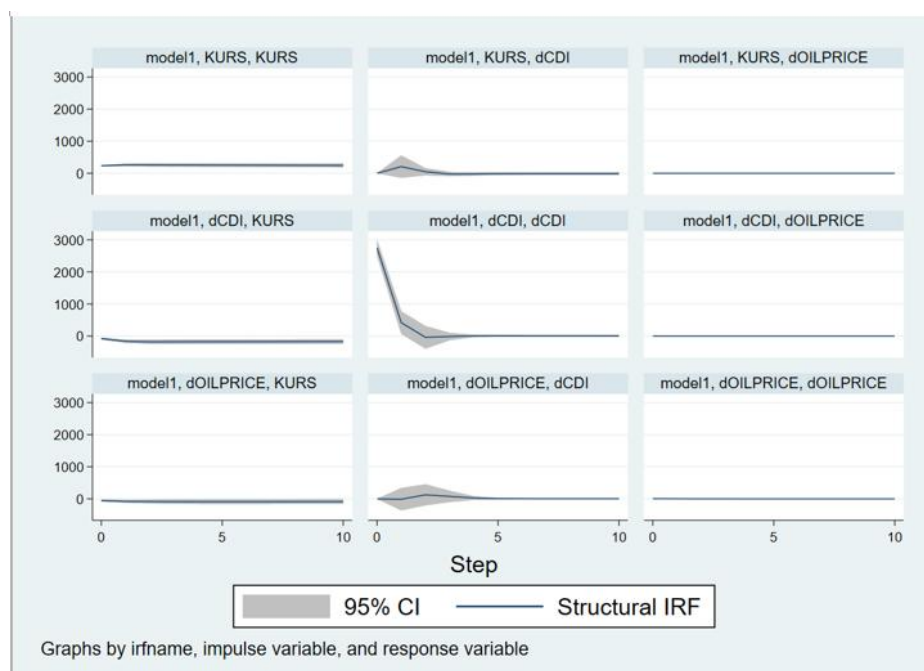
The coefficient of matrix A has a very important and statistically significant economic interpretation. Coefficient A [2.1] = -0.0084 ( $p = 0.004$ ) This figure shows that the contemporary increase in dCDI by one unit (million USD) is contemporaneous with a decrease in d.OILPRICE of 0.0084 USD per barrel. Although small in absolute magnitude, this statistical significance confirms the existence of a contemporary structural relationship between foreign exchange reserves and oil prices: when foreign exchange reserves increase (e.g. due to high export receipts or capital inflows), it correlates with lower oil price conditions in the same period, reflecting historical episodes in which low oil prices coincide with the accumulation of foreign exchange reserves.

The coefficient  $A[3,1] = 0.0247$  ( $p = 0.000$ ) indicates that the contemporaneous increase in dCDI is related to the increase in KURS (Rupiah depreciation). This can be interpreted as a reflection of a period when the accumulation of foreign exchange reserves occurred at the same time as the weakening of the Rupiah — for example when Bank Indonesia intervened in a two-way manner or when there was a large capital inflow but simultaneously with structural pressure on the exchange rate. The coefficient  $A[3,2] = 9.459$  ( $p = 0.001$ ) is the largest in absolute terms and has strong economic significance: the contemporaneous increase in dOILPRICE of 1 USD per barrel is contemporaneously related to the increase in KURS (depreciation of Rupiah) of 9,459 Rupiah. This directly confirms the mechanism of transmission of oil prices to exchange rates that works through import lines and oil and gas trade balances.

The diagonal coefficient of the matrix B —  $B[1,1] = 2752.29$ ,  $B[2,2] = 5.608$ ,  $B[3,3] = 236.42$  — represents the standard deviation of each structural shock. This means that one standard shock deviation in foreign exchange reserves is equivalent to USD 2,752 million; one standard shock deviation in oil prices equivalent to USD 5.61 per barrel; and one standard shock deviation at the exchange rate equivalent to Rp 236.42 per US Dollar. All coefficients of B were very significant ( $p = 0.000$ ) with z-statistic = 21.77, confirming that matrix B was well identified.

### Analisis Impulse Response Function (IRF) Struktural

The structural IRF analysis was carried out to trace and explore information on the dynamic response pattern of foreign exchange reserves to each structural shock over the next 10 periods. The following is the IRF graph result on the estimated STATA 17 output which shows  $3 \times 3 = 9$  response panels with a confidence interval of 95%



The dCDI's response to the dCDI shock itself showed a large positive response in the initial period (around 2,700-2,800 million USD) which then exponentially decreased and approached zero in the 4-5 period. This pattern reflects the mean-reverting nature of changes in foreign exchange reserves — idiosyncratic shocks in foreign exchange reserves tend to correct themselves in the short term in line with Bank Indonesia's policy of keeping foreign exchange reserves levels within a certain range.

The dCDI's response to the dOILPRICE shock showed a relatively flat and near-zero pattern along the entire horizon, with a slight positive response at the beginning that then faded. This indicates that in a model that uses first difference data, oil price shocks do not have a large and persistent impact on changes in foreign exchange reserves directly. These findings can be interpreted in two ways: first, the effect of oil prices on foreign exchange reserves works more through indirect channels (through exchange rates), rather than directly; second, because the SVAR uses the first difference, the impact of oil prices on the level of foreign exchange reserves in the long term must be interpreted cumulatively through the accumulation of changes.

The dCDI's response to the KURS shock shows the most policy-informative pattern: a negative response at the beginning (around -100 to -200 million USD per period) that then moves positively after 2-3 periods before finally converging to zero. The negative pattern at the beginning confirms Bank Indonesia's intervention mechanism — when the exchange rate experiences a sudden depreciation shock, Bank Indonesia uses foreign exchange reserves to stabilize the exchange rate, so that foreign exchange reserves are reduced in the very short term. The recovery that occurred afterwards reflected the normalization of the position of foreign exchange reserves after the pressure subsided.

### Forecast Error Variance Decomposition (FEVD)

Based on the FEVD (fraction of MSE due to impulse) graph on the estimated STATA 17 output, it can be identified that the relative contribution of each structural shock to the variation in foreign exchange reserves (dCDI) over various horizons. The following are the results of the FEVD graif in the estimated test that has been carried out

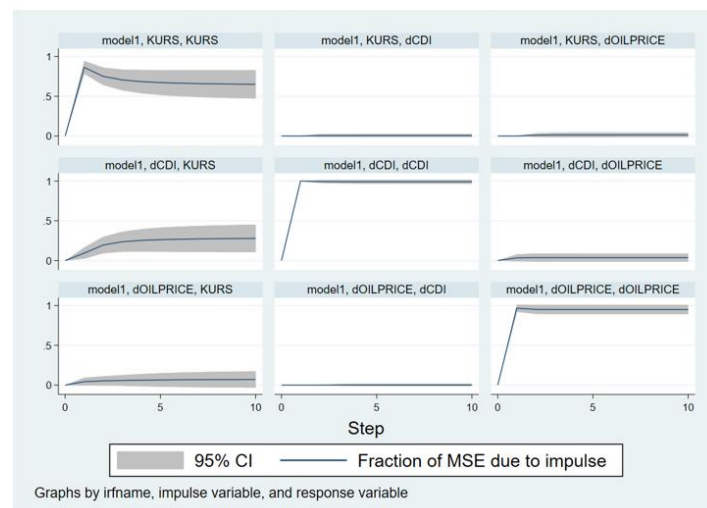


**Table 5. Estimated Contribution of Structural Shocks from the FEVD Chart (Foreign Exchange Reserves/dCDI)**

| Horizon (Bln) | Own Shock (dCDI) | OIL Shock<br>(dOILPRICE) | COURSE Shock |
|---------------|------------------|--------------------------|--------------|
| 1             | ~100%            | ~0%                      | ~0%          |
| 2             | ~70%             | ~5%                      | ~25%         |
| 4             | ~65%             | ~5%                      | ~30%         |
| 6             | ~62%             | ~5%                      | ~33%         |
| 10            | ~60%             | ~5-8%                    | ~35-40%      |

*Note: Percentages are visual readings of the FEVD graph of STATA output. Total per line = 100%.*

The results of the FEVD provide a very informative picture. In the first period (horizon 1), almost all variations in foreign exchange reserves (close to 100%) were explained by own shocks, which is natural because in the very short term changes in foreign exchange reserves are more a response to internal operational factors of Bank Indonesia. However, the contribution of KURS shock jumped significantly from the 2nd period and continued to increase, reaching around 25-40% on the 4-10 month horizon. This is the most important finding: in the medium term, exchange rate shocks are the second largest source of variability (after own shock) of Indonesia's foreign exchange reserves.

In contrast, the contribution of OILPRICE shocks to foreign exchange reserve variations remains very small and relatively stable in the range of 5-8% across the entire horizon. These findings confirm that the impact of oil prices on foreign exchange reserves works more indirectly through the exchange rate (as indicated by the significant coefficient  $A[3,2] = 9,459$ ), rather than directly. This means that the price of oil affects the exchange rate first, and the exchange rate then affects the foreign exchange reserves — not the price of oil that directly affects the foreign exchange reserves.

### Economic and Policy Implications

Overall, the empirical findings of this study are consistent with hypotheses built from theoretical frameworks and are in line with the findings of related studies. First, the finding that oil price shocks have a direct impact on the exchange rate ( $A[3,2] = 9,459$  significant) more than on foreign exchange reserves directly confirms the hypothesis that the transmission path of oil prices to foreign exchange reserves is indirect — through exchange rates as a mediating variable. This is consistent with the findings of Salisu et al. (2021) that oil price shocks first affect the exchange rate of importing countries, which then implications for external positions.

Second, the dominance of the contribution of the KURS shock to the variation in foreign exchange reserves in the medium term (~30-40%) compared to the OIL shock (~5-8%) provides a clear hierarchy of policy importance. Bank Indonesia should prioritize exchange rate stabilization policies as a key pillar in maintaining the resilience of foreign exchange reserves, above efforts to manage the impact of oil price volatility directly. These findings support Bank Indonesia's triple intervention strategy which is more intensive in the exchange rate market than commodity-based interventions.

Third, the very high  $R^2$  in the KURS equation (0.9903) but relatively low in the dCDI equation (0.0328) implies that changes in foreign exchange reserves are more volatile and less predictable by variables in the system than by exchange rate changes. This underscores the importance of strengthening the buffer of foreign exchange reserves through instruments outside of the existing market mechanisms in the model — such as the DHE (Foreign Exchange Export Yield) policy, bilateral financial diplomacy, and strengthening foreign exchange reserves through the allocation of SDRs from the IMF.

Concrete policy implications that can be formulated include: (1) Bank Indonesia needs to deepen the DNDF market and optimize SRBI instruments as a more cost-effective alternative to exchange rate intervention — not directly depleting foreign exchange reserves; (2) close coordination between Bank Indonesia and the Ministry of Finance is needed to ensure that fiscal policies related to fuel subsidies do not exacerbate exchange rate pressures when oil prices rise; (3) the implementation of the DHE Natural Resources policy (PP No. 36/2023) needs to be optimized to maximize inward foreign exchange flows from commodity exports; and (4) diversification of sources of foreign exchange reserves through the expansion of manufacturing and services exports is a crucial medium-term agenda to reduce dependence on commodity volatility.

## 5. CONCLUSION AND LIMITATION

This study analyzes the dynamic impact of global oil prices (OILPRICE) and Rupiah exchange rates (KURS) on Indonesia's foreign exchange reserves (CDI) using the Structural Vector Autoregression (SVAR) model with monthly data from April 2006 – December 2025 (237 active observations). Based on a series of systematic analysis procedures—including ADF assays, VAR estimation(2), SVAR identification through matrix restrictions A and B, structural IRF analysis, and FEVD—three main conclusions were reached.

First, the results of the ADF test confirmed that all variables (CDI, OILPRICE, EXCHANGE RATE) were I(1) and stationary at the first difference, with ADF statistics of -13,103, -10,341, and -12,422 ( $p = 0.000$ ), respectively, thus validating the SVAR estimation procedure in the first difference. Second, the SVAR estimates identified significant contemporary structural relationships, especially the coefficient  $A[3,2] = 9.459$  ( $p = 0.001$ ) which confirmed that the contemporary increase in oil prices of USD 1 per barrel is related to the depreciation of the Rupiah by Rp 9,459 — this is direct empirical evidence of the transmission line of oil prices to exchange rates. Third, the results of the FEVD show that

exchange rate shocks (KURS shocks) are the dominant external contributor to the variation in foreign exchange reserves in the medium term (~30-40% over the 4-10 month horizon), far exceeding the direct contribution of oil price shocks (~5-8%). This implies that the impact of oil prices on foreign exchange reserves works more indirectly through exchange rate channels, rather than directly.

Overall, the findings of this study confirm that the stability of the rupiah exchange rate is a more critical factor for the resilience of Indonesia's foreign exchange reserves than the management of the direct impact of oil price volatility. Strong monetary-fiscal policy coordination, strengthening exchange rate stabilization instruments that do not deplete foreign exchange reserves, and diversifying sources of foreign exchange receipts are the three main pillars of policy recommendations resulting from this study.

This research has several limitations that need to be recognized and used as a follow-up research agenda. First, the Cholesky recursive identification restriction used assumes a recursive causal sequence, which is a simplification of more complex economic realities—the approach of sign restrictions or external instruments could be considered as alternatives. Second, the estimated model is linear and does not capture possible response asymmetry—for example, the response of foreign exchange reserves to rising oil prices may differ from its response to a decline in oil prices, which can be captured through Nonlinear SVAR or Threshold VAR. Third, the three-variable system used has not included important macroeconomic variables such as the BI Rate, inflation, and global economic growth that are potential confounding variables.

## 6. REFERENCES

- Aizenman, J., Ito, H., & Pasricha, G. K. (2020). *Central bank swap arrangements in the COVID-19 crisis* (NBER Working Paper No. 27755). National Bureau of Economic Research. <https://doi.org/10.3386/w27755>
- Azwar. (2015). Dampak perubahan harga crude palm oil (CPO) dunia terhadap volume ekspor komoditas kelapa sawit dan perekonomian Indonesia (Pendekatan vector autoregression analysis). *Jurnal Info Artha*, 13(1), 1–18.
- Baumeister, C., & Hamilton, J. D. (2019). Structural interpretation of vector autoregressions with incomplete identification: Revisiting the role of oil supply and demand shocks. *American Economic Review*, 109(5), 1873–1910. <https://doi.org/10.1257/aer.20151569>
- Bank for International Settlements. (2022). *Annual report 2022*. Bank for International Settlements. <https://www.bis.org/about/areport/areport2022.pdf>
- Bank Indonesia. (2024). *Cadangan devisa Desember 2023 meningkat* (Siaran Pers No. 26/3/DKom). Bank Indonesia. [https://www.bi.go.id/id/publikasi/ruang-media/news-release/Pages/sp\\_260324.aspx](https://www.bi.go.id/id/publikasi/ruang-media/news-release/Pages/sp_260324.aspx)
- Bank Indonesia. (2024). *Cadangan devisa Indonesia* (berbagai siaran pers bulanan). Bank Indonesia.

- Enders, W. (2015). *Applied econometric time series* (4th ed.). Wiley.
- Kilian, L., & Lütkepohl, H. (2017). *Structural vector autoregressive analysis*. Cambridge University Press. <https://doi.org/10.1017/9781108164818>
- Khaliq, A. (2014). Mekanisme transmisi goncangan harga minyak dan harga pangan dunia terhadap perekonomian makro Indonesia: Pendekatan structural vector autoregressive (SVAR). *Jurnal Ekonomi dan Pembangunan*, 22(2), 123–145.
- Kementerian Keuangan Republik Indonesia. (2023). *Peraturan Pemerintah Nomor 36 Tahun 2023 tentang devisa hasil ekspor dari kegiatan perusahaan, pengelolaan, dan/atau pengolahan sumber daya alam*. JDIH Kementerian Keuangan. [JDIH Kementerian Keuangan](https://jdih.kemkeu.go.id/)
- Lizein, B., Triansyah, F. A., Acheampong, K., Ahmad, S. Y., & Mosavi, H. (2024). Fluctuations oil prices in the world and their impact on Indonesian macroeconomics. *IOP Conference Series: Earth and Environmental Science*, 1379(1), 012030. <https://doi.org/10.1088/1755-1315/1379/1/012030>
- Lütkepohl, H. (2005). *New introduction to multiple time series analysis*. Springer. <https://doi.org/10.1007/978-3-540-27752-1>
- Pangesti, D. A. (2023). Analisis pengaruh kurs, ekspor, dan impor terhadap cadangan devisa di Indonesia periode tahun 1992–2021. *Wawasan: Jurnal Ilmu Manajemen, Ekonomi dan Kewirausahaan*, 1(1), 49–59.
- Purba, A. S., Tiawon, H., & Beatris, D. (2023). Analisis faktor-faktor yang mempengaruhi cadangan devisa Indonesia dengan pendekatan Error Correction Model (ECM). *JEPP: Jurnal Ekonomi Pembangunan dan Pariwisata*, 3(2). <https://doi.org/10.52300/jep.v3i2.11537>
- Safitri, A. M., Anwar, K., & Abbas, T. (2022). Pengaruh harga minyak dunia, inflasi, dan ekspor netto terhadap pertumbuhan ekonomi di Indonesia. *Jurnal Ekonomi Regional Unimal*, 5(1), 21–29.
- Salisu, A. A., Cuñado, J., Isah, K., & Gupta, R. (2021). Oil price and exchange rate behaviour of the BRICS. *Emerging Markets Finance and Trade*, 57(7), 2042–2051. <https://doi.org/10.1080/1540496X.2020.1850440>
- Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48(1), 1–48. <https://doi.org/10.2307/1912017>
- Situmorang, S. E., & Barika. (2025). Analisis dampak harga minyak dunia dan nilai tukar terhadap pertumbuhan ekonomi Indonesia tahun 2009–2023. *Al-Kharaj: Jurnal Ekonomi, Keuangan & Bisnis Syariah*, 7(5), 1521–1533. <https://doi.org/10.47467/alkharaj.v7i5.7134>
- Sonia, A. P., & Setiawina, N. D. (2016). Pengaruh kurs, JUB, dan tingkat inflasi terhadap ekspor, impor, dan cadangan devisa Indonesia. *E-Jurnal Ekonomi Pembangunan Universitas Udayana*, 5(10), 1077–1102.