MATHEMATICAL MODELING OF THE IMPACT OF OIL PRICES ON THE EXCHANGE RATE IN IRAQ USING THE GRANGER CAUSALITY TEST

M. M. Tali

Collage of Administration and Economics - University of Kerbala - Iraq, Karbala
E-mail: mahdi.m@uokerbala.edu.iq

Crude oil plays a pivotal role in Iraq's economy as the main source of public revenue and exports, making fluctuations in global oil prices a direct determinant of the exchange rate and overall macroeconomic stability. Rising oil prices appreciate the Iraqi dinar, while declines reduce foreign inflows, deplete reserves, and generate fiscal deficits. This study examines the dynamic impact of oil prices on the Iraqi exchange rate during 2008–2022 using economic mathematical models. Specifically, a Vector Autoregressive (VAR) framework is employed, combined with Johansen's cointegration test to identify long-run relations and Granger causality to determine directional linkages. Methodological steps include testing stationarity with ADF and PP, estimating the VAR model, applying Granger causality, and analyzing Impulse Response Functions (IRF). Results indicate a bidirectional causal relationship between oil prices, the exchange rate, and foreign reserves, confirming oil price volatility as the dominant driver of exchange rate dynamics. Policy recommendations emphasize flexible monetary-fiscal coordination, reserve strengthening, and revenue diversification to mitigate oil dependency.

1. Introduction: Crude oil constitutes the primary source of government revenues and the cornerstone of economic activity in Iraq, as its exports account for more than 90% of total exports and nearly 60% of GDP. Consequently, any fluctuation in the global price of oil is directly and profoundly reflected in the country's macroeconomic structure, whether in terms of budgetary balance, economic growth, or exchange rate stability [1]. Given the nature of the Iraqi economy, it is characterized by a high degree of unilateral dependence on oil revenues, making it highly vulnerable to external shocks in global oil markets. For instance, during periods of rising oil prices, the trade balance records significant surpluses due to higher oil export receipts, while foreign reserves at the Central Bank increase, leading to a stronger Iraqi dinar against the US dollar. Conversely, a decline in oil prices results in falling public revenues, contraction in foreign currency inflows, depletion of international reserves, and mounting pressure on the domestic exchange rate, often culminating in fiscal deficits and lower growth rates [2]. Based on this significance, the present study seeks to analyze the dynamic impact of global oil prices on the exchange rate in Iraq, with a focus on the period (2008–2022), which witnessed sharp fluctuations in global oil prices and fundamental shifts in Iraqi monetary policy. The study adopts an economic mathematical modeling framework, employing the Vector Autoregressive (VAR) model, Johansen cointegration test, and the Vector Error Correction Model (VECM) to examine both the long-run and short-run relationships between the variables. Moreover, the direction of causality is tested using Granger causality and Impulse Response Functions (IRF) to evaluate the responsiveness of the Iraqi exchange rate to oil price shocks. Since the 1970s, crude oil has been the backbone of the Iraqi economy and the largest component of its exports, representing nearly 95% of total exports. Despite its abundant oil resources, Iraq suffers from weak refining capacity, making it a net importer of refined petroleum products, which imposes additional burdens on the trade balance and affects overall economic performance. Thus, global oil price volatility has become the most influential factor shaping Iraq's economic structure, growth trajectory, and financial stability. On the one hand, rising oil prices increase state revenues, creating a temporary illusion of financial abundance and encouraging an expansion of public expenditures, a phenomenon often associated with "Dutch disease" in the long run. On the other hand, higher oil prices raise production costs in industrial economies, thereby increasing the prices of manufactured goods imported by Iraq, which reduces the economy's real purchasing power and constrains the direct benefits of higher oil revenues. Given Iraq's heavy reliance on oil as the principal source of foreign currency, any decline in oil prices immediately translates into a weaker exchange rate, lower foreign currency inflows, and shrinking reserves, often leading to fiscal imbalances and sluggish economic growth. Iraq has already experienced this phenomenon during the oil crises of 2008 and 2015, when the price of oil fell from more than $100 per barrel to below $40, which was reflected in a deteriorating exchange rate and widening trade deficit [3]. Accordingly, the research problem lies in the insufficient understanding of the dynamic and complex relationship between global oil prices and the exchange rate in the Iraqi economy. Rising oil prices do not necessarily imply an improvement in the real import capacity or macroeconomic stability; in fact, they may sometimes entail adverse effects due to the varying time horizons and frequencies at which these variables interact [4]. Hence, the importance of adopting Frequency Domain Causality Analysis, which is considered more appropriate than conventional time-domain analysis. This method enables policymakers not only to identify the presence and direction of causal linkages but also to determine the specific time frequencies (short-term or long-term) at which these relationships occur. Such an approach provides a deeper understanding of economic phenomena and supports the design of more efficient policies [5]. In light of the above, this study attempts to answer the following core question: What is the nature of the relationship between global oil prices and the exchange rate in Iraq?

The significance of the study stems from the rentier nature of the Iraqi economy and its near-total dependence on oil revenues as the main source of foreign currency, making the exchange rate directly exposed to fluctuations in global oil prices. Against this backdrop, the research seeks to provide an in-depth econometric and mathematical treatment of the dynamic relationship between oil prices and the exchange rate in Iraq, using frequency domain causality as a more accurate tool compared to traditional time-domain analysis. This allows for identifying the transmission patterns of oil shocks across short- and long-term horizons and their implications for monetary and financial stability. The scientific contribution lies in building an economic mathematical model capable of explaining and quantifying the mutual impact between oil prices and the exchange rate across different frequencies, while highlighting temporal variations in the strength of the relationship. This, in turn, paves the way for designing more flexible and adaptive monetary and fiscal policies in response to external shocks. Furthermore, the study aims to test the core hypothesis that a bidirectional causal relationship exists between oil prices and the exchange rate in Iraq, whereby oil price fluctuations directly affect currency stability, while exchange rate movements influence the domestic value of oil revenues and the balance of payments. Thus, the expected results extend beyond enriching the theoretical literature on rentier economies, providing instead a practical foundation for Iraqi policymakers to formulate proactive strategies in managing foreign reserves, stabilizing the exchange rate, reducing excessive dependence on oil revenues, and strengthening the overall economy's resilience to external shocks.

1.1. The Reality of the Iraqi Economy: The Iraqi economy is classified as a Rentier Economy, due to its near-total dependence on oil revenues, which account for over 90% of public revenues and approximately 98% of total exports [6]. This excessive dependence has rendered the Iraqi economy highly vulnerable to external shocks, particularly fluctuations in global oil prices. Any decline in oil prices leads to severe imbalances in the trade balance and public budget, as well as direct pressures on the exchange rate. The Iraqi economic structure is characterized by low diversification and a weak contribution from non-oil productive sectors. The industrial sector, for instance, has significantly declined due to repeated wars, economic sanctions since the 1990s, and the extensive destruction following 2003, which disrupted factories and deteriorated infrastructure. Additionally, weak customs protection policies allowed unrestricted entry of imported goods, undermining domestic industries and increasing unemployment [7]. The agricultural sector, which should contribute to food security and employment, has also declined due to structural problems such as underdeveloped rural areas, insufficient investment, disrupted irrigation networks, water scarcity, and outdated agricultural technologies. Consequently, Iraq has increasingly relied on imports to cover food deficits, further increasing its dependency on oil revenues to finance imports [8]. The services sector has suffered deep distortions, as internal conflicts and post-2003 security conditions affected transportation, tourism, telecommunications, and banking services, impeding their developmental role in mobilizing savings and channeling them into productive investment. This situation has exacerbated inflation and unemployment rates while reducing citizens' purchasing power [9]. In addition to economic factors, financial and administrative corruption constitutes a major structural barrier to development in Iraq, having negatively impacted economic efficiency and drained public resources, thereby aggravating poverty, unemployment, and the unequal distribution of wealth and income [10]. Therefore, the structure of the Iraqi economy, as a mono-sector rentier economy, remains highly susceptible to fluctuations in oil prices, which directly affect the exchange rate. This research aims to provide a mathematical analysis of the relationship between oil-related and macroeconomic variables in Iraq using mathematical economics tools, contributing to the formulation of more sustainable economic policies. The supply-demand channel illustrates that any change in the value of the U.S. dollar directly affects oil prices, and consequently, the exchange rates of both importing and exporting countries. For Iraq, this impact is more pronounced due to the economy's heavy reliance on oil revenues; thus, oil price fluctuations influence the Iraqi dinar's value. Specifically: Short-term: Positive oil shocks may lead to an appreciation of the U.S. dollar due to a preference for dollar-denominated assets. Long-term: The effect of oil prices on the real exchange rate depends on trade structures and wealth distribution among economies, potentially reducing the competitiveness of exporting countries due to real currency appreciation [11].

1.2. Analysis of the Relationship between Global Oil Price Volatility and Macroeconomic Imbalances in Emerging Oil-Exporting Economies: Economic literature indicates that global oil price volatility generates substantial macroeconomic imbalances in emerging oil-exporting economies due to the specific characteristics of their economic structures, which render them more vulnerable compared to advanced economies. Despite being oil-exporting countries, these economies lack full control over global oil price levels, making them susceptible to recurrent external shocks, whether originating from geopolitical risks (such as the Russia–Ukraine military operation), global demand fluctuations, or alternative energy policies. Such shocks induce sharp fluctuations in oil prices, which directly affect economic growth, inflation, monetary stability, and international liquidity. Moreover, these economies typically experience adverse effects from contractionary monetary policies implemented by central banks in advanced economies in response to rising energy prices, as these policies exert deflationary pressures on capital flows and exchange rates, thereby reducing foreign reserves and increasing domestic inflationary pressures. The issue is further exacerbated in economies with fixed or managed-floating exchange rate regimes, where monetary policy becomes less effective in controlling inflation and more dependent on global financial fluctuations, making fiscal policy the primary instrument to regulate the business cycle [12][13]. Theoretically, both classical and contemporary models demonstrate that the effects of oil price increases vary between importing and exporting countries, where the Wealth Transfer Mechanism serves as a central explanatory channel. Rising oil prices lead to a redistribution of income and wealth from importing to exporting countries, impacting the current account and exchange rates. In importing countries, oil price hikes deteriorate the current account, depreciate the local currency, reduce consumption, and depress asset prices due to higher energy costs and reduced competitiveness. Conversely, in exporting countries, such shocks temporarily improve the current account and increase the value of local assets due to oil revenue inflows. These effects, however, are neither linear nor permanent; dynamic models [14][15][16] indicate that oil supply and demand shocks interact with financial valuation channels and asset markets, generating temporary imbalances in the current account and real exchange rate for both exporters and importers. Accordingly, the relationship between oil, the trade balance, and exchange rates cannot be understood in isolation from trade, wealth, and asset market channels. This necessitates the use of dynamic mathematical econometric models (VECM, IRF, Variance Decomposition) to identify causal directions and short- and long-term response patterns.

2.Methodology for Estimating the Model Using Granger Causality Test: The Granger causality test is a widely used standard econometric procedure in economics. In this test, the null hypothesis in each regression assumes that the first variable does not Granger-cause the second variable. Granger postulated that the future cannot cause the past [17] and stated that if the current values of Yt can be predicted more accurately using past values of Xt than without using them, then Xt is said to Granger-cause Yt. In the Granger causality test, to examine the hypothesis that Xt does not

Granger-cause Yt, a Vector Autoregressive (VAR) model is formulated as follows [18]:

$$\Delta Y_t = \alpha + \sum_{i=1}^{K} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{K} \gamma_i \Delta X_{t-i} + \lambda \varepsilon_{t-i} + \vartheta_t \quad (2)$$
$$Y_t = (Y_1 \cdots Y_t \cdots Y_T) \quad . \quad Y_h = (Y_{11} \cdots Y_{ts} \cdots Y_{Ts}) \quad (3)$$
$$Y_t = \sum_{u=1}^{s} c_u Y_{t.u} \qquad t = 1.\dots T \quad (4)$$
$$Y_h = X_h \beta + U_h \quad .E(X_h) = 0 \quad . \quad E(X_1) = V_h \quad (5)$$
$$Y_1 = X_1 \beta + U_1 \quad .E(X_1) = 0 \quad . \quad E(X_1) = CV_h C = V_1 \quad (6)$$
$$Y_t = b_{11} - b_{12} Z_t + \gamma_{11} Y_{t-1} + \gamma_{12} Z_{t-1} + \varepsilon_t \quad (7)$$
$$Z_t = b_{21} - b_{22} Y_t + \gamma_{21} Y_{t-1} + \gamma_{22} Z_{t-1} + \varepsilon_t \quad (8)$$
$$BX_t = \Gamma_0 + \Gamma_1 X_{t-1} + \varepsilon_t \Rightarrow Multiply\ by\ B^{-1} \Rightarrow B^{-1} B X_t = B^{-1} \Gamma_0 + B^{-1} \Gamma_1 X_{t-1} + B^{-1} \varepsilon_t \Rightarrow A_0 + A_1 X_{t-1} + e_t \quad (9)$$
$$Y_t = a_{10} + a_{11} Y_{t-1} + a_{12} Z_{t-1} + e_{1t} \quad (10)$$
$$Z_t = a_{20} + a_{21} Y_{t-1} + a_{22} Z_{t-1} + e_{2t} \quad (11)$$

One of the primary objectives of the Box-Jenkins methodology is to identify models in which the number of lagged periods of the variables is minimized. On the other hand, achieving accurate short-term forecasts requires the exclusion of irrelevant variables from the model. Sims' (1980) critique of structural models that impose incorrect identification restrictions implies that, in some cases, it is necessary to consider an alternative strategy for model estimation. To illustrate this point more clearly, let us consider the following generalized multivariate model:

$$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} + \cdots + A_p X_{t-p} + e_t$$

Where:

X_t -is an $n\times 1$ vector containing all n variables in the VAR model,

A -is an $n\times 1$ vector of constants,

A_i - is an $n\times n$ coefficient matrix,

e_i - is an $n\times 1$ vector of error terms.

The Sims methodology generally consists of: (1) identifying the appropriate variables to include in the model; (2) determining the suitable number of lags for the model. The selection of variables to include in the model relies on established economic theories. Tests are also employed to determine the optimal lag length, including the effect test and the maximum eigenvalue test. It should be noted that in these models, no attempt is made to remove or reduce model coefficients. The matrix contains the coefficients; hence, it is necessary to estimate them. Undoubtedly, the number of coefficients in the model is excessive because many estimated coefficients are not statistically significant. However, the objective of estimating these models is to capture the fundamental relationships among the variables rather than obtaining precise short-term forecasts; therefore, incorrect constraints on the model lead to the loss of important information. Additionally, in these models, the explanatory variables are usually highly contemporaneously correlated, so statistics for individual coefficients are not reliable tools for removing or reducing variables. Sims (1980) and Sims, Stock, and Watson (1990) argued that even if variables have a unit root, their differences should not be included in the system. Their reasoning is that the purpose of the analysis is to identify the interrelationships among variables, not parameter estimation. In other words, their primary argument for including the levels of variables is that differencing would eliminate information indicating the presence of cointegration among the variables. Similarly, it is argued that there is no need to remove trends from the variables in the model. In the model, the unit root process with a constant component provides a reasonable approximation of the trend model. However, it is essential that the types of variables included in the model correspond to the actual data-generating process. This issue becomes particularly important when the objective is to estimate a structural model. Due to the presence of feedback mechanisms in the process, in such cases, models (4) and (5) cannot be estimated directly because they are linked to the error component. Nevertheless, this issue does not arise, and the models can be estimated using their method. The question that arises is whether the information regarding equations (7) and (8) can be obtained from the above estimation results, or in other words, whether the preliminary model can be identified using estimates (9) and (10). The answer is negative. By estimating the second system, the variables can be estimated and calculated, whereas the initial system contains 10 coefficients, including two constants, four autoregressive coefficients, two feedback coefficients, and two standard deviations. In other words, the initial system has 10 coefficients, and estimating the model estimates the coefficients. Therefore, without imposing a restriction on one of the coefficients, the initial system cannot be identified, and the preliminary equations (7) and (8) are under-identified. One method for identifying the preliminary model is to use a type of iterative procedure proposed by Sims (1980). Suppose the coefficient equals zero. Consequently, equations (4) and (5) become as follows:

$$Y_t = b_{11} - b_{12}Z_t + \gamma_{11}Y_{t-1} + \gamma_{12}Z_{t-1} + \varepsilon_{yt} \quad (13)$$

$$Z_t = b_{21} + \gamma_{21}Y_{t-1} + \gamma_{22}Z_{t-1} + \varepsilon_t \quad (14)$$

It should be noted that imposing the restriction implies that it has a contemporaneous effect; however, it also exerts an effect with a lag. Clearly, applying this restriction, which can be based on economic theory, results in the original system of equations becoming exactly identified.

2.1. mpulse Response Function: It can also be transformed into a vector moving average. In other words, equation (3) can be considered a transformation of equation (2), where the variables are expressed in terms of their lagged values. This transformation is one of the fundamental features of the Sims (1980) methodology, as it allows for the analysis of the temporal path of shocks introduced into the system's variables. To better illustrate this, we consider a bivariate model in matrix form:

$$[Y_t\ Z_t\ ] = [a_{10}\ a_{20}\ ] + [a_{11}\ a_{12}\ a_{21}\ a_{22}\ ][Y_{t-1}\ Z_{t-1}\ ] + [e_{1t}\ e_{2t}\ ], \quad X_t = A_0 + A_1X_{t-1} + e_t \quad (15)$$

And from equation (15), we have:

$$[Y_t\ Z_t\ ] = [\underline{Y}\ \underline{Z}\ ] + \sum_{i=0}^{\infty} [a_{11}\ a_{12}\ a_{21}\ a_{22}\ ][e_{1t-i}\ e_{2t-i}\ ], \quad X_t = \mu + \sum_{i=0}^{\infty} A_1^i . e_{t-1} \quad (16)$$

In equation (16), the variables are expressed in terms of sequences and definitions. It is preferable to write equation (16) in terms of sequences, and from equations (10) and (11), we obtain:

$$(10) \Rightarrow e_t = B^{-1}\varepsilon_t \Rightarrow \{e_{1t} = \frac{(\varepsilon_{yt}-b_{12}\varepsilon_{zt})}{(1-b_{12}b_{21})}\ e_{2t} = \frac{(\varepsilon_{zt}-b_{21}\varepsilon_{yt})}{(1-b_{12}b_{21})} \Rightarrow [e_{1t}\ e_{2t}\ ] = \frac{1}{(1-b_{12}b_{21})}[1\ -b_{12}\ -b_{21}\ 1\ ][\varepsilon_{zt}\ \varepsilon_{yt}\ ] \quad (14)$$

$$\begin{bmatrix} Y_t \\ Z_t \end{bmatrix} = \begin{bmatrix} \bar{Y}_t \\ \bar{Z}_t \end{bmatrix} + \frac{1}{1-b_{12}b_{21}} \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix} \Rightarrow$$

$$\Phi_i = \frac{A_1^i}{1-b_{12}b_{21}} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \Rightarrow$$

$$\Rightarrow [Y_t\ Z_t\ ] = [\underline{Y}\ \underline{Z}\ ] + \sum_{i=0}^{\infty} \quad [\Phi_{11}(i)\ \Phi_{12}(i)\ \Phi_{21}(i)\ \Phi_{22}(i)\ ][\varepsilon_{yt-i}\ \varepsilon_{zt-i}\ ] \Rightarrow$$

$$X_t = \mu + \sum_{i=0}^{\infty} \quad \Phi_i . \varepsilon_{t-i} \quad (17)$$

The moving average transformation of the pattern constitutes a highly suitable tool for studying interrelationships. Using the matrix coefficients, the impact of the momentum variable on the entire temporal trajectory is analyzed; the four elements of the matrix represent the momentum multipliers. For instance, a coefficient indicates the immediate effect of a one-unit change, while other values reflect the impact of a one-unit change after a lag period. Moreover, the total effect of a unit of momentum on the two variables in the model can be obtained by summing the impulse response function coefficients. Under normal conditions, since the estimated model is under-identified, it is not possible to study the temporal evolution of changes and their inter-relations. Therefore, the standard Mathematical Economics must impose an additional restriction on the bivariate system to enable identification of the impulse response function. In line with Granger causality testing, the model must be estimated in the Vector Autoregressive (VAR) framework. Following a discussion of the theoretical foundations of Granger causality and VAR methodology, and after examining descriptive statistics and data sources, the proposed models were estimated, and the estimation results were analyzed. The analysis of results and findings will be presented along with recommendations for use by economic policymakers and future researchers in the field. Since unrestricted models contain numerous parameters, they cannot be used for short-term forecasting. However, determining the characteristics of the forecast error sequence is highly effective in detecting interrelationships among the system's variables. Suppose we know the coefficient values and want to predict different values conditional on observed data. If we shift equation (3) forward by one period, we obtain:

$$X_{t+1} = A_0 + A_1 X_t + e_{t+1} \Rightarrow E_t\ X_{t+1} = A_0 + A_1 X_t$$

We conclude that it also has a zero mean, constant variance, and is uncorrelated. Additionally, we have: $e_{t+1} = X_{t+1} - E_t\ X_{t+1}$

If we shift Equation (16) forward by two periods, we obtain:

$$X_{t+2} = A_0 + A_1 X_{t+1} + e_{t+2} \Rightarrow X_{t+2} = A_0 + A_1(A_0 + A_1 X_t + e_{t+1}) + e_{t+2} \Rightarrow$$

$$E_t\ X_{t+2} = (I + A_1)A_0 + A_1^2 X_t$$

The two-period-ahead forecast error is as follows: $e_{t+2} + A_1\ e_{t+1}$

Forward-looking forecasts: $E_t X_{t+n} = (I + A_1 + A_1^2 + ... + A_1^{n-1}) A_0 + A_1^n X_t$

And the forecast error for the forward period: $e_{t+n} + A_1 e_{t+n-1} + A_1^2 e_{t+n-2} + ... + A_1^{n-1} e_{t+1}$

Forecast errors can be calculated based on Equation (17) or alternatively using Equation (19).

$$X_t = \mu + \sum_{i=0}^{\infty} \Phi_i . \varepsilon_{t-i}$$

One-step-ahead forecast error: $\Phi . \varepsilon_{t+1}$

In general: $X_{t+n} = \mu + \sum_{i=0}^{\infty} \Phi_i . \varepsilon_{t+n-i} \Rightarrow X_{t+n} - E_t X_{t+n} = \sum_{i=0}^{n-1} \Phi_i . \varepsilon_{t+n-i}$

The forecast error for the lead period in terms of the sequence is:

$$Y_{t+n} - E_t Y_{t+n} = \Phi_{11}(\circ)\varepsilon_{yt+n} + \Phi_{11}(1)\varepsilon_{yt+n-1} + ... + \Phi_{11}(n-1)\varepsilon_{yt+1}$$

$$+ \Phi_{12}(\circ)\varepsilon_{zt+n} + \Phi_{12}(1)\varepsilon_{zt+n-1} + ... + \Phi_{12}(n-1)\varepsilon_{zt+1}$$

If we express the forecast error variance for the lead period in equation form, we have:

$$\sigma_y(n)^2 = \sigma_y^2[\ \Phi_{11}(\circ)^2 + \Phi_{11}(1)^2 + ... + \Phi_{11}(n-1)^2\ ]$$

$$+ \sigma_z^2[\ \Phi_{12}(\circ)^2 + \Phi_{12}(1)^2 + ... + \Phi_{12}(n-1)^2\ ]$$

If we represent the future forecast error variance by the following equation:

$$\frac{\sigma_y^2[\ \Phi_{11}(\circ)^2 + \Phi_{11}(1)^2 + ... + \Phi_{11}(n-1)^2\ ]}{\sigma_y(n)^2}$$

$$\frac{\sigma_z^2[\ \Phi_{12}(\circ)^2 + \Phi_{12}(1)^2 + ... + \Phi_{12}(n-1)^2\ ]}{\sigma_y(n)^2}$$

Since all values are non-negative, the forecast error variance must also increase as the forecast horizon lengthens. It is noteworthy that the future forecast error variance can be decomposed into the contribution of each shock term. By analyzing the forecast error variance, we can examine the extent to which changes in a given series are affected by the shock components of that same series, as well as by the shock components of other variables within the system. If a shock component does not explain any portion of the forecast error variance over the forecast horizon, we can infer that the series is exogenous under these conditions, meaning its changes are independent of the shock component and of other series. Conversely, if the model accounts for the entire forecast error variance during the forecast period, the series is considered fully endogenous.

3. Conclusions: Based on the estimation results, the hypotheses were tested. After examining the stationarity of the research variables and applying the Granger causality test, the VAR estimation method was selected for the research model. In this context, to ensure the robustness of the results, diagnostic tests were conducted to validate the hypotheses. Finally, both short-term and long-term Granger causality tests were performed. Given the sensitivity of the Granger causality test to the optimal lag length, it was first necessary to estimate the research model using the VAR approach and determine the optimal lag. Due to the relatively small sample size, the Schwarz Information Criterion (SIC) was used, and the optimal lag length for the model was determined to be two. According to the impulse response statistics of the research models, evidence confirmed the presence of a long-term convergence trend. The short-term Granger causality test indicates that, in the short run, there exists a bidirectional relationship between the global oil price and the exchange rate. However, the short-term relationship between the global oil price and other variables, such as foreign reserves and the trade balance, is unidirectional, flowing only from the global oil price to these variables. The long-term Granger causality test shows that, in the long run, there is a bidirectional relationship between the global oil price and the exchange rate. Nevertheless, the relationship between the global oil price and the trade balance remains unidirectional, running from the global oil price to the trade balance. Hypothesis 1: The relationship between the global oil price and the Iraqi exchange rate is bidirectional. Based on the long-term and short-term Granger causality test results, the relationship between the global oil price and the exchange rate is indeed bidirectional. This finding is consistent with the studies of [19], [20], [21], [22], and [23].

4. Recommendations: To make the research findings applicable, we first present suggestions and recommendations for policymakers, followed by proposals for future research. There exists a bidirectional relationship between the global oil price and the exchange rate, as well as foreign reserves in Iraq. Therefore, it is recommended that, given the global oil price is an exogenous variable in the Iraqi economy and Iraq cannot unilaterally control it, measures should be taken to stabilize foreign reserves similar to other oil-exporting countries. One practical solution is the establishment of a national development fund to shield the domestic economy from fluctuations in global oil prices.

Furthermore, to maintain and secure the Iraqi National Development Fund, it is advisable for the Iraqi government to explore membership or participation in sovereign wealth funds of the Gulf Cooperation Council (GCC) countries, including Bahrain, Kuwait, Oman, Qatar, the Kingdom of Saudi Arabia, and the United Arab Emirates.

Recommendations for Future Research: In this study, the focus was on the relationship between the global oil price and the exchange rate. It is suggested that future research should examine the role of the global oil price as an indicator of the exchange rate using mathematical and econometric models. While this study specifically addressed the relationship between the global oil price and the exchange rate, future studies are encouraged to explore the relationship between the global oil price and other macroeconomic variables affecting the economic growth of oil-producing countries.

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