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Forecasting Gold Prices in Iraq Using the MARIMAX Model in the Presence of Multicollinearity

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Abstract

Gold prices are important financial and economic indicators that reflect changes in the economic environment, owing to their direct relationship with Iraq's financial market and their relevance to everyday economic life. Gold prices may also be influenced over time by several external factors. Accordingly, this study aims to forecast weekly average gold prices using a MARIMAX model with two exogenous variables: the weekly average Iraqi dinar exchange rate and the weekly average price of Basra crude oil. MARIMAX(1,2,2) was identified as the most appropriate specification. Cross-correlation analysis of the time series indicated positive lagged effects of Basra crude oil prices and the exchange rate beginning at a one-week lag. Forecasts for the subsequent 16 weeks, based on the MARIMAX(1,2,2) model, indicate a limited but gradual upward trend in gold prices relative to the values observed during the study period from 9 May 2025 to 7 August 2026. The average forecast gold price is approximately IQD 982 thousand per mithqal.

Keywords: *MARIMAX Model, Gold Prices, Basra Oil Prices, Exchange Rates.*

I. INTRODUCTION

Gold prices are sensitive to changes in commodity, metal, and currency markets and to conditions of financial uncertainty. Consequently, modeling them solely as a function of time may be restrictive, especially when relevant external information is available. Recent literature supports viewing the relationship between gold and oil as time-varying. Luo and Pandit showed that incorporating a dynamic structure with SARIMAX produced a more appropriate representation of the relationship between gold and both Brent and West Texas crude oil [12]. Recent forecasting studies also indicate that oil and metal markets exhibit complex dynamics and that forecast accuracy improves when models are designed in a manner consistent with the temporal characteristics of the data [10].

In the context of the Iraqi economy, this issue is particularly important because oil plays a central role in economic activity, while the U.S. dollar exchange rate is also important in describing the transmission of external changes to domestic prices. Modeling local gold prices within a framework that permits the inclusion of oil prices and exchange rates is therefore not merely a formal extension of the ARIMA model; rather, it is an attempt to test whether these variables contain additional predictive information after controlling for the internal temporal dependence of the series. Applications of ARIMAX have shown that introducing oil as an exogenous variable can add explanatory and predictive power to models of economic or financial indicators [6], while applications of MARIMAX in the Iraqi environment have demonstrated the importance of determining the time lags of exogenous factors before including them in the model [8].

In recent studies, ARIMAX is treated as a dynamic regression model with ARIMA errors [1]. Among applications in this field, Abd et al. used Brent crude oil prices in an ARIMAX model to forecast the Dow Jones index and found an effect of the exogenous variable [6]. In another methodological direction, Jassim and Tahir used SARIMAX and MSARIMAX models to forecast water quantities in the Iraqi marshes by determining the time lag of exogenous factors through cross-correlation [8]. In commodity markets, Luo and Pandit found that the correlation between gold and oil changes over time and that ARIMAX provided greater forecasting ability than a stationary model for their data [12]. Lahmiri and Foroutan also demonstrated the difficulty of forecasting oil and precious-metal prices in the presence of nonlinearity and volatility, emphasizing the need to pay attention to model design and predictive performance [10].

The research problem arises from the fact that local gold prices may be affected by exogenous variables with different orders of integration, and the relationships and correlations among them may appear misleading because of the nature of the data or multicollinearity. This study therefore addresses multicollinearity among the exogenous variables and develops and estimates a MARIMAX model for weekly gold prices in Baghdad using Basra oil prices and the parallel-market exchange rate as exogenous variables. Effective time lags are determined after applying pre-whitening, multicollinearity is examined before and after stationarity is achieved, and the model's forecasting ability is evaluated to obtain future forecasts in the presence of the exogenous variables.

II. THEORETICAL FRAMEWORK

The ARIMA(p,d,q) model can be expressed using the backshift operator B as follows:

$$\varphi(B)(1-B)^d Y_t = \theta_q(B)\varepsilon_t \quad (1)$$

Where p is the autoregressive order, d is the order of differencing, q is the moving-average order, $\varphi_p(B)$ denotes the autoregressive polynomial, $\theta q(B)$ denotes the moving-average polynomial, Y_t is the time series, and ε_t is a random error term with mean zero and variance σ^2. Unit-root tests are used to determine the order of integration [2], whereas the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used as preliminary tools for model identification.

- *Multiple Integrated Autoregressive Moving Averages with Exogenous Variables (MARIMAX):*

The MARIMAX model describes the dynamic relationship linking input series $x_{i,t}$ to an output series y_t, such that the effect of the input series on the output is distributed over subsequent time periods. The exogenous variables and the output series can first be represented through a multiple linear regression equation [4]:

$$yt = \beta 0 + \beta 1x1, + \beta 2x2,t + \cdots + \beta kxk,t + \varepsilon t \quad (2)$$

Here $\beta_{0,1}, \ldots, \beta_k$ are regression coefficients for the exogenous (explanatory) variables; $x_{1,t}, x_{2,t}, \ldots, x_{k,t}$ are observations on k exogenous variables; and ε_t is a random error series independent of the exogenous variables. Combining the ARIMA and multiple-regression formulations gives the general MARIMAX form [6, 9, 10, 20, 21]:

$$\varphi_p(B)(1-B)^d y_t = \beta_0 + \sum_{i=1}^{k} \beta_i x_{i,t} + \theta_q(B)\varepsilon_t \quad (3)$$

For a single exogenous variable, the ARIMAX form is:

$$\varphi(B)(1-B)^d y_t = \beta_0 + \beta_1 x_t + \theta_q(B)\varepsilon_t \quad (4)$$

- *Pre-Whitening in the ARIMAX Model:*

Pre-whitening is the process of transforming a time series into an approximately white-noise series by removing known patterns generated by autoregressive or moving-average processes. This simplifies the input series and is achieved by matching the model of the input series to that of the output series. The filtering of the MARIMAX input and output series may be written as [3, 16, 18]:

$$\frac{\varphi_p(B)(1-B)^d}{\theta_q(B)} x_{i,t} = \omega_{i,t}, \qquad i = 1,2,\ldots,k \quad (5)$$

$$\frac{\varphi_p(B)(1-B)^d}{\theta_q(B)} y_t = \vartheta_t \quad (6)$$

Where $\omega_{i,t}$ is the random error term of the input series and ϑ_t is the random error term of the output series.

- *Cross-Correlation Function:*

The cross-correlation function (CCF) describes the strength and direction of association between time series and is a principal mechanism for identifying the time shifts through which input series affect a MARIMAX model. For lag r, the cross-correlation between output y_t and input $x_{i,t}$ is [3, 16]:

$$\rho_{x_i y}(r) = \frac{\sigma_{x_i y}(r)}{\sigma_{x_i}\sigma_y} = \frac{E\left[\left(x_{i,t}-\mu_{x_i}\right)\left(y_{t+r}-\mu_y\right)\right]}{\sqrt{E\left[\left(x_{i,t}-\mu_{x_i}\right)^2\right]}\sqrt{E\left[\left(y_{t+r}-\mu_y\right)^2\right]}} \quad (7)$$

$$\rho_{\omega_i,\vartheta}(r) = \frac{\sigma_{\omega_i,\vartheta}(r)}{\sigma_{\omega_i}\sigma_\vartheta} \quad (8)$$

Where $(\omega_i, \vartheta;\ r)$ denotes the cross-covariance between the filtered input and output series at lag r, while $\sigma(\omega_i)$ and $\sigma(\vartheta)$ denote their respective standard deviations.

- *Stages of Model Building:*

The MARIMAX model-building procedure can be summarized as follows [9, 11, 18]. First, the input and output series are prepared and diagnosed for stationarity. Nonstationarity in the mean is removed by applying the appropriate number of differences, whereas suitable mathematical transformations are used if variance is nonstationary. Second, the input and output series are filtered as in equations (5) and (6). Third, cross-correlations between the filtered series are estimated. Fourth, the lag order b is identified theoretically from the CCF of the filtered series; following Wei (2006), b is taken as the first significant positive-direction cross-correlation. Finally, the model parameters are estimated.

$$y_t = \beta_0 + \sum_{i=1}^{k} \beta_i x_{i,t-b} + \frac{\theta_q(B)}{\varphi_p(B)(1-B)^d}\varepsilon_t \quad (9)$$

The parameters of the MARIMAX model can be estimated using conditional maximum likelihood. The corresponding likelihood formulations for

MARIMAX, ARIMAX, and ARIMA are given in equations (10), (11), and (12) of the original study.

$$L(\beta_0, \beta, \varphi, \theta, \sigma_\varepsilon^2 \mid b, x, y) = (2\pi\sigma_\varepsilon^2)^{-n/2} e^{-\frac{1}{2\sigma_\varepsilon^2}\sum_{t=1}^{n}\varepsilon_t^2} \quad (10)$$

$$L(\beta_0, \beta_1, \varphi, \theta, \sigma_\varepsilon^2 \mid b, x, y) = (2\pi\sigma_\varepsilon^2)^{-n/2} e^{-\frac{1}{2\sigma_\varepsilon^2}\sum_{t=1}^{n}\varepsilon_t^2} \quad (11)$$

$$L(\varphi, \theta, \sigma_\varepsilon^2 \mid y) = (2\pi\sigma_\varepsilon^2)^{-n/2} e^{-\frac{1}{2\sigma_\varepsilon^2}\sum_{t=1}^{n}\varepsilon_t^2} \quad (12)$$

➢ *Multicollinearity Among Exogenous Variables:*

When more than one exogenous variable is present, the accuracy of parameter estimates is affected by the structure of the information matrix $X'X$, which can inflate parameter and model variances. Variance inflation for variable j is measured by the variance inflation factor (VIF):

$$\mathrm{VIF}_j = \frac{1}{1 - R_j^2} \quad (13)$$

In conventional regression, numerical VIF thresholds should not be treated as absolute laws; the effect of multicollinearity depends on the required estimation precision and sample size [3]. For nonstationary series, correlations in levels may be temporary or partly generated by common trends. Therefore, multicollinearity is examined in the predictor matrix that actually enters model estimation after stationarity has been achieved.

The order of an ARIMA or MARIMAX model is selected by screening candidate models and comparing information criteria, most importantly AIC and BIC [4,5]:

$$\mathrm{AIC} = -2\ell(\Theta) + 2K \quad (14)$$

$$\mathrm{BIC} = -2\ell(\Theta) + K\ln(n) \quad (15)$$

After selecting the model orders, model adequacy is assessed by examining residual autocorrelation. The Ljung–Box test is used for this purpose, while the Jarque–Bera test may support diagnosis of the randomness and distributional behavior of residuals.

$$Q(m) = n(n+2)\sum_{k=1}^{m}\frac{\hat{\rho}_k^2}{n-k} \quad (16)$$

➢ *Forecasting:*

If the information available up to time t is denoted by F_t, the h-step-ahead MARIMAX forecast is conditional on the future path of the exogenous variables:

$$\hat{Y}_{t+h|t} = E[Y_{t+h} \mid \mathcal{F}_t, \mathbf{X}_{t+1:t+h}] \quad (17)$$

III. APPLICATION

➢ *Data Description:*

These data were recorded for the period from 9 May 2025 through 7 August 2026, yielding a time series of 66 weekly observations. The data were obtained from their official sources in local and international markets and are presented in the Appendix. Table 1 below contains selected descriptive statistics for the variables examined in this study. As shown in Table 1, the mean weekly gold price was IQD 749,621.21, the minimum weekly average was IQD 642,000, and the maximum weekly average was IQD 925,000. In addition, Figure 1 below presents the output series y_t and the two input series x_{1t} and x_{2t}, together with the autocorrelation and partial autocorrelation coefficients for the three series. A preliminary inspection shows that the three series do not exhibit seasonal behavior over time. It also indicates that all three series are nonstationary, since a number of autocorrelation coefficients lie outside the confidence limits.

Table 1 Selected Descriptive Statistics.

Variable	Mean	SD	Minimum	Median	Maximum
Gold	749,621.21	87,743.29	642,000	725,000	925,000
Basra oil	66.56	3.40	59.18	66.43	73.24
Exchange rate	1,459.25	40.96	1,391.80	1,467	1,534.40

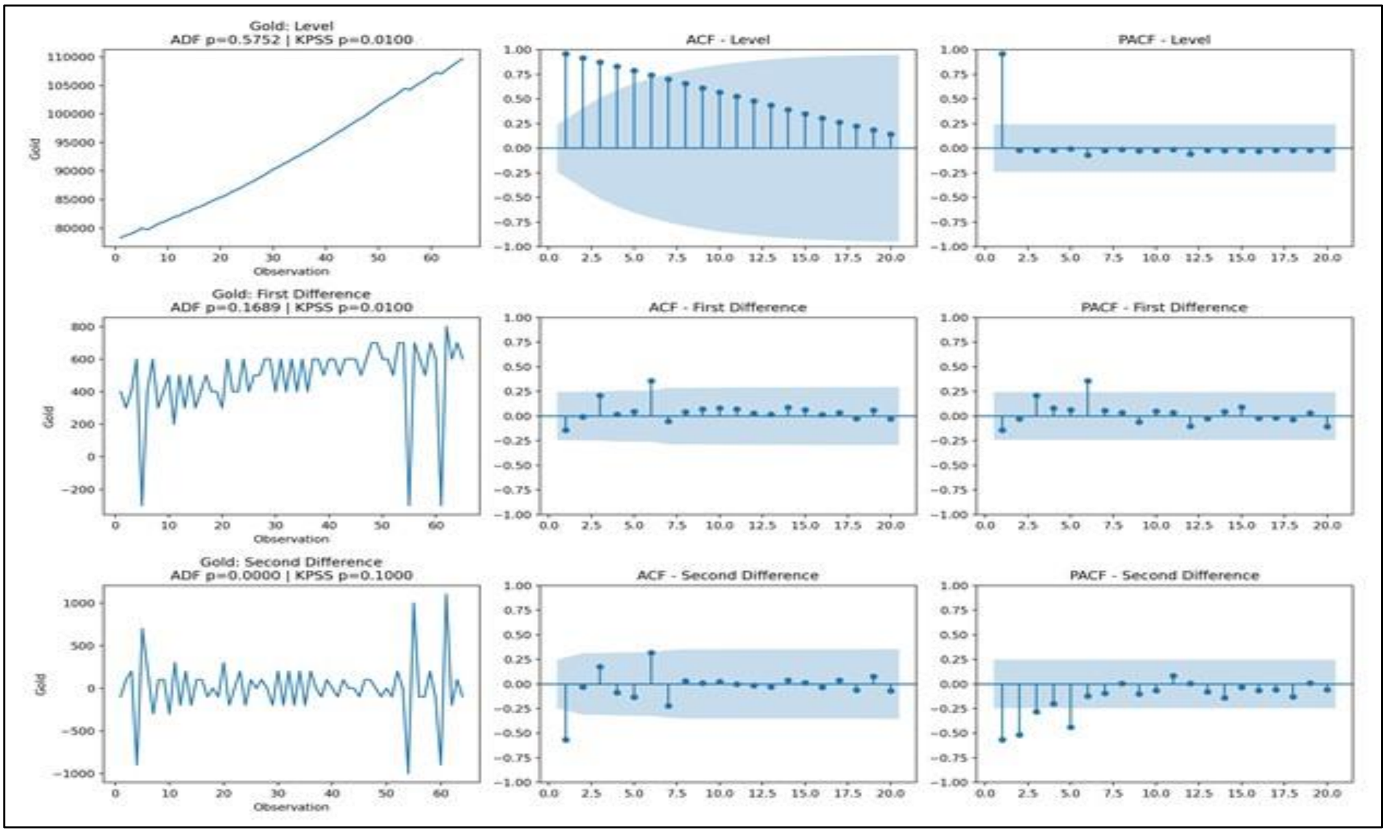

Fig 1 Series, ACF, and PACF

- *Stationarity:*

The Augmented Dickey-Fuller (ADF) test was also used to examine and analyze the stationarity of the three time series at a significance level of 0.01. The test results are reported in Table 2 above and are also illustrated in Figures 1 and 2 below. The results indicate that the output series y and the two input series x_{1t} and x_{2t} are nonstationary, since their p-values are greater than 0.01. The three time series also remained nonstationary after taking the first difference, because all ADF-test p-values were greater than 0.01. The autocorrelation coefficients likewise remained outside the confidence limits after the first differences were taken, confirming that stationarity had not yet been achieved. By contrast, all three time series became stationary after taking the second difference: all ADF-test p-values were below 0.01, and the autocorrelation coefficients of the differenced series fell within the confidence limits.

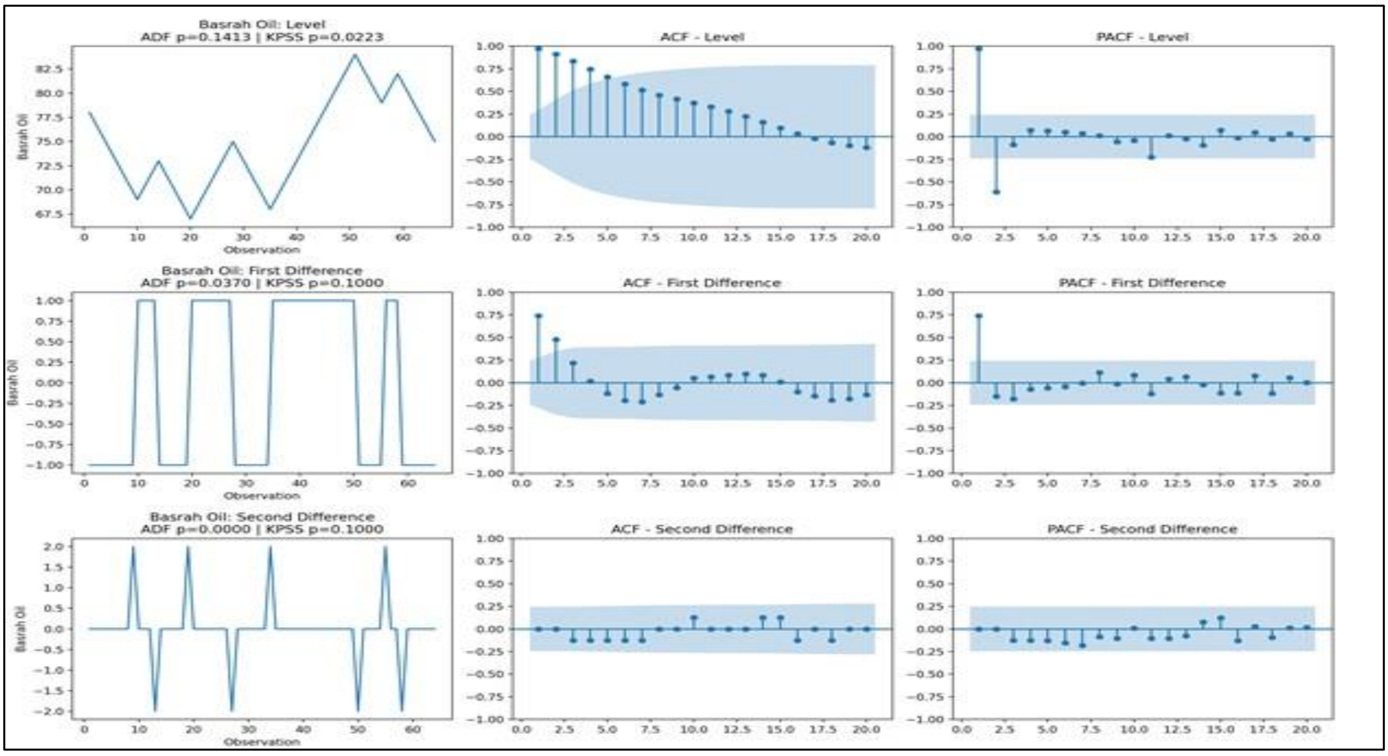

Fig 2 Basra Crude-Oil Series, ACF, and PACF at the Level, First Difference, and Second Difference.

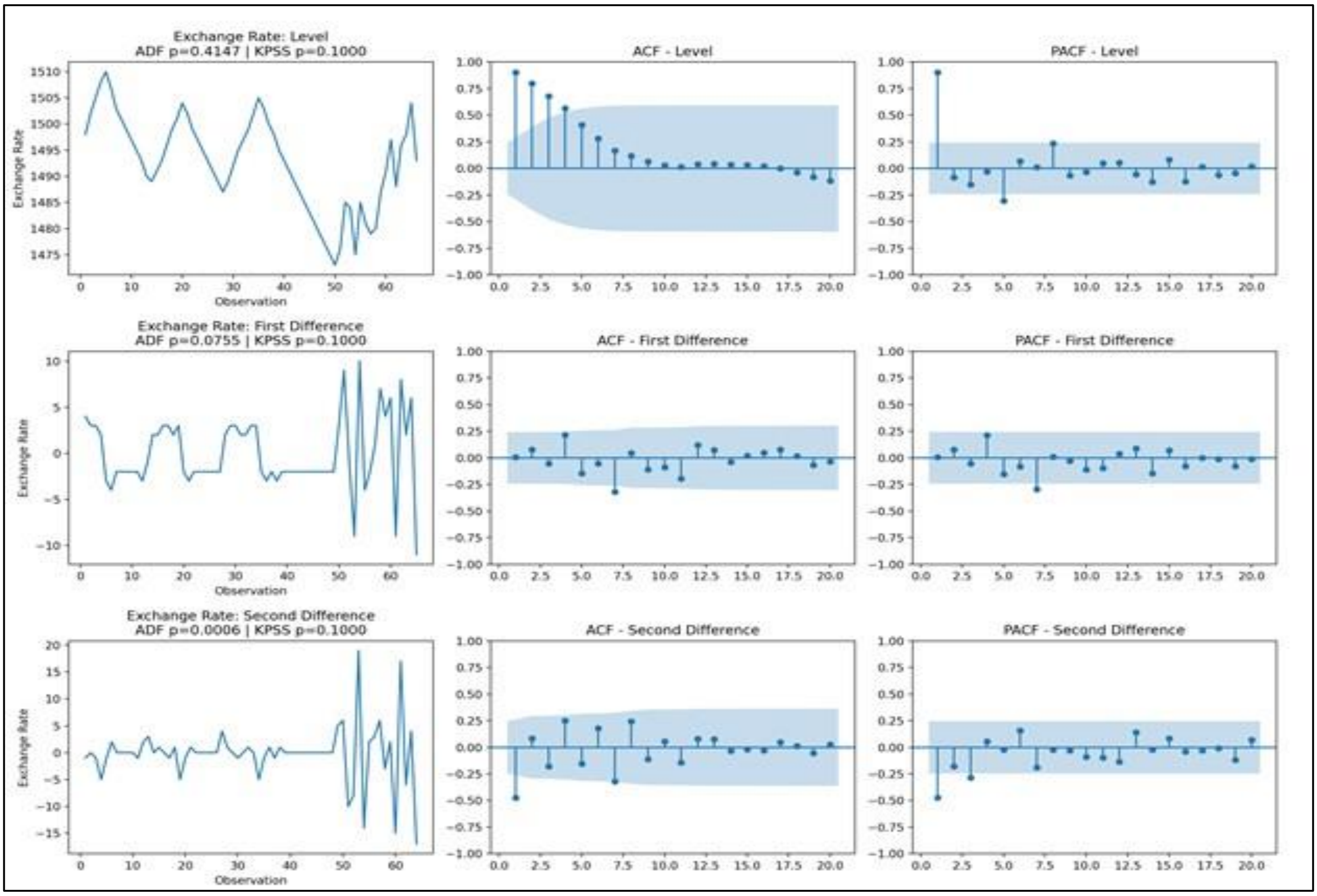

Fig 3 Exchange-Rate Series, ACF, and PACF at the Level, First Difference, and Second Difference.

Table 2 Augmented Dickey–Fuller (ADF) Test Results.

Series	ADF	P-value	Decision
Gold prices	1.4655	0.9974	Nonstationary
Gold prices, first difference	-2.3097	0.1689	Nonstationary
Gold prices, second difference	-3.6669	0.0046	Stationary
Oil prices	-1.1399	0.6989	Nonstationary
Oil prices, first difference	-2.3422	0.0214	Nonstationary at $\alpha = 0.01$
Oil prices, second difference	-8.7771	0.0000	Stationary
Exchange rate	-2.6842	0.0768	Nonstationary
Exchange rate, first difference	-2.8511	0.0262	Nonstationary at $\alpha = 0.01$
Exchange rate, second difference	-3.6423	0.0050	Stationary

To examine multicollinearity in the MARIMAX model, the variance inflation factor (VIF) was calculated, as shown in Table 3. At the level form, the VIF was approximately 5.723 for each of the two exogenous variables, indicating the presence of multicollinearity. After taking the first difference, the VIF decreased to 1.037. When the model inputs lagged by one week (lag 1) were examined, the VIF was 1.034. These results indicate that the multicollinearity problem was no longer present after differencing and lagging the model inputs.

Table 3 Variance Inflation Factor (VIF) Values.

Series	Oil VIF	Exchange-rate VIF
Original series	5.723	5.723
After first difference	1.037	1.037
Model inputs (lag 1)	1.034	1.034

After eliminating the multicollinearity problem, five candidate models were compared in order to identify the ARIMA model most appropriate for describing the output series. The comparison was based on the statistical criteria log-likelihood (Log-L), AIC, and BIC. The results reported in Table 4 indicate that ARIMA(1,2,2) was selected in the study as the best model for representing the series y_t.

Table 4 Model-Selection Criteria for Candidate ARIMA Models.

Model	Log-L	AIC	BIC
ARIMA(1,2,2)	**-538.123**	**1109.713**	**1117.157**
ARIMA(0,2,2)	-562.467	1111.128	1118.460
ARIMA(1,2,1)	-552.415	1134.840	1141.221
ARIMA(0,2,1)	-543.031	1138.483	1142.737
ARIMA(1,2,0)	-542.627	1159.013	1163.299

To identify the most appropriate MARIMAX model and determine the order and direction of the relationship between the input series and the output series, the cross-correlation coefficients were used. Accordingly, the crosscorrelation coefficients between the filtered output series ϑ_t and the two filtered input series ω_{1t} and ω_{2t} were estimated, as shown in the figure and Table 5 below. The first significant cross-correlation in the positive direction for the first filtered input series was positive and appeared at the first lag. For the second filtered input series, the first significant positive-direction crosscorrelation was also positive. Table 5 reports a significant exchange-rate correlation at lags +1 and +5. On the basis of the first significant positive lag used in the model, the time-delay coefficient was taken to be one week (b =1).

Table 5 Significant Cross-Correlations After Pre-Whitening.

Exogenous variable	Lag	CCF	Decision
Oil	+1	0.296	Significant
Exchange rate	+1 and +5	0.433 and 0.272	Significant

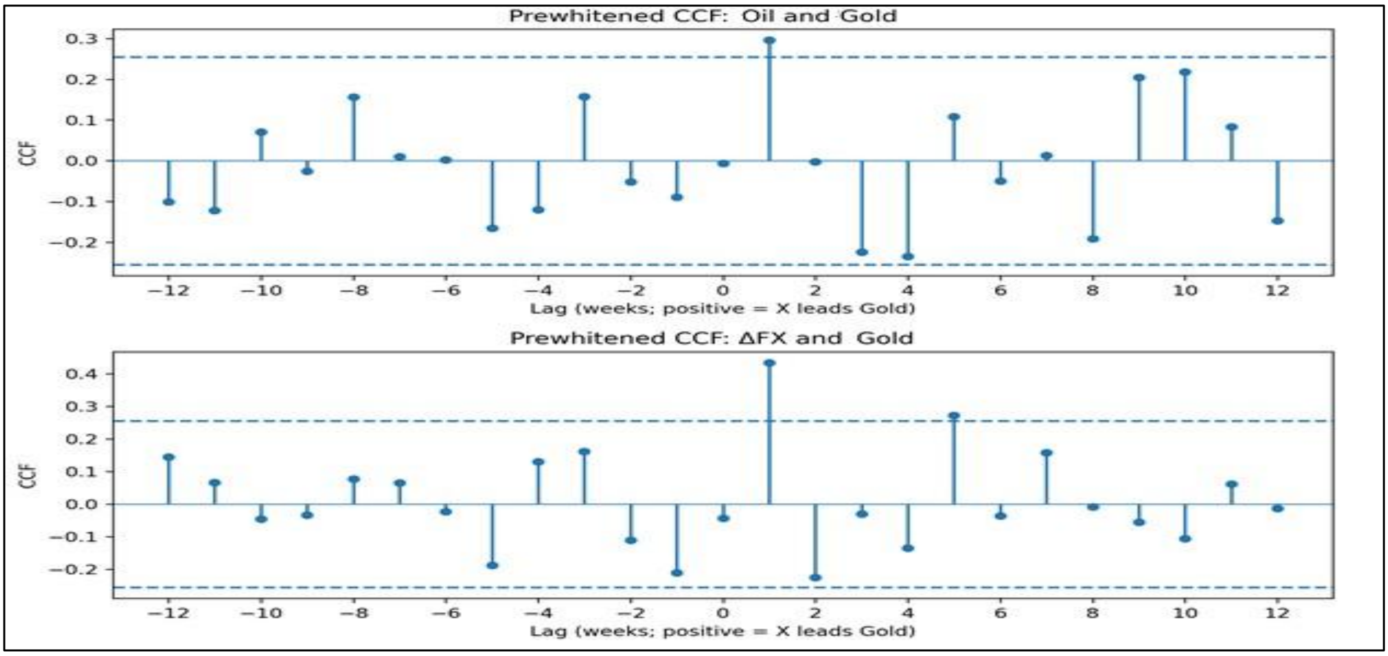

Fig 4 Cross-Correlation Function Between the Output Series and the Two Input Series After Pre-Whitening.

Table 6 Estimated MARIMAX (1,2,2) Parameters.

Parameter	Estimate	S.E.	t statistic
β_0	-75.983	30.954	-2.4547*
β_1	733.79	225.92	3.248*
β_2	84.699	24.696	3.430*
φ_1	0.751	0.240	3.128*
θ_1	-0.940	0.286	3.290*
θ_2	0.072	0.017	4.2352**

Accordingly, the parameters of the MARIMAX(1,2,2) model were estimated and the residuals were tested, as shown in Table 6. The results indicate that the estimated parameters are statistically significant, since the reported Z-test statistics are significant. The residuals of the model are also reported to be random and statistically acceptable: the p-values for both the Ljung-Box test, used to examine residual autocorrelation, and the Jarque-Bera statistic, used to examine the distributional behavior of the residuals, are greater than the adopted significance level. Specifically, the Ljung-Box statistic for the residual series was Q* = 3.5754 with p-value = 0.469, while the Jarque-Bera statistic was 0.2448 with p-value = 0.294.

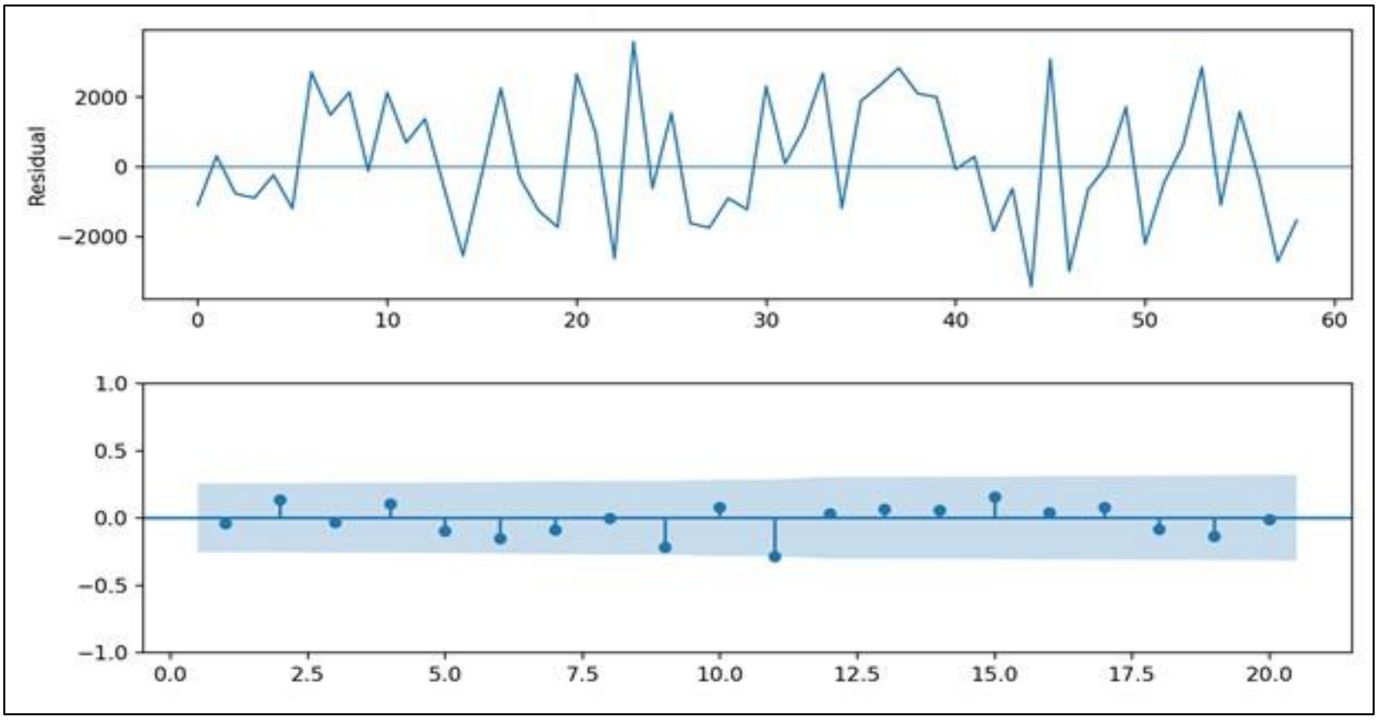

Fig 5 Autocorrelation and Normal-Distribution Diagnostics for the Residuals of the MARIMAX (1,2,2) Model.

Accordingly, the mathematical form of the model is as follows:

$$yt = \beta 0 + (2 + \varphi 1)t-1 + (1 + 2\varphi 1)yt-2 + \varphi 1yt-3 + \beta 1x1,t-1 + \beta 2x2,t-1 + \varepsilon t + \theta 1\varepsilon t-1 + \theta 2\varepsilon t-2$$

Substituting the parameter estimates reported in Table 6 gives:

$$y_t = -75.983 + (2 + 0.751)_{t-1} + [1 + 2(0.751)]y_{t-2} + 0.751y_{t-3} + 733.79x_{1,t-1} + 84.699x_{2,t-1} + \varepsilon_t - 0.940\varepsilon_{t-1} + 0.072\varepsilon_{t-2}$$

After the MARIMAX(1,2,2) model had passed all of the preceding diagnostic tests, it was employed to forecast the weekly average gold price in the presence of the effects of Basra crude-oil prices and the Iraqi dinar exchange rate for the next 16 weeks, beginning in August 2026. The forecasting results are presented in Table 7 and the forecast figure below. They show that all forecast values fall within the 95% confidence limits. The point forecasts for one mithqal rise gradually from approximately IQD 945 thousand to slightly above IQD 1.017 million over the forecast horizon. The original Arabic discussion states an average forecast of about IQD 940 thousand; however, the numerical forecasts listed in Table 7 have an arithmetic mean of approximately IQD 982 thousand. This numerical discrepancy is retained here explicitly so that the English translation accurately reflects both the prose and the table in the source.

Table 7 Forecast Values of Weekly Average Gold Prices

Week	Forecast	95% Lower	95% Upper
2026-08-14	945,039.56	941,515.97	948,573.03
2026-08-21	950,252.39	942,950.27	957,640.58
2026-08-28	955,433.66	943,803.45	967,193.34
2026-09-04	960,559.83	944,366.98	976,922.13
2026-09-11	965,617.61	944,379.92	986,985.53
2026-09-18	970,601.18	944,241.48	997,262.56
2026-09-25	975,510.07	943,682.58	1,007,812.24
2026-10-02	980,347.65	942,576.13	1,018,408.92
2026-10-09	985,119.93	941,404.58	1,029,061.08
2026-10-16	989,834.66	940,433.53	1,040,315.18
2026-10-23	994,500.72	938,705.63	1,051,083.09
2026-10-30	999,127.60	936,559.54	1,061,999.55
2026-11-06	1,003,725.10	934,065.46	1,073,616.51
2026-11-13	1,008,303.02	931,580.65	1,084,941.61
2026-11-20	1,012,871.03	929,211.78	1,096,619.72
2026-11-27	1,017,438.50	926,774.98	1,108,304.62

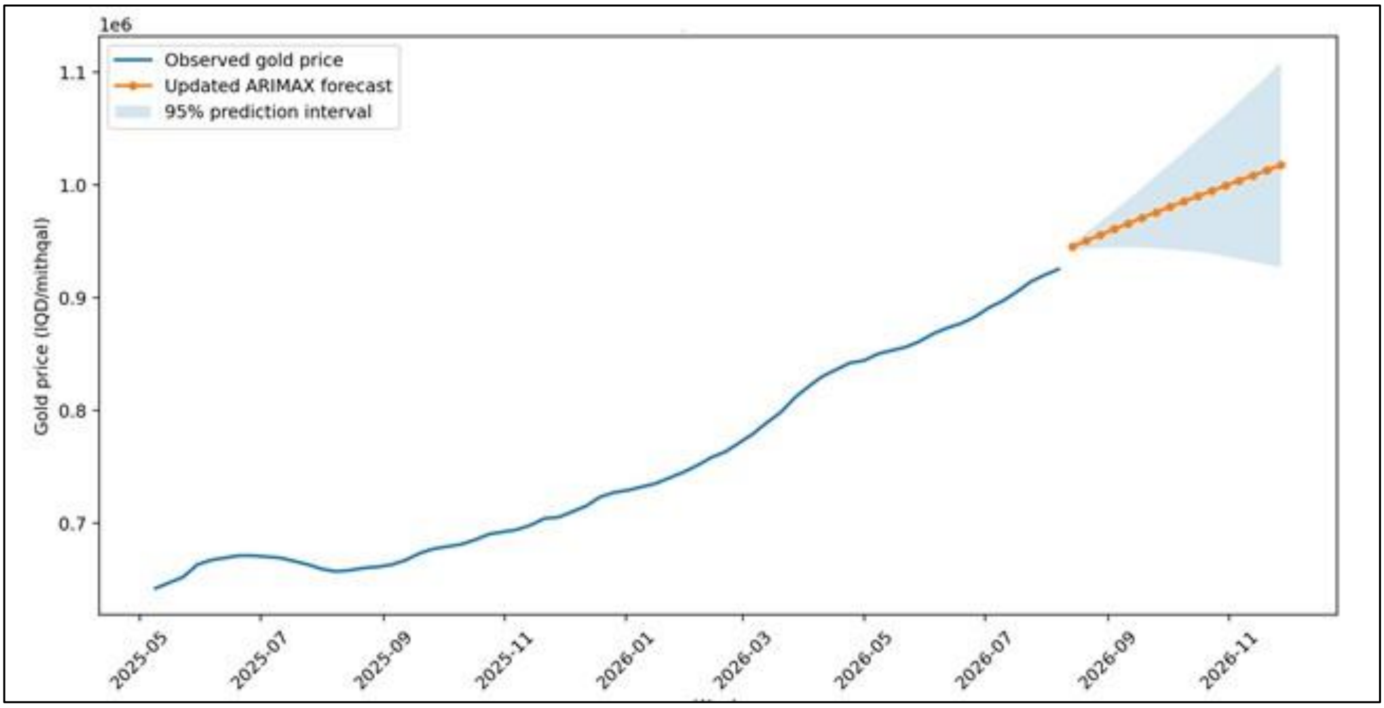

Fig 6 Forecast Values of the Weekly Average Gold Price According to the MARIMAX Model (Forecast Chart Corresponding to the Original Study).

IV. CONCLUSIONS

- The weekly average series of 21-karat gold prices in Iraq is a nonstationary time series and becomes stationary after taking the second difference. The two series representing the factors affecting gold prices - the weekly average Iraqi dinar exchange rate and the weekly average Basra Light crude-oil price - are also nonstationary. Stationarity was achieved through differencing, with the reported ADF results showing stationarity at the second difference under the 1% significance criterion used in the study.

- Multicollinearity was examined after transforming the series to stationarity. The variables were not deleted merely because multicollinearity appeared in their level values, since achieving stationarity by differencing removed the multicollinearity between the explanatory variables.

- ARIMA(1,2,2) is the model considered appropriate for estimating the weekly average gold-price series (the output series). Therefore, the series of factors affecting the market indicator (the two input series) were pre-whitened using this model.

- From the cross-correlation coefficients between the weekly average goldprice series and the two external factors affecting those averages, it was found that the effect of weekly Basra oil prices and the Iraqi dinar/U.S. dollar exchange rate in the parallel market appears after a one-week lag and has a positive direction.

- The forecast values of weekly average gold prices obtained using the MARIMAX model indicate that gold prices are expected to record a limited increase during the coming weeks. The Arabic conclusion states that the average may reach approximately IQD 940 thousand; the forecast values in Table 7, however, average approximately IQD 982 thousand. This inconsistency is present in the source and is therefore reported rather than silently altered in the translation.

REFERANCES

[1]. Al-Salim, Raja Abdullah (2018). “The Reciprocal Relationship between Oil Prices, Gold Prices, and the Iraqi Dinar Exchange Rate against the Dollar for the Period 1996–2015.” Al-Iqtisadi Al-Khaliji Journal, 34(35), 1–23. [Arabic source].

[2]. Al-Masri, Mahmoud Adnan (2015). “Analysis of the Relationships between Fluctuations in Gold Prices, Crude Oil Prices, the Jordanian Dinar Exchange Rate, and the Performance of the General Index of the Amman Stock Exchange for 2000–2013.” Master’s thesis, College of Economics and Administrative Sciences, Amman. [Arabic source].

[3]. Al-Mutawalli, Ahmed Shakir, and Jassim, Firas Munther (2024). “Forecasting Water Quantities in the Iraqi Marshes Using MSARIMAX Models.” Journal of Al-Rafidain University College, No. 154, pp. 89–99. [Arabic source].

[4]. Belsley, D. A., Kuh, E., & Welsch, R. E. (1980). Regression Diagnostics. John Wiley & Sons, New York.

[5]. Box, G. E., & Jenkins, G. M. (1970). Time Series Analysis: Forecasting and Control. Holden-Day, San Francisco.

[6]. Box, G. E., & Tiao, G. C. (1975). “Intervention Analysis with Applications to Economic and Environmental Problems.” Journal of the American Statistical Association, 70, 70–79.

[7]. Cryer, J. D., & Chan, K. S. (2008). Time Series Analysis with Applications in R, 2nd ed. Springer, New York.
[8]. Fun, J., et al. (2009). “The Analysis to Tertiary-industry with ARIMAX Model.” Journal of Mathematics Research, 1(2), 156–163.
[9]. Islam, F., & Imteaz, M. A. (2021). “The Effectiveness of ARIMAX Model for Prediction of Summer Rainfall in Northwest Western Australia.” 4th International Conference on Engineering Sciences, Vol. 1067.
[10]. Neog, B., Gogoi, B., & Patowary, A. N. (2022). “Development of Hybrid Time Series Models for Forecasting Autumn Rice Using ARIMAX-ANN and ARIMAX-SVM.” Annals of Forest Research, 65(1), 9119–9133.
[11]. Pankratz, A. (1991). Forecasting with Dynamic Regression Models. Wiley Series in Probability and Statistics.
[12]. Pandit, S., & Luo, X. (2025). “A Novel Prediction Model to Evaluate the Dynamic Interrelationship between Gold and Crude Oil.” International Journal of Data Science and Analytics, 20, 1161–1182. DOI: 10.1007/s41060-024-00519-8.
[13]. Periodic reports issued by the Iraq Stock Exchange, 2020–2023.
[14]. Reports on exchange rates in local markets, 2020–2023.
[15]. Shilpa, G. N., & Sheshadri, G. S. (2019). “ARIMAX Model for Short-Term Electrical Load Forecasting.” International Journal of Recent Technology and Engineering (IJRTE), 8(4), 2786–2789.
[16]. Tiao, G. C., & Box, G. E. (1981). “Modeling Multiple Time Series with Application.” JASA, 76(376), 802–816.
[17]. Ugoh, C. I., Uzuke, C. A., & Ugoh, D. O. (2021). “Application of ARIMAX Model on Forecasting Nigeria’s GDP.” American Journal of Theoretical and Applied Statistics, 10(5), 216–225.
[18]. Wei, W. S. (2006). Time Series Analysis: Univariate and Multivariate Methods. Addison-Wesley, United States of America. Investing.com.
[19]. Williams, B. M. (2001). “Multivariate Vehicular Traffic Flow Prediction: Evaluation of ARIMAX Modeling.” Journal of the Transportation Research Board, Vol. 1, 194–200.
[20]. Yang, M. (2017). “Application of the ARIMAX Model on Forecasting Freeway Traffic Flow.” 17th COTA International Conference of Transportation Professionals, 7–9 July 2017, Shanghai, China.

APPENDIX

Table 1 The weekly observations. The variables are weekly gold prices (IQD), Basra oil prices, and exchange rates.

No.	Week	Gold price	Oil price	Exchange rate
1	09/05/2025	642000	62.91	1468.0
2	16/05/2025	647000	65.38	1466.0
3	23/05/2025	652000	68.55	1471.6
4	30/05/2025	663000	67.62	1440.0
5	06/06/2025	667000	69.65	1423.8
6	13/06/2025	669000	70.83	1416.6
7	20/06/2025	671000	71.97	1403.2
8	27/06/2025	671000	71.49	1395.5
9	04/07/2025	670000	73.24	1393.6
10	11/07/2025	669000	72.08	1392.0
11	18/07/2025	666000	72.43	1391.8
12	25/07/2025	663000	72.37	1394.9
13	01/08/2025	659000	70.31	1402.3
14	08/08/2025	657000	72.43	1407.0
15	15/08/2025	658000	72.47	1398.0
16	22/08/2025	660000	70.41	1412.5
17	29/08/2025	661000	68.16	1421.8
18	05/09/2025	663000	69.22	1435.2
19	12/09/2025	667000	68.57	1453.3
20	19/09/2025	673000	67.19	1455.0
21	26/09/2025	677000	66.43	1470.4
22	03/10/2025	679000	65.76	1475.1
23	10/10/2025	681000	63.59	1490.0
24	17/10/2025	685000	65.03	1497.6
25	24/10/2025	690000	62.48	1500.0
26	31/10/2025	692000	63.35	1511.0
27	07/11/2025	694000	63.7	1495.9
28	14/11/2025	698000	63.44	1514.4
29	21/11/2025	704000	62.73	1495.7
30	28/11/2025	705000	63.26	1491.6
31	05/12/2025	710000	63.4	1504.6
32	12/12/2025	715000	63.8	1519.2
33	19/12/2025	723000	62.64	1505.7
34	26/12/2025	727000	63.09	1497.4
35	02/01/2026	729000	64.48	1504.2
36	09/01/2026	732000	66.15	1501.0
37	16/01/2026	735000	65.61	1497.6
38	23/01/2026	740000	65.74	1498.3
39	30/01/2026	745000	67.28	1484.2
40	06/02/2026	751000	65.77	1480.1
41	13/02/2026	758000	67.19	1465.3
42	20/02/2026	763000	67.93	1472.4
43	27/02/2026	771000	66.39	1463.7
44	06/03/2026	779000	66.5	1460.6
No.	**Week**	**Gold price**	**Oil price**	**Exchange rate**
45	13/03/2026	789000	66.42	1434.8
46	20/03/2026	798000	70.11	1436.3
47	27/03/2026	811000	69.5	1417.1
48	03/04/2026	821000	69.54	1407.2
49	10/04/2026	830000	68.55	1407.2
50	17/04/2026	836000	68.52	1414.3
51	24/04/2026	842000	68.53	1407.3
52	01/05/2026	844000	67.02	1423.9
53	08/05/2026	850000	66.91	1429.2
54	15/05/2026	853000	67.68	1424.2
55	22/05/2026	856000	66.77	1451.9

56	29/05/2026	861000	66.13	1458.8
57	05/06/2026	868000	65.4	1470.0
58	12/06/2026	873000	64.37	1468.0
59	19/06/2026	877000	64.92	1477.0
60	26/06/2026	883000	63.32	1480.5
61	03/07/2026	891000	62.69	1481.0
62	10/07/2026	897000	61.99	1491.4
63	17/07/2026	905000	61.73	1513.3
64	24/07/2026	914000	60.55	1521.2
65	31/07/2026	920000	59.18	1534.4
66	07/08/2026	925000	59.92	1523.5