European Economic Letters
ISSN 2323-5233
Vol 13, Issue 3 (2023)
http://eelet.org.uk

Forecasting of Gold Prices using ARIMA Model

[1]Shalini Kakkar, [2]Dr. Pradnya V. Chitrao
[1]Assistant Professor, Chetana's Institute of Management and Research,
Survey No. 341, Government. Colony, Bandra (East), Mumbai - 400051,
PHD Research Scholar, Symbiosis Institute of Management Studies(SIMS), A constituent
of Symbiosis International University , Khadki, Pune, India,
Shalini_kakkar@yahoo.com
[2]Professor, Symbiosis Institute of Management Studies(SIMS),
A constituent of Symbiosis International University, Khadki, Pune, India, pradnyac@sims.edu

Abstract

Accurate Prediction of prices of gold is important so that business prosperity of financial institutions and the common man remain healthy. Investment in gold is a saving in households as it comes as a rescue to overcome a financial crisis. The study has considered gold prices from Jan 2000 to March 2023. Application of ARIMA (Auto Regressive Integrated Moving Average method) has been established. The effectiveness of the model is checked through autocorrelation, partial autocorrelation, stationarity, and heterodecesacity. Hence ARIMA (1, 1,0) has been proven as the finest model for predicting gold prices. Outcomes of ARIMA model forecasting are important guidelines to understand investment in gold prices when momentum is observed in environmental and economic factors.

Keywords: Gold price, forecast, ARIMA, autocorrelation, stationery

Introduction

Perception of gold has changed from value adornment to safety investment as it becomes a favorite portfolio to invest against financial losses and uncertainty in inflation. Any type of political, economic, or financial crisis pushes it as an attractive asset. The gold price becomes a reflection point of the world economic situation. The control of gold price is difficult but estimated projections can be made so that decisions could be better. The global financial crisis led to severe volatility in the stock market which affected the entire economy. Investors took the refugee in the yellow metal thus diversifying their portfolio. Consequently, gold prices surged to approximately $1800 per ounce by the end of 2011. Hence forecasting becomes an important aspect to undermine whether volatility in gold prices is permanent. An investigation is required into the driving factors like inflation, rising interest rates, energy prices, oil prices, financial papers of gold contracts, and dollar situation which affect the fluctuations in the gold price.Gold is a financial asset widely circulated and is considered a main asset of international reserves.

According to World Gold Council, it is becoming the most trusted investment tool in the international market. It has been given recognition as the most trusted investment tool which is evident from increased demand of 15% since 2001. There has been a remarkable 74% increase in central bank purchases close to 651 tons in 2018 after the collapse of the Bretton wood system in year 1970.

Gold faced a lot of price fluctuations in the world market for numerous reasons. Firstly as in 2018 global stock market crashed fiercely with US and China trade disputes leading to the tax burden of China increasing from $50 billion to 2000$ billion, Syria and US had military strikes from UK, US and France , nuclear deal being withdrawn were the reasons that gold performance was enhanced. The decline of bond yield gave an added advantage to gold to shine in the lean period.

The "haven "characteristic of gold enables investors to diversify their portfolios by investing and ensuring long-term returns. The stock market uncertainty and geopolitical tensions will cause the investor's heart to take rational decisions of investment as some market-driven factors will lead to gold price changes. Gold investment has evolved from traditional ways to paper gold in the form of Gold Exchange ETF as the primary objectives for people have become hedging against inflation and diversifying risk to reduce volatility in the portfolio. Gold mining in India is minimal, hence it reasons well for India to import gold so that local demand can be met. National Stock Exchange and Bombay Stock Exchange have introduced gold investment instruments which facilitate the investor to charge associated with

jewelry purchases. There is a need to provide insights on forecasting gold prices so that decisions can be taken accordingly.

Literature Review

There are many approaches reviewed by many researchers in past decades to understand gold price determinants. One of the approaches is to develop a model to predict future gold prices based on historical data. Abdullah (2012) found that most fitted model to forecast gold bullion prices from 2002 to 2007 is ARIMA (2,1,2) .Khan (2013) in his research found that ARIMA(0,1,1) is a suitable model for forecasting the gold prices from 2003 to 2012. Davis, Dedu, & Bonye (2014) found that ARIMA (7, 1, 0) is an appropriate forecasting model from the period 2003 to 2012. Guha & Bandyopadhyay (2016) proved that ARIMA (1,1,1) is a model used for forecasting gold prices from the period of 2003 to 2014. Tripathi (2017) found that ARIMA (0,1,1) is the suggested forecasted model from the period from 1990 to 2015. Banerjee (2014) has used the ARIMA model in predicting stock indices that impact the state of the Indian economy. Lazim (2012) through forecasting by the ARIMA model found that selling prices of gold bullion shows an upward trend. Baber (2013) found that gold prices have risen from 2002 to 2012. Aidan Meyler (1998).et has given insights into Irish inflation by forecasting using the ARIMA model. Nambiar (2012) highlighted that ARIMA can be used only for forecasting immediate future gold prices. Pung et.al (2013) found that the GARCH model is more appropriate as compared to ARIMA for predicting gold prices as it captures the volatility of time series variables affecting the time series. Baur (2016) applied Dynamic Model Averaging (DMA) in forecasting uncertainty was there in model parameters. Ye(2014) found that results were accurate by predicting using the ARFIMA-GARCH model. Mombeini and Chamzini(2015) used artificial neural networks along with the ARIMA model and found that the artificial neural network model enhanced the performance. Kristjanpoller and Minutolo (2015) formalized a mixed model using artificial neural networks and GARCH to predict the spot price and future price of gold.

Objective

To forecast gold prices by applying the ARIMA model of time series forecasting

Data and Methodology

Secondary gold price data is taken from January 2000 to March 2023(reference in Annexure). Statistical tests using SPSS were done to compute the suitability of data for times series. Data was subjected for treatment through Durbin Watson Test and interpretation was made showing the autocorrelation presence for regression analysis.

The meaningful interpretation of the data is as if Durbin Watson's value is between 0 to 1.5 or between 2.5 to 4 is that data is longitudinal and is dependent on time. The value of Durbin Watson between 2.5 to 4 data is independent of time and its cross-sectional. Time series analysis is done to fulfilling the objective of forecasting using the ARIMA Model. The nonseasonal ARIMA (p, d, q) model is used to find the best fit where p indicates the total number of autoregressive terms,d indicates nonseasonal differencing the series done to make it stationary and q Indicates the forecasted errors lagging for prediction.

Time series must stationary to fit into ARIMA Model. Nonstationary time series is depicted by observing the sequence chart pattern and by finding the value of Augmented Dickey Fuller Test.

Steps involved in ARIMA Model Forecasting

1. The stationarity of the data series is checked
2. Differencing the time series for stationarity.
3. Exploring various models
4. Identifying the best fit
5. Forecasting the values based on the best-fit model.

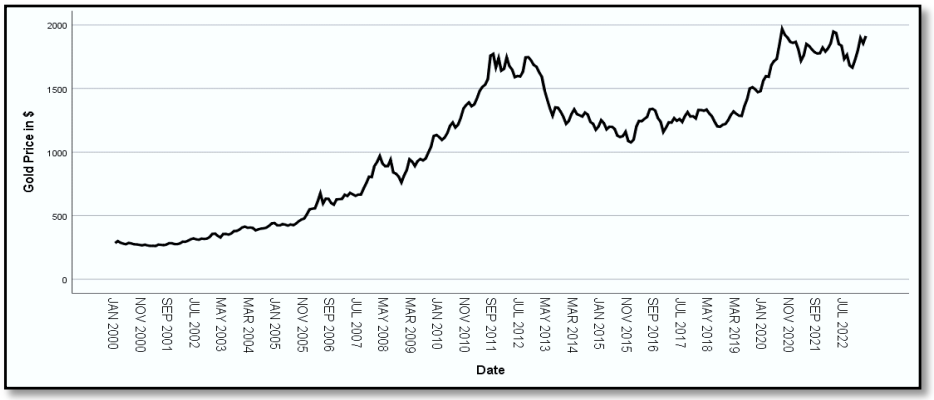
Errors in forecasting can be applied by computing MAE (Mean Absolute Error), RMSE (Root mean Square Error), MSE (Mean Square Error and, MAPE (Mean Absolute Percentage Error).

Data Analysis and Findings

Gold price data taken from Jan 2000 to March 2023 finds that value of Durbin Watson's (DW) value is 0.021which indicates an alarming positive autocorrelation. Gold price indicates 1st order correlation value as=0.989 which is high. it is computed using the formulae of Durbin Watson as = $2[1- \rho(1)]$.

European Economic Letters
ISSN 2323-5233
Vol 13, Issue 3 (2023)
http://eelet.org.uk

Figure 1: Exploratory Data Analysis: Sequence Chart gold prices from (Jan 2000- March 2023)



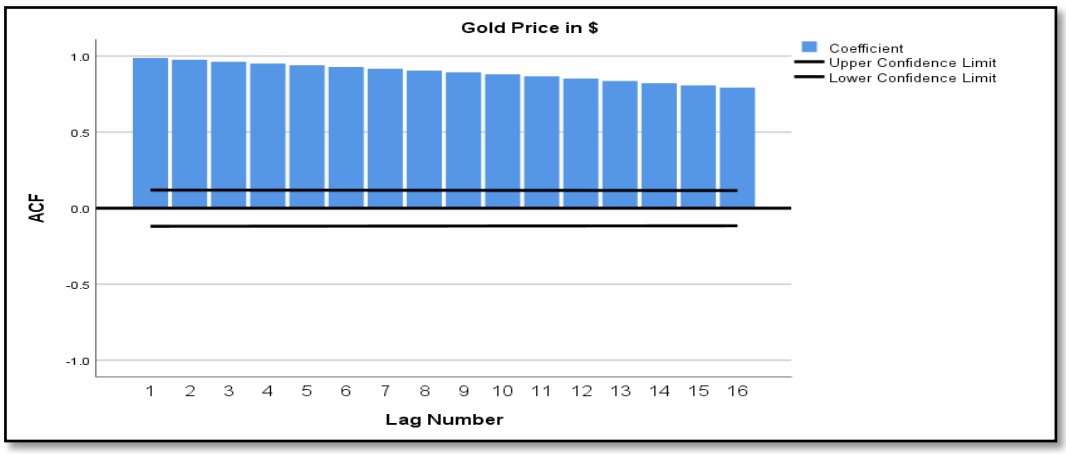
Referring to Figure-1 gold price trend shows a linear trend and hence the data is not stationary as the mean and variance are varying over time. The stationarity of the data is also checked by autocorrelation and partial autocorrelation. Figure 2 and Figure 3 depict the correlogram which proves that data is not stationary. Data is not stationary as the Augmented Dicker Fuller Test value =0.883

Dickey-Fuller test (ADF (stationary) / k = 6) / Log(Gold Price):

Tau (Observed value)	-1.284
Tau (Critical value)	-3.398
p-value (one-tailed)	0.883
Alpha	0.05

Test interpretation:
H0: The series has unit root series.
Ha: Unit root does not exist in the series
Based on the p value we conclude that series has unit root and series is not stationary.

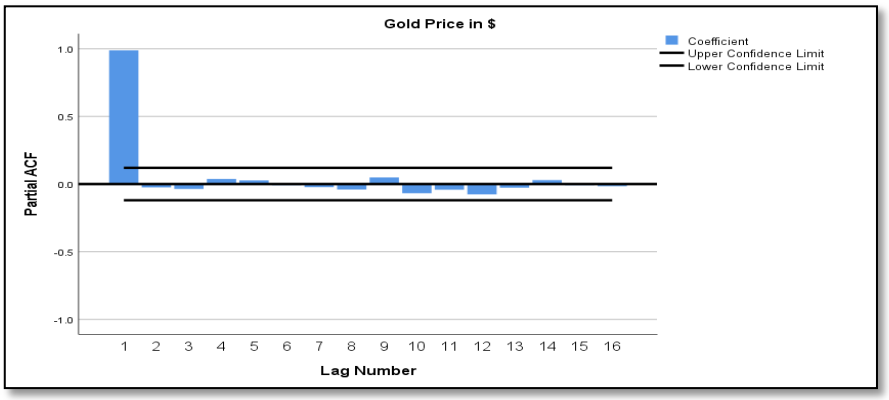
Figure 2 Auto Correlation Function (ACF)



Observations based on the Correlogram as depicted in Figure 2 indicate that ACF spikes are decaying with subsequent lag times and one spike in PACF as depicted in Figure 3 indicates first lag has high significance on future gold prices.

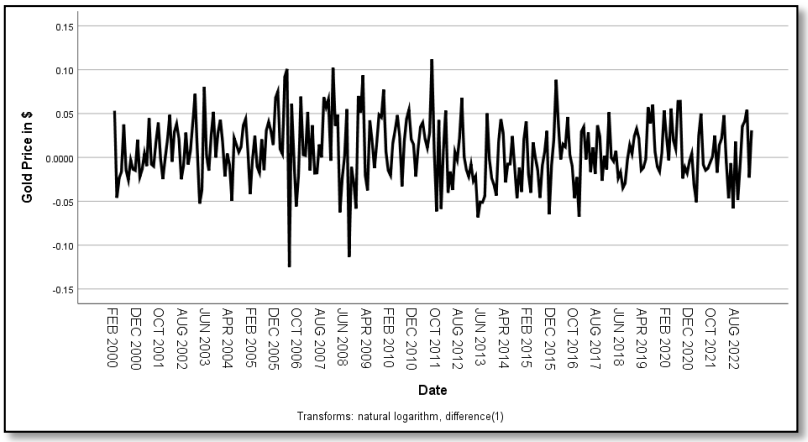
European Economic Letters
ISSN 2323-5233
Vol 13, Issue 3 (2023)
http://eelet.org.uk

Figure 3 Partial Auto Correlation Function (PACF)



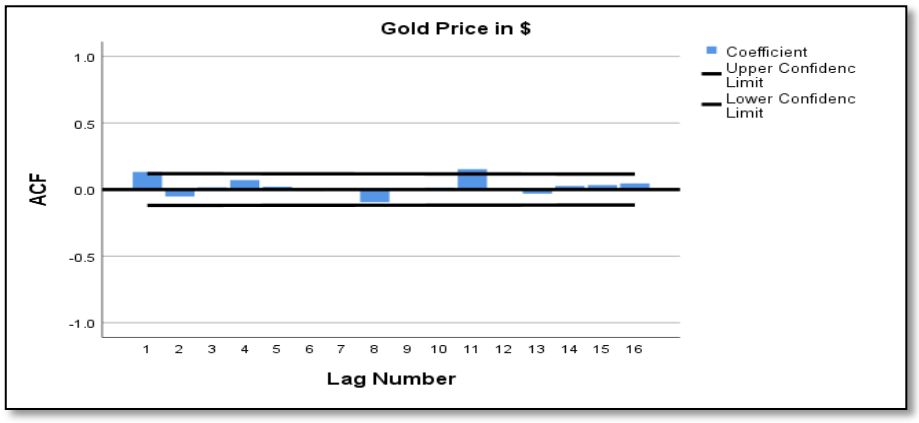
Gold prices are differenced once and converted into Natural log transformation so that series becomes stationary.

Figure 4 Exploratory Data Analysis: Sequence Chart of gold prices with natural Log and differenced one from (Jan 2000- March 2023)



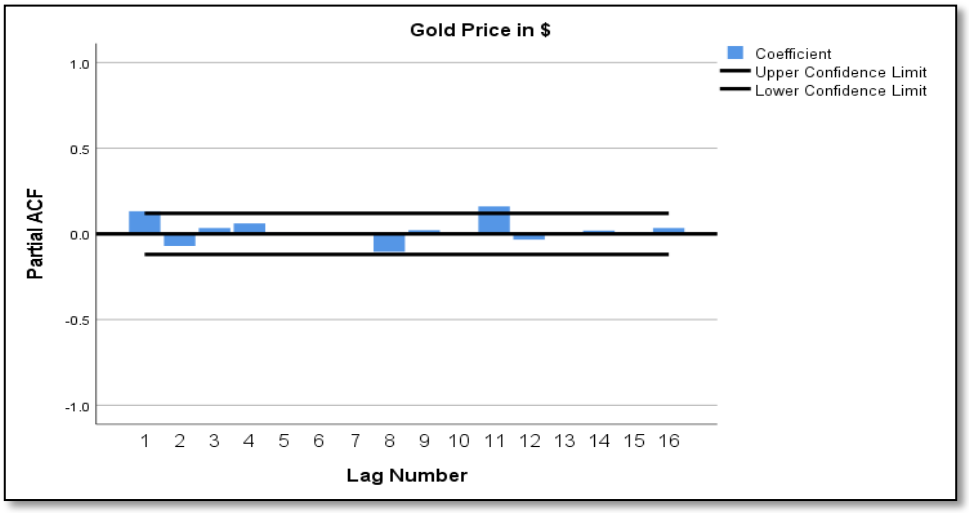
Observations in the sequence chart as depicted in Figure 4 indicate that mean and variance are constant over time, hence the series can be stationary. The correlograms as depicted in Figure 5 and Figure 6 show that the spikes are almost within the limits of standard error

Figure 5 Gold prices with natural Log and differenced one Auto Correlation Functions ACF from (Jan 2000- March 2023)



European Economic Letters
ISSN 2323-5233
Vol 13, Issue 3 (2023)
http://eelet.org.uk

Figure 6 Gold prices with natural Log and differenced one Partial Auto Correlation Functions PACF from (Jan 2000- March 2023)



Dickey-Fuller test (ADF (stationary) / k = 6) / differencing:

Tau (Observed value)	-5.907
Tau (Critical value)	-3.398
p-value (one-tailed)	**<0.0001**
Alpha	0.05

Test interpretation:

H0: Unit root is there in the series.

Ha: Unit root does not exist in the series.

Based on the p value we observe that unit root does not exist and hence series is stationary.

Hence by differencing once and transforming it into log transformations, we find that data has become stationary. The ADF value is 0.0001 which proves that data is stationary and hence can be best used to find a suitable ARIMA model.

Various models were examined in Figure 7 to find the best fit in the ARIMA model. A model with p=1, d=1, q=0 fits well with the criteria parameters as observed.

The values are BIC (Bayesian Information Criterion) = 7.491 which is low, Root Mean Square error (RMSE)= 41.477, Mean Absolute Percentage Error(MAPE) =2.858 and Mean Absolute Error(MAE)=30.227. All the errors are the least values. The Ljung Box Q value is greater than 0.05 = 0.603 showing that values are not random and independent over time as autocorrelation with one or more lags is different from zero.

ARIMA Model Parameters (p=1,d=1,q=0)

		Estimate	SE	T	Sig.
Gold Price in $-Model_1	Gold Price in $ Natural Logarithm	Constant	.007	.002	2.761	.006
		AR Lag 1	.133	.060	2.226	.027
		Difference	1			

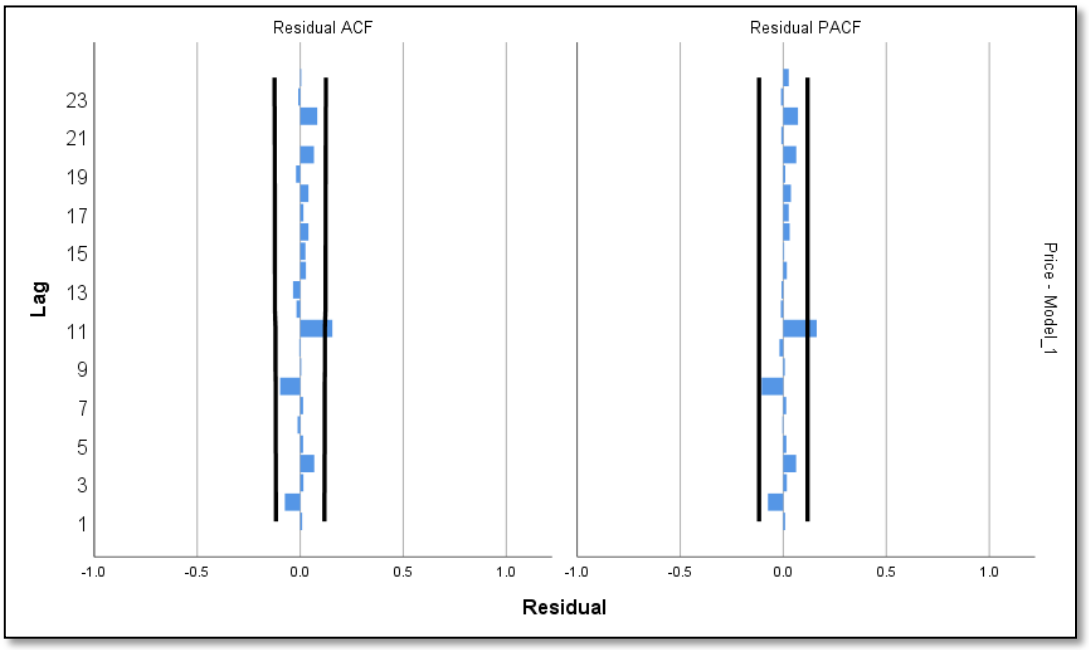
The Model parameters (p=1,d=1,q=0) depict significance as the p-value for AR Lag(1)= 0.027.

Figure 7: ARIMA Model Summary

ARIMA (p, d, q)	R-squared	RMSE	MAPE	MAE	Normalized BIC	Lungs Box Q (18) statistics (sig)
0,1,0	0.994	42.067	2.884	30.61	7.499	0.389
0,1,1	0.994	41.416	2.848	30.124	7.488	0.651
0,1,2	0.994	41.518	2.837	30.052	7.513	0.621
1,1,0	0.994	41.477	2.858	30.227	7.491	0.603
1,1,1	0.994	41.492	2.840	30.081	7.512	0.608
1,1.2	0.994	41.596	2.836	30.050	7.537	0.549
0,1,3	0.994	41.594	2.837	30.058	7.537	0.546
1,1,3	0.994	41.672	2.824	29.934	7.561	0.522
1,0,1	0.985	64.798	3.856	32.598	8.403	1
1,0,2	0.984	66.494	3.891	32.655	8.475	1
1,2,0	0.991	50.188	3.463	36.210	7.872	0
1,2,1	0.994	41.747	2.856	30.217	7.524	0.563
1.2,2	0.994	41.731	2.828	29.969	7.544	0.573

The correlogram depicted in Figure 8 indicates that the variation or spikes are within standard error in the lags.

Figure 8 Residual ACF and Residual PACF for ARIMA(1,1,0)



Tests for heteroscedasticity were done on residuals by using White Test and Breusch Pagan test which proved that the p-value is not significant, and the residuals are homoscedastic

H0: Residuals are homoscedastic.

H1: Residuals are heteroscedastic.

European Economic Letters
ISSN 2323-5233
Vol 13, Issue 3 (2023)
http://eelet.org.uk

Breusch-Pagan test / Residuals:

LM (Observed value)	18.837
LM (Critical value)	3.841
DF	1
p-value (Two-tailed)	**<0.0001**
Alpha	0.05

White / Squared terms only test / Residuals:

LM (Observed value)	21.015
LM (Critical value)	5.991
DF	2
p-value (Two-tailed)	**<0.0001**
Alpha	0.05

Figure 9 Model Fit based on Observed values and Forecasted on ARIMA Model (1,1,0)

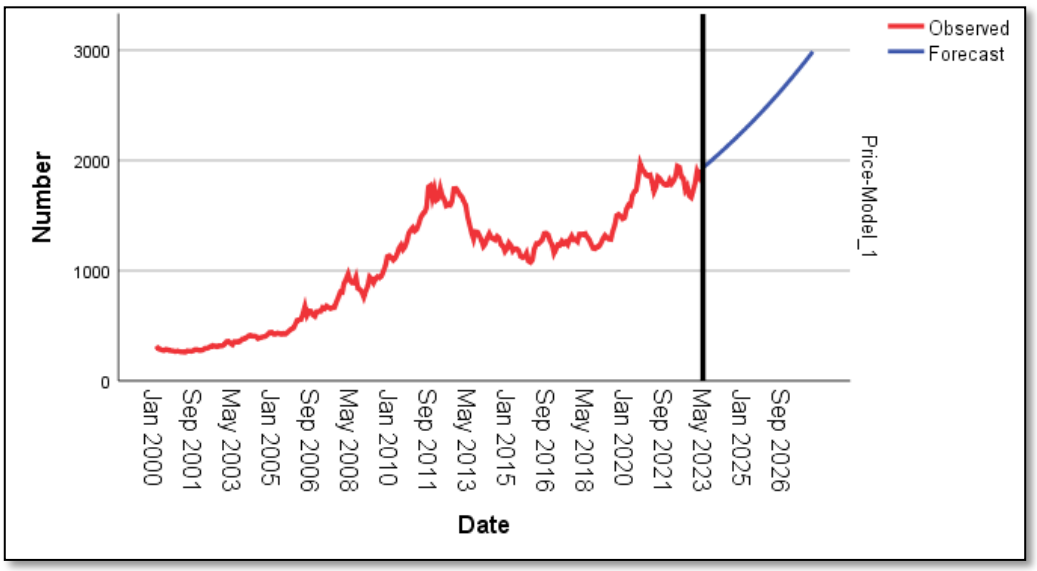


Figure 10: Forecasted Values

Model		April 2023	May 2023	June 2023	July 2023	August 2023	September 2023	October 2023	November 2023	December 2023
Gold Price in $-Model_1	Forecast	1933	1949	1965	1980	1995	2011	2026	2042	2058
	UCL	2075	2167	2243	2311	2374	2434	2492	2548	2602
	LCL	1799	1748	1712	1685	1663	1645	1629	1615	1604

Conclusion

ARIMA model is an important tool used for predicting gold prices. Since gold prices are highly volatile and subject to the influence of economic and market conditions, it becomes necessary to forecast the prices with the assumption that residuals from the values have no autocorrelation and heteroscedasticity. The assumption must be kept that factors affecting gold prices like operating product cost, supply of gold, demand, oil prices, dollar exchange rates, inflation,

stock prices, and political situation do not change much in a period. Some factors interact with each other, and they have a significant impact on the gold price The Accepted ARIMA model for future prediction is ARIMA (1, 1, 0) which fits best with the model. The result proves that the model used can help consumers in predicting gold prices as a guiding role in investment.

References

1. Abdullah L (2012) ARIMA Model for Gold Bullion Coin Selling Prices Forecasting. International Journal of Advances in Applied Sciences 1(4):153-158.
2. A Meyler, G. Kenny, and T. Quinn. (1998). Forecasting Irish inflation using ARIMA models. [Online]. MPRA Paper No. 11359, posted 3. November 2008 14:34 UTC. Available: http://mpra.ub.uni-muenchen.de/11359/
3. Baur, D. G., Beckmann, J., & Czudaj, R(2016), "A melting pot - gold price forecasts under model and parameter uncertainty," International Review of Financial Analysis, vol. 48, pp. 282-291.
4. Kshirsagar, P. R., Reddy, D. H., Dhingra, M., Dhabliya, D., & Gupta, A. (2022b). Detection of Liver Disease Using Machine Learning Approach. 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), 1824–1829. IEEE.
5. Kshirsagar, P. R., Reddy, D. H., Dhingra, M., Dhabliya, D., & Gupta, A. (2022a). A Review on Comparative study of 4G, 5G and 6G Networks. 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), 1830–1833. IEEE.
6. Veeraiah, V., Pankajam, A., Vashishtha, E., Dhabliya, D., Karthikeyan, P., & Chandan, R. R. (2022). Efficient COVID-19 Identification Using Deep Learning for IoT. 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), 128–133. IEEE.
7. Khan M (2013) Forecasting of Gold Prices (Box Jenkins Approach). International Journal of Emerging Technology and Advanced Engineering 3(3):662-670
8. Davis R, Dedu V K, Bonye F (2014) Modeling and Forecasting of Gold Prices on Financial Markets. American International Journal of Contemporary Research 4:107-113
9. D. Banerjee(2014), "Forecasting of Indian stock market using time-series ARIMA model," in Proc. Conference Paper, ICBIM-14.
10. Guha B, Bandyopadhyay G (2016) Gold Price Forecasting Using ARIMA Model. Journal of Advanced Management Science 4(2):117-121.
11. Kristjanpoller, W, & Minutolo, M (2015), "Gold price volatility: A forecasting approach using the Artificial Neural Network–GARCH model," Expert Systems with Applications, vol. 42, pp. 7245-7251.
12. L. Abdullah (2012), "ARIMA model for gold bullion counseling prices forecasting," International Journal of Advances in Applied Sciences, vol. 1, no. 4, pp. 153-158.
13. Mombeini, H. and A. Yazdani-Chamzini (2015), "Modeling Gold Price via Artificial Neural Network Journal of Economics," Business and Management, vol. 3, no. 7, pp. 699-703.
14. P. Baber, R. Baber, and G. Thomas, "Factors affecting gold prices: A case study of India," in Proc. Evolving Management Paradigms in Manufacturing and Service Sectors, March 13.
15. G. Nambiar, and R. M(2012), "Forecasting Price And Analysing Factors Influencing The Price Of Gold Using Arima Model And Multiple Regression Analysis," International Journal of Research in Management, Economics, and Commerce, vol. 2, no. 11, pp. 548-563.
16. Pung, Y.P., Nor, H.M., Maizah(2013), H.A, "Forecasting Malaysian gold using GARCH model," Applied Mathematical Sciences, vol. 7, no. 58, pp. 2879- 2884.
17. Tripathy N (2017) Forecasting Gold Price with Auto Regressive Integrated Moving Average Model. International Journal of Economics and Financial Issues 7:324-329
18. YE. J, ZHAO. K, WANG. C, & LIU. W(2014), "Analysis and Forecasts of Gold Price Based on the ARFIMA-GARCH Model," Journal of Qingdao University(Natural Science Edition), 4, p. 10.