Modelling and forecasting gold prices using Arima

P B Saranya

Assistant Professor,

GRG School of Management Studies,

PSGR Krishnammal College for Women.

Coimbatore.

Email: pbsaranya@grgsms.ac.in

Abstract

Indian investors consider physical gold as an important asset while investments in gold across the globe is considered as a hedging tool which provides diversification to the portfolio for an investor. It's often correlated with the stock markets during risk-on periods and inversely correlated during periods of stress. Indian investors have demonstrated strong affinity to physical since several decades. The demand for gold in the global market is more than 4000 tonnes during the last decade out of which 25% of the global demand is attracted by the Indian market. The annual average consumption of gold in the Indian market amounts to 850 tonnes since 2010.The increasing gold prices, economic slowdown and the outbreak of pandemic has resulted in lesser consumption of gold during 2020 in India. The continuous increase in prices has led to following study. This paper attempts to forecast the gold prices in the short run, for which 196 observations of the daily gold prices in USD were obtained for a period of 9 months from 1st November, 2019 to 31st July, 2020. The most popular tool the Box-Jenkins ARIMA was used to forecast the prices. The empirical results indicate that the adjusted ARIMA model provides better scope for predicting the prices in the near future. The gold prices in the short run is showing an increasing trend.

Introduction

Gold is widely considered as an important asset in the portfolio as it provides diversification and is often correlated with the stock markets during the periods when risk is low and inversely correlated during periods of stress. The gold prices in India have significantly increased by 60% and 30% during the year 2019 and during January to July, 2020 respectively. The demand for precious metal has also been highly impacted due to the outbreak of Coved – 19 pandemic. According to the report by World Gold Council the global demand for Gold was recorded at 2,076 tonnes which has declined by 6% during the first half

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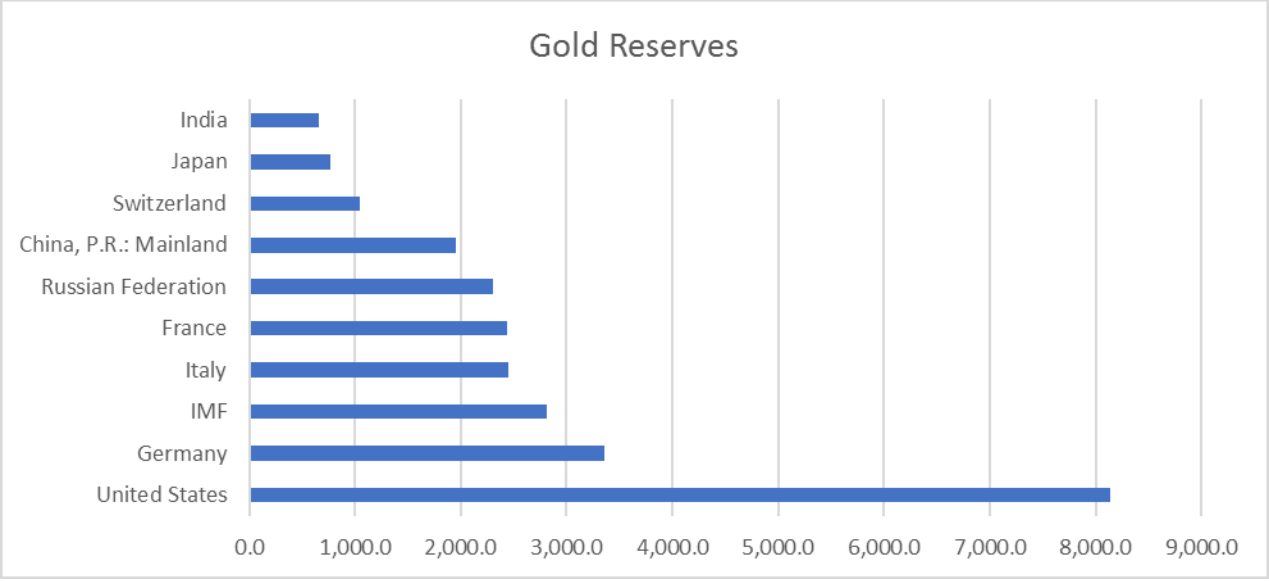
of 2020. Similarly the demand for gold jewellery and investments such as bar gold and coins in India declined drastically during 2019. The jewellery demand declined from 294.1 tonnes to 117.8 tonnes and the investment demand was 47.8 tonnes with a decline of 39%.The demand in Indian market during 2020 (Q2) was 63.7 tonnes, with a 70% drop, while the jewellery demand was 44 tonnes, which fell by 74% and the investment demand was 19.8 tonnes which dropped by 56%. Total gold recycled was 13.8 tonnes, which again has dropped by 64% from 37.9 tonnes a year ago. It is widely believed that the demand for gold in India may not have a significant recover till December, 2020n owing to increasing prices and a steep fall in demand by 56%. The demand for gold in the global market has been more than 4000 tonnes during the last decade out of which 20% demand lies in the Indian market. The average consumption of gold in the Indian market amounts to 850 tonnes since 2010. Similarly the net bullion imports by India amount 800 tonnes per year on an average. Approximately 65% of India gold consumption is concentrated toward the jewellery demand and he rest is towards investment such as coins and bars while the same is wise versa in all major counties.

The exhibit 1 represents the amount of gold reserves held by several counties. US ranks first with a total amount of reserves around 8200 tonnes followed by Germany and IMF with approximately 2800 tonnes. India holds a total reserves of approximately 700 tonnes.

Exhibit 1: Gold Reserves maintained by several countries



The exhibit 2 represents the demand for gold in the Indian market and the amount of gold imports since 2010. The overall consumer demand for gold in India is declining while the net imports had a drastic fall during 2016.

Exhibit 2: Consumer Demand for Gold and Net Bullion Imports in the Indian market (2010 – 2019)

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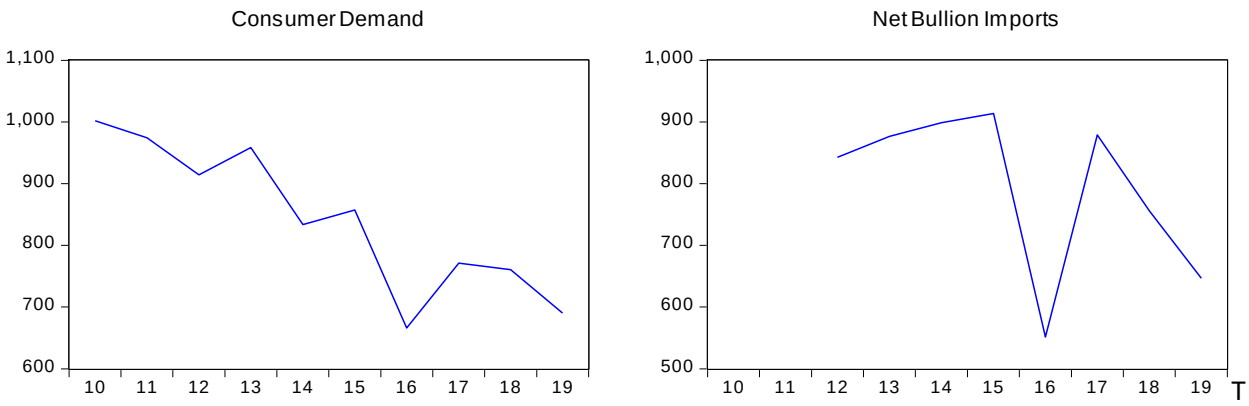
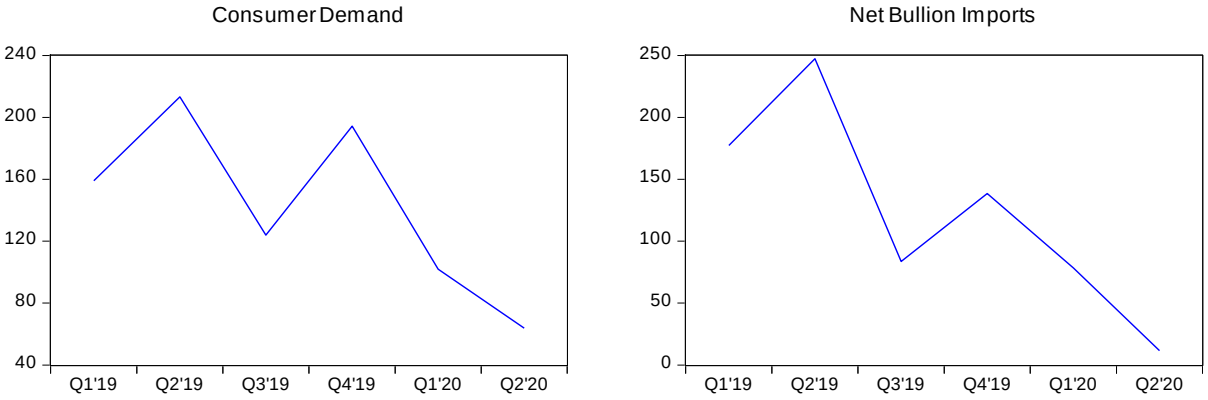


The **exhibit** 3 represents the demand for gold in the Indian market and the amount of gold imports during the last six quarters that is from 2019 to mid of 2020. The overall consumer demand for gold in India had all as well as raise in 2019 whereas in 2020 it continued to fall.

Exhibit 3: Consumer Demand for Gold and Net Bullion Imports in the Indian market (last 6 quarters)



Similarly the net imports is also continuing to decline. The slowdown in income expectations restricts the demand for gold in the Indian marketplace. Prices of the yellow metal have crossed Rs 52,000 per 10 grams mark, during August, 2020.The table 1 below represents the highest and lowest prices of gold since February, 2020.

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Table 1: Gold price range in India during February, 2020 to August, 2020

Month	Highest	Lowest	% Change
August	Rs.54,200 on August 7	Rs.49,120 on August 29	-4.33%
July	Rs.51,250 on July 31	Rs.46,100 on July 7	+9.65%
June	Rs.46,450 on June 29	Rs.44,270 on June 6	+2.55%
May	Rs.45,920 on May 31	Rs.43,410 on May 1	+3.87%
April	Rs.44,740 on April 29	Rs.39,440 on April 1	+11.44%
March	Rs.42,310 on March 6	Rs.38,340 on March 19	-0.90%
February	Rs.41,000 on February 24	Rs.38,380 on February 6	+1.63%

Due to the stress in the economy recently the Indian gold ETF's market has witnessed a greater demand since April, 2020 to the mid of May with an increase in the customer base by 17% that is 35,000 new investors have included gold ETF's to their portfolios. At present the Indian gold ETF market is valued about US$ 1 B in terms of asset under management. Two third of the market is held by retail investors while the later by institutional investors Gold ETF's were launched in India during 20007 by Mr. Vishal Jain the founder of the Indian gold ETF market. Initially when ETF's were launched in India there was fair interest found among the investors due to the strong cultural affinity for physical gold, gold as an asset in the portfolio lost its shine since 2013 as stock markets were bullish, the launch of sovereign gold bonds in 2015 by the Government of India. However when gold ETF's were introduced they had a lock in period of 3 years in lieu to enjoy the benefits of low capital gains taxes, but at present the lock in period for the same has been reduced to 1 year which is expected to bring positive interest among investors. Gold ETF's market is expected to grow in the near future.

Literature Review

Larry and Fabio (1996) discover that the actual appreciations or depreciations of the euro and the yen towards the U.S. greenback have profound outcomes at the charge of gold in all different currencies. Further they have a look at shows that the number one gold manufacturers of the sector (Australia,

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South Africa, and Russia) seem to have any significant impact over the sector charge of gold. Khaemusunun, (2009) predicts the Thai gold charge with the aid of using the usage of Multiple Regression and ARIMA version. The have a look at has examined the effect of currencies of the United States, Australia, Canada, Peru, Hong Kong, Japan, Germany, Italy, Singapore, Colombia, Oil Prices and Interest Rate at the gold charge. The have a look at unearths that American, Australian, Canadian, Japanese currencies are considerably affecting the Thai gold charge. The have a look at concludes that ARIMA (1, 1, 1) is the maximum appropriate version for predicting Thai gold charge. Ismail et al (2009) use a couple of linear regression (MLR) fashions for forecasting the gold prices. The have a look at has taken a couple of financial elements which includes commodity studies bureau destiny index, USD/Euro forex rate, inflation rate, cash deliver, New York Stock Exchange Index; preferred and Poor 500 index, Treasury invoice and USD index. The have a look at reveals that Commodity Research Bureau destiny index, USD/Euro forex rate, Inflation rate, cash deliver are having a considerable effect on gold price. The have a look at concludes that MLR version appeared to be beneficial for predicting the gold price.

Hammoudeh et al.(2010) indicates that gold impacts the volatility of the USD/Euro alternate fee. The look at concludes that there's an interdependent exist among the volatility of gold fee and the alternate fee. Kuna-Min et al. (2011) investigates the short-run and long-run inflation hedging effectiveness of gold with inside the United States and Japan. The look at unearths that gold go back is not able to hedge towards inflation in both US and Japan in the course of the little momentum structures. Ewing and Malik (2013) locate proof of volatility transmission among gold and oil destiny prices. Massarrat (2013) forecast the gold fee via way of means of the use of the ARIMA version. The effects advise that ARIMA (0, 1, 1) is the maximum appropriate version for predicting the gold fee. Pang, et al. (2013) forecast the gold fees of Malaysia via way of means of the use of ARIMA and GARCH version. The observe concludes that GARCH version is a extra suitable version than ARIMA Model for predicting the gold fees. Rebecca et al. (2014) use ARMA version and 6-step-in advance forecast version for predicting the month-to-month adjusted last fee of gold. The forecasted cost than as compared with original corresponding fees. The observations reveals that real values fell inside theforecast limits. Nicholas (2014) investigates the dynamic dating between gold fees, nominal and actual change price adjustments in Australia via way of means of the use of error correction version. The observations indicates that gold fee may be used to forecasting the Australian dollar/USD change price. The observations concludes that Gold fee statistics can enhance AU Dollar/USD change price forecasting significantly.

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Data and Methodology

The outbreak of Covid 19 pandemic and continuous increase in price of gold in the recent days has created the interest to model the gold prices. The study focuses on forecasting the gold prices during the first week of August, 2020 by using the most popular technique the Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA). The data used for the study consists of 196 observations for a period of 9 months ranging from 1st November, 2019 to 31st July, 2020. The daily gold prices in USD were obtained from the World Gold Council website. Box and Jenkins' (1976) ARIMA model is one of the widely used models for predicting prices in the short run. ARIMA model considers the past and present values of a series to predict its own future values. This model assumes that the future value of series dependent on the past values. In ARIMA (p, d, q) model, p represents the auto regressive process, q represents the moving average and d represents the order of integration based on Box-Jenkins methodology.

Results and Discussions

The daily gold prices obtained for the study is generally a dataset that holds the properties of time series data. Basically time series datasets have random value that is a random walk in the series is shall be found. The gold price dataset has the property of random walk as well as a drift that is trend prevailing which is again a property of the time series data. Time series datasets are mostly non stationary in nature. While using time series data for analysis it becomes crucial to confirm the stationarity in the data to obtain better results. The figure 4 (former) represents the daily gold prices in USD. The graph indicates that the series has a random walk along with an upward trend it. The later graph represents that he series is mean reverting which means the series is stationary after the process of differencing.

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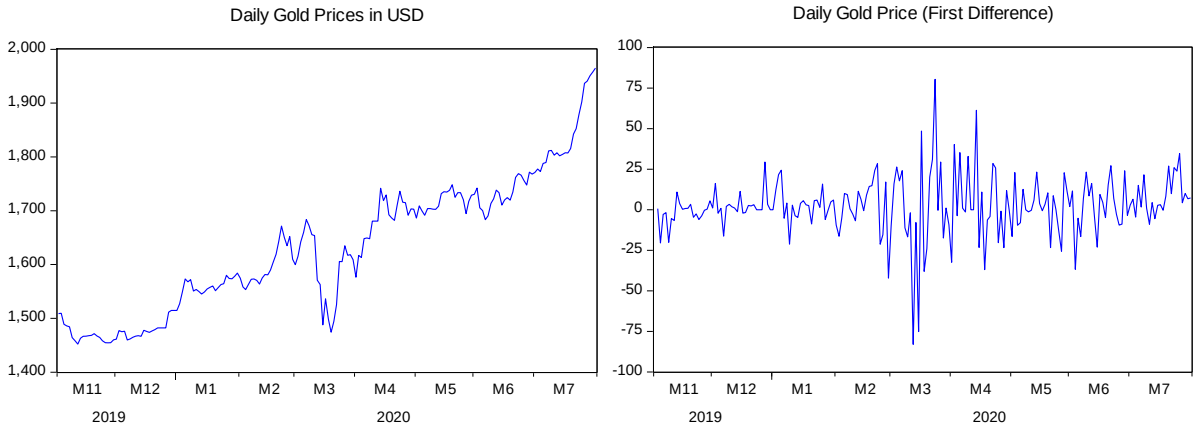
Exhibit 4: Non Stationarity and Stationarity in the dataset



One of the most important assumption of the ARIMA model is, the data must be stationary. The most popular Augmented Dickey-Fuller test has been conducted to test the Stationarity of the data set. The ADF test results are provided in table 2. When ADF test was applied for the daily gold prices, the p value was 0.9867 which is insignificant hence, the null hypothesis that daily gold prices has a unit root, the series is non stationary is accepted. In order to obtain Stationarity the data has been differenced. The ADF test results on the differenced data order of 1 indicates that the data is stationary as the p value is 0 which is significant. The null hypothesis that the differenced data has a unit root is rejected. This also indicates that the order of integration is 1. Hence ARIMA model shall be applied.

Table 2 : Augmented Dickey-Fuller test statistic				
Null Hypothesis: GOLD has a unit root				
1% level	5% level	10% level	t-Statistic	Prob.*
-3.463924	-2.8762	-2.574663	0.510606	0.9867
Null Hypothesis: DGOLD has a unit root				
1% level	5% level	10% level	t-Statistic	Prob.*
-3.46428	-2.876356	-2.574746	-7.890263	0

The Correlogram Test results in exhibit 5 clearly indicates that the ACF spikes slowly decays and one spike in PACF indicates the first lag has greater significance on future value. Autocorrelation exist which indicates the past value may influence the present and the future. The test results on the stationary series provides us a clear indication that few lagged terms have greater significance on the future values. This test is considered to be preliminary step in ARIMA modelling as this indicates the lagged terms that

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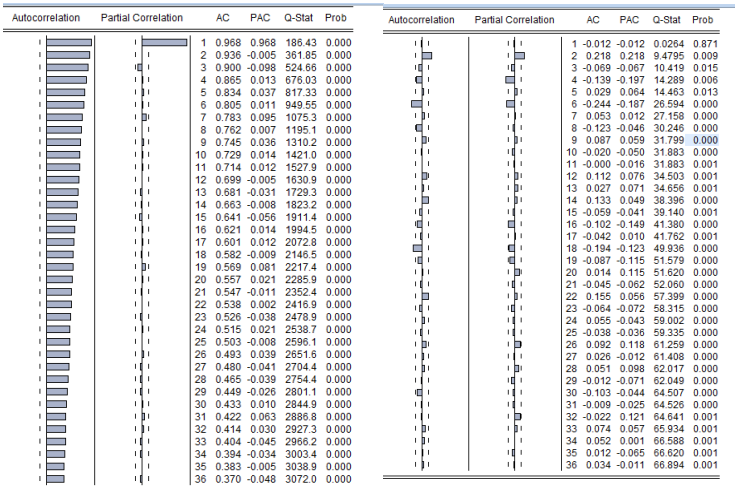
have an influence. According to the exhibit the lags 2 and 6 of ACF 2, 4 and 6 of PACF shall be used for developing the ARIMA model since the spikes at these lags bounces beyond the standard error. . The initial ARIMA model is expected to have few combinations of AR and MA terms.

Exhibit 5: Correlogram Test results for both Non Stationary and Stationary data



Based on the carallogram results the identified AR and MA terms were regressed on the dependent variable the difference gold prices. ARIMA models was tested based on the several combinations, those models with significant AR and MA terms are mentioned in table 3. To identify the best fitted model the parameters such as high adjusted R square, lowest coefficient of variance, AIC and SIC were considered. Based on the parameters the ARIMA model 6, 1, 2 was identified as the best model for father analysis.

Table 3: ARIMA Modelling

ARIMA	AR	MA	Coeff. Var	Adj R Sq	AIC	SIC
2,1,4	0	0.0022	308.3968	0.057586	8.611219	8.678357
2,1,6	0.0007	0.0001	302.9969	0.074087	8.594319	8.661457
4,1,6	0.0176	0	308.7919	0.056378	8.613571	8.68071
6,1,2	0.0001	0	298.3319	0.088343	8.579028	8.646166
6,1,4	0	0.0155	307.3874	0.06067	8.609007	8.676146
6,1,6	0	0.0048	307.1758	0.061317	8.609452	8.67659

Once the best model was identified, the residuals were analysed for the presence of autocorrelation in the error terms. As a result of the residual check the AR term 3 and MA term 4 was found to have

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significant impact. The adjusted ARIMA model was tested and it was found that the adjusted ARIMA model with AR terms 3, 6 and MA terms 2, 4 to be more significant. The adjusted R square was high and the AIC, SIC values were found to be lower when compared to the model 6, 1, 2. Once again the residuals were tested and was found that all lags were significant except the first lag. Again the first lag was introduced in both AR and MA term and it was found the p value of the AR1 and MA1 was insignificant. Hence the model AR (3) AR (6), 1, MA (2) MA (4) was considered to be best model for prediction.

Table 3: Adjusted ARIMA

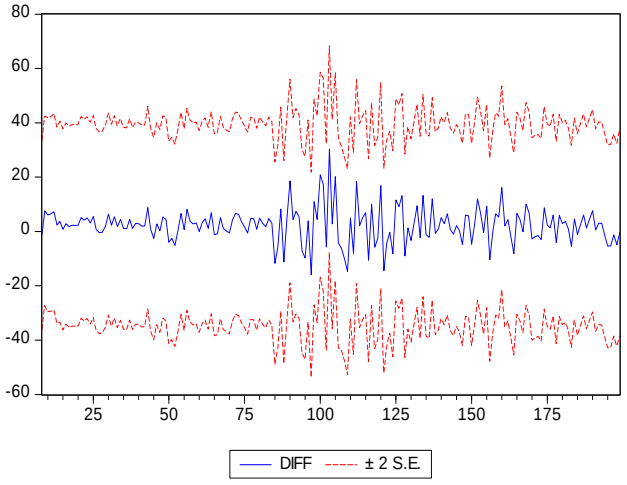
Adj. ARIMA	AR (3)	AR (6)	MA (2)	MA(4)	Coeff. Var	Adj R Sq	AIC	SIC
AR(3) AR(6), 1 , MA(2) MA(4)	0.0472	0	0	0.0236	290.9413	0.101519	8.575143	8.675851

The test for Hetroskedasticity in the residuals was undertaken and the p value 0.0786 which is greater than 0.05 indicates that the null hypothesis is accepted that is there is no Hetroskedasticity in the residues or error terms. The basic assumptions of the ARIMA model that the residuals should not have autocorrelation and hetroskedasticity is met. Hence the ARIMA model AR (3) AR (6), 1, MA (2) MA (4) was taken further for forecasting the future values.

Table 4: Hetroskedasticity Test: ARCH

F-statistic	R-squared	Prob. F(1,192)	Prob. Chi-Square(1)
3.112336	3.0946	0.0793	0.0786

Exhibit 6: Forecasted Error



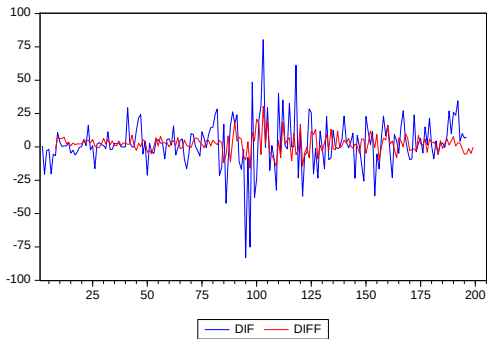
Forecast: DIFF
Actual: DIF
Forecast sample: 1 205
Adjusted sample: 8 199
Included observations: 189

Root Mean Squared Error	17.14962
Mean Absolute Error	12.01415
Mean Abs. Percent Error	181.9008
Theil Inequality Coefficient	0.673928
Bias Proportion	0.000224
Variance Proportion	0.480792
Covariance Proportion	0.518984

Date	Forecasted Difference	Forecasted Value	Actual Value	Error
03-08-2020	-1.292232636	1963.607767	1,958.6	-5.1
04-08-2020	-4.849567941	1958.758199	1,977.9	19.1
05-08-2020	-0.18382142	1958.574378	2,048.2	89.6

The difference in the prices were forecasted initially to ensure that the forecast error lies between the standard error as in exhibit 6. Once it was ensured ten the forecast was made as in exhibit 7.

Exhibit 7: Forecasted prices



Finally using the model the actual prices were for casted by summing up the previous price, difference and the forecasted error. The model was applied for the near future that is the first 3 days in august. There predicted and the actual values were different which indicated the residual.

Conclusion

ARIMA model is widely considered as one of the best tools for predicting the near future. Since the data used for this study is a high frequency data the predictions could not be for a larger time period. Similarly there are other parameters which also play a vital role in influencing the values in such datasets. Though there were few limitation still the empirical results in the study indicates that ARIMA model can be used as a tool to edict the near future.

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References

- Ai, H., Shouyang, W., Shanying, X. (2012), an interval method for studying the relationship between the Australian dollar exchange rate and the gold price. Journal of Systems Science and Complexity, 25(1), 121-132.
- Baur, D.G., McDermott, T.K. (2010), is gold a safe haven? International evidence. Journal of Banking and Finance, 34(8), 1886-1898.
- Baur, D.G., Lucey, B.M. (2010), Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. The Financial Review, 45(2),217-229.
- Corti, C.H., Holliday, R. (2010), Gold Science and Applications. USA: Taylor and Francis Group, LLC.
- Ewing, B.T., Malik, F. (2013), Volatility transmission between gold and oil futures under structural breaks. International Review of Economics and Finance, 25(C), 113-121.
- Hammoudeh, S., Yuan, Y., McAleer, M., Thompson, M. (2010), Precious metals-exchange rate volatility transmission and hedging strategies. International Review of Economics and Finance, 19(4), 698-710.
- Hossein, M., Abdolreza, Y.C. (2015), Modeling gold price via artificial neural network. Journal of Economics, Business and Management, 3(7), 699-703.
- Hossein, H., Emmanuel, S.S., Rangan, G. (2014), Forecasting the Price of Gold. Department of Economics Working Paper Series, University of Pretoria, Working Paper: 2014-28, June.
- Ismail, Z., Yahya, A., Shabri, A. (2009), Forecasting gold prices using multiple linear regression method. American Journal of Applied Sciences, 6(8), 1509-1514.
- Kuan-Min, W., Yuan-Ming, L., Thanh-Binh, N.T. (2011), Time and place where gold acts as an inflation hedge: An application of long-run and short-run threshold model. Economic Modelling, 28(3), 806-819.
- Nicholas, A. (2014), Can gold prices forecast the Australian dollar movements? International Review of Economics and Finance, 29, 75-82.

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