MODELLING AND FORECASTING GOLD PRICESUSING ARIMA

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ABSTRACT

Indian investors consider physical gold as an important asset while an investment 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 tones 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 2020in 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 price in the short run is showing an increasing trend.

KEYWORDS: *Gold Is Widely Considered, Similarly, the Investment, Approximately, Significantly.*

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 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 tons to 117.8 tones and the investment demand was 47.8 tones with a decline of 39%.The demand in Indian market during 2020 (Q2) was 63.7 tones, with a 70% drop, while the jewellery demand was 44 tones, which fell by 74% and the investment demand was 19.8 tones which dropped by 56%. Total gold recycled was 13.8 tones, which again has dropped by 64% from 37.9 tones 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 tones 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 tones since 2010. Similarly the net bullion imports by India amount 800 tones per year on an average. Approximately 65% of India gold consumption is concentrated toward the jewellery demand and the rest is towards investment such as coins and bars while the same is wise versa in all major counties.
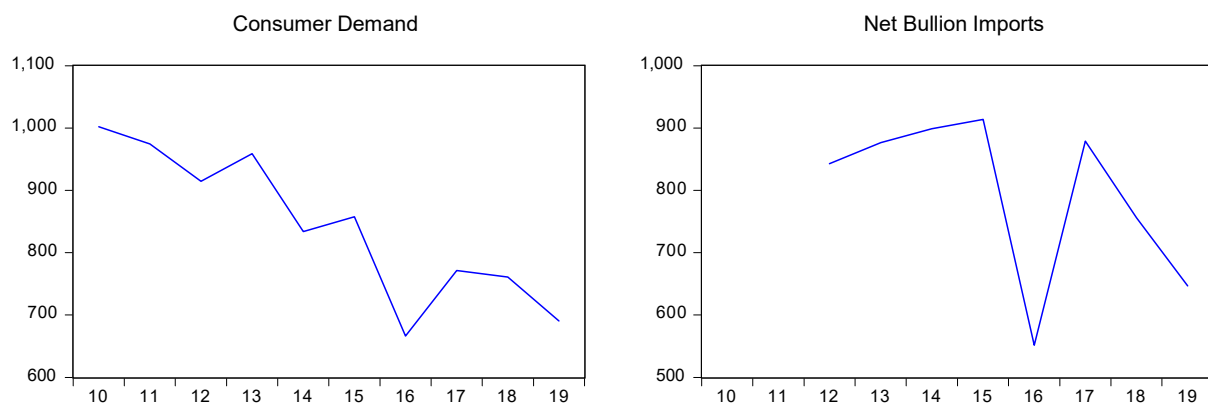
The exhibit1 represents the amount of gold reserves held by several counties. US rank first with a total amount of reserves around 8200 tones followed by Germany and IMF with approximately 2800 tones. India holds total reserves of approximately 700 tones.

Exhibit 1: Gold Reserves Maintained By Several Countries
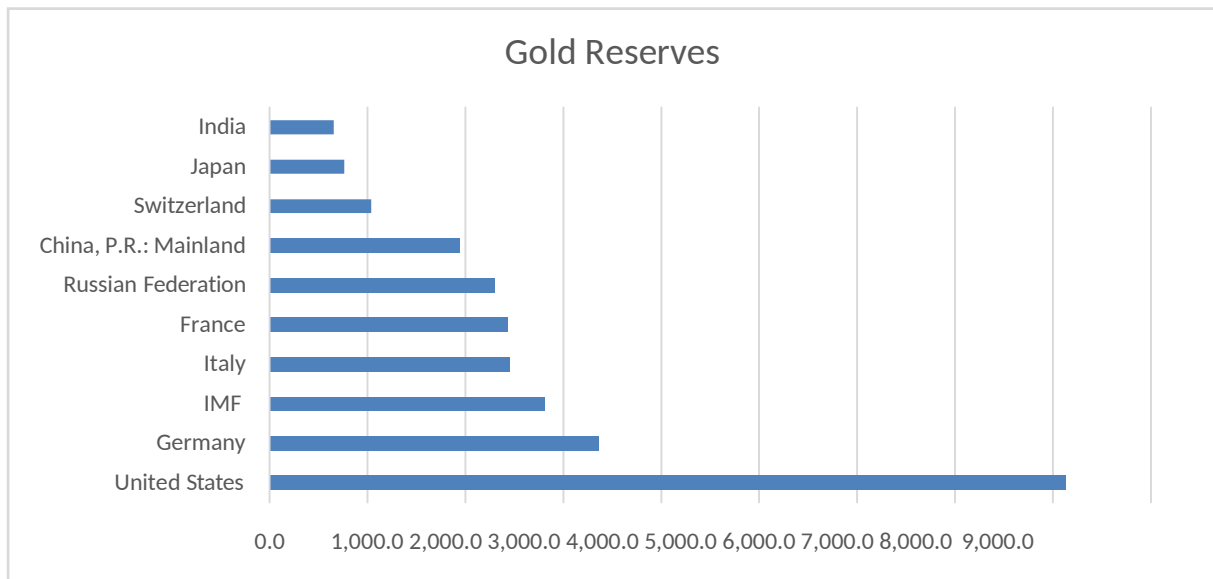
The exhibit2 represents the demand for gold in the Indian market and the amount of gold imports since 2010. The overall consumer demand for gold in India is declining while the net imports had a drastic fall during 2016.

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

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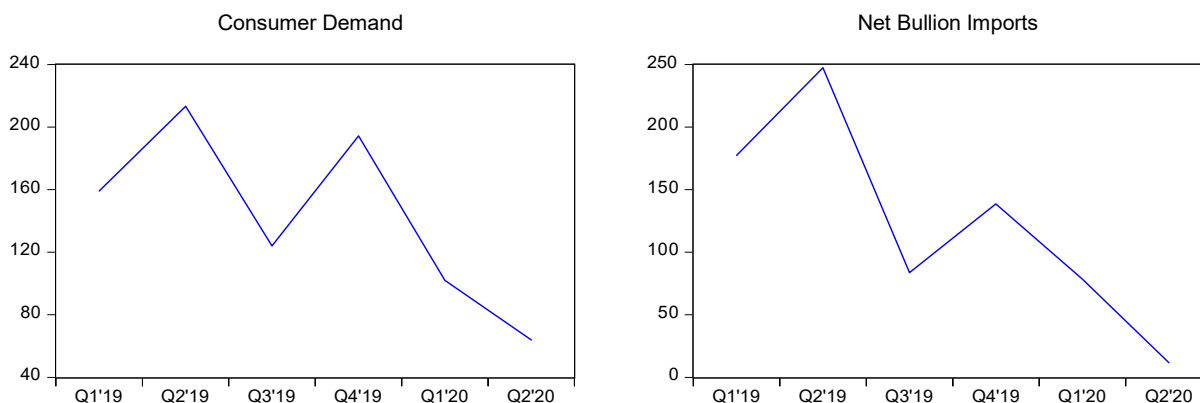
Similarly the net import is also continuing to decline. The slowdown in income expectations restricts the demand for gold in the Indian marketplace. Prices of the yellow metal have crossed Rs 52,000 per 10 grams mark, during August; 2020.The table 1 below represents the highest and lowest prices of gold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

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, 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 destinyindex, USD/Euro forex rate, Inflation rate, cash deliver are havinga 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 goldwithinside 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 thatarima (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 garchversion. The observe concludes that GARCH version is a extra suitable version thanarima Model for predicting the gold fees. Rebecca et al. (2014) use armaversion and 6-step-in advance forecast version for predicting the month-to-month adjustedlast 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.

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 data sets 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.

Exhibit 4: Non Stationarity and Stationarity in The Dataset

Daily Gold Prices in USD

Daily Gold Price (First Difference)
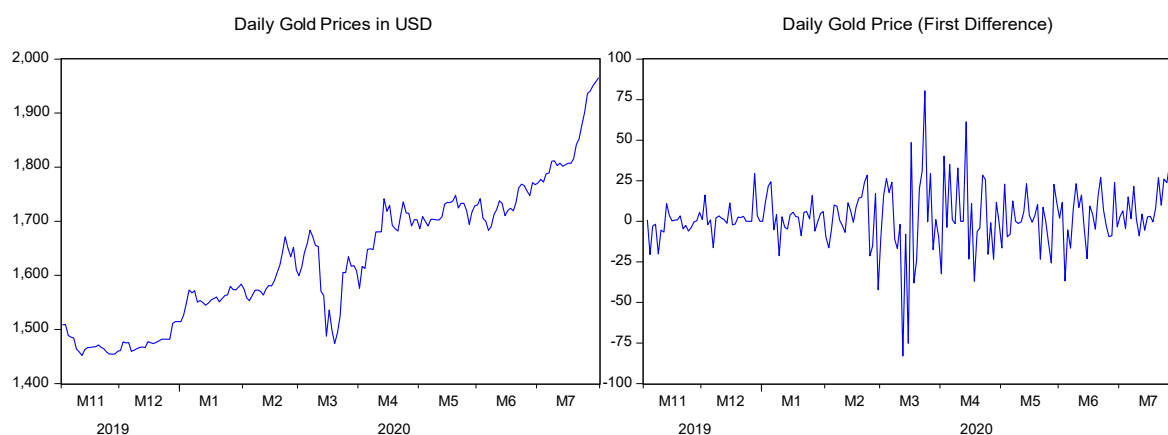
One of the most important assumptions of the arima model is, the data must be stationary. The most popular augmented dickey-fuller test has been conducted to test the stationarity of the data set. The adf test results are provided in table 2. When adf test was applied for the daily gold prices, the p 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 indicate 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 result 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 modeling as this indicates the lagged terms that 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 an

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.968	0.968	186.43	0.000
		2	0.936	-0.005	361.85	0.000
		3	0.900	-0.098	524.66	0.000
		4	0.865	0.013	676.03	0.000
		5	0.834	0.037	817.33	0.000
		6	0.805	0.011	949.55	0.000
		7	0.783	0.095	1075.3	0.000
		8	0.762	0.007	1195.1	0.000
		9	0.745	0.036	1310.2	0.000
		10	0.729	0.014	1421.0	0.000
		11	0.714	0.012	1527.9	0.000
		12	0.699	-0.005	1630.9	0.000
		13	0.681	-0.031	1729.3	0.000
		14	0.663	-0.008	1823.2	0.000
		15	0.641	-0.056	1911.4	0.000
		16	0.621	0.014	1994.5	0.000
		17	0.601	0.012	2072.8	0.000
		18	0.582	-0.009	2146.5	0.000
		19	0.569	0.081	2217.4	0.000
		20	0.557	0.021	2285.9	0.000
		21	0.547	-0.011	2352.4	0.000
		22	0.538	0.002	2416.9	0.000
		23	0.526	-0.038	2478.9	0.000
		24	0.515	0.021	2538.7	0.000
		25	0.503	-0.008	2596.1	0.000
		26	0.493	0.039	2651.6	0.000
		27	0.480	-0.041	2704.4	0.000
		28	0.465	-0.039	2754.4	0.000
		29	0.449	-0.026	2801.1	0.000
		30	0.433	0.010	2844.9	0.000
		31	0.422	0.063	2886.8	0.000
		32	0.414	0.030	2927.3	0.000
		33	0.404	-0.045	2966.2	0.000
		34	0.394	-0.034	3003.4	0.000
		35	0.383	-0.005	3038.9	0.000
		36	0.370	-0.048	3072.0	0.000

D Stationary data

		AC	PAC	Q-Stat	Prob
Autocorrelation	Partial Correlation				
1		-0.012	-0.012	0.0264	0.871
2		0.218	0.218	9.4795	0.009
3		-0.069	-0.067	10.419	0.015
4		-0.139	-0.197	14.289	0.006
5		0.029	0.064	14.463	0.013
6		-0.244	-0.187	26.594	0.000
7		0.053	0.012	27.158	0.000
8		-0.123	-0.046	30.246	0.000
9		0.087	0.059	31.799	0.000
10		-0.020	-0.050	31.883	0.000
11		-0.000	-0.016	31.883	0.001
12		0.112	0.076	34.503	0.001
13		0.027	0.071	34.656	0.001
14		0.133	0.049	38.396	0.000
15		-0.059	-0.041	39.140	0.001
16		-0.102	-0.149	41.380	0.000
17		-0.042	0.010	41.762	0.001
18		-0.194	-0.123	49.936	0.000
19		-0.087	-0.115	51.579	0.000
20		0.014	0.115	51.620	0.000
21		-0.045	-0.062	52.060	0.000
22		0.155	0.056	57.399	0.000
23		-0.064	-0.072	58.315	0.000
24		0.055	-0.043	59.002	0.000
25		-0.038	-0.036	59.335	0.000
26		0.092	0.118	61.259	0.000
27		0.026	-0.012	61.408	0.000
28		0.051	0.098	62.017	0.000
29		-0.012	-0.071	62.049	0.000
30		-0.103	-0.044	64.507	0.000
31		-0.009	-0.025	64.526	0.000
32		-0.022	0.121	64.641	0.001
33		0.074	0.057	65.934	0.001
34		0.052	0.001	66.588	0.001
35		0.012	-0.065	66.620	0.001
36		0.034	-0.011	66.894	0.001

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 analyzed 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 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
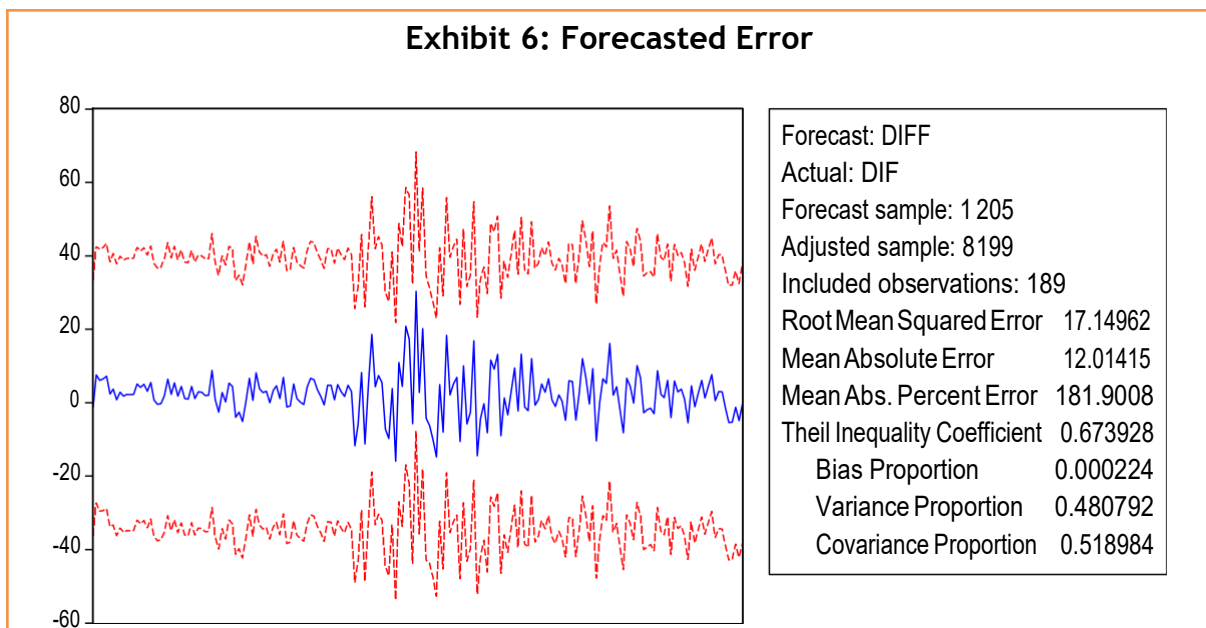
lower when compared to the model 6, 1, 2. Once again the residual were tested and was found that all lags were significant except the first lag. Again the first lag was introduced in both AR and MA term and it was found the p value of the AR1 and MA1 was insignificant. Hence the model AR (3) AR(6), 1, MA(2) MA(4) was considered to be best model for prediction.

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

Table 3: Adjusted Arima

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

Exhibit 7: Forecasted prices

Table 5: FORECASTED GOLD PRICES

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

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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