Forecasting Monthly Gold Prices using ARIMA Model: Evidence from Indian Gold Market

Rakesh Kumar Sharma, Anupam Sharma

Abstract*: In this paper an attempt has been made to give an overview of the Indian gold market so as to develop a model enabling the forecast of gold prices in India. One troy ounce is equal to 31.103 grams. The monthly sample data of gold price (in INR per troy ounce) is taken from December 1997 to December 2017.The entire data has been divided into two segments for estimation and validation sample and to find out the efficiency and accuracy of forecasting models. Since the gold price data series have shown much deviation after March 2006 the first segment of the data is taken from the time period of December 1997 to March 2006 and second segment from April 2006 to December 2017.Due to a larger value and a huge time span of the sample data, the natural logarithm of gold price has been taken to conduct the study and build an effective model to forecast future gold prices. The unit root tests of Augmented Dickey Fuller‖ and Philips Perron have been used to test the gold price series as stationary or non-stationary. It is observed that series are stationary at first difference in both the methods. At first difference the ACFs and PACFs were pattern less and statistically not significant. Box-Jenkins's Autoregressive Integrated Moving Average of Box-Jenkins methodology has been used for developing a forecasting model of gold price in India. Different models of ARIMA have been used to obtain best suitable model for forecasting using Eviews software 10 for both time periods i.e., December 1997 to March 2006 & April 2006 to December 2017

***Keywords* : AIC- Akaike Information Criteria, SIC- Schwarz Information criteria, Correglram**

I. INTRODUCTION

There are a number of investment alternatives or avenues which may be categorized according to the risk level associated with these alternatives viz., safe/low risk investment avenues, moderate risk investment & high risk Investment avenues. An investor may select one or a combination of the best investment options which appeals to him or her. The selection of the investment options also depends on the age, income, dependents, etc of a particular person. Investment in gold or silver may be classified under the traditional investment avenues. Gold is considered as one of the hard commodities, but it can also be considered as a currency. All the currencies of various countries are backed by gold including India. In India, if any person has a specific amount of Indian currency and is not interested in possessing the Indian rupee i.e. the currency, he can return the Indian Rupees (INR) to the Reserve Bank of India (RBI) and can get equivalent value gold. Hence gold can be perceived as a substitute of INR in India. In Indian economy a major portion of the gold asset is hidden and is not in circulation or available for buying or selling for investment purposes. The main cause of this high volume of gold being concealed is that it is kept in the form of jewelry and ornaments. Indian women are highly inclined to wear ornaments and jewelry of precious metals such as gold or platinum. Since Platinum is much costlier than gold, women prefer to wear ornaments of gold rather than platinum. India is an emerging economy where gross domestic product as well as per capita income is increasing. A large section of the society in the country belongs to the middle income group. These people are fond of putting their money in hard commodities such as gold. Actually they do not invest in gold in an organized and formal manner but prefer to invest ornaments or jewelry. Assuming that the prices of gold are sure to rise in the future they consider purchase of gold as a safer avenue of investment.

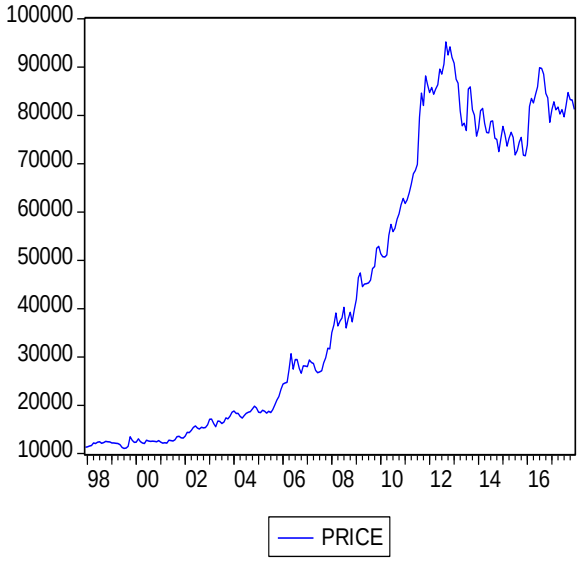

Figure 1: Gold Price Indian Rupee per Troy Ounce

Source : Author's calculation

Table 1: Gold Price Indian Rupee per Troy Ounce
Month Price Change (%)

Month	Price	Change (%)
Dec-97	11,324.79	
Dec-98	12,412.18	9.60
Dec-99	12,309.24	-0.83
Dec-00	12,690.44	3.10
Dec-01	13,217.92	4.16
Dec-02	15,977.80	20.88

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RakeshKumar Sharma,
Thapar University
Anupam Sharma,
Thapar University

Dec-03	18,553.24	16.12
Dec-04	19,442.87	4.80
Dec-05	23,290.20	19.79
Dec-06	28,110.36	20.70
Dec-07	31,678.21	12.69
Dec-08	39,696.17	25.31
Dec-09	52,911.99	33.29
Dec-10	62,809.68	18.71
Dec-11	86,328.88	37.45
Dec-12	92,015.30	6.59
Dec-13	75,670.14	-17.76
Dec-14	75,291.99	-0.50
Dec-15	71,639.46	-4.85
Dec-16	78,583.48	9.69
Oct-17	83,278.23	5.97

Source : www.indexmundi.com

Table 1 and figure 1 show the past trends of gold prices (per troy ounce) in India. It is evident that during the past 20 years gold price per troy has was lowest in the year 1997 has shown an increasing trend in the subsequent years. After 2006, however there is a considerable change in gold prices and a discernable hike in the gold price after this period is observed. The prices reached their highest level at the end of 2012, after which these gold prices declined and later showed volatility. During November 2015 again it reached the lowest level of Rs. 71,639.46 followed by a period of escalation again wherein the gold prices increased but remained volatile.

II. REVIEW OF LITERATURE

According to Batchelor and Gulley (1995) gold is one of the renewable assets, since there is no squalor in its quality but there may be an appreciation in the value of this commodity with the passage of time. This commodity could possibly be recycled and contribute to a decrease in the global demand for newly mined gold. In other words, gold reserves with the federal banks or the central banks of the country and jewelry can enter into the supply side equation in the gold market.

Earlier studies have shown that the volatility in gold prices have different effects on gold extraction and the value of gold mining stocks which vary from country to country and mine to mine (Blose, 1996; Blose and Shieh, 1995; Craig and Rimstidt, 1998; Doggett and Zhang, 2007; Govett and Govett, 1982; Rockerbie, 1999; Selvanathan and Selvanathan, 1999).

III. AUTOREGRESSIVE INTEGRATED MOVING AVERAGE MODEL

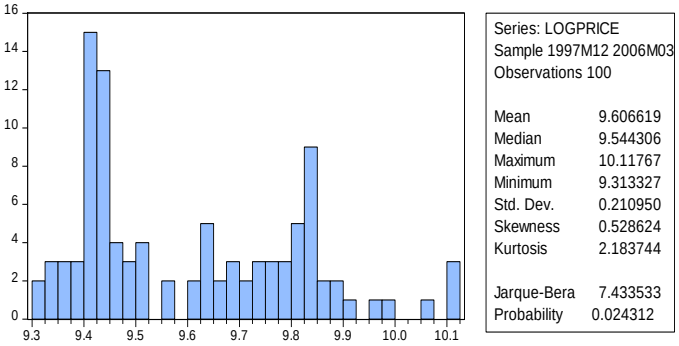
The Box-Jenkins ARIMA is onez of the most sophisticated techniques of time series forecasting. It is so common is econometrics that the terminology —time series analysis referred to the Box Jenkins approach to modelling time series. (Kennedy, 2008).

The general Box-Jenkins (ARIMA) model for y is written as:

$$y^* = \emptyset y_{t-1} + \emptyset y_{t-2} + \ldots + \emptyset y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q}$$

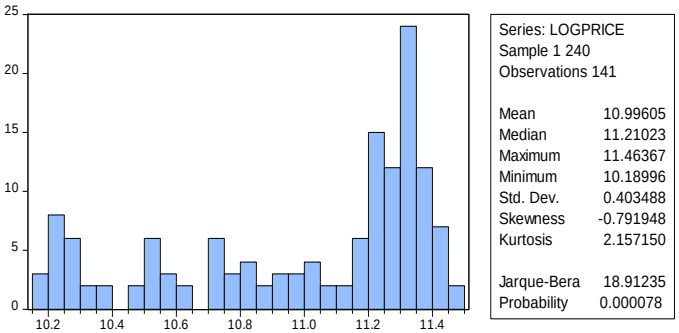
ARIMA(p,d,q): ARIMA models are, in theory, the most universal class of models for forecasting a time series which can be stationarized by transformations such as differencing and logging. In fact, the easiest way to think of ARIMA models is as fine-tuned versions of random-walk and random-trend models: the fine-tuning consists of adding lags of the differenced series and/or lags of the forecast errors to the prediction equation, as needed to remove any last traces of autocorrelation from the forecast errors.

Figure 2-Descriptive Statistics December 1997 to March 2006



Source: Authors calculation with Eviews10

Figure 3-Descriptive Statistics April 2006 to December 2017



Source: Authors calculation with Eviews10

Figure 2 and figure 3 show descriptive statistics of gold price (logarithm value) data series between the time period of *December 1997 to March 2006 and April 2006 to December 2017* respectively. *During the first period, average price remained 9.606619 (log value) per troy ounce* with standard deviation of 0.210950 which shows the low volatility in the gold prices in the Indian gold market. During this period its log value of gold price varied from 11.46367 high to a 9.313327 low. During the second time period, the average log value of gold price was 10.19605 with maximum value of 11.46367 and minimum 10.18996 respectively. Standard deviation was lowest to 0.403488 which again shows the less volatility in the second period. According to Malhotra & Dash (2009) to test the assumption of normal distribution, Skewness should

be within the range ±1 & Kurtosis value should be within range ±3. Some people use ±2 range of Kurtosis. In the present study both the values (Skewness & Kurtosis) meet the necessary conditions of normality.

IV. UNIT ROOT TEST:

Augmented (Dickey & Fuller, 1979) and (Philips & Perron, 1988) tests have been used to check unit root of data series and by setting up the following hypothesis:
H0 : ρ= 1 (Non stationary)
H1 : ρ ≠ 0 (Stationary)

Initially, both the tests are used to check gold price series is stationary for the first segment of study period i.e., December 1997 to March 2006. Later, again these two tests are used to know that gold price series is stationary at first level or first difference for second segment of study period.

Table 2: Augmented Dickey-Fuller Test (at Level)-1997 to 2006

Null Hypothesis: LOGPRICE has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			0.637964	0.9901
Test critical values:	1% level		-3.497727	
	5% level		-2.890926	
	10% level		-2.582514	
*MacKinnon (1996) one-sided p-values.				

Source: Authors calculation with Eviews10

Table 3: Augmented Dickey-Fuller Test (at 1st Difference) 1997-2006

Null Hypothesis: D(LOGPRICE) has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on SIC, maxlag=12)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.288779	0.0000
Test critical values:	1% level		-3.499167	
	5% level		-2.891550	
	10% level		-2.582846	
*MacKinnon (1996) one-sided p-values.				

Source: Authors calculation with Eviews10

Table 2 portrays Augmented Dickey Fuller Test for the time period of 1998 to 2006; the statistic value for direct values is 0.637964 so we cannot reject H0 at 5% level of significance. The gold price series (level) is non stationary. However Table 3 shows ADF unit root test statistic for first differential gold price data has significant value of test statistic, which is -8.288779, so we reject H0 and it shows that series is stationary at first difference. So as is evident from the Augmented Dickey-Fuller Test at level we can say that the gold price in India is non-stationary. However, Gold prices are stationary at first difference. At first difference the R square and adjusted R are also higher i.e., 0.484285 and 0.473312 respectively. The Durbin Watson ratio is exactly two and F statistics is highly significant, which further validates the condition that the gold price series is stationary at first difference.

V. THE MODEL-I EQUATION (DECEMBER 1997 TO MARCH 2006)

After model identification as per the criteria cited above the following model equation can be developed. Gold price at first difference will be taken as dependent variable which will be predicted using coefficient of a significant independent variable AR(1). Error terms of MA(1) to MA (3) are insignificant which will also be used for forecasting future gold prices (per troy ounce) in terms of Indian currency.

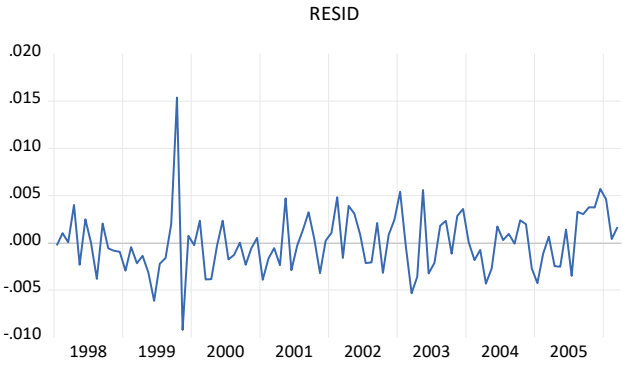
$$\hat{y} = + AR(n) + \beta MA(n) + e \quad \ldots\ldots\ldots\ldots (1)$$

The best suitable as per the different iteration is ARIMA (1,3) (0,0) or (1,1,3). Following is the equation of this model:

$$\Delta Y_t = \phi + \phi_1 Y_{t-1} + \theta_{1et-1} + \theta_{2et-2} + \theta_{3et-3} + e_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\Delta Y_t = 0.00787 + (-0.7509)(Y_{t-1}) + 0.91254(_{et-1}) + (-0.0774)(_{et-2}) + (-0.2984)(_{et-3}) + 0.000938 \quad \ldots\ldots\ldots (3)$$

Figure 9: The Model-I gold price series residual (December 1997 to March 2006)



VI. SOURCE: AUTHORS CALCULATION WITH EVIEWS10

Box Jenkins ARIMA (1, 1, 3) model, residuals are also plotted against for the predictor variable to check the presence of nonlinearities or heteroskedasticity (Figure 9). I examined this plot for nonlinearities or other signs of nonrandom behavior.

After developing the model equation, It is essential to check the model is appropriate. We apply the Box-Ljung test to the residuals from the ARIMA (1,1,3) model fit to determine whether residuals are random. In the present model (1, 1, 3), the Box-Ljung test shows that the first 36 lag autocorrelations among the residuals are 0.06 (p-value = 0.998), indicating that the residuals are random and that the model provides an adequate fit to the data. As with standard non-linear least squares fitting, the primary tool for model diagnostic checking is residual analysis. The line diagram is a convenient graphical technique for model validation in that it tests the assumptions for the residuals on a single graph. The

run sequence plot shows that the residuals do not violate the assumption of constant location and scale. It also shows that most of the residuals are in the range (-0.005 to 0.005) indicating that the residuals are random and that the model provides an adequate fit to the data.

VII. CONCLUSION

Gold one of the hardest commodities, emerges as a substitute to currency in many countries, including India, where their currencies are backed by gold. In India, it means if any person has a specific amount of Indian currency and if that person is not interested in the Indian rupee then he can return Indian Rupees (INR) to the Reserve Bank of India and exchange it for an equivalent value gold, making the metal a potent substitute of INR in India. Moreover, the only reason why gold is perceived as the best form of investment in India is country's highest consumer market for the precious metal in the world. Most of the people in India buy physical gold. Out of all precious metals, gold is one of the most popular investment alternatives. Most of investors use this investment alternative to diversify their portfolio and to minimize risk. The gold market is subject to speculation as are other markets, especially through the use of future contracts and derivatives. In the present paper I have tried to forecast the gold price per troy ounce with the help autoregressive integrated moving average method. In order to a develop good fit ARIMA model to forecast gold prices, the monthly sample data of gold price (in INR per troy ounce) was taken from October 1997 to October 2017. As stated earlier that entire data is broken into parts so as to find out the efficiency and accuracy of forecasting models. The unit root tests of the Augmented Dickey Fuller and Philips Perron have been used to test the gold price series are stationary or non stationary. It is observed that the series for both the time periods are stationary at the first difference.Box-Jenkins's Autoregressive Integrated Moving Average of Box-Jenkins methodology had been used for developing a forecasting model of gold price in India. An attempt has been made to have different models to obtain the best suitable model for forecasting. E-views software is used for fitting the coefficient of the model, using graphs, statistics, ACFs and PACFs of residuals andafter several iterations, the model selected ARIMA model is (1,1,3) used to forecast the gold prices post March 2006. By taking the post March 2006 gold price a second model is developed to forecast the gold prices after December 2017. Just like the first model, a base of minimum Akike Information Criteria (AIC) is used to develop model 2. Results state that ARIMA (0, 1,1) is most suitable to predict the gold prices in India. There is not much deviation between actual and predicted gold price using ARIMA model and percentage variation is also less than 2 percent which further authenticates the appropriateness and the goodness of the current model.

Model developed to predict future gold prices may be lucrative to all such parties who are keenly interested in investing in gold. By using the coefficient of all significant variables, investors may be able to foresee the future prices which may prevail in the Indian gold market (per troy ounce). Consequently, this may further assist them to design the best possible strategy to take a necessary action in the future and to optimize the returns. Forecasted prices may be utilized for calculating future spot prices and hedging future risks.

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