

## **Forecasting of Indian Gold Prices using Box Jenkins Methodology**

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### **Introduction**

Gold are one of the precious metal in the world and a part of by and large all types of civilization. Mankind has always been fascinated by Gold since ancient times. Gold has more concerns due to its value and impact on the economy. In the late 20th century Gold standards have been the most widespread source for monetary policies, which is displaced by paper currency now. Since 2009, the total quantity of Gold mine in human history is about 165,000 tons which is approximately equal to 5.3 billion troy ounces. The world Gold consumption in percentage volume is about 50% in jewelry, 40% in investments, and 10% in industry.

Since ancient times, Gold is one of the most valuable and expensive metal. Worldwide, Gold is a monetary system in which its value is being used as currency and economic standards of accounts in many international markets. Gold has been commonly used as a medium for monetary exchange throughout the world, In past it was valued with the use of Gold coins and was also recognized with bare metal quantities, whereas now it is found as Gold-convertible paper instruments after the establishment of Gold standards in which the overall worth of paper money is embodied in a store of Gold reserves.

Besides its extensive monetary and emblematic roles, Gold has been used practically in dentistry, electronics, and other fields. It is highly flexible, ductile, resistant to oxidization and chemical reactions, being a good *conductor of electricity* it is now used in electric wiring, colored-glass production and even Gold leaf eating. Because of Gold's distinguishing properties, it has numerous industrial uses, like applied in photography, coloring, and is currently for cancer treatments.

Hence, on the whole function of Gold in the global financial system today is yet more imperative than before, because of an emergent hazard to the rulers of a paper empire. In view of the fact that Gold market is an imperative fragment of global financial system (Sharma & Baby, 2015), its value determination for future is very important. The process has been done with econometric modeling of gold prices.

Historical figure showed that India possesses the prominent position among largest consumers of Gold in the world. The fluctuations in gold prices affect the in the economy in India. Thus, it is crucial to predict Indian gold prices which the core objective of this study.

## **Literature Review**

Gold prediction was initially done using regression analysis by different researchers all around the globe (Deepika, Nambiar, & Rajkumar, 2012; Ismail, Yahaya, & Shabri, 2009; Khashei, Hejazi, & Bijari, 2008; Zhang, Ma, & Wang, 2011). Box and Jenkins (1970) was the first, who introduced Autoregressive Moving Average Model

The ARIMA models have dual advantages. Firstly, ARIMA models are a distinct class of linear models which are proposed for linear time series and confined with linear features in time series. Secondly, ARIMA models has ideal hypothetical basis. That is why, ARIMA models are extensively used in many practical applications. But, the shortcoming of the ARIMA is that it is unable to capture nonlinear patterns of complex time series if nonlinearity exists (Shouyang, Lean, & Lai, 2005).The seasonally adjusted French monetary aggregates were analyzed and forecasted by a multiple time series. The forecasting performance of the multiple models is compared to that of univariate random walk ARIMA models(Machak, Spivey, & Wroblewski, 1987).Later (Abdullah, 2012; Banerjee, 2014; Deepika et al., 2012; Nielsen, 2005; L. Xu & Luo) have used ARIMA in forecasting time series .

ARCH and GARCH methodology was later explored by Tully & Lucey, (2007) in forecasting gold market to scrutinize both cash and futures prices and significant economic variables ,the study was based on the test of asymmetric power GARCH model (APGARCH) of Ding, Granger, & Engle, (1993) which is one of the its extension .

Parisi, Parisi, & Díaz, (2008)studied the dynamic networks predictive capacity with alternative conventional methods like ARIMA models to forecasts time series data and implies that the use of rolling recursive neural models could enhance the predictive power of the Gold prices movements. This would make it possible to a significant rise in return and decrease the risk related with the transactions of this metal. Than later neural networks were used by Khashei et al., (2008; Kılıç, (2013, 2015); Mombeini & Yazdani-Chamzini, (2015) .But Kılıç, (2015) had modeled first-order Markov chains of daily average gold prices along with Artificial neural networks and then predicted the trend estimated values. The predicted models give important information on the direction of the next day's bring-in. Liuyong and Zhengtao (2004) employed the historical data of the United States, and recognized the model affecting Gold price, for this purpose stock prices, inflation rate, exchange rate, interest rate were incorporated as the major factors affecting Gold price.

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Since the start of 21<sup>st</sup> century a lot of work has been done on forecasting Gold prices with the use of different modelling procedures which has prominent implications on different economies Abdullah, (2012); Askari & Askari, (2011); Baur & McDermott, (2010); Davis, Dedu, & Bonye, (2014); Deepika et al., (2012); Hadavandi, Ghanbari, & Abbasian-Naghneh, (2010); Ismail et al., (2009); Khan, (2013); Kılıç, (2015); Lineesh, Minu, & John, (2010); Liuyong & Zhengtao, (2004); Miswan, Ping, & Ahmad, (2013); Mombeini & Yazdani-Chamzini, (2015); Parisi et al., 2008; Pierdzioch, Risse, & Rohloff, (2014); Shafiee & Topal, (2010); Tharmmaphornphilas, Lohasiriwat, & Vannasetta, (2012); Tully & Lucey, (2007); G. Xu, 2011; Yazdani-Chamzini, Yakhchali, Volungevičienė, & Zavadskas, (2012); Zhang et al., 2011; Zhou, Lai, & Yen, (2012)

### **Data & Methodology**

This study is based on secondary data collected from World Gold Council of gold prices (in US per ounce, (London Gold Price Fixing) monthly frequency ranging from January 1979 to February 2017 which is a total of 459 data points.

The aim of this study is to predict Indian Gold prices using ARIMA model. For instance, we have the stationary series after differencing at first level. Now, the model that we are looking at is ARIMA (p, 1, q). We have to identify the model, estimate suitable parameters, diagnostic checking for residuals and finally achieve our objective of forecasting the future Gold prices.

### **Stationary Test**

First of all the collected data was tested for stationarity which is an initial step of suitability for time series analysis. To understand the nature of data, Durbin-Watson Test was carried out. Durbin and Watson (1951) developed this test to detect the presence of serial correlation for an appropriate for regression analysis. Suitable time lag and serial correlation between the values with are simultaneously important for modeling. The line graph of gold price data from January 1979 to February 2017 (London Gold Price Fixing) is showing an upward trend in Figure 1. Then the correlogram of gold price is shown in Table 1 and the mutual results are showing a random walk behavior. Table 2 shows a correlogram at first difference.

Figure.1. Line graph of Gold prices in INR

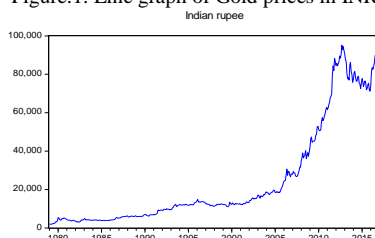
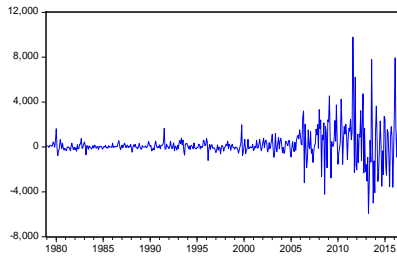


Figure 2. Line Graph of Gold Prices at First Difference  
DINR



### Unit Root Test

This unit root test has become widely used in time series analysis to check the stationarity of a variable using an autoregressive model. Unit root at level was tested which showed a non-stationary trend in series, thus data was tested at first difference which results in stationary series shown in table 1.

Table 1

*ADF Test for First Difference of Gold Prices*

Null Hypothesis: D(INDIAN_RUPEE) has a unit root		
Exogenous: Constant		
Lag Length: 0 (Automatic - based on SIC, maxlag=17)		
	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-18.80431	0.0000
Test critical values:		
1% level	-3.444467	
5% level	-2.867658	
10% level	-2.570092	

\*MacKinnon (1996) one-sided p-values.

Source: Econometrics results have been extracted from E-views 9.

The ADF test for first order difference from original Gold prices series is shown in Table 1. The zero in p-value indicates the ADF-statistic is significant. Thus, we reject the null hypothesis that states that the first order difference for daily Gold prices series is stationary.

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Figure 4. Correlogram at Level

Figure 5. Correlogram at first difference

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.993	0.993	454.40	0.000			
2	0.986	-0.011	903.14	0.000			
3	0.979	0.042	1346.8	0.000			
4	0.971	-0.073	1784.6	0.000			
5	0.964	-0.10	2216.3	0.000			
6	0.955	-0.079	2641.2	0.000			
7	0.946	-0.034	3068.9	0.000			
8	0.936	0.001	3499.4	0.000			
9	0.926	0.070	3973.8	0.000			
10	0.920	-0.001	4272.0	0.000			
11	0.912	0.021	4664.2	0.000			
12	0.904	-0.044	5050.0	0.000			
13	0.895	-0.004	5429.5	0.000			
14	0.888	0.077	5803.9	0.000			
15	0.881	0.010	6173.3	0.000			
16	0.874	-0.020	6537.6	0.000			
17	0.866	-0.061	6896.0	0.000			
18	0.859	0.015	7249.0	0.000			
19	0.851	0.004	7596.7	0.000			
20	0.844	0.007	7939.4	0.000			
21	0.836	-0.031	8276.7	0.000			
22	0.828	-0.12	8608.4	0.000			
23	0.821	0.011	8934.7	0.000			
24	0.813	0.008	9255.7	0.000			
25	0.805	-0.083	9570.8	0.000			
26	0.796	-0.030	9879.7	0.000			
27	0.787	0.038	10183.	0.000			
28	0.780	0.047	10481.	0.000			
29	0.772	-0.021	10773.	0.000			
30	0.763	-0.025	11060.	0.000			
31	0.754	-0.083	11340.	0.000			
32	0.745	-0.002	11614.	0.000			
33	0.736	0.014	11893.	0.000			
34	0.727	-0.005	12145.	0.000			
35	0.717	-0.025	12401.	0.000			
36	0.707	-0.042	12651.	0.000			

Autocorrelation		Partial Correlation		AC	PAC	Q-Stat	Prob
1	0.123	0.123	6.9693	0.008			
2	-0.060	-0.076	8.6346	0.013			
3	0.004	0.022	8.6421	0.034			
4	-0.026	-0.034	8.9472	0.062			
5	0.089	0.101	12.656	0.027			
6	0.092	0.064	16.611	0.011			
7	-0.080	-0.090	19.826	0.006			
8	-0.106	-0.080	24.854	0.002			
9	0.108	0.130	30.307	0.000			
10	0.024	-0.019	30.585	0.001			
11	0.113	0.116	36.554	0.000			
12	0.130	0.103	44.553	0.000			
13	-0.019	0.000	44.731	0.000			
14	0.067	0.075	46.872	0.000			
15	0.060	0.012	48.593	0.000			
16	0.034	0.034	49.125	0.000			
17	-0.049	-0.073	50.263	0.000			
18	-0.000	0.011	50.263	0.000			
19	-0.034	-0.014	50.813	0.000			
20	-0.082	-0.101	54.030	0.000			
21	0.055	0.047	55.508	0.000			
22	-0.024	-0.035	55.776	0.000			
23	0.014	0.006	55.876	0.000			
24	0.163	0.149	68.676	0.000			
25	0.019	-0.034	68.858	0.000			
26	-0.048	-0.039	69.961	0.000			
27	-0.021	-0.049	70.184	0.000			
28	-0.102	-0.110	75.307	0.000			
29	0.026	0.069	75.628	0.000			
30	0.160	0.105	88.150	0.000			
31	0.012	0.060	88.221	0.000			
32	-0.028	0.032	88.602	0.000			
33	-0.015	-0.043	88.709	0.000			
34	-0.036	-0.013	89.366	0.000			
35	0.071	-0.000	91.849	0.000			
36	-0.083	-0.182	95.259	0.000			

Source: Econometrics results have been extracted from E-views 9

In Figure 4 and 5, autocorrelation and partial autocorrelation charts at level and at first difference are generated.. The ACF dies out after lag and PACF dies out slowly after lag 1. Thus, the data becomes stationary at first difference as shown in figure 5.

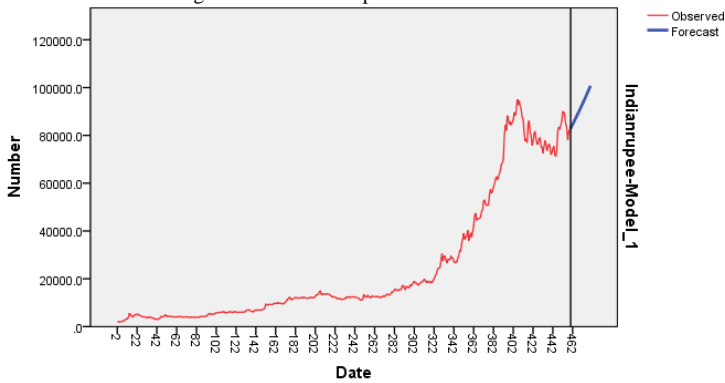
In the above table 2, different models are taken to estimate the best fit model, for this it is considered that the value of R-squared, Adjusted R-squared ,F-statistic, Log likelihood must be maximum and remaining values of Akaike info criterion, Schwarz criterion and Hannan-Quinn must be minimum whereas the value of Durbin-Watson stat corresponding to 2 . While analyzing the above table it is noticed that the parameters of ARIMA (1, 1, 2) fulfill the criteria.

Table 2

*Summary of Estimated ARIMA Models*

Fit Statistics	1,1,0	0,1,1	1,1,2	1,1,1
R-squared	0.015180	0.017642	0.011347	<b>0.021740</b>
Adjusted R-squared	0.010842	0.013314	0.006992	<b>0.015261</b>
F-statistic	5.491018	4.076601	3.917747	<b>3.355653</b>
Log likelihood	-3959.750	-3958.231	-3960.657	<b>-3958.231</b>
Akaike info criterion	17.34245	17.34996	17.34642	<b>17.34018</b>
Schwarz criterion	17.37953	17.37794	17.37850	<b>17.37628</b>
Hannan-Quinn criter.	17.36312	17.36063	17.35708	<b>17.35440</b>
Durbin-Watson stat	1.979710	2.017046	1.971996	<b>2.000531</b>

Source: Econometrics results have been extracted from E-views 9.  
Figure 4. Forecast Graph of selected Model



Source: Econometrics results have been extracted from SPSS21

*Table 2  
Forecasted Monthly Gold Price*

Time Period	Predicted Prices	Upper class Limit	Lower Class Limit	Class
31-Mar-2017	82861.5	75775.1	90427.6	
29-Apr-2017	83940.9	72908.0	96165.0	
31-May-2017	84644.0	71118.1	99988.2	
30-Jun-2017	85510.0	69746.8	103770.0	
29-Jul-2017	86321.4	68633.5	107180.2	
31-Aug-2017	87166.0	67705.3	110491.3	
30-Sep-2017	88008.6	66908.8	113676.3	
31-Oct-2017	88863.6	66217.0	116795.0	
30-Nov-2017	89725.1	65608.1	119856.5	
30-Dec-2017	90595.7	65068.0	122880.7	
31-Mar-2018	91474.4	64585.4	125876.8	
29-Apr-2018	92361.8	64152.2	128854.4	
31-May-2018	93257.7	63761.5	131820.1	
30-Jun-2018	94162.4	63408.3	134779.7	
29-Jul-2018	95075.8	63088.1	137737.7	
31-Aug-2018	95998.1	62797.3	140698.2	
30-Sep-2018	96929.3	62533.1	143664.5	

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31-Oct-2018	97869.6	62292.9	146639.5
30-Nov-2018	98819.0	62074.5	149625.7
30-Dec-2018	99777.6	61876.1	152625.4
31-Mar-2018	100745.5	61696.0	155640.5

Source: Econometrics results have been extracted from SPSS21.

Fig. 4 shows an upward trend of gold price over next 21 months (31-Mar-2017-31-Mar-2018) the period of ten years till January 2014. As per the objective of the study predicted future gold price with the best selected model given in Table 2 in accordance with the comparison and satisfying the criteria of fit statistics. Table 2 shows the forecasted gold prices with upper and lower limit of expected variation.

## Conclusions

The research study is under taken to obtain future forecast of Gold which is an important and eminent commodity, usually its worth is realized during the period of economic crisis and turn out to be a significant phenomenon where emerged as a qualitative entity in financial markets.

ARIMA models for forecasting Gold prices are employed to estimate suitable models. In order to develop a univariate Model, monthly data for 38 years (from January 1979 to February 2017) has been employed. We have used of Box-Jenkins methodology to forecast time series of Indian Gold prices. Initially a unit root test was applied on monthly data of gold prices. Among the different (ARIMA) models best model is selected as the best model. It is found that

ARIMA (1, 1, 1) is the suitable model under Box Jenkins approach of model identification, parameter estimation, diagnostic checking and forecasting future prices which helps us in predicting the future values of Gold.

## References

- Abdullah, L. (2012). ARIMA model for gold bullion coin selling prices forecasting. *International Journal of Advances in Applied Sciences*, 1(4), 153-158.
- Askari, M., & Askari, H. (2011). Time series grey system prediction-based models: Gold price forecasting. *Trends in Applied Sciences Research*, 6(11), 1287.
- Banerjee, D. (2014). *Forecasting of Indian stock market using time-series ARIMA model*. Paper presented at the Business and Information Management (ICBIM), 2014 2nd International Conference on.
- Baur, D. G., & McDermott, T. K. (2010). Is gold a safe haven? International evidence. *Journal of Banking & Finance*, 34(8), 1886-1898.
- Box, G. E. P., & Jenkins, G. M. (1970). *Time series analysis: forecasting and control*, 1976. ISBN: 0-8162-1104-3.
- Davis, R., Dedu, V. K., & Bonye, F. (2014). Modeling and forecasting of gold prices on financial markets. *Am. Int. J. Contemp. Res*, 4(3), 107-113.
- Deepika, M., Nambiar, G., & Rajkumar, 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*, 2(11), 548-563.
- Ding, Z., Granger, C. W., & Engle, R. F. (1993). A long memory property of stock market returns and a new model. *Journal of empirical finance*, 1(1), 83-106.

- Durbin, J., & Watson, G. S. (1951). Testing for serial correlation in least squares regression. II. *Biometrika*, 38(1-2), 159-178.
- Hadavandi, E., Ghanbari, A., & Abbasian-Nagheh, S. (2010). *Developing a time series model based on particle swarm optimization for gold price forecasting*. Paper presented at the Business Intelligence and Financial Engineering (BIFE), 2010 Third International Conference on.
- Ismail, Z., Yahaya, A., & Shabri, A. (2009). Forecasting gold prices using multiple linear regression method.
- Khan, M. M. A. (2013). Forecasting of gold prices (Box Jenkins approach). *International Journal of Emerging Technology and Advanced Engineering*, 3(3), 662-670.
- Khashei, M., Hejazi, S. R., & Bijari, M. (2008). A new hybrid artificial neural networks and fuzzy regression model for time series forecasting. *Fuzzy sets and systems*, 159(7), 769-786.
- Kılıç, S. B. (2013). Integrating artificial neural network models by markov chain process: Forecasting the movement direction of Turkish Lira/US dollar exchange rate returns. *Journal of Çukurova University Institute of Social Sciences*, 22(2), 97-110.
- Kılıç, S. B. (2015). Predicting the Direction of Gold Price Returns: Integrating Composite Artificial Neural Network Models by Markov Chain Process. *17(2)*, 15-28.
- Lineesh, M., Minu, K., & John, C. J. (2010). *Analysis of nonstationary nonlinear economic time series of gold price: A comparative study*. Paper presented at the International Mathematical Forum.
- Liuyong, Y., & Zhengtao, S. (2004). The Analysis of Long-term Factors Affecting Gold Price [J]. *Statistical Research*, 6, 21-24.
- Machak, J. A., Spivey, W. A., & Wroblewski, W. J. (1987). A Multiple Time Series Approach to Analyzing and Forecasting the Major French Monetary Aggregates. *Annals of Economics and Statistics / Annales d'Économie et de Statistique*(5), 88-107.
- Miswan, N. H., Ping, P. Y., & Ahmad, M. H. (2013). On parameter estimation for Malaysian gold prices modelling and forecasting. *International Journal of Mathematical Analysis*, 7(21-24), 1059-1068.
- Mombeini, H., & Yazdani-Chamzini, A. (2015). Modeling gold price via artificial neural network. *Journal of Economics, business and Management*, 3(7), 699-703.
- Nielsen, H. B. (2005). *Univariate time series analysis; ARIMA models*. Paper presented at the Proc. Econometrics.
- Parisi, A., Parisi, F., & Díaz, D. (2008). Forecasting gold price changes: Rolling and recursive neural network models. *Journal of Multinational financial management*, 18(5), 477-487.
- Pierdzioch, C., Risse, M., & Rohloff, S. (2014). On the efficiency of the gold market: Results of a real-time forecasting approach. *International Review of Financial Analysis*, 32, 95-108.
- Shafiee, S., & Topal, E. (2010). An overview of global gold market and gold price forecasting. *Resources Policy*, 35(3), 178-189.
- Sharma, A. M., & Baby, S. (2015). Gold Price Forecasting in India using ARIMA Modelling. *GE-International Journal of Management Research*, 3(10), 14-33.
- Shouyang, W., Lean, Y., & Lai, K. K. (2005). Crude Oil Price Forecasting With TEI@I Methodology. *Journal of Systems Science and Complexity*, 18(2), 145-166.
- Tharmmaphornphilas, W., Lohasiriwat, H., & Vannasetta, P. (2012). Gold price modeling using system dynamics. *Engineering Journal*, 16(5), 57-68.
- Tully, E., & Lucey, B. M. (2007). A power GARCH examination of the gold market. *Research in International Business and Finance*, 21(2), 316-325.
- Xu, G. (2011). *China gold futures price prediction model-From the perspective of the gray prediction*. Paper presented at the Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), 2011 2nd International Conference on.
- Xu, L., & Luo, M. Short-term Analysis and Prediction of Gold Price Based on ARIMA Model. *Finance and Economics*, 2011(1), 26-34.



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- Yazdani-Chamzini, A., Yakhchali, S. H., Volungevičienė, D., & Zavadskas, E. K. (2012). Forecasting gold price changes by using adaptive network fuzzy inference system. *Journal of Business Economics and Management*, 13(5), 994-1010.
- Zhang, Q., Ma, J. H., & Wang, Y. (2011). *Study on forecasting of gold price based on varying-coefficient regression model*. Paper presented at the Key Engineering Materials.
- Zhou, S., Lai, K. K., & Yen, J. (2012). A dynamic meta-learning rate-based model for gold market forecasting. *Expert Systems with Applications*, 39(6), 6168-6173.

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