

# Modeling Gold Price in Sri Lanka: Box Jenkins Approach

Yogarajah B.

Department of Physical Science, Vavuniya Campus, University of Jaffna,  
[yoganbala@vau.jfn.ac.lk](mailto:yoganbala@vau.jfn.ac.lk)

## Introduction

In recent years, the global gold price trend has attracted a lot of attention and the price of gold has frightening spike compared to historical trend. In times of uncertainty investors consider gold as a hedge against unforeseen disasters so the forecasted price of gold has been a subject of highest amongst all. In this paper an attempt has been made to develop a forecasting model for gold price. The sample data of monthly gold price (in Rs. per ounce) were taken from January 2000 to Jan. 2016. Data up till January 2015 were used to build the model while remaining was used to forecast the gold price and to check the accuracy of the model. Box-Jenkins, Auto Regressive Integrated Moving Average (ARIMA) methodology was used for building forecasting model. Investing in gold have evolved over a period of time for traditional ways by buying jewelries or by modern way as purchasing gold coins and bars or by investing in Banks in Sri Lanka. Importance of the Gold in our country has changed over a period of time and is treated as common exchange commodity but the demand is seasonal and is high during wedding season, Post-harvest season, festival season and during monsoon season. As an objective of this paper, gives an insight of forecasting of Gold price through time-series model using Box Jenkins Approach.

## Literature Review

Abdullah Lazim (2012) has addressed the forecasting of gold bullion coin prices through ARIMA model and had concluded by suggesting that the gold bullion coin selling prices are in upward trends and could be considered as a worthy investment. Wouter Theloosen (2010) has reviewed on the determinants of the price of gold and cited the different factors associated with the gold price fluctuation. Baber, Baber & Thomas (2013) found the factors affecting Gold prices in India and gives special emphasis on rise in gold price in the decade from 2002 to 2012. Deepika, Gautam Nambiar & Rajkumar (2012) has tried to study the forecasting of gold price through ARIMA model & Regression but their finding suggests that suitable model was not identified to forecast Gold price through ARIMA Model hence Regression analysis was carried out in the later part of their study.

## Methodology

This study is based on secondary monthly data for Gold price which is collected by the Central Bank of Sri Lanka from January 2000 to January 2016. Data of total Quantity in terms of 1000 grams and Value in Rs. Lakhs was taken for a particular month from Central Bank of Sri Lanka website. The Statistical package SAS 9.2 version was used for computation and graphical plotting of data. After collecting data it was tested for its suitability for time series analysis. For this purpose Durbin-Watson Test was carried out to understand the nature of data. According to James Durbin and Geoffrey Watson test statistics was developed to detect the presence of

autocorrelation for its suitability for regression analysis. Autocorrelation is interrelated between the values with suitable time lag.

The existing study applies Box-Jenkins (1970) forecasting model popularly known as ARIMA model. The ARIMA is an extrapolation method, which requires historical time series data of underlying variable. The ARIMA approach was first popularized by Box and Jenkins, and ARIMA models are often referred to as Box-Jenkins models. The general transfer function model employed by the ARIMA procedure was discussed by Box and Tiao (1975).

ARIMA has four major steps in model building- Identification, Estimation, Diagnostics & Forecast. With these four steps first tentative model parameters are identified through graphs ACF and PACF then coefficient are determined and find out the likely model, next steps involves is to validate the model and at the end use simple statistics and confidence intervals to determine the validity of the forecast and track model performance.

ARIMA model uses the historic data and decomposes it into Autoregressive (AR) Indicates weighted moving average over past observations, Integrated (I) Indicates linear trends or polynomial trend and Moving Average (MA) Indicates weighted moving average over past errors. Therefore, it has three model parameters AR(p), I(d) and MA(q) all combined to form ARIMA (p, d, q) model where p = order of autocorrelation, d = order of integration (differencing) and q = order of moving averages.

ARIMA models are sometimes expressed in a factored form. This means that the polynomials are expressed as products of simpler polynomials. For example, we could express the pure ARIMA model as

$$W_t = \mu + \frac{\theta(B)}{\varphi(B)} a_t$$
 where  $t$  indexes time  $w_t$ ;  $\mu$  is the mean term;  $B$  is the backshift operator,  $BX_t = X_{t-1}$ . and  $\varphi(B) = 1 - \varphi_1 B - \dots - \varphi_p B^p$  is the autoregressive operator, represented as a polynomial in the back shift operator:  $\theta(B) = 1 - \theta_1 B - \dots - \theta_q B^q$  is the moving-average operator represented as a polynomial in the back shift operator  $a_t$  is the independent disturbance, also called the random error.

The general notation for the order of a seasonal ARIMA model with both seasonal and non-seasonal factors is ARIMA(p,d,q). The term (p,d,q) gives the order of the non-seasonal part of the ARIMA model.

The Extended Sample Autocorrelation Function (ESACF) The Smallest CANonical (SCAN) methods can tentatively identify the orders of a *stationary or non-stationary* ARMA process based on iterated least squares estimates of the autoregressive parameters. Tsay and Tiao (1984) proposed the technique, and Choi (1990) provides useful descriptions of the algorithm.

## Results and Discussion

In the usual Box and Jenkins approach to ARIMA modeling the first steps involved in finding out autocorrelation, the ACF and PACF plots are compared with the theoretical correlation functions expected from different kinds of ARIMA models. By examining the SAS output of Proc ARIMA for the Gold price data, the sample ACF and PACF plots decays very slowly and it clearly indicates that the data is non-Stationary data.

The Augmented Dickey-Fuller white noise test of the hypothesis that none of the autocorrelations of the series up to a given lag are significantly different from 0 is also rejected. The p value for the test of the first six autocorrelations is less than 0.001, we can decide the Price is non-stationary. The Augmented Dickey-Fuller and Phillips-Perron tests show the differencing is needed. The next step is to transform it to a stationary series by differencing of lag 1. The PACF plots in *Figure 1* are also useful aids in identifying appropriate ARIMA models is p, d, q = 1 for the Gold price in Sri Lanka. . By considering several type of models in *Table 1* and minimizing

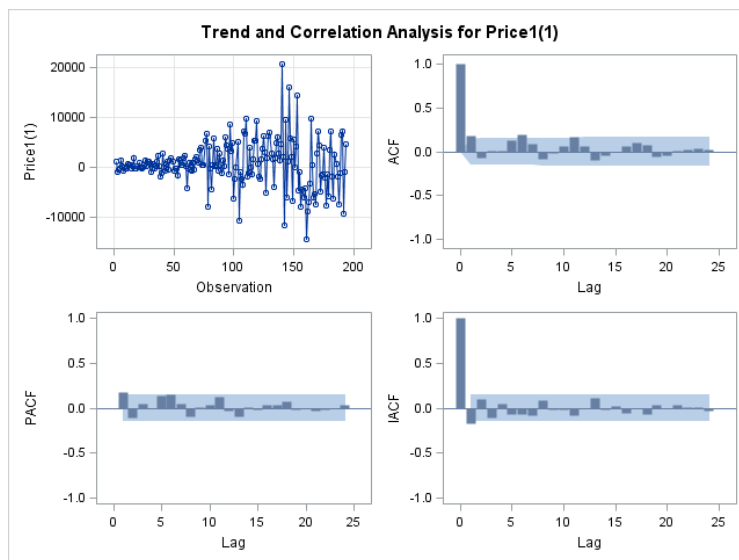
the criteria BIC, AIC and SBC using SCAN and EACF method and optimizing R-squared, RMSE, and MAPE to conform the order of the model(*Table2*). The results of which are summarized in the following tables and Figures. All coefficients are significantly greater than zero and satisfy the stationary.

**Table 1: ARMA (p+d, q) Tentative Order Selection Tests**

Minimum Table Value:  $BIC(1,0) = 16.83238$

| ARMA(p+d,q) Tentative Order Selection Tests |   |          |       |   |          |
|---|---|----------|-------|---|----------|
| SCAN  |   |          | ESACF |   |          |
| p+d   | q | BIC      | p+d   | q | BIC      |
| 2   | 1 | 16.85949 | 2     | 1 | 16.85949 |
| 0   | 6 | 16.93009 | 2     | 2 | 16.87116 |
| 6   | 0 | 16.91256 | 5     | 3 | 16.96985 |

(5% Significance Level)



**Figure1: Gold price data after differencing of lag 1 and ACF, PACF correlogram**

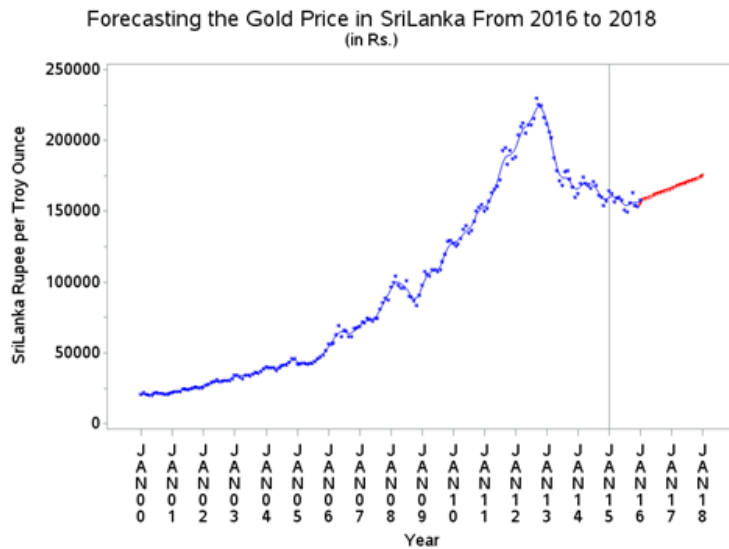


Figure2: Forecasting the Gold Price From 2016 to 2018

Table 2 : Model Validation

|                     | R-squared    | RMSE          | MAPE         | Normalized BIC |
|---------------------|--------------|---------------|--------------|----------------|
| ARIMA(1,0,1)        | 0.878        | 1300.41       | 4.846        | 0.366          |
| ARIMA(1,0,2)        | 0.878        | 1295.70       | 4.829        | 0.340          |
| ARIMA(1,0,3)        | 0.879        | 1274.90       | 4.707        | 0.231          |
| <b>ARIMA(1,1,1)</b> | <b>0.893</b> | <b>719.18</b> | <b>3.245</b> | <b>0.008</b>   |
| ARIMA(1,1,2)        | 0.893        | 720.74        | 3.261        | 0.005          |
| ARIMA(1,1,3)        | 0.823        | 726.35        | 3.135        | 0.019          |

### Conclusion

Key findings indicate that the Gold price patterns in the study period are auto-regressive, as such - they do depend on the past history of the data and combination of past random noises.

Analysis of performance of the gold price from preceding 15 years traded value gives us ARIMA (1, 1, 1) model which helps us in predicting the future values of Gold. ARIMA (1, 1, 1) was chosen from six different model parameters as it provides the best model which satisfies all the criteria of fit statistics while other five failed the fitted model is.

$$(1 - B)Price_t = 717.18 + \frac{1 + 0.62466 B^{**}(1)}{1 + 0.42386 B^{**}(1)} a_t$$

### Limitations

There are certain limitations in forecasting a data with ARIMA modelling. This technique is used for short run only, to detect small variation in the data. In case of sudden change, in the data set (when the variation is large) in case of change in government policies or economic instability (structural break) etc. it becomes difficult to capture the exact change, hence this model becomes ineffective to forecast in this scenario more over the forecasting with this method is based on assumption of linear historic data but there is no evidence that the gold price is linear in nature.

### References

- [1] Abdullah, L 2012, 'ARIMA Model For Gold Bullion Coin selling Prices Forecasting', *International Journal of Advances In Applied Sciences*, vol. 1, no. 4, pp. 153-158.

- [2] As'ad, M 2012, 'Finding The Best Arima Model To Forecast Daily Peak Electricity Demand, In Proc', *The Fifth Annual Asearc Conference*.
- [3] Baber, P, Baber, R, & Thomas, G 2013, 'Factors Affecting Gold Prices: ARIMA Model. A Case Study of India, In Proc. Evolving Management Paradigms in Manufacturing and Service Sectors'.
- [4] Banerjee, D 2014, 'Forecasting Of Indian Stock Market Using Time-Series ARIMA Model. In Proc', *Conference Paper, Icbim-14*.
- [5] Box, GEP. & Tiao, GC 1975, *Intervention Analysis with Applications to Economic and Environmental Problems*. JASA, pp.70, 70-79.
- [6] Box, GEP, Jenkins, GM, & Reinsel, GC 1994, 'Time Series Analysis: Forecasting and Control' Third Edition, Englewood Cliffs, NJ: Prentice Hall, pp.197-199
- [7] Meyler, A, Kenny, G & Quinn, T 1998, 'Forecasting Irish inflation using ARIMA models' [Online]. MPRA Paper No.11359, posted 3. November 2008 14:34 UTC. Available: <http://mpa.ub.uni-muenchen.de/11359/>
- [8] Yogarajah, B 2010, 'A Time-series Modeling Approach for understanding the behavior of Rainfall patterns in the Anuradhapura District' *Journal of the Sri Lanka Association of Geographers*, pp. 82-92.