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GOLD PRICE FORECASTING IN INDIA USING ARIMA MODELLING

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ABSTRACT

Historically, gold has been identified as a unique commodity because of its ability to act as a hedge against inflation and its stability during periods of financial volatility and crises. Tracing the trends in Gold prices and conducting a price forecast is relevant from the point of view of Gold producers, investors and various central banks in the world. Time series analysis is a popular forecasting method for predicting the future value of variables. Time series forecasting techniques attempt to account for changes in the variable over time by examining trends. This technique also uses historical data to predict the future value of a variable. The objective of this study was to develop a suitable forecasting model for the price of gold. ARIMA (Autoregressive Integrated Moving Average) model has been used in this paper for Gold price forecasting. Data pertaining to monthly average gold prices from the RBI website for the time period April 1990 – July 2015 were used to develop a suitable forecasting model on SPSS. Stationarity was checked through the Augmented Dickey Fuller test and through charts. The best fit was identified by examining various statistics and the forecasting errors.

KEYWORDS

Gold prices, Time Series, forecasting model, ARIMA , SPSS, forecasting errors, Augmented Dickey Fuller test,best fit.

INTRODUCTION

Gold is a unique commodity because of its store of value potential and investment asset status. It is the only commodity which retains value during periods of financial and economic crises. As

long as the world economy remains uncertain and investors feel inflation and sovereign default, gold will keep its allure (The Economist – July8, 2010).Its ability to act as a hedge against inflation and the use of Gold as a component of a country's official forex reserve makes it the most sought after commodity in the world. At a macro-level, forecasting gold price has a lot of applications in emerging markets. Bullish trends are expected for gold, for buildup of massive amount of debt. The move by central banks to buy Gold in recent years plus recent pick-up in physical flows from West to East is evidence to support to this. Tracing the trends in Gold prices and conducting a price forecast is relevant from the point of view of Gold producers, investors and various central banks in the world. Being the second largest consumer of Gold in the world, 75% of Gold demand in India has taken the form of jewellery in the last decade (World Gold Council). The seasonal nature of jewellery demand plays a very important role in forecasting Gold prices.

There has been more than 600% increase in price of Gold between 2001 and 2011.During this period price of Gold had gone up to $1923 per ounce. But from 2012 onwards Gold prices started declining from $1900 an ounce to $1200 an ounce. This was mainly due to better economic conditions, low interest rates and investors' preference towards better performing assets. This declining trend was continuing in 2013 also. Since Gold prices are influenced by factors like value of dollar, opportunity cost of holding Gold, inflation and deflation, hedging and de-hedging activities, central bank purchases, jewellery and investor demand, futures market, supply conditions etc, changes in external environment creates volatility in Gold price movements.

Forecasting – the art or science of predicting the future - is an integral aspect of business management as it helps in decision making and forward planning. But the existence of dynamic and uncertain business environment makes forecasting a highly complex and challenging function of analytics. Forecasting, especially commodity price forecasting is an essential activity which is helpful in analysing the demand supply dynamics existing in a market. There are several forecasting techniques, one of them being Time series data forecasting. Time series data are data gathered on a given characteristic over a period of time at regular intervals. Time series forecasting techniques attempt to account for changes over time by examining patterns, cycles, or trends, or using historical data to predict for the coming times. They include simple measures

like graphing the data to using simple averages, moving averages, weighted moving averages, smoothing, regression analysis, ARIMA modelling etc.

Most time series data are composed of four components – Trend, Seasonality, Cyclicality and Irregular components. Trend is defined as the long term general movement of data. Cycles are patterns of highs and lows through which data move. Seasonal effects are shorter cycles measured over months or quarters. They are generally measured over a year. Irregular fluctuations are rapid changes which are unexplained for e.g. Changes in trend due to riots or other unforeseen circumstances. Time series data that contain no trend, cyclicality or seasonality effects are said to be stationary.

Gold price forecasting using Time series analysis is well supported in the literature. While a number of papers are available on predicting the gold price using different time series techniques; most of them are done in the foreign context. India specific studies are very limited. The present research work is an attempt to fill this research gap. The study has a lot of applications in emerging countries like India. When concerned with investment options, developed markets behave differently than emerging markets. In emerging markets where interest rates are below inflation rates and where there is a growing middle class with greater disposable income investment in gold is a very good option for savers to hedge against inflation. This coupled with cultural factors increases the demand for Gold in countries like India.

The objective of this study was to develop a suitable forecasting model for the price of gold. For this purpose monthly average gold prices from the RBI website for the time period February 1990 – September 2014 were used.

The major hypothesis in analyzing the price oscillations in different markets (goods, stocks financial markets, etc.) is the accidental nature of the market. We know that one of the reasons of gold price change is the external effects such as economic policies, environmental conditions and cultural factors. One general assumption made in such cases is that the historical data incorporate all those behaviour. As a result, the historical data is the major input to the prediction process. There are several forecasting techniques available; those are developed mainly based on different assumptions, mathematical foundations and specific model parameters. However, for better results, it is important to find the appropriate technique for a given forecasting task. We have tried to explain the data by using ARIMA techniques. We have then calculated the forecasting

error and come to a final conclusion about the model which best fits the fluctuation in the gold market and best predicts gold prices. In this, we found that the ARIMA(0,1,1) works best.

LITERATURE REVIEW

This section provides a brief overview of the existing literature about gold price forecasting.

Rebecca Davis,et.al(2014) in their paper "Modeling and Forecasting of Gold Prices on Financial Markets" have conducted a study on Gold price forecasting using ARIMA model. Monthly adjusted price of Gold during the period January 2003 to April 2012 was used for analysis. The fitted ARIMA model was used for a six step ahead forecast. The forecasted values were compared with the actual to understand forecasting accuracy.

Gangopadhyay,Kausik.et.al(2014) in their paper "Forecasting the price of gold: An Error Correction Approach" have tried to identify the long term relationship of Gold price with factors like exchange rate,US Bond rates,oil prices, consumer price index and stock market index using Vector Error Correction model. Since the time series variables in the study were non-stationary, the authors have done the analysis in a co integrating approach using Vector error correction model provided by Johansen and Juselius.

Aye,Godness et,al (2014) in their working paper titled 'Forecasting the Price of Gold Using Dynamic Model Averaging' attempted to examine the possible factors influencing the price of Gold.Thorugh the analysis of data the authors tried to show superiority of the dynamic model averaging (DMA) and dynamic model selection (DMS) models over Bayesian model averaging and linear models. Based on the study it was identified that exchange rate factor and Fed's financial stress index have more impact on the gold prices than any other variables. It was also revealed that the exchange rate factor has the maximum impact of the gold prices.

Hossein Hassani*x*_,Emmanuel Sirimal Silva*x* and Rangan Gupta(2014) in their working paper "Forecasting the Price of Gold" made a comparison of the predictive power of 17 existing forecasting methods. The study was based on Gold price data obtained from www.kitco.com for a period from January 1972 to December 2013.Based on the results, the authors arrived at the conclusion that no single model is able to provide the best gold price forecast over different time

horizons. But,if we consider lowest average Root Mean Square Error as the criterion for judging the predictive power of a amodel,Exponential Smoothing(ETS) will be the best model.

Lili,Li and Diao Chengmei(2013) in their paper used Factor-Augmented Vector Auto-regression(FA VAR) model to predict gold prices. The authors have classified all major factors influencing gold prices(Y) into three principal components- gold reserve and prices of energy products (F1), financial market indices(F2), global macroeconomic indicators(F3).Through analysis of data from 1985 to 2005 it was identified that there was a positive relationship between F1 and Y negative relationships between F2 and Y and also between F3 and Y.

Dr.Ali Khan,Massarrat M(2013) has done a study on Gold Price Forecasting using Box Jenkins Auto Regressive Integrated Moving Average (ARIMA) Approach. His study aimed at building a model for Gold price forecasting and developing a framework for checking the accuracy of the model. The study was based on sample data of Gold price(in US$ per ounce) during the period January 2003 to March 2012.For building the forecasting model, the study has used Box Jenkins Auto Regressive Integrated Moving Average(ARIMA) method. After comparing the results from ARIMA(0,1,1) and ARIMA(1,1,0) models it was identified that ARIMA(0,1,1) is a more suitable forecasting model for Gold Price Forecasting. Forecasting Accuracy of the model was tested using Root Mean Square Error, Mean Absolute Error and Mean Absolute Percentage Error.

Abdulla,Lazim(2012),conducted a study using ARIMA model to forecast gold prices. This study was done in the context of Malaysian economy by taking daily selling Malaysian gold coin prices from 2002-2007.This study was mainly conducted with the objective of assessing the investment potential of Gold coins. As the forecasted gold coin prices using the ARIMA showed an upward trend, investment in gold coin is justified by the identified long term trends. Based on the study they arrived at the conclusion that ARIMA model is not suitable for making gold price forecasting because of the influence of too many factors on gold prices.

M.G Deepika, Gautam Nambiar and Rajkumar M (2012) in their paper identified that the short run and long run gold prices exhibited diverging trends.Thereofore they used two different methods to forecast the price of gold in the short run and long run. Short run gold price

forecasting was done using time series modeling and long run price forecast using multiple regression analysis.Thier study was based on the gold price data for the period from 1980 to 2012.Based on their study they arrived at the conclusion that ARIMA is not a suitable model for predicting gold prices.Therfore they have use the multiple regression model to analyse the influence of various factors in deciding gold prices. Through this analysis they identified three major factors which influenced the gold prices – worls stock prices,US$ index and inflation.

Anand Ashesh and Piyush Dharnidharka(2012) in their paper carried out a study about forecasting gold prices using time series analysis. They have used Box - Jenkins methodology to forecast the monthly average gold prices. Monthly average gold price data for the period January 2012 to June 2012 was taken for analysis. According to them, though many new models are used to make accurate forecasts in the long run, ARIMA models are still useful in making short term forecasting mainly because of the fair degree of precision which was identified in their study.

Shafiee,Shahriar and Erkan Topal(2010) developed a model for Gold price forecasting by using historical gold prices from January 1968 to December 2008.This model identified three components which were very important in influencing the gold price movements. These were long-term trend reversion component, diffusion component and jump/dip component. Long-term trend reversion component explain the tendency of gold prices to revert to the historical long term trend. The diffusion component defines a range for the random variations in gold prices compared to the long term historical trend. Based on analysis of data this random variation range was calculated as 25% which means that the gold price in the next month will increase or decrease by 25% compared to the long term trend. The dip/jump component explains the deviation of gold prices from the long term trend by more than 25%.The influence of these three components was validated with historical gold prices and the model was used to predict the gold price for next 10 years.

Ismail,Z et,al (2009) carried out Gold price forecasting using Multiple Linear Regression method. MLR was done with London PM Fix Gold Prices as the dependant variable and Inflation Rate,Money supply,Dollar-Euro exchange Rate,NewYork Stock Exchange Index,Standard and Poor Index, Reuters Commodity Research Bureau Future Index, Treasury

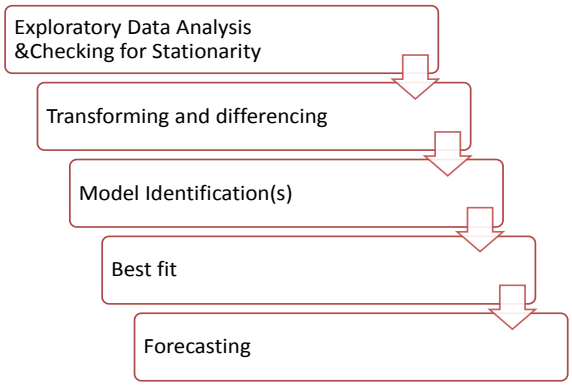
Bill and UD Dollar Index as independent variables. Forecasting using MLR generally leads to two major problems – multicollinearity and correlated error terms. The issue of multicollinearity was addressed in this study by the using step wise regression method and it reduced the number of independent variables to four. Prais-Winsten procedures were employed in the study to address the second problem of correlated error terms.This forecasting model using MLR finally identified four major factors influencing future Gold prices - CRB index, EUROUSD exchange rate, inflation rate and money supply (M1).

DATA AND METHODOLOGY

Data pertaining to monthly average gold prices from the RBI website for the time period April 1990 – July 2015 were used to develop a suitable forecasting model. There were a total of 304 cases starting from April 1990 – July 2015. The maximum value of gold was INR 31672.83 corresponding to September 2012 and the minimum was INR 3284.70 corresponding to July 1990. The mean value was 10487 and the standard deviation was 8886. The measures of skewness and Kurtosis were well within ± 3.

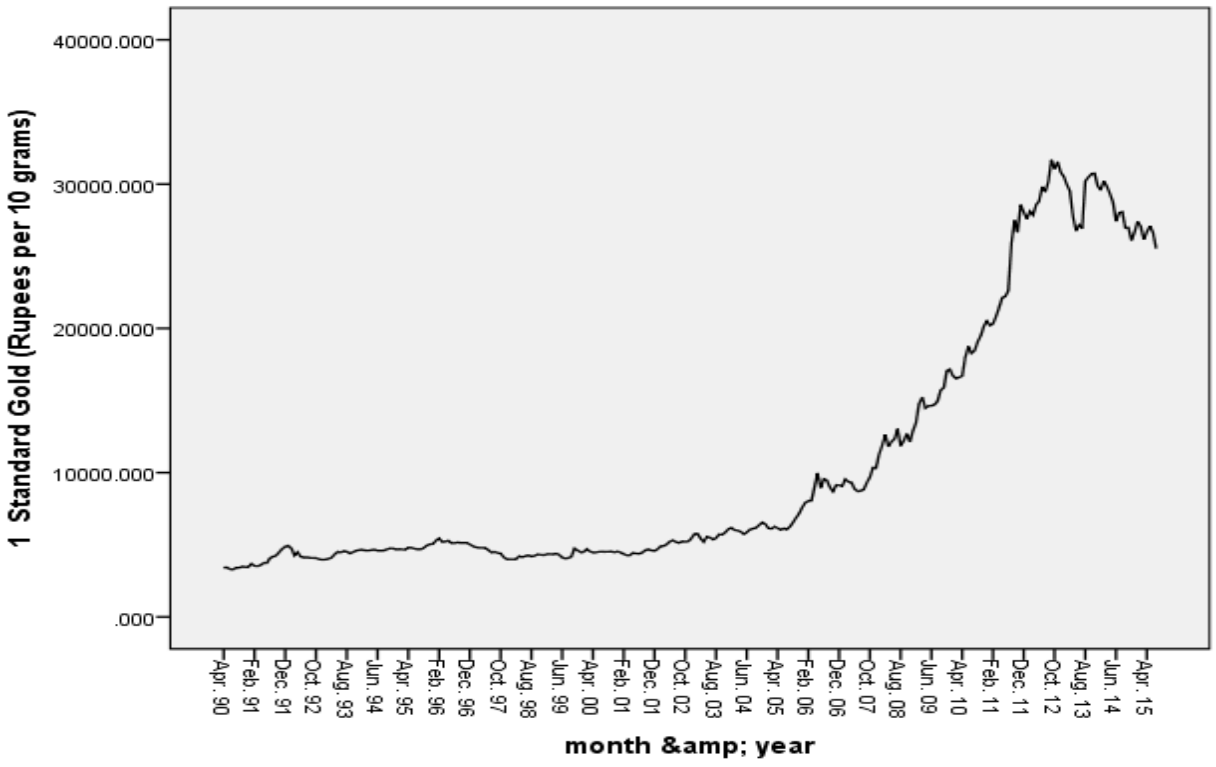
We used the Box-Jenkins methodology(ARIMA process) to find the best fit. Autoregressive Integrated Moving Average model is generally knows as ARIMA(p,d,q) model where *p* denotes the number of autoregressive terms, *d* the number of times the time series has to be differenced before it becomes stationary and *q* the number of moving average terms. ARIMA model is used for analysing a times series which shows non stationarity.Non stationarity can be removed by differencing the time series. Non stationarity was measured through sequence charts and The Augmented Dickey Fuller test. The ADF was checked through an Excel macro.

Methodology



We measured the forecasting errors through Mean Absolute Error (MAE), Root Mean Square Error (RMSE).Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE).

Figure 1: Exploratory Data Analysis : Sequence Chart



A stationary process has the property that the mean, variance and autocorrelation structure do not change over time.

Stationarity can be defined in precise mathematical terms, but for our purpose we mean a flat looking series, without trend, constant variance over time, a constant auto correlation structure over time and no periodic fluctuations.

We checked the data for stationarity by checking for autocorrelation and partial autocorrelation as well as through the ADF test. Figure 1 shows us that the data is not stationary and this is further corroborated by the ACF and PACF charts shown below in Figure 2 and 3. These show us that the data is not stationary.

The p value for the Augmented Dickey Fuller test was 0.83 which also proves that the data is non stationary.

Figure 2:Auto Correlation Function (ACF)

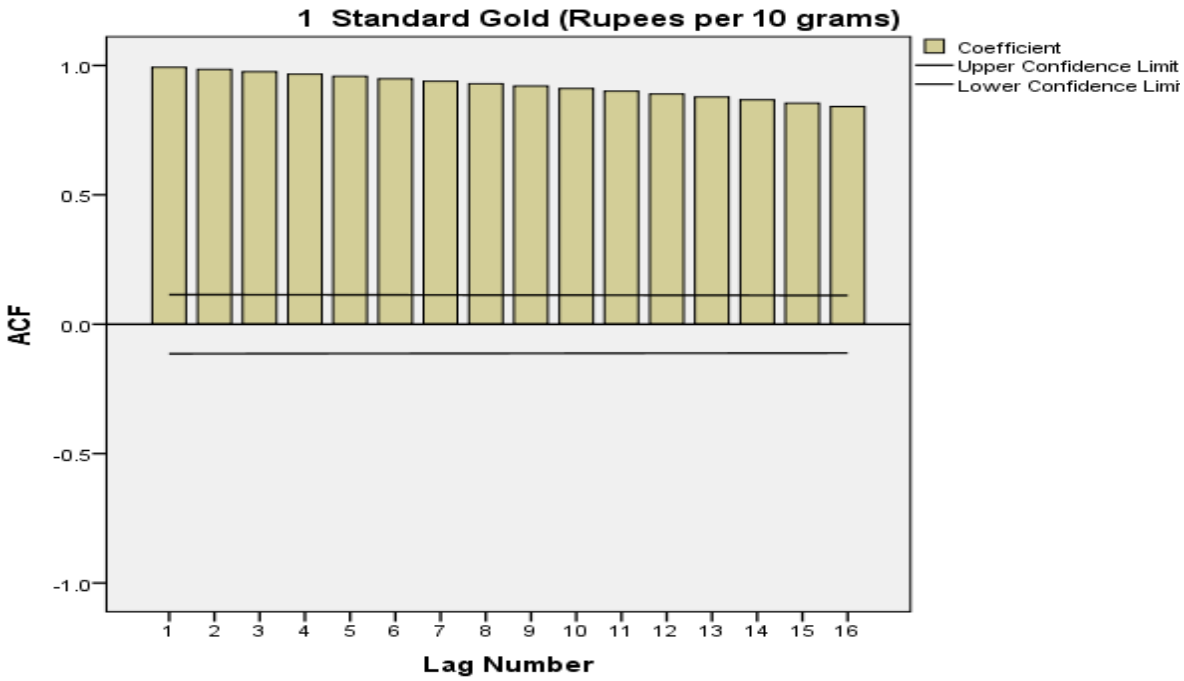
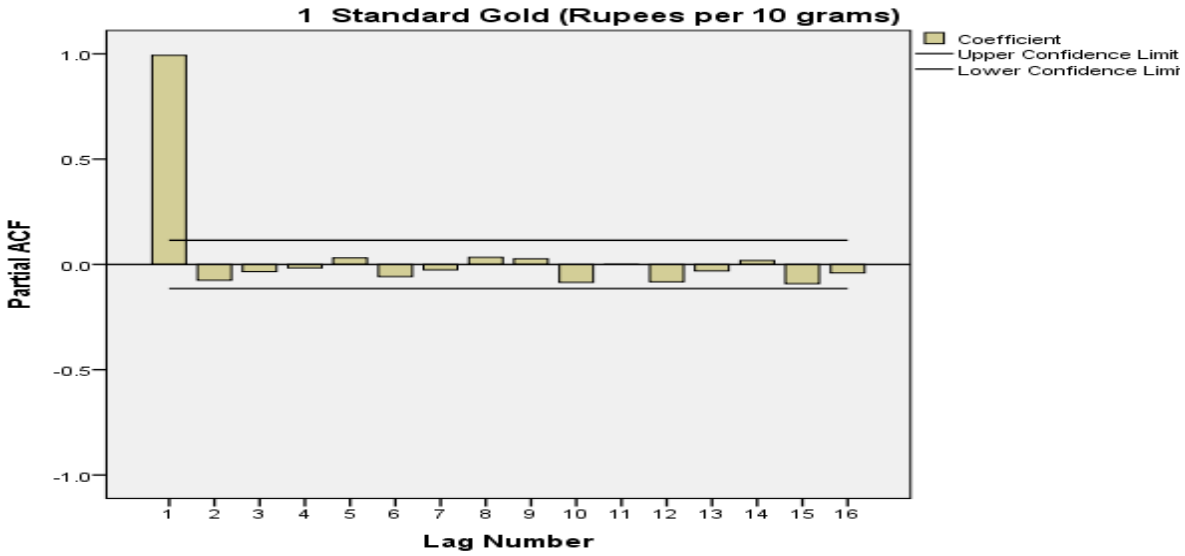


Figure 3:Partial Auto Correlation Function (PACF)



We then transformed data by differencing once and checked for stationarity.

Figure 4: Exploratory Data Analysis : Sequence Chart (Differencing Once)

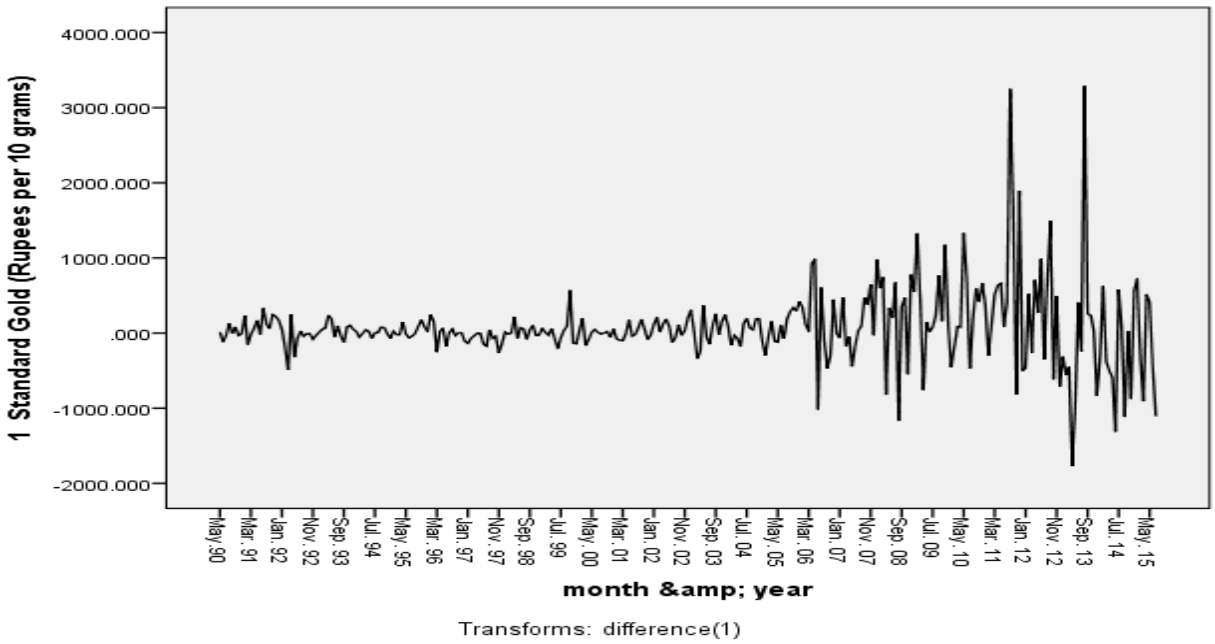


Figure 5:Auto Correlation Function (ACF) (Differencing Once)

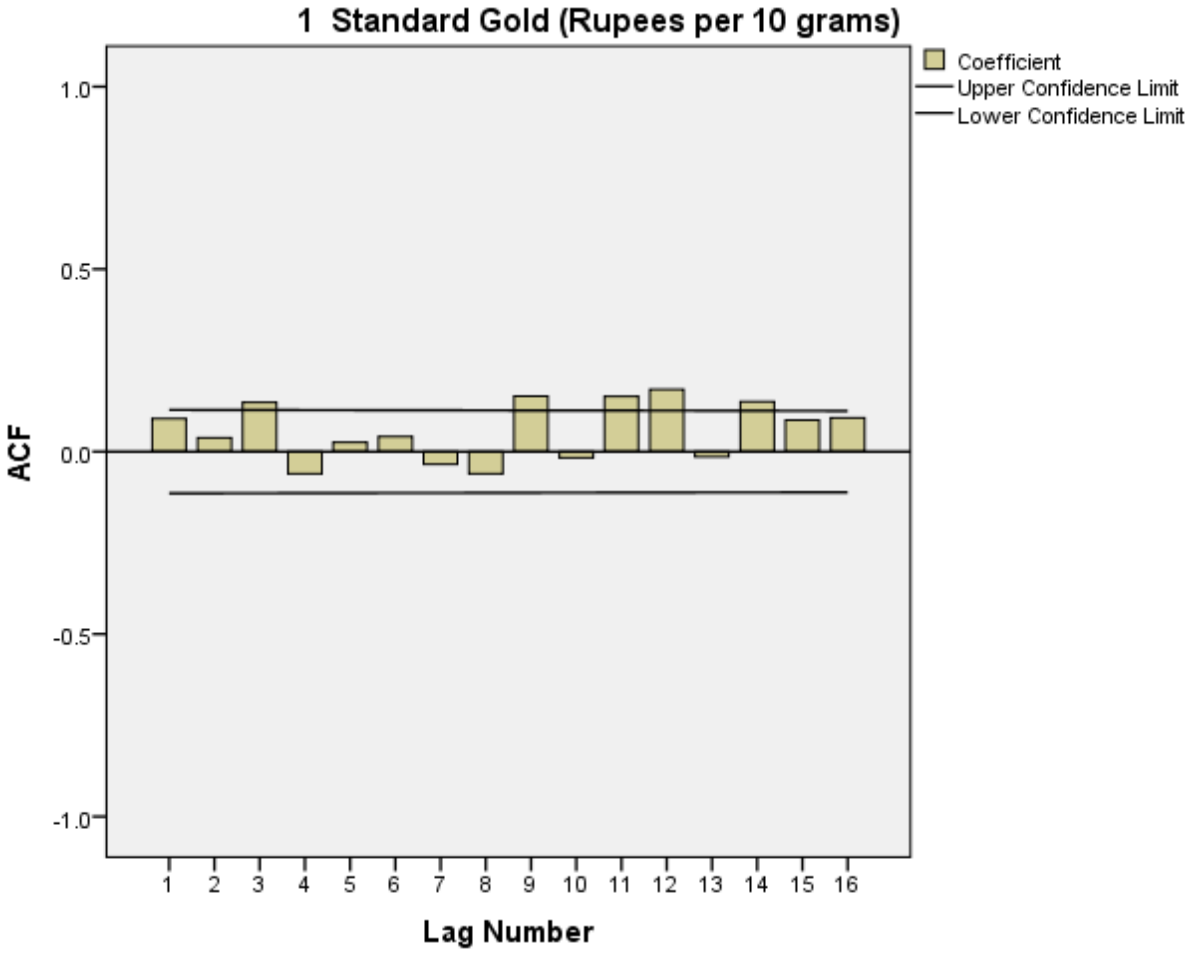


Figure 6 : PACF 9 (Differencing Once)

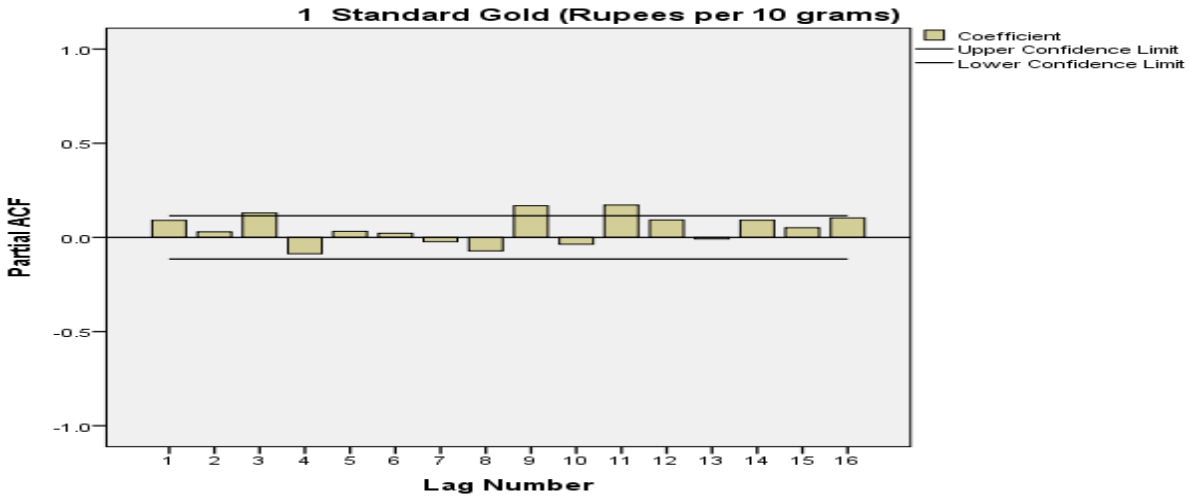


Figure 7: Exploratory Data Analysis : Sequence Chart (Differenced twice)

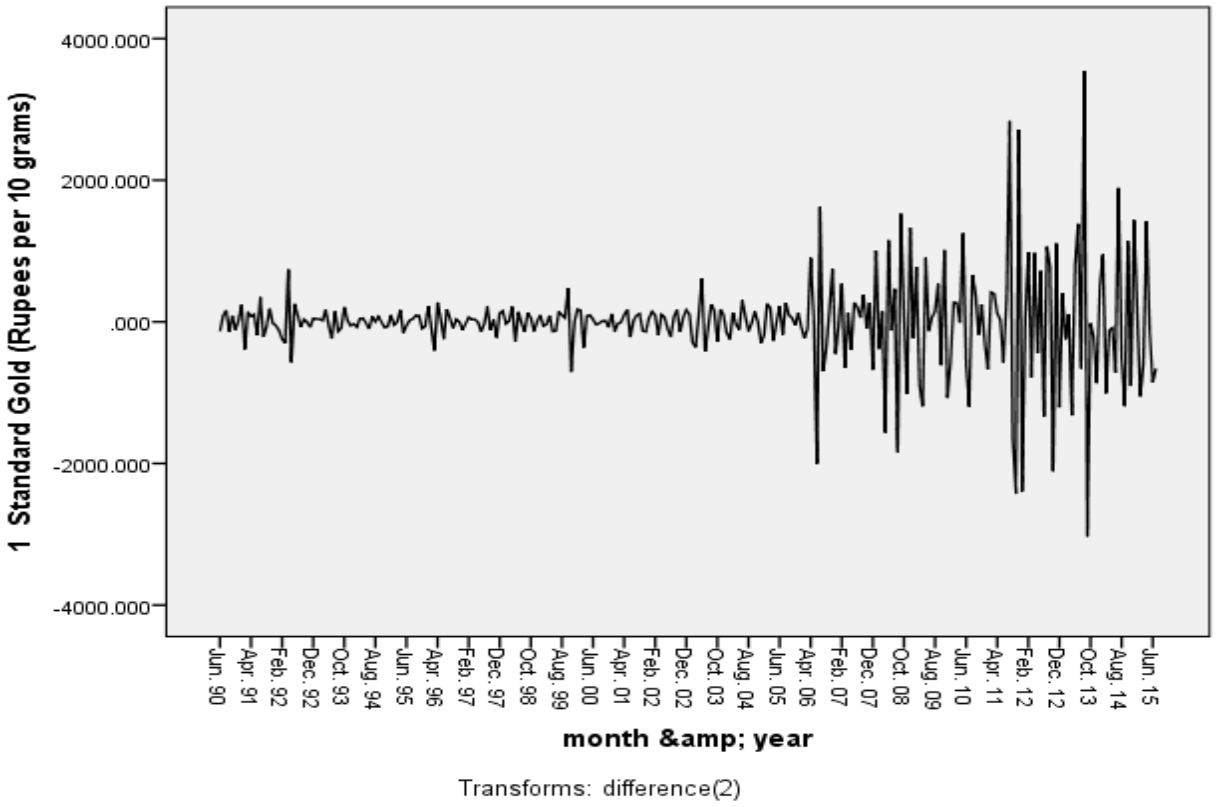


Figure 8:Auto Correlation Function (ACF) (Differenced twice)

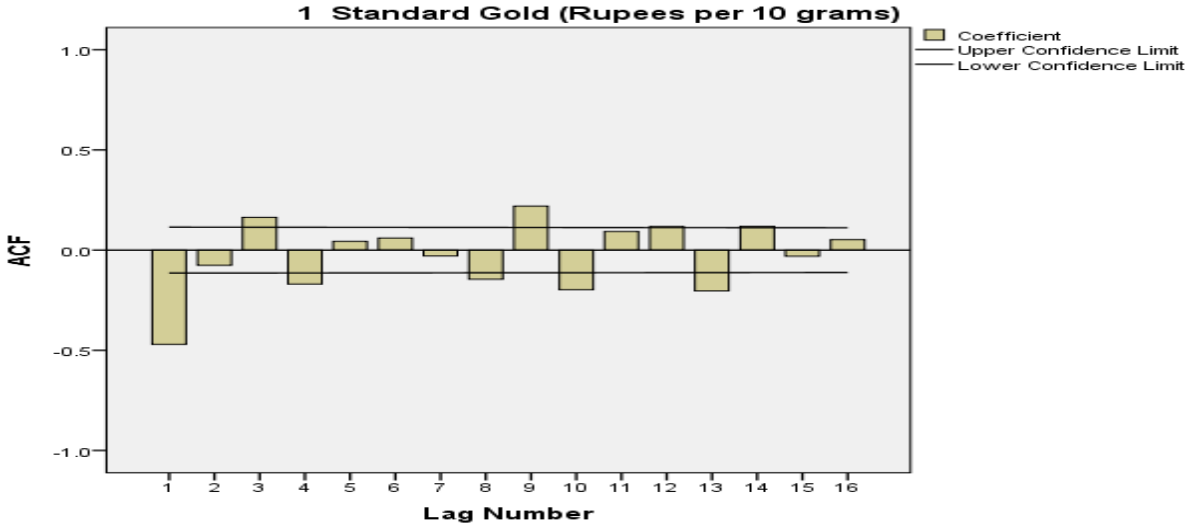


Figure 9:Partial Auto Correlation Function (PACF) (Differenced twice)

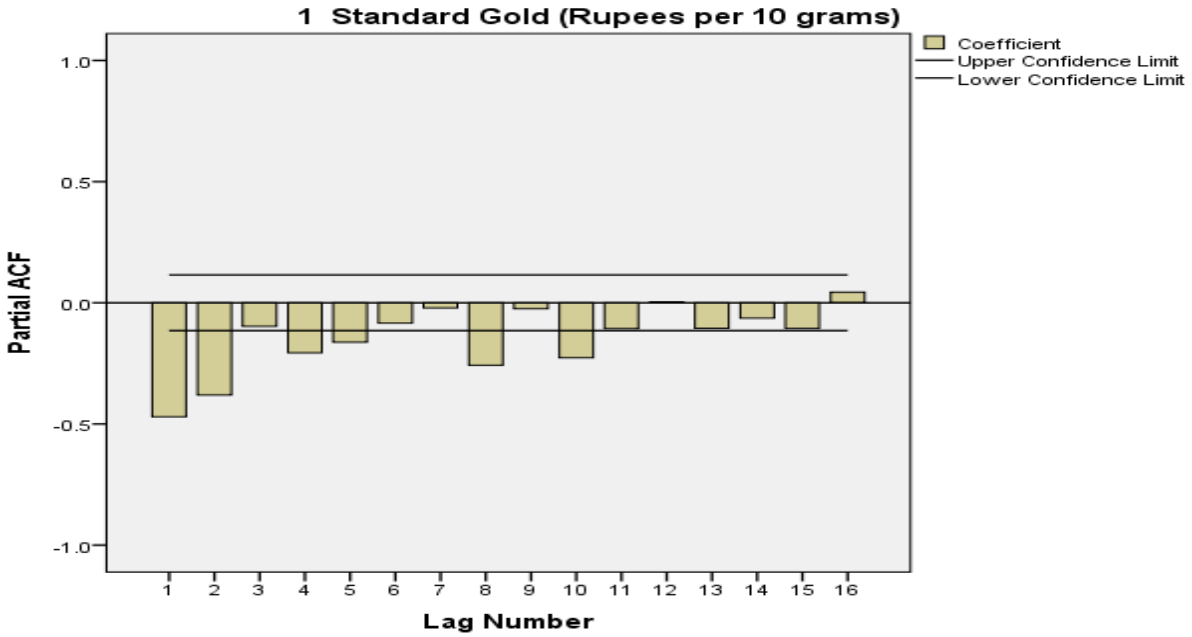


Figure 10: Exploratory Data Analysis : Sequence Chart (Natural log transformation and differenced once)

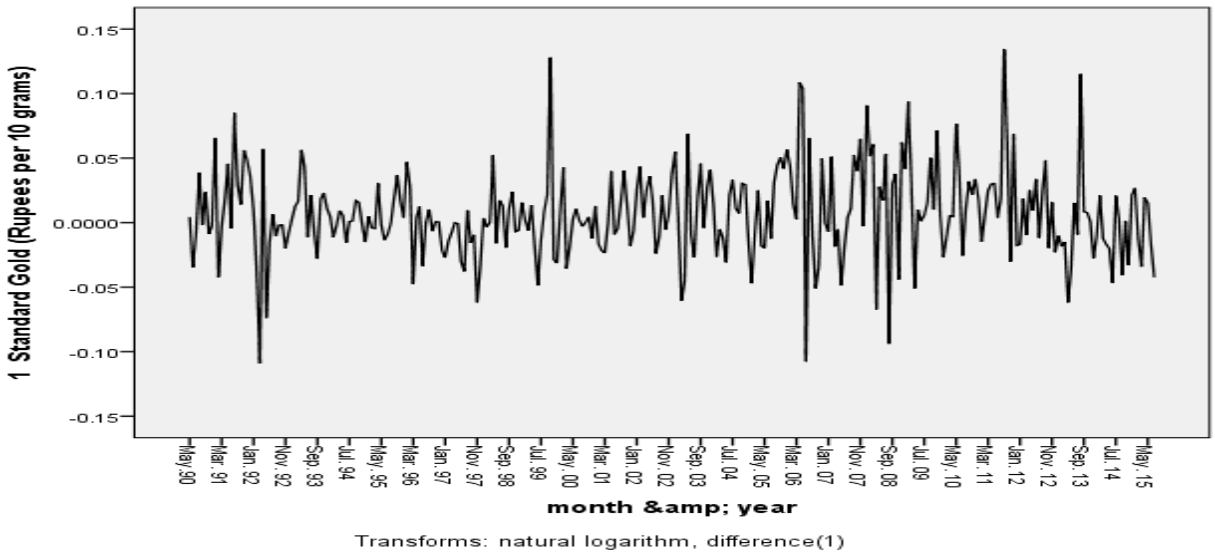


Figure11:Auto Correlation Function (ACF) (Natural log transformation and differenced once)

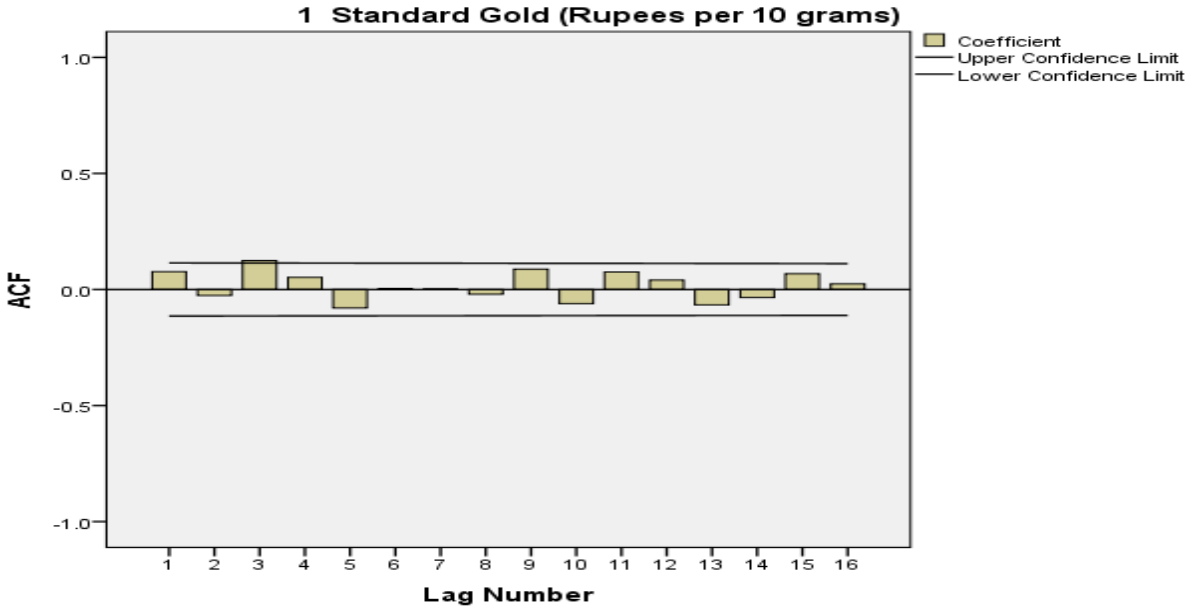
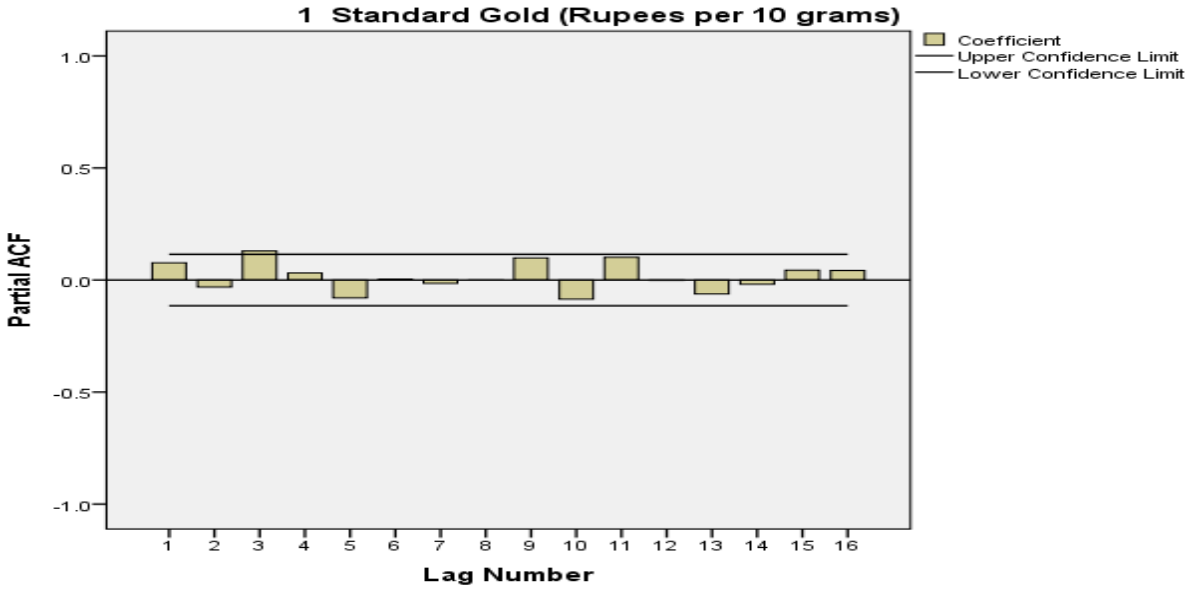


Figure 12:Partial Auto Correlation Function (PACF) (Natural log transformation and differenced once)



The p value for the Augmented Dickey Fuller test was 0.01 which proves that the data has become stationary

Figure 13: Exploratory Data Analysis : Sequence Chart (Natural log transformation and differenced twice)

LOGTRANSFORMED AND DIFFERENCED TWICE

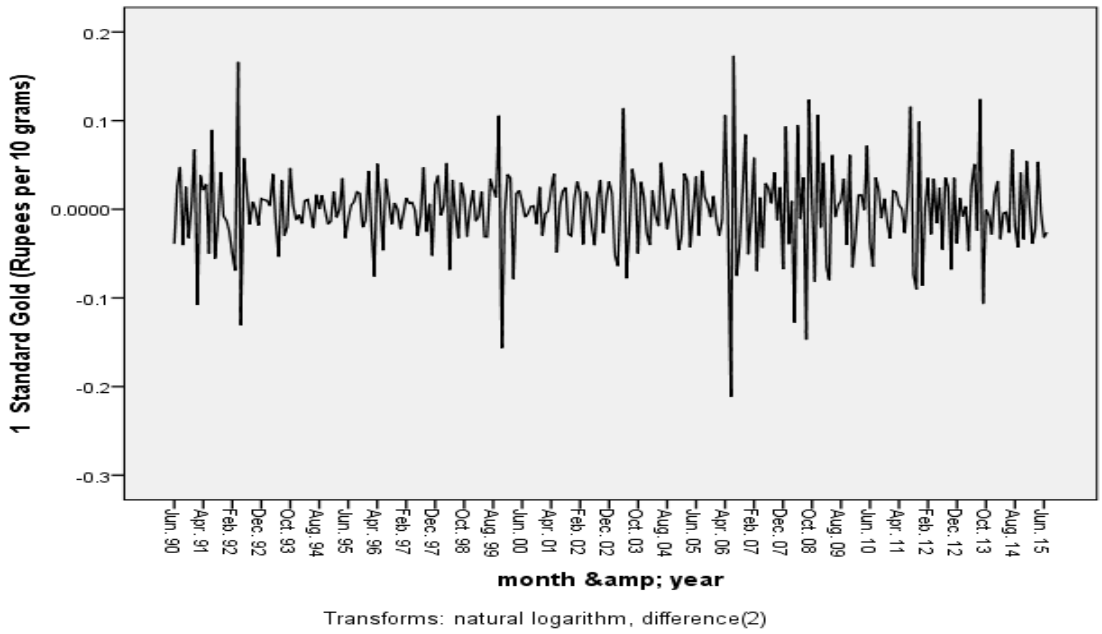


Figure 14:Auto Correlation Function (ACF) (Natural log transformation and differenced twice)

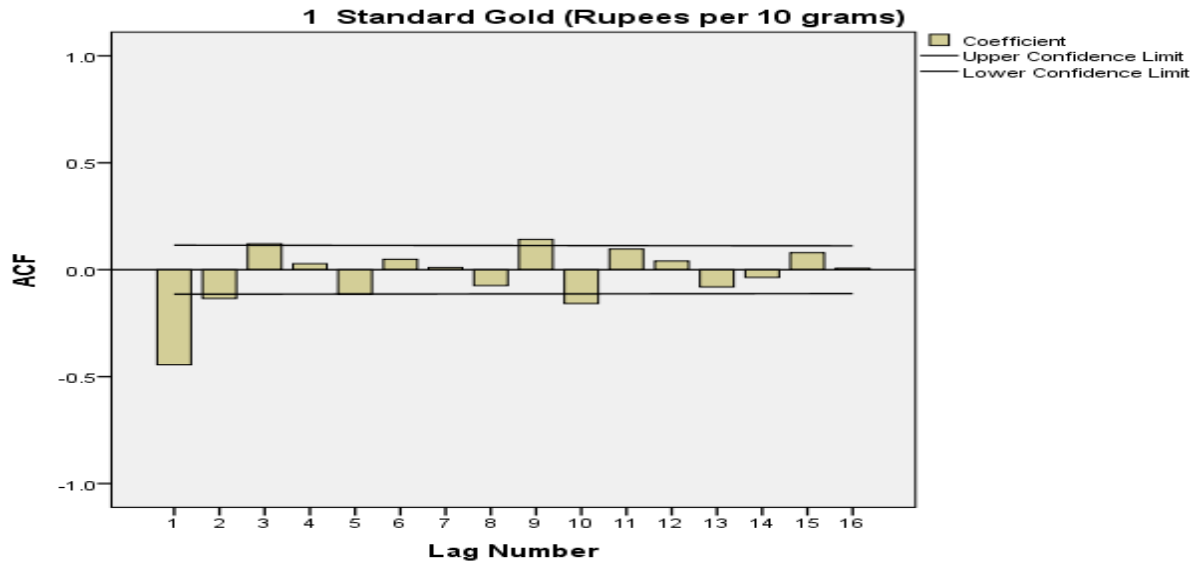
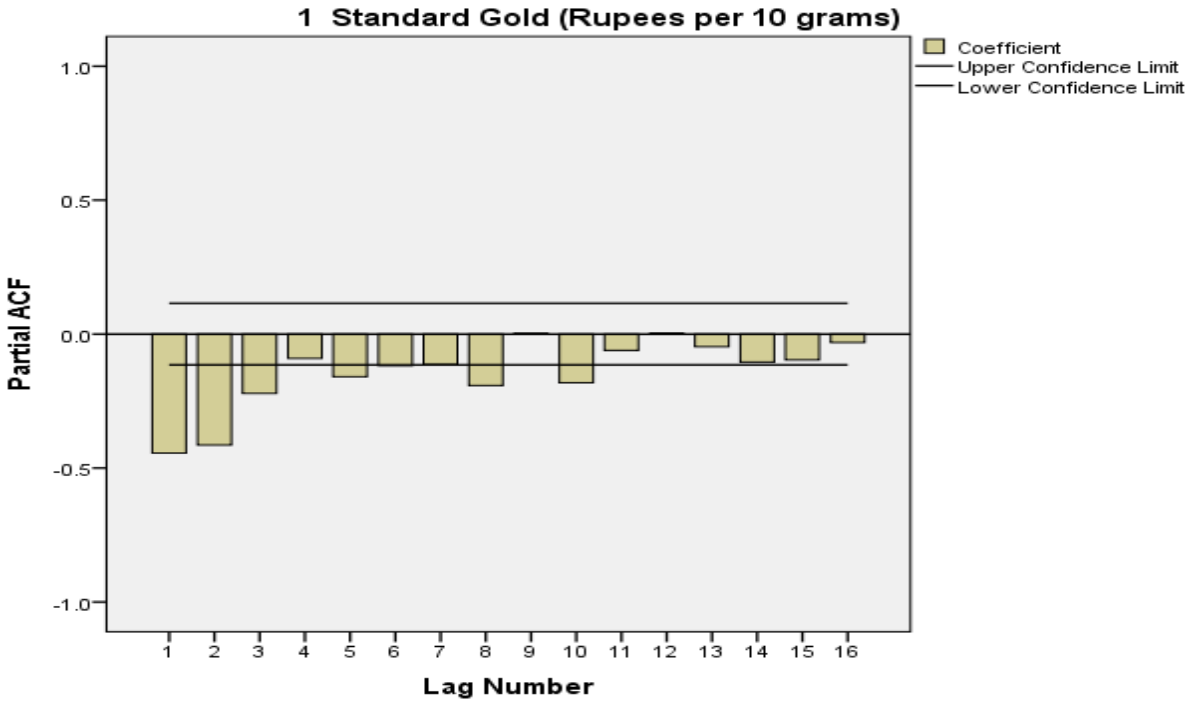


Figure 15:Partial Auto Correlation Function (PACF) (Natural log transformation and differenced twice)



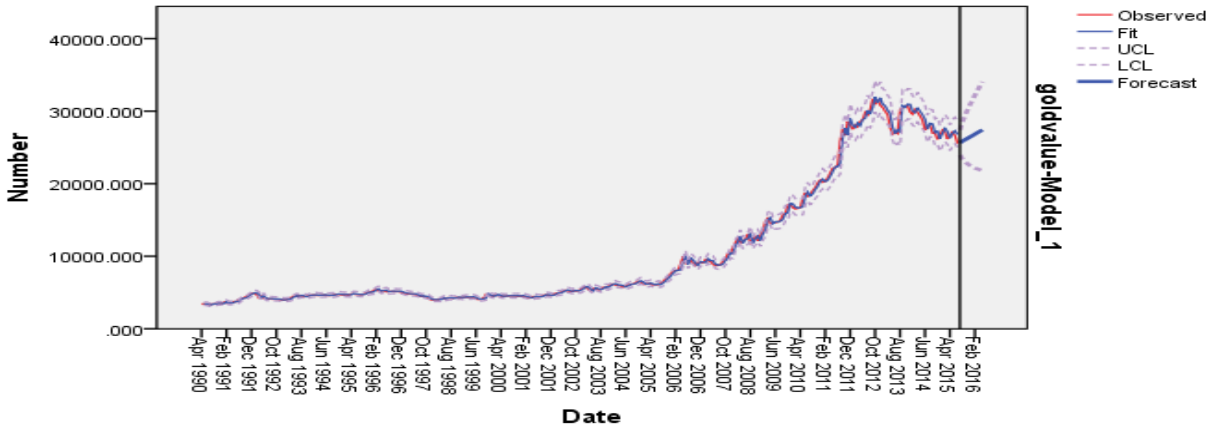
By examining the data through figures 1 to 15 we conclude that the data is stationary BY DIFFERENCING ONCE AND LOG TRANSFORMING. The ADF for that is also 0.01 proving that the data is now stationary. After making the data stationary, we tried identifying the best fit model using ARIMA modeller in SPSS and came out with the following models which fitted the data:

Model No	Model (p,d,q non seasonal) (p,d,q seasonal)	Ljung-Box Q	BIC	R squared	RMSE	MAE	MAPE	Forecast for September 2015	Lower Control Limit@ 5%	Upper Control Limit@ 5%
1	(0,1,0)(0,0,0)	0.233	12.417	0.997	492.185	282.404	2.533	25911.041	23531.062	28465.068
2	(0,1,0)(0,1,0)	0.000	13.036	0.994	670.801	406.796	3.636	24618.657	21512.474	28045.749
3	(0,1,1)(0,0,0)	0.158	12.431	0.997	491.025	281.847	2.514	25810.433	23345.280	28463.597
4	(0,0,0)(0,1,0)	0.000	15.309	0.945	2089.538	11300.838	10.840	29601.860	22468.043	38291.799
5	(0,1,2)(0,0,0)	0.152	12.454	0.997	492.169	281.179	2.508	25877.761	23398.076	28547.234

Actual value for gold on September 15, 2015 is Rs.24,550 (Source: http://www.goldpricesindia.com)

Of all the five models which fitted the data, model numbers 1,3 and 5 were a good fit. On examining the statistics, Model number 3 which is an ARIMA with non seasonal p=0,d=1 and q=1 fits the data the best as the BIC(Bayesian Information Criterion) is low and RMSE,MAE and MAPE are the least. As the Ljung Box Q is greater than 0.05,it shows that autocorrelations for one or more lags might be significantly different from zero which indicates that the values are not random and independent over time.

Figure 16: Model Fit



CONCLUSION

In this study of a univariate time series based on monthly Gold prices starting from April 1990 to July 2015, we used the standard gold price (22k) of the Mumbai market. We have examined the data and applied a log normal transformation and a differencing of one to make it stationary. We have used SPSS to fit various ARIMA models to the data. We find that the ARIMA(0,1,1) is the best fit for the said data (as shown in Figure 16). This model can be used to estimate the price of gold in the future.

FUTURE SCOPE:

There is scope for further research wherein the model can be applied using daily gold price data.

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