Analysis and Forecasting of Gold Prices Trends in India Using Auto Regressive Integrated Moving Average Model

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Abstract:
Gold is recognized as a major commodity in the international economy, which is now a key indicator of economic activity. In order to preserve financial stability, a company engaged in international trade needs to be able to forecast the price of gold. It shows the overall financial health of the global economy. Future price predictions are based on forecasting. Our selection of gold prices in the Indian market from 1964 to 2022 (until we know) was based on secondary sources.In the current study, we used an Auto Regressive Integrated Moving Average (ARIMA) model to predict the price of gold in India. For predicting timeseries data, it is one of the most effective statistical techniques. By using the Autocorrelation function (ACF) and the Partial autocorrelation function (PACF) on the chosen differenced series, the proper ARIMA model is found, and the gold price forecast is then shown. The primary objective of the current study is to predict gold prices from 2023 to 2035.According to the study's conclusions, the most accurate models for predicting Indian gold prices are ARIMA (1,1,1), ARIMA (1,1,0), ARIMA (0,1,1), and ARIMA (9,1,1).This study is particularly pertinent for investors and economists to understand how the price of gold might help them for better investment decisions and reduce the uncertainty of the market.

Keywords: Autoregressive Integrated Moving Average; Auto Correlation Function, Partial Auto Correlation Function, Box-Jenkins Methodology, Gold Price,Trend Analysis,Forecasting.

1. Introduction

Gold has captivated humanity since its discovery. It is one of the most valuable metals discovered to date, as well as the most liquid asset. Since its origin, gold has served as the foundation of all economies. It is the best investment for the average person. In today's world, investors utilize it as a tool to hedge their portfolio investments (Gründl et.al 2016). During the last decade, both monetary and non-monetary demand for gold has been on the rise. During international trade, every country in the world uses gold as a medium of exchange. Gold prices have risen dramatically over the last decade and continue to grow. It is frequently connected with stock markets during risk-on periods and inversely correlated during stress periods. Since several decades, Indian investors have shown a significant preference for physical assets. Various states kept and increased their gold holdings and were regarded as prosperous and progressive (IMF report 2021). gold is now held by central banks around the world to ensure the repayment of foreign debts as well as to prevent inflation. Furthermore, it represents the country's financial strength.In addition to market demand and supply, the performance of the world's main economies has a significant impact on gold rates. Apart from its investment value, gold is widely employed in the luxury and jewellery markets, as well as in the electronics and high-tech industries, where it is used as a high-grade conducting material to make printed circuit boards and semiconductor components (Gold Investor-2018). It is used in computers to transport digital information with high speed and accuracy from one component to another. Gold is employed in some surgical procedures, as a medicine to treat a limited number of medical disorders, in the identification of health conditions, and so on. Due to the global economic collapse caused by the COVID-19 epidemic, investors are flocking to buy gold-related assets because global currencies are rapidly losing value and are highly volatile (Yousef et.al, 2020).

Predicting the gold price is critical in this scenario, both from a business and academic standpoint, because it allows financial practitioners to forecast future financial situations. According to the majority of research studies, the price of gold reflects inflation forecasts. Many authors have provided the results of trends in displaying the fluctuation of gold prices over time for non-seasonal and seasonal data.Akaike (1974) determined an appropriate order of a non-seasonal model. Brockwell and Davies (1996) proposed a number of strategies for forecasting time series data. ARIMA model is one of the most famous models used by the researchers forforecasting. Aarti Sharma (2015), Guha and Bandyopadhyay (2016), Farah and Zahid (2016), Sandhyarani et al. (2017) proposedARIMA model to forecast gold prices.

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In this study, we analyze and forecast the gold prices using ARIMA model. The prediction accuracy is determined by different forecasting performance measures like Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Maximum Absolute Percentage Error (Max APE) and Root Mean Square Error (RMSE). The organization of paper is as follows: Section II highlights the trends of Gold in Indian Market, Section III covers literature review, Section IV describe data collection and methodology, Section V presented results and discussion and Section VI presents conclusion.

2. Trends of Gold in Indian Market

The 1990s saw a sharp increase in gold consumption as a result of the liberalization of the import policy for gold, strong economic growth, and favorable gold price fluctuations. Demand for gold is rising quickly on both a monetary and non-monetary level. Governments, institutions, and private buyers have all requested it. (Claessens et.al, 2013). Since 2001, the cost of gold has significantly increased. The cost of gold has risen by 900 percent in the last ten years. With a CAGR of 14.5 percent in US Dollar (USD) terms, gold has consistently outperformed other traditional asset classes over the years. (Neil Borate,2022). In contrast, global gold prices rose by an average of 6% during the 2008–2009 financial crisis, reflecting the opposite trend from many commodity prices that fell by 40%. It implies that the gold price will behave differently. Gold is a financial asset that is used for hedging and risk management. Gold is something that investors buy to hedge against possible losses. As a result, anticipating the price of gold has become an important subject in financial economics. Since it diversifies and is frequently correlated with stock markets when risk is low and inversely correlated when risk is high, gold is sometimes seen as an important asset in the portfolio. India's gold prices grew by 60% in 2019 and by 30% from January to July of 2020, respectively. (Naliniprava Tripathy, 2016 and 2017).The demand for precious metals has also been significantly impacted by the Covid-19 pandemic. The World Gold Council estimates that there was a 2,076-tonne global demand for gold in the first half of 2020, a 6 percent decrease from the prior year. (Saranya,2021).Demand in the second quarter of 2020 (Q2) on the Indian market was 63.7 tonnes, a 70% fall, while demand for jewellery was 44 tonnes, a 74 percent decrease, and demand for investments was 19.8 tonnes, a 56% decrease.India accounts for 20% of the total demand, which has increased to over 4000 tonnes over the past ten years. An average of 850 tonnes of gold have been consumed by the Indian market since 2010. Similar to this, India buys 800 tonnes or more of net bullion annually. The majority of gold consumed in India—around 65 percent—is used for jewellery, with the remainder going toward investments like coins and bars. However, this is not the case in other major economies. The Gold Consumption Trends Report by the World Gold Council projects that India's overall gold demand increase to 797.3 tonnes in 2021 from 446.4 tonnes in 2020. (Gold Focus 2020). The graph below depicts the trend of gold returns in the Indian market.

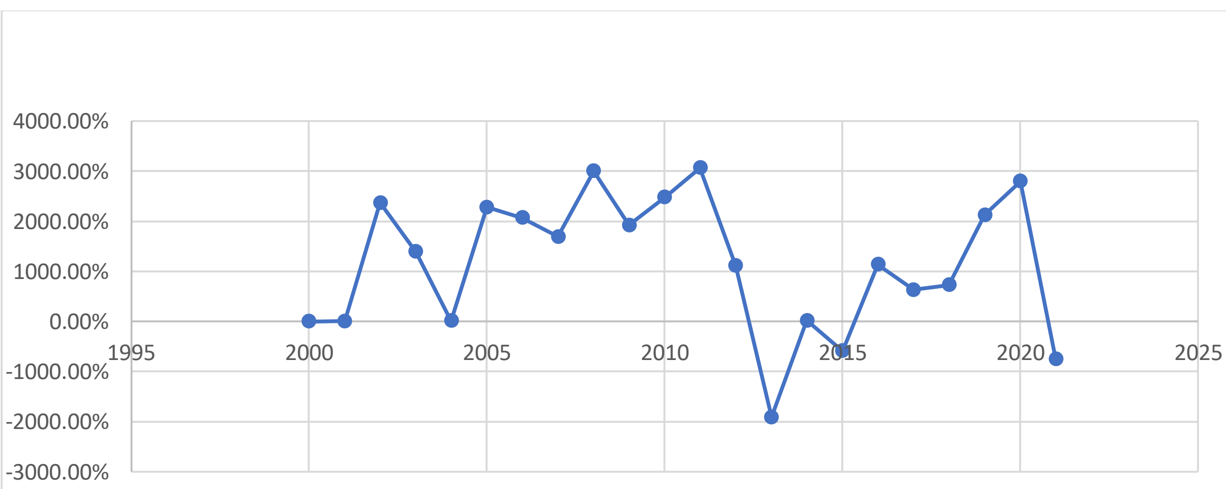

Figure 1: Gold Return in % of India

Source: https://www.abcbullion.com.au/

3. Literature Review

According to Larry and Fabio (1996), the price of gold in all other currencies is significantly impacted by the actual appreciation or depreciation of the euro and yen against the US dollar. Baber et.al (2013) assert that the dollar index affects gold prices. Gold has an impact on the volatility of the USD/EUR exchange rate, accomplishHammoudeh et al. (2010). The study comes to the conclusion that there is a connection between the exchange rate and gold price volatility. The interval approach is recommended by Han et.al. (2012) to look into the relationship between the Australian dollar, USD, and gold price. The empirical data demonstrates a long- and short-term relationship between the exchange rate and the price of gold.Ewing and Malik (2013) claim that there is evidence of volatility transmission between the future prices of gold and oil. In order to predict the price of gold, Hossein et al. (2014) employed both parametric and nonparametric time series models. The study concludes that none of the models can accurately predict the price of gold over the short and long terms. However, the study demonstrates that when it comes to gold price predictions, univariate models outperform multivariate ones.In-depth research on the intricate link between gold prices and the stability of the financial markets was conducted by Akgül et.alin 2015. Using a construct in which gold and the S&P 500 were assumed to be endogenous variables and crude oil was assumed to be an exogenous variable, this study identified the complex relationship and extensively used Bayesian models to find the correlation. The results showed that crude oil prices have a greater impact on the gold and S&P500 indices.One such study by Raza et.al. (2016) examines the influence of gold processes and their relationships with other commodities and finds that gold volatility has a detrimental effect on the broader financial markets, suggesting that gold price volatility is essential to international financial markets.

Gold price variations have been modelled using conventional multiple regression techniques, GARCH and ARIMA time series prediction models, and other mathematical or statistical models. Ismail et.al. (2009) used multiple linear regression (MLR) models to predict gold prices. The commodity research bureau future index, the USD/Euro exchange rate, the inflation rate, the money supply, the New York Stock Exchange Index, the Standard & Poor 500 Index, Treasury bills, and the USD index were among the economic factors taken into account by the study.The study found that gold prices are significantly influenced by the Commodity Research Bureau future index, the USD/EUR foreign exchange rate, the inflation rate, and the money supply. The study found that the MLR model proved to be effective at forecasting the price of gold. Thai gold prices are predicted by Khaemusununun (2009) using multiple regression and the ARIMA model. The study examined the effects of the currencies of the United States, Australia, Canada, Peru, Hong Kong, Japan, Germany, Italy, Singapore, and Colombia, as well as the price of oil and interest rates, on the price of gold. The study found that the prices of gold are significantly influenced by the currencies of the United States, Australia, Canada, and Japan. The analysis found that ARIMA (1, 1, 1) is the most accurate model for forecasting gold prices. Using multivariate regression models, Toraman et. al. (2011) assess the sensitivity of gold prices to several variables. Pung et al. (2013) used the ARIMA and GARCH models to predict Malaysian gold prices. The study comes to the conclusion that the GARCH model outperforms the ARIMA model at forecasting gold prices.Massarrat (2013) forecast the gold price using the ARIMA model. According to the findings, ARIMA (0, 1, 1) is the most accurate model for predicting gold prices. Rebecca et al. (2014) used the ARMA model with a 6-step-ahead forecast model to predict the monthly adjusted closing price of gold. The estimated value is greater than the initial matching pricing. The investigation found that actual values fell within the predicted limits. Mombeini (2015) employed the ARMA model, but the results show that ANN performs better than ARMA. They used data from 1990 to 2006 for training and data from 2006 to 2008 for testing. From November 2003 to January 2014, Bandyopadhyay (2016) forecasted and minimized gold price swings using the ARIMA time series model. Farah et.al. (2016) suggested using the Box Jenkins technique to predict gold prices. Patel (2016) used the logistic regression (LR) model to achieve 63.76 percent precision, 63.89 percent recall, and 61.92 percent accuracy with data spanning eight years. They believe that LR outperforms the SVM. Fang et.al (2018) demonstrated GARCH model with mixed data sampling.

Matenggo et.al. (2020) claim that machine learning and artificial intelligence have lately been used to anticipate the price of a number of financial assets, including gold. Varahrami (2011) discovered that the output of the prediction models fluctuates as a result of the frequent volatility and complex dynamics of price discovery in gold-based assets. Chen (2016) used text mining and artificial neural networks (ANN) to estimate gold prices and compared their results to those obtained using the autoregressive-moving average (ARMA) model.

4. Data and Methodology

Gold price modelling has gained popularity as a result of the Covid 19 pandemic wave and the steadily rising gold price that followed. Using the most popular technique, the Box-Jenkins Auto Regressive Integrated Moving Average, the study's main objective is to forecast gold prices (ARIMA). The study examined yearly data from 1964 to 2022 that included 58 years of gold prices. The gold prices were available on the World Gold Council website (24 carat per 10 grammes). According to Box and Jenkins, time series analysis requires at least 50 observations.

4.1 Autoregressive Integrated Moving Average Model (ARIMA)

The autoregressive integrated moving average (ARIMA) model is a generalisation of the autoregressive moving average (ARMA) model. Box and Jenkins (1976) used the Auto Regressive Integrated Moving Average (ARIMA) model to predict a time series.ARIMA model is divided into three processes: Auto-Regressive Process, Differencing Process and Moving Average Process. *Auto-Regressive process* is the term referring to several series that arise in forecasting equations. *Moving Average Process* is the appearance of lags in model predicting errors. The abbreviation ARIMA *(p, d, q)* stands for the auto-regressive, differencing, and moving average models, respectively. *'p'*stands for the order of the auto-regressive process, *'d'* for the differencing process, and *'q'* for the moving average process.

An autoregressive model is a linear regression of the current value in the series against one or more prior values of the series. In a linear regression model dependent variable Y_t is explained by regressed on its previous values Y_{t-1}. The value of p is the order of the autoregressive model. The order of the process corresponds to the number of parameters that need to be estimated. Autoregressive models can be analyzed with one of the various methods, such as standard linear least square technique. They can also have a straightforward interpretation. A common approach for modeling univariate time series is the autoregressive model. The auto regressive process can be expressed as

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots\ldots + \beta_p Y_{t-p} + e_t \qquad (1)$$

Where,

α= Constant related to the mean of the process.

β= Auto regressive parameter which describes the effect of a unit change in Y_{t-1} on Y_t.

e_t= Random error or white noise series assumed to be normally and independently distributed with mean zero, constant variance $\sigma_e{}^2$ and independent of Y_{t-1}.

Differencing process is used to find whether the time series is stationary or not. It determines whether the observed values are modelled directly, or whether the difference between two consecutive observations is modelled. If $d = 0$, means data is stationery and observations are modelled directly. If $d = 1$, represents the first difference and $d = 2$, represents the second difference and so on. Y_t either represents the raw data or the series obtained after making a transformation to stabilize the variance, such as a logarithmic or a square root transformation. The first difference can be represented by ∇y_t, defined as

$$\nabla y_t = y_t - y_{t-1} \qquad (2)$$

In general, the d^{th} order consecutive difference is represented by $\nabla^d y_t$ and is calculated by consecutively taking differences of the differences.

Moving Average Processdescribes how each observation is a function of the previous q error. For example, if $q=1$, then each observation is a function of only one previous error. i.e,

$$Y_t = \beta + \mu_1 e_{t-1} + e_t \qquad (3)$$

Where,

β= Constant term related to mean of the process,

μ= Moving average parameter which describes the effect of the past error on Y_t and

e_t = Random error.

The ARIMA model has four steps namely model "identification, model estimation, diagnostic checking and forecasting" (Nochai et.al, 2006).

- **Model Identification**

When dealing with stationary data, the ARIMA model might be used. Determine whether the series is stationary or non-stationary using the Auto Correlation Function (ACF) and Partial Autocorrelation Function (PACF).Auto correlation is measured by the simple correlation between current observation (Y_t) and observation p periods before the current one (Y_{t-p}). It is defined as

$$r_p = \frac{\sum_{t=1}^{n-p}(Y_t - \bar{Y})(Y_{t+p} - \bar{Y})}{\sum_{t=1}^{n}(Y_t - \bar{Y})^2} \quad (4)$$

The range is from -1 to +1. Box and Jenkins (1976) has suggested that maximum number of useful r_p are roughly *N/4*, where *N* is the number of periods upon which information on $Y_t$is available(Sharma, Aarti, 2015).Partial autocorrelation is used to measure the degree of association between Y_t and Y_{t-p} when the *Y* effects at other time lag *1, 2, 3…p-1* is removed. Partial correlation function gives an indication for the parameter '*p*'. The time series is stationary if the plot between autocorrelation and lag either stops off or goes out reasonably rapidly; otherwise, it is non-stationary.If the series is not stationary, differencing it can frequently make it stationary. In other words, a number of differences replace the original series. The differenced series is then supplied for an ARIMA model. Differencing continues until the ACF graph either abruptly ends or rapidly slows down. In time-series theory lag or backward linear operator (*B*) is defined as $BY_t = Y_{t-1}$. If the original series is stationary i.e.$d = 0$ then ARIMA model reduces to ARMA model (G. Box, G. Jenkins, 1976). The difference linear operator (Δ), defined by

$$\Delta y_t = y_t - y_{t-1} \quad (5)$$

$$\Delta y_t = y_t - By_t \quad (6)$$

$$\Delta y_t = (1-B)\, y_t \quad (7)$$

The stationary series W_t is obtained as the d^{th} difference (Δ^d) of y_t,

$$W_t = \Delta^d y_t \quad (8)$$

$$W_t = (1-B)^d\, y_t \quad (9)$$

The general form of ARIMA (*p,d,q*) is

$$\phi_p(B)(1-B)^d\, y_t = \mu + \theta_q(B)\varepsilon_t \quad (10)$$

or

$$\phi_p(B)W_t = \mu + \theta_q(B)\varepsilon_t \quad (11)$$

If the series is stationary then we decide the type of model that should be used for forecasting suggested by G. Box, G. Jenkins, 1976. (Table 1)

Table 1: Determine the Model by Using ACF and PACF Patterns

Model	**ACF (Autocorrelation Function)**	**PACF (Partial Autocorrelation Function)**
Auto Regressive (p)	Dies down	Cut off after lag q
Moving Average (q)	Cut off after lag p	Dies down
Auto Regressive, Moving Average (*p*,*q*)	Dies down	Dies down

**Dies down means tend to zero gradually*
**Cut off means disappear or is zero*

Analyzing the autocorrelation and partial auto correlation functions allows us to assess the relative importance of an auto-regressive (AR) and moving average (MA) process. The third order auto-correlation is inflated by the first order auto-correlation, which also causes the second order auto-correlation to be inflated. It is important to construct and plot the partial autocorrelation function for the higher order model in order to examine auto-correlations beyond the first order (or lag) without the fictitious boost from earlier auto correlations. Checks are made for any abrupt drops (cuts) off in the partial auto correlation function. (Keren, et.al, 1993)

- **Model Estimation**

Following the identification stage, one or more models that appear to offer statistically appropriate representations of the available data are tentatively selected.

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- **Model Checking**

This stage involves evaluating the model's suitability by taking the residuals' characteristics into account. An ARIMA model's residuals should be random and have a normal distribution. An overall check of the model adequacy is provided by Ljung-Box Q statistic (G. Box, G. Jenkins, 1976). The Q statistic is:

$$Q_m = n(n+2)\sum_{k=1}^{m}\frac{r^2{}_k(e)}{n-k} \sim X^2{}_{m-r} \qquad (12)$$

Where, $r^2{}_k$ is residual autocorrelation at lag k, n is the number of residuals, m is the number of time lags includes in the test. If the p-value associated with the Q statistic is small (p-value$<\alpha$), the model is considered inadequate. The analyst should consider a new or modified model and continue the analysis until a satisfactory model is obtained.

- **Forecasting with the model**

Model identification is followed by parameter estimates and forecast validation.

5. Results and Discussions:

The 58-year trend in gold prices is depicted on the line graph. It displays a rising trend.

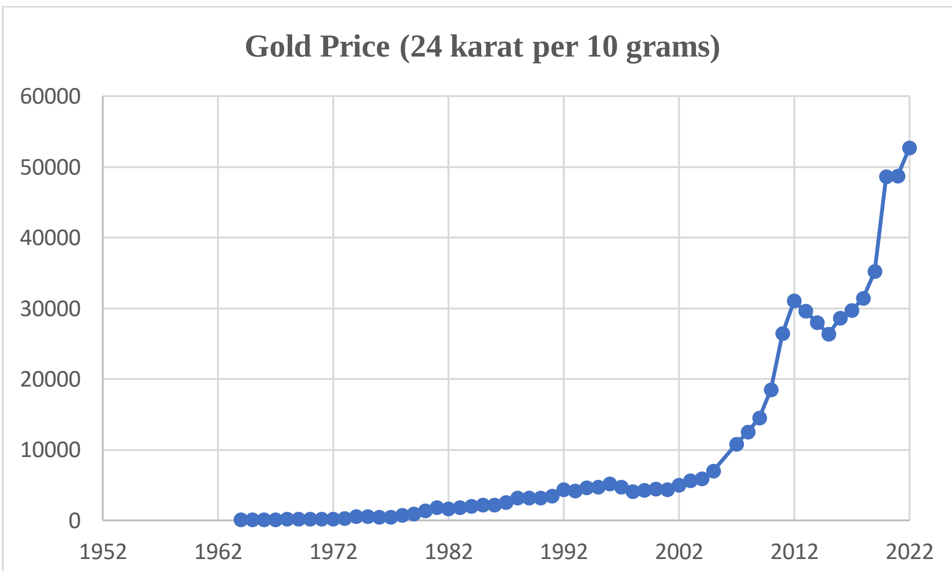

Figure 2: Trend of Gold Price in India

Table 2 displays all the qualities of gold datain India from 1964-2022.

Table 2: Descriptive Statistics of Gold

Gold Price (24 karat per 10 grams)	
Mean	9899.823276
Standard Error	1825.429782
Median	4092.5
Mode	1800
Standard Deviation	13902.05904
Sample Variance	193267245.5
Kurtosis	1.833586068
Skewness	1.670460256
Range	52626.75

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Minimum	63.25
Maximum	52690
Sum	574189.75
Count	58

In order to build ARIMA models for gold price prediction, three stages were taken. The model is identified and the stationary status of the gold price data is assessed using the ACF. In (Figure 3), a nonstationary time series is shown by a very slow linear decay pattern. This problem can be resolved by a first-degree order of differentiation. The fact that the lag 1 autocorrelation explains higher order autocorrelations is shown by the large spike that is present only at lag 1 in both the ACF (Figure 4) and the PACF plots (Figure 5).

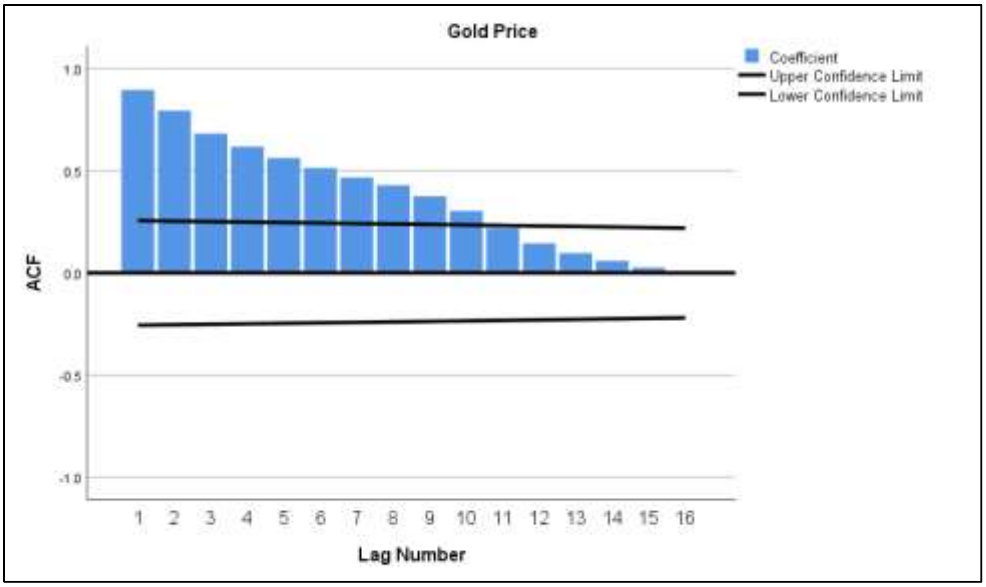

Figure 3:Autocorrelation plot of gold price data used to test for stationarity

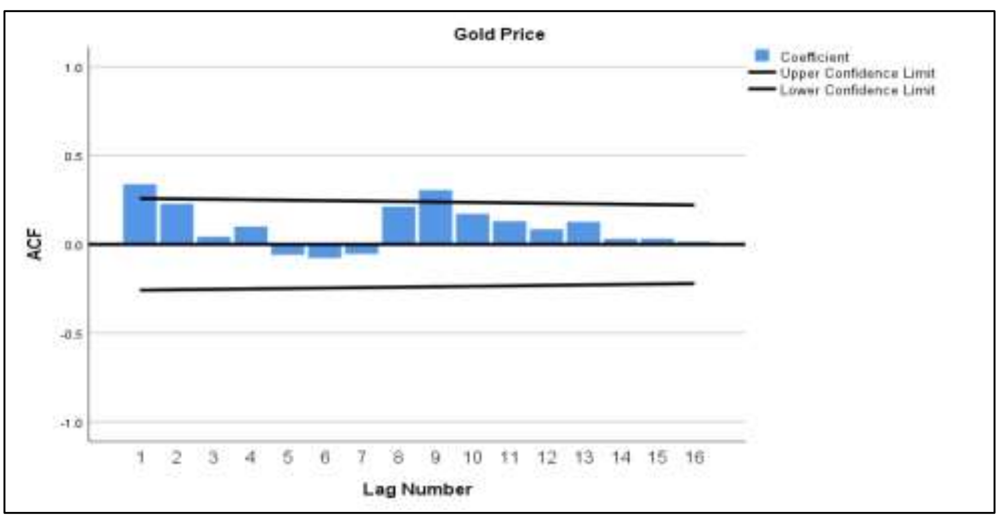

Figure 4:ACF plot after first order differencing of the gold price data.

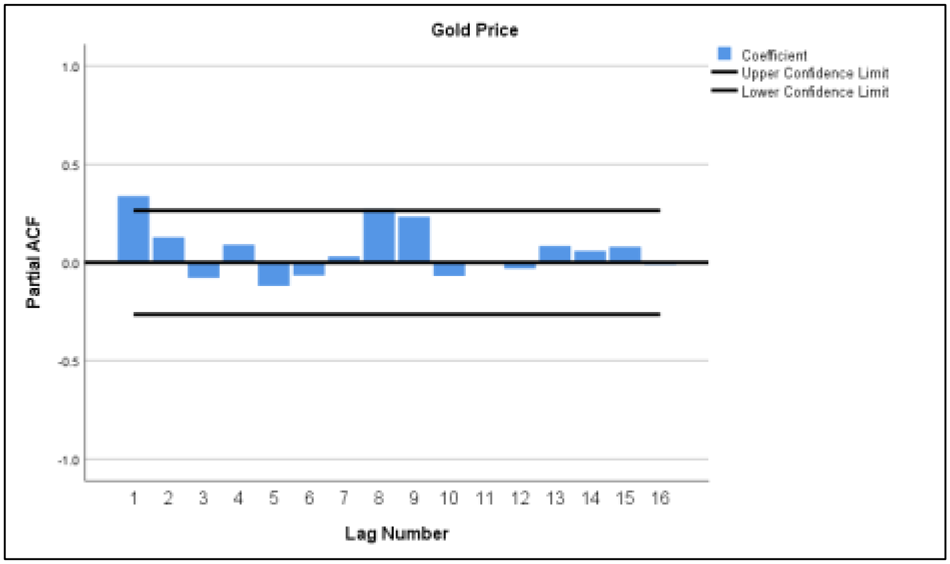

Figure 5:PACF plot after first order differencing of the gold price data.

After extensive trial and error, four models are chosen and assessed in an effort to identify one with a low normal BIC. Among the models in this group are ARIMA (1,1,1), ARIMA (0,1,1), ARIMA (1,1,0), and ARIMA (9,1,1). Expert modelers in SPSS estimate each model parameter using the ARIMA tab.

The ARIMA (0,1,0) model is shown as

$y_t = y_{t-1} + \varepsilon_t$(13)

where y_t is the current year, y_{t-1} is the lagged value and ε_t is the error term.Tables 3 and 4 below display the Fit Statistics of several ARIMA models with and without constants. All the selected models show the lowest RMSE, MAPE, MaxAPE, MAE, MaxAE, and Normalized BIC.

Table 3: Fit Statistics of all selected ARIMA Models with no constant

with no constant				
Fit Statistic	ARIMA (1,1,1)	ARIMA (0,1,1)	ARIMA (1,1,0)	ARIMA (9,1,1)
Stationary R-squared	0.091	-0.012	0.057	0.475
R-squared	0.975	0.972	0.974	0.985
RMSE	2247.327	2350.179	2268.582	1847.513
MAPE	11.776	12.162	11.926	12.606
MaxAPE	39.278	40.428	38.409	43.845
MAE	1031.598	1098.269	1044.974	893.139
MaxAE	11765.229	12426.413	11792.001	5809.029
Normalized BIC	15.577	15.595	15.525	15.752

Table 4: Fit Statistics of all selected ARIMA Models with constant

Include constant in model				
Fit Statistic	ARIMA (1,1,1)	ARIMA (0,1,1)	ARIMA (1,1,0)	ARIMA (9,1,1)
Stationary R-squared	0.13	0.088	0.118	0.472
R-squared	0.976	0.974	0.975	0.985
RMSE	2218.008	2251	2212.759	1871.878
MAPE	92.154	113.647	99.171	102.947
MaxAPE	1325.38	1295.774	1301.831	1364.907

MAE	1153.333	1285.823	1209.204	999.553
MaxAE	11517.805	11819.984	11510.503	5719.272
Normalized BIC	15.622	15.58	15.546	15.85

Tables 5 and 6 display the model statistics with and without constants, respectively. According to Ljung-Box Q statistics, all of the selected ARIMA models had non-significant p values at the 5% level of significance.

Table 5: Ljung Box Statistics with no constant of all selected ARIMA Models

Model Statistics (with no constant)				
	Stationary R-squared	Ljung-Box Q(18)		
		Statistics	DF	Sig.
ARIMA (1,1,1)	0.091	12.498	16	0.709
ARIMA (0,1,1)	-0.012	13.743	17	0.685
ARIMA (1,1,0)	0.057	11.427	17	0.834
ARIMA (9,1,1)	0.475	5.119	8	0.745

Table 6:Ljung Box Statistics with constant of all selected ARIMA Models

Model Statistics (include constant in model)				
	Stationary R-squared	Ljung-Box Q(18)		
		Statistics	DF	Sig.
ARIMA (1,1,1)	0.13	11.395	16	0.784
ARIMA (0,1,1)	0.088	14.509	17	0.631
ARIMA (1,1,0)	0.118	11.376	17	0.836
ARIMA (9,1,1)	0.472	4.477	8	0.812

The following tables 7, 8, 9, and 10 display the predicted values for the ARIMA (1,1), ARIMA (0,1), ARIMA (1,0), and ARIMA (9,1,1) with no constant and constant, respectively, along with lower and upper confidence levels at a significance level of 5%.

Table 7: Forecasted Value of Gold Price by ARIMA (1,1,1) with and without constant

ARIMA (1,1,1) with no constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	53852.54	51066.76	53965.5	49472.42	59124	61599.55	67812.43	66402.09	71512.07	69665.29	72961.28	68065.47	70698.85
LCL	47749.81	42435.19	43475.82	36753.69	44848.81	45630.61	50958.16	48107.16	51518.99	47330.74	48565.07	41086.92	41413.27
UCL	59955.27	59698.32	64455.19	62191.15	73399.2	77568.5	84666.71	84697.03	91505.14	91999.84	97357.5	95044.02	99984.44
ARIMA (1,1,1) include constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	53933.79	50864.71	53843.44	49160.38	58618.54	61074.33	67338.41	65880.84	71336.3	69295.06	72677.71	67799.47	70329.73

LCL	47852.5	42359.01	43613.53	36847.84	44949.8	45936.01	51518.47	48898.08	52971.93	48939.45	50651.58	43589.4	44238.7
UCL	60015.08	59370.4	64073.34	61472.91	72287.27	76212.65	83158.35	82863.59	89700.68	89650.68	94703.84	92009.54	96420.75

Table 8:Forecasted Value of Gold Price by ARIMA (0,1,1) with and without constant

ARIMA (0,1,1) with no constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	55612.24	56550.45	57488.67	58426.89	59365.11	60303.33	61241.54	62179.76	63117.98	64056.2	64994.41	65932.63	66870.85
LCL	48361.8	47342.22	46671.35	46210.61	45894.39	45685.42	45560.16	45502.57	45501.18	45547.43	45634.73	45757.89	45912.72
UCL	62862.67	65758.69	68306	70643.16	72835.82	74921.23	76922.93	78856.95	80734.78	82564.96	84354.1	86107.37	87828.98
ARIMA (0,1,1) include constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	55156.07	55479.19	55619.22	55679.9	55706.2	55717.6	55722.54	55724.68	55725.6	55726.01	55726.18	55726.26	55726.29
LCL	47213.5	44645.73	42306.43	40200.79	38297.08	36559.5	34957.25	33465.93	32066.66	30744.88	29489.28	28290.94	27142.73
UCL	63098.64	66312.65	68932	71159.01	73115.32	74875.7	76487.82	77983.42	79384.55	80707.13	81963.08	83161.57	84309.85

Table 9:Forecasted Value of Gold Price by ARIMA (1,1,0) with and without constant

ARIMA (1,1,0) with no constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	55976.92	57043.17	58028.33	58985.56	59933.18	60877.48	61820.65	62763.42	63706.05	64648.64	65591.21	66533.78	67476.34
LCL	48548.21	47181.09	46123.79	45310.35	44682.14	44195.84	43820.8	43535.22	43323.29	43173.27	43076.18	43025.01	43014.18
UCL	63405.63	66905.25	69932.87	72660.77	75184.22	77559.12	79820.49	81991.61	84088.81	86124.01	88106.25	90042.55	91938.51
ARIMA (1,1,0) include constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	54536.55	55459.83	56383.11	57306.38	58229.66	59152.93	60076.21	60999.49	61922.76	62846.04	63769.32	64692.59	65615.87
LCL	47919.65	47355.81	47025.4	46844.14	46768.85	46773.85	46842.41	46962.92	47126.93	47328.03	47561.29	47822.74	48109.2
UCL	61153.45	63563.84	65740.81	67768.62	69690.46	71532.02	73310.01	75036.05	76718.6	78364.04	79977.34	81562.44	83122.54

Table 10:Forecasted Value of Gold Price by ARIMA (9,1,1) with and without constant

ARIMA (9,1,1) with no constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Forecast	53852.54	51066.76	53965.5	49472.42	59124	61599.55	67812.43	66402.09	71512.07	69665.29	72961.28	68065.47	70698.85
LCL	47749.81	42435.19	43475.82	36753.69	44848.81	45630.61	50958.16	48107.16	51518.99	47330.74	48565.07	41086.92	41413.27
UCL	59955.27	59698.32	64455.19	62191.15	73399.2	77568.5	84666.71	84697.03	91505.14	91999.84	97357.5	95044.02	99984.44

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ARIMA (9,1,1) include constant													
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Fore cast	5393 3.79	5086 4.71	5384 3.44	4916 0.38	5861 8.54	6107 4.33	6733 8.41	6588 0.84	7133 6.3	6929 5.06	7267 7.71	6779 9.47	7032 9.73
LCL	4785 2.5	4235 9.01	4361 3.53	3684 7.84	4494 9.8	4593 6.01	5151 8.47	4889 8.08	5297 1.93	4893 9.45	5065 1.58	4358 9.4	4423 8.7
UCL	6001 5.08	5937 0.4	6407 3.34	6147 2.91	7228 7.27	7621 2.65	8315 8.35	8286 3.59	8970 0.68	8965 0.68	9470 3.84	9200 9.54	9642 0.75

Figure-6 shows the graph of observed and forecasted trend of gold price by ARIMA models with and without constant.

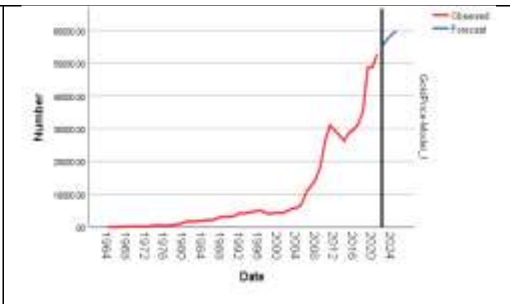
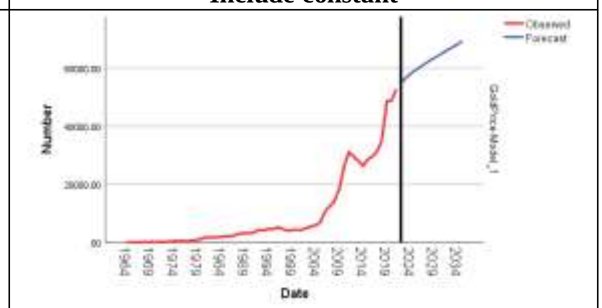
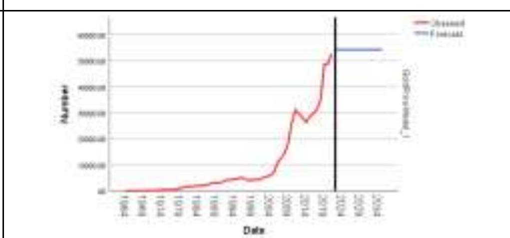
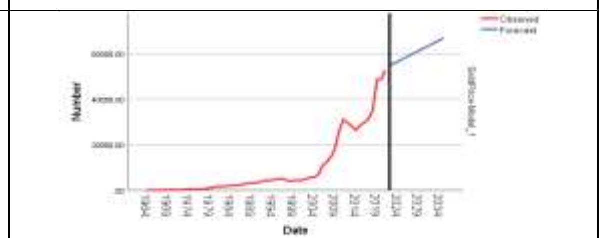
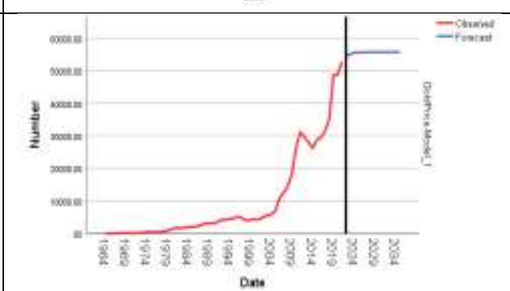
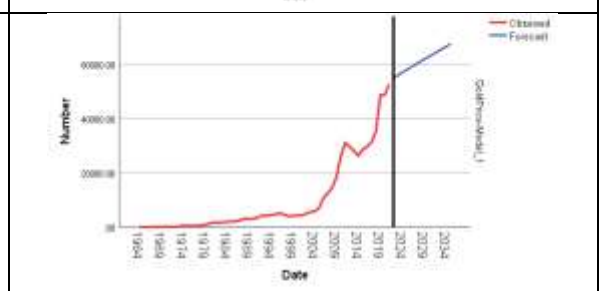
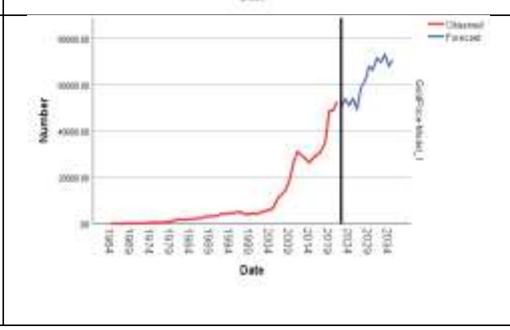
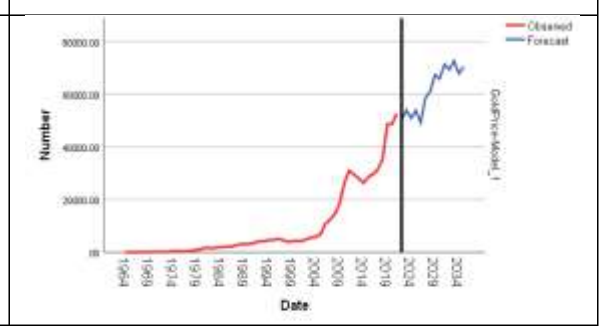
	With no constant	**Include constant**
ARIMA (1,1,1)		
ARIMA (0,1,1)		
ARIMA (1,1,0)		
ARIMA (9,1,1)		

Figure 6:Graph of observed and forecasted trend of gold price by ARIMA models with and without constant

6. Conclusion

One of the most valuable metals to date is gold. Gold is the foundation of all economies. One of the most important commodities traded on the global financial markets, it is viewed as an asset that holds its real worth as opposed to currencies depreciating in value. In addition to the supply and demand for the commodity on the market, the performance of the world's top economies has a considerable effect on gold rates. Gold is regarded as a safe asset since its physical worth is higher than its value in terms of exchange rates. Investors have flocked to gold assets during bad market times. This study's main objective is to make predictions about gold prices using the most popular technique, the Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA). Annual data from 1964 to 2022, spanning 58 years of gold prices, were used in the study. Based on three factors, we chose the ARIMA model (p, d, q). We calculated future gold prices, ran a diagnostic study, and made a prediction. Four models are chosen and assessed in order to choose a model with low normal BIC. These are ARIMA (1,1,1), ARIMA (0,1,1), ARIMA (1,1,0), and ARIMA (9,1,1).We forecasted gold prices for the period 2023-2035. The study examines the MAE, RMSE, Max AE, and MAPE in order to evaluate the model's accuracy.The outcome indicates that, in line with all credible forecasts, gold prices will increase in the following years. As a result, there is a considerable likelihood that gold investments will yield higher returns. Investors, economists, market regulators, and policymakers can make better investment decisions and develop proper risk management tools with a better understanding of the effectiveness of the gold price.

References

1) Aggarwal, R. and Soenen, L. A. (1988), “The Nature and Efficiency of Gold Market”, Journal of Portfolio Management, Vol. 14, No. 3, pp.
2) Akgül, I., Bildirici, M., &Özdemir, S. (2015). Evaluating the Nonlinear Linkage between Gold Prices and Stock Market Index Using Markov-Switching Bayesian VAR Models. *Procedia - Social and Behavioral Sciences*, *210*, 408–415. https://doi.org/10.1016/j.sbspro.2015.11.388
3) Baber, Prerana& Baber, Ruturaj& G, Thomas. (2013). Factors Affecting Gold Prices: A Case Study of India.
4) Brockwell, Peter & Davis, Richard. (2002). An Introduction to Time Series and Forecasting. 10.1007/978-1-4757-2526-1.
5) B. Guha, G. Bandyopadhyay, Gold Price Forecasting Using ARIMA Model, J. Adv. Manage. Sci. 4(2) (2016), 118-121.
6) C. Toraman, Ç. Basarir, and M. F. Bayramoglu, “Determination of factors affecting the price of gold: A study of MGARCH model,” Bus. Econ. Res. J., vol. 2, no.4, p. 37, 2011.
7) Ewing, B.T., Malik, F. (2013), Volatility transmission between gold and oil futures under structural breaks. International Review of Economics and Finance, 25(C), 113-121.
8) Khaemusunun, P. (2009), Forecasting Thai Gold Prices. Available from: http://www.wbiconpro.com/3-Pravit-.pdf
9) Fang, L., Chen, B., Yu, H., & Qian, Y. (2018). The importance of global economic policy uncertainty in predicting gold futures market volatility: A GARCH-MIDAS approach. *Journal of Futures Markets, 38*(3), 413–422. https://doi.org/10.1002/fut.21897
10) G. Box, G. Jenkins, Time Series Analysis, Forecasting and Control, Holden Day, California, USA, 1976.
11) H. Akaike, A New look of the statistical model identification, IEEE Trans. Autom. Control, 19 (6) (1974), 716-723.
12) Hassani, H., Silva, E. S., Gupta, R., &Segnon, M. K. (2015). Forecasting the price of gold. Applied Economics, 47(39), 4141-4152.
13) H. Mombeini and A. Yazdani-Chamzini, “Modeling gold price via artificial neural network,” J. Econ. Bus. Manag., vol. 3, no. 7, pp. 699–703, 2015.
14) Hammoudeh, S., Yuan, Y., McAleer, M., Thompson, M. (2010), Precious metals-exchange rate volatility transmission and hedging strategies. International Review of Economics and Finance, 19(4), 698-710.
15) Han, K. K. Lai, S. Wang, and S. Xu, “An interval method for studying the relationship between the Australian dollar exchange rate and the gold price,” J. Syst. Sci. Complex., vol. 25, no. 1, pp. 121–132, 2012.
16) Helmut Gründl, Ming (Ivy) Dong, Jens Gal*, The evolution of insurer portfolio investment strategies for long-term investing, OECD Journal: Financial Market Trends Volume 2016 Issue 1
17) Hossein, H., Emmanuel, S.S., Rangan, G. (2014), Forecasting the Price of Gold. Department of Economics Working Paper Series, University of Pretoria, Working Paper: 2014-28, June.
18) Ismail, Z., Yahya, A., Shabri, A. (2009), Forecasting gold prices using multiple linear regression method. American Journal of Applied Sciences, 6(8), 1509-1514.

DOI:10.9756/INTJECSE/V14I5.715 ISSN: 1308-5581 Vol 14, Issue 05 2022

19) Massarrat, A.K. (2013), Forecasting of gold prices (box Jenkins approach). International Journal of Emerging Technology and Advanced Engineering, 3(3), 662-670.
20) Matenggo, R., Bhakti, A., & Bakar, A. (2020). Gold price prediction in times of financial and geopolitical uncertainty : A machine learning approach, (September). https://doi.org/10.13140/RG.2.2.31050.39366
21) M. C. &. C.-C. C. Hsin-Hung Chen, "The Integration of Artificial Neural Networks and Text Mining to Forecast Gold Futures Prices," *Communications in Statistics - Simulation and Computation,* pp. 1532-414, 2016.
22) Larry, A.S., Fabio, S. (1996), The price of gold and the exchange rates. Journal of International Money and Finance, 15(6), 879-897.
23) Naliniprava Tripathy, Forecasting Gold Price with Auto Regressive Integrated Moving Average Model, International Journal of Economics and Financial Issues, 2017, 7(4), 324-329.
24) Naz, F., & Ahmad, Z. (2016). Forecasting of Indian Gold Prices Using Box Jenkins Methodology. *Journal of Indian Studies*, *2*(1), 75-83.
25) N. Sandhyarani, D. Veeraiah, M. Shanmugam, B. Raviraju, J. Amudhavel, An enhanced ARIMA model for predicting life cycle of the batteries for remote Wi-Fi enabled device, J. Adv. Res. Dyn. Control Syst. 9(12) (2017), 1183-1197
26) Raza, N., Jawad Hussain Shahzad, S., Tiwari, A. K., & Shahbaz, M. (2016). Asymmetric impact of gold, oil prices and their volatilities on stock prices of emerging markets. *Resources Policy*, *49*, 290–301. https://doi.org/10.1016/j.resourpol.2016.06.011
27) P. V. M. V. P. G. M. P. Sima P Patel, "Gold Market Analyzer using Selection based Algorithm," *International Journal of Advanced Engineering Research and Science (IJAERS),* vol. 3, no. 4, pp. 55-102, 2016.
28) Pung, Y.P., Nor, H.M., Maizah, H.A. (2013), Forecasting Malaysian gold using GARCH model. Applied Mathematical Sciences, 7(58), 2879-2884.
29) Rebecaa, D., Dedu, V.K., Bonye, F. (2014), Modeling and forecasting of gold prices on financial markets. American International Journal of Contemporary Research, 4(3), 107-113.
30) Saranya, P. B. (2021). Modelling and forecasting gold prices using Arima. *Asian Journal of Research in Business Economics and Management*, *11*(7), 1-10.
31) Stijn Claessens and M. AyhanKose, Financial Crises: Explanations, Types, and Implications, 2013 working paper of International Monetary Fund
32) Sharma, Aarti. (2015). Gold price Forecasting In India using ARIMA modelling. GE-International Journal of Management Research. 3. 14-33.
33) Varahrami, V. (2011). Recognition of Good Prediction of Gold Price Between MLFF and GMDH Neural Network. *Journal of Economics and International Finance*, *3*(4), 204–210.
34) V. K. F. B. Rebecca Davis, "Modeling and Forecasting of Gold Prices on Financial Markets," *American International Journal of Contemporary Research,* pp. Vol 4, No 3, 2014.
35) Y.-C. Hossein Mombeini, "Modelling Gold Price via Artificial Neural Network," *Journal of Economics, Business and Mangement,* vol. 3, no. 7, pp. 699-703, 2015.
36) Tripathy, Naliniprava. (2016). A Study on Dynamic Relationship between Gold Price and Stock Market Price in India. European Journal of Economics, Finance and Administrative Sciences.
37) https://www.livemint.com/money/personal-finance/does-gold-s-underperformance-and-short-bursts-of-price-rise-help-its-long-term-returns-11642093819220.html
38) https://www.metalsfocus.com/wp-content/uploads/2020/11/GOLD-FOCUS-2020.pdf
39) https://www.imf.org/en/About/Factsheets/Sheets/2016/08/01/14/42/Gold-in-the-IMF
40) https://www.gold.org/goldhub/research/gold-investor/gold-investor-july-2018/13231