

Original Research Article

Forecast Analysis of Ghana's Gross Domestic Product in Economic Growth using Time Series ARIMA

Abstract

This paper **analyses** Ghana's gross domestic product using time series Autoregressive Integrated Moving Average (ARIMA). Time series analysis involves the application of statistical models to time series data and is useful for analysing the dynamics of Gross domestic product. The Ghana's Gross domestic products (GDP) from 1980 to 2020 were obtained from the International Monetary Fund (IMF) datasets. Box Jenkins's methodology of time series analysis was employed to analyse the data. The autocorrelation function (ACF) and partial autocorrelation function (PACF) plot suggested an Autoregression of order one AR(1). The (ARIMA) models were obtained using the minimum AIC criteria. Model diagnostics tests were performed using Ljung-Box test. The paper established that Ghana's GDP will incline throughout the period of 2021-2025.

Key words: Gross Domestic Product (GDP), Stationarity, ARIMA Models, Time Series

Introduction

Time series analysis is a useful technique for policy decision making especially in healthcare, finance, business, economics and etc. Gross domestic products (GDP) plays a significant role in all economies as it helps the government in the preparation of the budget and also permits government agencies to make forecasts which assist in the study of the growing an economy as well as performing economically (Parkin and Bade, 2021). The application of time series in studying the general behavior of Ghana's Gross domestic products (GDP), identifying the fluctuations in its total monetary value indicators on the distribution of resources and market value, of finished goods and services produced within is important (Storbieski, 2021). In this sense, it's a measurement of domestic production and can be used to measure a country's economic health (Storbieski, 2021). When compared with prior periods, GDP tells us whether the economy is expanding by producing more goods and services, or contracting due to less output (Fagan, 2019). Policymakers, government officials, businesses, economists and the public alike rely on GDP to assess the economy's well-being and make informed decisions (Fagan, 2019). In this regard, this study is very important. There are four components of GDP namely consumption, investment, government and exports and imports (Storbieski, 2021).

Asenso, *et al.*, (2017) in their research of modelling and forecasting GDP in the Ghanaian economy, applied Autoregressive Integrated Moving Average model (ARIMA) in modelling their data. Their analysis was carried out using the GDP data of Ghana from 1970-2014 and came out with ARIMA (0, 1, 0) model. Forecasting was done for the GDP for the period 2015-2020 and the forecasted values compared with the values from the Ghana Statistical service and other international forecasting organizations. The forecasted values revealed

showed that the GDP for 2015 will be 37:365 billion USD and that of 2016 will be 38:086 billion USD. Asenso *et al.*, (2017) result has been in line with the annual report given by the Ghana statistical service, which gave a GDP of 36.66 billion USD for the first two quarters of 2015 service (2015). The results from the forecast revealed that the GDP of Ghana is mostly influenced by external factors and may experience an increase for the period 2015-2020.

Barbara, *et al.*, (2022), in their research on modeling and forecast of Ghana's GDP used ARIMA-GARCH model approach of time series analysis.. Their paper analysed a combination of both linear and non-linear time series models in making forecast of Ghana's GDP. The data used in the analysis were from 1980 to 2019 on Ghana's GDP current prices. Based on the AIC values, the best model selected was ARIMA (2, 2, 2) which was used in modeling the data, except that it is heteroscedastic. The combination with non-linear GARCH (1, 1) model was used to capture their variances over time. The diagnostics test further showed that the presented model is stable and quite reliable. Their study results discovered that the GDP of Ghana will continue to increase for the next 10 years which confirms that the nation is moving forward.

Gil-Alana, et. al., (2021) researched into the GDP per capita in sub-saharan Africa using long memory time series approach. Their paper examined GDP per capita in sub-Saharan Africa, and its properties through fractional integration. Their research further discussed the comparative institutional characteristics that underpin the growth properties of selected African countries. The use of time series enabled them to the study the trends, mean-reversion, nonstationary and breaks in a more flexible way than standard methods. Their findings, revealed negative relationships between level of income and persistence, inferring that countries with higher levels of GDP display lower degrees of integration, and thus effects of shocks disappearing faster than those in poorer countries (Gil-Alana *et al.*, 2021).

Etuk, (2012) worked on a seasonal ARIMA model for the Nigerian Gross Domestic Product.. A seasonal difference and then a non-seasonal one were obtained. The correlogram of the differenced series revealed seasonality of order 4. It also reveals an autocorrelation structure of a known seasonal model involving a seasonal autoregressive component of order one and a non-seasonal moving average component of order one. The selected model showed to be adequate in modelling Nigerian GDP series, which follows the seasonal model of $0.2356X_{t-4} - 0.9043\varepsilon_{t-1} + e_t$.

Elsayir (2018) investigated on the econometric time series model analysis of Sudan using statistical evidences and investigations provided an analysis for a time series data on gross domestic product (GDP). An econometric time series model with macroeconomic variables was conducted. Box-Jenkins procedure was used to determine the ARIMA model. It was found that the ARIMA (0, 0, 0) was the best model for the data and ordinary least squares (OLS) was used to estimate the model parameters. Performances chosen ARIMA model is verified on the basis of classical statistical tests and forecasting. The model features were interpreted on the basis of standard measures of forecasting performance. In conclusion, Sudan GDP annual growth Rate forecasts in billion US\$ as 99.51 (2017), 101 (2018), 106.58

(2019) and 112.62 (2020). The Annual growth rates were estimated to be about 5.3%, 5.36%, 5.52% and 5.67% for the above years respectively.

2. Objective

The gross domestic product (GDP) figure is not just the basis for diagnosing the economic problem. It is worthwhile for correcting it as well. The objective of a government policy is measured by the impact it has on GDP. However, a declining GDP would suggest a shrinking economy, which needs to be reversed before the economy go into recession thus affecting businesses and governmental policies. Most economist and businesses like to see GDP rising steadily (Anon., 2021). Hence, there is a need to ascertain whether this situation in Ghana is true with respect to IMF dataset.

3. Research Aim

The research aim is to select the best model using time series Autoregressive Integrated Moving Average (ARIMA). that is the most efficient in predicting Ghana's GDP.

4. Materials and Methods

The data used in this paper are yearly Gross Domestic Products (GDP) from 1980 to 2020 obtained from IMF GDP prices dataset for Ghana which is a secondary data obtained from the IMF at (Anon., 2021b). A time series analysis method is used to analyse the GDP data.

4.1 Time Series Analysis

4.1.1 Autoregressive Integrated Moving Average (ARIMA) Model

The Box-Jenkins model is based on two assumptions of the data, that is stationarity of the autoregressive (AR) model and invertibility of the moving average (MA) (Box *et al.*, 2016). Differencing is done to non-stationary time series having variation in the mean. To remove such variation, the method of integration is adopted. The series is called an integrated time series. The general model is $ARIMA(p, d, q)$ where p is the order of the AR part, d is the degree of differencing and q is the order of the MA part. The ARIMA process according to Anon., (2018) is written as

$$Y_t = \nabla^d Y_t = (1 - B)^d Y_t \quad (1)$$

The general ARIMA process is of the form:

$$Y_t = \sum_{i=1}^p \alpha_i Y_{t-i} + \sum_{i=1}^q \theta_i e_{t-i} + \mu + e_t \quad (2)$$

An example of ARIMA (p, d, q) process is the ARIMA (1, 1, 1) which has one autoregressive parameter, one level of differencing and one MA parameter and is given by

$$Y_t = \alpha_1 Y_{t-1} + \theta_1 e_{t-1} + \mu + e_t \quad (3)$$

$$(1 - B)Y_t = \alpha_1(1 - B)Y_{t-1} + \theta_1 e_{t-1} + \mu + e_t \quad (4)$$

which can be simplified further as

$$Y_t - Y_{t-1} = \alpha_1 Y_{t-1} + \alpha_1 Y_{t-2} + \theta_1 e_{t-1} + \mu + e_t$$

$$Y_t - Y_{t-1} = \alpha_1 (Y_{t-1} - Y_{t-2}) + \theta_1 e_{t-1} + \mu + e_t \quad (5)$$

The general behaviour of the ACF and PACF for ARMA/ARIMA models is summarized in Table 1 (Anon., 2021a).

Table 1: Behavior of ACF and PACF for ARMA models

	AR(p)	MA (q)	ARMA(p, q), p > 0, and q
ACF	Tails off	Cuts off after lag q	Tails off
PACF	Cuts off after lag p	Tails off	Tails off

4.1.2 Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF)

ACF measures linear dependence in time series, k time periods apart and plots the average correlation between data points in a time series and previous values of the series measured for different lag lengths (Reid & Allum, 2020). PACF measures linear dependence in time series k accounting for the values of the intervals as well as points of time as a function of the lag t . A PACF is similar to an ACF except that each correlation controls for any correlation between observations of a shorter lag length (Reid et al., 2020). However, the ACF plot will indicate if there is a seasonal component to the data. If there exist some spikes at regular intervals or lags, then the data contains a seasonal component. This is fixed by taking a moving average of one on the raw data. When there are spikes at regular intervals in the time plot, then the model has a seasonal component.

4.1.3 Model Identification

The model identification involves testing the data for stationarity and seasonality, as well as determining the order of the model's p , d , and q components. We used the unit root test, also known as the Augmented Dickey-fuller (ADF) test, in testing for stationarity. The ADF test employs the unit root test to determine whether or not differencing is required. When the data is not stationary, differencing will be required before the data can be integrated and then the integrated component of the Box-Jenkins model can be introduced.

4.1.4 Diagnostic Testing of the Model

Ljung-Box statistic is a diagnostic tool used to examine residuals from a time series model in order to see if all underlying population autocorrelations for the errors may be 0 (up to a specified point). It is purely based on the autocorrelation plot. Instead of testing for at each distinct lag, it tests rather the overall randomness based on a number of lags. The residuals are assumed to be “white noise,” meaning that they are identically, independently distributed (from each other). The ACF for residuals is that all autocorrelations are 0. This means that $Q(m)$ should be 0 for any lag m . A significant $Q(m)$ for residuals indicates a possible problem with the model. $Q(m)$ measures accumulated autocorrelation up to lag m (Anon.2018).

$$Q(m) = n(n + 2) \sum_{j=1}^m \frac{r_j^2}{n-j} \quad (6)$$

where n is the sample size after any differencing operation, and the test statistic follows the chi-square distribution with degrees of freedom (df) = $m-p$. The normal Q-Q plot is used to test the white noise component and the normality assumption.

5. Results and Discussion

Table 2: Descriptive Statistics

Sum	1331.90
Observation	41
Mean	32.4854
Range	58.94
Maximum	70.41
Minimum	11.47
Standard Deviation	20.75082
Skewness	0.583
Kurtosis	-1.280

Table 2 shows a summary of descriptive statistics on the GDP prices for the period under consideration (1980-2020). Overall, on the average, Ghana’s GDP price performance over the years (1980-2020) stood at 32.4854 Billion of U.S dollars. Under the period of review, the least GDP price for Ghana was 11.47(Billions of U.S dollars) and the highest recorded GDP price value was 70.41 (Billions of U.S dollars).

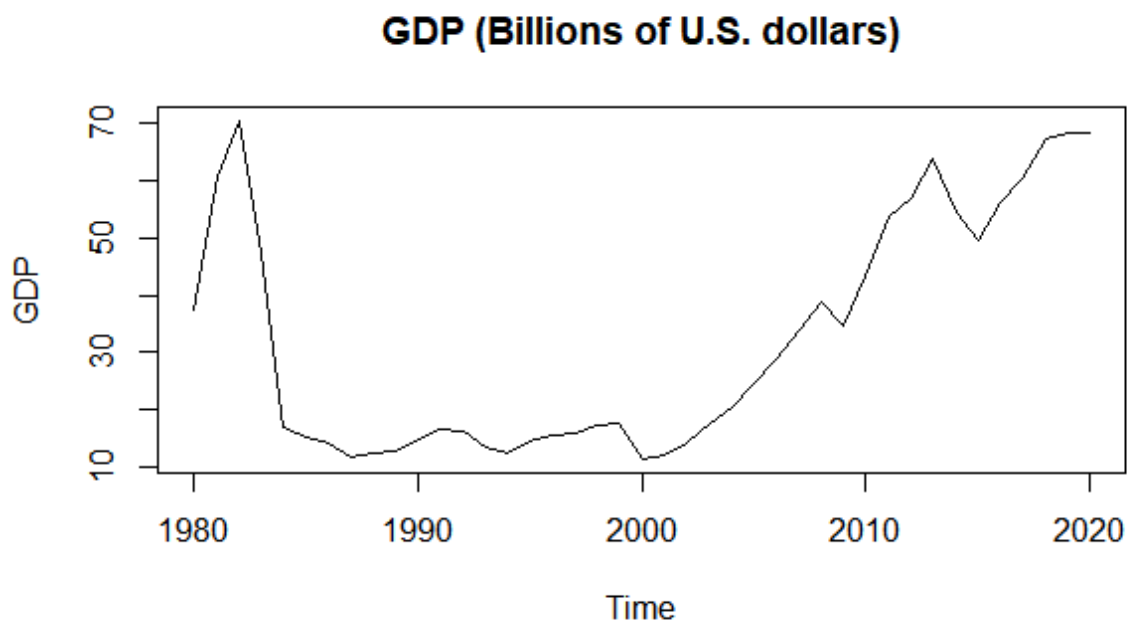


Figure 1. The plot of the time series of yearly GDP for the period 1980-2020

Figure 1 shows the plot of yearly data of Ghana's GDP from 1980–2020. From Figure 1 we observed the upward trend from 2000 to 2020, an indication that the data is not stationary. A further test to check the stationary was carried out using Dickey Fuller tests as shown in Table 3

Table 3: Augmented Dicky-Fuller Test for Stationarity

Data	Dickey-Fuller	Lag Order	P-value	Alpha value
Before differencing	-1.5887	0	0.7353	0.05
After differencing	5.3645	0	0.01	0.05

Augmented Dicky-Fuller Hypothesis Test for Stationarity

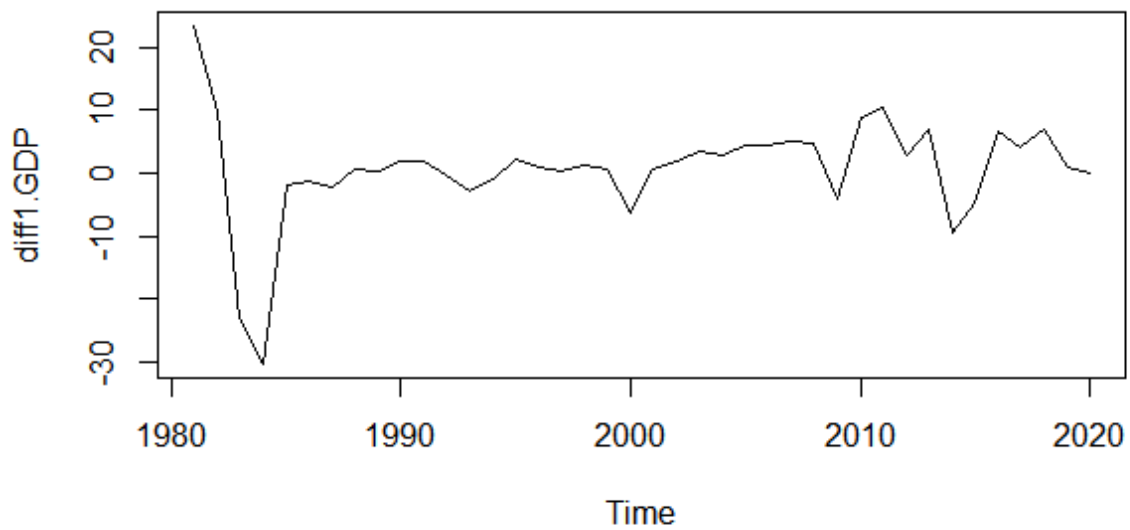
$H_o = \text{Series is non - stationary}$

$H_a = \text{Series is stationary}$

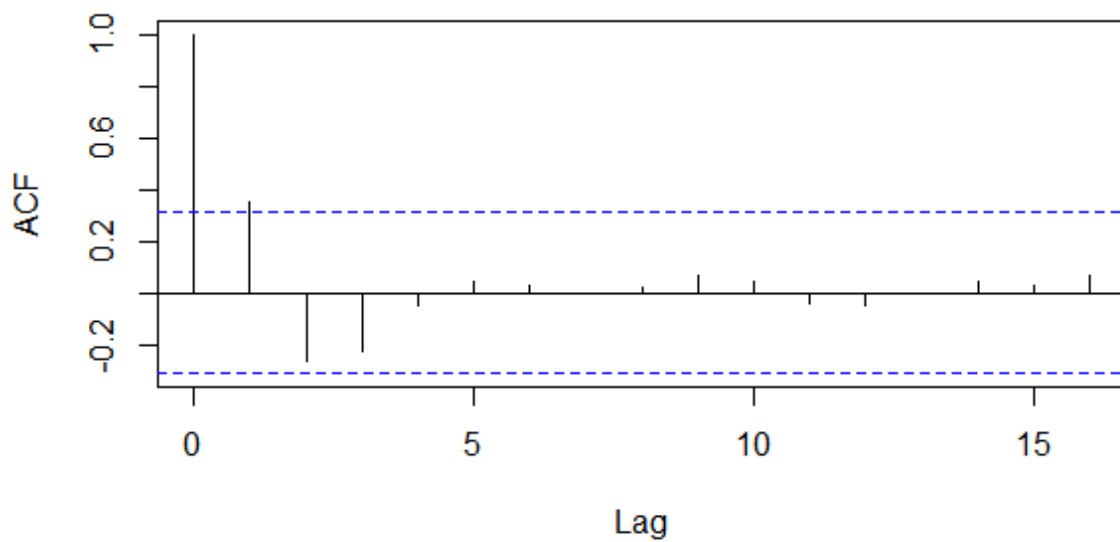
From Table 3, since the GDP data before differencing p-value of 0.7353 is greater than alpha value $\alpha=0.05$, we fail to reject the null hypothesis and conclude that the series of the before differencing GDP data is non stationary. After the differenced GDP data, since the p-value=0.01 is less than the significance level of alpha $\alpha=0.05$, we reject the null hypothesis

and accept the alternative hypothesis therefore conclude that the series of the differenced GDP data is stationary. The differenced series can now be used for forecasting.

diff1 GDP (Billions of U.S. dollars)



Series diff1.GDP



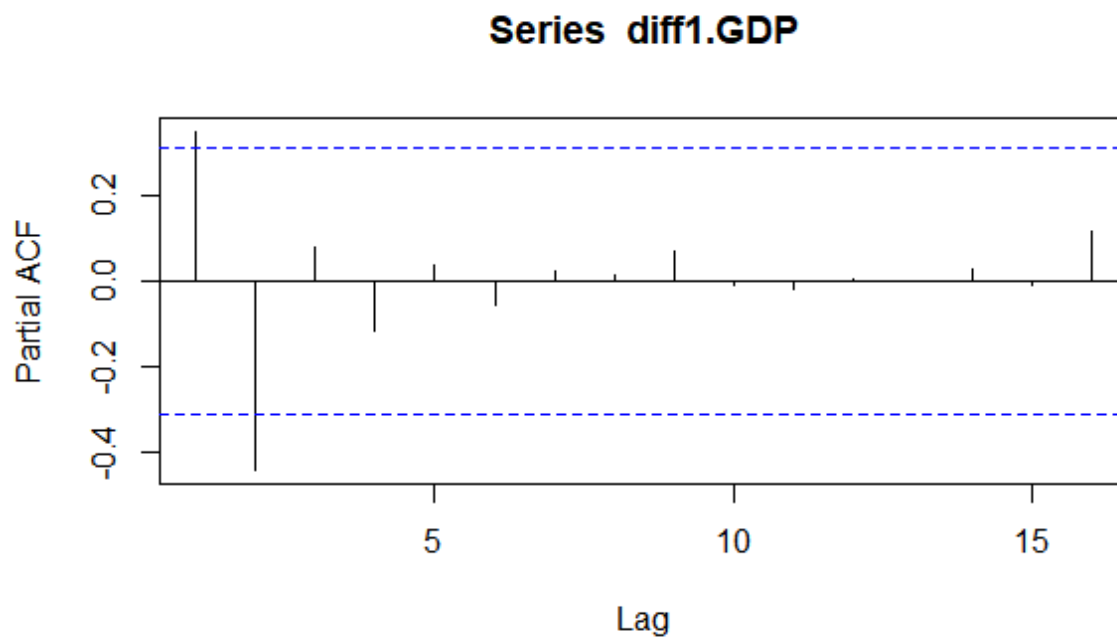


Figure 2: Autocorrelation and partial autocorrelation functions of GDP differenced data

Figure 2 plot were obtained when the data was transformed to obtain the ACF and PACF plots above which suggest that, the series is a mixture of AR and MA process.

Table 4: Summary of models for GDP data

MODEL	AIC Value	S.E ar1	S.E ar2	S.E ma1	S.E ma2
ARIMA(0,1,1)	6.805434			0.8114	
ARIMA(2,1,2)	6.886469	0.3542	0.2132	0.3156	0.2960
ARIMA(1,1,1)	6.84557	0.1910		0.1017	

The summary of the models is given in Table 4. The AIC of the model shows that AR1MA (0, 1, 1) model has the least AIC value of 6.805434 is a better model and thus chosen.

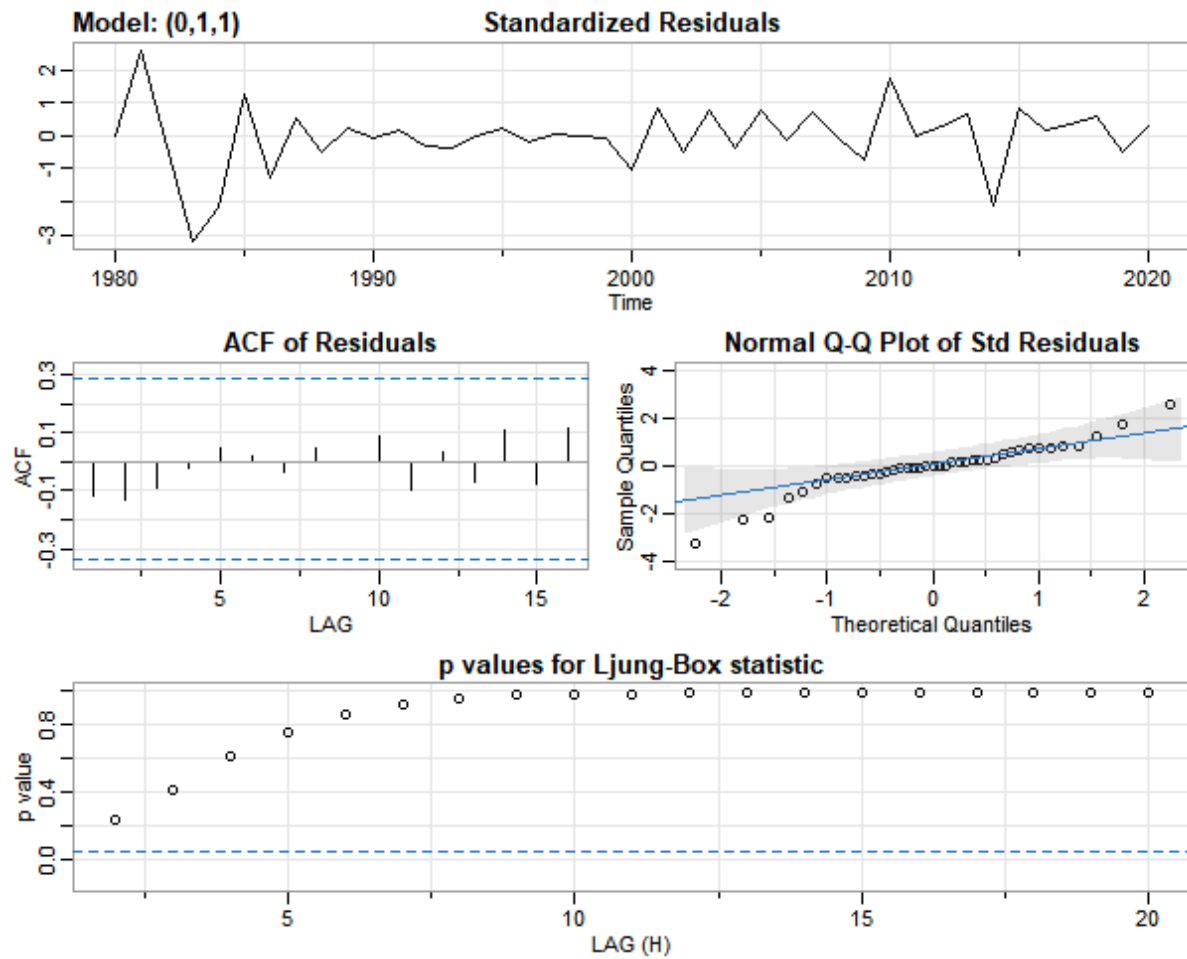


Figure 3: Model diagnostics of GDP data from Ljung-Box test showing the residuals are uncorrelated (ACF plot), independent and normally distributed by the QQ-plot.

5.1 Forecasting GDP for Ghana

The best ARIMA model, ARIMA (0, 1, 1) obtained from the GDP data were used to make a 5-year forecast. The forecasted values are presented in Table 4 and illustrated graphically in Figures 3.

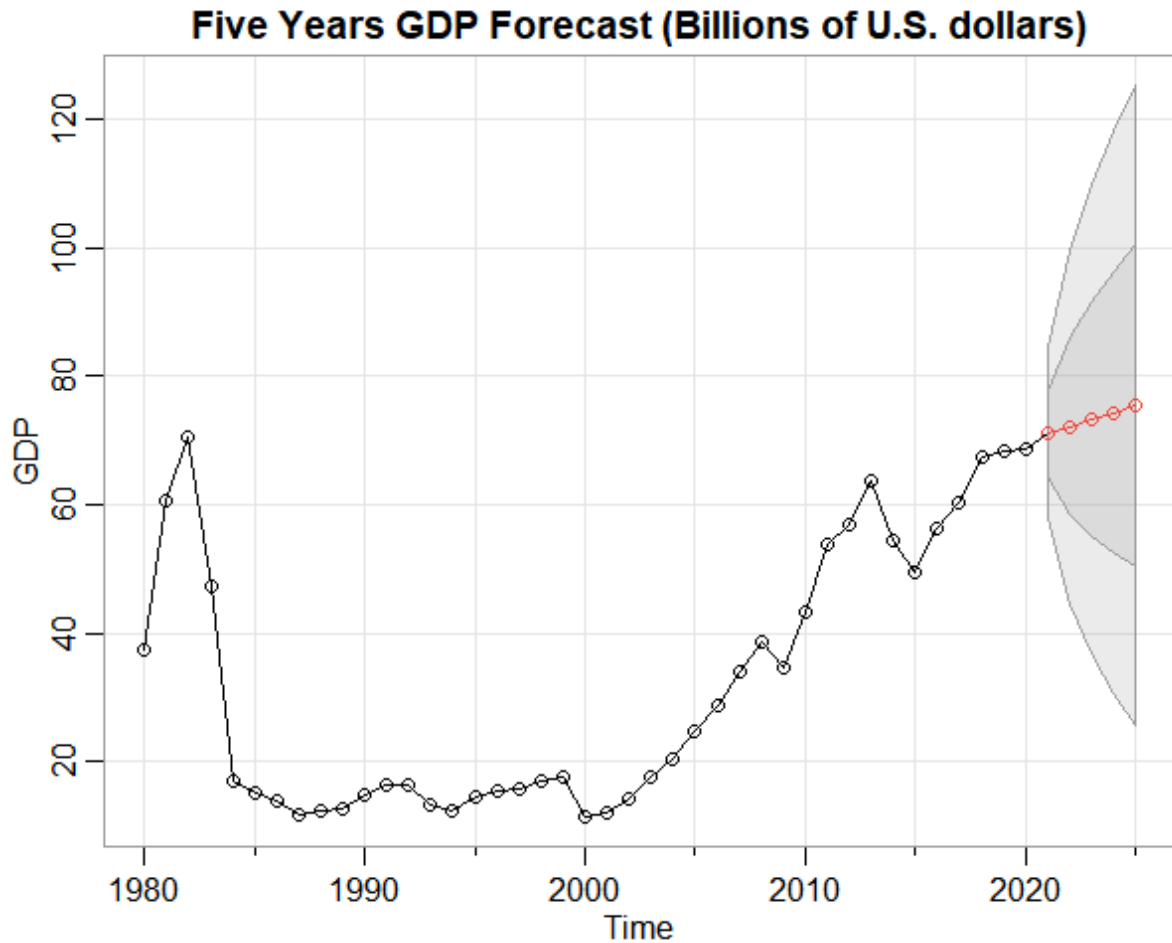


Fig. 4: Time plots of GDP prices (Billions of U.S. dollars) for five year forecast period for Ghana.

The plot for the forecasted analysis shows an increase over the five year period of Ghana's GDP prices in billions of U.S dollars. However, comparing the plot to the previous three years, it shows an increase in attendance instead.

Table 5: Forecasted values for GDP prices (Billions of U.S dollars)

YEAR	GDP
2021	70.98976
2022	72.09852
2023	73.20728
2024	74.31604
2025	75.42480

It can be seen from Table 5 that for GDP prices (Billions of U.S dollars) on the various years' groups over a two year period have seen an increase. This shows how Ghana's GDP assessment will continue to be increase boosting the economy. This suggests better performance for both business and government as well as on the verge of national evaluations, there will be a positive feedback on measuring the country's economic progress.

6. Conclusion

The forecasts from the model suggest that ARIMA (0, 1, 1) model is efficient in predicting GDP on Ghana's as the predictions associated with the ARIMA model are closer to the observed values by the IMF dataset. Based on this finding and from the comparison made with the IMF's datasets on only Ghana's GDP datasets, indeed Ghana's GDP as an economic indicator will continue to perform better over the years under forecast in this research that is from the years 2021-2025.

Future Research

More advanced future work can be done on the basis of this research, a comparative analysis with both IMF's datasets and other governmental institutions dataset on Ghana's GDP .

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are common and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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