Original Research Article

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

Abstract

This paper analysis 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

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 inS 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.

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 GPD display lower degrees of integration, and thus effects of shocks disappearing faster than those in poorer countries (Gil-Alana *et al*., 2021).

Etuk, (2012) also 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 $0.2356X_{t-4} - 0.9043\varepsilon_{t-1} + e_t$

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. For instance, 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.

2. Materials and Methods

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

2.1 Time Series Analysis

Autoregressive Integrated Moving Average (ARIMA) Model

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

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

The general $ARIMA$ process is of the form:

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

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

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

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

which can be simplified further as

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

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

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

2.2 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 at lag t . A PACF is similar to an ACF except that each correlation controls for any correlation between observations of a shorter lag length (et al., 2020).

3. 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).

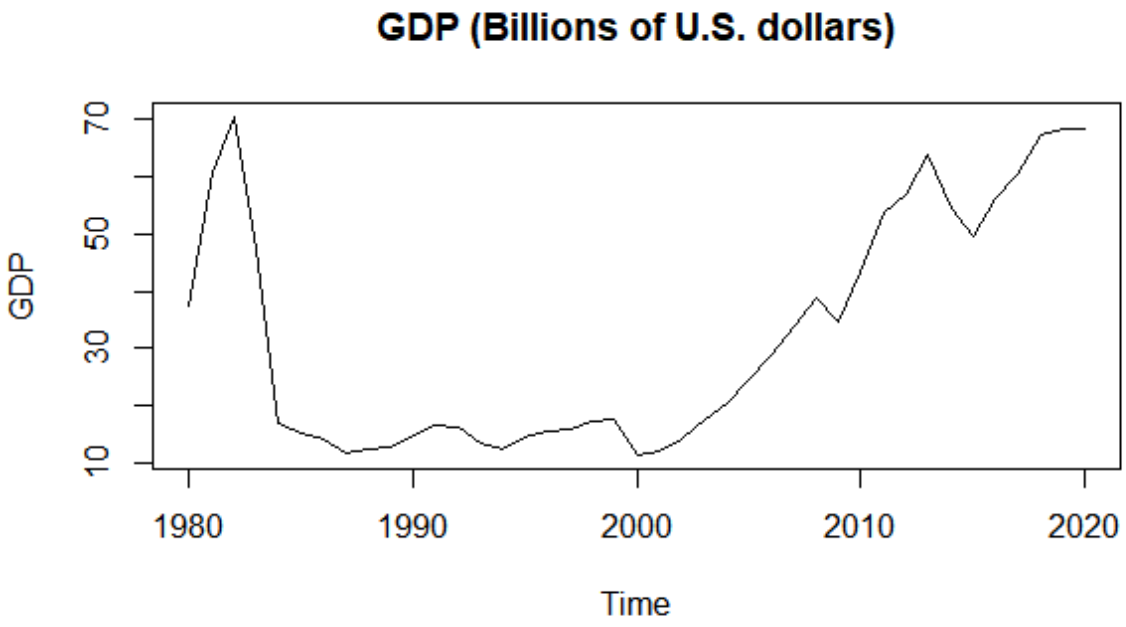


Figure 1. The plot of the time series of yearly GDP for the period 1980-2020

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. Further test to check the stationary was carried out using Dickey Fuller tests as shown in Table 3

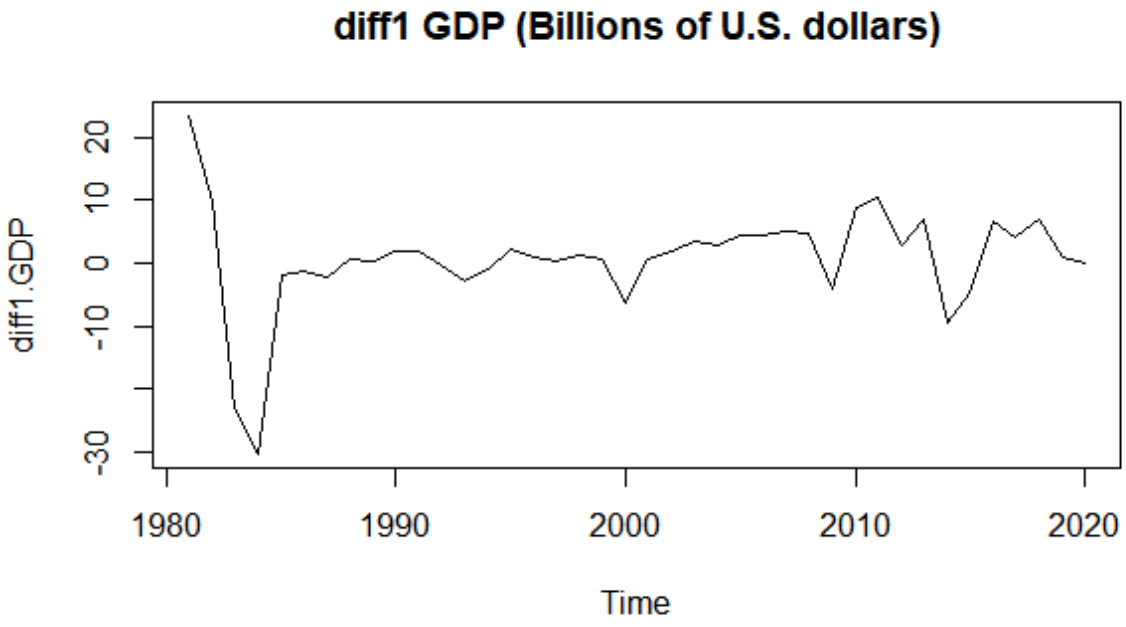
Table 3: Dicky Fuller Test (ADF(Stationary))

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

$H_o = Series\ is\ non-stationary$

$H_a = Series\ is\ stationary$

From Table 3, since the GDP data before differencing p-value of 0.7353 is greater than alpha value α=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 α=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.



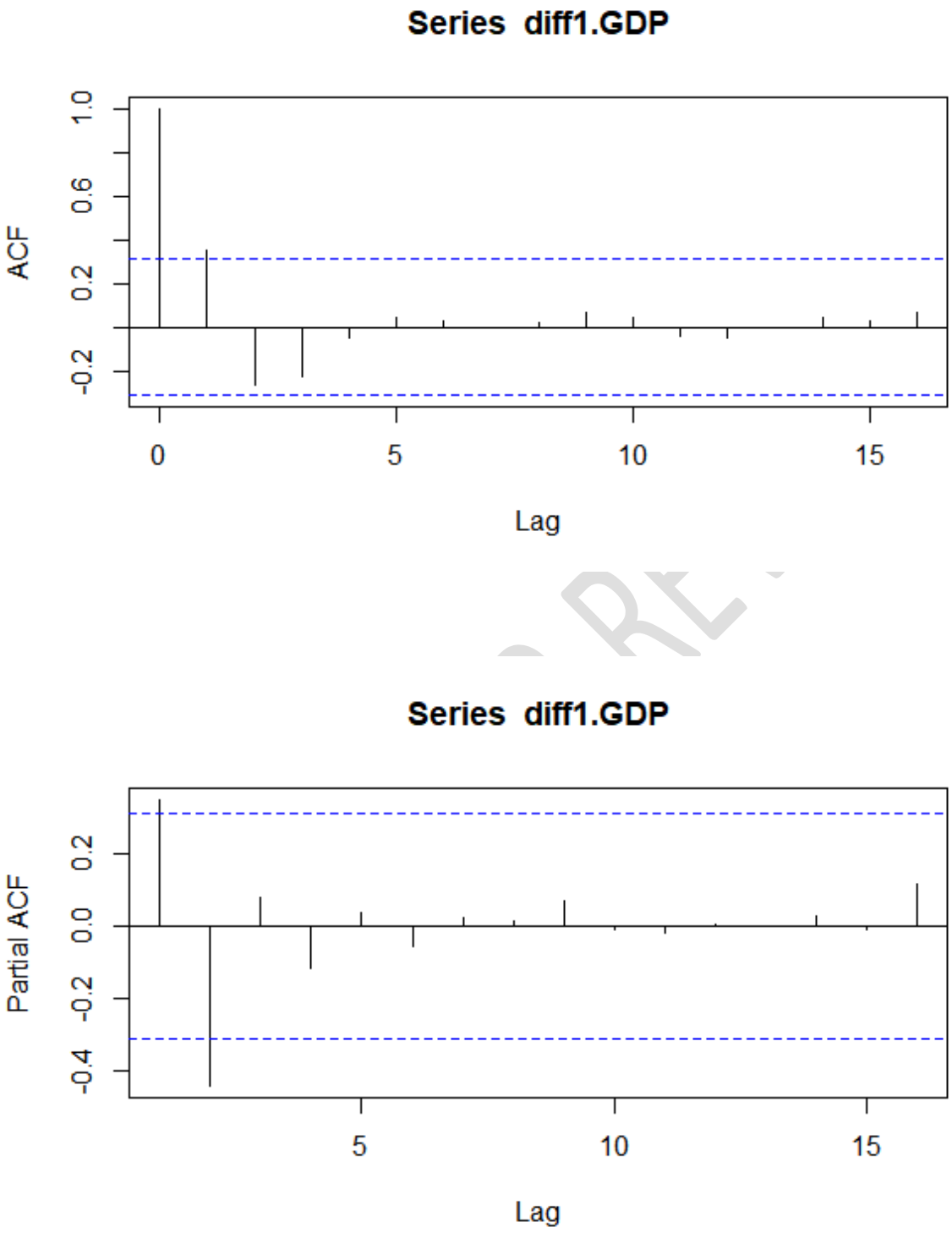


Figure 2: Autocorrelation and partial autocorrelation functions of GDP differenced data

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.

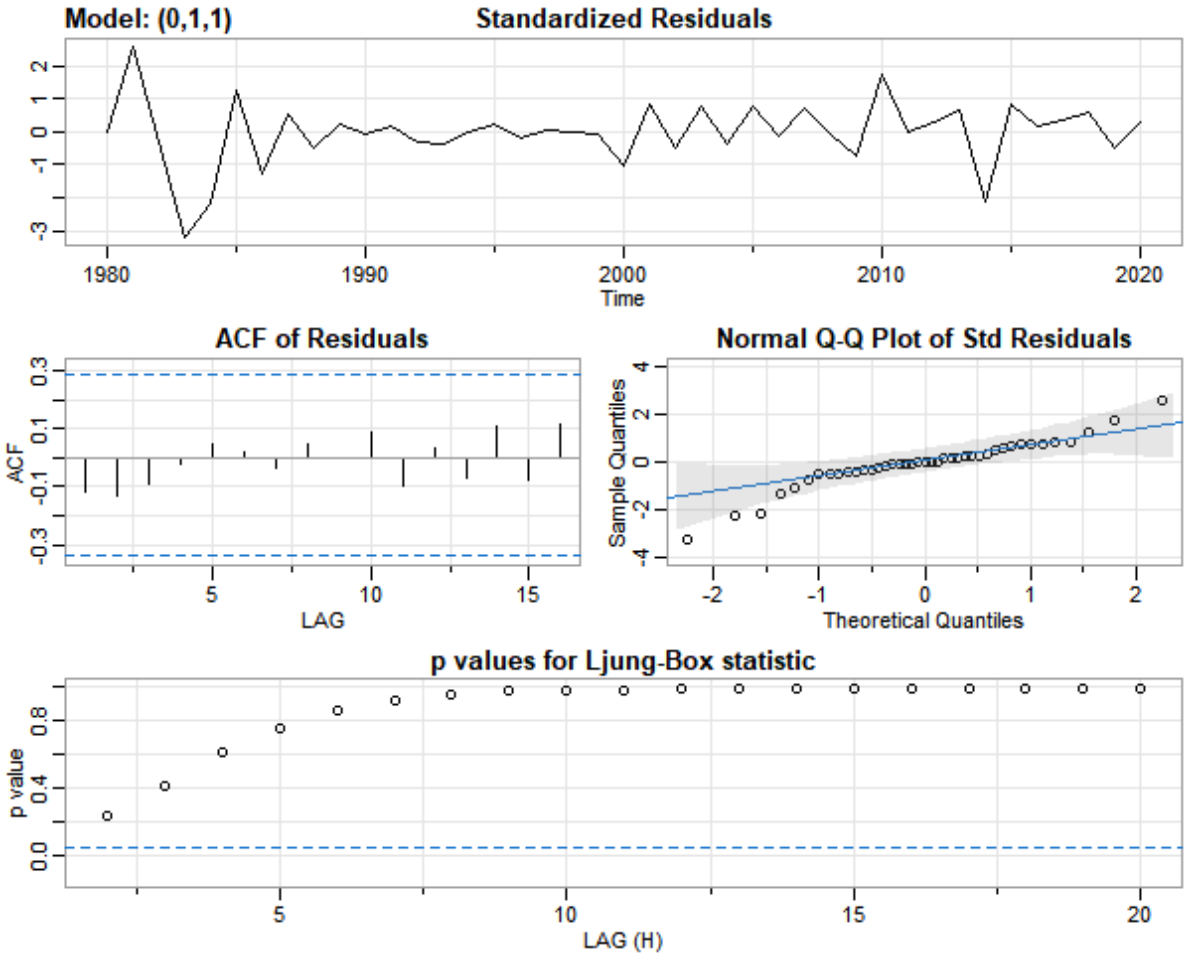


Figure 3: Model diagnostics of GDP data from Ljung-Box test showing the residuals are uncorrelated (ACF plot), independent and normally distributed by the QQ-plot.

3.1 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.

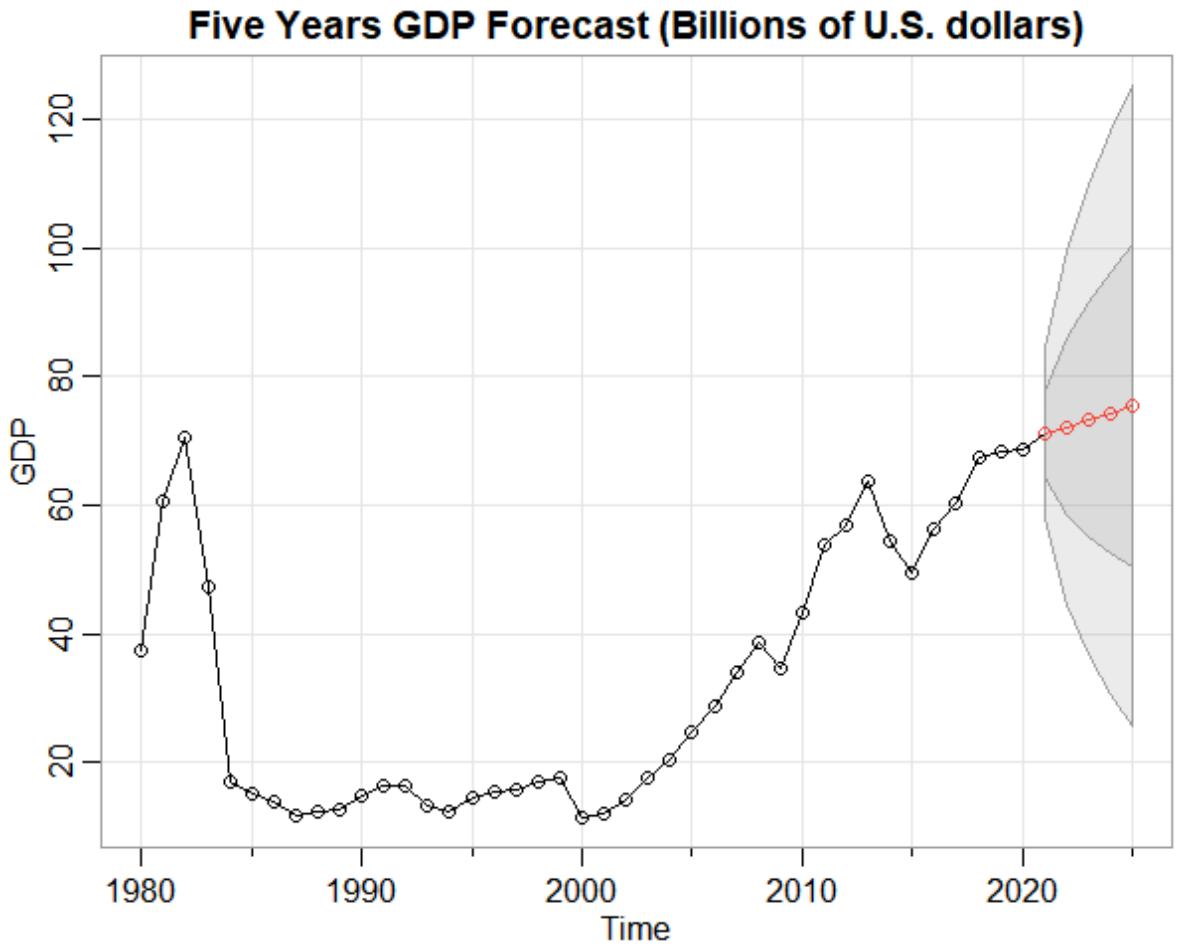


Fig. 4: Time plots of GDP prices (Billions of U.S dollars) for five year forecast period for Ghana.

The plot for the forecasted analysis shows an increase over the five year period of Ghana's GPD 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.

4. 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. Based on this finding and from the comparison made with 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.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly 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.

References

Anon. (2021a). Applied Time Series Analysis. Retrieved from https://online.stat.psu.edu/stat510/lesson/4/4.1

Anon. (2021b). Real GDP growth. Retrieved December 22, 2021, *International Monetary Fund* website: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/GHA?Year=2021

Anon. (2021). What is GDP and how is it measured? Retrieved December 1, 2021, from BBC News Services website: https://www.bbc.com/news/business-13200758

Asenso, T. Q., Tetteh-bator, E., Bidima, M., & Le, M. (2017). Time Series Modelling and Forecasting GDP in the Ghanaian Economy. *Mathematical Theory and Modelling*, Vol. *7* (No. 11), pp 63–70.

Etuk, E. H. (2012). *A Seasonal Arima Model for Nigerian Gross Domestic Product*. *Developing Country Studies* Vol. *2* (No..3), pp 46–53.

Fagan, D. (2019). What Is GDP, and Why Is It Important? Retrieved October 25, 2021, from https://www.stlouisfed.org/open-vault/2019/march/what-is-gdp-why-important

Gil-Alana, L. A., Robert, M., & Zerbo, E. (2021). GDP per capita IN SUB-SAHARAN Africa: A time series approach using long memory. *International Review of Economics & Finance*, No *72*, pp 175-190,. https://doi.org/https://doi.org/10.1016/j.iref.2020.12.008

Parkin, M., & Bade, R. (2021). Macroeconomics: Canada in the Global Environment. Retrieved November 30, 2021, from Pearson Canada website: https://www.pearson.com/store/p/macroeconomics-canada-in-the-global-environment/P100002864339

Reid, A.-K., & Allum, N. (2020). Learn About Time Series ACF and PACF in Stata With Data From the USDA Feed Grains Database (1876–2015). *Learn About Time Series ACF and PACF in Stata With Data From the USDA Feed Grains Database (1876–2015)*. https://doi.org/10.4135/9781529710298

Storbieski, T. (2021). Business Insights. Retrieved October 20, 2021, from Harvard Business School Online website: https://online.hbs.edu/blog/post/why-is-gdp-important