Comparative Analysis of the Contribution of the Agricultural Sector to the Gross Domestic Product of Ghana: Before and Within COVID-19 Pandemic

Christiana C. Nyarko, Michael Affam, Samuel K. Obeng
University of Mines and Technology, Tarkwa, Ghana

Abstract: **This paper seeks to analyse the trend of contributions of the Agriculture sector to the GDP of Ghana. A Time Series analysis was used to forecast the quarterly contributions of the Agricultural sector to the Gross Domestic Product (GDP) of Ghana from 2008 to 2019. The paper also compared contribution of the agricultural sector to the GDP before and during the COVID-19 era using data ranging from first quarter of 2018 through to third quarter of 2020 in millions of Ghana cedis from the Ghana Statistical Service. Results indicate that ARIMA (2, 1, 2) model was found to be the most suitable model with the least Normalised Bayesian Information Criterion (BIC) and Akaike Information Criterion values. It was further observed that the two – year forecast values of the model shows an increase in the subsequent years to the GDP of Ghana. However, due to the COVID-19 pandemic, the GDP from the Agricultural sector dwindled from 15,569.5 million Ghana cedis in the first quarter of 2019 to 12,080.10 million Ghana cedis in the second quarter of 2020. The differences between the first and second quarters from 2018 to 2020 were statistically significant at 95% confidence level. Although it picked up in the third quarter of 2020, it was just slightly higher than what it used to record pre-COVID-19 era.**

***Keywords*: GDP, ARIMA, Agriculture sector, BIC, COVID-19**

I. INTRODUCTION

Gross Domestic Product (GDP) is a term initiated by Simon Kuzetz in the 1930's as a way to measure a country's economic growth (Grytten, 2020). It sets a value on a nation's production, the wealth of a country and it is divided by the population in the country (Brodny and Tutak, 2020). GDP covers buyer spending, investment consumption, government expenditure and net exports, which shows an extensive picture of an economy and gives knowledge on the pattern of an economy by considering the GDP levels as an index (Collinao *et al.*, 2021). Estimation of GDP gives the general strength of the economy. It serves as an indicator by most governments and economic leaders for planning and policy making. Gross domestic product helps financial analysts by giving them direction about the condition of the economy. A declining GDP shows signs of economic instability (Phan *et al.*, 2021). At the point where the GDP improves, economic development also increases. When GDP development rate turns negative, the nation's economic strength begins to collapse (Eregha & Mesagan, 2020). Without an increase in GDP, there will certainly be weaknesses in economic development (Eregha and Mesagan, 2020).

Agriculture is a key sector of Ghana's economy. Until 2006, the agricultural sector was the engine of economic growth in Ghana, accounting for almost half of the country's GDP (48.8% in 1996) (Ofosu *et al.*, 2020). This was achieved through productive lands, good pattern of rains, budgetary allocations, and the large number of employees. The sector is the main source of livelihood for many Ghanaians and employed over 60% of the working age population in 2006 (Ofosu *et al.*, 2020).

It used to be the sector dominating in terms of contribution to the GDP and employment until the rebasing of the economy when its share continued to decline. Nevertheless, the decline can be said to be minimal since the sector still continues to play a key role in the promotion of food security and poverty reduction. It gave employment to about 50% of the working population and accounted for 22.7% of Ghana's GDP in 2012 (Bukari *et al*., 2021).

The Agriculture sector is one of the most important sectors which contribute greatly to the GDP of Ghana (Amewu *et al*., 2020). Over the years, the government of Ghana has put in effort to increase productivity in this sector of the Ghanaian economy by reducing price of fertilizers and giving out free seedlings to farmers to plant (Ali *et al.*, 2021).

Forestry and Logging, Crops, Livestock and Fishing are some of the subsectors of Agriculture that contribute to the GDP of the country. They also serve as sources of employment to earn a living. These areas of the economy also serve as a source of income to the government when these agricultural products are exported (Amewu *et al*., 2020).

Challenges faced by farmers in the production of these agriculture produce has resulted in low productivity and hence less goods are produced for consumption and for export. In a study conducted by Pu and Zhong (2020), it was found that, unreasonable restrictions would block the outflow channels of agricultural products, hinder necessary production inputs, destroy production cycles, and finally undermine production capacity. Also, in a study conducted by Ejeromedoghene et al. (2020), it was found that the restriction of movement lockdown policy instituted by various governments heavily affected local and national food production as farmers could not go to their farmlands. More so, there was price gouging on raw food items as local farmers were reducing cultivation and harvest because of their safety. The lockdown also affected the transportation

of food products from farms and local companies to the market and across inter-state or province borders. Additionally, many human infections traceable to disease outbreak from animal origin suggest a great risk of exposure to infectious agents by live animal farmers (Ejeromedoghene et al., 2020). This research investigates and analyses the trend and the impact of agriculture on the GDP of Ghana. In determining the influence of the agricultural sector on the trend of the GDP of Ghana, this paper seeks to forecast the impact of the agriculture sector on the GDP of Ghana for the next two years.

II. METHODS AND MATERIALS

2.1 Data

Data was obtained from Ghana Statistical Service which span from first Quarter of 2008 to first Quarter of 2019 and it was compared with the second Quarter of 2019 to 2020.

2.2 Model Formulation

2.1.1Autoregressive Moving Average (ARMA) Model

This model combines the AR and MA process. A mixed autoregressive moving average process which contains (p) AR terms and (q) MA terms is said to be an ARMA process of order (p, q). It is expressed in a general form as Equation (1)

$$Y_t = a_1 Y_{t-1} + a_2 Y_{t-2} + ... + a_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - ... - \theta_q \varepsilon_{q-1} \quad (1)$$

where $\{Yt\}$ is a mixed autoregressive moving average process of orders p and q respectively. The name of the process is presented as ARMA (p, q).

2.2. Model Identification

Testing for stationarity in the data is the first step in the data analysis process. This can be achieved by observing the graph of the data or plotting the autocorrelation and the partial autocorrelation functions.

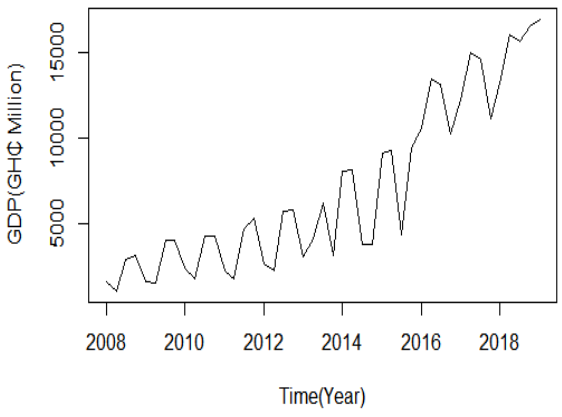

Figure 1 Plot of GDP

Figure 1 shows the trend and impact of agriculture on the GDP of Ghana from 2008 to 2018. Figure 2, is the graphical representations of the Partial Autocorrelation Functions (PACF) showing two spikes which is an indication of a non-stationary data. Therefore, both the PACF and the ACF show that the time series have a random walk.

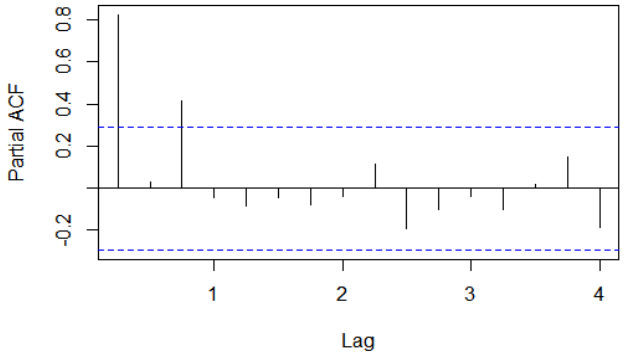

Figure 2 Graph of Partial Autocorrelation Function

From Figure 2, it can be observed that there is a decay in the plot, which is a characteristic of a non-stationary time series.

2.3 Unit Root Test

For further proof of non-stationarity, the ADF, KPSS and PP tests were used and the result is as follows. Hypothesis testing decisions with the various root tests are taken at 5% significant level. Thus, $\alpha = 0.05$.

ADF test hypothesis:

H_0 : Not stationary

H_1 : Stationary

The null hypothesis is rejected when the P-value is greater than the significant value else it is not rejected.

PP test hypothesis;

H_0 : Not stationary

H_1 : Stationary

The null hypothesis is rejected when the P-value is greater than the significant value else it is not rejected.

KPSS test hypothesis:

H_0 : Not stationary

H_1 : Stationary

The null hypothesis is rejected when the P-value is less than the significant value else it is not rejected.

Table 1 shows the results obtained from the ADF, KPSS and PP test.

Table 1 Test for Stationarity

Variable	P – Value		
	ADF	KPSS	PP
Agriculture	0.9172	0.01	0.0207

Table1 indicates that the p-value of the ADF test is 0.9172 which is greater than the level of significance of 0.05, so we do not reject the null hypothesis and concludes that the process is not stationary. Meanwhile, the KPSS test confirmed that the data is stationary with a p-value of 0.01 which is less than the significant value hence, we reject the null hypothesis while the PP test proved otherwise. Thus, it is concluded that the data is non-stationarity.

It is therefore essential to make the data stationary, and this can be achieved by differencing the data. The first differencing was observed to be stationary. The graph of the differenced data is plotted in Figure3

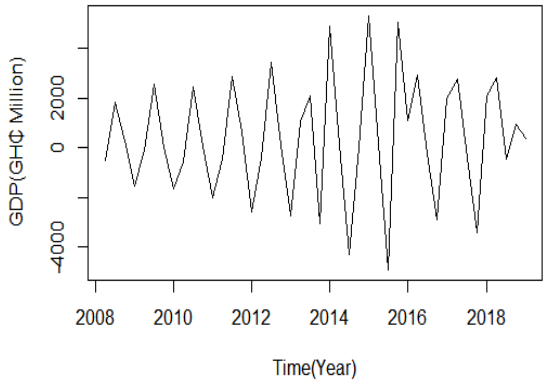

Figure 3Graph of the First Difference of Data

Figure 4 and 5 also show the graphical representations of the autocorrelation functions of the first difference and the partial autocorrelation functions respectively.

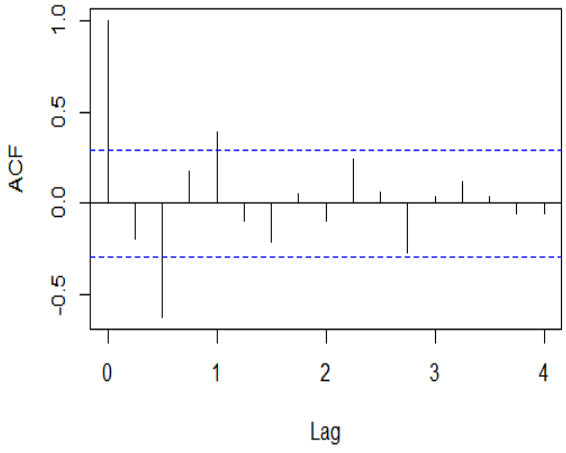

Figure 4 Graph of Autocorrelation of the First Difference

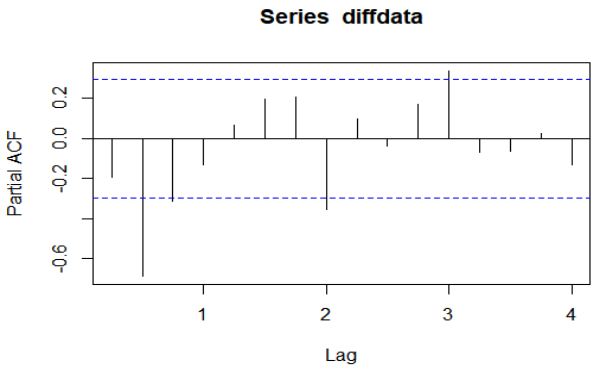

Figure 5Graph of Partial Autocorrelation of the First Difference

These partial autocorrelation plots (Figures 4 and 5) show clear statistical significance for lags 1 and 2. The next few lags are at the borderline of statistical significance. If the autocorrelation plot indicates that an AR model is appropriate, we could start our modeling with an AR(2) model. We might compare this with an AR(3) model.

Table 2 Stationary Test for the Differenced GDP

Variable	P – value		
	ADF	KPSS	PP
Agriculture	0.01	0.1	0.01

From Table 2, null hypotheses is rejected because the p-values of ADF and PP test are less than the level of significance, and therefore conclude that the process is stationary. The KPSS test also confirmed stationarity since the P-value is greater than the significant value.

Estimation of a Tentative Model

After model identification, the need arises to select a model based on the reliability of prediction. Bayesian Information Criterion (BIC), Akaike Information Criteria (AIC) and AIC corrected (AICc) were the information criteria used for the model selection.

Table 3shows the model selection criterion used to select a good predictive ARIMA model. It shows the AIC, AICc and BIC values which represent the information loss for each model. The model with the smallest AIC, AICc and BIC values is chosen, hence ARIMA (2, 1, 2) is selected as the model that best fits the GDP values. From Table 3 it can be observed that the ARIMA (2,1,2) model has the least AIC, AICc and BIC values. Therefore, ARIMA (2, 1, 2) is the best model for the forecast.

Table 3 Best ARIMA Model Selection Criteria

Model	**AIC**	**AIC_C**	**BIC**
ARIMA (1, 1, 2)	801.33	802.36	808.47
ARIMA (2, 1, 1)	793.26	794.29	800.4
ARIMA (2, 1, 2)	**786.73**	**788.31**	**795.65**

ARIMA (3, 1,1)	794.97	796.55	803.89
ARIMA (3, 1,1)	787.80	790.07	798.50

$$(X_t - X_{t-1}) = \alpha + \theta_1(X_{t-1} - X_{t-2}) + \theta_2(X_{t-2} - X_{t-3}) + \varepsilon_t - \alpha_1\varepsilon_{t-1} - \alpha_2\varepsilon_{t-2} \quad (2)$$

$$X_t - X_{t-1} = \alpha + \theta_1 X_{t-1} - \theta_1 X_{t-2} + \theta_2 X_{t-2} - \theta_2 X_{t-3} + \varepsilon_t - \alpha_1\varepsilon_{t-1} - \alpha_2\varepsilon_{t-2} \quad (3)$$

$$X_t = \alpha + X_{t-1} + \theta_1 X_{t-1} - \theta_1 X_{t-2} + \theta_2 X_{t-2} - \theta_2 X_{t-3} + \varepsilon_t - \alpha_1\varepsilon_{t-1} - \alpha_2\varepsilon_{t-2} \quad (4)$$

$$X_t = \alpha + X_{t-1}(1+\theta_1) + X_{t-2}(\theta_2 - \theta_1) - \theta_2 X_{t-3} + \varepsilon_t - \alpha_1\varepsilon_{t-1} - \alpha_2\varepsilon_{t-2} \quad (5)$$

Analyses on the model prediction can be obtained as Equation (6):

$$X_t = 1.2749X_{t-1} - 1.10899X_{t-2} + 0.815X_{t-3} + 0.8837\varepsilon_{t-1} - 0.8951\varepsilon_{t-2} + \varepsilon_t \quad (6)$$

Figure 6 shows the graph of the standardized residuals and the Autocorrelation Function (ACF) of the residuals model diagnosed. It also shows a plot of the p-values for Ljung-Box statistics. The figure revealed that the p-values of Ljung-Box test performed for the first ten lags are all greater than 5% significance bound. This shows that Ljung-Box test for lags between 1 and 10 has uncorrelated errors, which depicts that the model is adequate for forecasting.

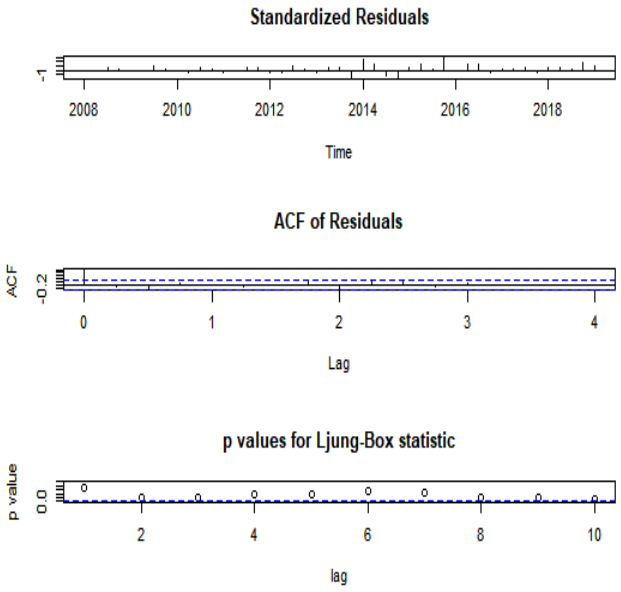

Figure 6Model Diagnosis

IV. RESULTS AND DISCUSSIONS

4.1Forecasted Projections for the Quarterly GDP

Table 4 shows quarterly forecasted values from second quarter of 2019 to first quarter of 2021. The trend of the forecast shows an increase in the GDP values from second quarter 2019 to first quarter of 2021.

Table 4 Forecast Values for 2019 to 2021

Period	Forecast
2019 Q2	17155.26
2019 Q3	18416.23
2019 Q4	18538.54
2020 Q1	17544.54
2020 Q2	17171.60
2020 Q3	17879.15
2020 Q4	18377.59
2021 Q1	17937.99

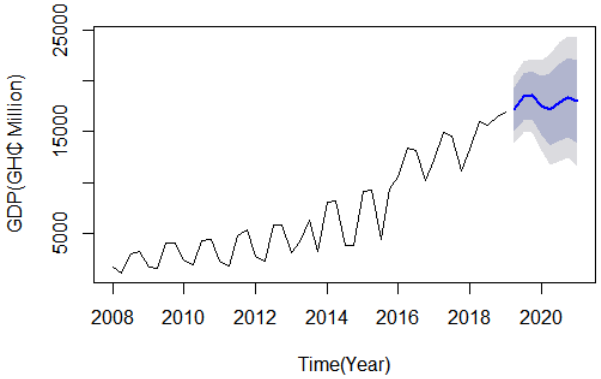

Figure 7Graph of forecasted quarterly GDP

4.2 Percentage Contribution to Total GDP

In Table 5, the data shows the total amount of GDP from first quarter of 2008 to first quarter 2019 with the contribution of the various sectors within this period. It also shows the percentage contribution of these sectors to the GDP of Ghana.

Table 5 Sector Contribution to Total GDP from 2008 to 2019

Sector	Industry	Agriculture	Service	Gross GDP Value
Total production from 2008 to 2019 (GhC Million)	281,722	250539.2	389,982	922,243.2
Contribution Rate to GDP (%)	30.5	27.2	42.3	100

4.3 Impact of COVID-19 on Agricultural GDP

Due to the COVID-19 pandemic, the GDP from the Agricultural sector dwindled from 15,569.5 million Ghana cedis in the first quarter of 2019 to 12,080.10 million Ghana cedis in the second quarter of 2019. Although, it has picked up in the third quarter of 2019, it was still lower than what it used to record pre-COVID-19 era. However, it is currently doing well from the fourth quarter of 2019. Comparing the differences between the first and second quarters of the contribution of agriculture to GDP from 2018 to 2020. It was obvious that 2019 recorded the highest from the difference between the first and second quarters in Table 6.

Table 6Impact of COVID-19 on Agricultural GDP

Year Quarter	Agric GDP	Difference (1^{st}-2^{nd})
2018_Q1*	14,575.50	
2018_Q2*	11,128.20	3,447.30
2018_Q3*	13,199.90	
2018_Q4*	16,020.00	
2019_Q1*	15,569.50	
2019_Q2*	12,080.10	3,489.40
2019_Q3*	14,765.90	
2019_Q4*	18,066.80	
2020_Q1*	17,651.30	
2020_Q2*	15,580.10	2,071.20
2020_Q3*	19,819.70	

A two-sample proportional test was further conducted using the first quarters as the base as a result of the small nature of the quarterly differences of the data points.

Table 7: Proportional test of the differences in Table 6

Statistics	2018and2019	2019 and2020
Difference	0.012	0.107
z (Observed value)	2.555	26.015
z (Critical value)	1.645	1.645
p-value (one-tailed)	0.005	0.0001
Alpha	0.05	0.05

The two tests indicate that the difference between the first and second quarters for 2018/2019 and 2019/ 2020 were statistically significant at 95% confidence level. It is therefore clear that the COVID-19 has really affected agricultural contributions to GDP between the first and second quarters of 2020.

V. CONCLUSIONS

The forecasted values for the under-study year shows an upward trend meaning, the GDP values for the next two years will be increasing. ARIMA (2, 1, 2) was the best model for the forecast. The differences between the first and second quarters of 2019 as well as the second quarters of 2018 and 2019 were statistically significant at 95% confidence level. Moreover, the study showed that the COVID-19 pandemic has really affected agricultural contributions to GDP between the first and second quarters of 2020. It is suggested that government as well as stakeholders should put in strict measures to eradicate the pandemic and assist farmers to increase productivity.

REFERENCES

[1] Ali, E. B., Agyekum, E. B., & Adadi, P. (2021). Agriculture for Sustainable Development: A SWOT-AHP Assessment of Ghana's Planting for Food and Jobs Initiative. Sustainability, 13(2), 628.

[2] Amewu, S., Asante, S., Pauw, K., & Thurlow, J. (2020). The economic costs of COVID-19 in sub-Saharan Africa: insights from a simulation exercise for Ghana. The European Journal of Development Research, 32(5), 1353-1378.

[3] Brodny, J., and Tutak, M. (2020), "Analyzing similarities between the European Union countries in terms of the structure and volume of energy production from renewable energy sources", Energies, 13(4), 913.

[4] Bukari, C., Peprah, J. A., Ayifah, R. N. Y., and Annim, S. K. (2021), "Effects of credit 'plus' on poverty reduction in Ghana", The Journal of Development Studies, 57(2), 343-360.

[5] Collinao, M. P., De Camino, C., Dorin, F., and Tovar Soria, M. (2021), "International Comparison Program: 2017 round for Latin America and the Caribbean. Methodology and main results", Economic Commission for Latin America and the Caribbean (ECLAC)

[6] Dickey, D.A., 1984 and Said, S.E. (1984), "Testing for unit roots in autoregressive-moving average models of unknown order". Biometrika, pp. 599-607.

[7] Ejeromedoghene, O., Tesi, J. N., Uyanga, V. A., Adebayo, A. O., Nwosisi, M. C., Tesi, G. O., & Akinyeye, R. O. (2020), "Food security and safety concerns in animal production and public health issues in Africa: A perspective of COVID-19 pandemic era". Ethics, Medicine and Public Health, 15, 100600.

[8] Eregha, P. B., and Mesagan, E. P. (2020), "Oil resources, deficit financing and per capita GDP growth in selected oil-rich African nations: A dynamic heterogeneous panel approach", Resources Policy, 66, 101615.

[9] Grytten, O. H. (2020), "Two centuries of economic growth: Norwegian GDP 1816-2020", NHH Dept. of Economics Discussion Paper, (10).

[10] GSS (2020), "Rebased quarterly gross domestic product 2013Q1-2020Q3", Quarterly GDP Bulletin, Ghana Statistical Service, Accra

[11] Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., and Shin, Y., (1992), "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit-root." Journal of Econometrics, pp. 159-178.

[12] Nelson, C. R., and Plosser, C. I., (1982), "Trends and Random Walks in Macroeconomic Time Series", Journal of Monetary Economics, pp. 139-162.

[13] Ofosu, G., Dittmann, A., Sarpong, D., and Botchie, D. (2020), "Socio-economic and environmental implications of Artisanal and Small-scale Mining (ASM) on agriculture and livelihoods", Environmental Science & Policy, 106, 210-220.

[14] Phan, D. H. B., Iyke, B. N., Sharma, S. S., and Affandi, Y. (2021), "Economic policy uncertainty and financial stability–Is there a relation?", Economic Modelling, 94, 1018-1029.

[15] Pu, M., & Zhong, Y. (2020), "Rising concerns over agricultural production as COVID-19 spreads: Lessons from China". Global food security, 26, 100409.