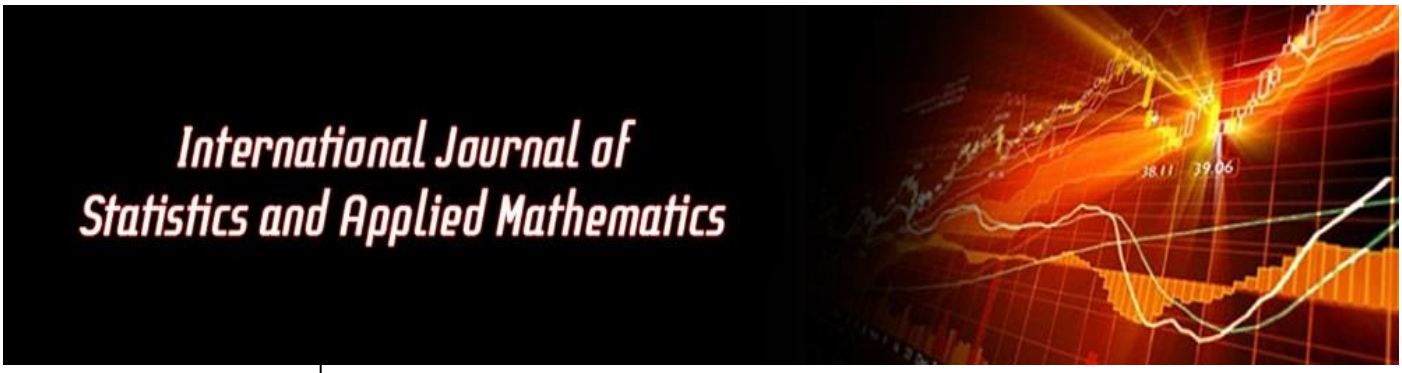

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Predicting inflation rate in Nigeria and Ghana using a suitable autoregressive integrated moving average (ARIMA)

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Abstract
A persistent increase in the average price of goods and services is called inflation, and it is typically bad for a country's economy. The data for the inflation rates of Nigeria and Ghana examined in this paper were taken from World Bank annual publications covering the years 1970 to 2021. This study used a quantitative research design. The main goal of this study is to use an appropriate autoregressive integrated moving average (ARIMA) model to forecast the inflation rate in Nigeria and Ghana. The unit root test with augmented dickey fuller (ADF) was applied to the examined inflation rate in Nigeria, and the results show that the series are integrated of order one. As a result, a time series autoregressive integrated moving average (ARIMA) analysis was carried out. The results show that ARIMA (1,1,2) and ARIMA (1,1,1) are the best-fitting ARIMA models based on the number of significant coefficients, volatility, adjusted R-squared, Akaike Information Criterion, and Schwarz Criterion.
The future inflation rate forecast for Nigeria and Ghana indicates a downward trend, which is a positive economic indicator. Despite this, the government should develop appropriate monetary policy measures to mitigate inflation's effects on the economy.

Keywords: Inflation rate, Unit root, ARIMA

1. Introduction
It is common knowledge that inflation is referred to as a persistent increase in the overall level of prices for goods and services. This rise in total prices for goods and services has a wide range of economic repercussions (Nathaniel & Emmanuel, 2018) [7]. On the bright side, it tends to increase the income of investors, and as earnings rise, it also has the possibility of benefiting lenders. In addition to this, there is the possibility that extra earnings could be obtained from new investments. On the other side, inflation causes a reduction in the salaries of individuals who save money and makes life more challenging for those whose incomes are fixed (such as salary owners). In addition to this, it has the consequence of causing instability in the balance of payments for the nation (Kelukume & Salami, 2014) [4]. It is necessary for there to be price stability, which may be achieved through the utilization of monetary policy, for there to be consistent and ongoing economic growth. The increase in the overall value level of a specified basket of goods and services in an economy over some time represents a sizeable portion of the rate at which the population's purchasing power is decreasing throughout that period. An increase in the general degree of prices, which is often reported as a percentage, shows that one unit of money currently buys less than it did in the past. This is because prices are typically expressed as a percentage. Inflation is not the same thing as deflation, which takes place when the purchasing power of money decreases while prices increase; nonetheless, economic growth is a factor in both inflation and deflation (Jason Fernando, 2020) [3]. Nevertheless, even though it is difficult to measure changes in the value of each thing over time, human requirements go beyond only a number of these objects, and this is true even though it is difficult to assess changes in the value of each object. People require a wide variety of goods and services to fulfil their needs and lead happy lives. Inflation is intended to measure the aggregate effect of price increases for a diverse range of goods and services over an indefinite period, and it takes into account a single value representation of the increase in the value level of services in the economy over the same period.

These include commodities such as food, metal, cereals, and fuel; utilities such as power and transportation; and associated services such as medical care, entertainment, and employment possibilities. The ability to monitor inflation effectively and efficiently as well as the ability to predict future levels of inflation reliably are both tremendously tough macroeconomic challenges for nations and central banks to handle. Within the scope of this study, we will investigate the levels of inflation in two countries located in West Africa, namely Nigeria and Ghana.

Despite this, the primary purpose of this research is to predict the inflation rate in Nigeria and Ghana by employing the ARIMA model that provides the best fit.

2. Literature review

Understanding the factors used as inflation barometers is crucial in today's society. The government of a country can obtain indicators of likely future inflation earlier by forecasting the inflation rate (Nyoni, 2018) [6-7]. Several factors, including the region's slow rate of development, the high cost of imported goods, the currency's ongoing depreciation on the foreign exchange market, and perhaps external factors like crude oil prices, can be blamed for the rise in West Africa's inflation rate. It is the responsibility of policymakers to predict the anticipated future inflation rate because one of the primary objectives of monetary policy is the stability and predictability of prices (Hadrat *et al*., 2015) [1]. A highly accurate capacity for prediction is necessary to accomplish this goal. When a nation implements an inflation concentration system, forecasting inflation is not only an important tool for policymaking but also plays a significant role because it can notify decision-makers of the need to take drastic action when inflation deviates from its target (Iftikhar and Iftikhar-ul-amin, 2013) [2].

There have been numerous studies on the modelling of inflation in Africa. Jere and Siyanga (2016) [10] used a model to simulate the inflation rate in Zambia. The series of inflation rates in this study were subjected to Holt's exponential smoothing and the ARIMA model. The ARIMA (12, 1, 0) model outperformed Holt's exponential smoothing, according to the study.

A model was developed by Mustapha and Kubalu (2016) [5] using data on Nigeria's inflation rates from January 1995 to December 2013. According to the findings of the study that compared the various models, ARIMA seems to be the model that best captures the relationship between the historical and present inflation rates in Nigeria. Otu *et al*. (2014) [9] used the ARIMA model to study Nigeria's inflation rate, and their findings suggested that the ARIMA model offers a more accurate forecast of the country's inflation rate.

Using the inflation dataset, Okafor and Shaibu (2013) [8] looked into the trends of the inflation rate from 1981 to 2010. The author looked at several ARIMA models. The study suggests that the best model for predicting Nigeria's inflation rate is ARIMA (2, 2, 3).

Similarly, Consumer Price Index (CPI) values from the Central Bank of Rwanda's database, calculated in Rwandan currency from 1995 to 2015, were used by Wanjoya and Waitiitu (2016) [11]. The parsimonious model was fitted to the data from 1995 to 2013, and its predictive power was evaluated using observations from 2014 and 2015. It has been discovered that ARIMA (4, 1, 6) is a useful model for foretelling the future values of the consumer price index as a gauge of inflation. Nyoni (2018) [6-7] used annual time series data from 2009 to 2018 and autoregressive models to predict and model Zimbabwe's inflation. The exponential smoothing model was found to be less reliable than the ARIMA model at forecasting future inflation rates.

This paper will select the best-fitted ARIMA model for forecasting inflation rates in west Africa from among the tentative ARIMA models using the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), the number of significant coefficients of the model, the volatility, and the adjusted R-squared.

3. Research Methodology

This study adopted a quantitative research design, and the data was collected from World Bank annual publications spanning 1970 to 2021 for two West African countries (Nigeria and Ghana) considered for this research paper. The selection of the two West African nations was based on the availability of data for the year under review, and the sampling method is purposive. The method of data analysis for this paper is descriptive statistics (using mean and standard deviation for the data summary) and time series using unit root test to test for stationarity of the inflationary series and autoregressive integrated moving average (ARIMA) to predict future inflation rates in the two West African nations. Version 11.0 of the EViews statistical software was used in the analysis of this paper.

3.1 Variable measurement

The variable used for this research paper in inflation rate and it is measured in percentage.

3.2 Unit root test

The unit root test, also known as the stationarity test, indicates the presence of a unit root when the series lacks stationarity and may lead to spurious results and the absence of a unit root when there is a presence of stationarity in the series. To resolve the problem of spurious results, the unit root test is accomplished through the use of the augmented Dickey-Fuller test (ADF). The hypothesis to accomplish the unit test can be stated as:

H_0: there is a presence of a unit root (series is not stationary) vs H_a: there is no unit root (the series is stationary). The ADF test can be presented mathematically as:

$$\Delta Y_t = \theta + \gamma Y_{t-1} + \sum_{i=1}^{p} \beta_i Y_{t-i} + \omega_t$$

Where, θ is a constant, γ is the coefficient of process root, β_i coefficient in time tendency, p is the lag order and ω_t is the disturbance (error) term. The inflation rate in two West African countries such as Nigeria and Ghana are the series considered for this study and when it is stationary, then further time series model like ARIMA will be applied.

3.3 Model specification

ARIMA model is generally expressed in the form (p, d, q) which was built from the combination of three building blocks, namely; p for Autoregressive (AR), d for Integration order term (I) and q for Moving Average (MA) for modeling the serial correlation in the disturbance. This means that ARIMA considers both the past values (AR) and the mean residuals of the error term (MA).

The general Autoregressive (AR (p)) of order p can be expressed below as:

$$y_t = p_1\mu_{t-1} + p_2\mu_{t-2} + \ldots\ldots + p_p\mu_{t-p} + \delta + \varepsilon_t \ldots\ldots \quad (1)$$

While MA (q) is specified as:

$$y_t = \mu_t + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \ldots\ldots - \theta_q\varepsilon_{t-q} \ldots\ldots\ldots\ldots \quad (2)$$

Therefore, ARMA (p, q) is given as:

$$y_t = p_1 y_{t-1} + p_2 y_{t-2} + p_p y_{t-p} + \varepsilon_t + \theta_1\varepsilon_{t-1} + \theta_2\varepsilon_{t-2} + \ldots.\ \theta_q\varepsilon_{t-q} \ldots \quad (3)$$

Hence, ARIMA process of order (p, d, q) can be specify using backward shift operator as:

$$\Phi(B)\Delta^d y_t = \delta + \theta(B)\varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$\Phi(B) = 1 - \varphi_1 B - \varphi_2 B^2 - \ldots\ldots - \varphi_p B^p \ldots\ldots\ldots\ldots \quad (5)$$

$$\text{And } \theta\,(B) = 1 - \theta_1 B - \theta_2 B^2 - \ldots\ldots - \theta_q B^q \ldots\ldots\ldots\ldots \quad (6)$$

Where Φ(B) is the autoregressive operator while θ (B) is the moving average operator
However, ARIMA (p, d, q) can also be expressed as:

$$y_t = \sum\nolimits^{p}_{i=1}\varphi_i y_{t-I} + \sum\nolimits^{q}_{i=1}\theta_i e_{t-I} + e_t \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

4. Results and Discussion

Table 1: Descriptive

Variables	Observations	Mean	Standard deviation
Nigeria Inflation rate	52	18.17	15.33
Ghana Inflation rate	52	28.12	27.37

Source: Author's computation using EViews software

Table 1 shows that average Nigeria inflation rate is about 18% with variability of about 15%. Ghana inflation rate on average is about 28% with variability of about 27% during the period under review from 1970 to 2021.

Table 2: Unit root test (Augmented Dickey Fuller)

Differenced Variables	Test statistic	P-value	Order
Nigeria Inflation rate	-7.34	0.0000*	I (1)
Ghana Inflation rate	-4.36	0.0011*	I (1)

Source: Author's computation using EViews software

Table 2 shows the unit root test using Augmented Dickey Fuller (ADF) and it reveal that the two series (Nigeria inflation rate and Ghana Inflation rate) are statistically significant at 1% level of significant and become stationary after the first difference, I(1) indicating that the series are integrated of order one. The stationarity of the series in Table 2 suggest that further time series analysis like autoregressive integrated moving average (ARIMA) can be performed.

Table 3: Results of estimated tentative ARIMA models for Nigeria Inflation rate

Model	No of significant Coefficients	Adjusted R-squared	Volatility (SIGMASQ)	Akaike Info Criterion (AIC)	Schwarz Criterion (SBIC)
ARIMA (1,1,4)	2	0.3178	147.90	8.00	8.15
ARIMA (3,1,1)	2	0.4130	135.23	7.91	8.06
ARIMA (1,1,2)	3	0.4326	130.00	7.88	8.03
ARIMA (2,1,1)	2	0.4251	132.44	7.89	8.04

Source: Author's computation using EViews software

Table 3 reveals the results of estimated tentative ARIMA models for Nigeria Inflation rate and we can see that ARIMA (1,1,2) is the best fitted model among other tentative models because it has the highest number of significant coefficients, highest adjusted R-squared, lowest volatility, lowest Akaike Info Criterion (AIC) and lowest Schwarz Criterion. Therefore, Nigeria inflation rate will be predicted with ARIMA (1, 1, 2).

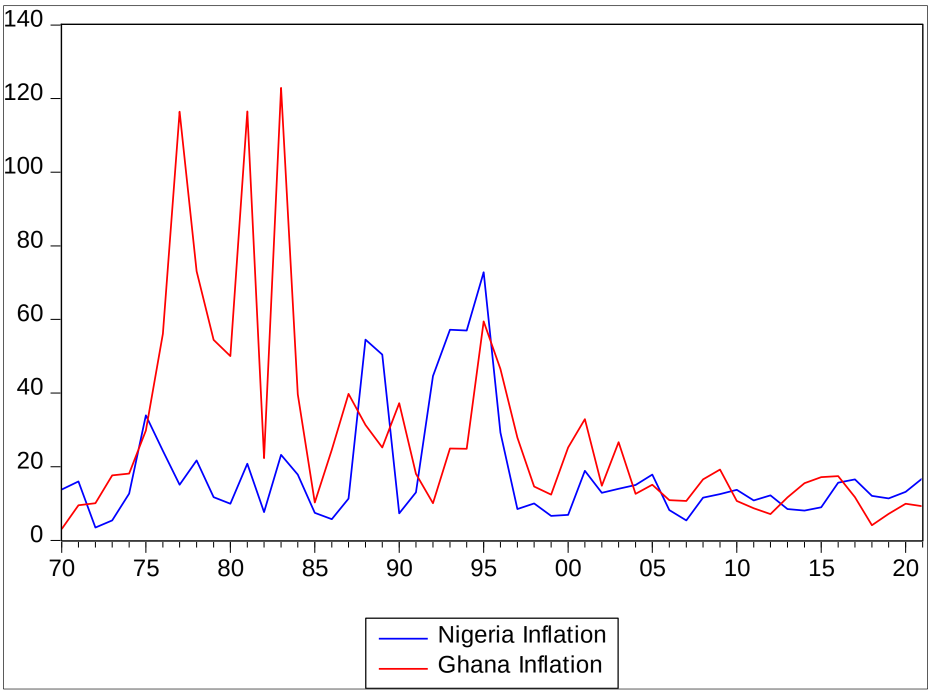

Fig 1: Graphical representation of Inflation rate in Nigeria and Ghana

Table 4: Results of estimated tentative ARIMA models for Ghana Inflation rate

Model	No of significant Coefficients	Adjusted R-squared	Volatility (SIGMASQ)	Akaike Info Criterion (AIC)	Schwarz Criterion (SBIC)
ARIMA (1,1,1)	3	0.2322	530.89	9.27	9.42
ARIMA (1,1,5)	2	0.1423	592.99	9.38	9.53
ARIMA (3,1,2)	2	0.1663	576.46	9.36	9.51
ARIMA (2,1,2)	2	0.1889	560.81	9.33	9.48

Source: Author's computation using EViews software

Table 4 reveals the results of estimated tentative ARIMA models for Ghana Inflation rate and we can see that ARIMA (1,1,1) is the best fitted model among other tentative models because it has the highest number of significant coefficients, highest adjusted R-squared, lowest volatility, lowest Akaike Info Criterion (AIC) and lowest Schwarz Criterion. Therefore, Ghana inflation rate will be predicted with ARIMA (1, 1, 1).

Figure 1 shows that the graphical representation of Inflation rate in West Africa Countries from 1970 to 2021 and we can see that Ghana tends to have high peak of inflation rate followed by Nigeria. Although we can see that the pattern of the inflationary rate in the two West Africa countries is not stable within the period under review.

Table 8: Predicting inflation rate in Nigeria and Ghana from 2022 to 2029

Year	Nigeria Inflation prediction	Ghana Inflation prediction
2022	14.5313	6.89009
2023	14.3939	6.08881
2024	14.2566	5.28753
2025	14.1192	4.48625
2026	13.9819	3.68497
2027	13.8446	2.88369
2028	13.7072	2.0824
2029	13.5699	1.28112
MAPE	76.105	94.557

Source: Author's computation using EViews software

Table 8 shows the prediction of the inflation rate in Nigeria and Ghana for this study and we can see that Nigeria have the best inflation rate forecast because it has the least mean absolute percentage error (MAPE) compared to Ghana inflation rate and the prediction shows that inflation rate will decline in the next either years while Ghana inflation rate also show that Inflation rate will decline in the next 8 years which is a good economic indication for both west African countries in the nearest future.

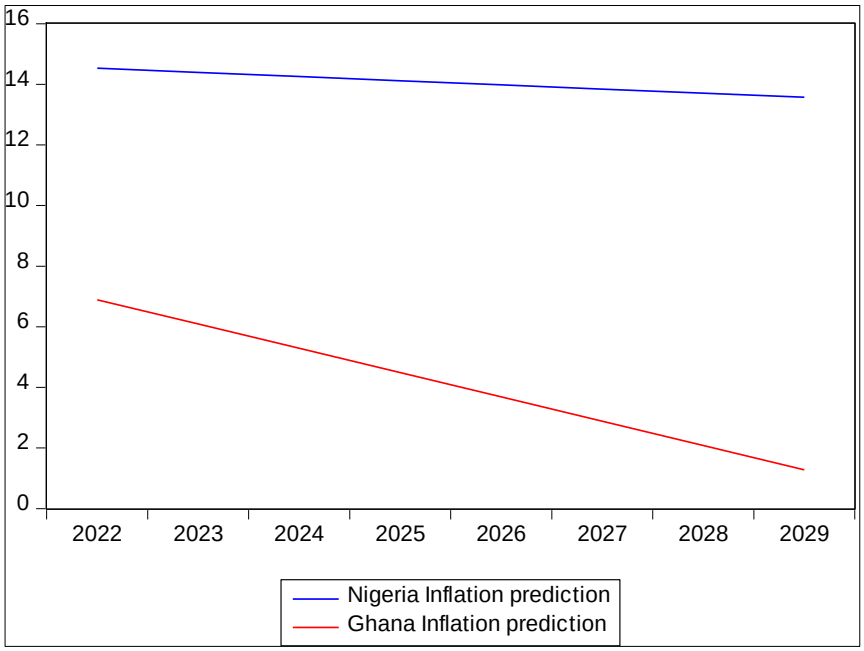

Fig 2: Graph of inflation rate prediction in Nigeria and Ghana

Figure 2 shows the virtualization of inflation rate prediction in two West Africa countries and we can see inflation rate tend to decrease in the next eight forecasted years and the future inflation rate is a good economic indication in the two countries which also implies that ARIMA model is a good predictive tool.

4.1 Discussion of findings

From the interpretation of the above result, the following are the notable findings: Ghana have the highest inflation rate because it has the highest mean values (see table 1) and also show the highest peak value (see figure 1).

The unit root test using augmented dickey fuller (ADF) was applied to the inflation rate in the two African countries under review and it shows that the series are integrated of order one which makes it possible for further time series analysis such as ARIMA to be performed.

ARIMA (1,1,2) and ARIMA (1,1,1) are the best fitted ARIMA models based on the selection criteria which include several significant coefficients, volatility, adjusted R-squared, Akaike Information Criterion and Schwarz Criterion.

The prediction of inflation rate shows that the two west African countries under review have a downward trend in the future inflation rate value which is a good positive economic indicator.

Nigeria has the best prediction inflation rate values because it has the lowest mean absolute percentage error (MAPE) and this supports the work of Mustapha and Kubalu (2016) [5] that concluded that ARIMA has a better forecasting ability of Nigeria's inflation rate.

5. Conclusion and policy formulation

Following the above findings, we can conclude that ARIMA (1,1,2) and ARIMA (1,1,1) are the best fitted ARIMA models suitable for the prediction of inflation rate in the two west Africa. The Prediction of inflation rate with autoregressive integrated moving average (ARIMA) shows a downward trend or pattern in the two west Africa countries inflation rate values in the nearest future with Nigeria having the best prediction inflation rate values because it has the lowest mean absolute percentage error (MAPE) and this support the work of Siyanga (2016) [10]; Nyoni (2018) [6-7]; Wanjoya & Waitiitu (2016) [11] that concluded that ARIMA has better predicting ability and performance than Holts exponential smoothing.

Based on the conclusion of this study, it can be recommended that the government, as well as the central bank in Nigeria and Ghana, should come up with a monetary policy that will cushion the effect of the inflation rate in the future.

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