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Application of ARIMA Methods on Unemployment and Inflation Rates in Nigeria

Clement Akobi & Adeniyi Ogunmola
Federal University Wukari, Nigeria
clementakobi1@gmail.com; ogunmola@fuwukari.edu.ng

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Abstract

In Nigeria, Unemployment and inflation rate are some of the problems bedeviling the economy. The inability of Job seekers to secure gainful employment tends to create disaffection among these people and cause some of them especially the youth, to resort to social vices. In the motivation to experience low unemployment rate and inflation rate which are economic indicators in Nigeria, deriving appropriate ARIMA model to give insight into future occurrence of these indicators for intervention calls for the application of ARIMA model. This study seek to fit ARIMA model to unemployment rate and inflation rate and forecast future values for both unemployment rate and inflation rate. Utilizing secondary data sourced from the National Bureau of Statistics (NBS) from 1991 to 2020. The findings reveal that, for each of the two series, to obtain the appropriate ARIMA model that fits the data, ten closely suitable ARIMA models were identified. Using the least values of AIC, AICc and BIC as selection criteria, ARIMA (0, 1, 1) was found to be the best fitted model for each of the two series. Subsequent diagnostic checks confirm the adequacy of the fitted models, with residual analyses indicating no significant autocorrelation or heteroscedasticity. The forecasted values for the unemployment rate series and inflation rate series maintain a constant point forecast. This implies that unemployment rate and inflation rate in Nigeria does not reveal a noticeable increase nor decrease but will be constant in Nigeria. Due to the unchanging forecasted value which appears not to be decreasing, there is need for interventions that will lead to the visible reduction of present unemployment rate and inflation rate in Nigeria.

Keywords: ARIMA, Unemployment rate, Inflation rate, Nigeria

INTRODUCTION

The ongoing discourse on various platforms highlights the persistent failure of policies to tackle high unemployment rates and the constant decline in the value of money in Nigeria. This situation is worsened by rising consumer prices and a growing number of young people unable to find decent jobs, among other economic challenges faced by the country. Achieving full employment while also keeping prices stable remains a difficult task for policymakers and economists (Vermeulen, 2017). The relationship between inflation and unemployment has sparked debates among stakeholders over the past decade, as efforts to address these issues simultaneously often lead to conflicting outcomes. Both unemployment and inflation have significant negative effects on economic growth, drawing attention from governments and researchers worldwide. Balancing low unemployment levels with stable prices is a key challenge for policymakers aiming to foster sustainable economic growth (Udabah, 2019).

Unemployment, which refers to the lack of job opportunities for qualified individuals, is a major concern in Nigeria and other developing countries. Efforts to tackle unemployment in Nigeria have fallen short, potentially exacerbating inflation while making only marginal improvements in employment rates. The social consequences of unemployment, including increased crime rates and reduced purchasing power, underscore the urgency of finding effective solutions (Osinubi, 2016; Alanana, 2016). Similarly, inflation has long been a problem in Nigeria, affecting various sectors of the economy. While inflation is widely discussed, many people do not fully understand its causes and effects. The coexistence of unemployment and inflation perpetuates a cycle of poverty in developing countries, necessitating efforts to improve economic efficiency and productivity (Mankiw, 2016).

Nigeria's experience with unemployment and inflation dates back to the 1980s, following the crash of oil prices, which the economy heavily relied upon. This period marked a shift from a previously stable economic environment characterized by favorable wage rates and moderate inflation. However, economic stagnation led to rising unemployment, exacerbated by policy measures such as the Structural Adjustment Program (SAP) and currency depreciation (Oyelaran-Oyeyinka & Lépissier, 2018).

In Nigeria, Unemployment and inflation rate are some of the problems bedeviling the economy, the inability of Job seekers to secure gainful employment tends to create disaffection among these people and cause some of them especially the youth, to resort to social vices such as robbery, suicide, prostitution, drug addiction, terrorism (especially in Nigeria) and political unrest. This research work therefore intends to fit appropriate ARIMA model to both unemployment and inflation rate and also predict their future values.

Literature Review

Unemployment

In general sense of the term, unemployment is a situation in which those who are able and willing to work at the prevailing wage rate do not find job. According to the International Labor Organization (ILO), only those belonging to the age group of 15 to 65 years should be included in the labor force of a country. Unemployment may also be defined as the gap between the potential full employment and the number of employed persons. Briggs (2017) defined unemployment as the difference between the amount of labor at current wage rate and working conditions and the amount of labor not hired at these levels. However, Gbosi (2015) defined unemployment as a situation in which people who are willing to work at the prevailing wage rate are unable to find jobs. National Bureau of Statistics (N.B.S). Nigeria defines unemployment as the proportion of the labor force that is available for work but did not work for at least thirty-nine (39) hours in the week preceding survey period.

Inflation

The concept of inflation has been defined as a persistence rise in the general price level of broad spectrum of goods and services in a country over a long period of time. Inflation has been intrinsically linked to money, as captured by the often heard maxim "inflation is too much money chasing too few goods". According to Hamilton (2015), inflation has been widely described as an economic situation when the increase in money supply is faster than the new production of goods and services in the same economy. Piana (2014) noted that economists usually try to distinguish inflation from an economic phenomenon of a onetime increase in prices or when there are price increases in a narrow group of economic goods or services.

Empirical Review

Umaru and Anono (2012) investigated the relationship between unemployment and inflation in the Nigerian economy between 1977 and 2009 through the application of Augmented Dickey-Fuller techniques to examine the unit root property of the series after which Granger causality test was conducted to determine causation between unemployment and inflation, then cointegration test was conducted through the application of Johansen cointegration technique to examine the long-run relationship between the two phenomenon, lastly ARCH and GARCH technique was conducted to examine the existence of volatility in the series. The results indicate that inflation impacted negatively on unemployment. The causality test reveals that there is no causation between unemployment and inflation in Nigeria during the period of their study and a long-run relationship exists between them as confirmed by the cointegration test. ARCH and GARCH results reveal that the time series data for the period under review exhibit a high volatility clustering. Their work recommends the use of inflation/unemployment theory in order to ensure their applicability in the Nigerian context, so as to achieve a desire reduction in unemployment and inflation which in turn boost economic growth and development.

Zeaud (2014) on the other hand investigated the existence of trade-off relationship between unemployment and inflation in the Jordanian economy between 1984 and 2011. Each of Granger-causality test is adopted to check relationship between variables and the direction of causation. Since these techniques are sensitive to stationary, integration and co-integration of the variables ADF and PP tests was applied to test the Stationary and integration order of the series while Johansen-Juselius procedure was carried out to explore the existence of co-integration between variables. The tests reveal that the variables' series have different degrees of integration, thus, their second differenced series - which have the same degree of integration- have been used to inquire about causality between the two phenomena. His results show no causal relationship between unemployment and inflation in Jordan during the study period which means there is no trade-off relationship between the two variables.

Thayaparan (2014) examined the effect of inflation and economic growth on unemployment in Sri Lanka for the period 1990-2012. To test unit root or stationary, Augmented Dickey Fuller Test was used. In addition to that, ordinary least square technique and to determine the causality among the above variables Granger Causality test also were applied. Results of the unit root test indicate that only Gross Domestic Product (GDP) was stationary and unemployment and inflation have unit root problem or non-stationary at level. But when these two variables are tested at first difference then the problem of unit root has disappeared and hence they have become stationary at first difference. Regression results revealed that the coefficient of inflation is negative and statistically significant influence on unemployment whereas gross domestic product is positive but it has no significant effect on unemployment. Finally, the study concludes that only inflation significantly reduces unemployment and gross domestic product positively but insignificantly influences on unemployment. Causality results proved that there is only a unidirectional causality between inflation and unemployment.

Bello and Auwal (2015) in their study examined how unemployment and inflation substantially affect economic growth. Ordinary Least Square (OLS) method, Augmented Dickey-Fuller (ADF) technique and Granger causality test. The result of the regression revealed that the coefficient of inflation is positive and statistically significant while unemployment is positive but has no significant effect on economic growth. This proves that inflation substantially affect economic growth, although unemployment has little substantial effect on it. Moreover, result of the unit root indicates that all the variables in the model are stationary whereas, the result of causality test suggests that unemployment does not granger causes economic growth and inflation, but economic growth and inflation Granger cause unemployment, also there exist Granger causality between economic growth and inflation. Therefore, their result suggests a one-way causation flowing from inflation to GDP. Consequently, the major policy implication of these results is that concerted efforts should be made by policy makers towards restructuring the economy, managing price instability and improving infrastructure.

Orji et.al (2015) examined the inflation and unemployment nexus in Nigeria. His study adopted a distributed lag model with data covering the period 1970-2011. His result reveals that unemployment is a significant determinant of inflation and that there is a positive relationship between inflation and unemployment rate in Nigeria. His findings invalidate the original proposition on the Phillips curve hypothesis in Nigeria. His study therefore recommends that the economy should be diversified and appropriate policies should be put in place by government and the monetary authorities in order to curb the menace of inflation and unemployment and consequently reduce the problem of stagflation in Nigeria.

Ademola and Badiru (2015) determined the effects of unemployment and inflation on economic performance in Nigeria 1981 to 2014. Ordinary Least Square (OLS) technique was adopted with various diagnostic tests to determine how fit are the data for the analysis. The result of Diagnostic test indicates that the data for their analysis are stationary at level and there are 2 cointegrating equation implying that there exist long-run relationship between RGDP, Unemployment and inflation. Their results indicated that unemployment and inflation are positively related to economic growth. The positive relationship between unemployment, inflation and RGDP indicates that Nigeria RGDP is driven by oil revenue that employs very limited highly skilled labor and the price of output of crude oil is determined externally which may not response as expected to growth of output in the country.

Cruz et all., (2020), based their studies on the analysis on how the Gross Domestic Product, Inflation rate, and population affects the Unemployment rate. They demonstrate that only the inflation rate, out of the five independent variables, has no significant link with the dependent variable, with a p-value of 0.178, which is more than the level of significance of 0.01 if the null hypothesis is accepted there is no significant relationship between the dependent and independent variable. Meanwhile, GDP shows a negative connection with the Unemployment Rate but a significant linear association with the unemployment rate based on their Pearson coefficient of determination. Moreover, the population shows a negative connection with the Unemployment Rate but a significant linear association with the unemployment rate based on their Pearson coefficient of determination. SARIMA (6, 1, 5) x (0, 1, 1) 4 is the formulated model for estimating and forecasting the unemployment rate in the Philippines. Forecasted values are within six to eight percent of actual values, and they are shown to be 72 percent accurate. Important determinants of the unemployment rate, Labor Force Rate, and Population are discovered. In addition, the dependent variable is Granger-caused by population, GDP, and GNI.

These factors can influence the unemployment rate. Any change in those factors can cause the unemployment rate to rise or fall. When unemployment falls, disposable income grows, demand rises, and prices rise.

Azizan et all., (2016) investigated the long-run relationship between these factors and GDP growth from 1995 to 2018 in ASEAN-5 countries (Malaysia, Indonesia, Thailand, Singapore and the Philippines). Their results show a strong dynamic long-run linkage between interest and inflation rates and economic growth, but the linkage between unemployment rate and economic growth is insignificant. Granger's test of causality indicates that interest, unemployment and inflation rates and economic growth are related. Policy makers should be aware of these relationships when making decisions to facilitate economic growth and stability.

Although a good deal of research work has been carried out on unemployment, inflation and GDP worldwide, not much has been carried out looking at the application of ARIMA methods on unemployment and inflation rates in Nigeria. When the time period is being considered, this work will serve as one of the most recent research works on the topic. The gap in the literature can be noted from the fact that most literature reviewed focused their attentions on the unemployment and inflation and their effect on economic growth from 1980 to 2014, this research work intend to fill the gap in the literature by fitting ARIMA model to unemployment and inflation rate series, making use of recent data from 1991 to 2020.

METHODS

The study made use the Box-Jenkins (ARIMA) methodology. The ARIMA process was built upon an earlier work done by Yule-walker (1927). The method model was simply denoted as ARIMA (p, d, q), where (p) shows the AR process, (d) is the integrated term which takes care of nonstationary process and (q) represents the MA process. The Box-Jenkins process of fitting and analyzing univariate time series can be classified into three iterative stages namely: The model specification stage, parameter Estimation stage and model Diagnostic checking stage.

Model Identification Stage

Model identification refers to a methodology in identifying the required transformation, such as variance stabilizing transformations, differencing transformation and the proper order of p and q in the model. The first step in developing a Box-Jenkins model is to build the time plot of the observed series to determine the various patterns displayed by the time series data. However, the two most important tools under the model identification stage are the autocorrelation function (ACF) and the partial autocorrelation function (PACF). The ACF of the time series measures the degree of association between current values of a series with earlier values of that same series when the influences of other time lag on the series are held constant. The ACF and PACF are used to perform two major checks at the model identification stage. A check for stationarity and seasonality may be verified from the ACF and PACF plot of the observed time series..

Model Estimation Stage

The model parameter estimation stage is carried out after identifying model for the time series. The Maximum likelihood estimation model is the generally preferred technique to estimating the AR and MA parameters. The three main penalty function statistic used to penalize fitted models with respect to parsimonious principles are the Akaike information criteria (AIC), corrected Akaike information criteria (CAIC) and the Schwarz Bayesian information criteria (BIC). The AICC value as the sample size (n) gets larger converges to AIC and it is recommended to use AICC penalty statistics, if the sample size (n) is small or the parameters (K) in the model is large.

$AIC = 2(K) - 2\ln(L)$

$AICC = AIC + (2k(k+1))/(n-k-1)$

$BIC = 2\ln(L) + k\ln(n)$

Where (L) is likelihood function, (n) denotes the sample size and (K) represent the model parameters. A test of statistical significance using the t-test is carried out on each estimated parameters in the model to test whether any of the parameters are significantly different from zero.

Diagnostic Checking

The diagnostic stage is used to examine whether the fitted model satisfies all the basic assumptions that is the residuals series are uncorrelated random shocks with zero mean and constant variance (white noise). These assumptions are verified by testing whether any of the autocorrelation values (k r) are significantly different from zero one at a time using the student ttest statistic. An alternative approach to testing the significance of the autocorrelation values (k r) one at a time, is using the Ljung-Box portmanteau (Ljung and Box, 1978). The Ljung-Box test which is modified version of the portmanteau test statistic developed by Pierce and Box (1978), is a test-statistic used for testing whether any group of autocorrelations are statistically different from zero. Instead of testing randomness at each distinct lag in the series, it tests the "overall randomness based on the number of lags being considered". The Ljung-Box test statistic has a distribution closer to the chi-square distribution which is considered better than the portmanteau test statistic proposed by Pierce and Box (1978). The Ljung-Box Q-statistic is normally used to test the adequacy of the model whether the residual have a zero mean, a constant variance and serially uncorrelated (white noise). The Ljung-Box test statistic is expressed as:

$$Q = n(n+2) \sum_{k=1}^{h} \frac{\hat{p}k^2}{(n-k)}$$

Where (n) denotes the sample size, ( ) is the square of the autocorrelation at lag k and (h) is the maximum lag being tested. The hypothesis to be tested is formulated as:

$H0$: The residuals are independently distributed

$H1$: The residuals are not independently distributed

It is important to check whether the residuals of the chosen models are normally distributed with zero mean and constant variance by using the residuals plot against time or Shapiro-Wilk Normality test expressed as:

$$W = \frac{\left(\sum_{i=1}^{n} \alpha_i x_i\right)^2}{\sum_{i=1}^{n} \left(x_i - \hat{x}_i\right)^2}$$

Where (x_i) is the i^th order statistics, x ̂= (x_1 +…+ x_n)/n is the sample mean and α = (α_1 +…+ α_n).

The decision of the Shapiro-Wilk normality test (Shapiro and Wilk, 1965) is based on the p-value against the chosen level of significance (0.05). The hypothesis for the Shapiro-Wilk normality test is given as

$H0$: The residuals are normally distributed

$H1$: The residuals are not normally distributed

While Lagrange multiplier (LM) test proposed by Engle, 1982 in order to test for the existence of Autoregressive Conditional Heteroscedasticity behavior based on the regression in a time series data set. The ARCH-LM test statistics is expressed as:

ARCH-LM =TR2

Where (R) is the sample multiple coefficients computed from the regression residuals 〖ε〗_t^2, ε_(t-1)^2, …, ε_(t-q)^2 on a constant and T is the sample size. The ARCH-LM hypothesis to be tested is expressed as:

H0: The residuals are homoscedastic.

H1: The residuals are not homoscedastic.

Under the null hypothesis that there is no ARCH effect, the test statistic is asymptotically distributed as chi-square distribution with (q) degrees of freedom. If the model fails to pass the entire diagnostic test, it is advised to restart the model building cycle until a more appropriate model is obtained for the observed time series.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 below shows the descriptive statistics of the unemployment rate and inflation rate series. It shows the number of observations in the series, the mean, median standard deviation, variance, skewness, kurtosis, and the minimum and maximum values of the series.

Table 1: Descriptive Statistics for Unemployment Series and Inflation Rate Series

Variable	N	Mean	Median	StDev	Variance	Min	Max	Skewness	Kurtosis
Unemployment Rate	30	15.33	13.25	11.37	129.36	1.80	42.90	0.79	0.05
Inflation Rate	30	17.34	10.31	16.09	258.73	0.69	75.40	2.07	5.02

For each of the series, the sample observation is 30. The mean for the Unemployment rate series is 15.33, while that of the inflation rate series is 17.34. The standard deviation for the Unemployment rate series is 11.37 while that of inflation rate series is 16.09. The variance for Unemployment rate series is 129.36, while that of Inflation rate series is 258.73. The skewness for the Unemployment rate series is 0.79 while that of Inflation is 2.07. Likewise, the kurtosis for Unemployment rate series is 0.05, while that of Inflation rate is 5.02. Furthermore, the minimum values for Unemployment rate series and Inflation rate series are 1.80 and 0.69 respectively. While their maximum values are 42.90 and 75.40, respectively. Generally, the series for Unemployment rate appears to be more normally distributed than the series of Inflation rate.

Time Series Plots for Unemployment Series and Inflation Rate Series

The time series plots for the series, typically display the movement of these economic indicator series over the time. Each point on the plot is the actual value of the specific series at the specific point in time. Figure 1 below shows the time plots of the two series, Unemployment rate and Inflation rate. The time plot of unemployment rate shows an upward trend up to the year 2016, and then shows a downward trend in a few years, and climbed up at year 2020. The plot for the Inflation rate shows upward trend till the year 1996, and then decreases downwards and later shows no trend till 2020.

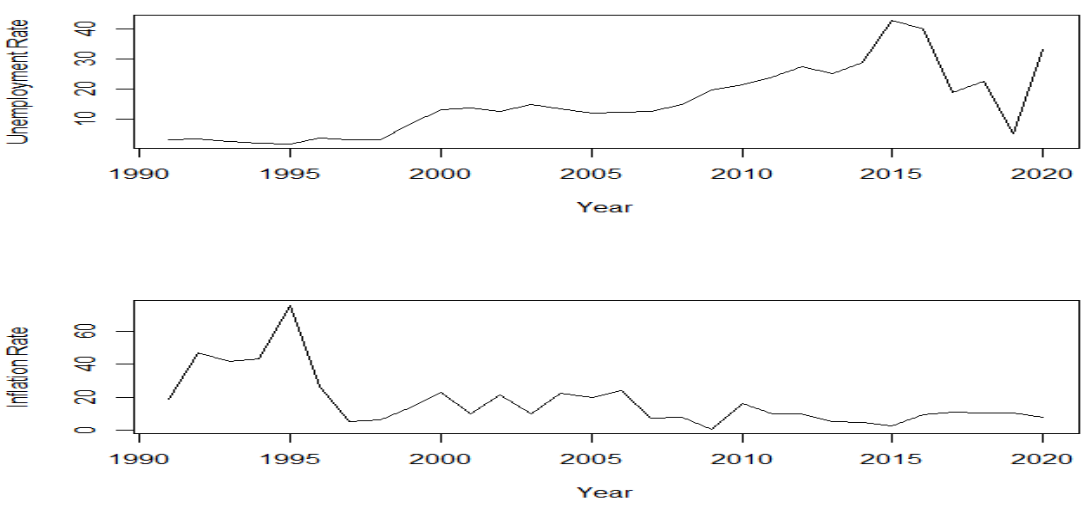


Figure 1: Time plots for Unemployment rate series and Inflation rate series

Testing for Stationarity of the Two Series

Figure 2 shows the results of ACF and PACF for Unemployment rate series. On the ACF plot, the first, second, third, fourth and fifth spikes fall outside the 95% confidence interval. While on the PACF plot only one spike is out of the 95% confidence interval. These indicate that Unemployment rate series is not stationary. Figure 3 shows the result of the ACF and PACF for Inflation rate series. On the ACF plot, first and second spikes fall outside the 95% confidence interval. While on the PACF plot, only one spike falls outside the 95% confidence interval. These indicate that the Inflation rate series is not stationary.

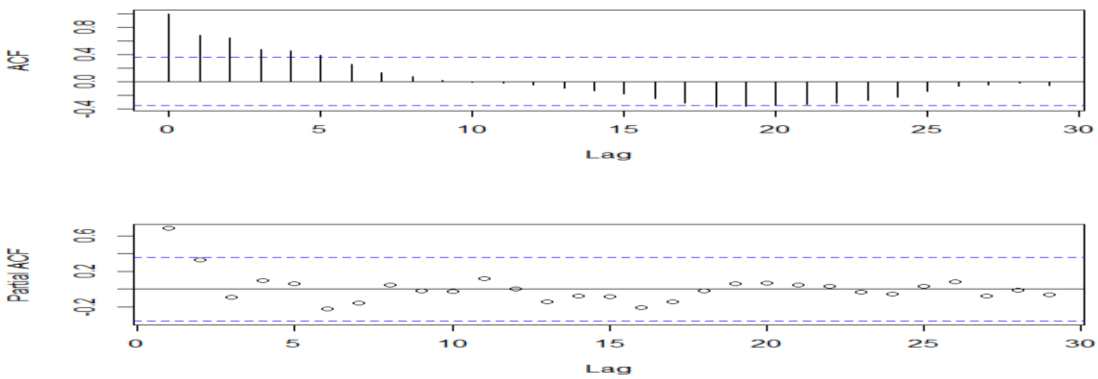


Figure 2: ACF and PACF plot for Unemployment rate

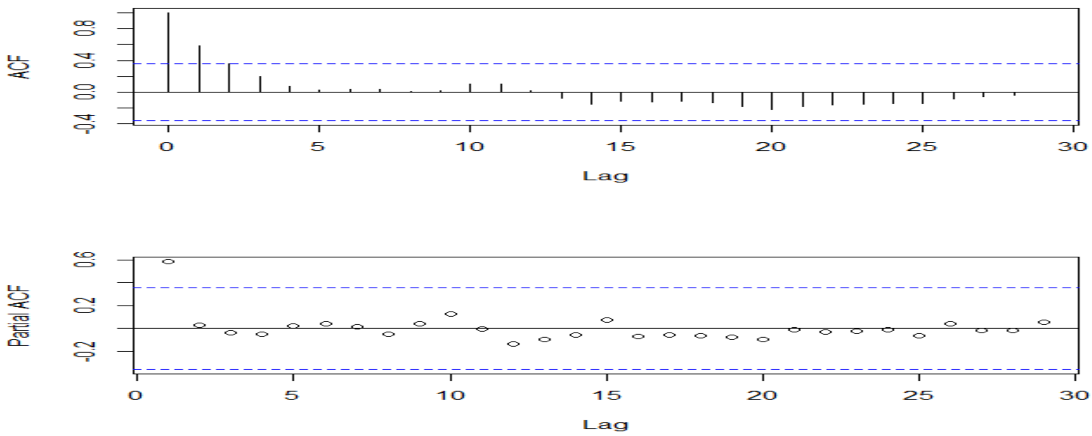


Figure 3: ACF and PACF plot for Inflation rate

To determine whether there is significant presence of unit root in the Unemployment rate series, KPSS and ADF are used. Testing the null hypothesis that there is stationarity around a deterministic trend, KPSS test statistic is used, Table 2 shows the result that, the KPSS test statistic value is 0.87141 and its corresponding p-value is 0.1. Since the p-value is not less than 0.05 level of significance, the null hypothesis is not rejected. And so, the series is stationary around the deterministic trend. Testing the null hypothesis that there is presence of unit root in the Unemployment rate series, ADF test statistic is used. Table 2 shows that the ADF test statistic value is -3.0256 and its corresponding p-value of 0.1787, since the p-value is not less than 0.05 level of significance, the null hypothesis of unit root being present in the unemployment rate series is not rejected. Since both KPSS and ADF results are contradicting for Unemployment rate series, there is the need to carry out differencing operation on the time series. Since both the KPSS result and the ADF result are contradicting, there is the need to carry out a differencing operation.

To determine whether there is significant presence of unit root in the Inflation rate series, the KPSS and ADF are employed. Table 2 shows the result that, the KPSS test statistic value is 0.59782 and its corresponding p-value is 0.02283. Since the p-value is not less than 0.05 level of significance, there no stationarity around the deterministic trend. Also, the ADF test statistic value with its corresponding p-value from Table 2, are -2.9198 and 0.2193 respectively. Since the p-value is not less than 0.05, there is the significance presence of unit root in the inflation rate series. Again, since both KPSS and ADF results are contradicting for Inflation rate series, there is the need to carry out differencing operation on the time series. Since both the KPSS result and the ADF result are contradicting, there is the need to carry out a differencing operation.

Table 2: KPSS and ADF test statistics summary for Unemployment rate and Inflation rate

Summary of Test Statistics For Unemployment rate				
Test Type	Null	Test Statistic	Lag Order	P – Value
KPSS	Trend	0.87141	2	0.1
ADF		-3.0256	3	0.1787
Summary of Test Statistics For Inflation rate				
Test Type	Null	Test Statistic	Lag Order	P – Value
KPSS	Trend	0.59782	2	0.02283
ADF		-2.9198	2	0.2193

Differencing Unemployment rate series and Inflation rate series once, the graphical plot of these first-order differenced series are depicted in Figure 4 below:

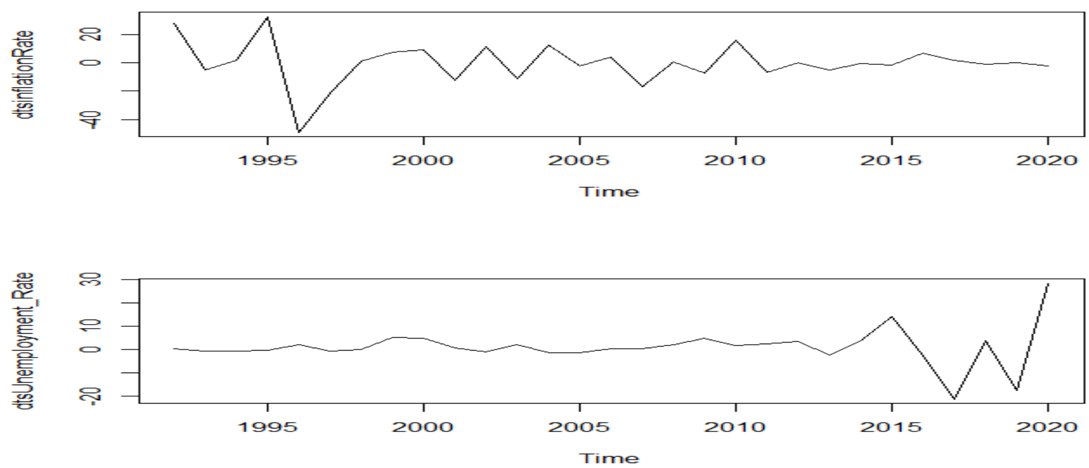


Figure 4: First-Order Differenced Unemployment rate and Inflation rate Series

From the graph in Figure 4 above, first-order Unemployment rate time plot shows that there are three large amplitude of size ± 20 at the beginning, then as the time progresses the series fluctuates around zero. For the Inflation rate time plot, it shows an amplitude close to zero at the beginning, but as time progresses, it experienced three large amplitude of size ± 10 towards the end.

Using ACF and PACF to determine whether there is stationarity in the first-order Unemployment rate series. ACF plot from figure 5 shows that all the spikes are below the upper and lower confidence bound. Also the corresponding PACF plot shows that the all the spikes are below the upper and lower confidence bound.

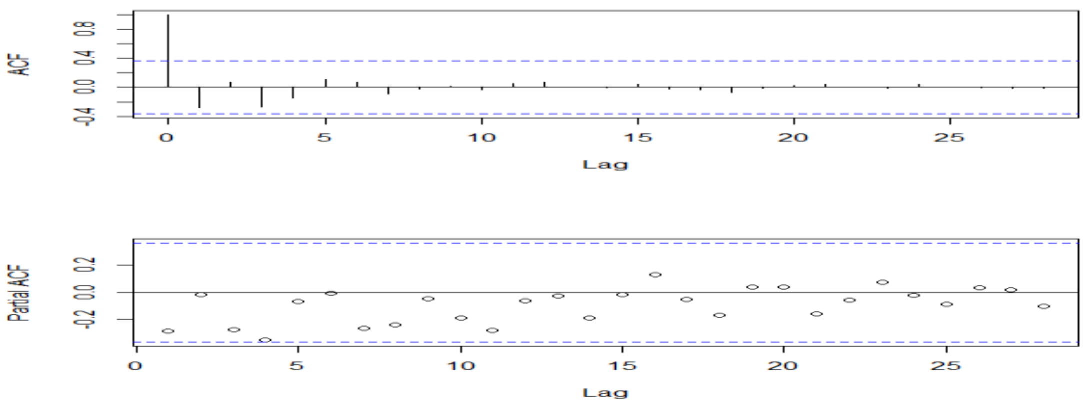


Figure 4.5: First-Order Differenced Unemployment Rate Series ACF and PACF Plots

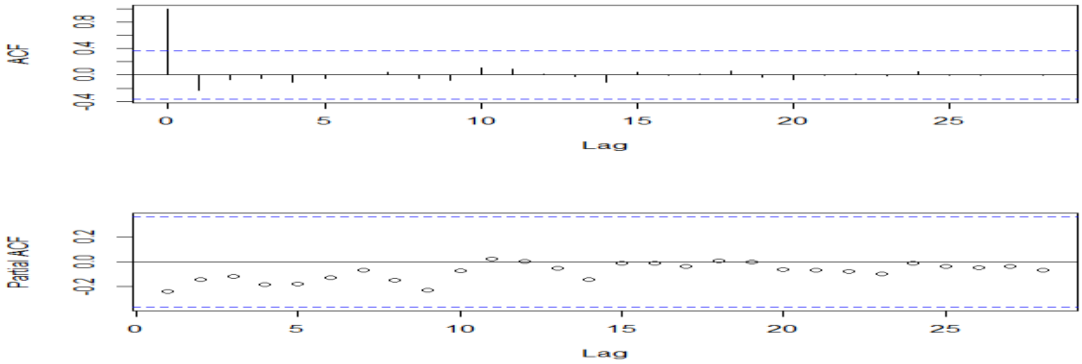


Figure 6: First-Order Differenced Inflation Rate Series ACF and PACF Plots

Using ACF and PACF to determine whether there is stationarity in the first-order Inflation rate series. ACF plot from figure 6 above shows that all the spikes are below the upper and lower confidence bound. Also the corresponding PACF plot shows that the all the spikes are below the upper and lower confidence bound.

To determine the stationarity of the first-order Unemployment rate series and Inflation rate series. The result from the unit root test after the series was differenced is displayed in Table 3. The trend KPSS test statistic for Unemployment rate is 0.0595 with corresponding p-value of 0.1, did not reject the null hypothesis of trend stationarity in the series, since the P-value is greater than the pre-chosen significance level of 0.05.The ADF test statistic is -4.29 and its corresponding p-value is 0.01. The null hypothesis of a unit root in the series is rejected. Since the ADF and KPSS result agrees that the series is stationary, there is no need for another differencing.

Table 3: KPSS and ADF test statistics summary for first-order Unemployment rate and Inflation rate series

Summary of Test Statistics For Difference Unemployment Rate				
Test Type	Null	Test Statistic	Lag Order	P – Value
KPSS	Trend	0.0595	1	0.1
ADF		-4.29	2	0.01
Summary of Test Statistics For Difference Inflation Rate				
Test Type	Null	Test Statistic	Lag Order	P – Value
KPSS	Trend	0.056915	2	0.1
ADF		-6.9246	3	0.01

Identifying the Appropriate ARIMA Model That Fits the Series

Applying ARIMA model the first-order Unemployment rate series, Table 4 shows the results of ten applied ARIMA models. The lowest values of AIC, AICc, BIC and Loglikelihood respectively, which are criteria for selecting the best ARIMA model are 203.66, 204.1, 206.38 and -99.82. The model with these lowest values of the selection criteria is ARIMA (0,1,1)

Table 4: Comparison of ARIMA (p,d,q) Models fitted to Unemployment Rate

TENTATIVE MODEL FOR UNEMPLOYMENT RATE				
SELECTION CRITERIA				
MODELS	**AIC**	**AICc**	**BIC**	**LOGLIKELIHOOD**
ARIMA(0,1,0)	205.49	205.64	206.86	-101.75
ARIMA(0,1,1)*	**203.66**	**204.12**	**206.38**	**-99.82**
ARIMA(0,1,2)	205.54	206.5	209.65	-99.77
ARIMA(0,1,3)	202.93	204.6	208.4	-97.46
ARIMA(0,1,4)	204.67	207.28	211.51	-97.34
ARIMA(0,1,5)	203.77	207.58	211.97	-95.88
ARIMA(1,1,0)	203.66	204.12	206.39	-99.83
ARIMA(1,1,1)	205.34	206.3	209.44	-99.67
ARIMA(1,1,2)	207.26	208.92	212.72	-99.63
ARIMA(1,1,3)	204.81	207.42	211.65	-97.41
ARIMA(1,1,4)	204.7	208.52	212.9	-96.35

Table 5 shows the results of ten applied ARIMA models for the first order Inflation rate series. The lowest AIC, AICc, BIC and Loglikelihood respectively, which measures the adequacy of the models are 238.61, 239.07, 241.35 and -117.31. The model with these lowest values of selection criteria is ARIMA (0,1,1).

Table 5: Comparison of ARIMA (p,d,q) Models Fitted to Inflation Rate

TENTATIVE MODEL FOR INFLATION RATE				
SELECTION CRITERIA				
MODELS	**AIC**	**AICc**	**BIC**	**LOGLIKELIHOOD**
ARIMA(0,1,0)	239.53	239.67	240.89	-118.76
ARIMA(0,1,1)***	**238.61**	**239.07**	**241.35**	**--117.31**
ARIMA(0,1,2)	238.84	239.8	242.95	-116.42
ARIMA(0,1,3)	240.4	242.06	245.87	-116.2

ARIMA(0,1,4)	242.09	244.7	248.93	-116.04
ARIMA(0,1,5)	243.89	247.71	252.1	-115.95
ARIMA(1,1,0)	239.71	240.17	242.45	-117.86
ARIMA(1,1,1)	238.39	239.35	242.49	-116.2
ARIMA(1,1,2)	240.39	208.92	245.86	-116.19
ARIMA(1,1,3)	242.29	244.9	249.13	-116.15
ARIMA(1,1,4)	244.04	247.86	252.24	-116.02

To estimate the MA coefficient in ARIMA (0,1,1) model, the result from Table 5 below shows that the estimated coefficient values, its t-statistic and the corresponding p-value. For the unemployment rate series, the estimated MA(1) value is 0.4550. While for the inflation rate series, the estimated MA(1) value is 0.4877. Since their p-values, 0.020973 and 0.000233 respectively, are less than 0.05 level of significance, the estimated values are significant for both series. The estimated coefficients strictly conforms to the bounds of stationarity and invertibility since their values lies between -1 and 1. Hence, the chosen model based on the principle of parsimony for unemployment rate series and inflation rate series respectively, are expressed as:

$$\hat{y}_t = \varepsilon_t + 0.4550\varepsilon_{t-1}$$

$$\hat{y}_t = \varepsilon_t + 0.4877\varepsilon_{t-1}$$

In both series, the current value of the series is linearly dependent on the current and past white noise error terms. So, the current value of each series is a weighted sum of the error terms.

Table 6: Parameter for ARIMA (0,1,1)

Model Fit Statistics For Unemployment Rate

Coefficient	**Estimate**	**Std.Error**	**t-value**	**p-value$P(>|t|)$**
MA(1)	0.4550	0.1971	2.308473	0.020973

Model Fit Statistics For Inflation Rate

Coefficient	**Estimate**	**Std.Error**	**t-value**	**p-value$P(>|t|)$**
MA(1)	0.4877	0.1325	3.680755	0.000233

Diagnostic Checking For the Fitted Model

Checking the adequacy of the fitted model in other to deem the model fit for forecasting the future values of Unemployment rate series and Inflation rate series. The diagnostic checking is performed using the correlogram plots of the model residuals coupled with other objective diagnostic tests such as the Box-Ljung serial correlation test, Shapiro-Wilk Normality test and the ARCH-LM test for heteroscedasticity. The model residuals series plots and correlogram plots are shown in Figure 4.5 below;

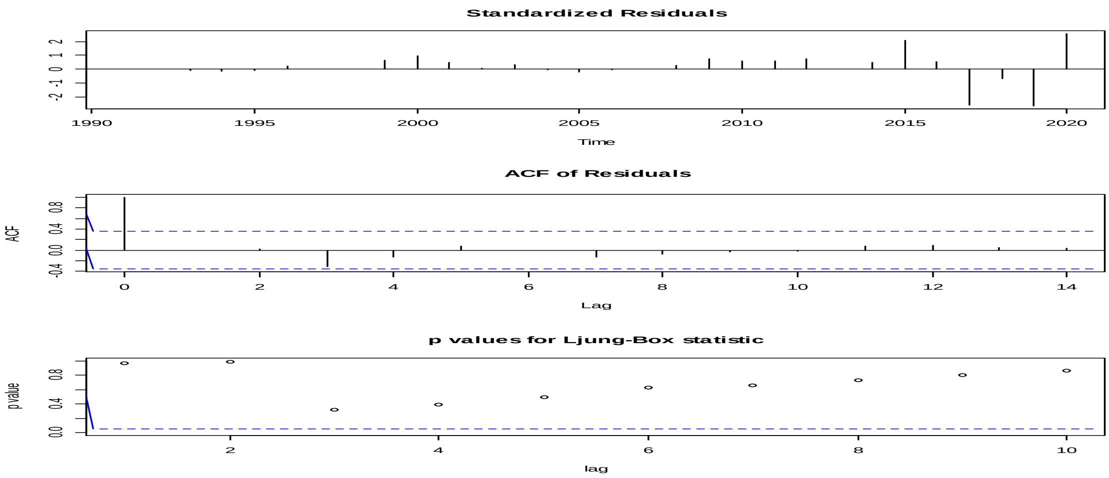


Figure 7: ARIMA (0,1,1) model residual diagnostic Plots for Unemployment rate series.

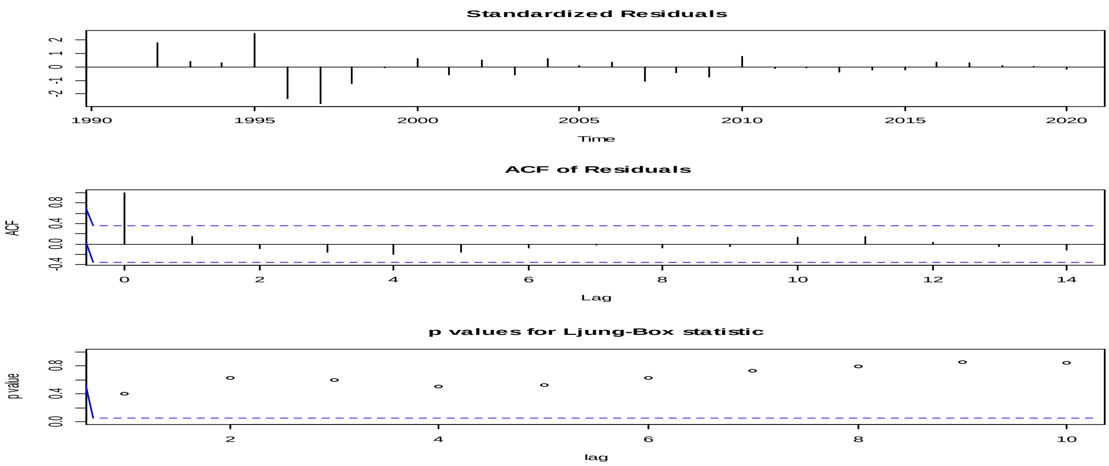


Figure 8: ARIMA (0,1,1) model residual diagnostic Plots for for Inflation rate Series.

The time plot in Figure 4 and Figure 5 above generally shows no pattern and may be conceived as independent and identically distributed sequence with a constant variance and zero mean. Also, no evidence exists in the plot that the error term are related with one another as well as no evidence of existence of outlier. This indicates that the residual of the fitted models are Gaussian white noise.

The Box-Ljung test for uncorrelated residuals, Shapiro-Wilk test for Normality and ARCH-LM test for heteroscedasticity results in Table 6 and Table 4.8 failed to reject the null hypothesis for each of the diagnostic test carried out on the model residuals at the 5% pre-chosen significance level.

ARIMA (0,1,1) Model Residuals Diagnostic Test for Unemployment Rate Series

Table 7 below revealed that Ljung-Box test, evaluating autocorrelation in ARIMA (0,1,1) model residuals, yielded a chi-square statistic value of 6.5034 with a corresponding p-value of 0.97. Since the p-value is greater than 0.05 level of significance, the null hypothesis of no presence of autocorrelation in the residuals is not rejected. This implies that assumption of no presence of autocorrelation in the residual is not violated.

Table 7: Diagnostic Checking for Unemployment Rate

Box-Ljung and ARCH-LM Test Statistics			
Test Type	Chi-Square	Df	P – Value
Ljung-Box	6.5034	15	0.97
ARCH-LM	0.0782	4	0.994

Similarly, the ARCH-LM test, assessing conditional heteroscedasticity, has a chi-square statistic value of 0.0782 with a corresponding p-value of 0.994. Since the p-value is greater than 0.05 level of significance, the null hypothesis of no presence of conditional heteroscedasticity is not rejected. This implies that assumption of no presence of conditional heteroscedasticity in the residual is not violated.

Table 8: Shapiro-Wilk Test for Unemployment Rate

Shapiro-Wilk Test Statistics		
	W	**p-value**
Shapiro-Wilk	0.81851	0.0001453

Table 8 above present the Shapiro-Wilk test for the unemployment rate residuals. The result has a p-value of 0.0001453 which is less than the 5% level of significance. Hence we reject the null hypothesis of the sample being drawn from the normal distribution. This implies that the residual is not normally distributed and therefore needs to be transformed.

Table 8 below shows the Shapiro-wilk test after log transformation. The result revealed that a p-value of 0.1329 which is greater than 5% level of significance. Hence we do not reject the null hypothesis of the sample being drawn from a normal distribution. This implies that the residual is normally distributed.

Table 9: Shapiro-Wilk Test for Unemployment Rate after Log Transformation

Shapiro-Wilk Test Statistics After Log-Transformation		
	W	**p-value**
Shapiro-Wilk	0.93981	0.1329

ARIMA (0,1,1) Model Residuals Diagnostic Test for Inflation Rate Series

Table 9 above revealed that Ljung-Box test, evaluating autocorrelation in ARIMA (0,1,1) model residuals, yielded a chi-square statistic of 7.8739 with 15 degrees of freedom, resulting in a high p-value of 0.9287. Thus, we fail to reject the null hypothesis of no presence of autocorrelation in the residuals indicating that significant autocorrelation is absent in the residuals of Inflation rate, suggesting the model adequately captures temporal dependencies in the data. This implies that the assumptions of no presence of autocorrelation in residual is not violated.

Table 10: Diagnostic Checking for Inflation Rate

Box-Ljung and ARCH-LM Test Statistics			
Test Type	Chi-Square	Df	P – Value
Ljung-Box	7.8739	15	0.9287
ARCH-LM	0.0604	4	0.9452

Similarly, the ARCH-LM test, assessing conditional heteroscedasticity, generated a chi-square statistic of 0.0604 with 4 degrees of freedom, yielding a very high p-value of 0.9452. Again, we fail to reject the null hypothesis of presence of conditional heteroscedasticity in the residuals of Inflation rate, indicating no evidence of conditional heteroscedasticity in the residuals, suggesting that the model effectively captures the variance. This implies that the assumptions of no presence of conditional heteroscedaticity in residual is not violated

Table 11: Shapiro-Wilk Test for Inflation Rate

Shapiro-Wilk Test Statistics		
	W	**p-value**
Shapiro-Wilk	0.90275	0.00981

Table 11 above present the Shapiro-Wilk test for the Inflation rate residuals, the result has a p-value of 0.00981 which is less than the 5% level of significance. Hence we reject the null hypothesis of the sample being drawn from the normal distribution. This implies that the residual is not normally distributed and therefore needs to be transformed.

Table 12: Shapiro-Wilk Test for Inflation Rate after Log Transformation

Shapiro-Wilk Test Statistics After Log-Transformation		
	W	**p-value**
Shapiro-Wilk	0.95625	0.5311

Table 12 above shows the Shapiro-Wilk test after log transformation. The result revealed that a p-value of 0.5311 which is greater than 5% level of significance. Hence we do not reject the null hypothesis of the sample being drawn from a normal distribution. This implies that the residual is normally distributed.

Models Forecast

A view into the future is one of the main objectives of model building. In this study, the forecast estimation function for optimal (h) periods ahead is expressed as:

$$\hat{y}_{T+h/T} = \theta_1 \hat{\varepsilon}_{T+h/T}$$

The error is the difference between the actual value of the series (unemployment rate series or inflation rate series) values and the fitted values. The forecast error $\hat{\varepsilon}(h)$ at lead time is given by:

$$\hat{\varepsilon}_t = y_{T+h} - \hat{y}_{T+h/T}$$

where y_{T+h} represent the actual series value at $T + h$.

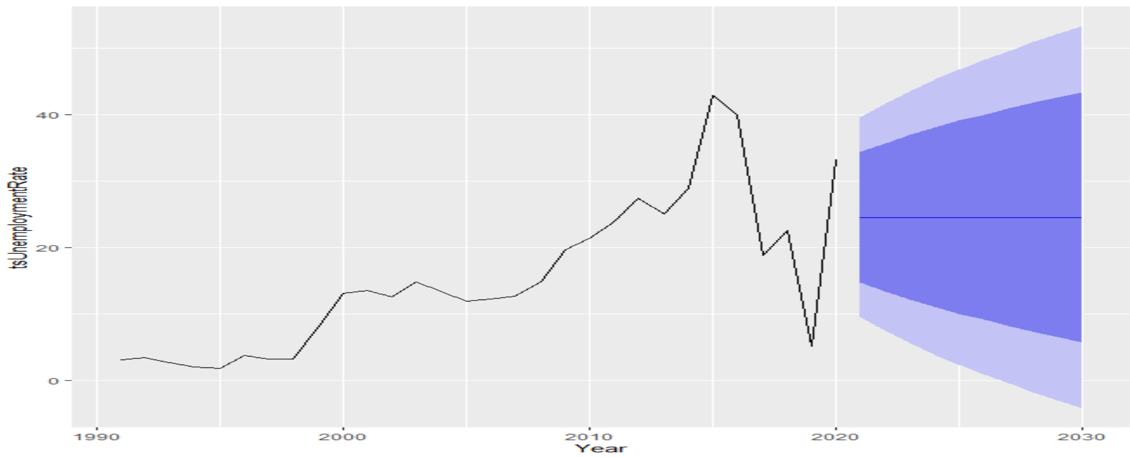
Since the fitted model for the unemployment rate series and the fitted model for inflation rate series have satisfied the requirement for model adequacy under diagnostic tests, next is to make predictions.

For the unemployment rate series and the inflation rate series, two years forecast values and 95% confidence interval for the for the forecast values are given in Table 13 below.

Table 13: Forecasted values of Unemployment and Inflation rate.

UNEMPLOYMENT RATE FORECAST VALUE			
Year	Forecast	95% lower ci	95% upper ci
2021	24.58686	9.560980	39.61274
2022	24.58686	7.473984	41.69973
INFLATION RATE FORECAST VALUE			
2021	7.849142	-20.63214	36.33043
2022	7.849142	-32.42947	48.12776

For the unemployment rate, the forecasted values for the year 2021 and 2022 are the same, 24.58686, with different confidence interval. For inflation rate, the forecasted values for the 2021 and 2022 are also the same, 7.849142, with different confidence interval. Figure 9 shows the forecasted plots for unemployment rate series and inflation rate series respectively.



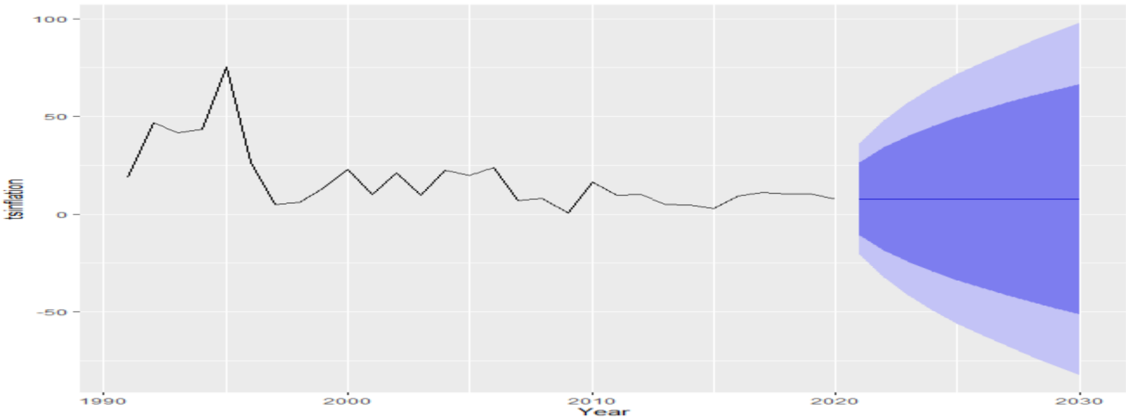


Figure 9: The Forecast Plot (2020-2022)

CONCLUSION

The annual data on Unemployment Rate and Inflation rate from 1991-2020 was used for this research project. Box-Jenkins (ARIMA) modeling procedure was applied to the data series and the findings from the analysis are obtained.

Results from time series plots of unemployment rate and Inflation rate both revealed an upward trend. Stationarity of the two series were examined using the ADF and KPSS, and revealed that the two series were not stationarity at 0.05 level of significance. To attain stationarity, the two series were differenced at first level. The results from ACF and PACF for the two series showed only a few significance lag spikes which depicts stationarity of the series. Also, ADF and KPSS statistics confirmed stationarity for the two series at 0.05 level of significance.

For each of the two series, to obtain the appropriate ARIMA model that fits the data, ten closely suitable ARIMA models were identified. Using the least values of AIC, AICc and BIC as selection criteria, ARIMA (0,1,1) was found to be the best fitted model for each of the two series. For each of the two series, the value of the estimated coefficient, MA(1) component in the model is significant. This implies that the estimated coefficient conformed to the stationarity and inevitability bounds in each of the two series. Also, their residuals were found to be white noise, having met all the necessary criteria on white noise residuals. In each of the two series, the current value of the series is linearly dependent on the current and past white noise error terms. So, the current value of each series is a weighted sum of the error terms.

For each series, the fitted model was subjected to diagnostic checks to confirm that the residuals are uncorrelated and normally distributed with zero mean and constant variance. Box-Ljung test, Shapiro-Wilk normality and ARCH-LM tests were used in the diagnostic checks. For each of the series, the three tests failed to reject the null hypothesis which implied that the residuals are white noise. For each of the series, the white noise residuals were clearly portrayed by the randomness of the residuals, nonsignificant spikes in the ACF and PACF residuals plots. Finally, the unemployment rate series model was used for forecast, and the years 2021 and 2022 forecasted values were obtained with their corresponding 95% confidence limits. Also, the inflation rate series model was used for forecast, and the years 2021 and 2022 forecasted values were obtained with their corresponding 95% confidence limits. These two series share the same similarities in their characteristics. The same ARIMA models is fitted to each of the two series, the two series passed the same diagnostic checks.

CONCLUSION

For unemployment rate series and Inflation rate series, ARIMA (0,1,1) model is the most suitable model for each of the two series with the estimated model selection penalty statistics AIC, AICC and BIC being the lowest and the residuals being Gaussian white noise. The fitted model is free of violations of the assumptions for fitting appropriate ARIMA model and forecasting. Finally, the forecasted values from the selected model revealed that Unemployment Rate and Inflation rate will be experiencing increase over the forecasted years (2021 and 2022) with respect to the white noise. The forecasted values for the unemployment rate series and inflation rate series maintain a constant point forecast. This implies that unemployment rate and inflation rate in Nigeria does not reveal a noticeable increase nor decrease but will be constant in Nigeria for the forecasted period.

Recommendation

From this research conducted, the following recommendations are made:

I. In a motivation to experience low unemployment rate and inflation rate which are economic indicators in Nigeria, deriving appropriate ARIMA model to give insight into future occurrence of these indicators for intervention calls for the application of ARIMA model.

II. Due to the unchanging forecasted value which appears not to be decreasing, there is need for interventions that will lead to the visible reduction of present unemployment rate and inflation rate in Nigeria.

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