Structural Analysis and Forecast of Nigerian Monthly Inflation Movement between 1996 and 2022

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ABSTRACT: Forecasting leads to adequate and comprehensive planning for sustainable development. A number of procedures are used to estimate, predict and forecast data, but not all are able to capture the historical path of the data generating process adequately. In view of this, the timeseries characteristics, structural changes and trend of inflation in Nigeria (1996-2022) were analyzed using ARMA, Holt-Winters, spline and other associated models. The results indicated that inflation in Nigeria has remained above acceptable limits in a cyclical trend during the period under study and that there is every possibility that Nigerian inflation would remain above 10% for some time to come. There were six shocks, the major stressors being food inflation, oil and gas prices and wages adjustment. For Nigeria to achieve a stable inflation rate regime of acceptable limits, a robust economic management and intelligence team using a global innovation platform as well as evidenced-based policies which ensure that Nigeria does not swerve away from the path to recovery should be established in consultation with the fiscal, monetary, and research authorities.

KEYWORDS: b-splines, Holt-Winters smoothing, Nigerian inflation, structural breaks, cyclical trend

Introduction

Inflation is one of the major financial difficulties confronting most African countries including Nigeria. It is also a major focus of worldwide economic policy (David 2001). There are distortions to economic patterns and redistribution of wealth that cause global concerns because inflation can occur when not anticipated. Inflation can be expressed as a situation whereby the demand for goods and services exceeds their supply in the economy (John and Patrick 2016). In real terms, inflation erodes the purchasing power of consumers. It results from imbalance between demand for and supply of money as well as increases in cost of production and distribution of goods and services or taxes on products. Inflation causes the price level of goods and services to rise, thereby reducing the purchasing power of national currency. When that happens, investors within and outside the country get discouraged as their confidence level on the safety of their investments reduces. Given the importance of inflation reduction to economic growth of a country, researchers and economists carry out analysis on it by applying various time series and econometrics models to forecast or model the rates (Otu et al. 2014; John and Patrick 2016).

NBS (2017) defines Consumer Price Index (CPI) as the average change in prices of goods and services purchased by consumers over time. In Nigeria, CPI is constructed by combining economic theory, sampling and other statistical techniques from survey data to produce a weighted measure of average price changes by economists, statisticians, computer scientists, data collectors and others. The difference between the CPI of one month in the previous year to that same month in the current year is the inflation rate (NBS 2017). In spite of the widely publicized negative effects of inflation, an economy is still considered good if there exists a moderate inflation rate of 2 or 3 percent. Such a rate is considered beneficial as it encourages investors to buy and borrow more as the interest rate remains low. Monetary, political and fiscal authorities always strive to achieve this optimal rate of inflation (Otu et al. 2014).

Time series forecasting has been a challenge due to the lack of a functional approach that takes data inadequacy into consideration (Hanif & Malik 2015; Giacomini 2015; Faust & Wright 2013; Binner et al. 2010). Estimation of models to forecast the future values of an economic time series is one of the econometric methods of information management (Rahman 2001). Some economic time series data might exhibit linear relationships over an entire sampled period whereas others may not. In the past, several studies (Fuller 1969; Philip 1990; Rahman 2001; Akpan et al. 2007; Alabi et al. 2008; Nmadu et al. 2009; Bivan et al. 2013) utilized the grafted polynomial procedures to and successfully estimated and forecasted some economic data. Fuller (1969) gave desirable properties and advantages of grafted polynomials and Nmadu et al. (2001), Nmadu (2002), Nmadu et al. (2004) utilized grafted polynomials to forecast sorghum production from 1997 to 2010 and found that the forecast was more stable than the forecast from the linear-based models like the growth model. Phillip (1990) successfully used the grafted model to forecast cotton production in Nigeria. Also, Rahman (2001) forecasted the production of maize production in Nigeria. In all the afore-mentioned studies, they observed that the forecasting ability of the model is superior to others, particularly the growth model because the model better traces the historical non-linear path of the data thereby having lower estimation error. In addition, Nmadu et al. (2009) evaluated various grafts using Nigerian GDP and revealed that there is no universality as to which type of graft is appropriate, rather all possible grafts should be tried and the one that gives the most consistent result when compared to observe data should be used. Therefore, in view of the apparent advantages of the grafted model over other forecasting models, this study aims to utilize the model to estimate and predict the inflation rate of Nigeria from 2003 to 2017 and forecasts it to February 2031. The objective of this study is to analyze the trend and forecast Nigerian inflation and compare the results using the grafted polynomial model and Holt-Winters smoothing model. The main hypothesis in this study is that the prediction and forecast of Nigerian inflation rate from 2018 to February 2031 is not different from the two procedures. The estimation is done by comparing the capabilities and similarities of grafted polynomials (b spline) and Holt-Winters smoothing models in R Core Team (2021).

Theory of Inflation in the Economy

There are basically two schools of thought as to what causes inflation, the monetarist and the structuralists. The structuralist, which was employed as theoretical framework in this study, holds the view that inflation is necessary with growth. According to this view, as the economy develops, rigidities arise which leads to structural inflation. In the initial phase, there are increases in non-agricultural incomes accompanied by high growth rate of population that tend to increase the demand for goods. As the demand for agricultural goods rises, their domestic supply being inelastic due to a defective system of land tenure and other rigidities in the form of lack of irrigation, finance, storage, marketing facilities and bad harvests. This eventually would lead to rises in the prices of agricultural goods. When the prices of food products rise, wage earners press for an increase in wage rates to compensate for the fall in their real incomes. Another cause of structural inflation is that the rate of export growth in a developing country like Nigeria is slow and unstable which is inadequate to support the required growth rate of the economy. The nature of the tax systems and budgetary processes also help in accentuating the inflationary trends in such economies (Jhingan 2003). The effects of increase in the wage rates on prices are illustrated in Fig. 1. When wage rates rise, the aggregate demand for goods increases from D1 to D2. But the aggregate supply falls due to an increase in labor costs which results in the shifting of the aggregate supply curve from S1S to S2S. Since the production of goods is inelastic due to structural rigidities after a point, the supply curve is shown as vertical from point E1 onwards. The initial equilibrium is at E1 where the curves D1 and S1 intersect at the output level OY1 and the price level is OP1. When supply falls due to an increase in labor costs, the supply curve shifts

from S1 to S2 and it intersects the demand curve D2 at E2 and production falls from OY1 to OY2 and the price level rises from OP1 to OP2.

The requirement for forecasting in recent times is expanding, as economists endeavor to diminish their over-reliance on possibility and rather turned out to be more logical in managing issues (Makridakis et al. 1998, Hanif & Malik 2015; Faust & Wright 2013; Binner et al. 2010). To obtain a more precise and dependable future forecast for economic variables, such as inflation, a few times series approach have been utilized by analysts in various economies around the globe. Suhartono (2005) compared the forecasting accuracies of three (3) approaches used in forecasting Indonesian inflation (Neural Networks, ARIMA and ARIMAX). The best models were selected based on forecasting ability by using the MSE and RMSE. Forecasts from the Neural Network approach outperformed the two other approaches. In another study, Barros et al. (2012) forecasts inflation in Angola with an ARFIMA (AutoRegressive Fractionally Integrated Moving Average) model. It was found that inflation in Angola is a highly persistent variable with an order of integration constrained between 0 and 1.

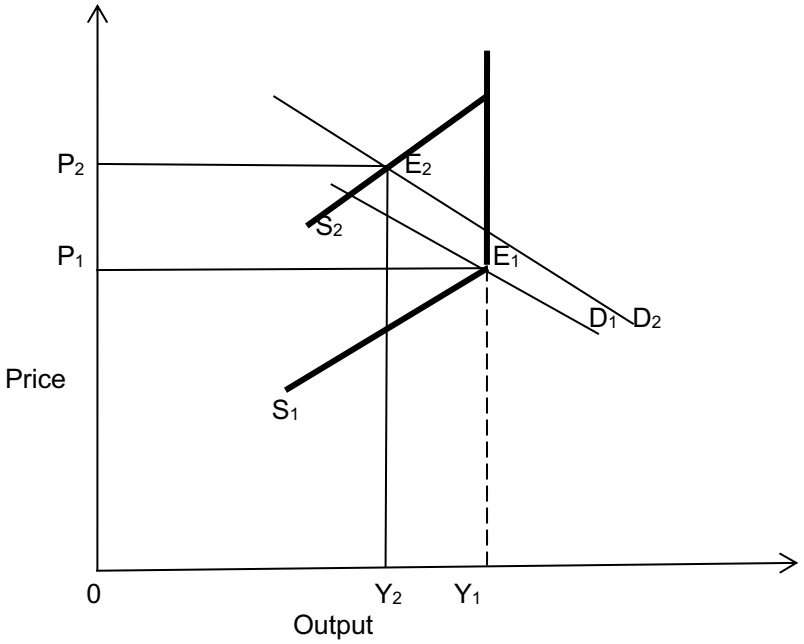

Fig. 1. Structural inflation adopted from Jhingan (2003).

Moreover, a structural break was found in August, 1996. Using the second sub-sample for forecasting purposes, the results reveal that inflation will remain low, assuming that prudent macroeconomic policies are maintained.

Pincheira and Medel (2012) explore the ability of several univariate models to predict inflation in a number of countries and at several forecasting horizons. The study placed special attention on forecasts coming from a family of ten seasonal models called the Driftless Extended Seasonal ARIMA (DESARIMA) family. Using out-of-sample Root Mean Squared Prediction Errors (RMSPE), the forecasting accuracy of the DESARIMA models was compared with that of traditional univariate time-series benchmarks available in the literature. The study revealed that DESARIMA-based forecasts display lower RMSPE at short horizons for every single country, except one. Also, the DESARIMA-based forecasts outperform the benchmarks at long horizons and the forecasting accuracy of DESARIMA models was high. Olajide et al. (2012) investigated the inflation rate in Nigeria using Jenkins's approach. The data used was yearly data collected for a period of 1961-2010. Differencing methods were used to obtain stationary process. The empirical study reveals that the most adequate model for the inflation rate is ARIMA (1,1,1). The model developed was used to forecast the year 2011 inflation rate as 16.27%. The study recommends effective fiscal policies aimed at

monitoring Nigeria's inflationary trend to avoid the consequences in the economy. Moreover, Omane-Adjepong et al (2013) investigated short-term out-of-sample forecast for Ghana's "Year-on-Year" inflation series, using the Seasonal-ARIMA and the Holt-Winters forecasting methods. The out-of-sample forecast accuracies of four Seasonal-ARIMA models and the two Holt-Winters (HW) forecasting approaches were assessed using various accuracy measure statistics. The forecast accuracies were ranked based on these statistics where four Seasonal-ARIMA forecast models were the top. The Seasonal Additive HW became fifth, while the Seasonal Multiplicative HW occupied the last position. The major setbacks of all the afore-mentioned models of analyzing times series data apart from HW and being able to adequately and comprehensively forecast it are that they assume a linear relationship and are best suited to short-term forecasts. Most time series data are not linear and would need a polynomial model, like grafted model and HW, to forecast them. Grafted polynomials are also better for long-term forecasts which is required to sustainable and stable planning. This is why this study compared the two polynomial models (grafted and HW) to indicate which one is better for long-term planning purposes.

Methodology

The study concerns the monthly inflation rate of Nigeria between 1996 and 2022. Nigeria is one of the largest economies in sub-Sahara Africa (SSA) which is dominated by oil and gas as well as agriculture, although the contribution of agriculture has continuously waned since the discovery of crude oil in the early 1960s. Nigeria has practiced presidential democracy since 1999 after the military terminated the first and second democratic governance in 1967 and 1983, respectively. Nigeria's economy has often come under intense pressure once there is an oil glut leading to low prices which has often made the government to rely on devaluation, privatization of state enterprises and either abolition or establishment of marketing boards as a means of financing expanding fiscal deficit. This often leads to a rise in inflation. Other stressors of the economy include fluctuating but unstable exchange and high interest rates as well as over-reliance on imported goods and services. There are also the high fiscal deficits which often lead to higher taxation and then, the attendant price increases.

The data used in this research are the monthly inflation rates of Nigeria from January 1996 to January 2022 obtained from the National Bureau of Statistics {NBS} (1996-2022) which gives a total of 313 samples. The period 1960-1995 was excluded because only annual inflation rates are available.

The data were analyzed using various models as outlined. First, descriptive statistics of Nigerian monthly inflation, like mean and standard deviation (SD) were obtained. Second, the type of ARMA exhibited by the data was determined using a number of procedures. The plot of auto-correlation and partial auto-correlation functions were used to suggest the number of lags, which was confirmed by estimating an auto-ARMA model (Hyndman & Khandakar, 2008). To obtain the number of structural breaks and the years those breaks occurred, the plots of the observed rates and fitted values of breakpoints of eq. (1-3) were made. The point of intersection between the two is a structural break and corresponds to the year it occurred (Zeileis et al., 2002).

$$Y = 1 \quad (1)$$

$$Y = t \quad (2)$$

$$Y = t + t2 \quad (3)$$

Where Y = Nigerian inflation rate, t = trend (1996/1-2022/1)

Then spline model in line with Fuller (1969, Nmadu et al. 2004) and Holt-Winters model (Winters 1960; Holt 1957) were estimated and used to forecast Nigerian inflation into the future. The results were presented in tables, graphics and other forms of visualization. The estimation, prediction, forecasting and visual presentation were done using R software (R Core Team 2021).

Results and discussion

Table 1 shows the ARMA properties of the inflation rate in Nigeria from 1996 to 2022, indicating that the trend is a HW-like data. Fig. 2 is the decomposed inflation rates for the entire period of study while Fig. 3 is the monthly trend. Fig. 4 & 5 are the autocorrelation and partial autocorrelation plots while Fig. 6 is an example of the plots of the observed data and the predicted breakpoints whereas Table 2 shows the predicted years of structural breaks from the models. Fig. 7 is the monthly trend of the predicted inflation rate from the spline model while Fig. 8 & 9 as well as Table 3 depict the decomposed HW predictions and forecast. Finally, Fig. 10 & 11 and Table [4]-[6] are the comparisons of the forecast and residuals as well as the forecast properties of the HW and spline models.

Table 1. ARMA properties of inflation rate

Parameter	Inflation Metrics
Autoregressive lag (p)	2
Differencing order (d)	2
Moving average lag (q)	1
Seasonal autoregressive lag (P)	0
Seasonal Differencing order (D)	12
Seasonal Moving average lag (Q)	0
Order of seasonality (m)	0

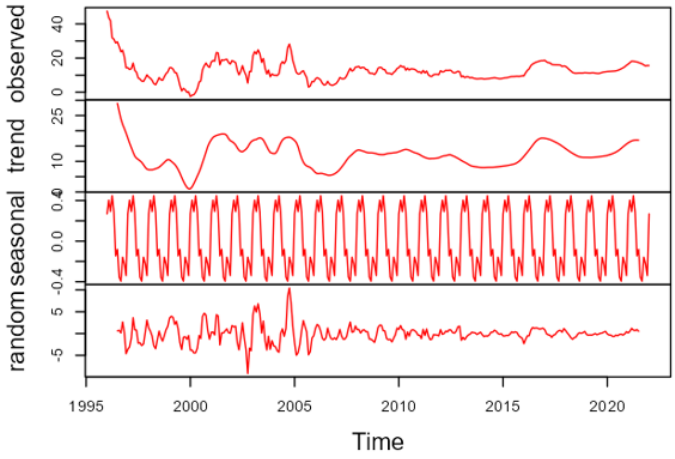

Fig. 2. The decomposed inflation rate

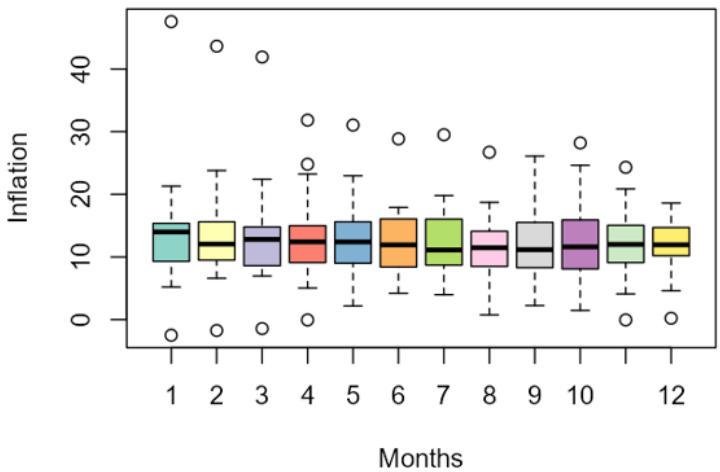

Fig. 3. Monthly trend of the inflation rate

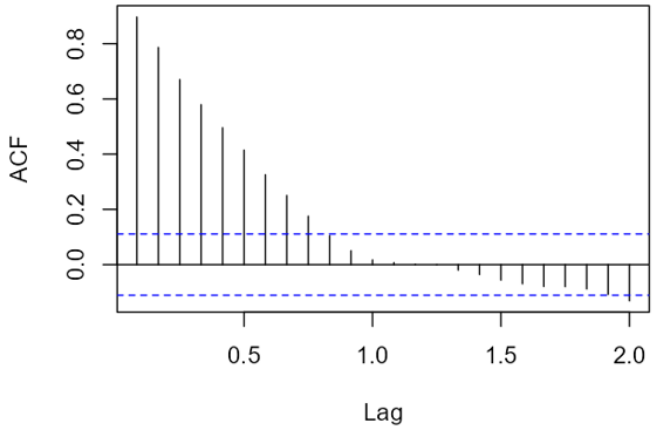

Fig. 4. Autocorrelation plot

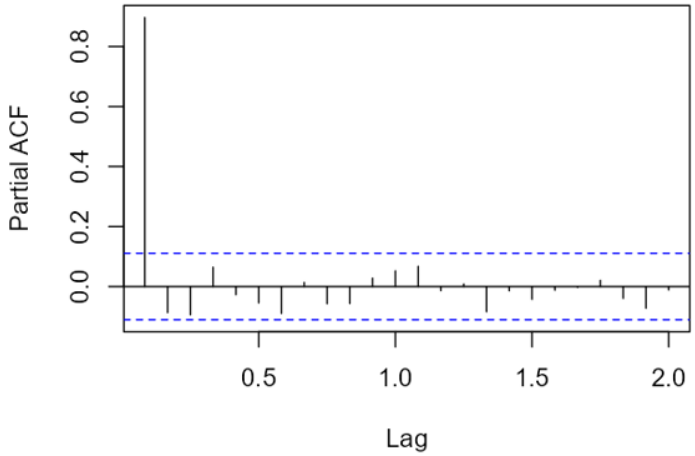

Fig. 5. Partial autocorrelation plot

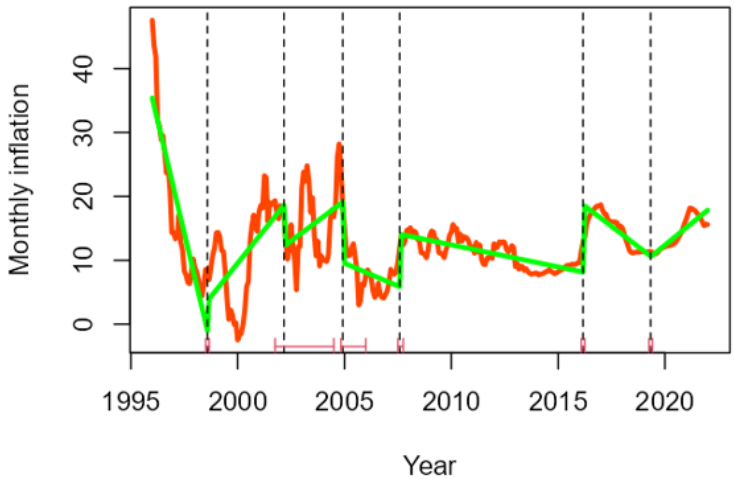

Fig. 6. Observed and breakpoints plot

Table 2. Structural breaks predicted from the trend models

	B.1	B.2	B.3	B.4	B.5	B.6
Level	1999	2001	2005	2008	2013	2016
Trend	1999	2002	2005	2008	2016	2019
Polynomial trend	1999	2001	2005	2008	2012	2017

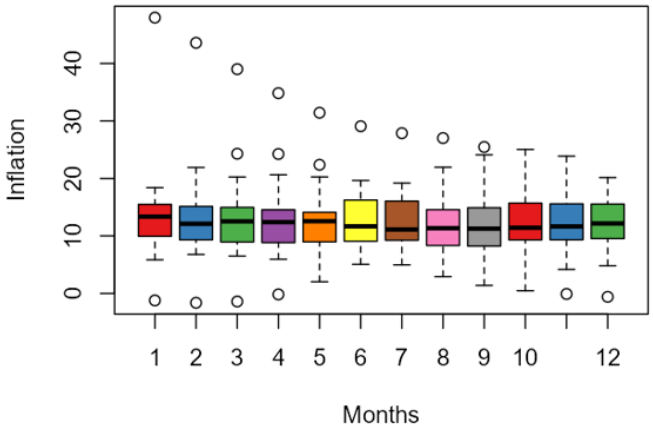

Fig. 7. Monthly trend of spline estimates

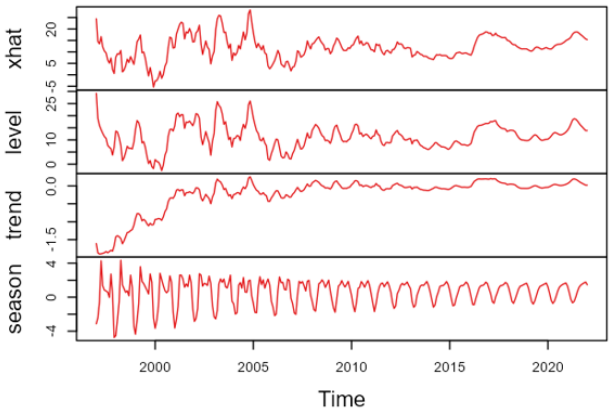

Fig. 8. Decomposed predicted HW estimate

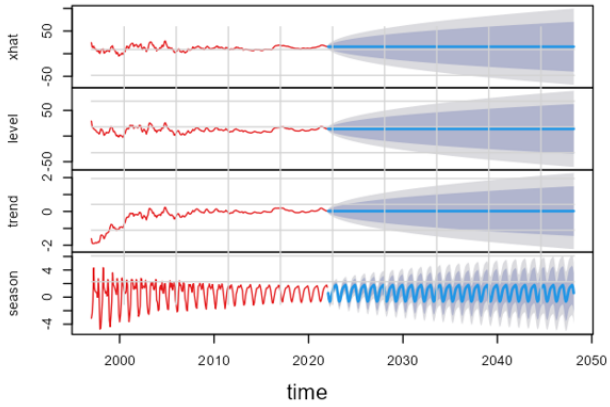

Fig. 9. Decomposed HW and forecast

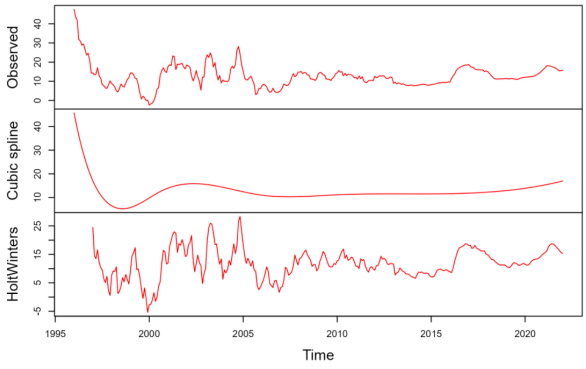

Fig. 10. Comparison of HW and spline estimates

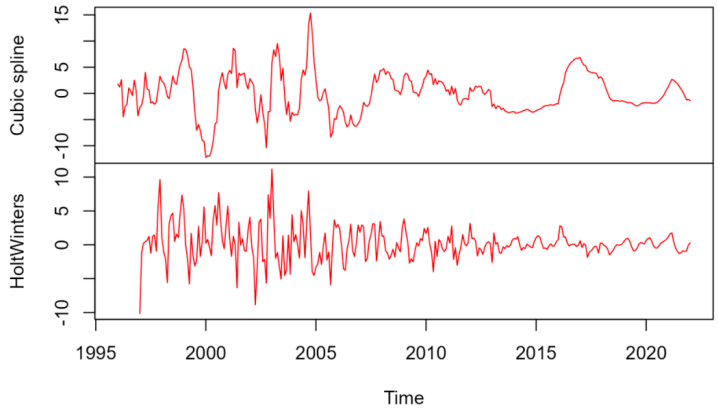

Fig. 11. Residuals from HW and spline estimates

Table 3. Summary of forecasts from the various models estimated

	Cubic	Holt Winters	Level	Season	Trend
Minimum	14.03	15	14	-0.66	0.02
Mean	14.65	15	14	0.74	0.02
Variance	0.18	0	0	0.73	0
SD	0.42	0	0	0.85	0
Maximum	15.28	15	14	1.79	0.02

Table 4. Turning points statistics of the two models

	statistic	Turning points	p value	alternative
Cubic spline	-27.2	5	5.98E-163	non randomness
Holt Winters	-11.64	115	2.72E-31	non randomness

Table 5. Goodness of fit properties of the two models [5]

	ME	MAE	MPE	MAPE	MSE	RMSE	U	CE
Cubic spline	1.6	3.1	122	-102	16	4	2	1
Holt Winters	1.4	2.8	21	15	45	6.7	3.4	1

Table 6. Properties of the various forecast models from Holt-Winters

	Log Likelihood	AIC	BIC	AICC	MSE	AMSE	Sigma square
Holt Winters	-1124	2255	2266	2255	5.84	12.77	5.88
Level	-1087	2179	2191	2180	4.54	12.12	4.57
Season	-606	1241	1297	1243	0.19	0.18	0.19

The range of inflation in Nigeria between 1996 and 2022 is -2.49 to 47.56 with overall mean of 12.64±6.13 shows wide variability which really indicated that the Nigerian economy has been unstable during the period under study. The mean was not within acceptable limits as highlighted by Otu et al., (2014). The AR(2) predicted in Table 1 is an indication that the inflationary trend does not revert to its mean quickly and may have some oscillatory trend,

which is observed in Fig. 2. But there is an indication that any random shocks {MA(1)} to inflation does not go beyond one period back. In addition, the decompose trend in Fig. 2 seems to suggest that there is a cyclical trend in inflation movement in spite of the fact that Nigeria experienced a stable inflation regime between January 2013 and February 2016, although January recorded the highest monthly mean (Fig. 3). This might be indicative of the fact that in most occasions, the annual budget is either passed or accented to January. In addition, the year-on-year inflationary trend is driven by food inflation and Nigeria's food prices show some cyclical patterns between periods of harvest of agricultural produce (when food is in abundance) and that of scarcity. It therefore means that if the inflation rate is to return to the single digit of January 2013, then superior policies, rather than trends, are needed.

Based on the estimates of eq. 1-3 and Fig. 6, each of the models predicted six structural breaks in the inflation movement, which might also be a pointer to some random shocks to the economy. The years predicted by each model, as shown in Table 3, indicated that there were some uniformities in the years of break, the major divergence being at the fifth and sixth breaks. The break in 1999 might have occurred as a result of change of government from military to civilian while between 200 and 2005, there were general adjustments in wages, which must have caused structural changes in inflation. The 2008 change might have occurred due to the global economic crisis from 2007. In addition to these general stressors, oil and gas prices might also have caused considerable shocks to the Nigerian economy spiking inflation since government revenues are largely derived from the sector. The changes between 2015 and the present might really be a result of a change in government from one political party to another, even though prior to this, it appeared that inflation had been brought under some level of stability.

Fig. 7-11 and Table 3-6 show that there was no major divergence between the two forecast methods, rather all the forecasts suggest that Nigerian inflation rate is likely to be well above 10% for some time to come particularly because it is an MA(2). What then is needed is a more robust economic management team, made up of seasoned professionals in the banking sector and academia in strong collaboration with the National Bureau of Statistics (NBS) and the Central Bank of Nigeria (CBN) that would ensure that stability is restored to the Nigerian economy through stable inflation management based on some set targets.

Conclusions

In this study, analyses have shown that Nigerian inflationary movement shows cyclical patterns and had remained high, above 10%. There have been at least six structural breaks which seem to show that the economy reacts to external shocks. However, the forecast from HW and spline models did not exhibit a major divergence. In order to restore stability through inflation management, more effort is required by evolving a more robust means, different from what has been utilized, and a wide-ranging expertise made up of robust economic management and intelligence team consisting of local and internationally-seasoned economists to manage the inflation rate in Nigeria. In view of the findings in this research, it is recommended that new methods and expertise in line with global realities are needed to manage the inflation regime within acceptable limits. In addition, a global innovation platform, as well as evidenced-based policies which ensure that Nigeria does not swerve away from the path to recovery should be established in consultation with fiscal, monetary and research authorities. Perhaps, the strategy might be to critically review some of the policies applied to inflation management during 2013 to 2015 and re-apply them with realistic amendments to take advantage of reality.

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