Investigating Predictors of Inflation in Nigeria: BMA and WALS Techniques

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2017

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Abstract
The recent economic conundrum arising from the fall in the international oil price has threatened the maintenance of price stability, a key function of the central bank, therefore the need to investigate predictors of inflationary measures arises. The model averaging method considers uncertainty as part of the model selection, and include information from all candidate models. We analysed a wide spectrum of inflation predictors and all the possible models for Nigeria CPI inflation using the Bayesian Model Averaging and Weighted Average Least Squares. The study uses fifty-nine (59) predictor variables cutting across all sectors of the Nigerian economy and three (3) measures of inflation, namely; all items consumer price index, core consumer price index and food consumer price index. The results from both model averaging techniques showed that maximum lending rate, world food price index and Bureau de change exchange rate are the significant drivers of inflationary measures among focus variables, while foreign assets, credit to private sectors, net credit to government and real effective exchange rate are the drivers of inflationary measures, for the auxiliary variables, strongly supporting the monetarist and open economy views on inflation. The structuralist view is reported to be relatively weaker because government expenditure is only significant at 10.0 per cent..

Key words: Bayesian estimation; BMA; Frequentist approach; Inflation rate

1. Introduction

Inflation will for a long time remain a subject of interest and concern not only to econometricians, statisticians and economists but majorly to the monetary authorities. The reasons are quite many, including: the macroeconomic effect on savings and investments; the uncertainty effect on fiscal budgeting; and the impact on international competitiveness and trade performance. According to Adewumi and Awosika (1982), inflation is one of the greatest problems plaguing the world economic scene. Thus, households, governments and investors are usually keenly interested in the movement and behaviour of inflation.

[1] This is part 1 of the abridged version of the full report on Forecasting and Determining the Predictors of Inflation in Nigeria: A Bayesian Model Averaging Approach, submitted to the Department of Statistics, Central Bank of Nigeria.

Inflation and inflationary factors can be explained by looking at the "Views of Inflation". For example in Fisher (1911), Friedmanic view believes that inflation is a common economic and monetary phenomenon, while the structuralist believes that inflation is a function of economic structure particularly in developing countries that are characterized by market segmentation, resource immobility and disequilibrium in sectoral demand and supply. According to the proponents of this view, due to structural rigidities, supply hardly responds to increase in demand arising largely from increase in income. Proponents of the globalist/open economy views are however of the conviction that Monetarist and structuralist perspectives to inflation are insufficient for the determination of exogenous multi-economic variables. Inflation, according to them, is an economic measure of imbalances between aggregate demand and aggregate supply factors largely determined by interaction of government regulatory policies as well as responses of firms and households in terms of economic decisions to those policies, considering the complex and intertwined global or meso-economics[2] factors across the globe. Thus, they recognized the effect of globalisation on changes in domestic prices.

Globalists linked the impact of improvements in terms of trade, low imports prices relative to domestic production or improved trade with low-cost economies on inflation measures. They adopted two distinct approaches to explain the workings of the global view on inflation, namely: The accounting identity and the estimated empirical relationships. The view of the open economy posits that, depreciation in the value of the domestic currency, for instance, other things being equal, leads to upward surge in the prices of imported goods relative to domestically produced goods, making imports more expensive, hence rise in domestic prices. From another perspective, increase in the prices of imported goods, particularly intermediate goods, implies increase in the cost of production which in-turn leads to increase in the cost of domestically produced goods that is eventually transferred to the end

[2] See Yew-Kwang (1986) for more on mesoeconomics.

users. Consequently, the exchange rate pass-through can be explained both from the perspective of direct and indirect channels.

Having all these views in mind, one can investigate the economic predictors of inflation. A very prominent tool for predicting inflation is the Phillips curve which applies a single measure of economic slack, say unemployment rate to predict future inflation. According to Koop and Korobilis (2010), four issues have been identified with Phillips curve's inflation prediction technique. Firstly, the coefficient on the predictors can change over time. Secondly, the model relevant for forecasting can potentially change over time, that is, some variables might predict well in expansions but not in recessions (see Stock and Watson, 2008). Thirdly, the number of potential predictors can be large, and this raises a serious statistical problem for model selection strategy. In the midst of uncertainty about the choice of the predictor variables to be included in the model, care should be taken not to have dropped a particular variable that could have contributed well in terms of in-sample prediction.

To overcome this problem, model averaging techniques have been introduced (see Magnus and Durbin, 1999; Danilov and Magnus, 2004; Magnus, Powell and Prufer, 2010; Luca and Magnus (2011). These techniques are unlike standard model estimators that are based on some pre-tests and post-tests for models estimation, thus, the techniques has a coherent way of making inference on the regression parameters of interests by taking into account the uncertainty due to both the estimation and the model selection steps. The two model averaging methods applied in this paper are the Bayesian Model Averaging (BMA) and Weighted-Average Least Squares (WALS). The two techniques average take into account all available information from various models; they are unlike the classical estimation methods via OLS where a final model that represents best the dataset is picked based on information criterion.

Given the above background, it worths applying the techniques on Nigerian inflation to determine its predictors. In this paper, we considered both BMA and WALS estimation methods. The burning research question is: what are the factors (monetary and fiscal) determining the path of inflation in Nigeria?

The remainder part of the paper is structured as follows: Section 2 presents literature on predictors of inflations with different econometric methods, including BMA and WALS techniques. Section 3 details the Methodology used. Section 4 presents the results and discussion of the analysis, while Section 5 gives conclusion and policy recommendation.

2. Review of Literature

Far back as 1980, the Phillips curve has been the traditional monetarist model for predicting inflation by the Federal Reserve Banks in the US. This model considered inflation as a function of current and past values of the monetary variable and the fiscal policy variable, with narrow money (M1) and government expenditure as proxies, respectively. The modified version of the curve, the NAIRU expressed inflation as a function of its own lagged value, the output gap and changes in the relative prices of food and energy (see Glassman and Stockton, 1983). However, the applicability of the NAIRU Phillips curve has been challenged by several authors (see Atkeson and Ohanian, 2001; Fisher, Liu and Zhou, 2002). The authors stated that the model is unstable and has no consideration for structural shifts, and also produces larger forecasts errors. In the Bank for International Settlements (BIS), Mohanty and Klau (2001) applied a modified Phillips curve that accounts for both demand and supply side factors in modelling inflation in emerging economies. The countries considered were: India, Korea, Malaysia, Philippines, Taiwan, Thailand, Brazil, Chile, Mexico, Peru, Chech Republic, Hungary, Poland and South Africa. The variables considered were the output gap, food prices, oil price and money supply. The results showed that food prices played a dominant role in inflationary process of all countries considered in the study.

Mehrotra and Sánchez-Fung (2010) applied a hybrid New Keynesian Phillips curve (NKPC) in modelling the inflationary process of China at Provincial level. The results indicated that the NKPC could only describe reasonably the inflationary process of coastal provinces. The results further showed that output gap and forward-looking inflation component are important drivers of inflation in advanced marketization province because of likelihood of excess demand pressure. Hayashi et al. (2015) constructed an econometric model of inflation for Sri Lanka during the period January 2006 to April 2015 using the framework of NKPC. The authors considered CPI for food and non-food baskets, output gap and nominal effective exchange rate. The results obtained showed that forward-looking NKPC holds in Sri Lanka for regressions with month-on-month inflation as dependent variable together with the output gap data, while the backward-looking hybrid NKPC model worked better with year-on-year inflation with exchange rate and domestic fuel prices acting as significant contributors. Vermuelen (2017) investigated the dynamic relationship between inflation and unemployment rates in South Africa using the Phillips curve. The author extended previous works in the South African literature such as Akinboade et al. (2002), Kumo (2015), Stigliz (2014), among others, and using different Phillips curve models estimated over the period 2000 to 2015 with employment and unemployment rates. The findings revealed that there is no evidence of a trade-off between inflation and the unemployment rate, while it found conflicting evidence of a positive relationship between inflation and employment growth. On the long run, the results indicated negative relationship between inflation and employment which is an indication that inflation hampers the creation of employment. Thus, the analysis did not include aggregate demand or proxy for output gap which are the usual variables often included in the estimation of Phillips curve.

The failure of Philips curve has led to the development of many other structural and dynamic econometric models for predicting inflation in the Federal reserve banks. These models include the Dynamic Stochastic General Equilibrium (DSGE) (Edge et al., 2006); Bank of Italy Quarterly Model (BIQM) (Locarno, 2008); constant, data-coherent error-correction (Aron et al., 2003; Bacchiocchi, 2003; De Brouwer and Ericsson, 2012); Large Empirical and Semi-structural (LENS) (Gervais and Gosselin, 2014); Bayesian Vector Autoregressive (BVAR) (Knotek and Zaman, 2013) and Knotek et al., 2015), while these authors considered various economic variables and other proxies but these models failed in their ability to mimic the prevailing inflation rates at that time. Some authors found that inflation rate cannot be modelled using a single cause, they therefore considered series of models. Others considered single equations such as the autoregressive and bivariate Phillips curve models

In the case of Nigerian inflation, the pioneering work on inflation is that of Oyejide (1972) which is based on structuralist view. The paper examined the impact of fiscal deficit on inflation in Nigeria between 1957 and 1970 and found a strong direct relationship between different measures of fiscal deficit and inflation. In another study by Fakiyesi (1996), bounds test was employed to model inflation dynamics in Nigeria. The finding showed that inflation was a function of broad money growth, exchange rate, growth rate of real income, level of rainfall and inflation expectation. Feridun and Adebiyi (2005) used Autoregressive analysis and single equation model to forecast inflation for Nigeria between 1986Q1 and 1998Q4. The variables considered in the study include; gross domestic product (GDP), narrow money supply (M1), broad money supply (M2), inflation rate, nominal exchange rate, interest rate and domestic debt. They tested the contribution of different monetary variables through an AR (1) process. Most of the variables considered in the model were found to be useful in predicting movements in prices, with exchange rate and domestic debt taking the lead. Thus, they concluded that although monetary variables play vital roles, they are not the only predictors of inflation in Nigeria. Using an error correction framework, Olubusoye and Oyaromade (2008) utilized annual data from 1970 to 2003 covering headline CPI, expected inflation, real GDP, real exchange rate, interest rate, fiscal policy to GDP ratio, money supply, oil prices and average rainfall to model inflation for Nigeria. While the long-run results considered fiscal deficit and variations in broad money supply as the drivers of inflation, the short-run dynamics reported inflation to be largely a function of its past values, perception about its future behaviour, petroleum prices and real exchange rate. The authors concluded that volatility in the price of crude oil in the international oil market is likely to hinder efforts of the monetary authorities to curb inflationary spirals.

The complex dynamic of inflation warrants the use of many models to judge its movement. This is the foundation upon which Bayesian Model Averaging is built. The Bayesian Model Averaging (BMA) methodology is increasingly witnessing wide spread applications across an array of disciplines including political science, social research, econometrics, etc. Notable contributions around inflation are indeed numerous. For instance, Jacobson and Karlsson (2002) consider BMA for predicting Swedish consumer price index using a large set of potential indicators, comprising some 80 quarterly time series covering a wide spectrum of Swedish economic activity. Similarly, Wright (2003) employs BMA for the prediction of U.S inflation using quarterly series from 1960 to 2003 for a total number of 93 predictor variables considered as alternative measures of economic slack and several asset prices. Lastly, a more recent study is Gonzalez (2010) which applies BMA to forecast inflation in Colombia. An application of BMA is implemented in constructing combined forecasts for the Colombian inflation rate, for the short and medium run. The dataset used for the empirical application consists of 73 monthly macroeconomic variables from 1999 to 2009. The series are grouped into three categories: Real Activity (26 series), Prices (23 series), Credit Money and Exchange Rate (24 series). The study finds BMA as a "useful and consistent way to select variables and models with high predictive power", better than the frequentist approach. The methodology for the BMA and WLAS techniques is presented in the next section of the paper.

3. Methodology

3.1 Bayesian Model Averaging Method

We assume linear regression models of the form:

$$y_j = X_j\beta_j + U_j \qquad j = 1,2,\dots,p \tag{1}$$

For the j[th] model. By assuming model combination having only a constant, and a regressor and a constant, for a k number of models, it is expected to have 2^k linear regression models, which differ only in their explanatory variables. Hence the specification in (1) can be re-written as

$$y = \alpha l_N + X_j\beta_j + U \qquad j = 1,2,\dots,p \tag{2}$$

where l_N = $N \times 1$ vector of ones, X_j is $N \times k_j$ matrix containing some (or all) the predictor variables. The vector of disturbance terms U, is assumed to be a multivariate Normal distribution with mean 0_N and covariance $\sigma^2 I_N$, N$(0_N, h^{-1}I_N)$ where $h = \sigma^{-2}$ is the error precision. Using the definition of the multivariate Normal density, the likelihood function for the j[th] model can be written as

$$P(y|\beta_j, h) = \frac{1}{(2\pi)^{N/2}}\left\{h^{1/2}exp\left[-\frac{h}{2}\left(\beta_j - \widehat{\beta_J}\right)'X_j'X_j\left(\beta_j - \widehat{\beta_J}\right)\right]\right\}\left\{h^{v/2}exp\left[-\frac{hv}{2s^{-2}}\right]\right\} \tag{3}$$

where $v = N - k$, $\widehat{\beta_J} = \left(X_j'X_j\right)^{-1}X_j'y$ is the ordinary least squares estimator and $s^2 = \frac{(y - X_j\widehat{\beta_J})'(y - X_j\widehat{\beta_J})}{v}$ is the mean square error.

Since the likelihood function of models determines the structure or distribution of the prior especially for easier interpretations and computations, therefore the natural conjugate prior for (3) is Normal-Gamma density. Thus, if we elicit a prior for β_j conditional on h of the form

$$\beta_j|h \sim N(\beta_{*j}, h^{-1}V_{*j}) \tag{4}$$

and a prior for h of the form

$$h \sim G({s_*}^{-2}, v_*) \quad (5)$$

then, the joint prior for the two parameters is given as

$$\beta_j h = (\beta_j | h \times h) \sim NG(\beta_{*j}, V_{*j}, {s_*}^{-2}, v_*) \quad (6)$$

The posterior will also have Normal-Gamma density of the form

$$\beta_j, h|D \sim NG({\beta_j}^*, V_j^*, s^{*-2}, v^*) \quad (7)$$

where $V_j^* = (V_{*j}^{-1} + X_j{}' X_j)^{-1}$; ${\beta_j}^* = V_j^*(V_{*j}^{-1}\beta_{*j} + X_j{}' X_j \widehat{\beta_J})$; $v^* = v_* + N$ and s^{*-2} is defined implicitly through

$$v^* s_j^{*2} = v_* s_*^2 + v s^2 + (\widehat{\beta_J} - \beta_{*j})' \left[V_{*j} + \left(X_j{}' X_j\right)^{-1}\right]^{-1} (\widehat{\beta_J} - \beta_{*j}) \quad (8)$$

By integrating out (7), we have the marginal posterior distribution for β, which is a multivariate *t* distribution, given as

$$\beta_j | D \sim t({\beta_j}^*, s_j^{*2} V_j^*, \ v^*) \quad (9)$$

where the mean, $E(\beta_j|D) = {\beta_j}^* = V_j^* X_j{}' y$, $v^* > 1$, and the variance, $var(\beta_j|D) = \frac{v^* s_j^{*2}}{v^* - 2} V_j^*$ $v^* > 2$. And the posterior for the precision given the data follows the gamma distribution:

$$h/D \sim G(s^{*-2}, v^*) \quad (10)$$

with the mean, $E(h/D) = s^{*-2}$ and the variance, $var(h/D) = \frac{2s^{*-2}}{v^*}$. By defining s_j^{*2} in term of the g in BMA, we have,

$$s_j^{*2} = \frac{\frac{1}{g_j + 1} y^1 R_{X_j} y + \frac{g_j}{g_j + 1}\left(y - \bar{y}_{i_n}\right)^1 \left(y - \bar{y}_{i_n}\right)}{\text{v*}} \quad (11)$$

where $R_{X_j} = I_n - X_j \left(X_j^1 X_j\right) X_j^1$. By using the g-prior, then,

$$P\left(D/M_j\right)\alpha\left(\frac{g_j}{g_j+1}\right)^{r_j/2}\left[\frac{1}{g_j+1}y^1R_{X_j}y+\frac{g_j}{g_j+1}\left(y-\bar{y}_{i_n}\right)^1\left(y-\bar{y}_{i_n}\right)\right]^{-\frac{n-1}{2}} \qquad (12)$$

where, r_j indicates the number of regressors in model j; $y^1R_{X_j}y$ is the Residual Sum of Squares (measures the lack of fit of model j); $\frac{g_j}{1+g_j}$ is the weight or shrinkage factor of the prior prediction error guess and $\left(y-\bar{y}_{i_n}\right)^1\left(y-\bar{y}_{i_n}\right)$ is the Total sum of squares (measures the Prior Prediction error guess). At this stage, the values of the prior hyper parameters β_{*j}, V_{*j}, s_*^{-2}, and v_*must be chosen to reflect the researcher's prior information or belief. The rule of thumb suggested by Koop (2003) is that "when comparing models using posterior odds ratios, it is acceptable to use non informative priors over parameters which are common to all models. However, informative, proper priors should be used over all other parameters." Thus, since error precision, h, and the intercept, α, are common to all models, the standard non informative prior can be used for them. To determining value for β_j, the usual practice is to center priors over the hypothesis that predictor variables are not related or have no effect on the dependent variable. Since there are many variables involved in BMA, we might suspect that some of them are not important. In that case, we set

$$\beta_{*j} = 0_{r_j} \qquad (13)$$

Finally, we left with choosing the value for V_j^*. This involves setting:

$$V_{*j} = \left(g_j X_j' X_j\right)^{-1} \qquad (14)$$

Finally, each model in the model space was assigned equal probability (uniform prior). That is:

$$P\left(M_j\right) = \frac{1}{2^k}. \qquad (15)$$

The posterior mean and variance for the regression coefficient in terms of the g-prior are given, respectively as follows. The mean:

$$E(\beta_j|D) = \beta_j{}^* = ((1 + g_j)X_j{}'X_j)^{-1}X_j{}'y, \quad (16)$$

and the variance as:

$$var(\beta_j|D) = \frac{v^* s_j^{*2}}{v^* - 2}((1 + g_j)X_j{}'X_j)^{-1} \quad (17)$$

3.2 Weighted Average Least Square Method

The Weighted Average Least Square (WALS) estimation method uses a linear regression model of the form in (2) where a vector of the constant is given as l_N = $N \times 1$ vector of ones, $N \times k_j$ matrix containing some (or all) the predictor variables. Thus, there is an $n \times 1$ vector of observations of interest; the $X_j\left(j = 1, 2, ..., p\right)$ are $n \times m_j$ matrices of observation on two subsets of deterministic regressors; the β_j are $m_j \times 1$ vectors of unknown regression parameters; and the model innovation follows multivariate normal distribution. Then, an $m_2 \times m_2$ orthogonal matrix K and a diagonal matrix P with $m_2 \times m_2$ elements are computed, such that

$$K'X_2'M_1X_2K = P \quad (18)$$

Then, define $Z_2 = X_2KP^{-1/2}$ and $\gamma_2 = P^{1/2}K'\beta_2$, and it implies,

$$\beta_2 = K'P^{-1/2}\gamma_2 \quad (19)$$

which is the original vector of auxiliary parameters β_2 from a linear regression model,

$$y = X_1\beta_1 + X_2\beta_2 + u \quad (20)$$

Using the orthogonal transformation to (20), the unrestricted OLS estimators of β_1 and γ_2 from a regression of y on X_1 and Z_2 becomes,

$$\hat{\beta}_{1u} = \hat{\beta}_{1r} - R\hat{\gamma}_{2u} \tag{21}$$

$$\hat{\gamma}_{2u} = Z_2{}'M_1 y \tag{22}$$

where $R = \left(X_1'X_1\right)^{-1} X'Z_2$ is the multivariate OLS estimator from a regression of Z_2 on X_1. Thus, under some minimal regularity conditions on weights λ_i, the WALS estimator of β_1 is given as,

$$\tilde{\beta}_1 = \sum_{i=1}^{I} \lambda_i \hat{\beta}_{1i} = \hat{\beta}_{1r} - RW\hat{\gamma}_2 \tag{23}$$

where W_i is a $m_2 \times m_2$ matrix whose j^{th} diagonal element is zero if $\gamma_{2j} = 0$ and $W = \sum_{i=1}^{I} \lambda_i W_i$ is a $m_2 \times m_2$ diagonal random matrix. Then, if the model space of WALS contains 2^{M_2} models, the computational burden of the WALS estimator $\tilde{\beta}_1$ is of the order m_2, thus we expect m_2 linear combinations of model weights λ_i. The MSE of $\tilde{\beta}_1$ is given as,

$$MSE\left(\tilde{\beta}_1\right) = \sigma^2 \left(X_1'X_1\right)^{-1} + R'\left[MSE\left(W\hat{\gamma}_2\right)\right]R \tag{24}$$

Now, using the Laplace or the Subbotin estimator $\eta = \left(\eta_1, ..., \eta_{m_2}\right)$, then, Magnus, Powell and Prufer (2010) expressed WALS estimators of the regression parameters β_1 and β_2 as,

$$\hat{\beta}_1 = \left(X_1'X_1\right)^{-1} X_1'\left(y - X_2\hat{\beta}_2\right) \tag{25}$$

$$\hat{\beta}_2 = sKP^{-1/2}\overline{\eta} \tag{26}$$

and the elements of variance-covariance matrix given by,

$$Var\left(\hat{\beta}_1\right) = \left(X_1'X_1\right)^{-1} + QVar\left(\tilde{\beta}_2\right)Q' \quad (27)$$

$$Var\left(\hat{\beta}_2\right) = s^2 KP^{-1/2}\Omega P^{-1/2}K \quad (28)$$

$$Cov\left(\tilde{\beta}_1, \tilde{\beta}_2\right) = -QVar\left(\tilde{\beta}_2\right) \quad (29)$$

where $Q = \left(X_1'X_1\right)^{-1} X_1'X_2$ and Ω is the diagonal variance-covariance matrix of $\bar{\eta}$.

4. Analysis and Discussion of Results

All the data used in this study are monthly, spanning January 1960 to June 2017. Although, observations are not available for all the variables across the period, the descriptive analysis are based on the period for which observations are available. The model estimations utilized 114 months (January 2008 to June 2017) for which data are available across the needed variables. Three key measures of inflation are of interest in the empirical analysis. These are: all items consumer price index (CPI), core CPI (CCPI) and food CPI (FCPI). The macroeconomic variables considered in the report are classified into 10 groups as shown in Table 1a and 1b.

4.1 Preliminary and Descriptive Analysis

The external behaviour of the variables is investigated by computing the appropriate measures of location and spread. The computed mean, standard deviation, minimum and maximum values are presented in Tables 1a and 1b based on the classifications in the previous section.

The summary statistics for the monetary aggregates in Table 1a shows that about 570 data months are available except for foreign assets of the Deposit Money Banks (DMBs) which has 296. The striking features of variables in this group are: (1) the average net credit to government is negative over the 570 data months; (2) the large values of standard deviation of CPS, NCG, FA, M1, and M2 indicate that observed values are farther away from their mean value, on average indicating that the monetary aggregates exhibit high degree of instability; and (3) the coefficient of variation (CV) indicates that, in relative terms, the variability is much higher with credit to private sector (CPS) when compared with other variables in the group (note that the high negative CV for net credit to FGN (NCG) is misleading). Real sector indicator variables are the nominal GDP (NGDP) and real GDP (RGDP), with mean values of N3,947,000 million and N3,964,000 million, respectively. The minimum value of NGDP is N510,426 million and maximum of N9,794,000 million, while for RGDP, the minimum value is N1828,000 million with maximum value as N6,271,000 million. Government total expenditure averaged N267,609 million with standard deviation of N175,473 million. Real and nominal capital expenditure averaged N2,800,000 million and N2,911,000 million, respectively. All the variables have observations available for 210 months and exhibit high degree variability around the mean. In relative term, the variability is higher in nominal private capital expenditure.

In the interest rate category, the average of interest rates for 7-day, twelve-month, one-month, three-month and six-month increased based on maturity periods though all are single digits. This category of interest rates spread widely around their average values. The minimum values hover between 1.27 and 2.00 percent while the maximum values between 22.00 to 29.00 percent. The average lending rate, prime lending rate and maximum lending rate recorded double digits of 15.42, 13.90 and 16.93 percent respectively. The monetary policy rate and treasury bills rate have single digit average values of 9.97 and 8.94 respectively for the 687 months period. In relative term, the most volatile of these rates are deposit rate, twelve-month, treasury bills rate and six-month interest rates in that order.

The exchange rate indices category consists of the official, Bureau de Change, nominal and real effective exchange rates. For official and BDC exchange rates, 318 months of data points were available for the analysis, while for nominal and real effective exchange rates 114 data points were available. The average BDC rates is N133.7/US dollar which is far higher compared to the official rate with average of N108.7/US dollar. The average nominal effective exchange rate is N102.3/US dollar, while the average real effective exchange rate is N82.77/US dollar. The variability around the average is very high among the variables in this group. The official rate hovers between N8.845/US dollar to N309.7/US dollar while the BDC ranges between N10.87/US dollar to N494.7/US dollar within 318 months. In relative term, the official rate exhibit high degree of variability with coefficient of variation of 0.64 compared with BDC with coefficient of variation of 0.60. The high degree of variability in the official rate comparatively to the BDC rate can largely be attributed to diverse foreign exchange regimes operated by monetary authorities whereas the BDC segment of the market remains determined consistently by market forces.

The capital market indicators are the all share index (ASI), market capitalization (MC) and bond yields (BR). The average ASI for the 390 months of data points is 15,240 with high standard deviation of 15,096. The minimum value is 111.3, rising to the maximum index value of 65,652 during the market peak before the global crash of stocks which affect Nigerian capital market in 2009. Market capitalization averaged N3,219 million with standard deviation of N4,215 million. The minimum value was N4.816 million rising to the maximum value of N14,028 million. Thus, the two series could be regarded as highly unstable and widely varied during the available data periods. It is also clearly evident that the capital market has witnessed phenomenon growth over the years. Bond yields is averaged at 12.13 percent, with low standard deviation of 2.7 percent. The minimum value ever reached is 5.6 percent, while the maximum value is 16.96 percent. In relative term, the market capitalization index with coefficient variation 1.309 is the most varied indicator in this category.

Table 1a: Descriptive Statistics

Monetary Aggregates	No. of months	Mean	St. dev.	CV	Min	Max
Credit to private sector (CPS)	570	3,153,000	5,993,000	190.1	329.2	2,318,000
Net credit to FGN (NCG)	570	-133,514	1,238,000	-927.2	-4,143,000	5,508,000
Foreign assets to DMBs (FA)	296	842,985	790,526	93.8	23,615	2,591,000
Narrow money supply (M1)	571	1,555,000	2,632,000	169.3	426.8	1,107,000
Broad money supply (M2)	571	3,352,000	5,975,000	178.3	642.2	2,339,000
Reserve money (RM)	570	817,728	1,531,000	187.2	297.8	6,163,000
Narrow money growth rate (M1g)	570	13.21	14.31	108.3	-20.87	68.06
Broad money growth rate (M1g)	570	10.67	16.19	151.7	-19.17	73.48
Real Sector indicators	No. of months	Mean	St. dev.	CV	Min	Max
Nominal GDP (NGDP)	210	3,947,000	2,707,000	68.6	510,426	9,794,000
Real GDP (RGDP)	210	3,964,000	1,281,000	32.3	1,828,000	6,271,000
Nominal private capital expenditure (NPCE)	210	2,911,000	2,141,000	73.5	366,731	8,315,000
Real private capital expenditure (RPCE)	210	2,800,000	681,147	24.3	1,454,000	4,384,000
Interest rate	No. of months	Mean	St. dev.		Min	Max
Seven-day (7D)	483	8.04	4.44	55.2	1.27	22.79
One-month (1M)	674	8.36	4.95	59.2	2.00	25.16
Three-month (3M)	674	8.77	5.18	59.1	2.00	27.00
Six-month (6M)	674	8.93	5.40	60.5	2.00	28.13
Twelve-month (12M)	666	8.95	5.44	60.8	2.00	29.13
Average Deposit rate (ADR)	674	5.94	4.22	71.0	1.40	19.38
Average lending rate (ALR)	687	15.42	6.90	44.7	7.25	41.55
Prime lending rate (PLR)	687	13.90	6.55	47.1	6.00	37.80
Maximum lending rate (MLR)	687	16.93	7.47	44.1	7.50	45.30
Monetary policy rate (MPR)	687	9.97	5.18	52.0	3.50	26.00
Treasury bills rate (TB)	687	8.94	5.42	60.6	1.04	28.00
Exchange rate indices	No. of months	Mean	St. dev.	CV	Min	Max
Official Exchange rate (EXR)	318	108.7	69.88	64.3	8.845	309.7
BDC Exchange rate (EXRB)	318	133.7	80.57	60.3	10.87	494.7
Nominal Effective Exchange rate (NEER)	114	102.3	20.01	19.6	70.63	160.5
Real Effective exchange rate (REER)	114	82.77	10.91	13.2	60.88	100.2
Capital market indicators	No. of months	Mean	St. dev.	CV	Min	Max
All share index (ASI)	390	15,240	15,096	99.1	111.3	65,652
Market capitalization (MC)	390	3,219	4,215	130.9	4.816	14,028
Bond yields (BR)	133	12.13	2.736	22.6	5.600	16.96

Table 1b presents descriptive measurements for the remaining five variable categories. The Prices category consists of Core CPI (CCPI), food CPI (FCPI), all items CPI (CPI), inflation rate (INF), inflation expectations (IFE) and price of PMS per litre (PMS). The three CPI measures averaged around 84 to 86. The minimum value of CCPI is 14.75, and the maximum value is 223. Also, maximum values for FCPI and CPI are 246.3 and 234.2, respectively. Inflation rate is average at 15.17 percent with standard deviation of 14.65 percent. The minimum inflation rate is -2.486 percent, while the maximum inflation rate is 89.57. Inflation expectation (IFE) is averaged at 13.74 percent with standard deviation of 10.64 percent. Minimum IFE is 0.826, while maximum IFE is 68.06 percent. Price of PMS put under this category is averaged at N35.22/litre, with standard deviation of N37.95/litre. This high standard deviation signaled that price of PMS has been unsteady and has increased astronomically over the years. Minimum price value is N0.20/litre and the current official price of N145/litre is the maximum value.

External sector indicators are the foreign reserve (FER), imports, exports, terms of trade (TOT) and growth rates of both imports and exports. Mean foreign reserve averaged at USD16,151 million with standard deviation of USD16,794 million. Based on minimum and maximum values recorded, Nigerian external reserves has grown reaching a maximum of USD62,082 million around September 2008. The average export is more than the average import, and this reflects in the averaged terms of trade which is 2.025 ratio, greater than 1, implying that the monetary value of Nigeria's exports is more than twice the value of its imports. Both exports and imports have been growing at the average rates of 17 and 27 percent, respectively, with standard deviation of 44.7 and 53.6 percent.

Indicators for agriculture that are included in this report are the real and nominal agricultural production and the average rainfall. Real and nominal agricultural productions averaged N953,691 million and N904,062 million respectively with high standard deviation of

N340,184 million and N555,958 million. Values for minimum and maximum of each of these variables actually indicate massive agricultural productions over the sampled period. Mean average rainfall is 120mm Hg with standard deviation of 96.62mm Hg. Minimum rainfall is 0 mm Hg, and this occurs around January and December in major meteorological zones of the country. Maximum recorded average country rainfall is about 300mm Hg.

Fiscal indicators are federation account allocation (FAAC), fiscal deficit to GDP ratio, real and nominal private capital expenditure, and government total expenditure. The average FAAC is N306,305 million with standard deviation of N125,807 million. The mean value of fiscal deficit to GDP ratio is -1.1, with minimum value of -10.04 and maximum value of 7.569. Two global/international indicators considered are the global inflation rate and world food index. The average global inflation rate over the sampled period is 3.67 percent, computed with standard deviation of 0.94 percent. Minimum value of this rate is 1.36 percent, while the maximum value is 6.91 percent. World food index averaged 130.2 with standard deviation of 35.88. The minimum index value observed is 76.85, while the maximum observed index value is 193.8.

Table 1b: Descriptive Statistics (cont'd)

Prices	No. of months	Mean	St. dev.	CV	Min	Max
Core CPI (CCPI)	270	84.90	55.57	65.5	14.75	223.0
Food CPI (FCPI)	270	86.20	57.00	66.1	20.56	246.3
All items CPI (CPI)	270	84.43	56.73	67.2	14.36	234.2
Inflation rate (INF)	270	15.17	14.65	96.6	-2.486	89.57
Inflation expectations (IFE)	270	13.74	10.64	77.4	0.826	68.06
Price of PMS (PMS/ltr)	390	35.22	37.95	107.8	0.200	145
External sector indicators	No. of months	Mean	St. dev.	CV	Min	Max
Foreign reserve (FER)	438	16,151	16,794	104.0	210.8	62,082
Imports (IM)	210	454,295	301,070	66.3	32,367	1,228,000
Exports (EX)	210	721,337	387,894	53.8	113,942	1,702,000
Import growth rates (IMg)	198	27.46	53.62	195.3	-62.03	237.1
Export growth rates (EXR)	198	17.04	44.73	262.5	-55.11	166.9
Terms of trade (TOT)	210	2.025	1.111	54.9	0.652	8.856
Agricultural indicators	No. of months	Mean	St. dev.	CV	Min	Max
Nominal Agric production (ANY)	210	904,062	555,958	61.5	95,612	2,210,000
Real Agric production (ARY)	210	953,691	340,184	35.7	296,336	1,724,000
Average rainfall (ARF)	210	120.2	96.62	80.4	0.0	300.1

Fiscal indicators	No. of months	Mean	St. dev.	CV	Min	Max
Federal account allocation (FAAC)	186	306,305	125,807	41.1	66,613	610,389
Fiscal deficit to GDP ratio (FPGDP)	186	-1.100	3.115	-283.2	-10.04	7.569
FGN Total expenditure (GE)	186	267,609	175,473	65.6	6,727	837,298
International indicators	No. of months	Mean	St. dev.	CV	Min	Max
Global inflation rate (GIF)	150	3.671	0.941	25.6	1.361	6.907
World food index (WFPI)	210	130.2	35.88	27.6	76.85	193.8

4.2 Model Estimation and Analysis

Three measures of inflation are considered in this study as used by Wright (2003). These are the CPI, core CPI and food CPI. Consequently, three models, one for each measure of inflation are estimated. For each of these three models, a total of 53 possible predictor variables are used. The predictor variables are classified into two, namely, focus variables and auxiliary variables. According to Danilov and Magnus (2004) and Luca and Magnus (2011), focus regressors are always included in the model "because of theoretical reasons or other considerations about the phenomenon under investigation" whereas auxiliary regressors are those which are less certain. To improve the statistical properties of the estimated focus parameters, different subsets of the auxiliary regressors are excluded from the model. In addition, the extracted factors are employed to help improve forecast performance.

Two different model averaging algorithms were used. These are: the Bayesian model averaging (BMA) and the weighted-average least squares (WALS). All results were obtained using the Stata commands introduced by Luca and Magnus (2011) for implementing the exact BMA and the WALS estimators. In all the estimations the subset of focus regressors included the constant term and other determinants of inflation and the subset of auxiliary regressors included price of PMS per litre, foreign assets of DMBs, inflation expectations, all share index, market capitalization and purchasing manager index as used in various inflation studies.

Table 2: Estimated BMA models for dependent variables CPI, CCPI and FCPI

Variable	CPI Model			CCPI Model			FCPI Model		
	Estimates	Std. Err.	PIP	Estimates	Std. Err.	PIP	Estimates	Std. Err.	PIP
FOCUS									
M2	7.58E-07	-6.30E-07	1.000	4.93E-07	-0.508	1.000	7.66E-07	-0.854	1.000
MLR	2.987	-0.501	1.000	2.043	-0.0263	1.000	3.928	-0.0408	1.000
GIF	0.554	-0.633	1.000	0.250	-2.99E-06	1.000	0.754	-6.06E-06	1.000
WFPI	0.116	-0.0315	1.000	0.133	-0.163	1.000	0.0890**	-0.249	1.000
RGDP	5.56E-06	-4.03E-06	1.000	3.64E-06	-0.00522	1.000	9.65E-06	-0.00868	1.000
FPGDP	-0.141	-0.200	1.000	-0.162	-5.08E-06	1.000	-0.0664	-9.45E-06	1.000
ARF	0.00715	-0.0065	1.000	0.0023	-0.0114	1.000	0.0139	-0.0189	1.000
ARY	-1.72E-06	-6.66E-06	1.000	1.01E-06	-0.508	1.000	-7.20E-06	-0.854	1.000
EXRB	0.0907	-0.0141	1.000	0.0918	-0.0263	1.000	0.0890	-0.0408	1.000
AUXILIARY									
FA	7.71E-06	-2.66E-06	0.966	8.37E-06	-1.92E-06	0.998	7.89E-06*	-4.13E-06	0.874
IFE	0.0245	-0.127	0.103	0.00429	-0.0777	0.078	0.0255	-0.151	0.099
ASI	0.00016**	-7.66E-05	0.873	0.000161	-5.66E-05	0.941	0.000188*	-0.000113	0.800
FER	5.62E-05	-0.000133	0.216	2.91E-05	-8.89E-05	0.159	0.000123	-0.000214	0.318
RM	6.76E-09	-3.88E-07	0.090	5.54E-09	-2.80E-07	0.079	1.72E-07	-7.27E-07	0.133
CPS	1.82E-06	-5.29E-07	0.988	2.29E-06	-4.04E-07	1.000	1.27E-06	-9.12E-07	0.757
NCG	3.29E-06	-5.72E-07	1.000	2.92E-06	-4.44E-07	1.000	3.92E-06	-8.11E-07	1.000
REER	-0.229	-0.0838	0.951	-0.304	-0.0564	1.000	-0.171	-0.126	0.734
TOT	-0.281	-0.779	0.177	-0.278	-0.691	0.201	-0.325	-0.934	0.171
EXg	0.000413	-0.00431	0.088	2.31E-05	-0.00296	0.076	0.000188	-0.0057	0.097
IMg	0.000394	-0.00473	0.086	-3.53E-05	-0.00353	0.078	0.00054	-0.00635	0.094
FAAC	1.44E-08	-2.00E-06	0.076	-1.92E-07	-1.84E-06	0.080	2.50E-07	-2.75E-06	0.083
GE	-7.90E-06*	-4.70E-06	0.827	-7.73E-06**	-3.75E-06	0.894	-6.61E-06	-5.93E-06	0.643
Constant	-29.96	-18.12	0.966	0.337	-12.9	0.998	-62.95**	-26	0.874

Note, SE and PIP mean standard error and prior inclusion probability.

Table 3: Estimated WALS models for dependent variables CPI, CCPI and FCPI

Variable	CPI Model		CCPI Model		FCPI Model	
	Estimates	Std. Err.	Estimates	Std. Err.	Estimates	Std. Err.
FOCUS						
M2	1.21E-06*	-6.41E-07	8.45E-07	-5.46E-07	1.13E-06	-7.72E-07
MLR	2.918	-0.511	2.092	-0.432	3.701	-0.622
GIF	0.610	-0.778	0.636	-0.663	0.700	-0.937
WFPI	0.127	-0.0368	0.152	-0.0311	0.102**	-0.0446
RGDP	7.32E-06*	-3.95E-06	5.43E-06	-3.33E-06	1.00E-05**	-4.83E-06
FPGDP	-0.127	-0.17	-0.122	-0.145	-0.135	-0.206
ARF	0.0104	-0.00646	0.00595	-0.00548	0.0155*	-0.00787
ARY	-4.66E-06	-6.48E-06	-1.97E-06	-5.46E-06	-8.12E-06	-7.92E-06
EXRB	0.0884	-0.0144	0.0891	-0.0122	0.0882	-0.0174
AUXILIARY						
FA	7.26E-06	-2.34E-06	7.46E-06	-1.98E-06	7.48E-06	-2.81E-06
IFE	0.195	-0.341	-0.0142	-0.290	0.283	-0.409
ASI	0.000137*	-7.15E-05	0.000122**	-6.02E-05	0.000159*	-8.76E-05
FER	0.000103	-0.00012	9.32E-05	-9.91E-05	0.000136	-0.00015
RM	4.01E-07	-1.13E-06	2.96E-07	-9.70E-07	8.50E-07	-1.35E-06
CPS	1.51E-06	-5.07E-07	2.13E-06	-4.28E-07	1.09E-06*	-6.14E-07
NCG	2.72E-06	-5.49E-07	2.44E-06	-4.64E-07	3.24E-06	-6.67E-07
REER	-0.180**	-0.0746	-0.229	-0.064	-0.157*	-0.0886
TOT	-2.030	-1.409	-2.052*	-1.226	-1.947	-1.653
EXg	0.0105	-0.0139	0.00606	-0.0121	0.0114	-0.0162
IMg	-0.005	-0.016	-0.00708	-0.014	-0.00224	-0.0186
FAAC	-1.57E-06	-6.75E-06	-4.69E-06	-5.67E-06	-5.74E-08	-8.15E-06
GE	-8.15E-06**	-3.47E-06	-7.12E-06**	-2.96E-06	-8.98E-06**	-4.19E-06
Constant	-42.16**	-17.8	-16.05	-14.99	-65.04	-21.51

Note, SE mean standard error and prior inclusion probability. , ** and * indicate significant of estimates at 1, 5 and 10%, respectively.

We present model estimation results in Tables 2 and 3 for BMA and WAS techniques, respectively. Table 2 gives results for BMA models using CPI, CCPI and FCPI. as dependent variables, over a number of explanatory variables. The explanatory variables are divided into focus and auxiliary variables. [3]The auxiliary variables in the sense that the modeller is uncertain whether they should be in the model or not. Similarly, Table 3 presents the results for WALS estimation approach.

Starting from the results of the BMA approach presented in Table 2, we found maximum lending rate (MLR), world food price index (WFPI) and Bureau de change exchange rate (EXRB) as significant drivers of all items CPI among focus variables while among auxiliary variables, FA, all share index (ASI), credit to private sectors (CPS), net credit to government (NCG) and real exchange rate (REER) are significant up to 5 percent level. Government expenditure (GE) is weakly significant, that is up to 10 percent level. These levels of significance agree with corresponding PIP values presented in Table 2. That is, in the real sense, the closer these PIP values are to unity, the more the significance of parameter estimates.

The case of WALS estimation method is presented in Table 3. Looking at CPI and CCPI models, among focus variables, drivers of CPI and CCPI are still MLR, WFPI and EXRB, while among auxiliary regressors for these models (CPI and CCPI), foreign assets to DMBs (FA), ASI, CPS, NCG, REER and GE are significant drivers of CPI only. The significant auxiliary regressors for FCPI at 1 percent significant level is NCG.

Using WALS estimation approach, for CPI model, broad money (M2), real GDP (RGDP) are significant at 10 percent, while MLR, WFPI and EXRB are significant at 5 percent level. Looking across other models (CCPI and FCPI), we found the consistency of significance of these three focus variables. This conclusion about significance of MLR, WFPI and EXRB

[3] Focus variables used as explanatory variables here are those variables assumed based on economic theory as drivers of inflation.

also agree with the results of BMA presented earlier in Table 2. Among the auxiliary variables, for CPI models, we found FA, CPS, NCG, REER and GE as significant regressors, while for CCPI model, FA, ASI, CPS, NCG, REER and GE are significant auxiliary regressors at 5 percent level. For FCPI model, FA, NCG and GE are significant auxiliary variables.

Now, among the significant drivers of CPI inflation, the direction is positive in most of the cases in the focus variables. The MLR, WFPI and EXRB have positive contagion with inflation proxies used as dependent variables (CPI, CCPI and FCPI) in both Tables 2 and 3, This is largely consistent with monetarist and imported/global inflation view. The monetarists are of the view that inflation is a function of money; hence anything that affects the quantum of money in circulation affects the general price level. Maximum lending rate is the interest rate applied to most credit created by the DMBs in Nigeria, thus increase in maximum lending rates translates to increase in the cost of production which results in rise in the prices of final goods. Moreover, the imported/global inflation view contends that inflation in an open economy is not solely a function of what happened in the domestic economy. Activities not only in the trading partner countries but also the global economy shapes the prices in the domestic economy. Globalist hence recognize the effect of globalization on changes in the domestic prices hence the consistently significant influence of world food price index and Bureau de change exchange rate on all variants of measures of domestic prices. While among the significant auxiliary regressors, REER and GE only have negative contagion with inflation proxies.

5. Conclusion and policy issues

Thus, the historical path of inflation is not only monitored by monetary authorities in both developed and developing countries, but attempt is also often made to determine its future path. This is done by using various methodologies which have been criticised to be defective, particularly in the area of the dynamism of the influence of the predictors on inflation over time. The large number of predictors, according to the critics of those methodologies, makes model selection cumbersome and difficult, hence the resort to the use of BMA which obtained the best predictive performance averaging forecasts constructed from several models. This study uses the Bayesian model averaging (BMA) methodology to determine the predictors of inflation for Nigeria.

This paper considered 10 macroeconomic groups of variables, used as regressors for three inflation measures (all items CPI, core CPI (CCPI) and food CPI (FCPI)). Those 10 groups were the monetary aggregates, real sector, interest rate, exchange rate, capital market, prices, external sector, agricultural, fiscal and international indicators. Taking the sample from January 2008 to June 2017, both BMA and WALS techniques presented similar results. Among the focus variable, the estimation techniques identified MLR, WFPI and EXRB as potential drivers of CPI, CCPI and FCPI. Among the auxiliary variable, FA, CPS, NCG, REER and GE are the significant predictors of CPI, CCPI and FPI. Now, looking at the direction of the contagion, the direction is positive in most of the cases in the focus variables, that is, the MLR, WFPI and EXRB have positive contagion with inflation proxies, and this is in agreement with monetarist and imported/global inflation view.

The monetarists are of the view that inflation is a function of money; hence anything that affects the quantum of money in circulation affects the general price level. Maximum lending rate is the interest rate applied to most credit created by the DMBs in Nigeria, thus increase in maximum lending rates translates to increase in the cost of production which results in rise in the prices of final goods. Moreover, the imported/global inflation view contends that inflation in an open economy is not solely a function of what happened in the domestic economy. Activities not only in the trading partner countries but also the global economy shapes the prices in the domestic economy. Globalist recognizes the effect of globalization on changes in the domestic prices, hence the consistently significant influence of world food price index and Bureau de change exchange rate on all variants of measures of domestic prices. While among the significant auxiliary regressors, REER and GE only have negative contagion with inflation proxies.

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