FORECASTING INFLATION IN DEVELOPING ECONOMIES: THE CASE OF NIGERIA

FERIDUN, Mete*
ADEBIYI, Michael Adebayo

Abstract: In this article, we have sought to establish whether monetary aggregates have useful information for forecasting inflation, other than that provided by inflation itself. We have approached the problem in two ways. First, we conducted forecasting experiments, using Mean Absolute Percentage Errors (MAPEs). We then evaluated whether each monetary variable improved the forecasts of a simple AR (1) model of inflation. From the study, we found that the MAPEs for all the variables were less than that of the benchmark AR (1) model. The forecasting experiments showed that, over the whole sample period, most of the variables examined served as important information variables for price movements. We found that the Treasury bill rate, domestic debt and M_2 provide the most important information about price movements. Treasury bill rate provided the best information, since it has the lowest MAPE. Conversely, the least important variables were the deposit rate, dollar exchange rate and M_1. M_2 provides more information about inflation than M_1 in the sample period. We also estimated an inflation equation and determined alternately whether M_2 enter the equation significantly. We found that M_2 is not significant. Exchange rate at level, and contemporaneous value of the domestic debt, are significant in the model. The results obtained are robust across the two methods used and we concluded that although the monetary variables contained some information about inflation, exchange rate and domestic debt may be more useful in predicting inflation in Nigeria. A number of policy implications emerge from the study

JEL codes: C51, O55
Key words: Forecasting inflation, Error Correction Model, Mean Absolute Percentage Errors

* Mete Feridun, Faculty of Economics and Administrative Studies, Cyprus International University, Nicosia, Cyprus. E-mail: mete.feridun@lycos.com
Michael Adebayo Adebiyi, Department of Economics, University of Lagos Lagos, Nigeria

I. Introduction

Conducting monetary policy is a difficult process because monetary policy affects the economy with a lag. Achieving goals requires some ability to peep into the future. Consequently, decision makers must make forecasts to help in decision-making. To conduct these forecasts, most central banks take a number of variables into account. The exclusive focus on one or a few selected variables as is done in the financial programming framework implies that the policy makers believe these variables must contain enough information about movements in the target variables. This research work attempts to evaluate the information content of not only the monetary aggregates used by the Central Bank of Nigeria (CBN) to target inflation, but other key variables such as interest rates, the domestic debt and the exchange rate, which have the potential of being useful inflation indicators. The understanding of inflation forecasting in relation to ECM as addressed in the present study crucial for the success of monetary policy. Efficient implementation requires policy makers to understand the direction policy takes to impact the macro-economy and the time horizon needed for the impact. Key policy issues in the current policy framework arise. For example, do changes in reserve money actually lead to changes in money broadly defined (M_2) and/ or inflation? If so, how long do these changes take to impact inflation? This information would then aid policy makers to know which instruments are more useful and which time horizon should be used to target inflation.

In this article, we seek to establish whether monetary aggregates have useful information for forecasting inflation, other than that provided by inflation itself. We will approach the problem in two ways. First, we will conduct forecasting experiments, using mean absolute percentage errors. Next, we will evaluate whether each monetary variable improves the forecasts of a simple AR (1) model of inflation. The rest of this paper is structured as follows. Section II provides a review of the literature. Section III discusses the methodology and data used. The empirical analysis is discussed in Section IV, while the last section concludes and points out the policy implications that emerge from the study.

2. Review of the Literature

From the early work of Sims (1972) empirical consideration of whether financial variables can usefully be employed in conducting monetary policy has focused not only on the ability of these variables to predict movements in output and inflation, but also on whether they could help predict fluctuations that are not predictable by information contained in output and inflation themselves. Empirical work has focused on the use of Vector Auto Regressions (VARs). The main attraction of tests from VARs is that they provide a natural basis for testing conditional predictability. As long as the financial variables contain some information that can independently predict movements in output or inflation, policy makers can exploit that information (Friedman and Kuttner (1992).

Many studies have employed Granger-causality tests between financial sector variables and output or inflation (Friedman and Kuttner (1992), Estrella and Mishikin (1997), Andersson and Sj (2000). Variance decompositions have been used to check how much of the forecast error variance, in output or inflation, is attributable to a given financial sector variable (Friedman and Kuttner (1992), Chandra and Tallman (1996), Emery (1996), Andersson and Sj (2000). Gray and Thoma (1998) have argued that some of the results obtained, using Granger-causality and variance decompositions, may be sensitive to changes in the sample. They may even be heavily influenced by the presence of one outlier in the data. They suggest the use of recursive regressions such as used in Emery (1996), which can reveal the sensitivity of the results to changes in the sample.

VARs have been used to conduct forecasts of output and inflation in systems that contain a financial sector variable (Chandra and Tallman (1997), Gray and Thoma (1998), Black et al. (2000). Using different measures to compare the accuracy of the forecasts, the results from different financial variables are then compared. In this way, the relative importance of different variables is also checked. Because the ultimate test of an equation lies in its out of sample tests, many studies have also extended the analysis to compare in sample and out of sample forecasts while others have used conditional forecasting. Single equation estimations of output and inflation have also been used to check the information content of financial variables. If a financial variable enters the equation significantly, then it contains useful information for policy (Chandra and Tallman (1997)). Numerous studies of inflation have also been done without particular reference to the issue of information content of the financial variables. However, almost all these studies include some financial sector variables like exchange rates and interest rates as explanatory variables so that if these variables enter these equations significantly, they can be said to contain some inflation information.

A number of studies that look at the information content of monetary aggregates for inflation and output have been carried out. The studies we could access, however, are mainly on developed countries. However, many inflation studies on developing countries in general and Africa specifically, although not focusing on monetary aggregates per se, have included money aggregates, exchange rates and interest rate measures as explanatory variables. These can give us an indication of the importance of these variables for inflation. We will, therefore, review a few studies specific to the topic and then some inflation studies on African countries. A number of studies have employed the VAR methodology. By evaluating F-statistics and forecast performance measures, empirical work has shown that the issue of whether monetary aggregates are important for inflation or not varies from country to country and from one period to another. One of the studies important to the discussion here, using US data, is that by Friedman and Kuttner (1992). They used F- statistics to determine the importance of money variables in a VAR model. They find that both M_1 and M_2 are significant for inflation before 1980 and the significance disappeared when the data set is extended beyond that period. Of particular interest, they find that the commercial paper bill spread was a good information candidate for industrial production. This conclusion sparked a debate and some of the resulting papers are those of Emery (1996) who estimates recursive regressions and uses both Granger-causality and variance decompositions. He attributes the importance of this variable to the presence of outliers in the data. Hafer and Kutan (1997) explored the importance of the commercial bill spread and argue that the conclusion on its significance was a result of wrong stationarity assumptions about the money variables. They find that by carefully modeling the data, money variables are still useful beyond the 1980s. Black et al. (2000) performed forecasts of inflation and output, using the same data. They estimated an AR (1) model as a base model and calculated its mean absolute percentage error. They then forecast inflation, adding one variable at a time to the AR (1) model and compared the Mean Absolute Percentage Errors (MAPEs) of the different models. They find that money improves the forecasts of inflation. Studies testing the importance of monetary aggregates have also been carried out using Australian data. One such study is that by Orden and Fisher (1993). They obtained variance decompositions and find that money shocks contributed up to 30% of variations of prices. Chandra and Tallman (1996) also use the VAR approach on Australian data. However, unlike in the Orden and Fisher (1993) study that measured inflation, using the GDP deflator, they use the CPI to measure the price level. They also extended the sample period to cover the period after financial deregulation. They find that although M_3 is important in some systems in the block exogeneity tests, it is not significant as an inflation predictor in any of the specifications. M_2 is significant in exogeneity tests only towards the end of the sample, but had no predictive importance either. Some studies used single equation estimations of inflation to check the importance of money aggregates to inflation. One of such studies is Chandra and Tallman (1997)'s extension of their 1996 study. Using the 5% significance level as their decision rule, they find that only M_3 is important to inflation. This agrees with the exogeneity test results in their 1996 study.

A number of inflation studies have been carried out with data from different African countries. The results obtained seem to be similar in most of these studies. Whereas in a few cases monetary aggregates are important for movements in prices, other variables such as the exchange rate, foreign prices and interest rate measures seem to be more significant in explaining movements in inflation. London (1989), analyzing the experience of 23 African countries for the period 1974-85, found considerable support for the role of exchange rate adjustments as well as monetary growth in explaining inflationary developments. In this study, both cross-section and time-series regressions indicate that models of inflation based solely on monetary expansion and real income growth (which is related negatively to the inflation rate) leave sizable portions of the inflationary process unexplained. Moreover, the addition of a bilateral exchange rate variable appears significantly relate to the rate of domestic inflation during the period 1980-85. Chhibber and others (1989), looking specifically at Zimbabwe, where data on wage costs and interest rates were available, identified unit labor costs and interest rates in addition to the exchange rate, foreign prices, monetary growth, and real income growth as factors explaining inflation. Tegene (1989), using Granger and Pierce causality tests, found evidence of causation running from monetary expansion to inflation in six African countries. Agenor (1989), examining trends in inflation in four African countries, has identified an important role for parallel market exchange rates, as compared to official rates, and monetary expansion in explaining both the decomposition of the forecast error variance of inflation rates and in estimating the response of the inflation rate to unit shocks to each of these variables. Except for Tegene and Agenor, the studies thus far have all employed traditional econometric techniques, which involve estimating structural economic models and are therefore subject to the usual problems of invalid restrictions and specification error. The Tegene and Agenor studies, which use VAR analysis, in principle avoid some these difficulties. But Tegene has examined only the basic causal relationships between monetary growth and inflation, while Agenor's paper focuses on the decomposition of forecast error variance in inflation, and then only for a very few countries. In addition, the variable in Agenor's paper that appears most important in explaining variations in the forecast error of inflation, the parallel market exchange rate, is not one over which policy makers have a direct influence. Rather, it is determined by, among other factors, anticipated devaluation and actual and projected rates of monetary growth. None of these studies thus provides conclusive evidence of whether monetary expansion or devaluation matters more as a cause of inflation in Africa. Durevall and Ndung'u (2001) estimated a dynamic error correction model of inflation for Kenya, covering the period 1974 to 1996. They find that money supply affects prices only in the short run. The excess money demand error correction term is not significant at any conventional levels. However, they find a significant role for the three-month Treasury bill rate. In a study of the monetary transmission mechanism in Uganda, Nachenga (2001) also finds a highly significant role for the Treasury bill rate. He also finds that the first lag of growth in money supply is significant. Sacerdoti and Xiao (2001) estimate a similar model for Madagascar, covering the period 1971 to 2000. They find that the money variable is insignificant at all conventional levels. They find a very significant role for the exchange rate. Similarly, Durevall and Kadenge (2001) find that after the reforms, money supply ceases to be an important determinant of inflation in Zimbabwe. Instead, the exchange rate and foreign prices became more important. In Zambia, Mwansa (1998) estimated both an error correction and VAR model of inflation. Using quarterly data for the period 1985 to 1996, he found that the second lag of M_1 is marginally significant for inflation. In the VAR model, he found that shocks to M1 explain 15% of the variations in inflation after 1 year, while shocks to the exchange rate explained as much as 22% of inflation variations after 6 months.Also, Andersson and Sj (2000), using single equation and multivariate causality tests, analyzed the relationship between money and inflation. The study covered the period 1987 to 1993 in which the first attempt at monetary policy reforms were made. Using an error correction term, they tested for Granger-causality between money and prices and found that money predicts prices. In the multivariate results, they found that the price level is Granger caused by a combination of money supply and the exchange rate.

In Nigeria, attempts to demonstrate the determinants and stability of money date back to the early 1970s. The pioneering work in the area of money demand function in Nigeria was conducted by Tomori (1972). He found out that income, interest rate and real income were the major determinants of demand for money in Nigeria. These findings, however, generated a lot of debate known as "TATOO"[1]

[1] TATOO is an acronym for Tomori, Ajayi, Teriba, Odama and Ojo. These were the economists that brainstormed on the issues of stability of money demand in Nigeria in 1972.

debate in the literature. Ajayi (1974), Teriba (1974), Ojo (1974) and Odama (1974) reacted to Tomori's findings based on stability and reliability of the elasticities of the demand for money function, as well as the speed of adjustment, policy relevance and the stability of the regression over the sample period. Since the 'TATOO' debate, other empirical studies on money demand have been conducted, which included, among others, Iyoha (1976), Akinnifesi and Phillip (1978), Fakiyesi (1980), Adekunle, (1980), Adejugbe (1988), Ajewole (1989), Teriba (1992), Oresotu and Mordi (1992) and Essien, Onwioduokit and Osho (1996). A recent study was conducted by Adebiyi (2004). He attempts to study the properties of money demand and evaluates the appropriate monetary policy using an error correction model (ECM). The study shows that the determinants of money demand are real GDP, nominal interest and inflation rate. The income elasticity of money demand is very high. The demand for money in Nigeria was stable between 1970 and 1998 despite the reforms programmes embarked upon in 1986.

3. Data and Methodology

The data for this study, the sources and description are contained in Appendix 1

3.1. Auto Regressive Analysis: The model estimated for this study take the form shown in the Equation 1.

$$pt = \Phi + \sum_{i=0}^{N} \sigma P_{t-1} + \sum_{i=0}^{N} \mu X_{t-1} + E_t \qquad (1)$$

where pt is the price level measured by the CPI and X_t is the variable used in addition to price in the model. σ and μ are constant parameters. E *is* the error term and t the time subscript. The number of lags is selected such that we use the lowest number of lags that eliminate residual autocorrelation in the regression model.

For forecasting, we define MAPE below for periods 1 to N of a single series where N is the number of observations. We start by obtaining the forecast error for a single period E_t where E is the error and t is a time subscript. Then,

$$E_t = p_t - \underline{p}_t \qquad (2)$$

Where $\underline{p}$ is the price level forecast. The percentage error *(PE)* then is

$$PE = ((p_t - \underline{p}_t)/p) \, x100 \qquad (3)$$

so that the absolute percentage error for period t is and the MAPE:

$$\text{APE} = 100\text{x}((\text{p}_t - \underline{\text{p}}_t)/\text{p}) \qquad (4)$$

$$\sum_{t=1}^{N} MAPE = \Sigma\,(\text{APE/N}) \qquad (5)$$

The MAPE has been said to be asymmetric in that it treats over estimations and underestimations differently. However, it remains one of the most widely used and reliable measures of forecast performance and so we proceed to use it here (See Simatele, 2003; Meade, 2000; Goodwin and Lawton, 1999; and Willemain, 1991) for discussions of the MAPE. The MAPE was found to be a more suitable measure than the mean square error (MSE) and the mean absolute error (MAE), which is not directly comparable across estimation periods and models (Makridakis et al. (1998).

3.2. Single Equation Estimation: For the period under study, Nigeria is assumed to be a small open economy. Although most studies of inflation in Africa recognize the fact that inflation is driven by a combination of factors falling across different theoretical assumptions, most recent studies focus on money demand and the external sector either through the Price Purchasing Parity (PPP) relationship. In this study, we take a more general approach as in Metin (1995), Hendry (2001) and Simatele (2003) and incorporate a wider number of factors in the estimation. We postulate different possible relationships between inflation and different factors and we discuss them each in turn below.

Money and Public Sectors: We begin by looking at the role of money creation where inflation can be produced by a rapid increase in the quantity of money supply relative to output (see Friedman and Scwartz (1982)). The starting point is the money demand function. In line with the general literature, we assume that demand for money is primarily a demand for real balances. In the absence of money illusion, an increase in the level of prices induces an increase in the demand for nominal balances leaving the level of real balances the same so that we can say that in equilibrium, individuals hold nominal balances in proportion to their nominal income. We assume that money demand is a function of transactions and asset motives. To keep the level of transactions the same, economic agents adjust their demand for nominal balances as prices change. Changes in the interest rate also induce changes in the amount of balances held as they affect the relative price of alternative uses of wealth. In an economy with no capital controls, changes in foreign interest rates and exchange rates also affect the amount of money held in the economy because alternative investment opportunities arise for domestic economic agents in foreign capital markets. To capture these motives, we assume that money demand is a function of income (*y*), money's own rate of return (dr) and the opportunity cost of holding money (tbr) and exchange rate (*e*). Since economic agents hold money in proportion to nominal income in equilibrium, inflation in the money market is generated by deviations from this equilibrium. Equilibrium in the money market requires that money supply (*Ms*) be equal to money demand (*Md*). We also wish to incorporate the role played by fiscal policy in propagating inflation. We use total government domestic debt (debt-GDP ratio) as the fiscal measure. Let P be the price level so that our money demand equation can be written as in Equation (6).

$$Ms/P=Md(y;e;tbr;debt\text{-}GDP;\ dr) \qquad (6)$$

The relationship between money and the variables is such that:
$dM^d/dy > 0$; $dM^d/ddr < 0$; $dM^d/dtbr > 0$; $dM^d/de < 0$; $dM^d/d(debt\text{-}GDP) < 0$

4. Empirical Results and Analysis

4.1 Time Series Characteristics: In this section, we discuss the data used in the estimations. The data used are quarterly for the period 1986:1 to 1998:4. The sources for each series are indicated in Appendix 1. Alongside the graphs, we discuss what order of integration each series exhibits. Table A1 shows the unit root tests for the variables used. Gross domestic product and broad money supply in Table A1 are in log levels. In checking for the unit root, we used the Philips-Perron tests[2]. The Phillips-Perron test may be more appropriate as it is a generalisation of the ADF test and is less restrictive on its assumptions about the residuals. Output and prices are plotted in Figure 1.

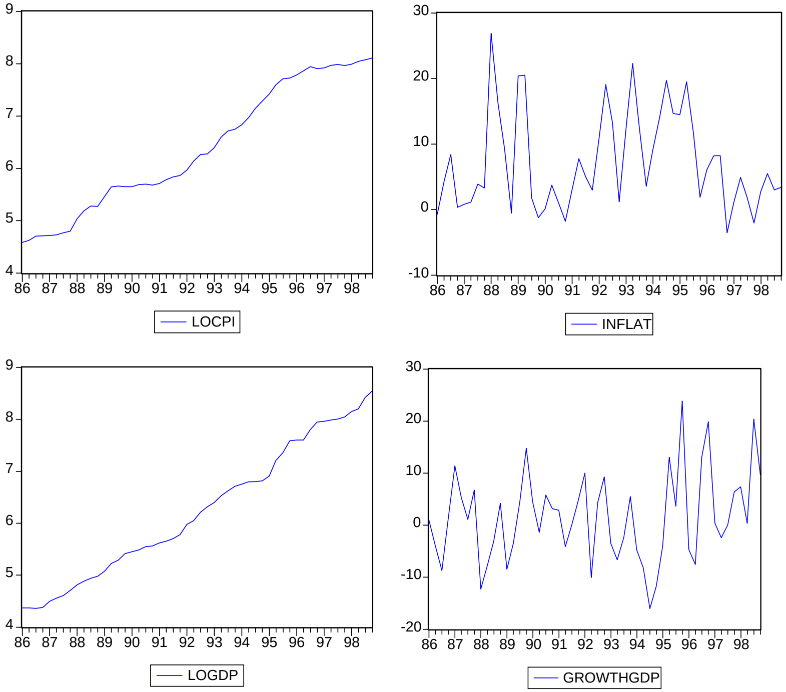
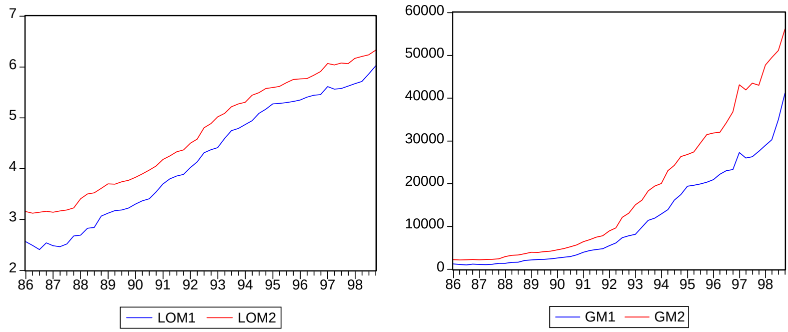


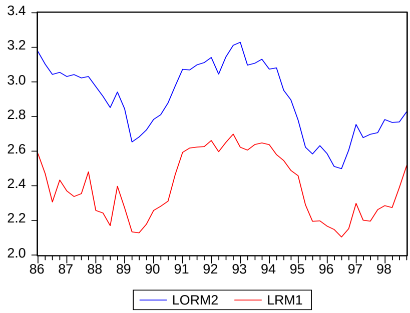
Figure 1: Prices and Output

Output is measured by real GDP interpolated from an annual to a quarterly series using the Sandee and Lisman method (quoted form Tucker, 2003). The unit root test shows that this series is trend stationary. We use this variable only in the fully specified inflation

[2] This is a method developed by Phillips and Perron (1988) and is a generalization of the Augmented Dickey-Fuller (ADF) test. The assumptions about error properties are less stringent than in the ADF method. The unit root tests the hypothesis that ½ = 1 in the equation ¢*y* = ¹+½*y*$_{t¡1}$+". The cumulative aid series shows a huge jump in the early part of the series as explained below. We therefore conduct the unit root tests from 1986:1 to 1998:4.

equation model. The price level is measured by the composite consumer price index (CPI). We plot this series and its first difference (quarterly inflation) in the upper panel of Figure 1. For most of the sample period, inflation has not been stable. Large fluctuations are observed in the latter part of 80s, which coincides with the early years after the reforms, and periods of very high inflation. M_1 and M_2 are used in the estimation alternately. In Figure 2 we plot the log levels in the upper panel, quarterly growth in the middle panel and the real series (deflated by the CPI) in the lower panel. The Phillips-Peron tests show that the series exhibit a unit root in nominal terms. The series are however stationary in first differences. We use two interest rates in the study and these are plotted in Figure 3.





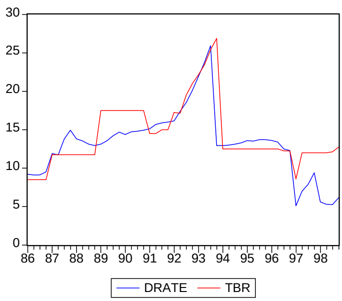


Figure 2: Monetary Aggregates

Figure 3: Interest Rates

The three-month Treasury bill rate (TBR) is used as the alternate interest rate and the average deposit rate (dr) as the own interest rate. The two interest rates are quite highly correlated. Spreads between the two rates are noticed in 1989-1991, 1997-1998. The deposit rate declined in 1997sharply and the spread from the Treasury bill rate continues to widen for the rest of the sample period. The unit root tests show that the deposit and Treasury bill rates exhibit a unit root in nominal terms. The series are however stationary in first differences. The nominal exchange rate[3] is measured by the rate of the naira to the dollar. This is an official exchange rate.

We decide to use official exchange rate because most transaction, including government transactions are conducted using this rate. The use of the US variables is motivated by the fact that most official transactions are conducted using the US dollar. We plot these variables in Figure 4 below. We also plot in the bottom panel the real exchange rates for the dollar. The exchange rate has been increasing over time until 1993 when the rate became stable. The nominal exchange rate is stationary at level.

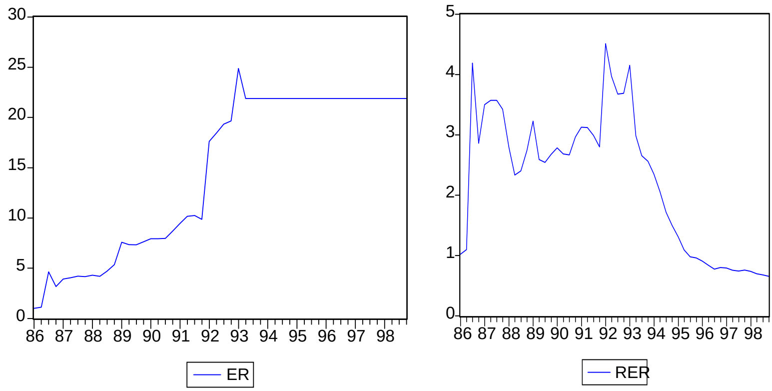


Fig. 4: Exchange Rates

We also use domestic debt as measured by government securities outstanding (debt GDP ratio) as a fiscal measure. The series and its growth rates are plotted in Figure 5 below. The series exhibit a unit root in nominal terms. The series are however stationary in second differences.

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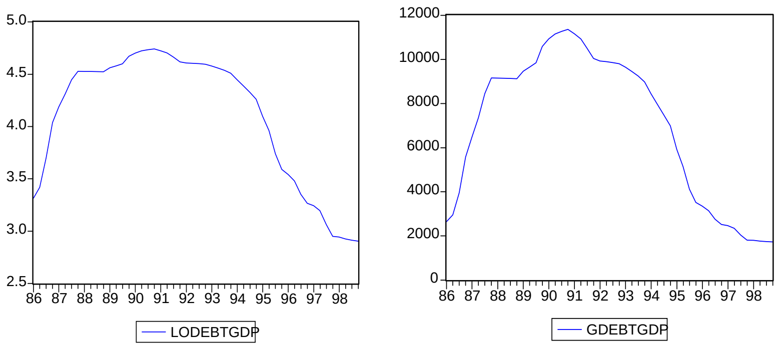


Figure 5: Domestic Debt

4.2. Estimation Results: We begin our discussion of the results with the forecasting experiments and then move on to discuss the estimation of the inflation equation. In the forecasting experiments, we explore the information content of the financial variables by looking at the relationships between prices and different possible information variables. These forecasting experiments are done in an auto regression setting as shown in Equation 5. In the inflation equation, our interest is to see if the financial variables and in particular the monetary aggregates enter the inflation equation significantly. This is particularly important in that it allows us to check the performance of the variables when we control for the presence of other variables. It has often been argued that when interest rates are added, money tends to loose its explanatory power (Simatele, 2003).

4.3.1. Forecasting: In this section, we discuss the forecasting experiments. The forecasts are all out of sample forecasts. The focus on out of sample forecasting experiments is an attempt to simulate real time policy decision-making. Each model is composed of the price level and one possible information variable. Each forecast is a one step ahead forecast. One-step- ahead forecasts were preferred as a way of mimicking the horizon the central bank faces given the data. The initial estimation is done between 1886:1 and 1989:4. We then make a forecast for 1990:1 to 1998:4. We then calculate the MAPE based on Equation 5 to decide if a variable adds significant information for forecasting or not. This decision is based on the relative performance of a benchmark model. The benchmark model used is the best-fitted autoregressive model for the price level. Preliminary analysis showed that the best model was an AR (1) model. We therefore estimate an AR (1) model as the base model. The higher the MAPE for a model relative to the benchmark model, the less information the additional variable has for forecasting inflation. This approach is superior to just looking at the performance of one model for our interest because it allows us to compare 'competing' information variables (Simatele, 2003). More importantly, we can check the importance of the information from the monetary aggregates relative to information from other variables by comparing their MAPEs. The data are used in log levels.

Forecasting with non-stationary variables produces forecast errors of similar forms as in stable cases (Luketpol (1993)). The method used to evaluate the forecasts does not suffer from the disadvantages of say the Mean Square Error (MSE) where the error grows with the forecast horizon. After obtaining the forecasts, we compute the percentage error for each period. We then use these to calculate the MAPE for the entire period. Each MAPE calculated here shows the accuracy of the model over the entire forecast horizon. We show the results in Table 1.

Table 1: Mean Absolute Percentage Errors (1990:1-1998:4)

AR (1)	9.79
M_1	7.75
M_2	6.49
Dollar exchange rate	8.31
Treasury bill rate	5.91
Deposit rate	8.72
Domestic debt	6.31

The out of sample forecasts are one-step ahead forecasts with the model estimated between 1986:1 and 1989:4 and then forecast for the period 1990:1 to 1998:4.

From the table we see that the MAPEs for all the variables are less than that of the benchmark AR (1) model. Using our decision rule, we can say that these variables have important information for forecasting inflation over the sample period. We can also say that the most important variable is the Treasury bill rate since it has the lowest MAPE. Conversely, the least important variables are the deposit rate and dollar exchange rate. M_2 provides more information about inflation than M_1 in the sample period. The forecasting experiments that we conduct in this section show that over the whole sample period most of the variables examined serve as important information variables for price movements. We find that the Treasury bill rate, the domestic debt and M_2 provide the most information about price movements.

4.3.2. Inflation Equation: In this section, we extend the above analysis and consider how the discussed variables perform in the presence of other control variables and whether these variables have a causal effect on inflation. To do this, we estimate a fully specified inflation equation. We start by looking at the co-integration relationships and then report the estimation of the error correction inflation model estimated.

4.3.3 Co-integration Analysis: Having confirmed the existence of unit root in the series in Table A1, co-integration tests in this paper are conducted by using reduced rank procedure developed by Johansen (1988) and Johansen and Juselius (1990). Table A2 in the Annex reports the estimates of Johansen procedure and standard statistics.

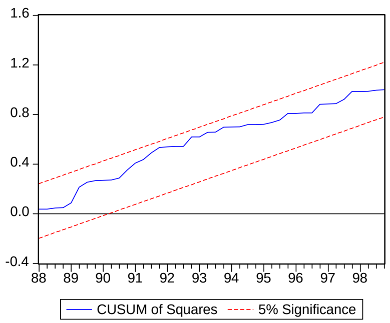
4.3.4. Error Correction Model: In this section, we discuss the estimation of an error correction model of inflation. Despite that the interest in the paper is to look at the role of financial sector variables, the estimation of a fully specified inflation equation allows us to check how the variables of interest perform in the presence of other control variables. In estimating the equation, we included one lag on each variable and searched for a parsimonious model by sequentially dropping the insignificant lags until only significant variables were left. We estimated the equation with M_2 since M_2 provides better information than M_1 in the forecasting test. The results of the parsimonious model with M_2 are shown in Table 2. We conduct stability and predictability tests. Most of the variables have the expected signs and the recursive coefficients using Cumulative Sum of Square (CUSUM) in Figure 6 shows stability in the parameters.

Table 2: Error Correction Model of Inflation 1986:1 to 1998:4

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(CPI(-1),1)	0.3755	0.1265	2.96	0.0048
D(ER,1)	0.0787	0.0412	1.91	0.0627
D(ER(-1),1)	0.0494	0.0456	1.08	0.2847
D(DEBTGDP,1)	-0.2472	0.1141	-2.16	0.0358
ECM1 (-1)	-0.1446	0.0513	-2.81	0.0073
C	0.0340	0.0124	2.73	0.0089
Adj. R-squared	0.3149			
Akaike crit.	-2.8067		**F-statistic**	5.5062
Schwarz crit.	-2.5773		**Durbin-Watson**	1.7423

Of the variables of interest, we find debt-GDP, lagged of CPI and exchange rate at level are important. These variables are significant and are correctly signed. The coefficient on the first lag of inflation is significant at the one percent level with 38 percent of previous period inflation feeding into current inflation. This result is quite similar to results obtained in other studies for African countries (see Simatele, 2003).

The exchange rate is significant and correctly signed. The contemporaneous effect of the growth rate in domestic debt is significant in the equation and is correctly signed. The error correction term is significant at the 1 percent level suggesting a significant long run relationship between prices in Nigeria and the explanatory variables. Actual, fitted and residual of inflation are reported in Figure 7.



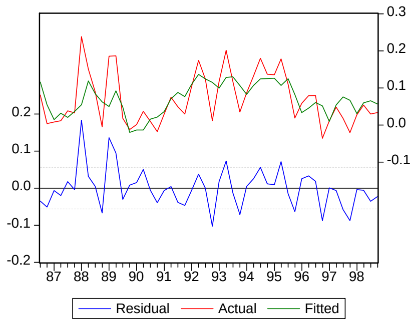


Figure 6: CUSUM of Squares. Figure 7: Actual and Fitted Inflation

As could be seen from Figure 7, the model incapable of tracking the historical values of endogenous variables with reasonable accuracy. The fiscal indiscipline in the 90s, leading to a deteriorating external balance, depreciation of the naira and the implementation of a structural adjustment programme in 1987 to date, have probably altered the equilibrium behaviour of the variables. A stable inflation equation did not exist in Nigeria from 1986:1-1998:4.

5. Conclusions and Policy Implications

We have sought to establish whether monetary aggregates have useful information for forecasting inflation, other than that provided by inflation itself. We have approached the problem in two ways. First, we conducted forecasting experiments, using mean absolute percentage errors. We then evaluated whether each monetary variable improved the forecasts of a simple AR (1) model of inflation. From the study, we found that the MAPEs for all the variables were less than that of the benchmark AR (1) model. Using our decision rule, we can say that these variables have important information for forecasting inflation over the sample period. The forecasting experiments that we conducted showed that, over the whole sample period, most of the variables examined served as important information variables for price movements. We found that the Treasury bill rate, domestic debt and M_2 provide the most important information about price movements. Treasury bill rate provided the best information, since it has the lowest MAPE. Conversely, the least important variables were the deposit rate, dollar exchange rate and M_1. M_2 provides more information about inflation than M_1 in the sample period. We also estimated an inflation equation and determined alternately whether M_2 enter the equation significantly. We found that M_2 is not significant. Exchange rate at level, and contemporaneous value of the domestic debt, are significant in the model. The results obtained are robust across the two methods used and we concluded that although the monetary variables contained some information about inflation, exchange rate and domestic debt may be more useful in predicting inflation in Nigeria.

As pointed out earlier, we have examined the usefulness of various variables in forecasting inflation. If a conditional model has MAPEs lower than those of the base model, we can argue that the variable in such a model is useful for forecasting inflation. This is particularly important with the out of sample forecasts. We can also say that the model with the least MAPE has more information for forecasting inflation than the other models. The full inflation equation results augment this analysis by checking the performance of the variable conditioning on the presence of other variables in the equation. If a variable performs well in most of the above analysis, we conclude that such a variable does have something to say about movements in inflation. We find that the monetary aggregates M_2 though provide a useful information about price level, was not significant in explaining inflation in Nigeria. The Treasury bill rate and domestic debt perform better than M_2. However, M_2 provides more information in the forecasting test than M_1, deposit rate, and dollar exchange rate. From the single equation estimations, we find that M_2 is not significant and, therefore, it was dropped in the parsimonious error correction model. Even though exchange rate provides less information in the forecasting results, it is significant in predicting inflation in the parsimonious error correction model. This result was very similar to that obtained by Andersson and Sj (2000). They find that they can only establish a link between money growth and inflation in a co-integrating VAR model only if the exchange rate is part of the system. This result shows that analyzing monetary policy independent of the foreign sector in Nigeria may be misleading. M_1 does not perform well in forecasting horizon. In the single equation estimation, the variable is not significant, and hence it was dropped from the parsimonious error correction model. The difference between M_1 and M_2 in Nigeria is time and savings deposits. One of the likely reasons for this is that banks convert time and savings deposits into loans. Since this is the vehicle through which money supply is more likely to affect inflation, we expect that a high deposit to loan ratio would be evidence of a significant effect of time and savings deposits on inflation. In the inflation equation, both the long and short run terms of the exchange rate are significant at the 10 percent level. The error correction term indicates a 15 percent disequilibrium correction each period. A significant long run relationship between the domestic and USA prices is established.

The forecasting results show that the MAPE of the Treasury bill rate is amongst the smallest. However, it was not significant in the ECM model. The MAPE of the deposit rate is the highest and one is not surprise for its insignificance in the error correction model. The government debt variable performs well in the forecasting horizon and even better than M_2. In the single equation results at level, it has 8 percent contemporaneous effect. Inflation exhibits a high level of inertia with over 37 percent of previous period inflation feeding into current period inflation. A number of reasons could account for this amongst which is fiscal dominance. If the conduct of domestic monetary policy is dictated or constrained by fiscal demands, the country becomes vulnerable to inflationary pressures of a fiscal nature. Where this is not checked, it induces the creation of formal and informal indexation mechanism, which can lead to inflation persistence. Widespread formal indexation is absent in Nigeria, but informal indexation is likely to exist. Wage and salary negotiations are infrequent in the public sector, which is still the largest employer in the country. In the private sector, trade unions negotiate for wage increases almost every year, which in a way provides an implicit wage indexation. One way of reducing these fiscal effects is to increase central bank independence. Provisions in the Central Bank of Nigeria Act (1958) gave the Minister of Finance powers over the conditions of service of the governor and powers to give directives to the Central Bank. These provisions compromise central bank independence but this was, however, modified by the CBN Amendment Decree of 1998, which made provision for operational autonomy of CBN.

Another reason why inflation exhibits high level of inertia could be poor initial policy credibility, which can lead to high levels of inflationary expectations resulting from long periods of high inflation. Prior to 1986, the Nigerian government had a history of backtracking on reforms. This could have created a situation where the public has no confidence in the government and policy announcements cannot influence public expectations. If this is the case, CBN may need to address the issue of policy transparency. Transparency tends to lower inflationary expectations by providing an implicit commitment mechanism on the part of the central bank (Svensson, 2002). This way policy becomes more credible and the public can form expectations that are closer to the policy targets. Since the 1999 fiscal year, policy targets are announced to the public. If these targets are actually realized, this could help restore public confidence in policy announcements. Unfortunately, statistics show that both the money growth and inflation targets were not met in most of the fiscal years (CBN, 2002; Ojo, 2001). The results as a whole show that while the monetary aggregates, especially M_2 contain useful information about inflation movements, the external sector and domestic debt variables are more useful in predicting inflation movements in Nigeria. On this basis, we provide the following recommendations.

First, monetary policy should be more transparent to address the issue of expectations as inflation exhibits a high degree of inertia. Prior to 1986, the Nigerian government had a history of backtracking on reforms. This has created a situation where the public has no confidence in the government and policy announcements could not influence public expectations. Thus, CBN needs to address the issue of policy transparency. Transparency tends to lower inflationary expectations by providing an implicit commitment mechanism on the part of the central bank. This way policy will become more credible and the public can now form expectations that are closer to the policy targets.

Second, there is also need to increase central bank independence in order to reduce the effect of fiscal pressure on monetary policy. The conduct of domestic monetary policy is dictated or constrained by fiscal demands and the country becomes vulnerable to inflationary pressures of a fiscal nature. This has induced the creation of formal and informal indexation mechanism, which has led to inflation persistence. Widespread formal indexation is absent in Nigeria, but informal indexation is likely to exist. Wage and salary negotiations are infrequent in the public sector, which is still the largest employer in the country. In the private sector, trade unions negotiate for wage increases almost every year, which in a way provides an implicit wage indexation. One way of reducing these fiscal effects is to increase central bank independence. Provisions in the CBN Amendment Decree of 1998 that made provision for operational autonomy of CBN is in the right direction.

Third, the buying and selling of securities in the open market operation (OMO) should be reconsidered. The use of OMO to stabilize price at the expense of output should be discouraged. The mopping of excess liquidity with the aim of stabilizing the economy has a negative impact on growth by raising lending rate and reducing investment. Lastly, there is need to restructure domestic debt in such that the non-public will be encouraged to hold more of the debt instruments. As at 2002, non-public held only 173.3 billion naira whereas the banking sector and Central Bank held 992.7 and 532.5 billion naira respectively (CBN, 2002). The composition and the holders of domestic public debt of the Federal government have implication on inflation in Nigeria.

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Appendix 1: Sources of Data and data Descriptions

Variable and Source	Descriptions
Gross Domestic Product (GDP). IMF: IFS	The output variable used in the study is real GDP. The raw data is available in annual series and to obtain monthly series, we interpolated. In the estimations, we use output data generated by Sandee and Lisman interpolation method (quoted in Tucker, 2003). The interpolation is with annual series to a quarterly output series.
Monetary Aggregates, M_1 and M_2. IMF: IFS. Bank of Nigeria: Statistical Bulletin	Monetary policy in Nigeria is implemented by using M_1 and M_2 as the intermediate targets. Reserve money is used as the operating target and can be seen as a monetary policy instrument.
Price Level or Inflation rate (IR)	For this variable, we use the log of the composite CPI. The control of inflation measured as the annual growth rate of this variable is the main goal of monetary policy and CBN sets a target
Nominal Exchange Rate (ER). IMF: IFS	Nominal exchange rate between the naira and the dollar. This variable has become an important policy variable in that CBN sometimes engages in foreign exchange open market operations partly as a monetary policy tool and partly to accrue foreign reserves on behalf of the government.
Interest rates. IMF: IFS. Central Bank of Nigeria: Statistical Bulletin, and ARSA	Two different interest rates are used in the estimations- treasury bill and deposit rates. They are used as short-term rates to capture the stance of monetary policy.
Domestic debts. Central Bank of Nigeria: Statistical Bulletin, and ARSA	These are debts incurred through the sale of treasury bill, treasury certificate and other debt instrument within the economy.

IFS: International Financial Statistics. ARSA Annual Report and Statement of Account.

Appendix 2. Integration and co-integration

Table A1: Unit Root Tests of Variables

Variable order	**Levels**	**1st difference**	**Integration**
m_2	-2.30	-6.17*	I(1)
m_1	-2.69	-6.08*	I(1)
p	-1.76	-4.12**	I(1)
y	-6.48*		I(0)
dr	-1.13	-8.26*	I(1)
tbr	-2.44	-7.83*	I(1)
debtgdp	-0.43	-2.02	I(2)
er	-3.85*		I(0)

*(**) Significant at 1% (5%) levels of significanceTests were obtained using the Phillips Perron method

Co-integration Analysis: Having confirmed the existence of unit root in the series in Table A1, co-integration tests in this paper are conducted by using reduced rank procedure developed by Johansen (1988) and Johansen and Juselius (1990). This method should produce asymptotically optimal estimates because it incorporates a parametric correction for serial correlation and the system nature of the estimator means that the estimates are robust to simultaneity bias, and it is robust to departure from normality (Johansen, 1995). Johansen method detects number of cointegrating vectors in non-stationary time series and allows for hypothesis testing regarding the elements of co-integrating vectors and loading matrix. In order to test for the number of cointegration relationships amongst the variables Johansen (1988) and Johansen and Juselius (1990) provides two different tests to determine the number of cointegrating vectors, namely trace and maximum eigenvalue tests. In the trace test, the null hypothesis is that there are at most r cointegrating vectors and it is tested against a general alternative. In the maximum eigenvalue test, the null hypothesis of r cointegrating vector is tested against r +1 cointegrating vectors. Once we determine r the number of relationships, we can do hypothesis testing on both loadings and co-integrating vectors. Restrictions can be imposed on the coefficients to test alternative theory based hypothesis on the long-run value of variables. Johansen procedure is used to determine the rank *r* and to identify a long-run inflation equation amongst the co-integrating vectors. The number of lags used in the VAR is based on the evidence provided by both AIC, however, in the case of serial correlation sufficient number of lags introduced to eliminate the serial correlation of the residuals. The co-integration tests amongst consumer price index (CPI), domestic debt (debtGDP), deposit rate (dr), gross domestic product (GDP), broad money supply (M_2), exchange rate (er), and Treasury bill rate (tbr) include four lags in the VAR. Table A2 reports the estimates of Johansen procedure and standard statistics. In determining the number of cointegrating vectors we used degrees of freedom adjusted version of the maximum eigenvalue and trace statistics, since in the existence of small samples with too many variables or lags Johansen procedure tends to over estimates the number of cointegrating vectors. These test statistics strongly rejects the null hypothesis of no cointegration in favor of one cointegration relationship for maximum eigenvalues and two co-integration relationships for trace statistic.

Table A2. Co-integration Tests

Eigenvalues	0.648	0.576	0.441	0.248	0.222	0.150	0.012
Hypothesis	r = 0	r ≤1	r≤2	r≤3	r≤4	r≤5	r≤6
λmax	54.398*	38.775	38.22	14.82	13.04	8.459	0.632
95% critical Values	46.231	40.078	33.87	27.58	21.13	14.26	3.841
λtrace	160.36*	105.962*	67.18	36.95	22.13	9.091	0.632
95% critical. Values	125.61	95.754	69.81	47.85	29.79	15.49	3.841

Notes: VAR includes four lags on each variable and a constant term. The estimation period is 1986:1-1998:4. None of the deterministic variable is restricted to the co-integration space; the a λmax and λtrace are maximum eigenvalue and trace test statistics, adjusted for degrees of freedom. The critical values are taken from Osterwald-Lenum (1992). The * indicates rejection of likelihood ratio tests at 5% significance level.