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Inflation Volatility and Economic Growth in Nigeria: A Preliminary Investigation

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Abstract: This study aims at determining the effects of inflation uncertainty on economic growth in Nigeria. Several studies have been carried out to ascertain the effects of inflation on economic growth in the literature, however only few studies could be found on the extent to which inflation uncertainty has affected growth. It was as a result of the dearth of literature in this area that gave the motivation for this study. The study uses the Generalized Autoregressive Conditional Heteroscedascity (GARCH) estimation technique to discover that inflation uncertainty directly and indirectly affects economic growth negatively in Nigeria.

Key words: Inflation uncertainty, economic growth, GARCH, Unit-root test, quarterly basis, Nigeria

INTRODUCTION

In its simplest form, inflation uncertainty means unpredictability of the level of inflation. In the 1970s, most studies define inflation uncertainty as simply the variance of observed inflation. An obvious criticism of this approach is that an increase in the variance of inflation does not imply a corresponding rise in inflation uncertainty if available information allows agents to predict some of the increased volatility. However, recent studies measured inflation uncertainty using proxies obtained from either forecasters' estimates or models of inflation. These empirical results have discovered that inflation uncertainty affect the economy. Thus, studying the effects of inflation uncertainty on economic growth is not only important but also highly desirable and feasible in Nigeria where there are dynamics in the inflation rates. Friedman (1997) argued that inflation uncertainty is costly since it distorts relative prices and raise the risk of doing business. Thus, as inflation becomes unpredictable, investment and growth slow down.

Empirical studies by Fischer (1993) and Kormendi and Meguire (1995) found that inflation uncertainty was relatively lower in economies with low inflationary rates. They concluded that inflation uncertainty increases mainly when monetary policy changes. The effects of monetary policy on inflation are ambiguous and it will take some time for monetary policy to affect inflation. First, monetary policy affects the banking system then through the banking system, the effect will spill over to the real sector and finally, a pass-through to inflation will be observed. The timing and the extent to which monetary policy affects inflation depend on the economic circumstances and are difficult to predict. Friedman (1977) argues that inflation uncertainty causes an adverse output effect. This outcome is based on the idea that uncertainty about future inflation distorts the allocative efficiency aspect of the price mechanism. More specifically, inflation uncertainty affects both the intertemporal (through its effect on the interest rate) and intratemporal (through its effect on relative prices in the presence of nominal rigidities) allocation of resources.

The dynamics of inflation have been heavily debated over the years. Three main factors have recently reignited interest. The first is the major changes in the conjuncture of low inflation and real economic growth in many industrialized countries in the 1990s (i.e., behaviour seems to have changed).

Secondly, the policy problem has changed and new monetary institutions have emerged. Economic and Monetary Union in Europe has led to the establishment of a single monetary policy that has to cope with strikingly different processes of price development in the 12 member states.

Lastly, recent theoretical advances have produced alternative views of the dynamic process which have crucially different implications for the design of optimal monetary policy. In particular, we can contrast the implications of the expectations augmented Phillips curve in the tradition of Phelps (1967), Friedman (1968) and Lucas (1976) with the New Keynesian Phillips curve of Taylor (1980), Calvo (1983) and Fuhrer and Moore (1995).

However, economic theory postulates certain causality relationships between nominal uncertainty, real

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uncertainty, the rate of inflation and output growth. The empirical evidence on many of these relationships remains scanty. Thus, due to inadequate comprehensive study on the empirical relationships among these variables especially, the effects of inflation uncertainty on economic growth gave the motivation for this study. Therefore, this study tends to determine the effects of inflation uncertainty on economic growth in Nigeria.

The few empirical studies in the literature looked at the causality between inflation, inflation volatility and growth using granger causality (Sweidan, 2004; Chimobi, 2010) using nominal inflation rate to capture inflation uncertainty. However, this study will derive the variable that will be use to measure inflation uncertainty from the volatility test called Generalized Auto-Regressive Conditional Heteroscedascity (GARCH). The Generalized ARCH model, called GARCH (p, q), contains both autoregressive and moving average components. GARCH techniques estimate a model of the variance of unpredictable innovations in a variable rather than simply calculating a variability measure from past outcomes like moving standard deviation. That is a GARCH model estimates a time-varying residual variance that corresponds well to the notation of uncertainty in Cukierman and Meltzer (1986). In this study, a GARCH model is used to generate a time varying conditional variance of surprise inflation as a measure of inflation uncertainty. Specifically, most of the studies in the literature looked at the inflation and growth while the few that studies inflation uncertainty looked at its effects on inflation. Some even model inflation uncertainty itself, however only very few of the studies determine the effects of inflation uncertainty on economic growth. Further, literature on this issue is relatively scarce and negligible in Nigeria. It is to this end that this study finds it worthwhile investigating the effects that inflation uncertainty would have economic growth in Nigeria.

MATERIALS AND METHODS

Using GARCH to measure uncertainty: There are 2 broad classes of techniques available to measure uncertainty in empirical studies; ex-post versus ex-ante approaches. The ex-post constructs uncertainty measures based on the historical data of the process that generates the random variables of concern. This group of methods includes the measures: normal statistical variance; variance of the unpredictable part of a stochastic process; the conditional variance estimated from the General Auto-Regressive Conditional Heteroskedastic (GARCH)-type models; the variance estimated from the geometric Brownian motion. The ex-ante method mainly refers to the variance derived from survey data. The main advantage of using survey data to derive uncertainty measures, compared with the methods in the ex-post class is that uncertainty measures are able to represent individual perceptions of risks based on the information available to individual agents. In practice, many studies apply ex-post methods in deriving uncertainty measures in empirical studies. For discrete observations, the variance of the unpredictable part of a stochastic process and the GARCH-type modeling of volatility are the most popular ones especially for the studies at the macro-level.

The first step in time varying volatility modelling is to specify a sufficient equation for the conditional mean of the series under investigation. Given the absence of a commonly accepted structural model for inflation, autoregressive specifications are popular in the empirical literature and are employed by Grier and Perry (1998) among others to analyse the UK experience. We chose time series models for inflation and output growth based on inspecting correlegram for the series, estimating several plausible models and then choosing the one with the highest adjusted R^2. Based on the Akaike-Schwartz information criteria and the whiteness of the residuals, general to specific approach led to the following models:

$$\pi_t = \beta_0 + \sum_{i=1}^{8} \beta_i \pi_{t-1} + \beta_7 \sigma^2_{\varepsilon_t} + \beta_8 \sigma_{v_t}{}^2 + \beta_9 \varepsilon_{t-2} + \varepsilon_t \quad (1)$$

$$\sigma^2_{\varepsilon} = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \sigma^2_{\varepsilon_{t-1}} \quad (2)$$

$$Y_t = \Theta_0 + \sum_{i=1}^{4} \begin{matrix} \Theta_1 Y_{t-1} + \Theta_3 \pi_{t-1} + \\ \Theta_4 \sigma^2 + \beta_9 \varepsilon_{t-4} + v_t \end{matrix} \quad (3)$$

$$\sigma^2_{v_t} = \alpha_3 + \alpha_4 v^2_{t-1} + \alpha_2 \sigma^2_{v_{t-1}} \quad (4)$$

The GARCH M model by explicitly incorporating variance measures in the equation describing Y_t and Π_t facilitates estimation and statistical inferences about the effects of variances on means. The model allows the explicit parameterization and estimation of time-varying inflation uncertainty, defined as the conditional variance of the disturbance to an equation for the inflation rate. With the GARCH M generalization the researchers can estimate and test hypothesis about the effect of the time varying inflation uncertainty on the conditional means of macroeconomic variables such as the inflation rate itself and the rate of growth of output. Equation 1 describes the mean inflation rate as a function of 8 lags of inflation a

12th order moving average term and the conditional variances of inflation and output growth. Equation 2 gives the conditional variance of inflation. The variance α_{ct}^2 is a function of an intercept α_0, a shock from the prior period α_1 and the variance from last period α_2. The GARCH-M specification implies that the conditional error variance of inflation follows an ARMA(1, 1) process. We use this estimated variance Θ_4 as the time series measure of inflation uncertainty. Equation 3 describes the conditional mean of real output growth as a function of 4 lags of output growth, one lag of inflation, a 4th-order moving average term and the conditional variances of inflation and output growth.

Equation 4 is the GARCH M equation for the conditional variance of output growth. The researchers estimate the system of Eq. 1-4 using the Berndt *et al.* (1974) numerical optimization algorithm to calculate the maximum likelihood estimates of the parameters. Bollerslev (1986) shows that under the assumptions, the Berndt-Hall-Hall Hausman (BHHH) estimate of the asymptotic covariance matrix of the coefficients will be consistent. Given that the researchers have >131 observations, the estimated asymptotic t-statistics should be relatively accurate. The statistical model incorporates tests of all four theories discussed earlier. The coefficient Θ_4 on the conditional variance of inflation α_{ct}^2 in the output equation directly tests Friedman's hypothesis of the effect of inflation uncertainty on real output growth. If inflation uncertainty adversely affects real output growth, Θ_4 will be negative and significant in Eq. 3.

This research makes use of seasonally adjusted time series on the Nigerian consumer price index and Industrial production which were obtained from (IFS) International Financial Statistical CD-ROM 2007. The sample includes 146 quarterly observations covering the period of 1970-2007. Inflation is measured as the annualized quarterly difference of the log of the Consumer price index II = Log (CPI_t-CPI_{t-1})*100. Real output growth (Y) is measured as the annualized quarterly difference in the log of industrial production Y_t = Log ($IP_{t-1}IP_{t-1}$)*100. The choice of industrial production as a proxy for GDP is due to the fact that the researchers need data on high frequency either monthly or quarterly. However, GDP is not available on either monthly or quarterly basis.

Both output growth and inflation are positively skewed and display significant excess kurtosis with both series failing to satisfy the null hypothesis of the Jarque and Bera (1980) test for normality. This research have used 2 stationarity tests for the time series properties, However, a series of Ljung-Box tests for serial correlation suggests that there is a significant amount of serial dependence in the data. More so a Lung-Box tests for serial correlation in the squared data provides strong evidence of conditional heteroskedasticity in the data.

RESULTS AND DISCUSSION

Stationarity test: To test for a unit root in the data, the reasearchers apply Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to both the inflation and output growth rates. The results of these tests are shown in Table 1. Both tests reject the null hypothesis of a unit root at the 0.01 significance level implying that the researchers can treat the inflation rate and growth rate of industrial production as stationary processes. A stationary series is one whose statistical distribution is constant through out the series. In practice a series is called stationary if it is mean is roughly constant (no obvious trend) and the variance is roughly constant. If a series is not stationary model fitting becomes difficult. In Table 1, the null hypothesis of a unit root in the inflation rate and output growth rate is rejected at the 0.01 level indicating that both series are stationary at level.

Regression result: The researchers first start by estimating Eq. 1 and 3 via least square without the conditional variances. The adjusted forms of the equations are:

$$\pi_t = \beta_0 + \sum_{i=1}^{8} \beta_1 \pi_{t-1} + \sum_{i=1}^{3} \beta_2 \varepsilon_{t-2} + \varepsilon_t \quad (5)$$

$$Y_t = \Theta_0 + \sum_{i=1}^{4} \Theta_1 Y_{t-1} + \Theta_2 \pi_{t-1} + \sum_{i=1}^{2} \beta_3 \varepsilon_{t-4} + \nu_t \quad (6)$$

The result of the estimation is shown in the Table 2. A further test is then performed on the residual to ensure the error terms are no longer serially correlated. The standard test is a Langrange multiplier test developed by Engle (1982) and involves regressing the squared OLS residuals from the conditional mean against a constant and their lagged values. Panel A of the Table 2 reports an OLS inflation equation with 8 lags of inflation and 3 moving average terms as regressors in the mean inflation equation. Panel B reports the output growth equation with 4 lags of output growth and a lag of inflation. The researcher chose to include the lag of inflation because

Table 1: Result of Unit root test

Variables	ADF	Integration	PP order	Integration order
Output growth	-42.43540	I (0)	-47.881	I (0)
Inflation rate	-35.32456	I (0)	-35.324	I (0)

Researcher's calculation based on IFS data; AT 5% critical value, the ADF statistics is 2.884 while the Phillips Peron is 2.8873

Table 2: Result of OLS model

Panel A: Inflation Eq. 1			Panel B: Output Eq. 3		
Variables	Coefficient	Prob.	Variables	Coefficient	Prob
C	3.37306	0.0602	C	1.56663	0.1997
π_{t-1}	-0.74970	0.0000	Yt-1	-0.95034	0.0000
π_{t-2}	0.92413	0.0000	Yt-2	-1.03710	0.0000
π_{t-3}	0.63872	0.0002	Yt-3	-0.92370	0.0000
π_{t-4}	-0.03910	0.2106	Yt-4	0.09437	0.0777
π_{t-5}	0.09840	0.0205	MA4	0.07730	0.2582
π_{t-6}	0.02150	0.8159	MA2	0.17840	0.0396
π_{t-7}	0.00860	0.0676	INF(-1)	-0.09650	0.3925
π_{t-8}	-0.03410	0.7400	-	-	-
MA(2)	-0.48500	0.0000	-	-	-
MA (4)	-0.62330	0.0000	-	-	-
MA (22)	0.12880	0.0000	-	-	-
R^2	0.85310	-	R^2	0.91490	-
Adjusted R^2	0.84140	-	Adjusted R^2	0.90970	-

Researchers calculation based on IFS data

Table 3: ARCH-LM test for conditional heteroscedasticity

Number of lags	Output obs*R^2	Inflation obs*R^2	Critical value
$TR^2$1	10.81	12.64	3.84
$TR^2$4	14.72	14.28	9.48
$TR^2$8	21.15	14.68	15.51

Table 4: GARCH-M model of inflation and output growth regression result

Panel A: Inflation mean Eq. 1			Panel B: Output mean Eq. 3		
Variables	Coefficient	Prob	Variables	Cofficient	Prob
C	59.54900	0.0602	C	1.56663	0.1737
π_{t-1}	-0.27220	0.0000	Y_{t-1}	-0.95034	0.8666
π_{t-2}	-0.81560	0.0000	Y_{t-2}	-1.03710	0.000π_{t3}
	0.59460	0.0002	Y_{t-3}	-0.92370	0.1225
π_{t-4}	0.68820	0.2106	Y_{t-4}	0.09437	0.4460
π_{t-5}	-0.03130	0.0205	INF(-1)	-0.09650	0.0000
π_{t-6}	0.13240	0.0000	Θ_4	-0.55970	0.0113
π_{t-7}	0.16470	0.0000	Θ_5	-0.13600	0.1737
π_{t-8}	0.10010	0.0000	-	-	-
MA_2	-0.58210	0.0003	-	-	-
β_7	0.58529	0.0003	-	-	-
β_8	0.02910	0.8170	-	-	-
R_2	0.87860	-	-	-	-
Adjusted R^2	0.84510	Adjusted R^2	0.9876	-	-
Variance equation		-	-	-	-
Constant	6.29000	0.0000	Constant	0.77000	0.2842
α_1	1.29000	0.0000	α_3	0.23000	0.0550
α_2	0.04000	0.0013	α_4	0.76000	0.0000

Researcher's calculation based on IFS data

Grier and Perry (2000) noted that it is often assumed that the level of inflation is often thought to be related to inflation uncertainty, it is important to include the level of inflation in the output equation to distinguish between the effects of inflation on output and the effects of inflation uncertainty on output.

Table 3 shows the result for the test of conditional heteroskedasticity via LM style ARCH tests, estimating auto regressions using the lagged squared residuals from the OLS regression above. The variable denoted with Obs*R^2 is the White test statistic. It is computed as the number of observations times R^2 from the test regression. It is asymptotically distributed as a χ^2 with degrees of freedom equal to the number of slope parameters. In the case of both series the null hypothesis of no ARCH effects is rejected at the 0.05 level at 3 reported lag lengths (1, 4 and 8). The results signify persistent presence of an ARCH effect. Since, the correlation in both sets of squared residuals is some what persistent, the researchers will use a GARCH (1, 1) specification of the error variances of both inflation and output. Next is an estimate of the GARCH M model using the quasi-maximum likelihood estimation proposed by Bollerslev and Wooldridge.

The mean and conditional residual variance equations for inflation are reported in Panel A of Table 4. The sum of the lagged inflation coefficients is 0.57 here. The size of the ARCH and GARCH parameters determine the short run dynamics of the resulting volatility time series. Large ARCH error coefficient means that the volatility reacts intensely to market movements and large lag coefficient indicates that shocks to conditional variance take a long time to die out. However, the coefficient of the ARCH parameter is 1.29 while the coefficient of the GARCH parameter is 0.04 both parameters are statistically significant at the 5% level. The volatility persistent thus proves high. The relatively small GARCH coefficient means that inflation shocks create temporary inflation uncertainty. In the mean and conditional variance equation for output in panel B of the table, the sum of the lag output coefficients is -0.6085. The lagged level of inflation is negative and significant at the 0.5% level. The ARCH parameter in the residual variance equation is not significant at the 0.05 level. However, the coefficient on the GARCH parameter is 0.7690 and is significant at 0.05% level. The coefficient on the lagged residual variance for inflation (0.06) is smaller than that of output (0.7690) suggesting that inflation growth shocks have shorter-lived effects on inflation uncertainty than output shocks have on output uncertainty.

The Friedman hypothesis that asserts that inflation uncertainty lowers output growth implies a negative and significant coefficient on the residual variance of inflation in the output growth equation. The estimated coefficient on inflation uncertainty in the output equation is negative (-0.5597) and significant at the 0.05% level (prob. = 0.0113). The results thus provide strong empirical confirmation of Friedman's hypothesis, contrary to Dotsey and Sarte (2000) that predict a positive effect of inflation uncertainty on growth. Similarly, the estimated coefficient of inflation uncertainty in the inflation equation is positive and significant at the 5% level. This result thus finds support for the Cukierman-Meltzer hypothesis that argues that higher inflation uncertainty leads to higher inflation. The coefficient of output uncertainty in the inflation equation which measures

Devereux hypothesis, Taylor effects turned out to be positive (0.029) but statistically insignificant. Thus the researchers do not find support that output uncertainty raises average inflation in Nigeria as predicted. The coefficient for output uncertainty in the output equation is negative (-0.136) and is statistically insignificant. The Nigerian data fails to find support for the business cycle model, Pindyck (1991) and Black (1987) models which predict zero, negative and positive effects of output uncertainty in output.

CONCLUSION

This research has used a GARCH-M model to simultaneously examine the relationship between uncertainty in inflation rates and economic growth. The uncertainty studied here basically refers to the exogenous shocks on both inflation and output. From the result of the estimation, a number of noteworthy findings were made. First, the uncertainty associated with inflation leads to higher average inflation as argued by Cukierman and Meltzer (1986). Second, output uncertainty does not lead to higher inflation.

Third, the uncertainty associated with inflation affects output growth negatively as argued by Friedman (1977). Fourth, output uncertainty does not influence the level of average output. Furthermore, this research addresses a fundamental issue in macroeconomics, the economy's dynamic response to uncertainty. To address this issue the study employ the use of quarterly data on inflation and output growth in Nigeria, to examine the relationship between uncertainty, inflation and output. Using the GARCH methodology to measure uncertainty, the study arrived at a number of conclusions. First, inflation uncertainty negatively influences real growth. This effect takes place both directly and indirectly, via the nominal uncertainty channel as put forward by Friedman (1977). This finding supports the view that inflation does have real effects and justifies the goal of a low inflation rate for monetary policy making.

Also, the central Bank of Nigeria tends to cause inflation shocks in the presence of more inflation uncertainty, providing support to the view of Cukierman and Meltzer (1986). Thirdly, the researchers do not find evidence for the theoretical arguments of Black (1987) and Blackburn and Pelloni (2004) that output uncertainty is a significant determinant of the rate of output growth. The implications of these results are that high inflation produces direct negative effects in the economy through different channels. Second, inflation uncertainty increases future inflation. This uncertainty disrupts the economic decision-making of individuals and generates adverse effects on the efficiency of resource allocation and the level of real activity. Thus, the monetary authority should target the level of inflation as to reduce the adverse effects on the economy. The central bank task is to alter monetary conditions to keep inflation close to the target. It follows that, typically, the forecasting of inflation plays a critical role in the conduct of monetary policy. However, inflation targeting requires the central bank to be free to change monetary conditions in order to pursue the target. An inflation-targeting regime can take various forms. These range from simply making a public announcement of numerical targets for inflation for the year (s) ahead to a full-fledged monetary policy operating strategy.

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