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Inflation and inflation uncertainty in Ghana

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The study investigates the relationship between inflation and inflation uncertainty for the period 1984-2011. The work uses the monthly Consumer Price Index to proxy inflation. The General Autoregressive Heteroscedasticity (GARCH) model is employed to estimate the conditional variability of inflation. The work uses two approaches to find out the relationship between inflation and inflation uncertainty. The first one is the two-step procedure of Granger causality test, which obtains generated variables in stage one as dependent variable in the second stage. The second procedure involves inclusion of conditional variance and inflation in the mean and conditional variance equations respectively, and Full Information Maximum Likelihood (FIML) technique is used in the estimation of the two equations. The two methods established the same result that in high inflationary periods, inflation uncertainty also rises and that inflation uncertainty causes inflation, which is in support of Cukierman-Meltzer hypothesis. Therefore, decreasing inflation uncertainty is expected to reduce inflation.

Keywords: Inflation; Consumer; Uncertaintiy; Regression; Variance.

JEL Codes: C22, E31

INTRODUCTION

The relationship between inflation and inflation uncertainty has since the early twenty first century undergone both theoretical and empirical investigation by both academicians and policymakers. The study intensified when every country's objective is to stabilize its economy to enhance economic growth. The aim of every country is to increase economic growth in order to enhance the welfare of its citizenry. However, there is a relationship between inflation, inflation uncertainty and output growth (Grier and Perry, 2000; Vale, 2005; Hwang, 2007).

In 1983 when the country was in a serious economic crisis of which inflation had reached a three digit figure of 122.8%, the highest recorded since independence, Breton Wood institutions, the International Monetary Fund (IMF) and the World Bank, came in with Economic Recovery and Structural Adjustment Programmes respectively in phases to put the economy back on track. The stabilization programmes embarked on by the two institutions of which reduction of inflation to acceptable threshold is also included in the programme. Apaloo (2001), pegged inflation threshold for Ghana at 9% for which growth would be enhanced. Although, the two programmes reduced inflation to two digits, the rate was still considered to be too high in the economy. Ocran (2009), posits that the stabilization programmes by the IMF and the World Bank was not successful as far as inflation and variable inflation are concerned. In the work of Catoa and Terrones and cited in Ocran (2009), Ghana is one of the 25 countries considered to be wallowing in high inflation in the world.

The chronic high inflation the country experienced for the past 35 years coupled with missing end of year inflation target by the policymakers has caused the business environment to be entangled in uncertainty. The whole business climate becomes murky, making forecasting difficult. Friedman (1977), points out that high inflation brought about increased inflation uncertainty and impacts negatively on economic activities which lowers information content about prices and distorts relative prices, hence a decline in economic welfare or efficiency. The low and middle income earners in Ghana, who constitute the majority, prefer to purchase goods and

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services currently for future consumption, for fear of future income erosion if saved. This explains why some financial institutions' advice to Ghanaians to inculcate the habit of saving for future consumption or investment was not successful.

The purpose of this paper, therefore, is to find out the relationship between inflation and inflation uncertainty and which of the two variables causes the other. The insight gained from the study will provide a policy thrust of monetary authorities on reducing inflation from its root cause, which will be a lasting solution to high inflation problem. The work proposed that acquisition of knowledge on how economies work as a result of knowledge gained from empirical experience induced for the relationship between inflation and inflation uncertainty.

LITERATURE REVIEW

The theoretical linkage between inflation and inflation uncertainty was pioneered by Milton Friedman, in 1977, whose arguments concern the real effects of inflation. In periods of high inflation, more uncertainty about the future rate of inflation is created. According to Golob (1994), in periods of low inflation, monetary authorities try to maintain it. When this is achieved, then inflation level will be low and stable. On the other hand, when inflation is high, the monetary policy makers aim to reduce it to a low level. The policy's objective which is to reduce inflation rate rather creates more inflation variability. The timing and immediate impact of the policy on inflation is uncertain. The policy does not impact directly on inflation. It affects the financial system through to the real economy before it finally hits inflation. This takes unpredictable time for the impact to be felt on inflation. The complex nature of forecasting the level and time period prices would adjust to monetary policy bring about uncertainty, even if the magnitude of the impact of the monetary policy is well known with certainty.

In stabilizing Fed hypothesis, Holland (1995), posits that as inflation uncertainty rises, as a result of increasing inflation, the monetary authority would respond by contracting money supply growth in order to reduce inflation uncertainty and its negative impact in the economy hence an inverse relationship between inflation uncertainty and inflation. This implies that the theoretical relationship between inflation and inflation uncertainty is therefore mixed. Miles and Schreyer (2009); Ungar and Zilbrfarb (1993) weighed the effect of inflation on inflation uncertainty with the cost of inflation and the cost incurred in obtaining information to predict future inflation. When the cost of inflation outweighs the cost of gathering information to predict it, then its uncertainty would be low. On the other hand, when the cost of inflation is lower than the cost incurred in gathering information in its prediction, then uncertainty of inflation would be high.

The direction of the relationship between inflation and inflation uncertainty has been a controversy in both the theoretical and empirical arena. Friedman (1977), argued that, high inflation creates inflation uncertainty as policymakers through their monetary tools attempt to reduce future inflation. The reason is that, agents in the economy are uncertain about the action of the policymakers to reduce the general price level therefore; uncertainty about the future price level.

Friedman's argument was popularized in the work of Ball (1992), in the examination of asymmetric information of the public reaction towards inflation uncertainty. In the work, the public faces two different policymakers that are in office and whose economic policies differ from each other. Both groups are conscious of maintaining inflation at low level, but in high inflationary period, their disinflationary policy differs from each other. In times of high inflation, uncertainty is created about which policymaker will be in office in the next period. The uncertainty rises as a result of the rate at which there is money growth and therefore inflation. During low inflation, the uncertainty does not rise. The rise of inflation uncertainty during high inflationary period and a fall in inflation uncertainty in low inflation time has been accredited to Friedman and Ball as Friedman-Ball hypothesis, which states that there is a positive impact of inflation uncertainty on inflation.

However, Cukierman and Meltzer (1986) also established a causal link between inflation and inflation uncertainty, which directly opposed Friedman and Ball hypothesis. They have come out that, inflation uncertainty rather causes inflation. That is, high inflation uncertainty clouds out the economic environment which may provide monetary authorities an edge and incentive to surprise unsuspecting agents with measures that acts to increase inflation. This is what they term the opportunistic central banker behaviour. The motivation for policymakers to involve in this behaviour is the benefits, among others, the seigniorage and reduction in the real value of government debt. The success of this phenomenon depends on the credibility of the monetary authorities upon which agents' respond.

The empirical work focuses specifically on the direction of causality between inflation and inflation uncertainty. The two schools of thought, Friedman-Ball and Cukierman -Meltzer with their associate policy implications compelled further empirical investigations. Fountas (2000), Hwang (2001), Thornton (2008), Crawford and Kasumovich (1996), Neyapti (2008), Berument *et al* (2001), Samimi and Motameni (2009), Farshid and Mojtaba (2010) and Heidari and Bashiri (2010) have provided evidence in favour of Friedman-Ball hypothesis that high inflationary periods are associated with high inflation uncertainty in the various countries in which the work is done. All the studies employed various GARCH models to capture inflation uncertainty with monthly CPI as a proxy for inflation. Although, various

GARCH models and specifications were used, with the exception of Heidari and Bashiri (2010), that used GARCH-in-Mean with Full Information Maximum Likelihood (FIML) technique of estimation, others used the two-stage procedure with Granger causality.

In contrast, Bredin and Fountas (2006) used four European countries data between 1966 and 2005, except Italy and Holland whose data begin from 1960 and 1977 respectively. The study employs quarterly data of GDP and proxy inflation as the logarithm difference of GDP deflator but uses CPI for Italy. Markov regime-switching heteroscedasticity model was employed in the study. The reason is that, it allows regime shift in both the mean and the conditional variance of inflation in both short and long horizons which does not exist in the various GARCH models. It also segregates inflationary shocks into permanent and transitory. The study found that there is a positive or no association for transitory shocks and negative or no association for negative shocks. This implies that Friedman hypothesis is partially established, only in the short run. This work does not totally agree with that of early researches. This might be due to choice of model and the kind of data used. Bhar and Hamori (2004) earlier on took the similar study in G-7 countries from 1961 to 1999 and found out that high inflation uncertainty is associated with high inflationary periods in Canada and Japan in the long run and USA in the short run giving support to Cukierman-Meltzer hypothesis. Germany experiences positive relationship between inflation and inflation uncertainty while Canada had an inverse relationship between the two variables in the short run. In high inflationary periods which are associated with increased uncertainty in the short run, Germany and USA experienced less stable monetary policy. However, when inflation rate falls below a threshold, the monetary authorities have more room to operate monetary aggregates for stable economy in Canada. This implies that Germany and USA may have stable economic policy in the short run.

In Africa, Arabi (2010) and Sintim-Aboagye and Byekwaso (2005) also used CPI with different periods to examine the relationship between inflation and inflation uncertainty in Sudan, Ghana, Senegal and Uganda respectively. Various GARCH models were used to derive inflation uncertainty. There was a simultaneous feedback linkage between the two variables indicating that both Friedman-Ball and Cukierman-Meltzer hypotheses hold in the economy of Sudan. In the rest of the countries, the findings were mixed in terms of before, during and after the Breton Wood institutions interventions in each country. Their finding was that, during the pre-adjustment period, Cukierman–Meltzer hypothesis failed to hold in its true form. During the adjustment period, Ghana and Uganda experienced an inverse relationship between inflation and inflation uncertainty, implying that the effort of monetary authorities to calm down inflation in response to increase inflation uncertainty was successful. Also, Friedman–Ball hypothesis was observed in Ghana and Uganda over the entire regimes (pre-adjustment, adjustment, post adjustment and overall) but Senegal had mixed results.

THE METHODOLOGY AND MODEL

Model specification

The model of the study may be derived as the General Autoregressive Hetereoscedasticity (GARCH). The general GARCH (p, q) specification which measure uncertainty in relation to inflation shock with conditional variance of residuals is given by:

$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \varepsilon_t$, (1)
$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{n} \alpha_i \varepsilon_{t-p}^2 + \sum_{j=1}^{q} \lambda_j \sigma_{t-q}^2$, (2)
where i = 1… n, j = 1… q, $\alpha_0 > 0, \alpha_i^{,s}, \lambda_j^{,s} \geq 0$

The first equation is the mean and the second is the conditional variance equation of the GARCH model.
The mean equation includes, π_t = inflation at time t, β_0 = intercept, β_i = coefficient of the i-th lag of inflation, ε_t = discrete time varying stochastic process and n = lag length. The mean equation follows an autoregressive process of order n. The discrete time varying stochastic process follows a normal conditional distribution with zero mean and variance $[\varepsilon_t \sim N(0,1)]$.

The variance equation is a function of its lags and the lags of the residuals generated from the mean equation. It is composed of three parts. The mean, which is the long term average (α_0), the second term is news about volatility from the previous period, the ARCH term $(\sum_{i=1}^{n} \alpha_i \varepsilon_{t-p}^2)$ and the GARCH term $(\sum_{j=1}^{q} \lambda_j \sigma_{t-q}^2)$. The summation of the coefficients of both the ARCH the GARCH terms should be less than unity $\left(\sum_{i=1}^{n} \alpha_i + \sum_{i=1}^{q} \lambda_j < 1\right)$ and that all coefficients should be positive $(\alpha_{0,>0,} \alpha_i^{,s}, \lambda_j^{,s} \geq 0)$ as a sufficient condition to satisfy both stationary (non explosiveness) and non-negativity of the conditional variance. The general GARCH (p, q) represents p number of lags of the inflation residuals and q number of lags of the conditional variance in the conditional variance equation and account for time varying volatility.

The conditional variance equation assumes that the economic agents forecast of current level of variability of inflation is a weighted average of a long term average (constant term), the forecast from the previous period inflation and what have been learned about the past period inflation uncertainty. An unexpected change in inflation would increase variability of inflation in the next period. This implies that, when the coefficients in the variance equation are positive and statistically significant, then positive relationship would emerge between inflation and inflation uncertainty.

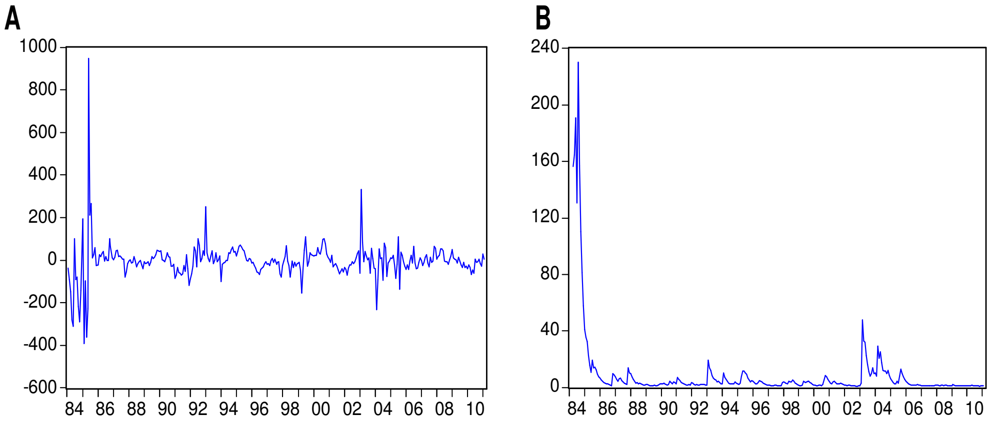

Figure 1. (a) Inflation rate, (b) Inflation uncertainty (Source: Ghana Statistical Service, Statistics for Development and Progress)

Table 1. The Summary Statistics of Monthly Inflation Rate

Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J.B	Prob.
0.452	42.205	-29.008	11.094	0.555	4.793	42.786	0.000

Most of the empirical studies on the relationship between inflation and inflation uncertainty make use of two-stage procedure. Thornton (2007), Sintim-Aboagye (2005) and Caporale and Paeami (2009) all employed the GARCH model. They estimate the conditional variance of inflation by various GARCH models in the initial stage and later perform Granger causality test between the generated conditional variance and inflation in the second stage. Heidari and Bashiri (2010) however used FIML estimation procedure instead of two-stage procedure which might have misspecification problem. Friedman-Ball and Meltzer-Cukierman hypothesis posit that inflation causes inflation uncertainty and vice versa respectively. It implies that the mean and conditional variance equations in (2) and (3) may include conditional variance and inflation respectively and therefore re-specify as follow:

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \gamma\sigma_{t-q}^2 + \varepsilon_t, \quad (3)$$
$$\sigma_t^2 = \alpha_0 + \alpha_i\sigma_{t-q}^2 + \rho\pi_t, \text{ i, q} = 1, 2, 3 \quad (4)$$

The two equations are estimated jointly using FIML. In (4), if ρ>0 and significant different from zero, it implies that there is a positive relationship between inflation and inflation uncertainty and that high inflation creates more variable inflation confirming Friedman-ball hypotheses. On the other way, if γ>0 in the mean equation, (3) and significant from zero also indicates a direct relationship between inflation and inflation uncertainty and that, inflation uncertainty causes inflation confirming Cukierman-Meltzer hypothesis. The study employs the two methods discussed above for feedback confirmation.

Data

The study employs monthly Consumer Price Index (CPI). Inflation is measured as the annualized monthly difference of the natural log of the CPI: $\pi_t = (InCPI_t - InCPI_{t-1})$ where t=current period, t-1= immediate previous period. The sample period for the study is 1984:01 to 2011:03. Data is sourced from Ghana Statistical Service (GSS), Statistics for Development and Progress.

The figures 1a and b show inflation rate and inflation uncertainty in the Ghanaian economy from 1984:1 to 2011:3, Figure 1a above shows the volatility of inflation rate in the Ghanaian economy. There is high volatility clustering from the beginning to around 2008 after which it dissipates. The indication is that for three decades, Ghanaian economy had been experiencing volatility of inflation rate. The summary statistics of monthly inflation rate is provided in table 1.

The average inflation rate is approximately 0.5. The implication is that, over the data span for the study, inflation rises by 0.5 per cent in a month. The range which is the difference between the maximum and the minimum inflation rate is very large, 71.213. The high range provides general overview on the high volatility clustering of inflation rate recorded within the period. The standard deviation is also large, which confirms the range value of a high volatility of monthly inflation rate. The positive skewness also implies that the inflation rate is non-symmetric towards the right tail of the distribution. The Kurtosis exceeded the normal distribution value of 3

Table 2. Augmented Dickey-Fuller and Phillips-Perron Stationarity Test Results

Test	Include in Test Equation	Statistics	Critical Values		
			1%	5%	10%
ADF	Intercept	-11.1294*	-3.4588	-2.8740	-2.5735
	Trend and intercept	-11.2260*	-3.9986	-3.4296	-3.1383
PP	Intercept	-11.6832*	-3.4588	-2.8740	-2.5735
	Trend and intercept	-11.7435*	-39986	-3.4296	-3.1383

Note: * Indicates Null Hypothesis of a Unit Root is Rejected at 1% Significant Level

Table 3. Ordinary Least Squares Estimation of Inflation Rate

Variable	Coefficient	Std. Error	t - statistic	Prob.
Constant	1.351*	0.278	4.884	0.000
Π_{t-1}	1.255*	0.025	51.204	0.000
Π_{t-3}	-0.314*	0.022	-14.551	0.000

Note: * Indicates Significant at 1% Level

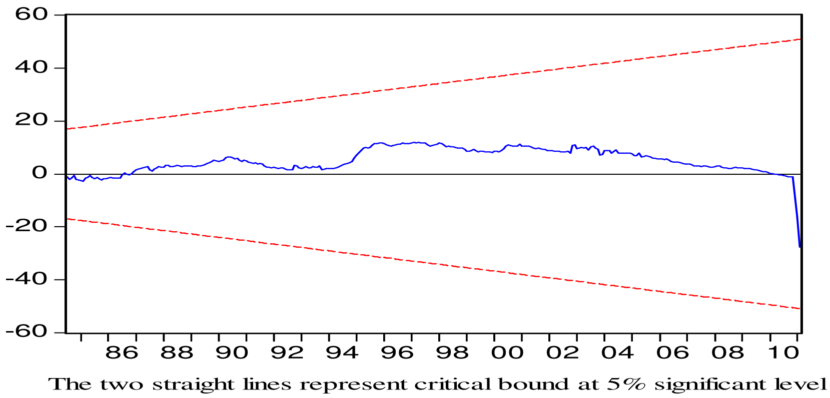

Figure 3. The plot of cumulative sum of recursive residuals

by 1.793, which is an indication that inflation rate has a small-tailed. The series therefore does not follow normal distribution. The Jarque–Bera (J.B) statistics of 42.786 rejects normality at 1% level.

Unit root test

Time series data needs to be tested for presence or not of unit root to avoid spurious regression of which no meaningful reliable analysis and forecasting can be made Dickey and Fuller (1979). The stationarity status of the data is determined by the use of Augmented Dickey-Fuller (ADF) and Phillips-Parron (PP) tests. The monthly inflation rate is stationary (no unit root) in intercept as well as in trend and intercept at 1% level of significance at level with ADF and PP, the result is in table 2.

ESTIMATION RESULTS

The appropriate time series model for monthly inflation rate for the period under study includes 1 and 3 of its lags. The lags selection is based on the minimum value of AIC and SBC criteria, significance of the t-values and R-square value. The estimation result is as follows (See Table 3).

The Cumulative Sum of Recursive Residuals (CUSUM) test for stability of parameters of the estimate for the sample period shows that there is no structural break in the estimation. Figure 3 shows the plot line of the parameter estimate, which can be found within the 5% critical lines bound, indicating that there is no systematic change in the coefficients of the regression parameters.

The Breush-Godfrey serial correlation Lagrange Multiplier (LM) test rejects null hypothesis of the presence

Table 4. Breusch-Godfrey Serial Correlation LM Test

F-Statistic	**1.3025**	**Probability**	**0.2190**
Obs*R-Square	15.6560	Probability	0.2075

Table 5. GARCH (1, 1) Estimation Results

Variable	**Coefficient**	**Std. Error**	**Z - Statistic**	**Prob.**
		Mean Equation		
Constant	0.409**	0.133	3.073	0.002
Π_{t-1}	1.296**	0.023	56.158	0.000
Π_{t-3}	-0.319**	0.022	-14.389	0.000
		Conditional Variance Equation		
Constant	0.303*	0.139	2.184	0.029
ε_{t-1}^2	0.313*	0.136	2.294	0.023
σ_{t-1}^2	0.680**	0.071	9.589	0.000

** (*) Significant at 1% (5%) level

of serial correlation in the residuals of OLS estimation of inflation rate. The test result is shown in table 4. Next, a test for non-constant residual variance as outlined in Bollerslev (1986) in the work of Crawford and Kasumovich (1996). The presence of GARCH effect test is performed on the square residual of which OLS residuals are regressed against the constant and their 1st, 4th, 8th and 12th lags. The next is to compute TR^2, where T is the number of observations in the sample and R^2 is the proportion of variation explained by the explanatory variables; TR^2 values were 2.0445, 5.7978, 18.8149, and 21.1371 respectively. The corresponding probability values were 0.1527, 0.2148, 0.01588, and 0.04841. The result of GARCH test indicates that, the null hypothesis of no GARCH effect for lags 1 and 4 is rejected. This implies that the existence of GARCH effect is present in the residuals up to lag 4. However, the existence of GARCH effect for higher order lags diminishes.

After determining the existence of GARCH effect in lags 1 and 4, which shows existence and persistence of non-constant conditional variance, the GARCH model is estimated as GARCH (1, 1) after various specifications were estimated of which the parsimonious model is considered on the basis of the level of significance of parameter estimates. The regression result is reported in table 4.

The GARCH (1, 1) results from table 4.3 indicate that all coefficients were significant at 1% or 5% as shown in table 4.5. The estimated results satisfy Bollerslev's sufficient condition of model stationarity and therefore not explosive. That is the coefficients in the conditional variance equation are positive and the sum of the slopes (ARCH term and GARCH term) is less than unity. The sum of the ARCH term and GARCH term in the conditional variability equation is (0.313 + 0.680), 0.993, which is close to 1. The implication is that any shock to the variability of inflation does not die out but rather persist permanently. The ARCH (1) term, which has the value 0.313 is the volatility obtain from the news of the previous period. The last period forecast of the variance, GARCH (1) term (0.680) impacts on the current conditional variance more than the news about inflation generated from the previous period. This implies that the contribution of the previous inflation uncertainty to the current inflation uncertainty outweighs that of economic agents' information on the current news on inflation. The current inflation uncertainty is estimated as the weighted average of the three terms of the conditional variance, 0.303, 0.313 and 0.680.

The most popular test to establish the causality between two or more variables is the Granger causality test. To confirm the initial results of the causal relationship between inflation and inflation uncertainty the study further performed Granger causality test. Table 6 provides the estimation results.

Granger causality test was performed with several lag lengths. However, it was lags 1 and 2 that were statistically significant and confirms the initial result. In lags 1 and 2, in table 4.7, the null hypothesis of inflation uncertainty does not Granger causes inflation at 1% and 5% respectively are rejected. This implies that at both lags, inflation uncertainty Granger causes inflation. Therefore, the Granger causality test confirms the initial result that inflation uncertainty impacts on inflation, which is in support of Cukierman–Meltzer opportunistic central bank behaviour hypothesis

In GARCH model, it is only the magnitude of the unanticipated change in the mean equation that affects the volatility due to the square of the ARCH term in the

Table 6. Granger Causality Test

Lag	Null Hypothesis	F - statistic	Prob.
Lag 1	Inflation uncertainty does not Granger cause inflation	51.104	6.0e-12*
	Inflation does not Granger cause inflation uncertainty	1.841	0.176
Lag 2	Inflation uncertainty does not Granger cause inflation	5.927	0.003*
	Inflation does not Granger cause inflation uncertainty	2.174	0.115

* Indicates Rejects the Null Hypothesis

Table 7. The FIML Estimation Result of GARCH (1, 1)

Variable	Coefficient	Std. Error	Z - statistic	Prob.
Constant	1.366**	0.315	4.33	0.000
Π_{t-1}	1.214**	0.019	63.724	0.000
Π_{t-3}	-0.267**	0.0173	-15.374	0.000
σ_t^2	0.021**	0.006	3.488	0.001
ε_{t-1}^2	-0.296	2.485	-0.119	0.905
σ_{t-1}^2	0.876**	0.008	105.776	0.000
π_t	0.038	0.0823	0.461	0.645

** Indicates Significant at 1% Level

conditional variance equation. Therefore, in GARCH estimation, (since conditional variance is invariant of the sign of the ARCH term) there is a positive relationship between inflation and its uncertainty. To determine whether inflation impact on inflation uncertainty or otherwise, equations 3 and 4 were estimated jointly. In other to come out with unbiased estimate, Heidari and Bashiri (2010) suggested that all the lags in the system (GARCH model) should also be included in the estimation. The estimation results are shown in table 7.

The estimation results in the table 6 indicate that the coefficient of conditional variance, which measure inflation uncertainty in the mean equation, is positive and significant at 1% level. The implication is that inflation uncertainty positively relates to inflation and that high inflation variability increases inflation rate. This relationship supports Cukierman–Meltzer hypothesis. On the other hand, the coefficient of inflation was not significant in the conditional variance equation. This indicates that inflation does not affect inflation uncertainty; hence, Friedman-Ball hypothesis does not prevail.

Conclusions

The study ascertains the relationship between inflation and inflation uncertainty using Ghanaian monthly data from 1984 to the first quarter of 2011 with the GARCH model. The study uses two approaches, the two-step Granger causality and the GARCH-in-Mean. The two methods confirm each other's estimation result that inflation uncertainty causes inflation, which is in support of Cukierman-Meltzer hypothesis. The implication of this phenomenon in Ghana for the past three decades is that the monetary authorities are more concern with the government policies to achieve rapid economic growth than reducing inflation to a threshold, even though they seek to target single digit inflation. This unachievable target may only be cosmetic statement. Implementation of discretionary policies to stimulate growth, engage in time-inconsistent behaviour increases inflation uncertainty that causes an increase in the long run inflation rate.

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