Ghanaian Journal of Economics, Vol. 4, December 2016

Inflation targeting and economic growth in Ghana: An empirical investigation

Alhassan Mohammed*, Yusif Hadrat# and Buabeng Emmanuel+
*,#, +Department of Economics, Kwame Nkrumah University of Science and Technology, Ghana
Corresponding author: hadraty@yahoo.co.uk

Abstract

The Bank of Ghana formally adopted inflation targeting in 2007 and the goal was to stabilize inflation and increase real economic growth. However, much is not known regarding the success and/ or otherwise of this monetary policy regime. This paper has investigated the effect of inflation targeting, inflation and inflation volatility on economic growth using time series data for the period 1980-2013. We found that average inflation and inflation volatility were lower during the post-inflation targeting period compared with the pre-inflation targeting period. The study showed that inflation volatility has significant negative effect on economic growth.

Key words: *Inflation targeting; Economic growth; Conditional variance; Ghana*

1. Introduction

Between 1970 and 1983, macroeconomic indicators generally showed deteriorating trends in Ghana. Over this period, average annual inflation rate was 50.01%, annual average GDP grew at the rate of -0.43%, fiscal deficit averaged -6.24% of GDP, interest rate spread recorded an average of 5.42% per annum and external debt stock averaged 30.74% of Gross National Income (Computed from the World Bank's Development Indicators (WDI) database, 2015). A combination of these factors resulted in unstable macroeconomic environment. In 1982, monetary authorities shifted from the use of exchange rate targeting to monetary targeting as a means of addressing the macroeconomic instability. The government also embarked on a comprehensive growth agenda in which economic recovery and structural adjustment programmes (ERP and SAP) were adopted in 1983. Subsequently, from 1984 to 1992, average annual inflation rate dropped to 26.25%, average annual GDP growth increased to 5.22%, fiscal deficit reduced to -4.28% of GDP per annum while external debt stock rose to an annual average of 59.06% (Computed from WDI database, 2015).

However, in 1992 Open Market Operations (OMO) was adopted by the Bank of Ghana (BoG) to deliver stable low inflation (Kwakye, 2012). OMO is a monetary policy instrument that involves the use of government financial securities to regulate money supply. With the adoption of OMO, inflation uncertainty still remained a contentious subject as average annual inflation rate fluctuated between 59.46% and 10.92% from 1993 to 2006 (Computed from WDI database, 2015 Edition). This phenomenon suggests that OMO was ineffective in delivering the principal macroeconomic goal of stable low inflation. Kwakye (2012) attributed the ineffectiveness of OMO to underdeveloped financial sector, fiscal indiscipline, deficient monetary policy transparency and lack of clear separation between public sector borrowing requirement (PSBR) and OMO.

To keep inflation less variable and improve real GDP growth, the BoG followed the example of other countries (New Zealand, Chile, Spain, United Kingdom, and South Africa) and adopted soft inflation targeting (IT) in 2002 and then full-fledged inflation targeting in 2007. The adoption of inflation targeting in Ghana and other countries was aimed at maintaining stable low inflation and achieving sustainable high economic growth. This has inspired research on inflation targeting, inflation and economic growth (see Malik and Chowdhury 2001; Ball and Sheridan, 2004; Batini and Laxton, 2007; Goncalves and Salles, 2008; Obamuyi, 2009; Brito and Bystedt, 2010; Barugahara, 2013; Geraats, 2013; Daboussi, 2014; Puni *et al*., 2014; Kumo, 2015).

Yet, there is no consensus on the effect of inflation targeting on economic growth. On the one hand, Batini and Laxton (2007), Goncalves and Salles (2008) and Daboussi (2014) found that inflation targeting has a positive relationship with output growth. The idea is that inflation targeting enhances monetary policy transparency which contributes to monetary policy effectiveness. Policy makers are able to manage private sector expectations, thus leading to low inflation. Stable low inflation could lead to cut in wage costs, thereby making more resources available for savings; domestic investment increases which enhances sustained real GDP growth.

On the other hand, Duerker and Fischer (2006); Ceccheti and Ehrman (2000); Romdhane and Mensi (2014), Kumo (2015) have concluded that inflation targeting has no significant impact on economic growth. These studies appear to suggest that inflation targeting is too rigid and central banks might be tempted to focus more on low inflation objective at the expense of increase in real GDP or other goals. Thus, central banks could achieve lower inflation and inflation volatility during inflation targeting regime but the effect on growth could be insignificant.

In the Ghanaian context, inflation targeting was formally introduced in 2007 and the goal was to properly anchor inflation expectations and achieve macroeconomic stability, thus reducing inflation and also inflation volatility. These were expected to provoke real GDP growth through increase in investor confidence, increase savings and lower cost of investment. Consumers could benefit from lower prices as real income increases, releasing more private resources for savings and investment. But, monetary policy is under scrutiny as a result of unstable exchange rate and rising interest rate. For example, in January, 2007 the rate of exchange between the Ghana cedi (GH¢) and US Dollar ($) was GH¢0.9244 for 1US$ (Bank of Ghana databse, 2016). By January, 2016 the exchange rate was GH¢3.8063 for 1US$. As regards interest rate, in 2016, it was 26% in Ghana compared with 14% in Nigeria and 10% in Kenya (Bank of Ghana database). These developments have provoked increasing debate among economists, bankers and policy makers regarding the influence of inflation targeting, a key monetary policy instrument in Ghana, on economic growth in the country.

But, only Puni *et al*. (2014) has investigated the effects of inflation targeting policy regime on GDP growth in Ghana. They applied ordinary least square (OLS) estimation technique to annual time series data from 2000 to 2013 (7 years of pre-inflation targeting and 7 years of post-inflation targeting). They concluded that inflation targeting in Ghana has reduced inflation rate but the reduction in inflation rate did not have any significant positive effect on real growth. Perhaps the high interest rate (26%), unstable exchange rate (GH¢3.8063=1US$) together with energy crisis in Ghana overwhelmed the opportunity for investors to invest more, employ many people and increase real GDP. In fact, issues of growth and unemployment appear to be the major macroeconomic problems facing Ghanaians. There is the need for much more empirical studies to validate the correlation between inflation targeting, inflation rate, inflation volatility and growth in the country.

Our paper proposes to employ the ARDL framework for estimation. ARDL addresses the dynamic sources of biases (misspecification and regressor endogeneity bias) associated with OLS estimation technique. This makes our study different from Puni *et al*. (2014). The present paper will be useful to monetary policy authorities regarding the conduct of inflation targeting policy in the country. Should the focus of Bank of Ghana (BoG) be shifted to what Kumo (2015) has labelled real targeting approach, thus targeting real GDP growth, targeting employment creation, or targeting poverty reduction?

The remaining sections of the paper are organized as follows: Section 2 presents the review of previous studies, section 3 describes the methodology. Section 4 analyzes and discusses the regression results whilst section 5 is the concluding remarks.

2. Review of previous studies

A number of research in both developed economies (Daboussi, 2014; Ball and Sheridan, 2004; Geraats, 2013; Walsh, 2009; Judson and Orphanides, 1999) and developing economies (Kumo, 2015; Brito and Bystedt, 2010; Puni *et al*., 2014) have examined the influence of inflation targeting, inflation level and inflation volatility on growth. These countries have different development levels and structural features (Mishkin and Schmidt-Hebbel, 2007). The literature review in this section is to provide a brief examination of the findings of some these studies.

2.1 Literature on developed economies

In the developed economies studies regarding inflation targeting and economic growth have arrived at varied conclusions. In 2004, Ball and Sheridan examined differences in economic performance among 33 (20 inflation targeting and 13 non-targeting) OECD countries using difference-in-difference estimation technique. They reported that inflation targeting significantly lowers inflation level and volatility and enhances economic growth. They argue that inflation targeting has the tendency to stabilize inflation expectations, which could lead to increase in output growth. But, Ball and Sheridan (2004) also reported that non-inflation targeting countries also achieved similar improvements in the macroeconomic indicators.

Walsh (2009) used propensity score matching estimation technique and examined the effect of inflation targeting policy on output growth and output volatility in seven (7) inflation targeting and 15 non-targeting industrialized economies. Walsh (2009) found that inflation targeting policy has no significant impact on output growth. Similary, Daboussi (2014) conducted a panel study of inflation targeting and non-targeting countries using an extended form of difference-in-difference estimation methodology. The study found that inflation targeting significantly lowers inflation volatility and enhances economic performance. This is because inflation targeting reforms the behaviour of monetary authorities in the way and manner they operate their instruments. However, the study failed to account for the effects of institutional, social, financial and economic developments on economic performance.

Other studies (Barugahara, 2013; Bhar and Malik, 2010; Judson and Orphanides, 1999; Coulsion and Robins, 1985) have investigated the correlation between inflation level, inflation volatility and economic growth. Various estimation techniques (GMM approach to dynamic panel linear models, cross-sectional and panel data, multivariate exponential GARCH-M framework, GARCH (1,1)) were used. These studies have concluded that there is a negative association between inflation level and economic growth and also between inflation volatility and economic growth.

The general conclusion from studies in the developed economies is that countries that have adopted inflation targeting have reduced the rate of inflation and inflation variability compared to non-inflation targeting countries (Walsh, 2009; Mishkin and Schmidt-Hebbel, 2007). Again, inflation level and inflation volatility are found to be negatively correlated with output growth (Barugahara, 2013; Bhar and Malik, 2010; Judson and Orphanides, 1999; Coulsion and Robins, 1985).

2.2 Literature on developing economies

Unlike the developed economies few studies (Brito and Bystedt, 2010; Kumo, 2015; Puni *et al*., 2014; Goncalvas and Salles, 2008) have investigated the effect of inflation targeting on growth in the developing economies and especially in Africa. Brito and Bystedt (2010) examined the influence of inflation targeting policy on macroeconomic performance for forty six developing economies. The study indicated that inflation targeting stabilizes inflation but at the expense of output loss. In a recent study, Kumo (2015) examined the effect of inflation targeting and inflation volatility on economic growth in the pre and post-targeting regimes in South Africa. Kumo (2015) found that inflation targeting has succeeded in reducing inflation rate and inflation volatility. Lower inflation rate and inflation volatility were expected to improve investor confidence, increase savings, lower interest rate and increase credit demand and thus lead to growth. But, the reduction in inflation level and inflation volatility did not translate into real economic growth in South Africa. In the Ghanaian context, Puni *et al*. (2014) studied the effect of inflation targeting and inflation rate on economic growth and indicated that inflation targeting has declined the rate of inflation in Ghana but did not have any significant impact on economic growth.

These findings appear to corroborate previous studies (Goncalvas and Salles, 2008; Vega and Winkelried, 2005) that inflation targeting developing countries have lowered their rates of inflation compared with non-inflation targeting countries. Indeed, controlling the rate of inflation is essential as lowering the inflation rate reduces inflation volatility which also reduces the potential negative impact on growth (Kumo, 2015). Based on Kumo (2015) and Puni *et al*. (2014) one thing is clear. The low and stable inflation rates achieved in the inflation targeting Africa countries have not translated into stronger economic growth and significant reduction in the high unemployment rates that have characterized these countries. Structural bottlenecks in Africa have weakened the spillover effects from low and stable inflation to real economic growth. However, for generalization, much more research regarding the relationship between inflation targeting and economic growth in Africa is crucial.

3. Methodology

This section presents data and variable description, model specification, measurement of inflation volatility and estimation strategy.

3.1 Data and Variable Description

The macro-economic data for all studied variables were sourced from World Bank's Development Indicators (WDI) database (2015). Annual time series data on real per capita GDP (rpgdp), inflation rate (inf), domestic credit to private sector-GDP ratio (dcps) and gross domestic fixed capital formation-GDP ratio (gdfcf) were used. Seasonally adjusted annual inflation series for the period 1980 – 2013 were fitted in the EGARCH (1, 1) model to construct conditional variance proxies for inflation volatility. Dummy variable was used to capture inflation targeting; it took the value 0 for the pre-inflation targeting period (1980-2006) and 1 for the post-inflation targeting period (2007-2013). Domestic credit to private sector-GDP ratio (dcps) and gross domestic fixed capital formation-GDP ratio (gdfcf) were captured in equations (3) and (4) as control variables.

The dependent variable is real per capita GDP (rpgdp) and was measured as GDP-population ratio. The natural log of 'rpgdp' was used as proxy for growth. The main regressor, 'inf' which represents seasonally adjusted inflation rate was measured as annual percentage change in CPI.

3.2 Model Specification

This paper used annual time series data for analysis and following previous studies (Barugahara 2013; Kumo 2015) we applied the autoregressive distributed lag (ARDL) and the Ordinary Least Square (OLS) estimation techniques to the data set. Inflation targeting is the variable of interest but we also included other potential determinants of growth; which are inflation rate, inflation volatility, and financial development (dcps).

Population and gross domestic fixed capital formation enter the framework as labour and capital respectively. Economic growth in the Ghanaian economy is measured as overtime changes in real per capita GDP (see Barugahara, 2013). However, this paper separates the growth effects of inflation level and volatility as shown in equations (1) and (2). The models follow the generalized Cobb-Douglas production function.

$$rpgdp_t = \left[(\inf_t)^{\beta_1}(dcps_t)^{\beta_2}(gdfcf_t)^{\beta_3}(Dum)^{B_4}\right]e^{\varepsilon_t} \tag{1}$$

$$rpgdp_t = \left[(Vol_t)^{\alpha_1}(dcps_t)^{\alpha_2}(gdfcf_t)^{\alpha_3}(Dum)^{\alpha_4}\right]e^{\mu_t} \tag{2}$$

The specific operational models in log form are given by equations (3) and (4).

$$\ln rpgdp_t = \beta_0 + \beta_1 \ln \inf_t + \beta_2 \ln dcps_t + \beta_3 \ln gdfcf_t + \beta_4 Dum + \varepsilon_t \tag{3}$$

where ε_t is the error term; β_0 is the constant term; β_i (for i = 1, 2, 3, 4) are parameter estimates; $rpgdp_t$ is real GDP per capita at time t; Ininf is log of Inflation level; *Dum* is inflation targeting dummy; *lndcps* is log of domestic credit to private sector-GDP ratio and *lngdfcf* is log of gross domestic fixed capital formation-GDP ratio.

$$\ln rpgdp_t = \alpha_0 + \alpha_1 \ln Vol_t + \alpha_2 \ln dcps_t + \alpha_3 \ln gdfcf_t + \alpha_4 Dum + \mu_t \tag{4}$$

where μ_t is the error term; α_0 is the constant term; α_i (for i = 1, 2, 3, 4) are parameter estimates; and InVol is log of conditional variance (inflation volatility).

The study expects that $\beta_1 > 0$. 'Vol' represents inflation volatility, which was measured as conditional variance of inflation level. It is expected that $\alpha_1 > 0$. 'dcps' is domestic credit to private sector which enters the model as an indicator of financial deepening. We expect that $\beta_2, \alpha_2 > 0$. Finally, 'gdfcf' represents accumulation of domestic capital which was measured as gross domestic fixed capital formation-GDP ratio. It is our expectation that $\beta_3, \alpha_3 > 0$.

3.3 Measurement of inflation volatility

Inflation volatility is commonly proxied by unconditional standard deviation. However, Taylor (2005) argues that conditional variance is a better proxy for inflation volatility since it is conditionally unbiased. Studies such as Coulson and Robins (1985), Becker et al. (1995), Wilson (2006), Grier and Grier (2006) applied the ARCH to construct conditional variance series. However, for short-memory data, the GARCH and univariate exponential GARCH are considered suitable for predicting volatility as the ARCH is likely to result in possible loss of degrees of freedom.

Following Kumo (2006), Bollerslev and Mikkelsen (1996) and given the generalized GARCH (p, q) specification, the variance of the disturbance term is incorporated in the autoregressive process as shown in equation (5):

$$H_t = \tau_0 + \sum_{i=1}^{q} b_i \varepsilon^2_{t-i} + \sum_{j=1}^{p} \delta_j H_{t-j} \tag{5}$$

But, the GARCH model imposes the non-negative constraint on the parameters, b_i and δ_i. Nelson and Cao (1991) have argued that the non-negativity constraints in the linear GARCH (1, 1) model are too restrictive. In the present paper, the initial estimation of the GARCH (1,1) model revealed a violation of the non-negativity condition. As a result, the EGARCH model was explored. In the EGARCH model, the variance equation, H_t, is an asymmetric function of lagged disturbances.

$$\ln(H_t) = \kappa + \sum_{i=1}^{q} \lambda_i \left| \frac{\varepsilon_{t-i}}{\sqrt{H_{t-i}}} \right| + \sum_{i=1}^{q} \alpha_i \frac{\varepsilon_{t-i}}{\sqrt{H_{t-i}}} + \sum_{j=1}^{p} \beta_j \ln(H_{t-j}) \tag{6}$$

Where κ, λ_i, α_i and β_j are parameters to be estimated. The left hand side is the log of the conditional variance series. This makes the leverage effect exponential instead of quadratic, and therefore the estimates of the conditional variance are guaranteed to be non-negative. Just like the TARCH, the EGARCH also allows for the testing of asymmetries. If $\alpha_1 = \alpha_2 = ... = 0$, then the model is symmetric. Otherwise, if $\alpha_i > 0$, then negative shocks generate late volatility than positive shocks of the same magnitude.

The advantages of the EGARCH model are that, it allows for conditional variance to depend on previous own lags and thus improving consistency of estimates and making them reliable. Also, EGARCH model yields robust estimates with few parameters and unlike linear GARCH, it does not impose restrictive non-negative constraints.

3.4 Estimation strategy

We employed the EGARCH (1, 1) model to construct conditional variance series, which is a proxy for inflation volatility. The paired sample t-test was adopted to test whether there is a significant difference between pre-targeting inflation rate/volatility and post-targeting inflation rate/volatility. By way of estimation strategy, we used a combination of autoregressive distributed lag (ARDL) bounds testing approach to co-integration by Pesaran *et al*. (2001) and the ordinary least square (OLS) method.

We conducted stationarity tests to ascertain the order of integration of all variables. Time-series estimation involving non-stationary series could generate illogical deductions and conclusions, as the conventional student t and F tests are biased (see Hendry *et al*., 1988). Besides, it is crucial to determine the order of integration of all variables in equations (3) and (4) because it serves to provide a clue on the choice of suitable estimation technique. The DF-GLS test by Elliot *et al*. (1996) and the ADF test by Dickey and Fuller (1979) were used to test for the existence of unit roots. The DF-GLS and ADF tests work to perfection if the series exhibit an unusual mean or trend (Sakyi *et al*., 2015).

The test for stationarity involved testing the null hypothesis that unit root exists against the alternative hypothesis of non-existence of unit root. The DF-GLS and ADF tests results, as shown in Table A.1 (see appendix), indicate that at conventional levels of significance all the other variables are non-stationary at levels except for inflation. The implication is that inflation level is integrated of order zero while the other variables in the model are integrated of order one.

The Wald test was also executed to test unit root in volatility process. According to Taylor (2005) cited in Kumo (2015), the null hypothesis for general volatility models is stated as H_0: $\varpi = 1$ where ϖ is the persistence parameter. For GARCH (1, 1) model, it is stated as H_0: $b_1 + \delta_1 = \varpi = 1$; if this restriction holds, then the conditional variance series is said to be strictly covariance stationary. Wald test Results in Table A.2 (see appendix) show that the volatility process is strictly covariance stationary. This suggests that the use of the conditional variance series to estimate the growth model will not result in spurious regression.

After determining stationarity of the variables, the OLS and ARDL techniques were used to estimate the growth regressions. Studies by Barugahara (2013) and Kumo (2015) employed OLS method and System Generalized Method of Moments

(GMM) respectively, to examine the impact of inflation and inflation volatility on economic growth. Most single equation estimation methods for evaluating growth determinants assume economic growth as purely endogenous thereby testing for uni-directional causality. This mostly results in regressor endogeneity bias. To address this, we employed ARDL to evaluate long-run and short-run dynamics of inflation targeting, inflation and real GDP per capita growth in Ghana for the combined sample (1980-2013). The choice of ARDL is because it corrects for the regressor endogeneity and can be used to estimate time-series regardless of whether the underlying series are purely I (0) or purely I (1) and/or both.

The first stage of the ARDL involves testing for the existence of long-run stochastic trend. Engel and Granger (2001) point out that the presence of co-integration among variables implies the existence of forces that tend to ensure convergence to long-run equilibrium each time there are exogenous shocks to the independent variables. The ECM for models I and II are specified as follows;

$$\Delta rpgdp_t = \eta_0 + \sum_{i=0}^{q} \varphi_1 \Delta rpgdp_{t-i} + \sum_{i=1}^{q} \theta_h \Delta \inf_{t-i} + \sum_{i=1}^{q} \beta_q \Delta D_{t-i} + \delta_1 rpgdp_{t-1} + \delta_h \inf_{t-1} + \delta_p D_{t-1} + v_t \quad (7)$$

where Δ represents the first difference operator, 'rpgdp' is the dependent variable, 'inf' and 'D' are the regressors as defined in the baseline model. 'D' is a vector of control variables of growth. η_0 is the drift component, δ_s are coefficients of the lagged level variables, v_t is the disturbance term which is white noise and q is the optimal lag.

$$\Delta rpgdp_t = \lambda_0 + \sum_{i=0}^{q} A_1 \Delta rpgdp_{t-i} + \sum_{i=1}^{q} B_h \Delta Vol_{t-i} + \sum_{i=1}^{q} C_q \Delta D_{t-i} + m_1 rpgdp_{t-1} + m_h Vol_{t-1} + m_p D_{t-1} + \eta_t \quad (8)$$

where Vol is an independent variable, λ_0 is the drift component; η_t is the disturbance term which is white noise; m_s are coefficients of the lagged level variables; and all other variables are defined as previous.

The second step involves the use of bounds test within the ARDL framework to determine the existence of co-integration. The null hypothesis of no co-integration among the variables was tested. This was done by testing if the coefficients of the lagged level variables in equations (7 and 8) are statistically different from zero. That is, [H_0: $\delta_1 = \delta_h = \delta_p = 0$ against H_1: $\delta_1 \neq \delta_h \neq \delta_p \neq 0$] and [$H_0$: $m_1 = m_h = m_p = 0$ against H_1: $m_1 \neq m_h \neq m_p \neq 0$]. The F-statistic was computed within the ARDL framework and compared with the asymptotic critical lower and upper bounds. As shown in Table A.3 (see appendix), we found that for the two models, the F-statistic was greater than the upper bound at 1% level of significance. This implies rejection of null hypothesis, hence existence of co-integration among the variables. In estimations where the F-statistic turns out to be smaller than the lower bound, that would imply non rejection of the null hypothesis hence no long-run stochastic trend. The result is however inconclusive if the F-statistic falls between the lower and upper bounds (Sakyi *et al*., 2015).

The existence of co-integration meant that it was feasible to corroborate the existence of a non-spurious, unique and long-run relationship among the variables. Hence, equations (9) and (10) were estimated;

$$\Delta rpgdp_t = \eta_0 + \sum_{i=0}^{q} w_1 \Delta rpgdp_{t-i} + \sum_{i=1}^{q} w_h \Delta \inf_{t-i} + \sum_{i=1}^{q} w_p \Delta D_{t-i} + v_t \tag{9}$$

$$\Delta rpgdp_t = \lambda_0 + \sum_{i=0}^{q} g_1 \Delta rpgdp_{t-i} + \sum_{i=1}^{q} g_h \Delta Vol_{t-i} + \sum_{i=1}^{q} g_p \Delta D_{t-i} + \eta_t \tag{10}$$

The short-run specifications of ARDL are presented in equations (11) and (12).

$$\Delta rpgdp_t = \eta_0 + \sum_{i=0}^{q} a_1 \Delta rpgdp_{t-i} + \sum_{i=1}^{q} a_h \Delta \inf_{t-i} + \sum_{i=1}^{q} a_p \Delta D_{t-i} + a_1 ecm(-1) + v_t \tag{11}$$

$$\Delta rpgdp_t = \lambda_0 + \sum_{i=0}^{q} b_1 \Delta rpgdp_{t-i} + \sum_{i=1}^{q} b_h \Delta Vol_{t-i} + \sum_{i=1}^{q} b_p \Delta D_{t-i} + b_1 ecm(-1) + \eta_t \tag{12}$$

where *ecm*(–1) is the error correction term and a_1, b_1, (for $\leq a_1$, $b_1 \leq 1$) signifies the speed of adjustment which must be negative and statistically different from zero. All parameters of the short-run models relate to the short-run dynamics of the system's convergence to long-run equilibrium. In selecting ARDL (1, 0, 1, 0, 0) order for both models I and II, the Akaike information criterion (AIC) was used (see Duasa, 2006).

4. Empirical results and discussion

In this section, results for the paired sample t-test, EGARCH (1, 1) model, short-run and long-run estimations are presented in Tables 1-6. For the diagnostic and stability tests results refer to Appendix A.4.

4.1 Results for the paired sample T-Test

The paired sample t-test was used to test for significant difference in inflation and inflation volatility in the pre and post-targeting periods. Indeed, inflation targeting was implemented officially in 2007, therefore in conducting the paired sample t-test, the seven years for inflation targeting period, 2007-2013, and corresponding seven years for the non-targeting phase, 2000-2006, were used. The results in Table 1 indicate that there is significant difference between mean inflation rate and inflation volatility in the pre and post-inflation targeting regimes. The results indicate that differences in inflation level and volatility was not due to chance. Essentially, the paired sample t-test reveals that mean inflation and inflation volatility were significantly lower under the inflation targeting regime.

Table 1: Result of paired sample T-Test

Variable		Mean	Standard Deviation	Standard Error	T-value P-Value)
Inflation Level	Pre IT – Post IT	7.41	9.4513	1.78612	4.149 (1.27043E-13)
Inflation Volatility	Pre IT – Post IT	27.971	23.818	4.5011	6.2143 (1.89311E-06)

Source: Authors' estimations

Results in Table 1 are confirmed by the appreciable decline in mean inflation rates during the inflation targeting regime to the extent that single digit inflation was attained for a thirty-month period between 2010 and 2011.

4.2 Results for the estimated EGARCH (1, 1) model

In constructing conditional variance series (inflation volatility), we fitted the EGARCH (1, 1) model to seasonally adjusted annual inflation series. Results of the EGARCH (1, 1) estimation are presented in Table 2.

Table 2: Results of the Estimated EGARCH (1, 1)

Independent Variable	An EGARCH (1, 1) model for the LNINF-100	
	Coefficient	Standard error
Constant	1.295749	0.504925
LNINF(-1)	0.531383	0.165706
Variance Equation		
Constant	0.467757***	0.031375
|RES|/SQR[GARCH](1)	-0.637844***	0.004956
RES/SQR[GARCH](1)	-0.012359	0.115563
EGARCH(1)	0.993152***	0.083900
R-Squared 0.1494	DW 2.2225	
Adjusted R-Squared 0.1228	S.E of regression 0.6276	
Log likelihood -21.602		

**** denotes rejection of the null hypothesis at 1% significant level.*

From the estimated coefficients in Table 2, the constant term gives an indication of last period's volatility, |RES|/SQR[GARCH](1) represents impact of long term volatility and RES/SQR[GARCH](1) denotes the leverage effect. Because the coefficient of RES/SQR [GARCH] (1) is positive and statistically insignificant, it indicates that $a_1 = a_2 = ... = 0$, and therefore the model is said to be symmetric. In this case, negative shocks are likely to generate minimal effects on the volatility of the series than positive shocks of the same magnitude. This means that investors are more prone to good news about inflation relative to bad news.

4.3 OLS estimates for models I and II: Pre and post-inflation targeting

For the pre and post targeting analysis, the OLS method was used to estimate models I and II. To improve consistency of the estimates we included lag of 'real per capita GDP' as a regressor. The results are presented in Table 3.

Table 3: OLS estimates for models I and II: Pre-IT and post-IT

Variable	**Dependent Variable is Lnrpgdp**			
Independent	Pre-inflation targeting		Post-inflation targeting	
	I	II	I	II
Constant	0.96225*** (0.273575)	1.117995*** (0.235671)	8.31557* (3.488910)	1.323860 (2.547876)
Lninf	-0.01108 (0.006805)		-0.084652 (0.331050)	
Lngdfcf	0.05739*** (0.00907)	0.037283*** (0.010026)	1.006760 (1.066934)	0.231755 (0.187040)
Lnrpgdp(-1)	0.83479*** (0.043846)	0.807147*** (0.037847)	-0.636740 (0.936754)	0.698195 (0.446944)
Lnvol		-0.033539*** (0.009347)		-0.026514 (0.081043)
R^2	0.97948	0.98593	0.470355	0.967130
R^2adj	0.97668	0.983515	0.073121	0.934261
F-Statistic	349.9997	498.1743	1.184075	29.42317
Log-Likelihood	67.17391	71.68355	6.060917	16.54028
DW	1.647521	1.833914	2.717747	2.978661

*Note: Standard errors are indicated in parenthesis. *** and * indicate rejection of the null-hypothesis at 1% and 10% significance levels. IT is inflation targeting.*

Table 3 shows that inflation level (*Lninf*) has a negative but statistically insignificant impact on economic growth in both pre and post-inflation targeting regimes in Ghana. Also, the coefficient of inflation volatility (Lnvol) is negative and statistically significant in the pre-targeting regime but insignificant in the post-targeting period. This indicates that a unit increase (fall) in inflation volatility is likely to trigger a fall (rise) in economic growth by 0.009 in the pre-targeting period. Indeed, high inflation volatility discourages savings and investment and these have negative impact on real GDP growth in an economy. Our finding is consistent with Kumo (2015). For the post-targeting period, the estimates appear to suggest that inflation targeting succeeded in anchoring private agents' expectations thereby eliminating the negative impact of inflation volatility on growth.

From model II, the coefficient of gross domestic fixed capital formation-GDP ratio is positive and statistically significant in the pre-targeting period at 1% significance level. Increase in fixed capital is likely to increase the productivity of businesses, investment increases and this could lead to real economic growth. Previous studies (Barugahara, 2013; Kumo, 2015) have also reported that investment has an expansionary effect on economic growth. Its impact on economic growth is 5.74% for model I and 3.73% in the case of model II.

4.4 Long-run regression results: Combined growth model

In estimating the model for the full sample period (1980 – 2013), we used the ARDL framework to evaluate long-run dynamics, with inflation targeting dummy capturing the impact of the shift in monetary policy in 2007. The data set is the same for the control variables i.e. domestic credit to private sector-GDP ratio and gross domestic fixed capital formation-GDP ratio. Except that we excluded domestic credit to private sector-GDP ratio in the specific sample estimation because of the problem of misspecification bias. Inflation volatility for the entire sample was estimated by fitting the EGARCH (1, 1) model to seasonally adjusted inflation series (from 1980-2013) so as not to overlook the effect of regime breaks. The long-run regression results for the combined growth model are presented in Table 4.

Table 4: Estimated long-run regression results

Independent variables	Dependent variable is Lnrpgdp	
	I	II
Lninf	-0.120434 (0.086623)	
Dum	0.554175*** (0.162697)	0.289052*** (0.080209)
Lndcps	-0.031780 (0.017552)	0.0175334 (0.072752)
Lngdfcf	0.441785* (0.016029)	0.175334* (0.100700)
LnVol		-0.176079*** (0.057575)
Constant	5.816292*** (0.384011)	5.812482*** (0.183080)

*Note: Standard errors are indicated in parenthesis. *** and * indicate rejection of the null-hypothesis at 1% and 10% significance levels. IT is inflation targeting.*

The result obtained from model I indicates that inflation level has a negative and insignificant impact on economic growth in the long-run. This is consistent with the results for the pre and post-inflation targeting periods. It thus appears to suggest that inflation targeting policy has achieved its primary objective of ensuring macro-economic stability in Ghana.

Also, inflation volatility has a negative and statistically significant coefficient in the long-run. A unit increase in inflation volatility is likely to trigger a fall in economic growth by 0.17607. This confirms the results obtained for the pre-inflation targeting but it is inconsistent with results of the post-targeting regime. Our finding consolidates the idea that inflation targeting was effective in maintaining a less variable inflation thereby stimulating economic growth. Similar findings have been reported by Barugahara (2013) and Kumo (2015).

The coefficient of the dummy variable (inflation targeting) is positive and statistically significant at 1% significance level for both models I and II. This indicates that inflation targeting predicts economic growth in Ghana. Batini and Laxton (2007) and Goncalves and Salles (2008) have reported similar findings. In the Ghanaian context, inflation and inflation volatility were relatively lower during the inflation targeting regime and the economy might have benefitted from these in terms of investor confidence and savings. In fact, real economic growth increased from 3.7% (pre-inflation targeting period) to 7.89% in 2010 (post-inflation targeting period). However, within the inflation targeting period (2007-2013), growth declined from a high of 14% in 2011 to 7.3% in 2013. Economic growth declined further to 3.9% in 2015 (Ghana Statistical Service files, 2016). This appears to suggest that for sustained growth much more needed to be done by policy makers. For example interest rate is still relatively high, 26% in 2016 compared with 14% in Nigeria and 10% in Kenya. Exchange rate between the dollar and the Ghana Cedi has deteriorated from GH¢0.9244 for 1US$ in January, 2007 to GH¢3.8063 for IUS$ in January, 2016 Bank of Ghana Database, 2016). These are likely to stifle economic growth associated with inflation targeting in the country. Perhaps, policy makers could, in addition to inflation targeting, explore real targeting approach. In this case real GDP growth and employment creation could be seriously targeted.

As regards the control variables, domestic credit to private sector-GDP ratio (Lndcps) has no significant impact on economic growth. But, the coefficient of gross domestic fixed capital formation/GDP ratio (Lngdfcf) for models I and II are positive and statistically significant. In line with economic theory, a unit rise in gross domestic fixed capital formation-GDP ratio is likely to trigger rise in economic growth by 0.44178 and 0.17533 in models I and II respectively. The results indicate that domestic investment drives economic growth in Ghana.

4.5 Short-run regression results: Combined sample

The short-run regression results for models I and II are reported in Table 5. It is important to note that the statistical adequacy and fit of the ARDL model depends on the computed error correction coefficient. Table 5 shows that for both models I and II, the computed error correction coefficient is negative and statistically significant.

This confirms the bounds test results that a unique and long run relationship exists between the dependent and independent variables. The error correction coefficients give an indication of a less than average speed of adjustment from past period disequilibria to current period equilibrium. The results suggest that approximately 12.5% to 19.6% of the past period's disequilibrium converges back to the long run in the current period.

Table 5: Estimated short-run regression results

Independent Variables	Dependent variable is Lnrpgdp	
	I	II
ECM(-1)	-0.124983** (0.054726)	-0.196110*** (0.050611)
D(Lninf)	-0.015052* (0.008045)	
D(Dum)	0.033673 (0.026073)	0.022468 (0.023630)
D(Lndcps)	-0.003972 (0.017552)	0.003356 (0.014686)
D(Lngdfcf)	0.055215*** (0.016029)	0.034385*** (0.015610)
D(LnVol)		-0.034531*** (0.010398)

*Note: Standard errors are indicated in parenthesis. *** ** and * denote rejection of the null hypothesis at 1% ,5% and 10% significance level.*

Also, the coefficient of inflation level is negative and statistically significant at 10%. This proposes that all other things being equal, a unit increase in inflation is likely to trigger decline in real GDP per capita growth by 0.01505 in the short-term. This is inconsistent with results of the pre and post-inflation targeting regimes and the long-run results for the combined model. But, the finding is consistent with Fischer (1993), Barro (1995), Judson and Orphanides (1999).

Again, as expected, the coefficient of inflation volatility is negative and statistically significant at 1% level. Holding all other variables fixed, a unit increase in inflation volatility is likely to trigger 0.034531 decline in real per capita GDP growth in the short-run. This finding is consistent with results obtained for the pre-targeting regimes and also the long-run estimates. It is however, inconsistent with results of the post-targeting period. Our results support the impression that the inflation targeting policy has not fully attained its objective of mitigating the negative effect of inflation volatility on economic growth.

The coefficient of the dummy variable (IT) was insignificant in the short-term.

Perhaps, this prevails because of long lags in policy – it takes significant amount of time for policy changes to yield the desired outcome. Again, the domestic credit to private sector-GDP ratio variable has a negative and statistically insignificant impact on growth. This might be due to the dearth of well-developed financial systems in Ghana that have the institutional capacity to convert some uncertainty into quantifiable risks and improve access to financial resources at all levels.

Finally, for both models I and II, the coefficient of gross domestic fixed capital formation-GDP ratio is positive and statistically significant. This is consistent with the exogenous growth model that investment is an essential driver of growth. In terms of size effect, the impact of domestic capital on real economic growth is roughly equal to that of inflation volatility, which suggests that monetary policy is not the only panacea for a balanced and sustained long-term growth.

5. Conclusion

This paper has investigated the effect of inflation targeting, inflation and inflation volatility on economic growth in Ghana. Using the paired sample t-test, we found that inflation rate and inflation volatility were significantly lower during the inflation targeting period. We estimated two growth models using a combination of ARDL bounds testing approach to co-integration and the OLS estimation technique. For model I, the explanatory variable of interest was inflation whilst for model II, it was conditional variance, proxy for inflation volatility. For each of the two models we controlled for domestic credit to private sector-GDP ratio (dcps) and gross domestic fixed capital formation-GDP ratio (gdfcf). A dummy variable was used to capture inflation targeting.

The interesting result is that in the long run, inflation targeting has a significant positive association with economic growth in Ghana. Indeed, data from the Ghana Statistical Service indicate that average GDP growth rate for 2000-2006, representing pre-inflation target period was 4.98% compared with 7.11% for 2009-2015 representing post inflation targeting period. But, our finding is not consistent with Puni et al. (2014). Curiously, within the inflation targeting period, GDP growth at constant 2006 prices, had declined from a high of 14% in 2011 to 4% in 2014. This is puzzling and appears to suggest that there might be other important factors that contribute to growth in Ghana. Or, policy makers now concentrate more on inflation rate at the expense of real GDP growth? Much more empirical studies on determinants of growth in Ghana are needed.

Consistent with past studies (Barugahara, 2013; Kumo, 2015), we found that inflation volatility has a negative and statistically significant impact on economic growth in the pre-inflation targeting period. An estimation of the growth model was repeated by combining the pre-inflation targeting and post-inflation targeting periods. It was revealed that inflation had a weak negative and statistically significant impact on real growth. For the short run results the coefficient of inflation is negative and statistically significant at 10%. Generally, inflation is negatively correlated with growth.

But, our results should be interpreted with caution since yearly data were used for analysis. Much more research using quarterly or monthly data are needed to confirm our findings. This notwithstanding, we recommend that monetary authorities should continue to pursue inflation targeting in Ghana. However, the high interest rate and continuous depreciation of the Ghana Cedi appear to have increased cost of production and thus stifling the full impact of inflation targeting.

References

Ball, L. M., & Sheridan, N. (2004). Does Inflation Targeting Matter? In *The Inflation-Targeting Debate* (pp. 249-276). University of Chicago Press.

Bhar R. and Malik, G. (2010). Inflation, Inflation Uncertainty and Output Growth in the USA, *Physica A*. 389, 5503-10.

Bank of Ghana files, 2016.

Barro, R. J. (1995). Inflation and growth. *Review-Federal Reserve Bank of Saint Louis*, 78, 153-169

Barugahara, F., (2013). Main and interaction effects of inflation level and volatility on economic growth. Online at http://www.gdn.int/adm/uploads/editor/filesparallel%20Session, 10/09/2015.

Batini, N., & Laxton, D. (2007). Under what conditions can inflation targeting be adopted? The experience of emerging markets. Central Banking, Analysis, and Economic Policies Book Series, 11, 467-506.

Becker, K. G., Finnerty, J. E., & Kopecky, K. J. (1995). Domestic macroeconomic news and foreign interest rates. *Journal of International Money and Finance*, 14(6), 763-83.

Bollerslev, T., & Mikkelsen, H. O. (1996). Modeling and pricing long memory in shock market volatility. Journal of Econometrics, 73(1), 151-84.

Brito, R. D. & Bystedt, B.(2010). Inflation Targeting in emerging economies: Panel evidence. *Journal of Development Economics*, 91(2), 198–210.

Ceccheti, S. G., & Ehrman, M. (2000). Does inflation targeting Increase Output Volatility? An international comparison of policy makers' preferences and outcomes. National Bureau of Economic Research, WP.7426

Coulson, N. E., & Robins, R. P (1985). Aggregate economic activity and the variance of inflation: another look. *Economic Letters*, 17(1-2), 71-75.

Daboussi, O. M. (2014). Economic performance and inflation targeting in developing economies. *Journal of World Economic Research*, 3 (1), 1-7.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for autoregressive time series with a unit root. *Journal of American Statistical Association*, 74(366a), 427-31.

Duerker, M. J., & Fischer, A. M. (2006). Do Inflation Targeters Outperform Non-Targeters? *Reserve Bank of St. Louis Review*, 88(5), 431-50

Duasa, J. (2006). Determinants of Malaysian trade balance: An ARDL bound testing approach. *Global Economic Review*, 36(1), 89-102.

Elliott, G., Rothenberg, T., & Stock, J. (1996). Efficient tests for an autoregressive unit root. *Econometrica*, 64, 813–36.

Engel, R., & Granger, C. W. J. (2001). Co-Integration and Error-Correction: Representation, Estimation, and Testing. *Econometric Society Monographs*, 33, 145-172.

Fischer, S. (1993). The Role of Macroeconomic Factors in Growth. *Journal of Monetary Economic*s, 32, 5, 455-511.

Geraats, P. M. (2013). The effect of inflation targeting: A Mean-Reverting Mirage? Monetary Economics Conference, University of Cambridge.

Goncalves, C. E. S., & Salles, J. M. (2008). Inflation targeting in emerging economies: what do the data say?*Journal of Development Economics*, 85(1), 312-18.

Grier, R., & Grier, K. B. (2006). On the real effects of inflation and inflation uncertainty in Mexico. *Journal of Development*, 80(2), 478-500.

Hendry, D.F., Naale, A. J., & Srba, F. (1988). Econometric analysis of small linear systems using PC-FIML. *Journal of Econometrics*, 38(1), 203-26.

Judson, R., & Orphanides, A. (1999). Inflation, volatility and growth. *International Finance*, 2(1), 117-38.

Kwakye, J. K. (2012). Key issues in the choice of an appropriate monetary policy framework for Ghana. *Institute of Economic Affairs Working Paper Series*

Kumo, W. L. (2006). Macroeconomic uncertainty and aggregate private investment in South Africa. *South African Journal of Economics*, 72(2), 190-204.

Kumo, W. L. (2015). Inflation targeting monetary policy, inflation volatility and economic growth in South Africa, WP.216.

Malik, G., & Chowdhury, A. (2001). Inflation and Economic Growth: Evidence from four South Asian Countries. *Asia-Pacific Development Journal*, 8(1), 123-33.

Mishkin, F. S. and Schmidt-Hebbel, K. (2007). Monetary policy under inflation targeting: An introduction.

Obamuyi, T. M. (2009). An investigation of the relationship between interest rates and economic growth in Nigeria, 1970-2006. *Journal of Economics and International Finance*, 1(4), 93.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289–326.

Puni, A., Osei, B. A., & Barnor, C. (2014). Effects of Inflation Targeting Policy on Inflation Rates and Gross Domestic Product in Ghana. *European Journal of Business and Management*, 6(21), 54-60

Romdhane, I. B., & Mensi, S. (2014). Assessing the macroeconomic effects of inflation-targeting: Evidence from OECD Economies. *International Journal of Economics, Finance and Management*, 4(1), 38-44.

Sakyi, D., Commodore, R., & Eric, E. E. O. (2015). Foreign Direct Investment, Trade Openness and Economic Growth in Ghana: An Empirical Investigation. *Journal of African Business*, 16 (1-2), 1-15.

Taylor, S. J. (2005)). Asset price dynamics, volatility and prediction. Princeton, NJ: Princeton University Press.

Vega, M. and Winkelried, D. (2005). Inflation Targeting and Inflation Behavior: A Successful Story? *International Journal of Central Banking*, 1(3), 153-75.

Walsh, C. E. (2009). Inflation-Targeting: What have we Learned?*. *International Finance*, 12(2), 195-233.

Wilson, B. K. (2006). The links between inflation, inflation uncertainty and output growth: New time series evidence from Japan. *Journal of macroeconomics*, 28(3), 609-20.

World Bank (2015). World Development Indicators. Washington, USA.

APPENDIX

Table A.1: Results of ADF and DF-GLS Unit Root Tests

Log Level		ADF		DF-GLS	
	Variable	Constant no T	Constant & T	Constant no T	Constant & T
	lnrpgdp	3.156824**	0.046264	0.059592	1.119656
	lninf	3.544721**	5.292265***	3.223255***	5.463407***
	lndcps	1.481240	2.5910112	0.298030	2.694415
	lngdfcf	5.059794***	1.737251	0.998120	1.886613
First Difference					
	lnrpgdp	3.004658**	3.662996**	2.076465**	3.54699**
	lninf	5.190258***	8.582899***	6.7033244***	8.168303***
	lndcps	5.679929***	5.810988***	5.477615***	6.072146***
	lngdfcf	5.667575***	5.795395***	1.483972	5.522551***

*Note: T is trend, lnrpgdp is log of real per capita GDP, lninf is log of inflation, lndcps is log of domestic credit to private sector/GDP ratio and lngdfcf is log of gross domestic fixed capital formation/GDP ratio.*** (**) denotes rejection of the null hypothesis at 1% (5%) levels of significance.*

Table A.2: Results of Wald Covariance Stationarity Test

Test statistic	Estimate	Degrees of freedom	Probability
t-statistic	-1.585155	28	0.1154
F-statistic	2.512717	(1, 28)	0.1154
Chi-square (χ2)	2.512717	1	0.1129
Null-hypothesis: C(4) + C(5) = 1 or (b1 + = 1) Summary			
Normalized restriction	Value	SE	
-1 + C(4) +C(5)	-0.023326	0.014715	

Note: Restrictions are assumed to be linear in parameters. The F and Chi-square statistics are insignificant implying the conditional variance series passed the test for unit roots. Inflation volatility is strictly covariance stationary.

Table A.4: Model Diagnostic and Stability Tests

Test Statistic	Dependent variable is Lnrpggp					
	Pre-IT		Post-IT		Combined Period	
	I	II	I	II	I	II
Serial Correlation $\chi 2$ (1)	0.323069 (0.0.728)	1.405336 (0.2685)	3.170242 (0.2398)	8789.825 (0.0705)	0.511994 (0.6057)	3.479652 (0.0471)
Normality $\chi 2$ (1)	2.43491 (0.29598)	0.014100 (0.99298)	0.204216 (0.9029)	1.897058 (0.38731)	3.52312 (0.17178)	5.128201 (0.07699)
Functional Form $\chi 2$ (1)	11.34999 (0.0492)	2.403560 (0.1360)	0.008581 (0.9320)	9.404852 (0.0919)	7.809985 (0.0980)	0.886621 (0.3554)
Heteroscedasticity $\chi 2$ (1)	1.523872 (0.2362)	5.332333 (0.0605)	5.890811 (0.0598)	0.247483 (0.8593)	1.35033 (0.2713)	1.246461 (0.3157)
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMQ	Stable	Stable	Stable	Stable	Stable	Stable

Note: indicated in parenthesis are p – values. The results show that models I and II passed the tests against normality, Serial Correlation, functional form and heteroskedasticity. The CUSUM and CUSUM of square tests of recursive residuals show variable stability within the boundary of critical points. Models I and II are thus reliable, stable and correctly specified for all the distinct sample periods.