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## Article

# Estimating bank of Ghana's policy responses in the context of Taylor rule: Is the inflation target realistic?

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## FINANCIAL ECONOMICS | RESEARCH ARTICLE

# Estimating bank of Ghana's policy responses in the context of Taylor rule: Is the inflation target realistic?

Abdul-Aziz Iddrisu<sup>1</sup> and Imhotep Paul Alagidede<sup>2</sup>

**ABSTRACT:** Although literature acknowledges the nonlinearity in monetary policy behaviour of central banks, the appropriateness of the models used to capture the nonlinearity remains questionable. Moreover, the paucity of research on nonlinear monetary policy rules in the context of Africa and Ghana in particular is worrying, given the numerous breaches of the publicly announced inflation targets. The study estimates the Bank of Ghana's policy responses over the inflation targeting period using the Taylor rule. We find that the Bank of Ghana reacts asymmetrically to inflation gap below and above the estimated inflation threshold of 16.4% with considerable inflation accommodation instead of targeting it. We question the logic behind the prevailing upper and lower bounds inflation target given the evidence to the contrary. The average inflation over the targeting period, the estimated inflation threshold and the structure of the Ghanaian economy raise questions of feasibility of achieving the inflation target on sustainable basis. Policy implications are discussed.

**Subjects:** Economics; Finance; Management and Accounting

### ABOUT THE AUTHOR

Abdul-Aziz Iddrisu is a senior lecturer in finance at the Banking Technology and Finance Department of Kumasi Technical University, Ghana. His research interest covers monetary and fiscal policies, banking sector efficiency and stability, development finance, corporate finance and health economics. He completed his PhD at the Wits Business School, University of the Witwatersrand, South Africa. He holds an MSc in Finance and Management from Cranfield University's School of Management, UK. He is a Principal Consultant at AREF Consult. Imhotep Paul Alagidede is a metaeconomist and professor of finance at the University of the Witwatersrand. His research and teaching interests transcend traditional academic boundaries, delving into the possibilities and limits of human consciousness. Imhotep is the grand editor of the *Journal of Indigenous and Shamanic Studies*, Editor-in-Chief of the *Ghanaian Journal of Economics*, Managing Editor of the *Journal of African Political Economy and Development* and Executive Director of AREF Consult.

### PUBLIC INTEREST STATEMENT

The Bank of Ghana, since the launch of its inflation-targeting framework in 2007, has missed the publicly announced inflation target many times than it has achieved it. This paper gauges the monetary policy responses of the Bank of Ghana over that period in the Taylor rule context. The results show considerable inflation accommodation, given the relative weights on expected inflation gap below and above the estimated inflation threshold of 16.4%. The average inflation rate over the period of study, the estimated inflation threshold and the nature of the country's economic fundamentals raise questions of feasibility of the announced inflation target on sustainable basis with ramifications for the central bank's credibility. The results hold policy relevance for the Bank of Ghana and a number of developing economies considering an explicit inflation targeting framework.

| **KEYWORDS: Monetary Policy Rule; Threshold; Inflation Targeting; Sample Splitting**

## 1. INTRODUCTION

Monetary policy rules have long been advocated for in the wake of economic instabilities and prolonged inflationary episodes that were thought to have been occasioned by monetary mistakes (Taylor, 2017). Taylor (1993) provided one of the foundations of rule-based monetary policy by formulating a linear model that adequately described the monetary policy behaviour of the Federal Reserve Bank particularly between 1987 and 1992. This phenomenal success endeared the Taylor (1993) rule to many practitioners and occasioned an unprecedented volumes of policy rule research with varying results for different countries (see Allegret & Benkhodja, 2015; Li & Liu, 2017; Aguiar-Conraria et al., 2018; Bleaney et al., 2020;; Mgadmi et al., 2021).

A burgeoning paradigm in the policy rule literature is the argument that monetary policy behaviour of central banks is not necessarily linear, raising doubts about the famous Taylor (1993) rule in a linear context. Business cycle variations (Liu et al., 2018), heterogeneity in the objectives and preferences of monetary policy authorities (Caglayan et al., 2016;; Su et al., 2016) and the nonlinear relationship between macroeconomic variables (Caporale et al., 2018) are ample reasons why policy behaviour is not linear. Indeed, some authors (Surico, 2007;; Hasanov & Omay, 2008) assert that asymmetry in monetary policy behaviour can be attributed to political pressures on central banks. Their argument is that when a central bank tightens monetary policy to dampen inflation, it may come under immense political pressure as compared to when it loosens policy to buoy employment. A fundamental limitation of the growing nonlinear monetary policy rule literature is the approach of unearthing the nonlinearity (Iddrisu & Alagidede, 2021). As argued by Liu et al. (2018) and Caporale et al. (2018), a large number of these nonlinear studies use models such as logistic smooth transition regression, regime switching and structural change that are inherently linear and therefore fail to capture the nonlinear characteristics properly. The models also exhibit characteristics of structural breaks across regimes. However, in the short term, monetary policy makers seldom engage in adjustments of monetary policy rule on a large scale (Liu et al., 2018).

Furthermore, the dearth of research on nonlinear monetary policy rules on Africa is worrying. We observed that not only are studies on Africa limited, they are largely based on linear policy rules. Meanwhile, literature acknowledges that when monetary policy is optimal in each country, the global monetary policy space becomes optimal on the aggregate (Taylor, 2017). Monetary policy optimality of central banks in Africa is certainly part of the story as it is one of the continents with the largest number of countries and invariably the largest number of central banks. The nonlinear studies, to the best of our knowledge, across the whole of Africa are Ncube and Tshuma (2010), Naraidoo and Raputsoane (2011), Naraidoo and Paya (2012), Baaziz et al. (2013), and Iddrisu and Alagidede (2021) for South Africa, Baaziz and Labidi (2016) for Egypt and Tunisia and Mgadmi et al. (2021) for Tunisia.

Notably missing in the nonlinear policy rule literature in the context of Africa is Ghana, the only other African country apart from South Africa to have adopted full-fledged inflation targeting framework that in itself is a form of a policy rule. The Bank of Ghana has struggled to achieve the inflation target since the adoption of the explicit inflation targeting framework in 2007 with inflation peaking at 20.7% in June 2009. Ghana therefore provides an important case for policy rule studies to unearth the nature of policy responses and the extent of success of the targeting framework.

The current study therefore makes a number of contributions to the policy rule literature. First, to capture nonlinearity appropriately, as that has been a major limitation in the literature, we employ the sample splitting and threshold estimation technique developed by Hansen (2000). This model, in addition to an accurate threshold effect estimation, also unravels the varying effects of output and inflation gaps on the policy rate when inflation exceeds or falls below the optimal threshold. The functional form of nonlinearity or otherwise that the relationship between the regressors and the policy variable taken is not assumed or superimposed *a priori* by the model. Indeed, an important virtue of our estimation technique is the fact that it empirically provides the confidence intervals for the threshold's statistical significance with the aid of the asymptotic theory. In addition, the resulting asymptotic distribution of the threshold parameter's least square estimate is devoid of nuisance parameters that other threshold models suffer (Hansen, 2000). Moreover, the approach does not require a predetermination of the threshold value as this is done by the model itself. The nonlinear monetary policy rule estimation for Ghana becomes a major contribution in the literature as the limited existing studies on the country by Boamah (2012) and Bleaney et al. (2020) are all linear policy rule characterizations.

We find a threshold inflation 16.4% which is far from the upper limit of 10% of the inflation target range, raising questions of feasibility of the set target range in the face of numerous misses. We observe substantial inflation accommodation on the part of a central bank that is supposed to be targeting inflation.

### **1.1. MONETARY POLICY FRAMEWORK IN GHANA**

Ghana is the second country in Sub-Saharan Africa to adopt full-fledged inflation targeting framework after South Africa with a clear mandate for the Bank of Ghana to deliver price stability. The medium-target inflation (headline) in Ghana is currently  $8\% \pm 2$  jointly determined by the monetary and fiscal authorities. The Bank of Ghana enjoys operational independence enshrined in the Bank of Ghana Act (2002) and particularly instrument independence to guide inflation to the stipulated target. Monetary policy decisions are made by the Monetary Policy Committee which has seven members. Five out of the seven members are internal staff of the central bank with the governor as the chairperson of the committee. The remaining two members are external and appointed by the Finance Minister (Bank of Ghana, n.d.).

The Monetary Policy Committee sits every other month (thus every 2 months with dates published in advance) for the purposes of determining monetary policy rates meant to anchor expectations and rein in inflation. Each of these meetings takes place in 2 days with a climax of a press conference on the monetary policy decision on the third day. Every member of the committee has a single vote on the interest rate determination backed by justifications for the stance of the individual. The eventual decision on a particular policy rate or policy stance is reached through consensus. While economic reports underpinning the policy decisions of each meeting are published, the minutes of the meetings are not. When the inflation target is missed, the Bank of Ghana is not under any legal obligation to explain the reasons for the failure to either the parliament of the country or the fiscal authorities. The parliament's finance committee can, however, summon the governor of the central bank to explain developments in the country (Bank of Ghana, n.d.).

## **2. LITERATURE REVIEW**

The Taylor (1993) linear rule, formulated to characterize the monetary policy of the Federal Reserve Bank of the United States (Fed) from 1987 to 1992 eventually became a model for rule-based monetary policy and monetary policy assessment globally. The widespread implementation of the Taylor rule in the literature follows its phenomenal success in exacting the characterization

of the Fed's monetary policy over the sample period. In its basic form, the Taylor (1993) rule was formulated as:

$$i = \pi + 1/2(y) + 1/2(\pi - 2) + 2$$

such that the  $y$  represents deviations of real GDP from its target,  $i$  denotes the federal funds rate and  $\pi$  is inflation rate over the last four-quarters. The federal funds rate is formulated to adjust upwards when output soars beyond its trend and when inflation breaches 2%. Following its success, the Taylor rule in its basic form has been implemented in contexts other than the United States of America and the results are varied (see Allegret & Benkhodja, 2015; Li & Liu, 2017; Aguiar-Conraria et al., 2018; Bleaney et al., 2020;; Mgadmi et al., 2021). Such differences in the results are not far-fetched given that the economic architecture and fundamentals of many countries are naturally disparate from that of the United States for which the policy rule was initially formulated.

The heterogeneities in the economic realities that confront different countries prompted the need for modifications of the basic Taylor rule in application to different contexts. For small open economies in particular, the basic Taylor rule might be far from reality given the colossal role of the external sector through the exchange rate that the basic Taylor rule ignores. Caglayan et al. (2016) underscored the need for a departure from monetary policy rules that dwell on close economy context to a one that embraces open economy characteristics through exchange rate. Other authors to have called for the inclusion of exchange rate in the policy rule formulation of small open economies include Froyen and Guender (2018), Caporale et al. (2018), Ghosh et al. (2016), and Daude et al. (2016). Beyond exchange rates, Papadamou et al. (2018) have put forward an argument for the augmentation of the policy rule with measures of financial stability whiles Wang et al. (2019) and Beckmann et al. (2017) have, respectively, considered measures of wealth and international spillovers.

With the observed business cycle variations (Liu et al., 2018), heterogeneity in the objectives and preferences of monetary policy authorities (Caglayan et al., 2016;; Su et al., 2016) and the non-linear relationship between macroeconomic variables (Caporale et al., 2018), questions of suitability and validity of the linear Taylor rule in capturing monetary policy behaviour of central banks became apparent in the literature and precipitated phenomenal volumes of nonlinear policy rule expositions. However, Liu et al. (2018) and Caporale et al. (2018) posit that in capturing the nonlinearity in monetary policy behaviour, a large number of these nonlinear studies use models that are themselves inherently linear. Importantly, the right characterization of the monetary policy behaviour of central banks is even more crucial (Iddrisu & Alagidede, 2021). The current study adopts a threshold estimation technique that captures nonlinearity adequately devoid of *a priori* impositions and free of nuisance parameters that other models suffer.

### 3. METHODOLOGY

#### 3.1. Data and data sources

We used monthly data for all the series from January 2007 to June 2018. Given that the study examines the nature of monetary policy responses over the inflation targeting period, the collection of data is matched with that period. As explicit inflation targeting framework was unveiled in Ghana in 2007, the data for this study also starts from 2007. We obtained the data on all the variables from the website of Bank of Ghana (<https://www.bog.gov.gh/economic-data/time-series/>).

### 3.2. Description of variables

In estimating the nonlinear Taylor rule, we used output and inflation gaps and monetary policy instrument. These are defined in Table 1 below:

### 3.3. Descriptive statistics

We provide, in Table 2,3, the summary statistics. The average inflation rate in Ghana over the period is 13.35% which is 3.35% above the upper limit of 10% of the inflation target range. Indeed, for most part of the period, Ghana's inflation has well been above the upper limit of 10%, with inflation reaching as high as 20.7% in June 2009. Even though the country enjoyed single-digit inflation between June 2010 and 2012 and more recently between April and August 2018, the lower band of 6% has since eluded the country.

In Figure 1 we present the line graph of monetary policy rate and inflation over the inflation targeting period. We observe that monetary policy and inflation have tended to move together with occasional drift.

### 3.4. Test for stationarity

We ascertain the stationarity properties of our series using the Phillips Perron (PP) test developed by Phillips and Perron (1988) and the Augmented Dickey–Fuller (ADF) test developed by Dickey and Fuller (1981). In both the ADF and the PP tests, we include intercept and trend and we find all the variables except the output gap to be stationary after the first difference. Output gap is stationary at the level. The variables that are not stationary at the levels enter the model after the first difference.

### 3.5. Empirical approach

The threshold variable, in a typical threshold analysis, would normally have a quadratic term imposed on it *a priori*. However, not only is that questionable, but such an approach also fails to capture the mediation role that the initial values of the threshold variable would play in the threshold effect (Alagidede et al., 2018;; Ibrahim & Alagidede, 2018). Our estimation technique, in addition to an accurate threshold effect estimation, also unravels the varying effects of the regressors on the policy rate when inflation exceeds or falls below the optimal threshold. The study uses the Sample Splitting and Threshold Estimation developed by Hansen (2000).

Our linear model is expressed as:

$$mpr_t = \beta_0 + \beta_1 (E_t[\omega_{t+k} - \omega_t^*]) + \beta_2 (E_t[y_{t+k} - y_t^*]) + \varepsilon_t \quad (2)$$

such that the monetary policy instrument is represented by  $mpr_t$ , inflation is represented by  $\omega_{t+k}$  while target inflation is represented by  $\omega_t^*$  and therefore the inflation gap is represented by  $\omega_{t+k} - \omega_t^*$ . Then  $y_{t+k} - y_t^*$  represents the output gap, and  $\varepsilon_t$  is the error term. The  $E_t$  in the specification represents expectations. The incorporation of expectation in our model specification is in line with the argument that policy makers respond to future or expected inflation and output gaps (Woodford, 2001; Clarida et al., 1999;; Svensson, 1996). As a result, the data on inflation gap and output gap are two-month lead variables. The choice of two-month period lead is informed by the fact that the Monetary Policy Committee of Bank of Ghana meets every 2 months to decide on the policy rate (thus a total of six times in a year).

From the above equation, representing the dependent variable by  $y$  and the regressors by  $x$ , then the set  $\{y_i, x_i, \theta_i\}_{i=1}^n$  represents the observed sample such that  $x_i$  denotes an  $m$ -vector while  $y_i$  and  $\theta_i$  are real-valued. Meanwhile,  $\theta_i$ , which denotes the threshold variable and given by  $\theta_i = \omega_{t-2}$  has

**Table 1. Variables Description**

Variable name	Description
Monetary policy instrument	To capture monetary policy, we used the monetary policy rate which is the policy instrument used by the Bank of Ghana. The Bank of Ghana sets the monetary policy rate as a reflection of its monetary policy stance.
Inflation gap	We estimate the inflation gap as the difference between the year-on-year change in inflation rate and the midpoint of Bank of Ghana's inflation target which is similar to the work of Bleaney et al. (2020). We expect that the Bank of Ghana would react more aggressively to positive inflation gap than negative inflation gap. More specifically, monetary policy authorities would respond positively to increasing inflation gap.
Output gap	<p>Output gap: Data on gross domestic product (usually used as proxy for output) is not available in monthly series, forcing us to rely on an alternative measure of output or economic activities. We used the composite index of economic activities compiled by the Bank of Ghana as a measure of output in line with Bleaney et al. (2020) and therefore the output gap becomes the percentage change in the log of composite index of economic activity from its trend. To calculate the trend, we employed the univariate structural time series model which decomposes the output series into the cycle and trend components in line with the work of Koopman et al. (2009). For the purpose of the decomposition, the model is specified as follows:</p> $(1) \quad y_t = \mu_t + \delta_t + \varepsilon_t \in \text{NID}(0, \sigma_\varepsilon^2); t = 1 \dots T$ <p>such that <math>y_t</math> represents output, <math>\mu_t</math> denotes the trend component, with the cycle component denoted by <math>\delta_t</math>, and the irregular component is represented by <math>\varepsilon_t</math>. The estimation is done by way of Maximum Likelihood. Previous studies (Ma, 2016; Liu et al., 2018; and Caporale et al., 2018) had used the filter of Hodrick and Prescott (1997) popularly known as the HP filter. However, the HP filter suffers from various inadequacies. The HP filter requires a prior determination of the parameter (<math>\lambda</math>) that penalizes smoothness versus fit, the choice of which is usually arbitrary (Alvarez &amp; Gómez-Loscos, 2018). Additionally, for series that have a classical spectral shape, the HP filter is said to engender spurious cycles (Alvarez &amp; Gómez-Loscos, 2018). Moreover, the HP filter behaves poorly in respect of observations or periods that are most recent (Caporale et al., 2018; and Alvarez &amp; Gómez-Loscos, 2018). Furthermore, the HP filter may erroneously specify the structure of the economy as the values put forward by the filter are idiosyncratic to the United States' economic setting (Caporale et al., 2018; and Sarikaya et al., 2005). For emerging markets and Africa in particular, the volatility of output is an inherent characteristic and therefore the use of HP filter for trend estimation may suffer greater variability (Caporale et al., 2018). The model-based approach for decomposing cycle and trend used in this study has the advantage that it implicitly defines the filters and for which reason the filters deliver optimality. These filters exhibit consistency with each other as well as with the output data we used (Harvey &amp; Trimbur, 2003). Importantly, the consistency of the filters with each other is seen both at the start and end of the output data. That is, they adapt automatically to the ends of our sample. Significantly, by estimating the parameters, the output series' properties are in synchrony with the accompanying filters (Harvey &amp; Trimbur, 2003).</p>

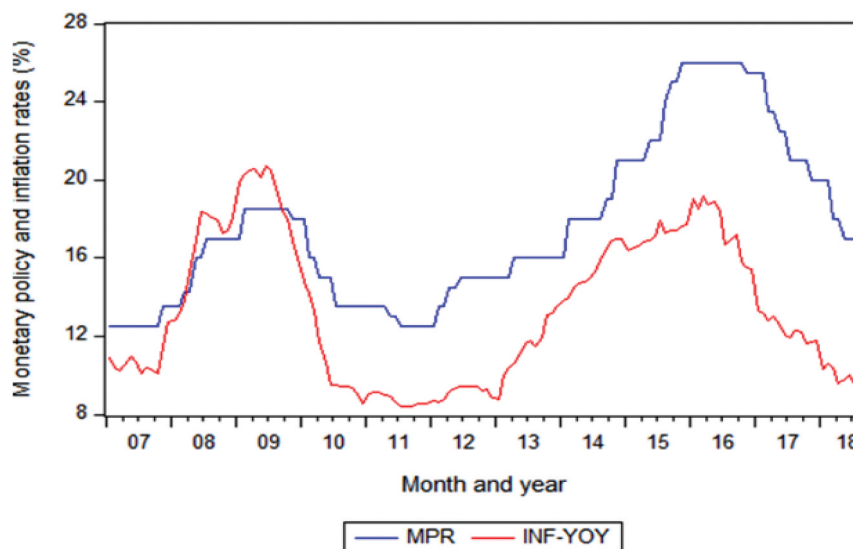


**Table 2. Summary Statistics**

	MPR	INF	OUTPUT
Mean	17.67571	13.34971	334.9969
Maximum	26.00000	20.70000	1148.830
Minimum	12.50000	8.390000	14.60000
Std. Dev.	4.237260	3.744857	119.0975
Skewness	0.662517	0.321194	2.146463
Kurtosis	2.360419	1.725088	16.93870
Observations	140	140	140

Note: MPR is monetary policy rate and INF is inflation rate

**Figure 1. Ghana's monetary policy rate and inflation.**



a continuous distribution. The lag of inflation is the threshold variable in line with Caporale et al. (2018) with the intuition that policy makers aggressively react more to the overshooting of inflation than the undershooting of inflation and particularly as we are dealing with an inflation targeting central bank.

Our estimation of threshold is specified as follows:

$$mpr_t = (\beta_{11} + \beta_{21}(E_t[\omega_{t+k} - \omega_t^*]) + \beta_{31}(E_t[y_{t+k} - y_t^*]))d_i\{\theta_i \leq \theta_i\} + (\beta_{12} + \beta_{22}(E_t[\omega_{t+k} - \omega_t^*]) + \beta_{32}(E_t[y_{t+k} - y_t^*]))d_i\{\theta_i > \theta_i\} + \varepsilon_t \quad (3)$$

such that an indicator variable denoted by  $d_i\{\cdot\}$  is a dummy which has a value of 1 when the condition in the indicator function is fulfilled, otherwise it is 0. Meanwhile,  $\theta$  represents the threshold value.

Prior to the threshold estimation, we begin with the test for linearity and our null hypothesis is that  $\beta_{i1} = \beta_{i2}$  against  $\beta_{i1} \neq \beta_{i2}$ .

**Table 3. Stationarity Test**

	ADF TEST		PP TEST	
	Level	First Diff	Level	First Diff
$mpr_t$	-2.901	-3.5034 ***	-1.0991	-11.9768 ***
$y_{t+k} - y_t^*$	-10.9932 ***	-7.7712 ***	-10.9970 ***	-127.5025 ***
$\omega_{t+k} - \omega_t^t$	-2.7513	-3.9890 ***	-1.6813	-8.5265 ***

Note: \*\*\*, \*\* and \* indicate significance at 1%, 5% and 10% respectively. For the ADF test, we used Schwarz Information Criterion for the selection of lag length. The estimate of PP test is based on the Bartlett-Kernel with the aid of the Newey-West bandwidth. Both the ADF and the PP are estimated on the basis of a null hypothesis that the series have a unit root against the alternative hypothesis of no unit root.

We reduce equation (2) to

$$y_i = \beta' x_i + \partial_i' x_i(\theta) + \varepsilon_i \tag{4}$$

such that  $\partial_n = \beta_{i2} - \beta_{i1}$ , where  $\partial_n = \beta_{i2} - \beta_{i1}$  denotes the threshold effect. Importantly, the solution is provided by  $\partial_n \rightarrow 0$  when  $n \rightarrow \infty$  with  $\beta_{i2}$  held constant such that when  $n \rightarrow \infty$ ,  $\beta_{i1} \rightarrow \beta_{i2}$  with the virtue that the resulting asymptotic distribution of  $\hat{\theta}$  is devoid of nuisance parameters that other threshold models suffer (Hansen, 2000).

Putting equation (4) into a matrix form with an  $n \times 1$  vectors of  $\varepsilon_i$  and  $y_i$  through the stacking of both and then  $n$  matrices  $X$  and  $X_\theta$  through the stacking of the vectors  $X_i'$  and then  $X_i(\theta)'$  it yields the following equation:

$$Y = X\beta + X_\theta \partial_n + \varepsilon_i \tag{5}$$

The parameters of interest that we estimate are  $\beta, \partial$  and  $\theta$  by way of least squares. The least squares estimates  $\hat{\beta}, \hat{\partial}$  and  $\hat{\theta}$  then minimize the Sum of Squared Errors (SSE) in equation (5) given as

$$SSE_n(\beta, \partial, \theta) = (Y - X\beta + X_\theta \partial_n)' (Y - X\beta + X_\theta \partial_n) \tag{6}$$

Meanwhile, the threshold value is confined to a bounded set  $[-\theta, \bar{\theta}] = \bar{\varphi}$  for the purpose of minimization. The approach then uses the concentration technique to obtain the least square estimates  $\hat{\beta}, \hat{\partial}$  and  $\hat{\theta}$  such that  $SSE_n(\theta)$  is minimized by the value  $\hat{\theta}$  and is determined uniquely by

$$\hat{\theta} = \underset{\theta \in \bar{\varphi}}{\text{argm}} SSE_n(\theta)$$

such that  $\bar{\varphi}_n = \bar{\varphi}_n \cap \{\theta_1, \theta_2, \dots, \theta_n\}$  and we estimate the slopes as  $\hat{\beta} = \hat{\beta}(\hat{\theta})$  and  $\hat{\partial} = \hat{\partial}(\hat{\theta})$ .

We use the Likelihood Ratio test to test the hypothesis  $H_0 : \theta = \theta_0$  which is given by  $LR_n(\theta) = n \frac{SSE_n(\theta) - SSE_n(\hat{\theta})}{SSE_n(\hat{\theta})}$

For large values of  $LR_n(\theta)$ , the null hypothesis  $H_0$  is rejected. To determine the reliability of  $\theta$ , we examine where it lies within the asymptotic confidence interval for  $\theta$  given the Likelihood Ratio

$LR_n(\theta)$  that is expressed as  $\hat{\varphi} = \{\theta : LR_n(\theta) \leq c\}$  as developed by Hansen (2000) and is superior to confidence intervals resulting from the Wald and t-statistic inversion (Ibrahim & Alagidede, 2018). The model approximates, asymptotically, the distribution of the threshold parameter's least square estimate ( $\hat{\theta}$ ), a feature that places this model above the other threshold models.

#### 4. EMPIRICAL RESULTS AND ANALYSIS

##### 4.1. Threshold test

We present, in Table 4, the results of our null hypothesis of linearity against that of the threshold hypothesis. We bootstrapped 5,000 replications at a trimming percentage of 15, and test the significance of the threshold statistically using the p-values of the bootstrap. The null hypothesis that there is no threshold is rejected, given the large Lagrangian Multiplier test statistic.

The bootstrap p-value of 0.029 is a manifestation that the policy behaviour of the Bank of Ghana is not linear. Thus, the responses of the Bank vary across two different regimes (below and above the threshold values). In Figure 2,3, we present the threshold graph along with the confidence intervals of the normalized Likelihood Ratio ( $\theta$ ) which is a function of the inflation threshold based on the Hansen (2000) threshold test.

The results indicate an inflation threshold value of 16.4% with a confidence interval of [8.6%, 17.2%] and these are the points on the graph at which the Likelihood Ratio ( $\theta$ ) crosses the critical line at 95% confidence. Putting this threshold inflation value side by side with the publicly announced inflation targets reveal interesting perspectives.

For the greater part of the inflation targeting period in Ghana, actual inflation has largely been above the announced inflation targets and the recent target of  $8\% \pm 2$  is not an exception. In 2007 when full-fledged inflation targeting was launched, a target range of 7%–9% was announced and yet the actual inflation rate at the end of that year was 12.7%. In 2008, a target range of 6%–8% was announced and yet inflation was 18.1%, more than double the upper limit. The story was the same in 2009 where, although inflation dropped to 15.9%, it was still above the target. Fast forward, the inflation target range announced in 2013 was 7.5%–11.5% and yet actual inflation was 13.5%. In 2014, the announced target range was 11%–15% and yet actual inflation was 17%. Since 2015, a medium-term target of  $8\% \pm 2$  (6%–10%) was announced and yet actual inflation was 17.7% at the end of 2015, 15.4% at the end of 2016 and 11.8% at the end of 2017. Clearly the targets have fundamentally been missed. It was in 2010, 2011 and 2012 that the targets were met but were even above the midpoint target. Indeed in 2011 when the announced target was 9%, inflation reached 9.2% in February of that year.

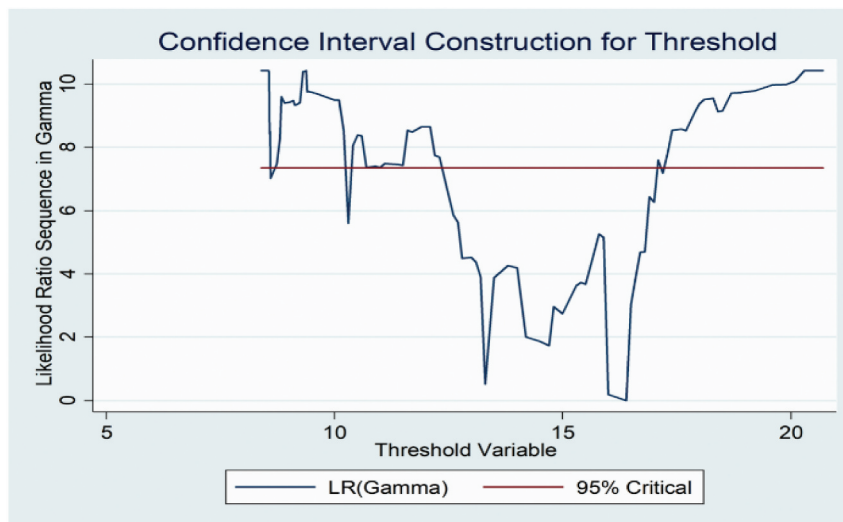
The failure to meet the publicly announced targets raises fundamental questions of how the inflation targets in Ghana are arrived at. Whether such targets are supported by the economic fundamentals of the country and if they were subjected to any empirical investigation are ques-

**Table 4. Threshold Test**

Moderated by	No. of Bootstrap replications	Trimming Percentage	LM-Test of no threshold	Bootstrap p-values
Inflation	5,000	15	10.86	0.029

Note: The errors are corrected for heteroscedasticity.

Figure 2. Confidence Interval.



tions that deserve further considerations. Meanwhile, a publicly announced inflation target is one that is supposed to be consistent with the economic credentials of the economy and policy optimality. Policy optimality is, in turn, supposed to be welfare-maximizing. It also raises fundamental questions of whether the inflation forecasting by Bank of Ghana is up to scratch to inform policy stance. An important component of the tool box of policymakers in a targeting framework is inflation forecasting based on developments within and outside the economy. Getting the forecasting wrong is an obvious precursor to missing the target. Apart from inflation forecasting, the other prerequisites for a successful inflation targeting such as absence of fiscal dominance, well developed financial markets to aid transmission and reasonably low inflation rates are problematic in Ghana. The fiscal balance in Ghana has persistently been in deficit over the inflation targeting period, posing a significant upside risk to inflation and potentially dictating the nature of monetary policy stance indirectly. The Bank of Ghana Act (2002) Act 612 prohibits the country's central bank under section 30(2) from financing more than 10% of the government revenue in any particular fiscal year. This is to deal with issues of policy independence and fiscal dominance. Sadly, in 2008 the Bank of Ghana's financing of the government's fiscal deficit amounted to 10.2% of the total government revenue (including grants). This was even worse in 2012 where the financing by Bank of Ghana amounted to 13.2% of the total government revenue (including grants). It raises questions of whether the central bank is indeed committed to inflation targets. On the issue of financial sector development to aid transmission for a successful inflation targeting, a large number of the country's population do not have access to the banking sector. As at 2017, only 57.7% of the country's population above the age 15 hold bank and mobile money accounts according to the World Bank data. Behind this figure is the stark reality that it is even the mobile money platform that has more penetration to the rural and informal sector than the bank accounts in Ghana. In addition, the country's financial sector continues to be primary with non-existent secondary markets. The dominant sector is the banking sector, which has been plagued by liquidity and solvency issues in the recent past. Indeed, the regulator (Bank of Ghana) had to revoke the banking licenses of a number of indigenous banks in 2017 and 2018 on account of insolvency to safeguard the stability of the banking system.

Moreover, the structure of the Ghanaian economy raises questions about a single-digit inflation target on a sustainable basis. The Ghanaian economy is one that continues to export mainly primary products and imports finished and intermediate goods. The country is a net importer with frequent large current account deficits and its accompanying effect on the currency and upside inflation risk. The agricultural sector in Ghana has long been overtaken by the services sector in terms of contribution to GDP leading to importation of many of the components of the consumption basket with dire consequences for imported inflation and the effect on the country's currency and food prices. Food inflation has been a behemoth in driving inflationary pressures in Ghana and when Ghana experienced single-digit inflation for the first time in 2010, it was largely on the back of a significant fall in food inflation from 11.8% in 2009 to 4.5% in 2010. With such an economic structure and susceptibility to external shocks, a single-digit inflation on a sustainable basis is naturally questionable. The continuous failure to achieve the set targets (over the period under review) clearly demonstrates that the targets are impractical given the economic fundamentals of the economy and this is detrimental to the credibility of the Bank of Ghana and undermines the intended objective of anchoring inflation expectations with public announcement of the target. Meanwhile, public confidence is an essential building block of the foundations of inflation targeting framework.

#### 4.2. Regression results

After assessing the threshold characteristics of inflation, we now present the results in Table 5 on the response of policy to inflation and output gaps across both regimes (below and above the threshold value). In the table, the first part of the results (panel A) represents the linear global

**Table 5. Results on the Linear and Threshold Models**

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	Global OLS		Regime 1: [ $\emptyset \leq \theta$ ]		Regime 2: [ $\emptyset > \theta$ ]	
Intercept	0.034	(0.049)	-0.059	(0.058)	0.213**	(0.088)
$y_{t+k} - y_t^*$	0.041	(0.074)	0.022	(0.095)	0.095	(0.669)
$\omega_{t+k} - \omega_t^i$	0.226***	(0.076)	0.341**	(0.124)	0.113	(0.072)
Diagnostics (Linear Model)						
Observations	138					
Sum of Squared Errors	45.53					
Residual Variance	0.34					
R Squared	0.06					
Heteroscedasticity Test (p-value)	0.98					
Diagnostics (Threshold Model)						
Threshold estimate	16.4					
95% confidence interval	[8.6, 17.2]					
Observations			95		43	
R Squared			0.12		0.02	
Sum of Squared Errors			29.66		12.81	
Residual Variance			0.32		0.32	
Joint R Squared	0.12					
Heteroscedasticity Test (p-value)	0.98					

Note: \*\*\* and \*\* represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

ordinary least square results without threshold while the second part (panel B) presents the results of the two regimes (below and above the threshold).

#### **4.3. The linear model**

We find that the Bank of Ghana responds to only inflation gap in the linear model. Specifically, we find that a 1% increase in inflation gap induces a 0.23% increase in the monetary policy rate in Ghana. The findings on the inflation gap in the linear model is similar to the work of Bleaney et al. (2020) in the context of Ghana. However, the crux of the current study is the nonlinear exposition which we turn to below.

#### **4.4. The threshold model**

As the null hypothesis of no threshold is rejected, the threshold model is now considered. The analysis begins with the results in regime 1 which is the response of policy to output and inflation gaps below the inflation threshold. The results show that the inflation gap beneath the threshold is positive and significant statistically, implying that the Bank of Ghana reacts to positive inflation gap. That is, when expected inflation rises by 1% below the threshold, the Bank of Ghana adjusts the monetary policy rate upwards by 0.34%. The positive coefficient of the inflation gap below the threshold is similar to the findings of Iddrisu and Alagidede (2021) for the South African context. The size of the coefficient for Ghana is problematic especially as it involves an inflation targeting central bank that has struggled to achieve its inflation target on numerous occasions. Much as a one-to-one pass through or response is obviously not expected, a policy response of less than half of the expected inflation increase is a clear indication of inflation accommodation. This is surprising, if not worrying, as a considerable number of the inflation outcomes below the estimated threshold are still above the publicly announced inflation target range. The estimated threshold inflation of 16.4% is 6.4% more than the publicly announced upper limit of 10%. Indeed, out of the 95 inflation observations that are equal to or fall below the estimated threshold of 16.4%, as many as 58 of them are above the upper limit of 10% Ghana has set for itself. Only 34 out of the 95 observations fall below the 10% and even so it is instructive to note that all of these 34 observations are between the midpoint target of 8% and the upper limit of 10%. Two inflation outcomes out of the 95 are exactly equal to the 10% upper limit and one observation is equal to 16.4%. For an inflation targeting central bank, this is deleterious to their credibility and raises enormous doubts about their commitment to fighting inflation under a targeting framework. Losing credibility is inimical to the need to earn public trust and anchor their inflation expectations appropriately to achieve announced inflation targets.

The output gap below the threshold, although positive, is statistically insignificant, implying that the Bank of Ghana does not respond to output gap below the threshold. Putting this into context, the inflationary process in Ghana and the underlying causes that elicited responses from the central bank over the period under review were factors other than output dynamics. The years 2010 and 2018 for instance, were relatively disinflationary and the inflation outcomes in those years did fall below the inflation target (reaching 8.6% in 2010) and by extension the optimal inflation. The accommodative monetary policy stance of the Bank of Ghana in 2010 was in response to better inflation outlook underpinned by stability of the domestic currency, reduction in food inflation from 11.8% in the prior year to 4.5% in 2010 and the sluggish global economic recovery. The monetary policy rate was reviewed downwards from 18% to 16% in February 2010, then to 15% in April and finally 13.5% in July 2010. Similarly, in 2018 where inflation dropped to 9.4%, policy rate was cut by 3% cumulatively from 20% to 17% by May 2018 on the back of fiscal consolidation, strengthening of the domestic currency, falling non-food inflation and to lessen the debt servicing plight of the government to foster the fiscal consolidation drive.

Having looked at the Bank of Ghana's monetary policy response below the threshold, the policy responses above the threshold (regime 2) are considered next. We find results similar to that of the lower regime but with different coefficients. The differences in the coefficients across the two regimes is an affirmation that policy behaviour is asymmetric and corroborates the rejection of linearity observed earlier. The asymmetric responses are also similar to the findings of Caglayan et al. (2016) for the central banks of the United Kingdom and Canada, Su et al. (2016) for the central eastern European countries, Iddrisu and Alagidede (2021) for South Africa and Mgadmi et al. (2021) for Tunisia. We find that although the Bank of Ghana responds to inflation gap above the estimated threshold, the said response is statistically insignificant. Indeed, the quantum of response is lower compared to the response below the threshold. While the Bank of Ghana adjusts the policy rate upwards by 0.34% when inflation gap increases by 1% below the threshold, it increases the policy rate by 0.113% when inflation gap increases by 1% above the threshold that is insignificant statistically. The finding is much akin to that of Caporale et al. (2018) for Israel, Thailand and Turkey in their panel study where the coefficient of inflation gap in the low inflation regime is higher than the coefficient in the high inflation regime. This is surprising as policymakers are expected to respond more aggressively when inflation soars above the target. We observed that the policy responses of the Bank of Ghana to the very high inflationary periods of 2007, 2008, 2009, 2013, 2014, 2015, 2016 and 2017 where inflation exceeded announced targets speak to this policy conundrum. For instance, while inflation in 2007 increased by 2.5% on the aggregate, the accompanying policy tightening was by only 1% on the aggregate. In 2008 when inflation increased by 5.3% on the aggregate from 12.8% to 18.1%, the resulting policy tightening was an increase in policy rate by an aggregate of 3.5%. Notably, when inflation increased by 4.7% on the aggregate in 2013, policy rate was only increased by 1% on the aggregate. The Bank of Ghana must take a sterner policy stance during inflationary episodes if indeed it wants to rein in inflation and achieve the stated target to help anchor inflation expectations following its inability to meet the stated target for the greater part of the inflation targeting period. For instance, although 43 inflation observations are above the estimated threshold of 16.4%, as many as 102 inflation outcomes out of the total 138 observations are above the upper limit of 10% publicly announced. We also find that the Bank of Ghana does not respond to the output gap above the inflation threshold. While it is true that inflation was driven up by factors other than output over the years, the rather volatile output growth should have attracted the attention of the Bank of Ghana in terms of response to stabilize output. For instance, over the period under review, Ghana grew by 7.3% in 2008, then 4% in 2009, 7.7% in 2010, 14.4% in 2011 as oil production came on board, down to 7.9% in 2012, then to 7.3% in 2013, down to 4% in 2014, 3.7% in 2015 and 2016 and then 8.5% in 2017. Meanwhile, the narrow focus on inflation is not yielding the desired results either.

#### **4.5. Robustness checks**

We vary the specification of our model (for robustness checks) as we augment it with exchange rate of the Cedi to the United States dollar. The choice of exchange rate flows from the intuition that Ghana is a small open economy and therefore exchange rate plays an important role in the macroeconomic dynamics. The results, presented in Tables 6 and 7, show that our earlier findings are resilient. We find that the threshold inflation rate is still 16.4%. The Bank of Ghana is still unresponsive to output gap below and above the estimated threshold. The policy response to inflation gap above the threshold by the Bank of Ghana is still less than the policy response below the threshold, although the response above the threshold is now statistically significant.

**Table 6. Threshold Test—Robustness Check**

Moderated by	No. of Bootstrap replications	Trimming Percentage	LM-Test of no threshold	Bootstrap p-values
Inflation	5,000	15	13.48	0.012

Note: The errors are corrected for heteroscedasticity.

**Table 7. Controlling for Exchange Rate**

Panel A: The Linear Model			Panel B: The Threshold Model			
Variables	Global OLS		Regime 1: [ $\theta \leq \theta$ ]		Regime 2: [ $\theta > \theta$ ]	
Intercept	0.036	(0.056)	-0.110*	(0.061)	0.276***	(0.091)
$y_{t+k} - y_t^*$	0.042	(0.074)	0.017	(0.082)	0.503	(0.656)
$\omega_{t+k} - \omega_t^i$	0.227***	(0.077)	0.315**	(0.115)	0.172**	(0.073)
$EXCH_{t+k}$	-0.207	(1.945)	4.489*	(2.459)	-4.628***	(0.830)
Diagnostics (Linear Model)						
Observations	138					
Sum of Squared Errors	45.52					
Residual Variance	0.34					
R Squared	0.06					
Heteroscedasticity Test (p-value)	0.98					
Diagnostics (Threshold Model)						
Threshold estimate	16.4					
95% confidence interval	[14.2, 16.5]					
Observations				95		43
R Squared				0.15		0.11
Sum of Squared Errors				28.64		11.67
Residual Variance				0.32		0.30
Joint R Squared	0.17					
Heteroscedasticity Test (p-value)	0.98					

Note: \*\*\* and \*\* represent 1% and 5% significance levels respectively. The standard errors in brackets are corrected for heteroscedasticity.

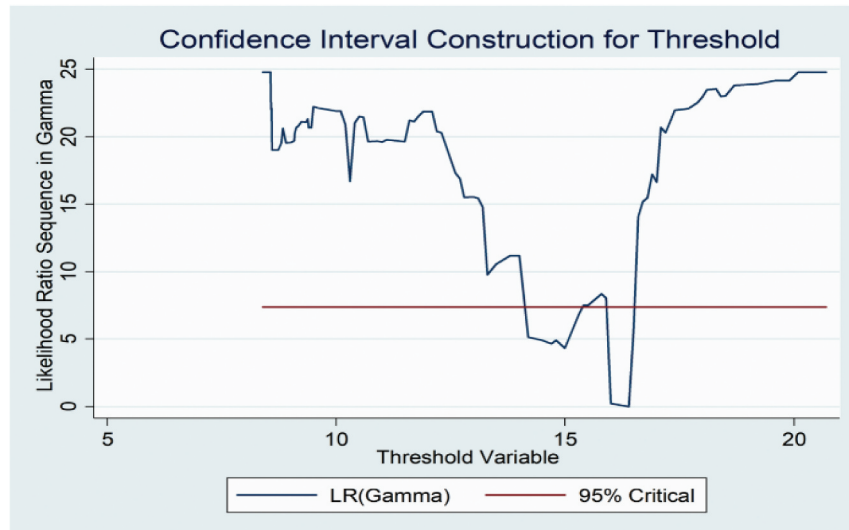
## 5. POLICY DISCUSSION AND CONCLUSION

The study estimated the monetary policy responses of the Bank of Ghana in the Taylor (1993) rule context. With a bootstrap p-value significant at 5%, the linearity proposition is rejected. In other words, the policy responses and behaviour of the Bank of Ghana are better captured by a nonlinear Taylor rule. The results from the threshold model indicate that the Bank of Ghana adjusts the monetary policy rate by 0.34% below the inflation threshold of 16.4% following a percentage change in expected inflation gap. Above the threshold, monetary policy response to inflation gap is positive but insignificant statistically. Indeed, the size of the coefficient of inflation gap above the threshold is far less than the response below the threshold.

The findings in our study carry enormous policy relevance. With an estimated inflation threshold of 16.4%, the set inflation target of  $8\% \pm 2$  is far from the country's economic credentials. Indeed, the average inflation rate of 13.35% over the period and the failure by the Bank of Ghana on



**Figure 3. Confidence Interval (Robustness).**



a number of occasions to meet the set target over the inflation targeting period lend credence to our assertion. A review of the target is necessary to help anchor inflation expectations properly. Setting an unachievable target is a sure way to reputational damage, confidence derailment and macroeconomic jeopardy. The whole inflation targeting framework thrives on central bank credibility and so continuous failure to achieve inflation targets derail the very essence and foundation of the framework that the Bank of Ghana practices. When the public gets used to these failures, it becomes very difficult to convince them that the Bank of Ghana is capable of achieving publicly announced inflation target and anchoring inflation expectations becomes very difficult, if not impossible. The finding that the Bank of Ghana is less aggressive during inflationary episodes is a serious policy challenge, if not enigma. As an inflation targeting central bank, policy restriction is expected when inflationary momentum increases. The Bank of Ghana would need to ensure policy consistency and deliver appropriate responses when inflation outlook deteriorates and when inflationary outcomes are above the set targets to engender disinflation and guide price levels to the announced targets. The rather volatile growth pattern in Ghana deserves some policy attention. The narrow focus on inflation which the country has struggled to achieve may not be helpful to the growth dynamics of the country.

The quantum of policy response relative to the rise in expected inflation is revealing of the extent of inflation accommodation by the central bank that is supposed to be targeting inflation. This is perilous to policy credibility and public confidence, which shakes the very foundation of inflation targeting framework. The Bank of Ghana would need to demonstrate commitment to reigning in inflation when it rises by taking sterner policy stance as appropriate. As indicated earlier, when the public gets used to such inflation accommodation and less commitment to fighting it, it becomes very difficult for the central bank to anchor expectations of inflation towards the publicly announced targets in the future. Public confidence is not built only by transparency through the publication of monetary policy committee proceedings and related indicators. Indeed, the level of commitment to fighting inflation and the successes thereof are perhaps more germane to public confidence building.

A typical Taylor rule involves a response of monetary policy rate (interest rate) to inflation and output gaps that have been captured by our model. Some augmentations have also been suggested in the literature including exchange rate for small open economies, which we have done as well. The inflation dynamics of Ghana also reveal important factors that drive inflation but which were not explicitly measured or included as regressors in our model. These factors are crude oil

prices, food inflation and fiscal balance, particularly the effect of debt burden. Future research should look at these variables in the policy rule construction.

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#### Disclosure statement

We do not have any conflict of interest.

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