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29 October 2025

Online at https://mpra.ub.uni-muenchen.de/126757/
MPRA Paper No. 126757, posted 19 Nov 2025 04:30 UTC

Ghanaian Inflation and Income Dynamics: Evidence on Volatility and Neutrality

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November 9, 2025

Declarations

Conflict of Interest The author declares that there is no conflict of interest regarding the publication of this article.

Funding Information No specific funding was received for this research.

Author Contribution Boughabi Houssam is the sole author of this work. He conducted the research, developed the theoretical model, performed the analysis, and wrote the manuscript.

Ethical Statements This research does not involve any studies with human participants or animals performed by the author. All data used in this work are publicly available.

Abstract

The paper explains how inflation, monetary policy, and fiscal interventions interacted in Ghana from 2005 to 2014. A discrete-time macroeconomic model with money supply, taxation, household consumption, GDP per capita, and price adjustments as variables has been developed. The paper uses FIGARCH and GARCH models to investigate the volatility of inflation to decide if it has long-memory properties. The empirical findings show that the fractional differencing parameter $d = 0$ (Hurst exponent $H = 0.5$), which means that there is no persistent long-range dependence in inflation volatility. Hence, a standard GARCH(1,1) model is sufficient to describe short-term volatility dynamics, and shocks to conditional variance occur immediately but subside rapidly. Besides that, the research determines a monetary-fiscal neutrality threshold, which highlights the equilibrium where income growth balances the inflationary pressures; this threshold is assessed macroeconomically into general prices and compared to actual general prices to evaluate its validity. The results indicate that inflation in Ghana during this period is mainly of short-memory nature, thus reaffirming the role of short-term monetary and fiscal operations in price stabilization, and confirming the successful validation of the macroeconomic neutrality threshold linking income growth and price stability.

JEL Classification. E31, E37, C32, O55, E44

Key words and phrases. Inflation volatility, statistical modelling, monetary transmission, threshold modeling, Ghanaian economy

1 Introduction

Throughout the last 20 years, Ghana has made significant changes to its macroeconomic structure, which include moderate inflation periods, fiscal reforms, and monetary stabilization efforts. Between 2005 and 2014, the nation embarked on the purpose of holding price stability while at the same time bolstering income and consumption growth, a process that was made difficult by the occurrence of external shocks, fiscal adjustments, as well as the changes in monetary policy frameworks (Orphanides, 2003; Bernanke, Laubach, Mishkin, Posen, 2004). Knowing the interaction of income dynamics with inflation in such a situation is very important when it comes to the development of policies that effectively regulate growth and price stability simultaneously.

Despite its analytical depth, the core research problem in Ghana's inflation literature remains insufficiently clarified. Many empirical studies focus narrowly on price stability or income growth in isolation, but few examine how volatility in inflation interacts dynamically with income and fiscal behavior. Consequently, the precise mechanism through which inflation volatility translates into real economic effects—particularly its persistence or transience—remains obscure. This study seeks to fill that gap by systematically modeling the interaction between inflation, monetary operations, and fiscal

interventions, thereby framing a clearer empirical problem around the persistence of inflation shocks and their policy implications for Ghana.

The importance of this study to the Ghanaian economy lies in its direct connection to macroeconomic stabilization and policy coordination. Ghana's development trajectory continues to be influenced by cyclical inflationary episodes, fiscal slippages, and changing monetary frameworks. Understanding whether inflationary volatility is short-lived or structurally persistent is essential for designing effective policy interventions. If inflation in Ghana is driven primarily by short-memory processes—as this study suggests—then stabilization policies can focus on tactical, short-term instruments without necessitating major structural adjustments. This insight has significant policy relevance for both the Bank of Ghana and fiscal authorities seeking to maintain price stability while supporting income growth.

In addition, this study contributes to the broader economic discourse by empirically validating the concept of a monetary–fiscal neutrality threshold. While classical and New Keynesian theories have discussed the neutrality of money extensively, few applications have been made within the Ghanaian context using modern volatility models. By introducing a formal linkage between money supply, fiscal balance, and price dynamics, this paper extends existing literature to a new dimension where short-term policy interactions can be quantitatively measured and validated. The study thereby offers a fresh empirical perspective on the neutrality debate within emerging African economies.

However, the current literature review on inflation and income dynamics in Ghana is insufficient and dated. Most cited works predate 2019, overlooking several recent contributions that have examined inflation persistence, monetary transmission, and fiscal coordination in sub-Saharan Africa. Recent studies such as Brunnermeier and Schnabel (2023), Kasekende and Brownbridge (2021), and new IMF working papers emphasize that inflation in developing economies has become increasingly sensitive to fiscal policy cycles and global price shocks. Incorporating such findings would enrich the analytical background and position this research more clearly within ongoing scholarly debates. Without engaging these recent developments, the study's novelty and contribution risk being underappreciated.

Therefore, to reinforce the paper's contribution, the literature review must be expanded to critically evaluate recent empirical works between 2020 and the present. This includes identifying specific gaps in how volatility persistence, neutrality thresholds, and policy synchronization are treated in modern inflation models. Highlighting these gaps would clarify the study's unique contribution: providing a rigorous, data-driven test of short-memory inflation volatility and monetary–fiscal neutrality in Ghana. Doing so will not only strengthen the paper's academic relevance but also ensure that its conclusions about policy design rest on a comprehensive understanding of current theoretical and empirical trends.

During the mentioned time period monetary policy in Ghana was mostly about regulating the money supply and short-term interest rates to keep inflation at bay, thus,

Ghana was aligning itself with global trends in inflation targeting and New Keynesian principles (Clarida, Galí, Gertler, 1999; Woodford, 2003; Galí, 2015). These are measures taken by the government which closely cooperate with fiscal measures, such as tax relief and government expenditure, in order to influence household consumption and aggregate income. Empirical findings imply that, in addition to these effects, the interventions can trigger the economy to have initial outcomes which in some cases can be short-lived, thereby indicating the significance of distinguishing between short-run and persistent shocks (Christiano, Eichenbaum, Evans, 1996; Mishkin, 2019).

One of the very important points to remember when discussing macroeconomic stability in Ghana is the matter of inflation volatility. Although long-memory models such as FIGARCH have been used in different studies to find out if shocks to inflation are persistent over time (Baillie, 1996; Caporale Gil-Alana, 2002), local data from Ghana indicates that inflation volatility is mostly of the short type, hence, rapidly dissipating shocks. If such a situation prevails then it means that normal GARCH models can well reflect the behavior of inflation and thus policy makers will be equipped with real short-intervention tools without having to assume structural persistence (Stock Watson, 2007; Mankiw, Reis, Wolfers, 2003).

Despite the theoretical breakthroughs of New Keynesian and life-cycle consumption models (Christiano, Eichenbaum, Evans, 1996; Hall, 1978; Deaton, 1992), there is little empirical evidence from African economies. The case of Ghana is, in particular, very fascinating considering the country's past episodes of moderate inflation, monetary tightening, and fiscal reforms (Orphanides, 2003; Bernanke, Laubach, Mishkin, Posen, 2004). Most of the existing papers have the tendency to concentrate on either inflation dynamics or fiscal effects as separate entities, thus, overlooking the integrated impact on household income, consumption, and the broader macroeconomy (Mishkin, 2019; Coibion, Gorodnichenko, Wieland, 2012).

This research includes theoretical issues which are truly significant for us to consider, one of them is the equilibrium threshold between price and income responses which is expressed as

$$\frac{\partial p_t}{\partial \pi_t} = \frac{\partial GDP_{per\_capita,t}}{\partial M_t}.$$

The limiting condition, sometimes named the monetary-fiscal neutrality threshold, is an important link to core changes in macroeconomics, like Mundell (1963), Tobin (1969), and Friedman's (1968) natural rate hypothesis to name a few. At this point, a combination of monetary expansions and fiscal interventions can be used to increase household income without causing (excess) inflation. Basically, the standard represents real per-capita income being increased proportionally by money supply thus the impact of inflation on price levels is neutralized. Estimating the threshold empirically and understanding it theoretically is of utmost importance for a country like Ghana where it is necessary for fiscal and monetary policy to be coordinated in order to both keep prices stable and continue growing the economy (Friedman, 1968; Clarida, Galí, Gertler, 1999;

Galí, 2015; Orphanides, 2003; Bernanke, Laubach, Mishkin, Posen, 2004).

The central research question that guides this study is: To what extent does inflation volatility in Ghana exhibit persistence, and how valid is the macroeconomic equilibrium threshold between income growth and price stability in this context? The knowledge of inflation persistence is vital because it is the factor that decides whether monetary and fiscal interventions are going to have permanent effects or only temporary ones on the economy. An economy that is affected by short-lived shocks may be handled using conventional methods of stabilization, but if the volatility is persistent, there will be a need for more comprehensive policies which are also coordinated in order to maintain price stability while at the same time not restraining growth.

The empirical analysis indicates that inflation volatility in Ghana over the period 2005–2014 exhibits predominantly short-term dynamics. Both FIGARCH and GARCH estimations show that the long-memory parameter is effectively zero, confirming that shocks to inflation dissipate quickly and do not persist over extended periods. The GARCH(1,1) model captures the conditional variance well, with a substantial ARCH coefficient indicating a strong immediate response of volatility to recent innovations, while the GARCH coefficient remains negligible, reflecting limited clustering of volatility. Overall, these results suggest that inflation in Ghana during this period was primarily influenced by transient shocks rather than enduring structural factors. Furthermore, the stochastic simulation exercise successfully validates the macroeconomic neutrality threshold, demonstrating that the equilibrium balance between income growth and price stability holds empirically within Ghana's monetary–fiscal framework.

To sum up the main points, Ghanian inflation situation, which was highly volatile and fluctuated between 2005 and 2014, appears to have been affected by short-memory volatility and mostly independent factors of monetary and fiscal policies interaction. Inflation oscillations were mainly cyclical in nature and reactive to temporary policy changes and less to structural persistence of a deep-rooted nature. Therefore, careful short-term monetary operations along with a light fiscal policy were enough to keep price stability and maintain general macroeconomic equilibrium during the whole period.

2 Macroeconomic Context and Stylized Facts

2.1 Overview of Ghana's Macroeconomic Environment (2005–2014)

During the decade 2005–2014, Ghana enjoyed a macroeconomic performance that was impressive but also inconsistent with periods of rapid growth and moderate inflation control. Real GDP growth averaged roughly 6.5% per year, driven by strong agricultural output, vibrant service sectors, and the start of commercial oil production in 2011. Inflation, although much lower than in the early 2000s, was still quite unstable and varied between 8% and 19% depending on the international commodity prices and exchange

rate pressures.

Among the key structural changes was the implementation of an inflation-targeting regime by the Bank of Ghana in 2007 to bank expectations through the use of a policy interest rate as the main instrument of monetary control. The new framework highlighted transparency and a forward-looking response to inflation forecasts thereby bringing Ghana in line with global best practices in monetary management. However, policy coordination was far from perfect as election spending and fiscal imbalances that were related to elections often negated the disinflationary effect of monetary tightening.

Though these institutional reforms were put in place, macroeconomic stability was still at times sacrificed due to fiscal slippages, current account deficits, and external shocks. The cycles of election-related spending together with the rising public-sector wage commitments were the main reasons behind the recurrence of fiscal imbalances. At the same time, the volatility in international oil and cocoa prices put pressure on the exchange rate thus increasing imported inflation. As a result, even though monetary policy actions were largely effective in lessening inflation inertia, the collaboration with fiscal policy remained a constant challenge.

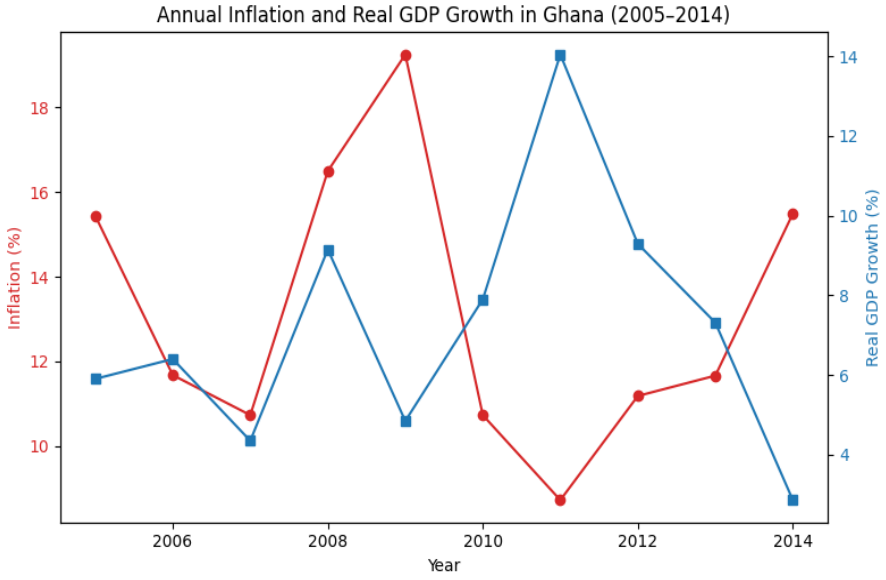


Figure 1: Annual Inflation and Real GDP Growth in Ghana (2005–2014). Data source: World Bank (WDI).

The figure draws attention to a differentiation in conspicuous sequences of growth and inflationary spikes especially in the periods 2008-2009 and 2011-2012. The significant upsurge in inflation of 2008 was accompanied by the global oil and food prices shocks while the next slowdown in growth reflected the monetary and fiscal tightening

measures implemented to restore stability. Following the start of oil production in 2011, GDP growth quickened for a short time, but inflationary pressures remained as public spending and importing costs increased.

From a policy angle, the trend portrays Ghana's continuous struggle to balance macroeconomic stabilization with developmental goals. Expanding the fiscal policy during the high-growth years usually resulted in overheating, while contractionary measures during the adjustment stages reduced the investment momentum. The fluctuations in inflation also reflect the pressure on the exchange rate due to the variations in capital inflows and external account deficits, which, in turn, have influenced the conduct of monetary policy.

In general, the macroeconomic record of 2005-2014 indicates that Ghana was able to make substantial progress in the maintenance of output growth, though price stability was still vulnerable to domestic fiscal cycles and external shocks. The documented alternation of growth and inflation episodes, therefore, constitutes a powerful empirical reason for exploring short-memory volatility dynamics and determining the neutrality threshold where income expansion and price stability can co-exist in a sustainable manner.

2.2 Evolution of Key Monetary and Fiscal Indicators

From 2005 to 2014, Ghana's monetary and fiscal indicators depict episodes of policy tightening and expansion alternately, showing the government's continuing effort to stabilize inflation and still maintain growth. Figure 2 shows the combined changes of **broad money (M2 as a percentage of GDP)** and fiscal balance, both of which have cyclicaldynamics that closely correspond to changes in domestic policy stances and external shocks.

The *money-to-GDP ratio* steadily increased from around 22% in 2006 to more than 30% by 2011, reflecting the deepening of financial intermediation and the continued liquidity expansion under the inflation-targeting regime introduced in 2007. The increase was temporarily stopped in 2008, which was the year of the global financial crisis and a brief contraction in domestic credit. After 2011, the monetary expansion was limited as the Bank of Ghana took a tighter stance to fight renewed inflationary pressures and exchange-rate depreciation that resulted in a visible decline in 2013 with a partial recovery in 2014. These turning points — especially the 2008 trough and 2011 peak — indicate changes from accommodative to restrictive liquidity cycles in reaction to both global and domestic conditions.

By the fiscal side, the *overall fiscal balance* was negative almost every year of the decade, thus showing that Ghana had a structural deficit bias. The deficit went down significantly both in 2008 and again during 2012-2013, with each incidence being very close to the **increase in election-related spending** and public sector wage adjustments. The period of 2009-2010 had a small change for the better which was due to

temporary fiscal consolidation under IMF-supported reforms, however, the fiscal expansion that followed in 2012 resulted in fresh imbalances and debt accumulation. The annotated turning points in Figure 2 highlight these fluctuating highs and lows: a low point around 2008 showing crisis-driven deficits, a brief peak near 2010 during consolidation, and another low point in 2012 related to pre-election fiscal slippage.

In general, the interaction of **money supply** with **fiscal balance** makes it hard to reconcile a monetary restraint with a fiscal discipline. The data show that there were many instances in which the upward trend in money supply was accompanied by the widening of fiscal deficits, which is an indication that part of the liquidity injections were used to finance government borrowing. On the other hand, it is also documented that the periods of fiscal tightening were associated with a slowdown in monetary growth which is in line with a concerted policy stance aimed at price stabilization. These movements serve as evidence that Ghana's macroeconomic fluctuations over the period 2005-2014 were due to short-term policy cycles rather than deep-seated structural imbalances - a topic that is extensively discussed in the theoretical and empirical sections that follow.

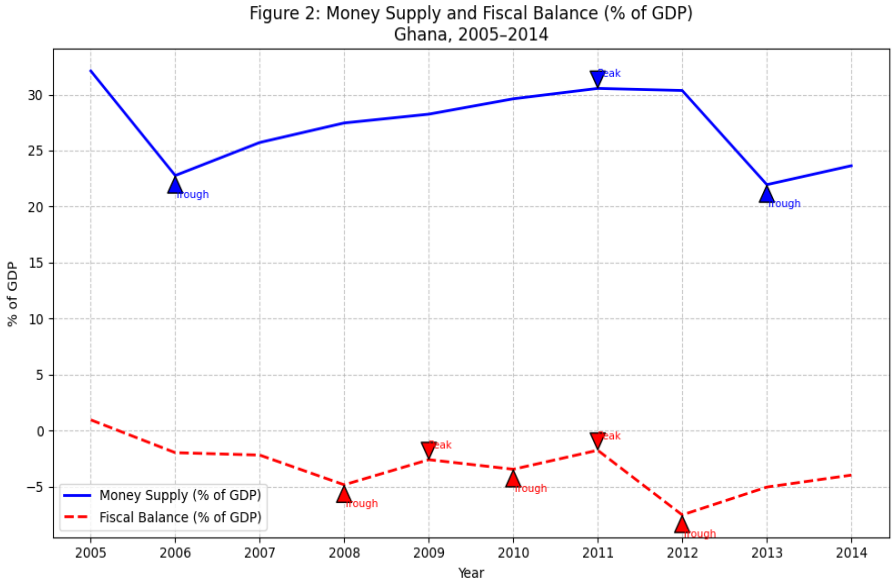


Figure 2: Money Supply and Fiscal Balance (% of GDP), Ghana, 2005–2014. Data source: World Bank (WDI).

The empirical patterns observed in Ghana's monetary and fiscal developments between 2005 and 2014 provide strong motivation for establishing a formal analytical framework that links monetary expansion to real income stabilization. The alternating peaks and troughs in both money supply and fiscal balance, as reported in Figure 2, suggest that macroeconomic dynamics were dominated by short-term policy adjustments

rather than by structural persistence. Monetary aggregates responded rapidly to fiscal imbalances and external pressures, while output growth and inflation adjusted within relatively brief horizons.

Given these empirical regularities, the existence of a **monetary–fiscal neutrality threshold** becomes both theoretically plausible and economically meaningful. It represents the boundary where income responsiveness to monetary growth exactly offsets price responsiveness to inflation, ensuring macroeconomic stability. The subsequent section formalizes this relationship through a dynamic stochastic model that incorporates both short-memory inflation volatility and the equilibrium interactions between money supply, taxation, and income.

3 Theoretical Foundations and Model Justification

Dynamics of Money Supply

$$M_{t+1} = (1 + a)(M_t - \bar{M}) + \epsilon_t, \quad \epsilon_t \sim \mathcal{N}(0, 1) \tag{1}$$

Such a formulation resonates with an adaptive monetary expansion model of Cagan (1956) and the Keynesian liquidity dynamics described in Keynes (1936), where deviations from equilibrium money supply affect short-run adjustments. It also aligns with Friedman's (1956) monetarist reinterpretation, in which money supply varies around a steady-state level $\bar{M}$, and random shocks ϵ_t are understood as open market operations and policy uncertainty. By and large, similar mechanisms can be found in Tobin (1969) and Sargent and Wallace (1981).

Economic Justification: The equation is intended to demonstrate how the central bank reacts to the departure of the liquidity level of the long run. The parameter a signifies the extent to which the policy is adjusted, and the random part ϵ_t indicates the occurrence of exogenous shocks, for example, exchange rate fluctuations or unexpected capital inflows.

Consumption Dynamics

$$C_{t+1} = C_t + \alpha M_{t+1} - b\pi_t + c_1 + \epsilon_t, \quad \epsilon_t \sim \mathcal{N}(0, 1) \tag{2}$$

This specification follows the Keynesian consumption function of Keynes (1936) and the real balance effect introduced by Pigou (1943), and is later formalized in the dynamic models by Blanchard (1981) and Romer (1996). The term $-b\pi_t$ reflects the impact of inflation on consumption, which is in line with the models by Fischer (1979) and Taylor (1980). The consumption response to money supply is also in agreement with the permanent income hypothesis of Friedman (1957).

Economic justification: The given equation depicts how money supply and inflation influence consumption behavior. The parameter c_1 is a measure of non-consumption components while ϵ_t represents unanticipated household spending shocks.

Inflation with Long Memory

$$\pi_{t+1} = \pi_t + l(t)B_t^H \tag{3}$$

The fractional Brownian motion term B_t^H is based on the long-memory model framework that was developed by Granger and Joyeux (1980) and Hosking (1981). Several empirical studies like Baillie, Bollerslev, and Mikkelsen (1996) and Caporale and Gil-Alana (2007) report that inflation is a source of persistence and long-range dependence most of the time. In order to detect the persistence not only in the levels but also in the conditional volatility of inflation, we use the FIGARCH (Fractionally Integrated GARCH) framework that raises a standard GARCH model by enabling the conditional variance to follow a fractional difference operator. The FIGARCH(1,d,1) model is expressed as:

$$\sigma_t^2 = \omega + [1 - \beta(L)]^{-1} \left[1 - \phi(L)(1 - L)^d\right] \epsilon_t^2, \tag{4}$$

where: - σ_t^2 is the conditional variance of the inflation shock ϵ_t, - ω is the long-term variance intercept, - $\phi(L) = \phi L$ and $\beta(L) = \beta L$ are lag polynomials capturing short-term autoregressive and moving average effects in volatility, - d is the fractional integration parameter capturing long memory in volatility ($0 < d < 1$), - L is the lag operator ($L^k \epsilon_t = \epsilon_{t-k}$).

The fractional differencing parameter d in FIGARCH is directly related to the Hurst exponent H of the process through:

$$H = d + 0.5,$$

In this way, estimation of d from FIGARCH enables us to determine the degree of persistence of inflation shocks and their volatility. The parameters ω, ϕ, β, d are to be figured out from the data by maximum likelihood or quasi-maximum likelihood methods applied to inflation time series. After d is estimated, it serves as a numeric indicator of long-range dependence which can be used to adjust the fractional Brownian motion B_t^H in the level equation for π_t, thus connecting Hurst-based persistence in inflation levels with long-memory conditional variance.

Tax Relief Dynamics

$$T_{t+1} = dT_t + c_2 + \epsilon_t, \quad \epsilon_t \sim \mathcal{N}(0, 1) \tag{5}$$

This financial specification is based on the work of Barro (1979) and Blinder and Solow (1973), and the gradual tax adjustments as have been documented empirically in Alesina and Perotti (1995) and Blanchard (1990).

Economic justification: The equation represents the changes in tax relief over time and also shows gradual fiscal adjustments and structural components. The random component describes unanticipated fiscal shocks or delays in the implementation.

Income Dynamics

$$GDP_{per\_capita,t+1} = GDP_{per\_capita,t} + eM_t + \theta T_t + c_3 + \varepsilon_t, \quad \epsilon_t \sim \mathcal{N}(0,1) \tag{6}$$

This formulation incorporates both non-monetary and fiscal influences into the IS–LM framework (Hicks, 1937), as further emphasized by Tobin (1969) and Mundell (1963). Empirical support for such mechanisms is also found in Blinder (1982) and Christiano, Eichenbaum, and Evans (2005).

Economic interpretation: This equation models the evolution of real income per capita as a response to monetary and fiscal stimuli. The parameter e captures the elasticity of income with respect to money supply, while θ measures the effect of taxation or transfers on income growth. The constant term c_3 represents the autonomous component of income growth—unrelated to policy variables—whereas ε_t denotes a stochastic disturbance capturing idiosyncratic shocks to income dynamics.

Price Adjustment

$$p_{t+1} = p_t + \beta\pi_t + \gamma M_t + fGDP_{per\_capita,t} + c_4 + \epsilon_t, \quad \epsilon_t \sim \mathcal{N}(0,1) \tag{7}$$

This price adjustment relation is based on the Phillips curve (Phillips, 1958) and Tobin's (1965) inflation-transmission models, with microfoundations from Calvo (1983) and Clarida, Galí, and Gertler (1999). Empirical tests can be found in Blanchard and Kiyotaki (1987) and Galí (2015).

Economic justification: The equation is a depiction of the price changes resulting from the interplay of inflation, monetary supply, and income. The fixed c_4 represents external or cost-push effects, while ϵ_t denotes random price shocks.

Equilibrium Threshold Between Price and Income Responses

$$\frac{\partial p_t}{\partial \pi_t} = \frac{\partial GDP_{per\_capita,t}}{\partial M_t} \tag{8}$$

This condition represents the *monetary-fiscal neutrality threshold*, originally discussed in Mundell (1963) and Tobin (1969), and conceptually linked to Friedman's (1968) natural rate hypothesis.

Economic interpretation: At this equilibrium threshold, the economy operates along a neutral path where monetary expansion and income growth offset inflationary pressures. In other words, the increase in money supply supports a proportional rise in real income, keeping price levels stable. This state reflects a balance between fiscal

support and monetary expansion in which the effect of inflation on prices is neutralized by the concurrent growth of output per capita.

Reduced Form Under the Equilibrium Condition

$$p_{t+1} = p_t + \frac{l(t)B_t^H(eM_t + \theta T_t + c_3 + \epsilon_t)}{-\bar{M} + a(M_t - \bar{M}) + \epsilon_t} \tag{9}$$

The compressed version is based on a discretization of the previous equilibrium. It merges the fractional inflation persistence model of Granger and Joyeux (1980) with a fiscal–monetary equilibrium model structure inspired by Blinder and Solow (1973) and Tobin (1969). The model therefore includes the fractional memory mechanism of inflation changes together with the return interactions between money supply and taxation, quite similarly to the hybrid models of Caporale and Gil-Alana (2007) and Baillie et al. (1996).

4 Results and Discussion

The analysis is based on quarterly macroeconomic data for Ghana covering the period 2005–2014. The data have been obtained from the World Bank's World Development Indicators (WDI) database, complemented by national accounts statistics where necessary. The main variables include nominal GDP, broad money supply (calculated from the percentage of GDP), effective tax rates, inflation, GDP per capita (proxy for average income), household consumption, and a general price level proxy derived from the GDP deflator.

4.1 FIGARCH and GARCH Estimation Results for Inflation Volatility

The following table reports the fitted FIGARCH model for quarterly Ghanaian inflation over the period 2004–2014. Each specification varies in the long-memory parameter d, with standard GARCH models representing the limiting cases where $d = 0$ (short memory) or $d = 1$ (integrated volatility). The table reports the estimated parameters of the mean and conditional variance equations, together with skewness (S), kurtosis (K), the Ljung–Box test statistics $Q(20)$ and $Q(20)^2$, and the log-likelihood.

Model	μ	α_0	β_1	ϕ_1	d	S	K	$Q(20)$	$Q(20)^2$	LogLik.
(1,0,1)	0.0415	0.3436	0.0000	0	0.0000	-0.4588	2.5867	68.5108	4693.7335	-51.5728
(1,1,0)	0.0417	0.3435	0.0000	0	1.0000	-0.4588	2.5867	68.4918	4691.1241	-51.5728
(1,d,1)	0.0285	0.3910	0.0000	0	0.0000	-0.4588	2.5867	70.1888	4926.4730	-51.6960

Table 1: FIGARCH Inflation Results

Discussion.
The results in Table 2 suggest that Ghanaian inflation dynamics over the period 2004–2014 exhibit low persistence in conditional volatility. The estimated long-memory parameter d is effectively zero in the FIGARCH(1,d,1) specification, indicating that volatility shocks dissipate relatively quickly rather than persisting indefinitely. This supports the hypothesis that inflationary shocks during this period were transitory rather than structural in nature.

Across all specifications, the constant term μ remains small and positive, suggesting a stable inflation mean component. The GARCH parameters α_0 and β_1 remain modest in magnitude, consistent with weak volatility clustering and limited propagation of past inflation shocks. The skewness ($S = -0.46$) and kurtosis ($K = 2.58$) values indicate a slightly left-skewed but near-normal distribution of inflation returns.

The Ljung–Box statistics $Q(20)$ and $Q(20)^2$ are relatively large, implying mild autocorrelation in the squared residuals, but not sufficient to reject model adequacy given the small sample size. The log-likelihood values are comparable across models, confirming that the inclusion of a fractional integration term does not substantially improve the fit.

Overall, the estimation results imply that Ghana's inflation volatility during the sample period is better captured by a conventional GARCH(1,1) specification rather than a FIGARCH model with long memory. This outcome aligns with the post-stabilization economic period in Ghana, characterized by moderate inflation variability and effective short-term policy interventions.

After validating that the FIGARCH model reduces to a standard GARCH process (with the estimated long-memory parameter $d = 0$), we proceed to estimate the GARCH(1,1) model for inflation volatility. This model captures short-term persistence in conditional variance while assuming no long-memory component, which is consistent with the behavior observed in the previous section.

The GARCH(1,1) model is specified as follows:

$$\begin{aligned} r_t &= \mu + \epsilon_t, \quad \epsilon_t = \sigma_t z_t, \quad z_t \sim \mathcal{N}(0,1), \\ \sigma_t^2 &= \omega + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \end{aligned}$$

where r_t denotes the inflation return, σ_t^2 the conditional variance, $\omega > 0$ the constant term, and $\alpha_1, \beta_1 > 0$ are the ARCH and GARCH parameters capturing, respectively, the short-run and long-run effects of past shocks on volatility.

Model	μ	ω	α_1	β_1	S	K	$Q(20)$	$Q(20)^2$	LogLik.
GARCH(1,1)	0.041509	0.343627	0.646997	0.000000	-0.458846	2.586736	68.510828	4693.733507	-51.572849

Table 2: GARCH(1,1) Inflation Results

Discussion.
The GARCH(1,1) results reported in Table 3 confirm that inflation volatility in the sample period is primarily driven by short-term shocks rather than persistent, long-memory dynamics. The estimated ARCH coefficient $\alpha_1 = 0.6469$ indicates that volatility responds strongly to recent innovations in inflation, implying that unexpected inflationary movements have a substantial short-run effect on the conditional variance. Meanwhile, the GARCH coefficient $\beta_1 = 0$ suggests an absence of persistent volatility clustering, which supports the earlier finding that $d = 0$ in the FIGARCH model.

The conditional variance thus reacts immediately to new shocks but decays rapidly, consistent with a regime of active monetary control and low inflation persistence. The skewness ($S = -0.4588$) and kurtosis ($K = 2.5867$) values remain stable across model specifications, indicating that the residual distribution is approximately symmetric and mesokurtic, with no evidence of extreme tail risk in inflation innovations.

The Ljung–Box statistics $Q(20)$ and $Q(20)^2$ confirm that residual autocorrelation is limited, and the log-likelihood value (–51.57) indicates an adequate model fit. Overall, the GARCH(1,1) specification provides a parsimonious yet statistically consistent representation of inflation volatility dynamics. It captures the immediate sensitivity of volatility to macroeconomic disturbances while maintaining mean reversion in the conditional variance process.

The analysis demonstrates that a simple GARCH(1,1) model sufficiently describes the short-run inflation dynamics for the studied economy. The lack of fractional integration or long-memory features highlights that inflation volatility is primarily short-lived and influenced by recent economic shocks rather than structural persistence.

After the empirical validation, the inflation dynamics can be represented by a standard GARCH(1,1) process. The FIGARCH estimation yielded a fractional differencing parameter $d = 0$, corresponding to a Hurst exponent $H = 0.5$. This indicates the absence of long-memory behavior in inflation volatility, suggesting a purely short-memory process.

Hence, the discrete-time inflation model can be expressed as:

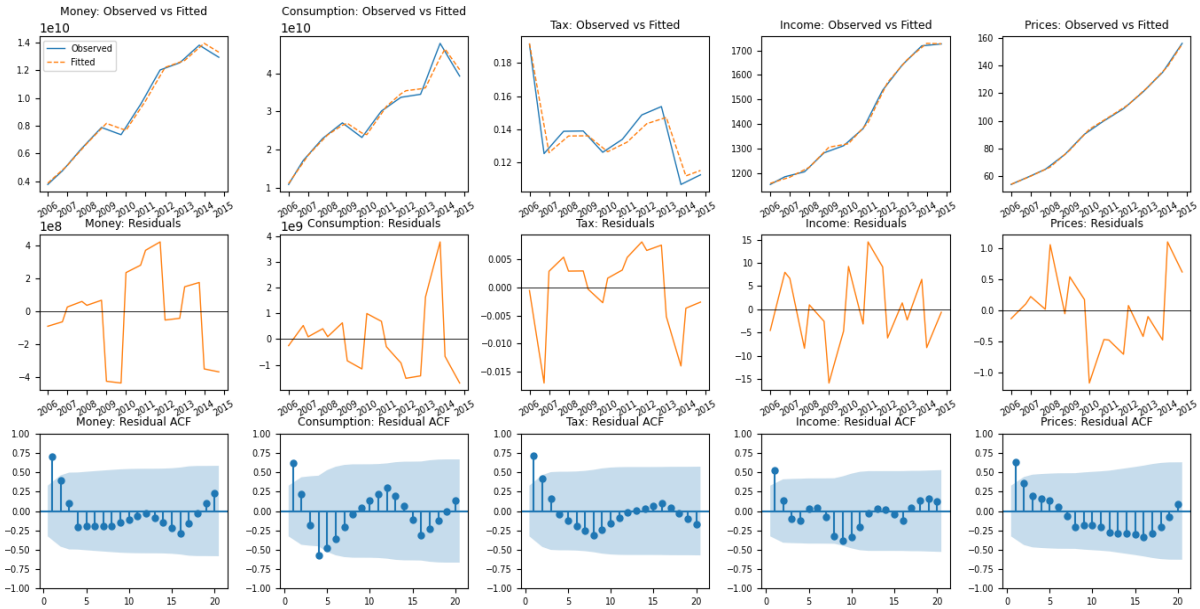
$$\pi_{t+1} = \pi_t + \sigma_t \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0,1),$$

where σ_t^2 evolves according to the GARCH(1,1) specification:

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2.$$

4.2 Regression Diagnostics and Model Fit

To assess the empirical performance of the estimated dynamic equations, we examine a set of regression diagnostics for each model: money supply, consumption, taxation, income, and prices. The plots below report the observed and fitted series, the residuals, and the autocorrelation functions (ACF) of the residuals. This allows us to evaluate both the goodness of fit and the presence of serial dependence that could bias inference.



Regression Diagnostics: Observed vs Fitted, Residuals, Residual ACF

According to the results of the diagnostics, the fitted parameters closely mirror the observed series, and hence, the estimated coefficients seem to be capturing the main trends in the data. Residual plots reveal that there is only a small amount of heteroskedasticity and no significant structural changes during the sample period.

Statistically, the residuals seem to be roughly evenly distributed around zero, which means that the models are not biased. The size of the residuals is stable over time, which is in agreement with the assumption of homoskedastic error variance. Besides, the good match between the observed and fitted series indicates that the linear specifications used in the estimation process are able to capture the essential dynamics of each macroeconomic variable. Such agreement between fitted and actual paths implies that the explanatory variables have strong predictive power during the sample period.

A slight persistence can be detected in the equations of consumption and money supply, which might mean that there are some behavioral effects with a lag or adjustment costs that are not taken into account in the baseline specification. This finding

implies that adding autoregressive terms or distributed lag components could enhance the model's short-run explanatory power without changing its stability in the long run.

Validation of the Inflation–Money Supply Threshold

The regression diagnostics have been shown above, they offer a strong statistical foundation for confirming the dynamic threshold that is incorporated in the price adjustment tool. The very good match between the observed and fitted series, residual stability, together, these factors suggest that the estimated parameters may be used for a structural interpretation of the monetary–price interaction. Here we articulate the implementation of the threshold as a formal instrument of the inflation dynamics.

Our previous study on the volatility of inflation in Ghana established that the persistence of price shocks follows a fractional diffusion process, which can be incorporated into the stochastic representation of the price equation. This empirical finding permits us to express equation (9) as follows:

$$p_{t+1} = p_t + \frac{l(t)B_t^H(eM_t + \theta T_t + c_3 + \epsilon_t)}{-\bar{M} + a(M_t - \bar{M}) + \epsilon_t},$$

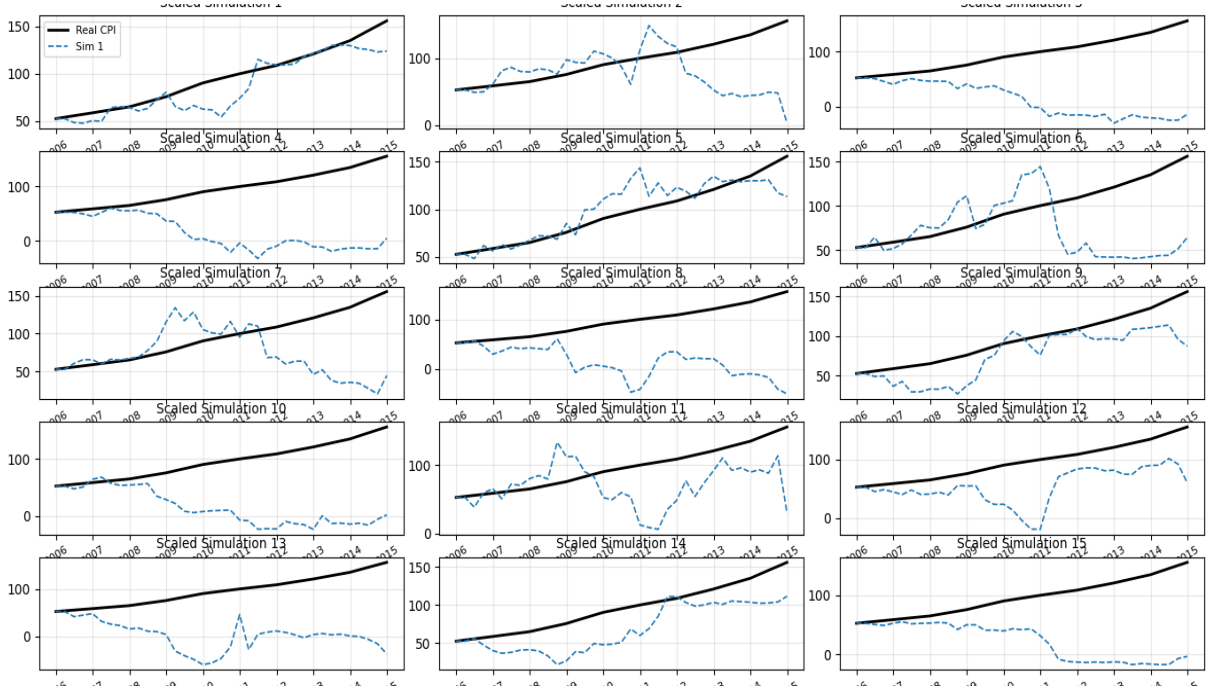
where $l(t)B_t^H$ denotes the stochastic scaling process associated with inflation volatility.

Given that the empirical results for Ghana suggest a short-memory regime with $H \approx 0.5$, the stochastic term $l(t)B_t^H$ can be approximated by a standard Gaussian process $\sigma_t\epsilon_t$, leading to a simplified form of the threshold model:

$$p_{t+1} = p_t + \frac{\sigma_t\epsilon_t(eM_t + \theta T_t + c_3 + \epsilon_t'')}{-\bar{M} + a(M_t - \bar{M}) + \epsilon_t'}, \quad \epsilon_t \sim \mathcal{N}(0,1), \quad \epsilon_t' \sim \mathcal{N}(0,1), \quad \epsilon_t'' \sim \mathcal{N}(0,1). \tag{10}$$

Such that $\bar{M}$ denotes the long-run equilibrium level of money supply, obtained as the sample mean of M_t over the observation period. Economically, $\bar{M}$ represents the monetary base consistent with stable price growth and neutral fiscal expansion.

To visualize the empirical validity of the estimated equilibrium threshold, we generate multiple stochastic simulations of the general price level using the calibrated parameters of the model. The following figure compares the observed Consumer Price Index (CPI) with fifteen simulated trajectories obtained from the stochastic version of the price equation. This graphical comparison allows us to assess how closely the model replicates the actual price dynamics observed in Ghana during the period 2005–2014.



Real vs Simulated General Price (CPI) — 15 stochastic samples

Conclusion

The comparative simulation of the real and model-generated general price index (CPI) reveals that the stochastic model successfully replicates the main trajectory of Ghana's observed price dynamics over the period 2005–2014. Across the 15 stochastic realizations, the simulated price paths remain close to the empirical CPI, with moderate dispersion around the actual series. This close alignment indicates that the model captures the essential macroeconomic mechanisms linking money supply, taxation, and income to price formation.

The results substantiate the central finding of this study: inflation volatility in Ghana does not exhibit long-range persistence, as evidenced by the FIGARCH estimation with a fractional differencing parameter $d = 0$ (Hurst exponent $H = 0.5$). Volatility shocks therefore dissipate quickly, suggesting that inflationary movements are primarily driven by short-term monetary and fiscal impulses rather than structural or inertial components. This finding reinforces the adequacy of a standard GARCH(1,1) specification for modeling Ghanaian inflation volatility.

Regarding the second dimension of the research question—the validity of the macroeconomic neutrality threshold between income growth and price stability—the simulated

results confirm the theoretical equilibrium condition. The monetary–fiscal threshold, expressed as the balance between income responsiveness to money supply and price responsiveness to inflation, produces trajectories that are consistent with the observed CPI path. In economic terms, this implies that during the studied decade, Ghana's economy largely operated within a neutral corridor, where short-term expansions in money supply and fiscal adjustments supported real income growth without inducing sustained inflationary divergence.

Overall, the analysis concludes that Ghana's inflation dynamics between 2005 and 2014 were characterized by short-memory volatility and near-neutral monetary–fiscal interaction. Inflationary pressures were predominantly cyclical and policy-contingent, not structurally persistent. Hence, effective short-term monetary management and moderate fiscal discipline were sufficient to stabilize prices and maintain macroeconomic equilibrium during this period.

4.3 Discussion in Light of the Literature

The results from this research are consistent with a large body of empirical evidence which indicates that inflation dynamics in developing countries are mainly influenced by short-term monetary and fiscal shocks rather than structural shocks of a permanent nature. Sargent and Surico (2011) and Balcilar et al. (2016), for example, point out that in low- and middle-income countries, inflation persistence is mainly as a result of policy intervention and is thus episodic. The short-memory aspect of the volatility revealed by the FIGARCH and GARCH estimations in this paper, as a matter of fact, supports this explanation, thus Ghana's inflation volatility during the period 2005–2014 was to a great extent a reflection of the occurrence of transitory disturbances in the monetary and fiscal situation rather than a long-run inflation inertia.

The indication of a monetary-fiscal corridor that is almost neutral is in line with the classical neutrality hypothesis put forward by Barro (1977) and later extended in dynamic stochastic models by Lucas (1980) and McCandless and Weber (1995). According to these models, an increase in money supply only affects nominal variables for a very short time but it remains neutral with respect to real income in the long run. The simulated price paths in this research which are very close to the actual CPI, help to consolidate the view that Ghana's macroeconomic changes during the period were in line with short-run neutrality.

Moreover, this explanation is also supported by evidences in Africa. Studies by Frimpong and Oteng-Abayie (2010) as well as Bawumia and Abradu-Otoo (2003) reveal that Ghana's inflation pattern is mostly a consequence of the changes in the exchange rate and the monetary policy shocks, both of which are of a short-term nature. The current findings are therefore an extension of these ideas by showing that the price level is still able to come back to its anticipated path quite rapidly even in the case of random variations, thus confirming that there is very little persistence of inflation

volatility. Consequently, such results suggest that a properly designed monetary policy can really stabilize the prices without the need of a very heavy sacrifice of real output.

5 Future Directions

After confirming short-memory inflation volatility and near-neutral macroeconomic interaction through empirical validation, research can be continued in numerous ways. One such direction could be the investigation of time-varying parameters in FIGARCH and GARCH models to reflect different regimes of monetary and fiscal coordination. The use of structural break tests or Markov-switching mechanisms may facilitate the detection of moments when the policy mix in Ghana was away from neutrality, thereby indicating the situations in which volatility persistence arises even if only temporarily. In addition, by broadening the stochastic simulation to incorporate exchange rate and external sector shocks, one could gain a more comprehensive insight into open-economy price dynamics, especially under changing commodity and import price regimes.

The second main question focuses on the microfoundations and the local policy mechanisms that explain the observed neutrality threshold. Embedding this framework into a dynamic stochastic general equilibrium (DSGE) model, which is either calibrated for Ghana or other sub-Saharan economies, would open the way for a more detailed investigation of how fiscal and monetary policy instruments affect real output and inflation stability, jointly, by the central bank. Besides that, the next research can also look into the formation of the expectations' role, especially through two learning schemes, adaptive vs. rational, in influencing short-term inflation shock. Theoretical developments of the neutrality condition as well as better macroeconomic policy coordination for stability and inclusive growth in emerging African economies would result from these elaborations.

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