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Monetary Policy in a Markov-Switching VECM: Implications for the Cost of Disinflation in Ghana

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Abstract: Monetary policy assessment in Ghana has been conducted using vector auto-regression. This however, presumes stability of long run outcomes and particularly ignores monetary policy regime changes that has characterized the economy overtime. This study thus introduced the possibility of switches in the long run equilibrium in co-integrated vector auto-regression by allowing both the covariance and weighting matrix in the error-correction term to switch. The study did not find any significant difference in monetary response in the different states. However, significant difference was obtained for the cost of disinflation across states. Though, disinflation cost has declined as the Bank of Ghana shifts from monetary targeting to inflation-targeting regime, overall cost is still high. This has implication on disinflation policy given the development agenda pursue by the country.

Keywords: Monetary Policy, Markov-Switching, Sacrifice Ratio JEL Classification: E31 E52

Introduction

Monetary policy has been the main tool used for macroeconomic stabilization in Ghana. Overthe years, the monetary framework has undergone important changes regarding implementation (shocks) and policy (regime) framework. The policy regimes involve switches in the policy rule (i.e., from credits to interest rate instruments) to reflect monetary authorities' reaction to targetinflation and output. Emerging from a direct control approach, monetary policy has evolvedvia monetary targeting approach (an indirect approach under the requirement of structuraladjustment program) to its current state of inflation targeting.

These evolution processes aim to enhance the impact of monetary actions on the aggregateeconomy. Though, monetary policy objectives compose of wide range of aggregates (includinggrowth, exchange rate stability, interest rate and among others), its paramount effort is tocurtail the high prices that have bedeviled the economy through disinflationary strategies. This is predominantly motivated by the high cost associated with high and volatile prices.

However, following from Okun (1978), there is potential loss in output or employmentassociated with disinflationary policy. Given that Ghana is a developing country and desires toaccelerate growth in its development path, knowledge about the cost of disinflationary policiesis worthwhile. This will guide monetary policy implementation because policy makers will beguided by the economic cost of their actions in terms of output loss.

Also, the regime changes can potentially have a large effect on the volatility of money, interest rates, outputs and prices. This study thus investigates monetary shocks by exploringthe cost implication of regime changes on the disinflation strategy adopted by Ghana. Theinvestigation is conducted within the periods 1960 to 2013. We conduct this study for Ghanabecause no literature has been identified on this theme. Secondly, since the focus of the Bank of Ghana is price stability, it is important to understand the economic effect of thispolicy directions in terms of output loss. This is because a fore knowledge of the economic costassociated with the disinflation policy will aid monetary authorities in implementing monetarypolicy.

The study adopted the modelling approach based on multivariate Markov-Switching Vectorerror Correction Model (hereafter MS-VECM). This strategy explicitly allows for regime changesin the variables since Ghana overtime has been characterized by different monetary and policyregime. The regime changes might have potential stochastic effects on both the short and longrun dynamic impacts of monetary policy. MS-VECM modelling approach can accountfor the long run properties in this

regard. Existing evidence on the impact of monetary policy in Ghana were based on vector error correction model but the results are mixed (Abradu-Otoo *et al*., 2003). Hitherto VAR models assume linearity and thus are unable to representmany non-linear dynamic patterns such as asymmetry, amplitude dependence and volatilityclustering. For example, GDP growth rates typically fluctuate around a higher level and aremore persistent during expansions, but they stay at a relatively lower level and are less persistentduring contractions. Given this peculiarity, it would not be reasonable to expect a single, linearmodel to capture these distinct behaviors.

Also, the underlying linearity assumption implies that the dynamic multipliers obtainedfrom the VAR are invariant about the history of the system, size and sign of theshocks. However, the time-invariance of the parameters and Gaussianity are problematic for thebetter understanding of monetary policy shocks in Ghana especially regarding the structuralshocks that has characterized the economy overthe period. For example, as Fig. 2 show, the distribution of GDP and CPI are bi-model. This implies that the single distributionalassumption used in hitherto VAR might have probable inference consequences on the estimatesand monetary behavior in Ghana. Hence, this paper in its first attempt for Ghana providesan important contribution to the literature in this context.

The study proceeds with section 2 providing a brief literature on monetary policy in Ghana. Section 3 describes the econometric strategy employed. Section 4 presents the results anddiscussion whiles section 5 concludes the study with some policy recommendations.

Literature Review

The empirical literature directed to verify monetary policy implementation and its effectivenesshas grown extensively overtime. Given that monetary policy changes can occur in the implementation of policy (shocks) as well as objectives of policy (regimes), the implementation ofpolicy (shocks) has been typically modelled as vector innovations to a Vector Auto-Regression (VAR) where monetary policy is identified by structural restrictions on the contemporaneousimpacts of the variables (Neville and Owyang, 2004; Sims, 1992). The structural VAR literature on monetary policy exists in several studies (Cambazoglu and Karaalp, 2012; Epstein and Heintz, 2006; Luke, 2000; Moscarini and Postel-Vinay, 2010; Bernanke and Mihov, 1998). VARModels however, assume linearity and thus it is unable to represent many non-lineardynamic patterns such as asymmetry, amplitude dependence and volatility clustering.

Due to these inherent weaknesses in the VAR model, switching monetary policy regimeshave gained a lot of attention in recent literature (Boivin and Giannonni, 2002; Hanson, 2002; Ghiani *et al*., 2014; Thams, 2007). Policy regimes engage switches in the policy rule that mirrorchanges in the policy maker's reaction to deviations from the target inflation rate and or outputgrowth. Switching monetary policy studies are also able to account for unrelenting adjustmentsin policy which result from changes in central bank leadership or transparency which also affectthe volatility of money, output and interest rates (Clarida *et al*., 2000; Dennis, 2001; Hanson, 2002). For instance, Dennis (2001) argues that a change in policy maker preferences has shiftedafter -1979 inflation target from around 7% to a value below 2%.

Other studies have examined both the regime changes (objectives of policy) and policyshocks (policy implementations). To these studies, monetary policy is relevant not only to thepolicy maker's response to the exogenous economic shocks but also to the contemporaneouseffects of the monetary policy innovations (Owyang, 2002; Sims and Zha, 2002). These papershowever, failed to address the long-run objectives and impacts of monetary policy. The paper, like Neville and Owyang (2004) incorporates these long-run impacts. Regime switches in thelong run relationship through the weighting matrix of the error correction term is also takencare off.

Although a lot of studies have used the Markov Switching in an error correction framework (Clarida *et al*., 2003; Paap and Van Dijk, 2003; Hanson, 2002 and among others) around theworld, Monetary policy studies in Ghana has been based on Vector innovations to a Vector Auto Regression (VAR) (Abradu-Otoo *et al*., 2003; Epstein and Heintz, 2006; Atta-Mensah and Bawumia, 2003). Such studies are unable to represent many non-linear dynamic patterns. Also, these studiesignored monetary policy regime changes that has characterized the Ghanaian economy overtime.This study thus comes handy to address such issues.

Econometric Modelling

The aim of the study is to explore monetary policy implementation in regime switching. Hencethe study adopted a vector error-correction model that allows for different states of the economy. The regime switching can either be modelled to allow all or part of the coefficient matrix toswitch independently or with the error-correction term. However, this study allows the switchwith the error term. This approach thus, assumes a stable long-run relationship i.e., regimeinvariant co integrating vector whereas the short run dynamics are analyzed in a Markov-Switching framework which allows the error correction to respond to regimes. By this, thestudy can examine the state dependent responses to monetary policy shocks.

The study by specifying a Markov-Switching Vector Error Correction Model (MSVECM) of:

$$\Delta Y_t = \alpha + \sum_{i=1}^{k} \sigma_i \Delta Y_{t-1} + \omega_{st} Y_{t-1} + \in_t \quad (3.1)$$

Where:

ΔY_t = An n dimensional vector of differenced variables of interest
α = A vector of intercepts
α_i = *nXn* parameter matrices
ω_{st} = The state-dependent long run impact matrices

The long run state dependent matrix comprises of *rXn* matrix of co integrating vector β and *nXr* state-dependent weighting matrix τ_{st}. Therefore:

$$\omega_{st} = \tau_{st}\beta$$

Given a two state first order Markov process $S_t \in \{0, 1\}$ with its associated transition kernel P, where $P_{ij} = Pr[S_t = i | S_{t-1} = j]$, then Equation 3.1 can be re-written as:

$$\Delta Y_t = \alpha + \sum_{i=1}^{k} \sigma_i \Delta Y_{t-1} + \tau_{st}\beta^T Y_{t-1} + \in_t \quad (3.2)$$

Though, the long run state-dependent matrix can either switch in the co integrating vector,the weighing matrix or both, this study allows only switches in the error-correction term whichimplies a single set of long run relationship. This means that the correction mechanism dependson the state. By implication, switches in this framework are interpreted as differences in therate at which the common long run relation is obtained.

Allowing switches only in the error term is predominantly motivated by some potentialinterpretations. Given a regime-invariant long run relationship between the variables, the state-dependent coefficient assign weights to each relationship which implies that any perturbation tothe system could have different long run effects across states (though the long run relationshipis unchanged). For example, monetary perturbation has different long run effects dependingon the monetary objective (targets). The different effect is because the long run response coefficients ($\omega_{st} = \tau_{st}\beta$) is a function of the switching elements (Hamilton, 1994, pp.579-581).

Estimation of Equation 3.2 is through the Gibbs sampling techniques. The procedure determines the co integrating relationships at the initial stage which are used to draw parametervalues from the posterior prior. The study used the Bayesian methodology that uses Sims and Zha (2002) prior. This approach uses prior which accounts for non-estimated co integrating vectors.This therefore, does not require any explicit modelling of the co integrating vectors.

To analyze the effect of monetary policy shock, the study adopts the Cholesky ordering which places the policy instrument last in the system ordering. In this three-variable system comprising price, output and policy instrument, the study assumes that monetary authoritiesobserve prices and output before determining the level of the instrument. By this identification,it is assumed that policy does not contemporaneously impact on prices and output.

Empirical Results

Data

Annual data ranging between 1964 and 2013 obtained from the World Development Indicator (WDI) were used for the analysis. The variables include consumer price index, gross domesticproduct at constant local currency unit and broad definition of money (M2). Though thecentral bank of Ghana in recent times is using interest rate instrument, the study adopted M2as proxy for policy instruments because the time frame of the study includes periods of monetarytargeting regime. To eliminate outliers, all the variables are logged. Figure 1 shows the graphof the series at both level and first differenced. We observe spikes in the plot of the differencedseries suggesting structural changes and regime shifts. Thus, we conducted a preliminaryexploration analysis to inspect the distribution of the series with some of its lags. This gives first-hand information on whether any of the series contain regimes.

Figure 3 and 4 depict non-parametric plots of the series versus their first to fourthlags. The figure reveals a linear approximation for the series. This suggests that a linearapproximation for the analysis may not be questionable since the entire series exhibits lineartrend with no possibilities of regime shifts. However, the distributional plot for CPI and GDPin Fig. 5 indicates that the series depict bi-modal distribution suggesting the possibilities ofregimes (i.e., the evolution process of the series might differ across periods). Following this bothregime and non-regime unit root test were conducted on the series. Table 1 shows the testresults for both regime and non-regime unit root tests. The non-regime unit root tests wereconducted using the ADF test, whiles the regime test is conducted on a unit root null hypothesisagainst stationary SETAR. The test statistic is compared with the bootstrapped critical value 16.181, 18.4 and 23.01 for 10, 5 and 1% respectively. As Table 1 shows, the results fromboth tests indicate the presence of unit root in the series.

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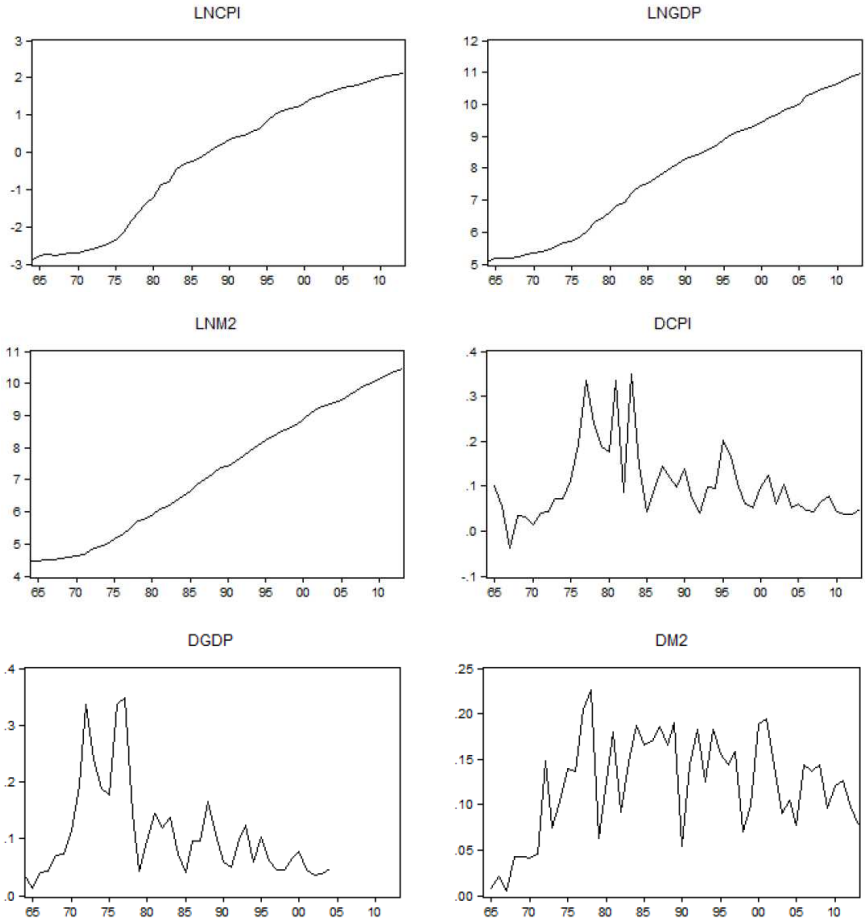

Fig. 1. Series at levels and first differenced

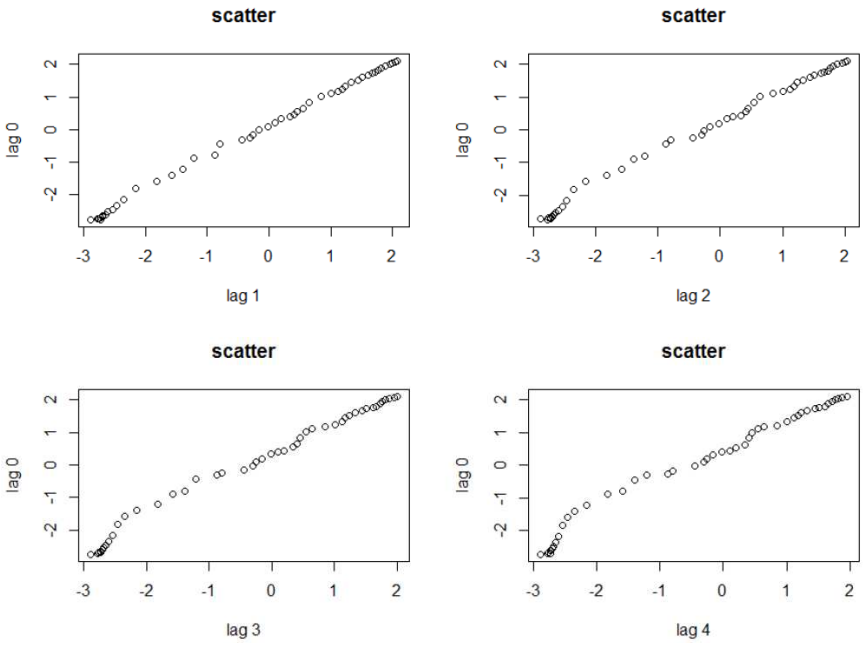

Fig. 2. Series distribution (CPI)

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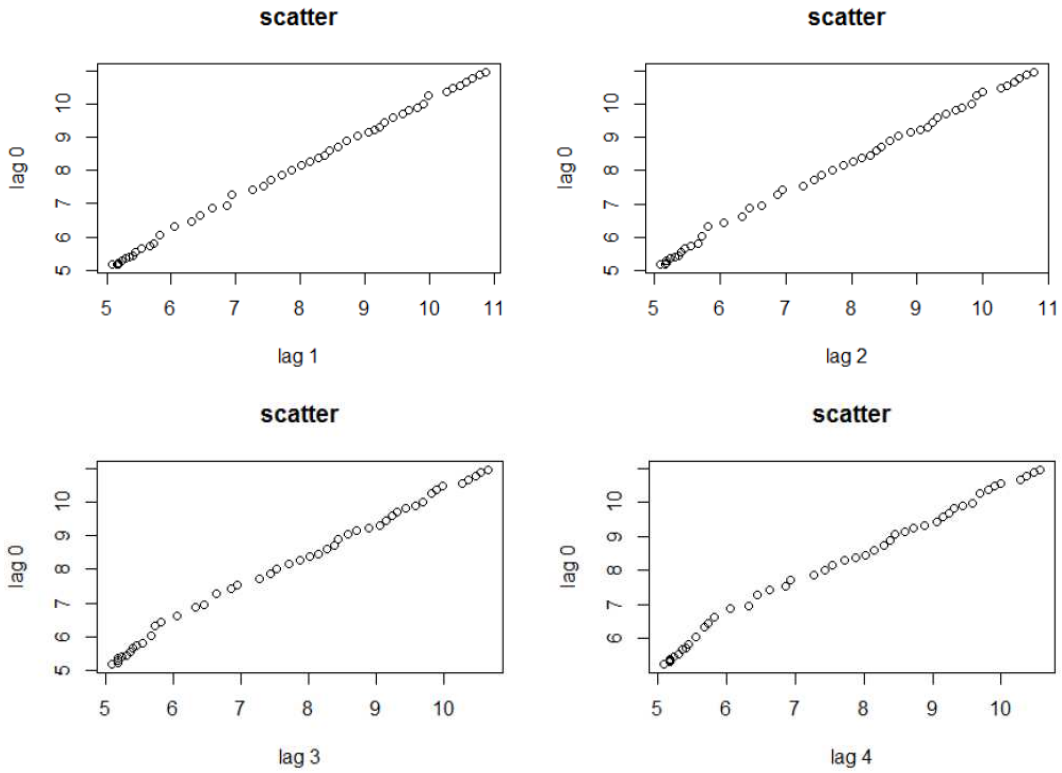

Fig. 3. Series distribution (GDP)

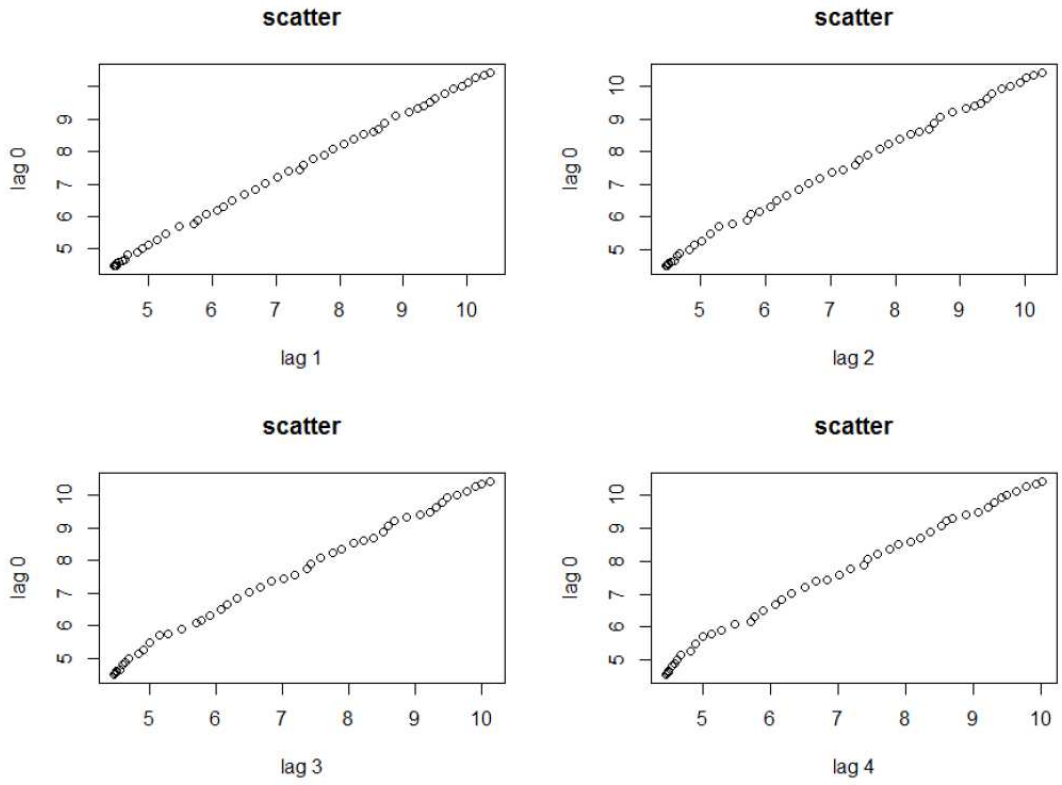

Fig. 4. Series distribution (M2)

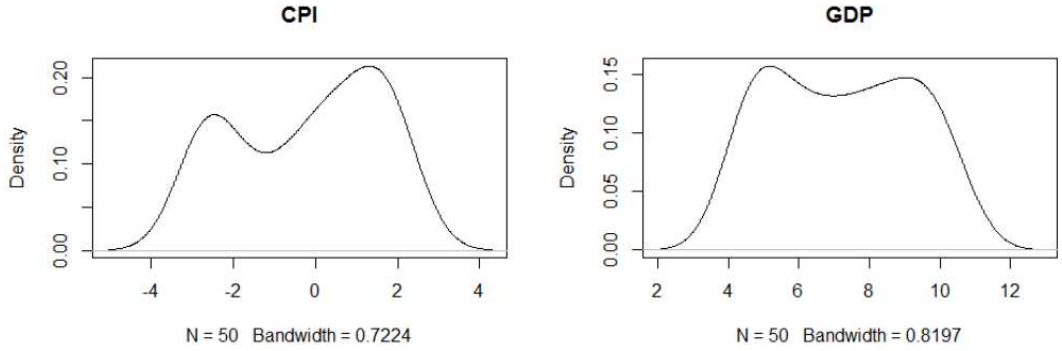

Fig. 5. Distribution plot of series

Table 1. Unit root tests

	Non-regime test		
Series	Level	1st Difference	Regime test
CPI	-1.1035(0.7073)	-3.8250(0.005)***	32.933
GDP	0.81076(0.9933)	-4.9832(0.000)***	48.681
M2	1.7178(0.9996)	4.2401(0.002)***	15.616

(a) P-Value in parenthesis. *, (**), *** indicate rejection of unit root at 10, 5 and 1 percent respectively. (b) The test is for unit root against stationary SETAR. The test statistic is compared with the boot rapped critical value 16.181, 18.4 and 23.01 for 10, 5 and 1 percent respectively.

Table 2. Co-integration test result

	H_0	
H_1	Linear VAR	No co-integration
TVAR(1)	38.24(0.07)	-
TVAR(2)	60.641(0.30)	-
Threshold co-integration	11.0977(0.44)	16.548(0.93)

NB: P-value in parenthesis

The study further conducted a formal test to investigate the presence of co integrationamong the series. The formal test result is provided in Table 2. The test was conducted on twohypotheses. First, a test of no co integration against threshold co integration was conducted. A P-value of 0.93 fails to reject no co integration in the series. The second, a test of linear co integration against threshold co integration, supports the presence of linear co integrationgiven a P-value of 0.44. Though, both tests reject threshold co integration, a test of model fitsupports a model with one threshold. A P-value of 0.07 associated with the test statistic in themodel fit test of linear VAR versus threshold VAR indicate that at 10% critical level, modelling the data in one threshold regime is superior. Based on this, the study proceeds in aMarkov switching approach with one regime.

Result and Discussion

Given the study's objective to investigate monetary shocks in regimes, the study estimated aVECM model with extensions to accommodate states. This follows the exploratory analyseswhich indicate the presence of co-integration among the variables. The VECM is estimatedin the presence of state restrictions following a tractable Markov process. The innovation ofmonetary shocks is estimated within a simple Cholesky specification ordering the policy variable (i.e., M2) last.

Table 3 reports that there is only one co-integrating relationship and provides the weightingmatrix for the relation that vary across regimes. The co-integration vector is fixed acrossregimes.

States

The transition probabilities for each state is reported in Table 4. The probability estimatesindicate high level of persistence in each state. The probability of transition from one state toanother is approximately the same in the arena of about 12%.

Response to Policy Shocks

The study considered the short run response to a one standard deviation shock to the policyinstrument (i.e., money supply). The impulse response function is generated for a horizon upto twelve years. The generated IRF are either conditioned or not conditioned on the state (i.e., when the shock is generated in one state, it is transmitted through that particular state). Figure 6 depicted the IRF in each regime and the average for the entire period.

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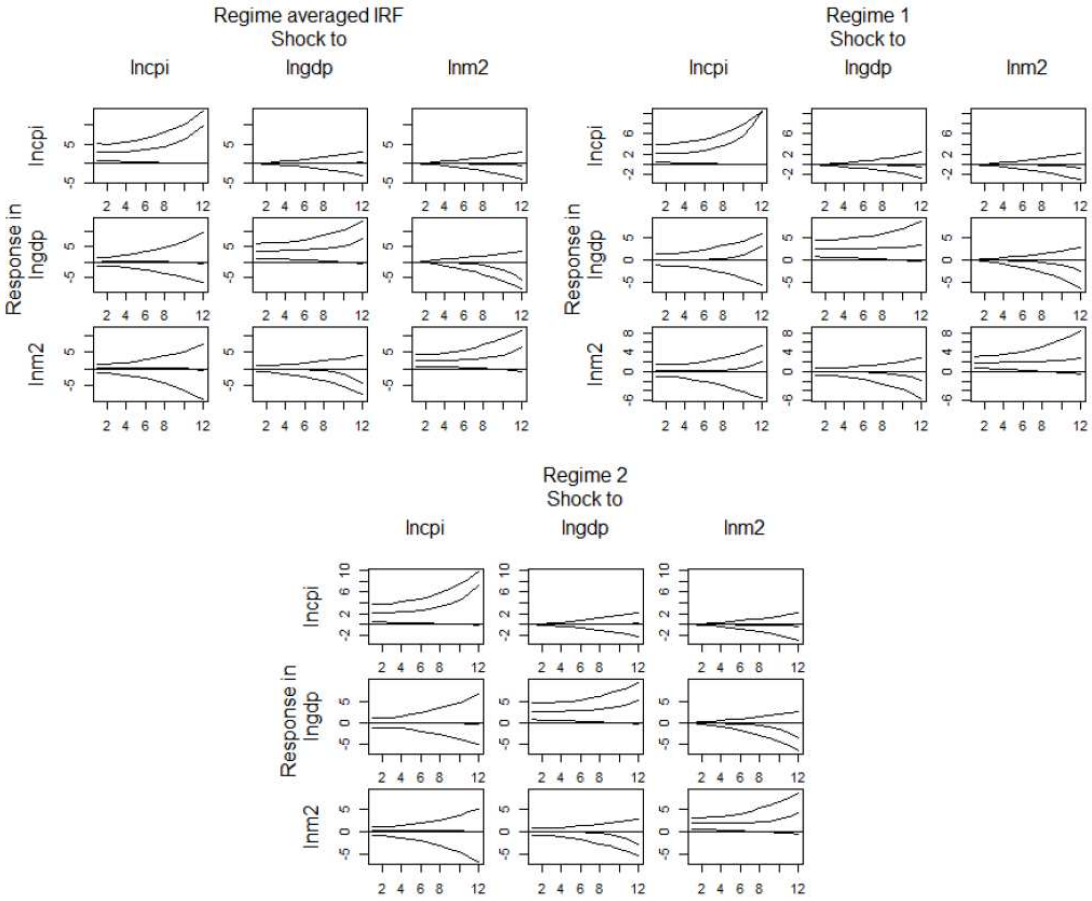

Fig. 6. Impulse response function to a standard deviation shock

Table 3. Estimation results

		P	Y	M
Cointegrating vector	β	1.000	4.6498	1.3789
Adjusting vector	$\alpha(S_1 = 1)$	-0.2377	-0.0513	0.17978
	$\alpha(S_1 = 2)$	-0.7670	-0.2842	0.5048

Table 4. Transition matrix

	Regime 1	Regime 2
Regime 1	0.8815	0.1185
Regime 2	0.1191	0.8809

The graph shows that there are no significant differences in how prices and output respondto the policy instrument. The effect of policy changes on prices and output is very minimal withcoefficient ranging the same in both state 1 and state 2. The effect of policy instrument hitsprices and output respectively from the 11 months and 8 months onwards in state 1. Similarevidence is found in state 2.

Cost of Disinflation

High inflation has bedeviled the economy of Ghana for long. However, in recent times inflation has showed a downward trend overthe past few decades. In comparing the developmentsin the current monetary regime (inflation-targeting) to the control regimes and the monetarytargeting regimes, the inflation rate has been quite stable. It averaged 50.0% per annumduring the 1970s, 44.5% during the 1980s and was 27.9% during the 1990s and further down to 16.2% in the early six years of 2000s. Within the period 2009 and 2010, the rate has been stable at single-digit, though the trend has reverted upward in recentyears. The favorable downward trend in the inflation rate together with the gains in thegeneral macroeconomic trends raise issues in the short run tradeoff between stability and growth particularly given that Ghana is a developing country and desires to accelerate growthfor development purposes. Thus, this study estimated the cost of disinflationary policyfor Ghana.

Table 5. Sacrifice ratio

Regimes	Markov process	Pre-specified
Within state 1	1.46	0.59
Within state 2	1.90	0.43
From 1 to 2	0.44	-
From 2 to 1	1.02	-
Pooled sample	-	1.42

NB: The cost is calculated at 10 years' horizon

The tradeoffbetween output and inflation has been a popular area of research for years.Though, there are consensus among economists that high inflation is inimical to the economy, disinflationary policies on the other hand result in some short-run costs in terms of loss inoutput. As identified by (Okun, 1978), disinflationary monetary policy result in output or employment loss (See among others Cecchetti and Rich, 2001; Fuhrer, 1995) a one percentage point fall in inflation.

Various methods for estimating the sacrifices ratio has been suggested in the literature (Ball, 1994; Zhang, 2001; Cecchetti and Rich, 2001). To calculate the sacrifice ratio, this study adopted Cecchetti and Rich (2001) VAR approach toaccess the output cost of disinflationary monetary shock within a single regime. As argued by Neville and Owyang (2004), this modelling approach can measure the cost of disinflationoccurring because of switches between regimes.

Following Neville and Owyang (2004), this study posits two distinct disinflationary episodesto include disinflationary periods driven by a policy shock and one driven by change in regime. Aside using the Markov process for the states, the study experimented to investigate the credibility of monetary authorities as policy switched from monetary targeting to inflation targetingframework. The aim is to identify if the credibility is enhanced given that credibility underscoreinflation targeting. The estimated sacrifice ratios for both within and across states are reportedfor both the Markov process and pre-specified regimes in Table 5. As showed in the table, thewithin-regime sacrifices ratio is estimated to be 1.46 and 1.90 for state 1 and 2 respectively. Forthe pre-specified, the study estimated the ratios for the periods prior to 2002 and the aftermathrepresenting monetary and inflation targeting regimes respectively. The results indicate thatthe sacrifice ratio has fallen from 0.59 to 0.43. This has implication for expectation formationhence, credibility from monetary authorities. The results suggest that agents can forecast inflation very well since they are utilizing the same information available to monetary authorities. By this the cost of disinflation becomes minimal.

Generally, the study found a low sacrifice ratio which is in conformity with Kinful (2007) study. Though, the foregoing discussions indicate disinflationary cost has fallen within theinflation targeting period, the overall (pooled sample) sacrifice ratio estimated at 1.42 suggestsa cumulative output loss of approximately 15%. This produces a worrying situation giventhat Ghana is a developing country which desires to accelerate growth for development.

Conclusion and Recommendation

This study examined monetary policy shock in a Markov-switching vector error correctionframework. The study assumed a stable long run co-integration relationship, whiles allowing long run variations through switches in the weighing matrix of the error correction term.While as this approach overcomes the linearity assumption in dealing with monetary policyshock, it's theoretical appealing goes to the rational expectation critique of model of this kind.

In investigating monetary impulse, the study found that though, monetary shocks generatedifferent impulse in each state, the monetary response do not differ significantly across regime. The study also analyzed the cost implication of disinflationary policy in Ghana. The estimatedsacrifice cost of disinflation differs within and across states. In conformity with studies in theliterature, the result indicates that the cost of disinflation is very low though.

The finding of this study has some policy implication for the conduct of monetary policy in Ghana. The sacrifice ratio obtained indicate that monetary policy should be conducted withcare in order not to erode output growth given the state of economic development in the country. Further, the study suggests that cost of disinflation is low within inflation targeting periodbecause agents can forecast better due to enhanced credibility. By implication, policymakers should be more transparent and credible in their actions to help minimize associatedcost.

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Author's Contributions

Richard Kwabi Ayisi: Contributed from conceptualizing the ideas, analysis and writing the manuscript.

Joseph Adu: Contributed by organizing data, analyzing the data and helped in writing the manuscript.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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