Akosah, Nana K.

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Is the Monetary Policy Rate Effective? Recent Evidence from Ghana

Nana K Akosah
Bank of Ghana

Rue de Lausanne 132
P.O. Box 136
CH - 1211 Geneva 21
Geneva, Switzerland

Is the Monetary Policy Rate Effective? Recent Evidence from Ghana

Akosah, Nana K[1]

Bank of Ghana

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Abstract

We examine the effectiveness of monetary policy transmission mechanism in Ghana using several of statistical and econometric techniques for the period 2002M1 – 2014M12. We find monetary policy rate (MPR) to be quite effective in signaling the money market interest rates in both the short run and long run, as the effect is incomplete (that is, not one-to-one). In addition, a hierarchy of short-term money market rates in Ghana is identified as follows: *Monetary Policy Rate*, *Treasury bill rate*, *Interbank rate and retail rates (preferably, lending rate)*, accentuating the large role played by Treasury bill interest rate in the interest rate transmission channel in Ghana. Essentially, monetary authority responds positively and contemporaneously to output and inflationary pressures. Inflation is mostly driven by interest rate shock over the medium to long term, pointing to an impact of monetary policy. In the short term, however, exchange rate shock has relatively larger influence on inflation than that emanating from interest rate. In contrast, output is largely driven by credit and assets prices shocks. This suggests that agents' knowledge about future output prospects are immediately reflected in assets prices before impacting on output. The paper therefore supports policies that would promote strong financial and macroeconomic stability to help inure effective monetary policy transmission in Ghana.

Key Words: Monetary Policy, Inflation Targeting, Transmission Mechanism, Structural Shocks.

JEL Codes: E52, E58

[1]Nana Kwame Akosah: nana.akosah@bog.gov.gh and akosahk@gmail.com. The author thanks Yi Huang and Cedric Tille of the Graduate Institute of International and Development Studies (GIIDS) in Geneva, Switzerland, for their useful comments, suggestions and supervision from the inception to the completion of this paper. This research has benefited immensely from the distance coaching program under the Bilateral Assistance and Capacity Building for Central Banks (BCC), a partnership between GIIDS and the Swiss Economics Secretariat (SECO). The views expressed in this paper are those of the author and do not reflect the position of the Bank of Ghana.

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I. Introduction

The primary objective of Bank of Ghana (BOG) is to maintain stability in the general level of prices[2] , as enshrined in the BOG Act 2002 (Act 612) subsection 3(1). More details are provided in Box 1 at appendix A. To achieve these mandates amid macroeconomic complexities, the central bank adopted inflation targeting (IT) formally in 2007[3] as its monetary policy framework. Many policymakers sceptically viewed this move by Bank of Ghana as a pioneering experiment for a country with an underdeveloped financial system, undisciplined fiscal policy and many other headwinds (Gemayel et al, 2011)[4]. The sceptics were however proven wrong as the IT regime has drummed up remarkable disinflation, achieving single-digit inflation for thirty-two (32) consecutive months from June 2010 to January 2013 (figure 1). Although unprecedented in Ghana's modern economic history, the disinflation however remains a debate in policy discourse as to whether it was as a result of a good policy or good luck.

While there is ample theoretical and empirical literature on how monetary shocks affect macroeconomic aggregates in developed and emerging economies with well-functioning financial markets, little is known about the empirics on monetary policy transmission in Ghana. As a small opened economy, increasing financial globalization has considerable implications on the monetary policy transmission mechanisms in Ghana[5]. Therefore, with the prime objective of price stability, monetary authority requires better understanding of the monetary transmission process in order to develop instruments that can reinforce the efficacy of monetary policy transmission in Ghana. This paper intends to contribute constructively to Ghana's inflation targeting implementation by addressing the following lingering fundamental questions:

- What is the nature and speed of transmission of monetary policy rate to other interest rates? In other words, does monetary policy rate possess a strong signaling ability to other money market interest rate?
- Are retail market interest rates sticky downwards in response to changes in wholesale interest rate?
- How does monetary authority response to and influence macroeconomic shocks?
- What is the dominant monetary policy transmission channel in Ghana in the midst increasing financial globalization and trade openness?

We address the above questions in two parts. In Part I, we examine the hierarchy (or speed of adjustment) of money market interest rates to changes in monetary policy rate. In Part II, we analyze the response of monetary authority to macroeconomic shocks and also identify the shocks that are relevant to output and inflation. Other notable studies on the interest rate transmission process in Ghana include Abradu-Otoo et al. (2003), Acheampong (2005)[6], Ghartey (2005)[7],

[2]The stability in general level of prices therefore implies stability in inflation, interest rate and exchange rate.

[3]With an IT preparatory stage from 2002 to 2006 following the promulgation of Bank of Ghana act 2002 (act 612) which granted the Bank an operational independence.

[4]Studies have revealed different speed of interest rate adjustments across countries, financial institutions and financial products (see, Hofmann and Mizen, 2004) and a potential asymmetric response of short term interest rates to rising and falling policy interest rate.

[5]For instance, as financial globalization increases, currency value may become more responsive to interest rate differentials, thereby reinforcing the exchange rate channel of monetary transmission mechanism. Similarly, financial globalization might be altering the evolution of liquidity and credit condition, as lending activities of foreign banks may be less affected by the domestic conditions and hence weakening the credit channel. In the same vein, capital flow can exert upward pressure on asset prices and thus can make the asset price channel stronger.

[6]Acheampong (2005) examines the bank interest rate channel of monetary policy transmission in Ghana for the period September 1994-February 2014. The study concludes that policy shift has some impact on lending rate decisions of the banks but no significant effect on the borrowing rate.

[7]Ghartey (2005) also examines the impact of monetary policy on the term structure of interest rate in Ghana during 1994-2004 and report that there is a significant effect from monetary policy to Treasury bill interest rate.

Kovaren (2011), CEPA[8] (2012) and Fukac and Baldini (2014). In particular, Kovaren (2011) examines the interest rate pass through of monetary policy in Ghana with dataset spanning the period 2005-2010 using Vector Autoregressive (VAR) framework and simulation techniques. He found a relatively strong short term response of wholesale market interest rate (interbank and treasury bills) to changes in monetary policy rate, but a delayed long term response of the former (interbank rate) to changes in the latter. In addition, Fukac et al (2014) also examined inflation and monetary policy transmission in Ghana during 2007-2012 and found reduced-form evidences that the interest rate transmission mechanism is now central to keeping inflation in check. They however found a limited signaling ability of monetary policy rate to other money market rates in 12-ordered Vector Autoregression (VAR) model.

Nevertheless, a black box in the Ghanaian literature is the lack of information on the relative importance of the various monetary policy transmission channels to aid monetary policy decision and the type of instrument required to precisely influence the target variables (output growth and inflation). This is the focus of this paper. It is therefore essential to note that this paper is different from other studies on Ghana in two ways. First, we outline the wholesale and retail interest rates in their pecking order in response to changes in monetary policy rate (MPR). Second, we thoroughly examine the relative importance of the main monetary policy transmission channels in a single model. To the best of our knowledge, this is the first paper to exploit the relative importance of the interest rate shock, credit shock, exchange rate shock and asset price shock in the monetary policy transmission mechanism to the real sector in the context of Ghana. Therefore, the paper provides more or perhaps better information about how these transmission channels work to adequately enhance the conduct of monetary policy by the Bank of Ghana.

The empirical results suggest that the MPR influences the other money market interest rates in both the short run and long run although the impact is not one-to-one. This suggests that the effect of MPR on the other money market interest rate is incomplete and also corroborates the Fukac et al (2014) that MPR has a limited signaling influence on the money market. This is however not surprising as the financial system in Ghana is still underdeveloped with large non-banked populaces. We identify a hierarchy of short-term money market rates in Ghana as follows: *Monetary Policy Rate*, *Treasury bill rate*, *Interbank rate and retail rates (preferably, lending rate)*. This also accentuates the dominant role of Treasury bill interest rate in the interest rate transmission channel in Ghana. In particular, a persistent positive influence of Treasury bill rate on lending rate was also observed, suggesting that upward trends in the former tends to act as a drag on the economy, because it potentially crowds-out private sector investments via higher lending rates.

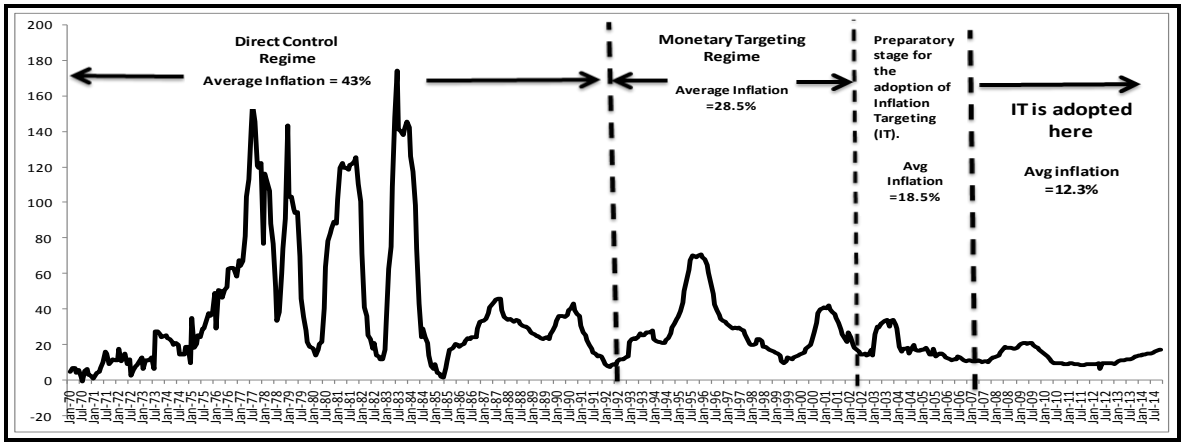
In addition, we observed a well-functioning macroeconomic interrelationship between monetary policy and the targeted real sector variables. In the first place, monetary authority responds appropriately (positive) and contemporaneously to output and inflationary pressures. Shock to MPR mainly move lending rate and exchange rate, signifying that the monetary policy transmission to inflation is largely via both the interest rate (lending rate) and exchange rate channels. Consistent with economic theory, a one standard deviation positive shock to commercial banks' lending rate

[8] Centre for Policy Analysis (CEPA) (2012) assesses the relevance of monetary policy rate in the transmission mechanism between November 2009 and May 2012. The finding of the study was that the changes in MPR strongly impacted on both the interbank and 91-day Treasury bill interest rate.

leads to decline in output, inflation, credit and share prices but an appreciation in the real (or nominal) exchange rate, pointing to a desirable monetary policy outcome. A positive credit shock, on the other hand, leads to an increase in output and also depreciation in the domestic currency against the major trading currencies. Conversely, inflation initially declines before picking up after a positive shock to real credit. Although this is an oddity to economic theory, it perhaps accentuates the notion that inflation in Ghana is not purely a monetary phenomenon. Moreover, following a positive shock in real exchange rate (appreciation), inflation declines and is statistically significant. The decline in inflation is plausible as the appreciation in the domestic currency tends to restrain imported inflation since the CPI basket contains a sizeable proportion of foreign items. In contrast, output remains generally flat following domestic currency appreciation. This may be attributable to the loss of trade competitiveness which tends to offset the economic gains from the enhanced capability to import high quality goods for domestic production. In the case of a positive shock to share price, both output and inflation increase, while the domestic currency appreciates.

Based on the analysis of forecast error variance decomposition (FEVD), the paper observes that inflation is mostly driven by interest rate shock over the medium to long term (within either 24th-month or 36th-month horizon), pointing to an impact of monetary policy. In the short term (within 12th month horizon), however, exchange rate shock has relatively higher influence on inflation than that emanating from the interest rate. On the contrary, output is largely driven by credit and assets prices shocks. This suggests that agents' knowledge about future output prospects are immediately reflected in assets prices before impacting on output.

Figure 1: Inflation History in Ghana (%, 1970-2014)



The paper is structured as follows: Section 2 provides brief stylized facts on the IT regime in Ghana and its current implementation challenges. Section 3 provides data sources and characteristics. Section 4 evaluates the hierarchy (speed of adjustment) of money market interest rates to changes in MPR in both short run and long run. In this case, we used Vector Error Correction framework, VAR Granger causality (or block exogeneity) test and impulse responses functions (IRFs). Section 5 investigates the response of monetary authority to macroeconomic shocks and also appraises the shocks that are relevant for output and inflation. Here, we develop a structural VAR framework that incorporates two target variables (output and inflation), four intermediate variables (i.e. interest rate, credit, exchange rate and asset price) and monetary policy rate (MPR) to monitor monetary policy transmission channel. The final section (6) provides the conclusion and policy recommendations.

2. Ghana: Stylized Facts

A. IT Framework

The Bank of Ghana Act 2002 (Act 612) Section 3 sub-section 2 grants the central bank operational independence while Section 27 Sub-section 1 also promulgates the establishment of Monetary Policy Committee for the implementation of inflation Targeting (IT) framework. The IT framework is based on the notion that policy is designed to target inflation through an inflation forecast. Given that the inflation forecast is a function of many macroeconomic variables, policy reacts to a whole range of variables, not just money supply as in the case of monetary targeting framework. That is, the IT framework is premised on the fact that inflation is not solely a monetary phenomenon, but other factors do influence prices. In this framework, the monetary policy tool of the BOG is the monetary policy rate (MPR), while the operating target is the overnight money market interest rate (Interbank rate). The MPR is the rate around which a policy corridor is defined for central bank's acceptance of deposit and granting of credit to commercial banks. The MPR is set, every other month, at a level considered appropriate by the Monetary Policy Committee (MPC) to deliver end-year annual CPI inflation target set jointly by the Bank of Ghana and the Ministry of Finance. Essentially, the MPR is expected to communicate the stance of monetary policy of the Central Bank and also serve as a guide to all other market interest rates. That is, for the monetary policy to have the desired impact on inflation (the prime objective) and the overall economy, it is critical that changes in MPR affect retail interest rates (e.g. lending and deposit rates) via the wholesale interest rates (preferably, interbank rate) and ultimately influence the overall economy and inflation.

The IT process particularly begins with public announcement of an explicit quantitative target for inflation. Currently, the inflation target for the medium term (2015-2017) is 8% (±2%) although the end-year target for 2015 is 11.5% (±2%). When inflation stays above target for some obvious reasons, the MPC's aim would be to steer interest rates so that inflation can be brought back to target within a reasonable period of time without creating undue instability in the economy[9].

Monetary Policy Committee (MPC) meets every other month to assess a comprehensive set of forecast based presentations on the real, monetary, fiscal, external, and financial sectors to ascertain medium term risks to the attainment of the annual end-year CPI inflation target. Assessment of deviation of actual inflation from the target determines how much the monetary policy rate (MPR) has to be adjusted by the MPC. Presently, decisions on the MPR are arrived at by consensus at the MPC meetings and communicated to the public via press releases, media encounters, briefing sections & seminars and publication of flash reports. The final part involves the implementation of the policy decision by the treasury department of the BOG via repo and reverse-repo activities in the interbank markets, BOG and GOG securities markets, bonds issuance and redemption as well as through the sale and purchase of foreign exchange in the interbank market.

In order to increase the efficiency of the transmission of monetary policy and enhancing the transparency and competitiveness of the interbank money market, the BOG has since 2005 introduced a number of policy reforms. This included the introduction of interest rate corridor,

[9] By law, the Central Bank is not bound to take any instruction from the executive wind of Government, and for that matter, the Ministry of Finance, in the conduct of monetary policy. However, the Governor of the Central Bank may be summoned to the Finance Committee of parliament to explain developments within the economy especially as it relate to inflow and outflow of foreign currency.

bordered by the reverse repo and repo rates (currently set at the MPR plus/minus 300 basis points) in a bid to influence liquidity in the interbank market[10].

B. Current Implementation Challenges

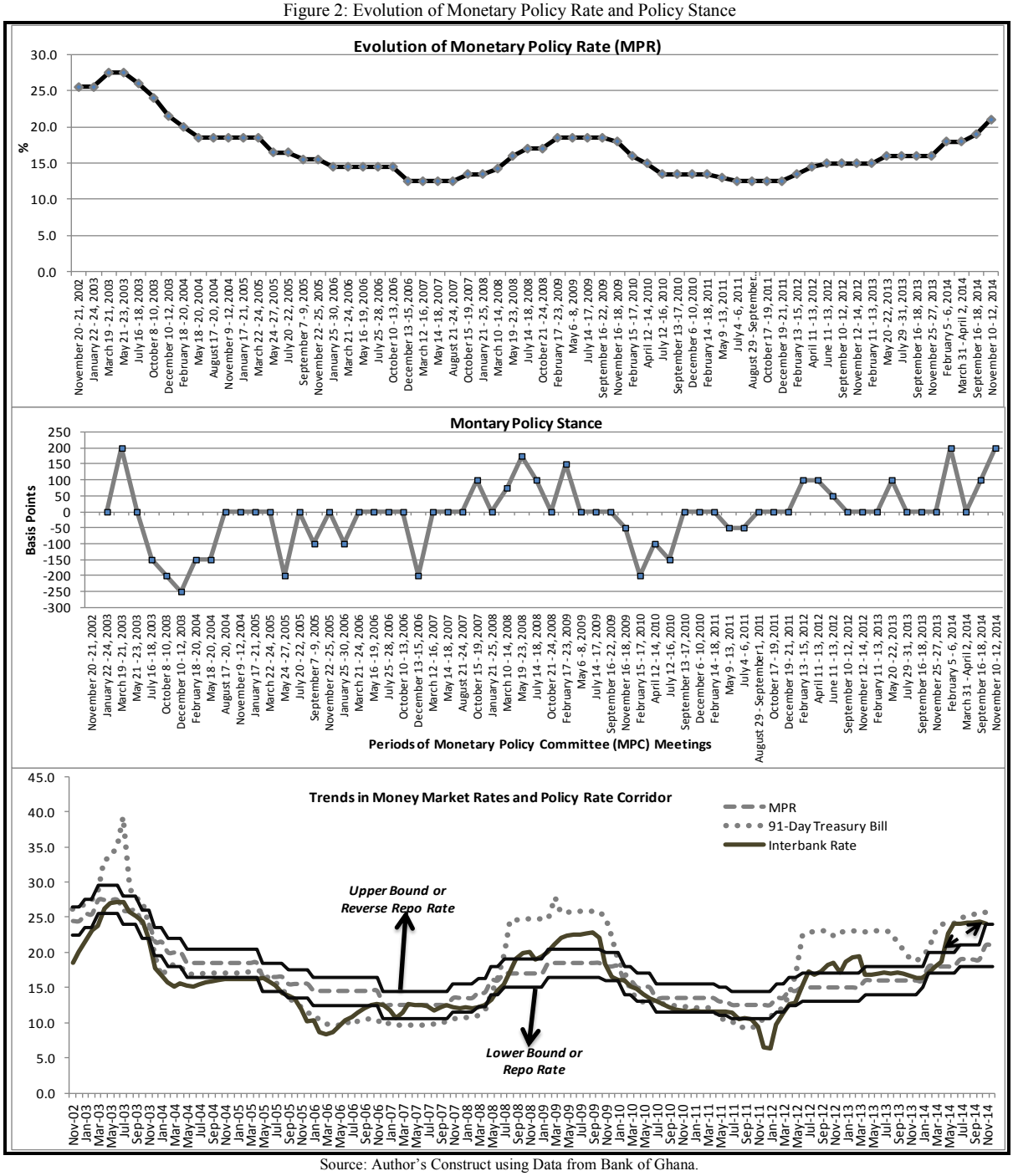
Since 2002, the MPC has held a total of 62 meetings. In Figure 2, the upper panel (UP) displays the evolution of monetary policy rate (MPR), the middle panel (MP) demonstrates the policy stance of the MPC while the lower panel (LP) exhibits the trends in money market rates and policy rate corridor. On a whole, MPR was unchanged in more than half (33) of the 62 MPC meetings, while the MPR was increased in 13 occasions with the residual 15 meetings yielding reductions in MPR (see MP of figure 2).

In addition, the central bank has been unable to contain the targeted overnight interbank market rate into the policy rate corridor on several occasions (see, the LP of figure 2), perhaps driven by monetary policy implementation challenges due to the persistence fiscal dominance. This further attests to the fact that the central bank's ability to contain the operating target (overnight interbank rate) within the policy interest rate corridor as well as achieving the final inflation target is often hampered by the underlying feeble macroeconomic fundamentals. Indeed, macroeconomic headwinds to IT implementation in Ghana are multifaceted as the economy is small but highly opened to international trade with little or no buffers, coupled with policy trade-offs. Among the fastest growing economies in sub-Saharan Africa, bolstered by the fledgling crude oil production and exports since 2011, economic growth impetus in Ghana is largely driven by high import content and this has reflected in persistent external imbalance.

More so, the public sector remains the largest player in the economy in terms of employment and consumption which has also fomented persistent fiscal deficit and inured a pervasive fiscal dominance. Analysis of government expenditure structure however indicates not only a preponderance of recurrent expenditures (Figure 3C) but declining capital expenditures over the last decade. This has significant adverse implications on long term economic growth prospects and the value of the domestic currency as these expenditures ultimately fall on imported goods and services. As a result, the economy is battered by perennial twin deficits problems (figure 3A, B &C), precipitating into rapid public debt accumulation (since 2006) and significant pressures on domestic currency (figure 3E). The fiscal profile of Ghana has thus attracted considerable academic, political and international attentions. In the midst of these discourses, the international rating agencies (including Moody's, Fitch, and Standard & Poors) recently downgraded Ghana's sovereign rating to B- with negative outlook. This adverse rating heightens the risk of doing business in the country and possibly triggers capital outflows (especially portfolio investments) with unfavourable implication on exchange rate and the inflation target.

[10] The reforms also include the Separation of BOG's open market operations (OMO) and auction for the Public Sector Borrowing Requirements (PSBR). Non-resident participation in the domestic government securities are also permitted for instruments with maturity of 3 years and above. BOG also introduced over-night Standing Deposit and Standing Lending facilities window for effective liquidity management of the commercial banks after 4.0 pm when the window for the interbank repo and reverse repo market is closed.

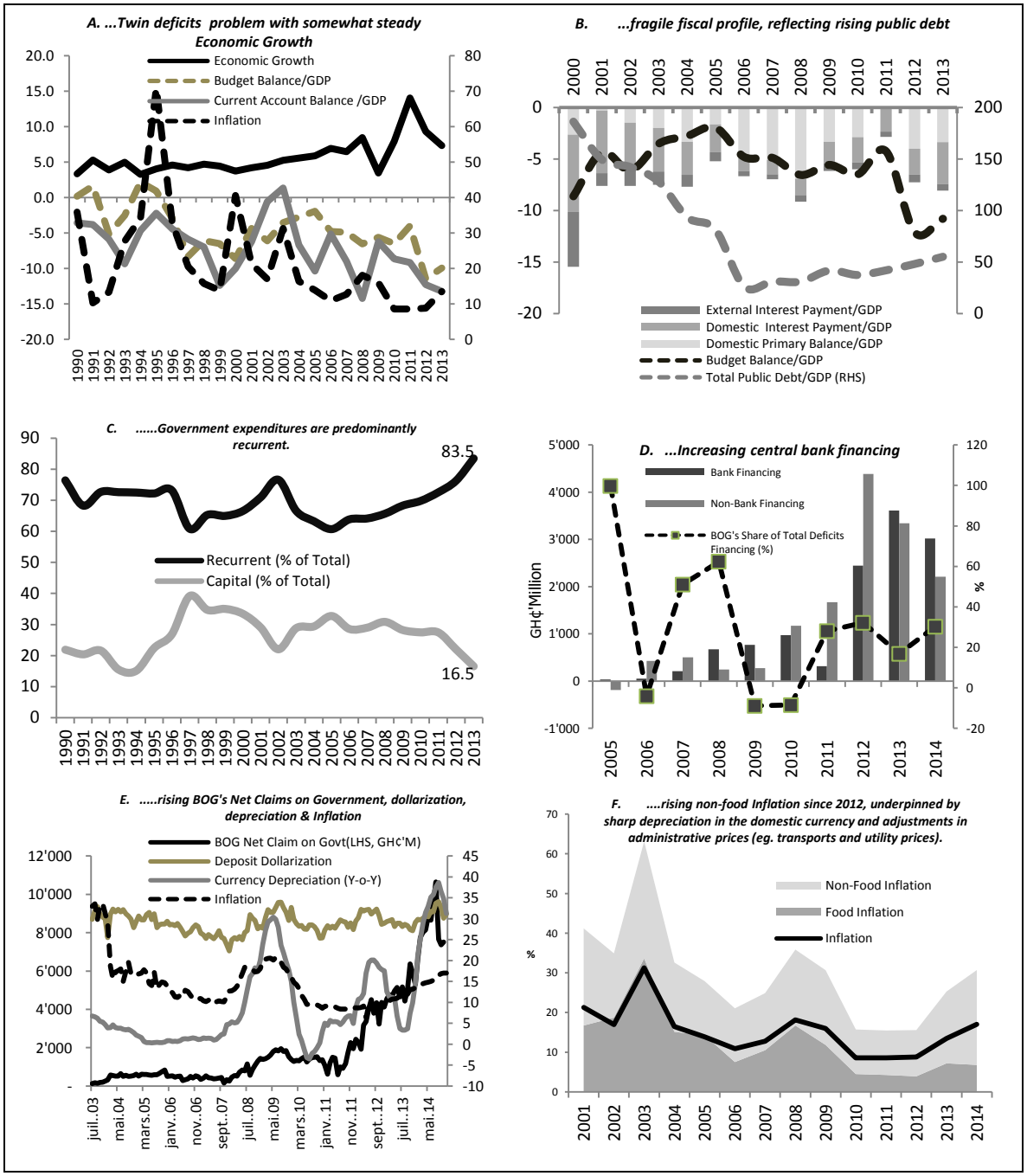
Figure 2: Evolution of Monetary Policy Rate and Policy Stance



Source: Author's Construct using Data from Bank of Ghana.

Amid weak revenue mobilization efforts by government, fiscal dominance remains a perennial concern as this has reflected increasing central bank financing or net claims on government (figure 3D & E) with implication on inflationary expectations. Besides, the irregular and lumpy adjustments of prices of utilities and petroleum products alongside unpredictable wage setting behaviours in Ghana ultimately affect inflation. In particular, the recent upsurge in inflation is largely due to the adjustments in petroleum and utility prices in conjunction with domestic currency depreciation (which affected imported items in the CPI basket), leading to an increase in non-food inflation index (Figure 3F).

Figure 3: Macroeconomic Profile of Ghana



Source: Author's construct with data from Ministry of Finance, Bank of Ghana and Ghana Statistical Services.

Moreover, the financial system remains shallow and underdeveloped with virtually non-existent secondary market while large segment of the populaces are also non-banked, having considerable toll on the effectiveness of monetary policy transmission. More so, central bank's policies are sometimes resisted by the market and hence, fail to yield the intended purpose. For instance, the recent enforcement of foreign exchange measures in February 2014, which was intended to curtail the pace of dollarization and strengthen the use of domestic currency rather generated public apprehension. This led to sharp depreciation in the value of domestic currency, forcing the Bank to eventually withdrawal the policy in August 2014, affecting the credibility of the central bank.

Despite these challenges, disinflation has ensued during the era of IT implementation although Ghana's inflation remains high when compare to the peers in sub-Saharan Africa.

3. Data Sources and Characteristics

On a whole, monthly time series data covering the period 2002M1 – 2014M12 (that is 156 observations) was used. The interested variables include monetary policy rate (MPR), wholesale (91-day Treasury bill rate and interbank market interest rate) and retail market interest rates (lending and savings rates), CPI inflation, real exchange rate, real credit, GSE all share index and Bank of Ghana's Composite Index of Economic Activity (as a proxy for output growth). The data was mainly sourced from Bank of Ghana and Ghana Statistical Services. With the exception of the interest rates, all variables in this study are in logarithmic terms.

A. Interest Rate Developments

Over the period 2002M11-2014M12, MPR has ranged between 12.5% and 27.5% with a mean of 16.7% while Treasury bill rate had the highest range of 9.1%-39.3% with a mean of 18.0% (see Appendix B1). Similarly, interbank rate ranged between 6.4% and 27.2% with an average of 16%, while lending rate averaged 28.2% with a range of 24.1%-38.5%. Savings and 3-month time deposit rates however remained generally low with a range of 4.1%-13% and 7.3%-19.0% respectively. In addition, 91-day Treasury bill rate is the most volatile, recording the largest standard deviation of 6.8% during the period. This is followed sequentially by interbank rate (4.7%), MPR (3.7%), lending rate (3.5%), time deposit rate (3.0%) and saving rate (2.3%).

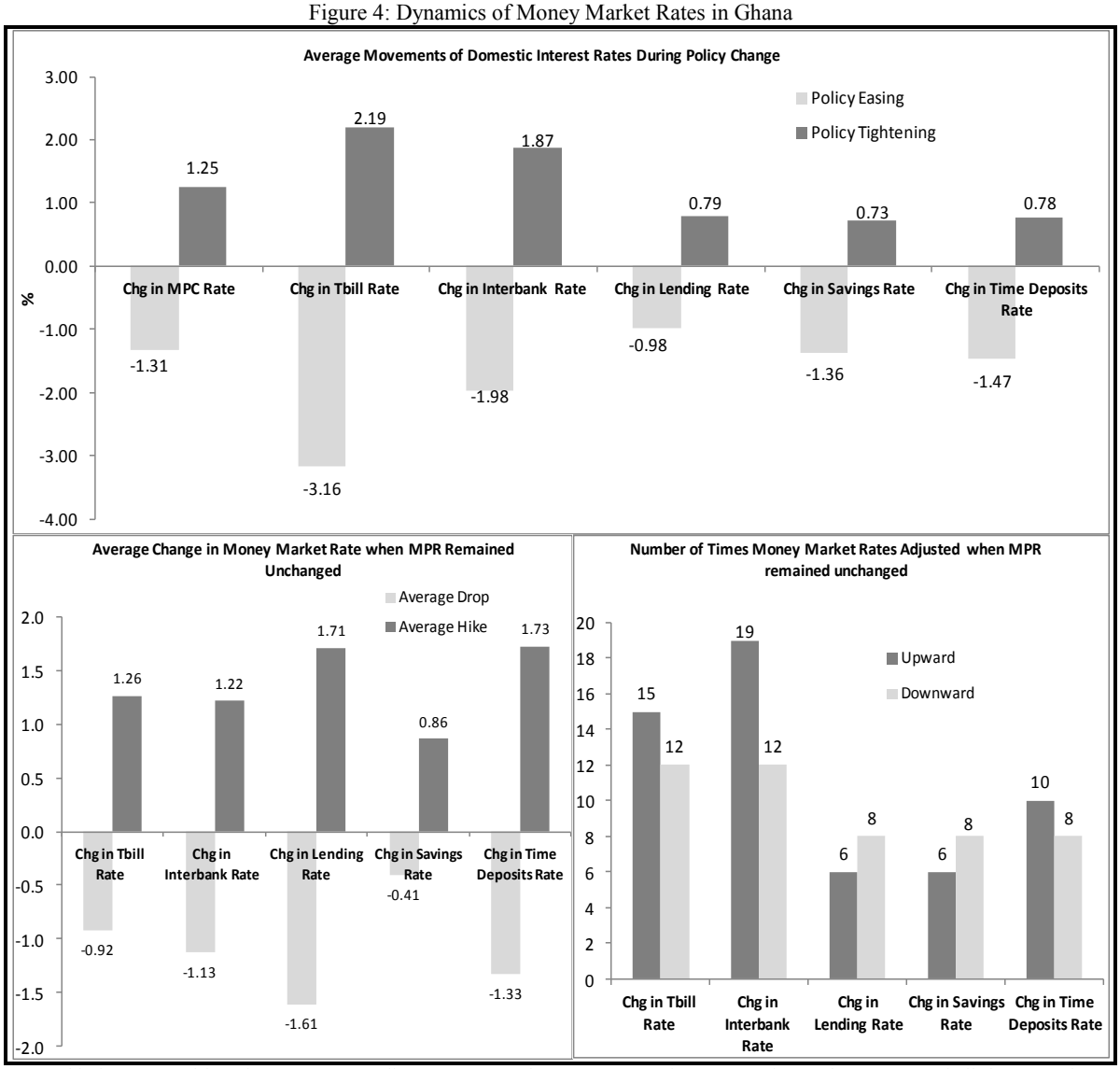
We also observed a strong positive correlation between MPR and other money market rates (as exhibited in Appendix B2). However, the link between overnight interbank rate and 91-day Treasury bill rate appears to be much stronger with a correlation coefficient of 94% (although the link has moderated somewhat since 2008)[11]. Similarly, the retail rates (lending and saving deposits rates) have strong positive correlation with both the MPR and other wholesale market rate**s.**

B. Are interest rates sticky downwards?

We investigate the notion that money market interest rates are sticky downwards in response to MPR changes using "event" analysis whereby movements in money market interest rate are decomposed based on three monetary policy stances; namely, tightening (when MPR is hiked), easing (when MPR is reduced) and neutral (when MPR remained unchanged). For instance, we compute the average increase in interest rates during the period of tight monetary policy while average percentage decline is computed for period of easing monetary policy. As regard the policy neutral, we separated the movements in the money market interest rates into "hikes and drops" and computed averages. We believe that this approach help to better comprehend the dynamics of the money market rates with and without the influence of MPR.

[11] This compares with the correlation coefficient of 83% (though increased to 90% since 2008) between interbank rate and MPR, same as the link between 91-day Treasury bill rate and MPR.

Figure 4: Dynamics of Money Market Rates in Ghana



Note: This is computed based on monetary policy stance over the 62 MPC meetings. We estimate the averages of all the upward or downward movements in MPR and the corresponding changes in the other money market rates. For instance, in the upper panel, we estimate the average of all increases in MPR for the 13 period of policy tightening and the resulting change in the other market rates. The lower panel however presents both the average percentage decline or rise (LHS) and number of times of such changes (RHS) in other money market rate when MPR remained unchanged.

The result in figure 4 below (especially the upper panel) generally illustrates that the movements in the money market interest rates are "near-symmetry"[12]. This suggests that the money market rates are not sticky downwards, as they also show greater tendency to decline, consistent with the findings of Acheampong (2005). In particular, the wholesale market rates (interbank and 91-day Treasury bill rates) show greater tendencies to adjust upwards when MPR remained unchanged (33 times)[13]. The increased variability in the rates on interbank and 91-day Treasury instrument even

[12] As shown in the UP of Figure 4, MPR increased by approximately 1.25% (on average) for the 13 periods of policy tightening. This was associated with average increases in Treasury bill rate, interbank rate, lending rate, savings rate and 3-month time deposits rate by 2.19%, 1.87%, 0.79%, 0.73% and 0.78% respectively. On the other hand, an average decline of 1.31% in MPR during 15 periods of policy easing was also linked with relatively higher declines in Treasury bill rate, interbank rate, lending rate, savings rate and 3-month time deposits rate by (on average) 3.16%, 1.98%, 0.98%, 1.36% and 1.47% respectively. Besides, the LP of Figure 4 displays the average changes in other money market rates for the 33 periods that MPR remained unchanged.

[13] The interbank rate recorded the highest total number of movements (31), followed by the 91-day treasury bill rate (27), 3-months time deposit rate (18), while lending and savings rates recorded 14 adjustments each. In particular, the interbank rate rose 19 times

though MPR remained unchanged suggests a strong link between the two wholesale market interest rates[14] and also affirms that other factors apart from MPR strongly influence interest rates in the money market.

4. Interest Rate Hierarchy and Signaling Ability of MPR

Since the preceding analysis relies largely on correlation which does not necessarily connote causality, we explore the potency of MPR in driving the other money market rates using more standard econometric technique. However, as required in standard econometric analysis, the variables were subjected to unit root tests to ascertain their stationary properties. In this case, both Augmented Dickey-Fuller (ADF) and Philip and Perron (PP) unit root tests were adopted[15]. The results of ADF and PP unit roots tests are presented in Appendix B3. With the exception of time deposit and interbank rates, both tests indicate that all the money market rates are non-stationary at levels but they become stationary after first difference. While both ADF and PP unit roots tests showed time deposit rate as stationary with drift at levels, the result was however mixed for interbank rate. The ADF test showed interbank rate to be non-stationary at levels, while the PP test indicated a weak level stationarity with drift at 90% confidence.

In addition, we established the optimal lag length and the stability of the VAR model. The results of optimal lag order selection and VAR stability tests are presented in Appendix B4 and B5 respectively. Three of out five selection criteria opted for lag length two (2) as the optimal VAR lag order, which supports the bi-monthly meetings adopted by the Monetary Policy Committee. However, the stability condition is satisfied up to 14-ordered VAR.

A. Vector Error Correction Model (VECM)

To quantify the extent of impact of MPR changes on wholesale money market rates and the onward impact of the latter on retail interest rates in both the short-run and long-run, we applied the following Vector Error Correction (VECM) model[16]:

$$\Delta r_t = \sum_{i=1}^{m} \phi_i \, \Delta r_{t-i} + \sum_{j=0}^{p} \theta_j \, \Delta X_{t-j} - \Omega[r_{t-1} - \pi - \psi X_{t-1}] + \epsilon_t, \quad (1)$$

---

with an average increase of 1.22% but declined in 12 occasions with an average drop of 1.13%. The interest rate on the 91-day Treasury instrument also increased in 15 times with an average hike of 1.26%. It however recorded 12 declines with an average drop of 0.92%.

[14] The correlation between interbank and 91-day Treasury bill rates increases to 96% when MPR remains unchanged.

[15] The Augmented Dickey-Fuller (ADF) test constructs a linear correction for higher-order correlation by assuming that the "Z" series follows an AR(*p*) process and adding "*p*" lagged difference terms of the dependent variable "Z" to the right-hand side of the test regression:

$$\Delta Z_t = \alpha Z_{t-1} + x_t'\sigma + \beta_1 \Delta Z_{t-1} + \beta_2 \Delta Z_{t-2} + \cdots + \beta_p \Delta Z_{t-p} + \mu_t,$$

With the testing hypothesis

$$H_0: \alpha = 0$$

against the alternative hypothesis

$$H_1: \alpha < 1$$

Unlike ADF test, the PP unit root test is a non-linear method that controls for serial correlation. The PP method estimates the non-augmented Dickey-Fuller test equation and modifies the t-ratio of the "α" coefficient so that serial correlation does not affect the asymptotic distribution of the test statistic. Both tests included a constant, a constant and linear time trend, or neither of the two in the test regressions, assuming a null hypothesis of non-stationarity against the alternative of stationarity.

[16] Similarly, Kovanen (2011) examines the transmission of MPR to wholesale rates (i.e. 91-day Treasury bill and interbank market rates) and the onward impact on retail market rates in Ghana using VECM. In the paper, he estimated the long run relationship between the wholesale interest rates and MPR. With the retail interest rate, however, he used a panel of bank-specific lending and time deposit rates and regressed them on the wholesale interest rates.

In this equation, π, Ω and ψ are assumed to remain constant over time. The dependent interest rate is denoted by r_t, while X_t is the independent interest rate variables. The model provides an estimate of the long-run interest rate elasticity, denoted by ψ, and an estimate of the speed of adjustment towards the long-run equilibrium, denoted by Ω. The error term, ϵ_t, is normally distributed with zero mean and a constant variance. This is to assess whether changes in MPR are fully reflected in the other money market interest rates (that is, one-to-one effect) or the effect is incomplete even in the long run.

The short run and long run estimates of interbank and Treasury bill interest rates are presented in Appendix C1. The VECM estimates illustrate a clear evidence of a positive long run effect of MPR on both interbank market rate and 91-day Treasury bill rate. However, the impact is not one-to-one, indicating an incomplete long run impact. The long run adjustment of interbank rate (0.55%) to changes in MPR is relatively higher when compared to the adjustment in Treasury bill rate (0.48%) to changes in MPR. On the other hand, the short run positive impact of MPR on Treasury bill rate is much stronger (0.84%) than that on the interbank rate (0.38%). In particular, the coefficients of the error correction terms (ECM_{t-1}) are significantly negative as required. It takes approximately six months for interbank rate to revert back to its long run equilibrium, while Treasury bill interest rates takes approximately six and half months to return to its long run equilibrium.

Concerning the onward interaction between wholesale and retail market interest rates, Appendix C2 displays the short run and long run estimates for commercial banks' lending and deposit interest rates. In the long run, banks' lending rate increases by 0.51% and 0.39% to a percentage increase in interbank rate and Treasury bill rate respectively.

Also, savings rates have positive long run significant impact on lending rate (Model LR3-5 in Appendix C2), which confirms the cost channel from savings to retail lending rate. This is consistent with Kovanen (2011). Similarly, the coefficients of the error correction terms (ECM_{t-1}) are significant, negative and less than one. However, the short run impact of changes in both interbank and Treasury bill interest rate on lending rate appears to be weak, as the coefficients of the wholesale interest rates are insignificant. A positive long run adjustment of deposit rate to changes in wholesale market interest rate was also detected. However, the response to changes in interbank rate is relatively higher (0.50%) when compared to that of Treasury bill rate (0.37%). Likewise, the coefficients of the error correction terms (ECM_{t-1}) are significantly negative as required, reinforcing the existence of a long run relationship between deposit rate and the wholesale market interest rates. On average, it takes approximately six months for deposit rate to revert back to its long run equilibrium. Moreover, a significant positive short run effect of Treasury bill rate on deposit rate was detected during the second month, while no significant short run effect of interbank rate was established.

B. VAR Granger-Causality/Block Exogeneity Tests

Due to weak short run coefficients of the wholesale interest rates in the VECM estimates of the retail interest rates, the paper further evaluated the short run dynamics using Granger-Causality/Block exogeneity test from a stationary VAR model in equation (2).

$$z_t = \Omega_0 + \sum_{i=1}^{k} \Omega_i z_{t-i} + v_t \dots\dots\dots\dots\dots\dots (2)$$

where z_t denotes matrix of endogenous variables (such as the MPR, wholesale and retail market interest rates), Ωs are the parameters to be estimated in the system and v_t is the error term. The system in equation (2) permits the testing for effect of past values of Z on current values.

Essentially, this approach will enable us to assess whether MPR granger causes the other money market rates as well as decode the hierarchy of money market interest rates in Ghana. Unlike Fukac et al (2014), we applied different time horizons (such as 2-months, 6-months, 10-months and 12-months horizons) in order to assess the extent of pass-through of MPR to other short-term money market rate within a year.

Table 1 also summarizes the results of the VAR Granger causality tests. The results indicate that MPR granger-causes the short-term money market rates within the 2-month, 6-month and 10-month horizons. This implies that monetary policy rate (MPR) is effective in influencing the other short-term money market rates within the first 10 months. This result is also consistent with Fukac et al (2014) which found limited signaling ability of MPR in 12-ordered VAR framework. The test also highlights the dominant position of Treasury bill in the hierarchy of short term interest rates. We observed significant influence of Treasury bill rate on the interbank rate and retail rates in all the selected horizons. On the other hand, the effects of interbank rate on the Treasury bill and retail rates are noticed in the 12-month and 6-month horizons respectively.

Table 1: VAR Granger Causality Test Results in Different Time Horizons

	MPR	Interbank Rate	Tbill Rate	Lending Rate	Savings Rate	Period
MPR	-	-	-	-	-	2-Months Horizon
Interbank Rate	[0.00]*	-	[0.00]*	-	-	
Tbill Rate	[0.00]*	-		-	-	
Lending Rate		-	[0.08]***		[0.01]**	
Savings Rate	-	-	-	-	-	
MPR	-	-	[0.02]**	-	-	6-Months Horizon
Interbank Rate	[0.02]**	-	[0.02]**	-	-	
Tbill Rate	[0.00]*	-	-	-	-	
Lending Rate		[0.01]**	[0.08]***	-	-	
Savings Rate	[0.05]***	[0.00]*	[0.00]*	-	-	
MPR	-	-	-	-	-	10-Months Horizon
Interbank Rate	-	-	[0.07]***	[0.01]**	[0.01]**	
Tbill Rate	[0.04]**	-	-	-	-	
Lending Rate	-	[0.00]*		-	-	
Savings Rate	-	[0.01]**	[0.00]*	-	-	
MPR	-	-	-	-	-	12-Months Horizon
Interbank Rate	-	-	[0.00]*	[0.02]**	[0.00]**	
Tbill Rate	-	[0.09]***	-	-	-	
Lending Rate	-	[0.01]**	-	-	-	
Savings Rate	-	[0.06]***	[0.02]**	-	-	

Note: the table displays the p-values of Granger causality test that are significant up to 10% alpha level.
Columns indicate the causal direction; that is interest rate heading a column affects the interest rate on a row if a p-value is reported.
This is based on 2nd, 6th and 12th -lagged vector autoregressive model estimated on monthly data spanning 2002M11 –2014M14.
*, ** & *** denote 1%, 5% & 10% significant levels respectively. The model only violated the VAR stability condition after 14th lag length.

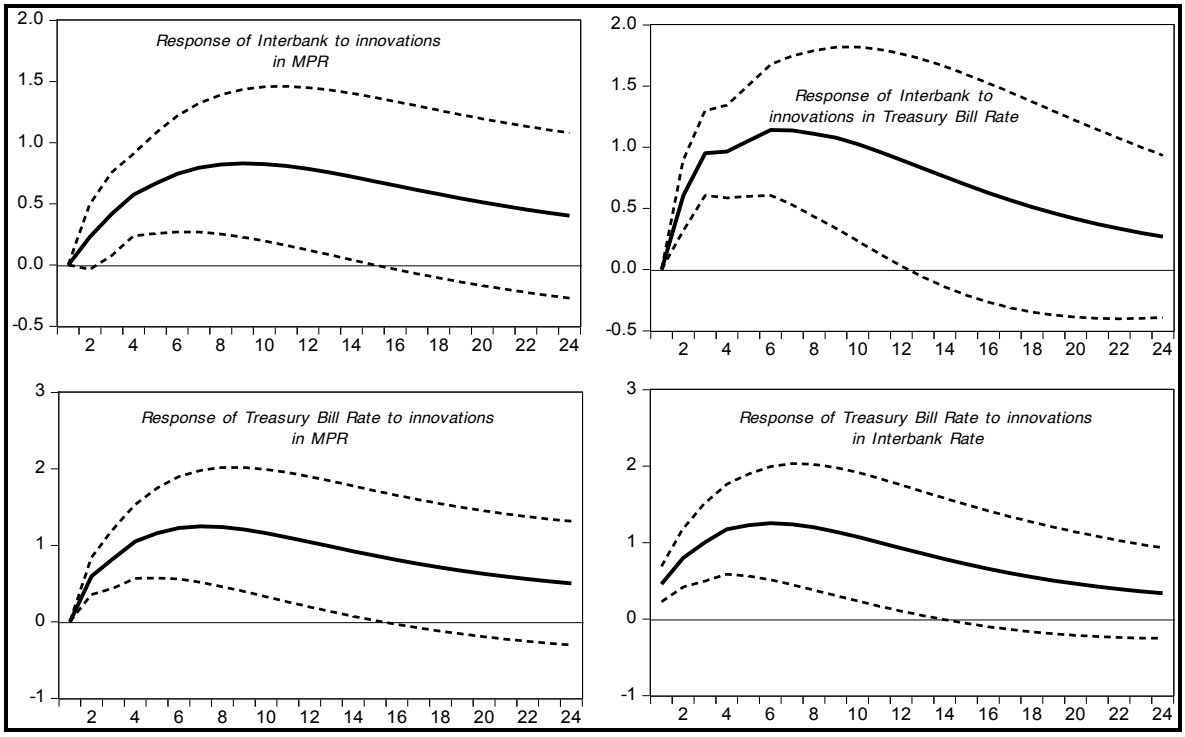
Besides, the causality emanating from Treasury bill rate to interbank rate is stronger (significant at 1% alpha level) compared to the reverse causation (significant at 10% alpha level).This implies that

although both wholesale rates contemporaneously Granger-caused each other, the Treasury bill rate precedes the interbank rate in terms of hierarchy of influence in the money market rates in Ghana. Likewise, a contemporaneous dual causality exists between interbank and retail rates (bank lending and saving/deposit rates). This is essential for interest rate transmission channel because lending and savings (or time deposit) rates move in response to interbank rate and vice versa.

C. Robustness using IRFs

We further assess the robustness of the result from the causality test using impulse responses function (IRFs). Figure 5 displays the IRFs of the impact of innovations in MPR on wholesale market interest rates, while figure 6 exhibits the IRFs of changes of the wholesale market interest rates on retail market interest rates. The IRFs (in figure 5) reinforces that MPR effectively signals the wholesale market interest rates. Consistent with the Granger causality test, the positive effect of MPR on Treasury bill rates appears to be larger than that on interbank rate. The IRFs also show a high degree of persistence of MPR on the wholesale market interest rates.

Figure 5: Effects of changes in MPR on Wholesale Interest Rates

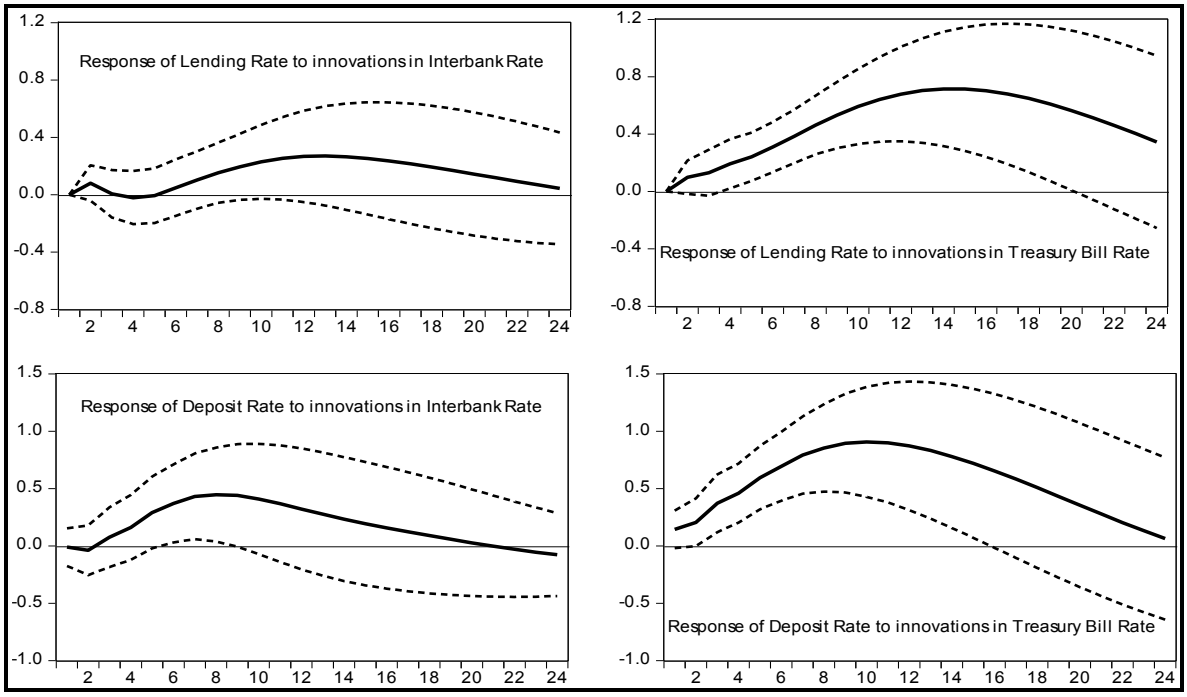


With respect to the retail market interest rates, the IRFs (in figure 6) demonstrate a weaker short run influence of interbank rate on both lending and time deposit interest rates, reaffirming the preceding VECM estimates[17]. On the contrary, IRFs exhibit that innovations in Treasury bill interest rate have significant positive and larger impact on both retail market interest rates and the effect tends to be persistent. This suggests that the rate on Treasury bill instrument play a larger role in the interest rate structure in Ghana. Essentially, the positive and persistent influence of Treasury bill rate on lending rate connotes that rising trends in the interest rates on government

[17] While no significant impact of impulses in interbank rate was observed on lending rate for the 24 periods, shock to interbank rate has a significant influence on time deposit rate between the 5th and 9th periods.

securities could serve as a drag on economic growth because it potentially crowds-out private sector investments.

Figure 6: Effects of Changes in Wholesale Interest Rates on Retail Interest Rates



In synthesis, the preceding deliberations of VAR Granger causality, VECM and IRFs suggests the existence of the following hierarchy of short-term money market rates in Ghana: *Monetary Policy Rate*, *Treasury bill rate*, *Interbank rate and retail rates (preferably*, *lending rate)*. In addition, the result robustly indicates that MPR effectively acts as a signaling rate in the money market in the short and long runs, although the transmission is incomplete (that is, not one-to-one).

5. Monetary Policy and the Macroeconomy

In this section, we examine how monetary authority responds to macroeconomic shocks as well as how monetary policy shock is transmitted to the real economy using structural VAR analysis. This is to appraise the existence of a standard interest rate channel for monetary policy as well as the relative importance of the various shocks in the monetary policy transmission process in Ghana. Unlike other studies, we incorporate all the theoretical monetary policy transmission mechanisms (as shown in appendix A2) in the following baseline structural VAR (SVAR) framework in levels[18]:

$$z_t = \Omega_0 z_t + \sum_{i=1}^{k} \Omega_i z_{t-i} + v_t \dots\dots\dots\dots\dots\dots (3)$$

where Z_t denotes endogenous variables with the following Cholesky ordering:

$$\{LRCIEA,\ LCPI,\ MPR,\ LENDRATE,\ LTRCRD,\ LREER3CORE,\ LGSEP\} \qquad (3a)$$

with $LRCIEA$ representing the log of Bank of Ghana's Composite Index of Economic Activity, as a proxy for real GDP (or output), $LCPI$ is the log of consumer price index (or inflation), MPR is the

[18] Sims, Stock and Watson (1990), Bernanke and Blinder (1992), Sims (1992), Levy and Halikias (1997), and Peersman and Smet (2001) used VAR at levels while Tahir (2012) used structural VAR at levels. Table 10 at Appendix B also presents the Johansen Cointegration test result.

monetary policy rate, $LENDRATE$ is lending rate of commercial banks, $LTRCRD$ is the log of real credit by the commercial banks, $LREER3CORE$ is the log of real effective exchange rate of the three major trading currencies (the US dollar, pound sterling and the euro) - an increase is appreciation, while a decrease is a depreciation of the domestic currency and $LGSEP$ is the log of share price index. It is essential to note that the ordering of policy interest rate (MPR) as a third variable in the baseline model is to allow monetary policy to response contemporaneously to demand and supply pressures.

A. Cholesky Identification Restriction

The literature outlines various approaches used to identify orthogonal (structural) disturbance but the most common methodology is the Choleski identification which assigns all correlations between the orthogonal errors to the equation that is earliest in the ordering. Choleski decomposition presumes that a shock to a variable does not contemporaneously affect the variable that precedes it in the ordering but does affect them with a lag. Due to the sensitivity of Choleski decomposition to the ordering of the variable, we use a model-based identification strategy to estimate the impact of the shocks. The restrictions applied in the SVAR to identify a monetary policy shock are that contractionary shock increases interest rate, appreciates exchange rate, and reduces output, inflation and credit. In particular, the identification restrictions of our framework is mainly based on real and nominal rigidities, informational advantages of central bank over private agents and inflation forecast target because Ghana is an IT country.

The first two variables, output and inflation are target variables. To check the relative strength of transmission channel (as exhibited in appendix A2), we need intermediate variables that would represent a certain transmission channel. Our intermediate variables are lending rate, private sector credit, exchange rate and share prices representing the traditional lending channel, credit channel, exchange rate channel and share price (asset) channel respectively. Similar to Tahir (2012), we do not include typical monetary aggregate variables like M1 or M2 as usually done in the literature (see, Kim and Roubini, 2000).

We impose restriction on the structural (contemporaneous) parameters and no restriction of lagged parameters, to enable us obtain reasonable economic structure. In the first place, output responds to all the domestic variables only with a lag as firms' decision to either increase capacity or utilize the existing capacity takes time. Similarly, we assume that the other target variable, CPI responds contemporaneously to only pressure emanating from output. Ordering of MPR as a third variable describes the reaction function of the central bank. As a forward looking inflation targeting central bank, our baseline model assumes that the central bank responds contemporaneously to output and inflationary pressures. The transmission of policy rate to the above two target variables is evaluated based on the subsequent restrictions in the intermediate variables. According to our ordering, bank lending rate will respond to CPI and policy rate as studies believe that banks are quick to translate policy rate into their lending rate. We further assume that banks' real total credit responds to banks' lending rate. In addition, due to high import content in Ghana's economic growth process, we assume that real exchange rate response to output, CPI, credit and policy rate. Finally, since share price is a financial variable and quick to react, we assume that share price react contemporaneously to shock on output, CPI, lending rate, real credit, exchange rate and policy rate. That is, we examine how domestic factors influence the movements in share price in Ghana.

Moreover, alternative Cholesky ordering was investigated to assess the robustness of our results. In this case, MPR was ordered as the first variable while CPI and RCIEA were placed as the 6th and 7th variables respectively. That is, we assumed that the MPR is only endogenously affected by the other variables in the system with a lag. Also, to capture shock that is outside the control of the central bank since Ghana is small-opened economy, we augmented SVAR framework in equation (3a) by including international crude oil price as an exogenous variable.

In synthesis, as it is common in the flexible IT regime, we have two target variables, four intermediate variables which represent each monetary transmission channel and lastly a policy variable in our model. Also monetary shock is measured by innovations in interest rate, so an increase in policy rate means tighter (or contractionary) monetary policy stance.

B. Expected Signs

Regarding the expected movements of macroeconomic variables included in the model after different shocks, the theory is lucid on the effect of monetary shock on inflation (that is an increase in interest rate causes inflation to decline), but it remains vague in the case of output. The dynamics in output to monetary shock would largely depend on the extent of money non-neutrality in the short run. However, as an IT country, we expect reasonably strong impact monetary shock on inflation than on output since the main thrust of monetary policy is to achieve stable prices (inflation). With respect to the intermediate targets, we expect monetary tightening to trigger a rise in commercial banks' lending rate which in turn moderates credit growth, in line with the credit view documented by Bernanke and Blinder (1988). The response of exchange rate to monetary shock is somewhat unclear as Ghana appears to have high inflationary environment due to the prevalent fiscal dominance. On one hand, if the monetary tightening leads to an increase in real interest rate, then domestic currency will appreciate. On the other hand, if the expected inflation increases more than nominal interest rate which leads to a decline in real interest rate, then domestic currency will depreciate. Thus, the behaviour of exchange rate to monetary policy tightening depends upon Fisherian effect. Although the debate on the extent to which interest rate affect share price is still ongoing, we expect an increase in monetary policy rate to have an adverse impact on share prices in Ghana.

In addition, we consider innovations in the intermediate targets as each represents a transmission channel. Economic theory is clear that an increase in credit will increase both output and inflation. The theoretical persuasion of the macroeconomic effects of real exchange rate depreciation is unclear[19]. Ghana is a small-opened economy with high import content in its growth process and also has high imported items in the domestic CPI basket. This notwithstanding, we expect real (nominal) exchange rate depreciation to increase output (via gaining trade competitiveness) and also exacerbate inflationary pressures. The opposite is also true. Moreover, since stock exchange is a barometer of economic activity and the price of share is a claim on the future output, we expect that a positive share price shock will trigger an increase in future output. The response of inflation is unclear as it may depend on the source of increase in share prices and its influence on the exchange rate.

[19] The simple text book argument is that real exchange rate depreciation proffers competitive gains and improves trade balance. There also exist theoretical underpinnings that real depreciation can have adverse impact on the economy.

C. Estimated Contemporaneous Effects

The following section presents the estimated contemporaneous coefficients and the impulses response functions (IRFs) for the case of Ghana. Table 2 presents the estimated contemporaneous coefficients in the baseline structural models (equation 3a)[20]. The key message is that monetary authority responds appropriately (positively) and contemporaneously to innovations in output and inflation. That is, when there is an increase in output or inflation gap or pressure on domestic currency, the central bank increases policy interest rate (MPR), as expected. On the other hand, contractionary monetary policy tend to contemporaneously increase lending rate and also decrease real credit, consistent with the notion that commercial banks are quick in translating policy hikes in their lending rate. Although, no significant direct link is observed between monetary policy rate and GSE share prices, their interaction could be via the exchange rate. The results are robust as the quarterly estimated contemporaneous coefficients in Appendix D3 yielded similar outcome.

Table 2: Contemporaneous Coefficients from Structural VAR

		Shocks						
		RCIEA	CPI	MPR	Lending Rate	Real Credit	Real Exchange Rate	Share Prices
Contemporaneous Responses	RCIEA	0.031[18.27]*						
	CPI	-0.081[2.44]**	0.013[18.27]*					
	MPR	1.057[0.76]	0.702[0.22]	0.561[18.27]*				
	Lending Rate	0.372[0.17]	2.743[0.56]	0.197[1.68]***	0.854[18.27]*			
	Real Credit	0.052[1.33]	-0.410[-4.55]*	-0.002[-0.74]	0.0001[-0.07]	0.015[18.27]*		
	Real Exchange Rate	-0.047[-0.69]	0.651[3.93]*	-0.005[-1.19]	-0.001[-0.32]	-0.238[-1.78]***	0.027[18.27]*	
	Share Prices	-0.019[-0.04]	-0.385[-0.38]	-0.004[-0.19]	-0.001[-0.04]	0.879[1.12]	0.669[1.49]	0.160[18.27]*

Note: columns are impulses, while rows are responses. Also *, **&*** denote 1%, 5% & 10% significant levels respectively.
Source: Author's calculation.

D. Structural Impulse Response Function (SIRFs)

In terms of the lagged effects of monetary policy changes, we used SIRFs to examine the responses of a one-standard deviation positive impulse over 36-months with one-standard deviation confidence error band.

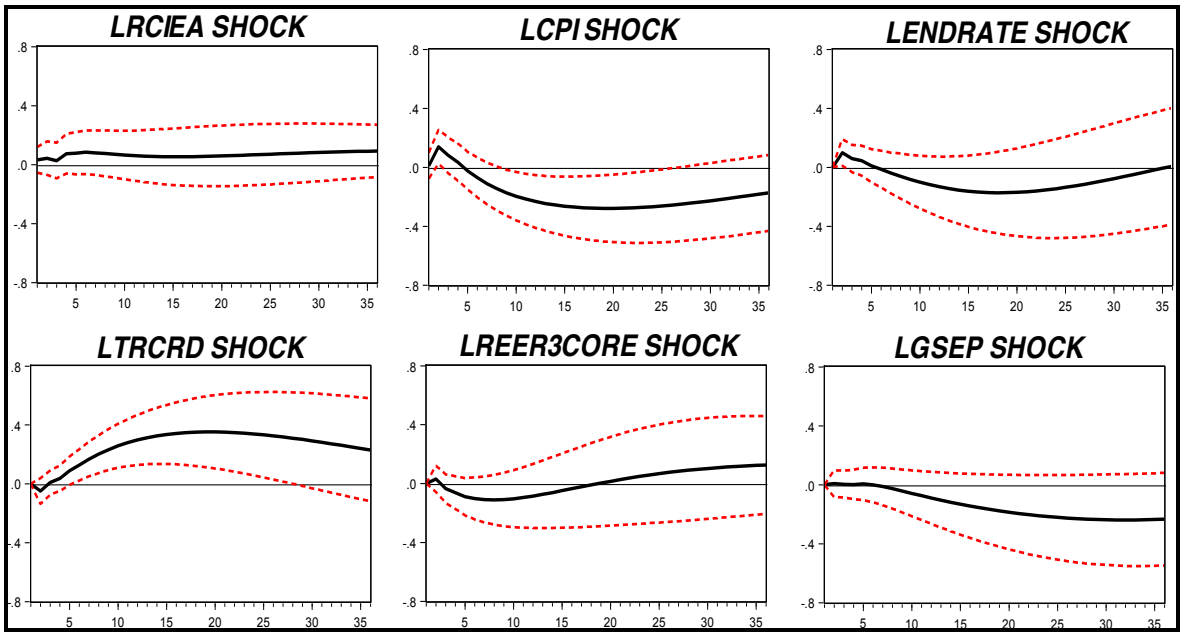
(i) Monetary Authority's Responses to Macro-Shocks

Figure 7 displays the response of monetary authority to innovations in the selected target and intermediate variables. The SIRFs show that the central bank tends to response positively to inflation shock during the first two periods and is significant at the 2nd month. In contrast, the central bank's response to output shock is also positive but statistically insignificant over the entire 36-month horizon. This confirms that the monetary authority is more concerned about inflation than output growth. The benign response of monetary authority to positive output shock is perhaps not surprising because the Bank of Ghana Act 2002 (Act 612) Section 3 Sub-section 2 also mandates the central bank to promote economic growth without prejudice to price stability. Therefore, so far as economic growth is not inducing inflationary pressures, we expect the central bank to be less responsive to output shocks.

[20] Appendix D2 and D2 presents the lag selection criterion and Johansen cointegration test results respectively for equation 3.

We also observe a weak (insignificant) response of monetary authority to positive real exchange rate shock (appreciation) and share prices. However, the results in Appendix E2 illustrates that monetary authority tends to increase policy interest rate in response to nominal exchange rate depreciation. This suggests that the monetary authority is perhaps more concerned about the pass through of nominal exchange rate depreciation to inflation due to the considerable number of foreign goods in the domestic CPI basket. Accordingly, initial monetary policy responds to a positive innovation in exchange rate (appreciation) is generally negative but statistically insignificant. This is instinctively plausible because exchange rate appreciation also acts as a contractionary monetary policy. In contrast, the central bank responds positively and significantly to a one standard deviation positive shock to real credit. This is intuitive because while exchange rate appreciation is likely to dampen inflationary pressures, a pick-up in real credit has the penchant to exacerbate inflationary pressures.

Figure 7: Monetary Authority's (MPR) Response to structural One Standard Deviation….



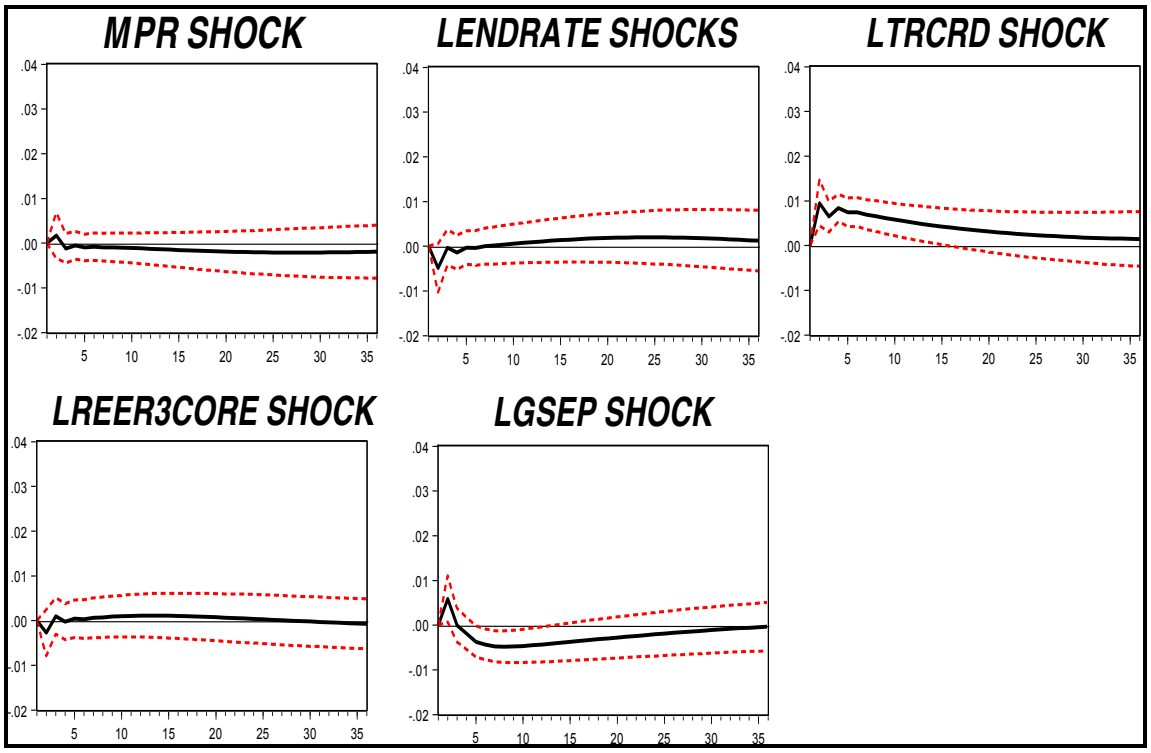
(ii) Output Response to Macro-Shocks

Figure 8 displays the response of output to one standard deviation shock to selected financial indicators. In particular, we observe that the shocks that are relevant to output are those emanating from real credit and share prices. As expected, output tends to rise in response of credit shock and this is statistically significant, persisting up to the 15th month. This is intuitively plausible as a rise in real credit tends to boost private investments and eventually output growth. Regarding share price shock, output rises initially but declines after the 3rd month and significantly persists up to the 13th month.

In contrast, the response of output to one standard deviation positive innovations in monetary policy rate (MPR) and commercial bank's lending rate is generally flat (statistically insignificant), suggesting that money is neutral even in the short run. Likewise, output remains generally flat following a positive shock to real exchange rate (appreciation). On the contrary, the results from the alternative specification in Appendix E2 seem to suggest that output rise in response to a one

standard deviation positive shock to nominal exchange rate (depreciation). However, this is statistically insignificant.

Figure 8: Response of LRCIEA to structural One Standard Deviation….



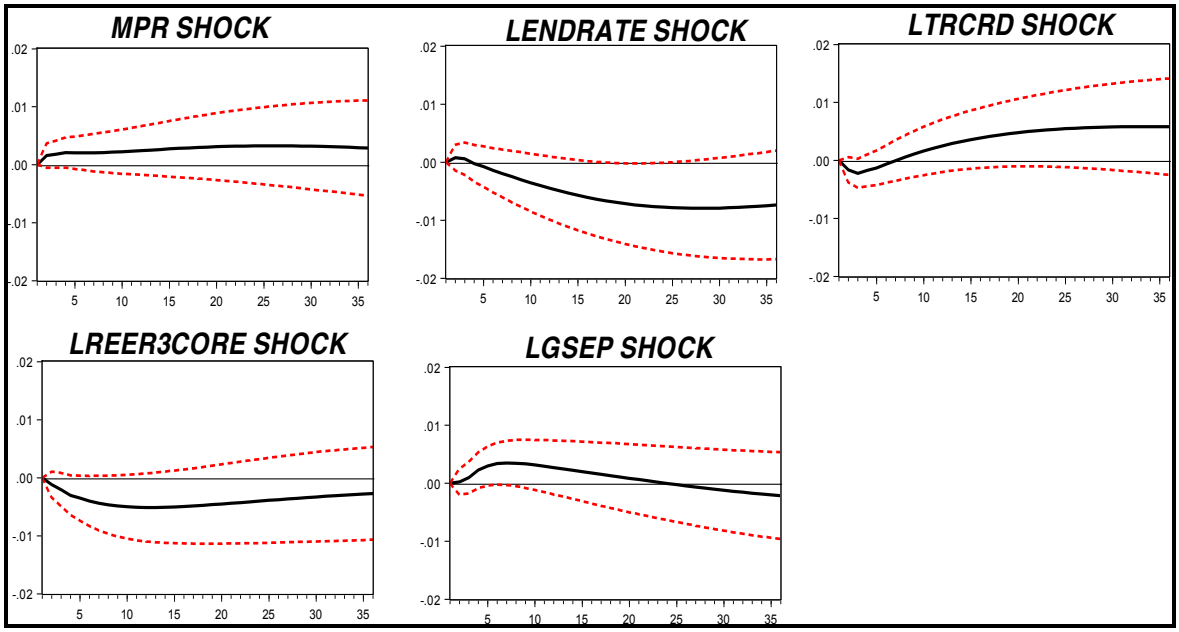
(iii) Price Response to Macro-Shocks

Figure 9 exhibits the response of prices (inflation) to innovations in the selected financial indicators. Surprisingly, inflation somewhat increases after a positive shock to MPR but statistically insignificant. The weak (or perhaps positive initial) response of inflation to tight monetary policy may also suggest that Ghana is not yet a successful inflation targeter. This also reflects the price puzzle which accentuates the tendency for prices to increase temporarily after surprise interest rate hikes (Sims, 1992). In contrast, inflation declines as expected after a positive shock to commercial bank's lending rate (LENDRATE). This is statistically significant between the 15th and 28th months.

Unexpectedly, inflation tends to initially decline before increasing in response to a shock to real credit (though statistically insignificant). This perhaps reinforces the notion that inflation is not purely a monetary phenomenon in Ghana. On the other hand, inflation declines following a positive shock to real exchange rate (appreciation) and this is statistically significant for about 13 months. This is can be explained that a real appreciation reduces imported inflation as there are a considerable number of imported items in the CPI basket. On the contrary, inflation increases in response to positive innovation in share prices. Intuitively, this may be explained that a rise in share price increases the wealth of economic agents which in turn increases consumption expenditures and hence, exacerbates aggregate demand pressures.

In terms of magnitude, however, innovations in commercial bank's lending interest rate and real exchange rate appear to exert greater impact on prices than that emanating from credit and asset price shocks.

Figure 9: Price Response to Structural One Standard Deviation……



(iv) Interaction of the intermediate variables

Since monetary authority tends to have some control over interest rate and credit growth, we appraise the responses of the intermediate variables to innovations in MPR, lending rate and credit. Figure 10 presents the results of the interested IRFs. As expected, commercial bank's lending rate increases and persists up to 10 months in response to a one standard deviation positive shock to MPR and this is statistically significant. On the other hand, both credit and asset prices remain flat in response to positive shock to MPR. In contrast, real exchange rate tends to depreciate initially in response to contractionary monetary policy before appreciating, consistent with the Grill and Roubini (1993) exchange rate puzzle (See, also Dornbusch (1978) exchange rate overshooting model).

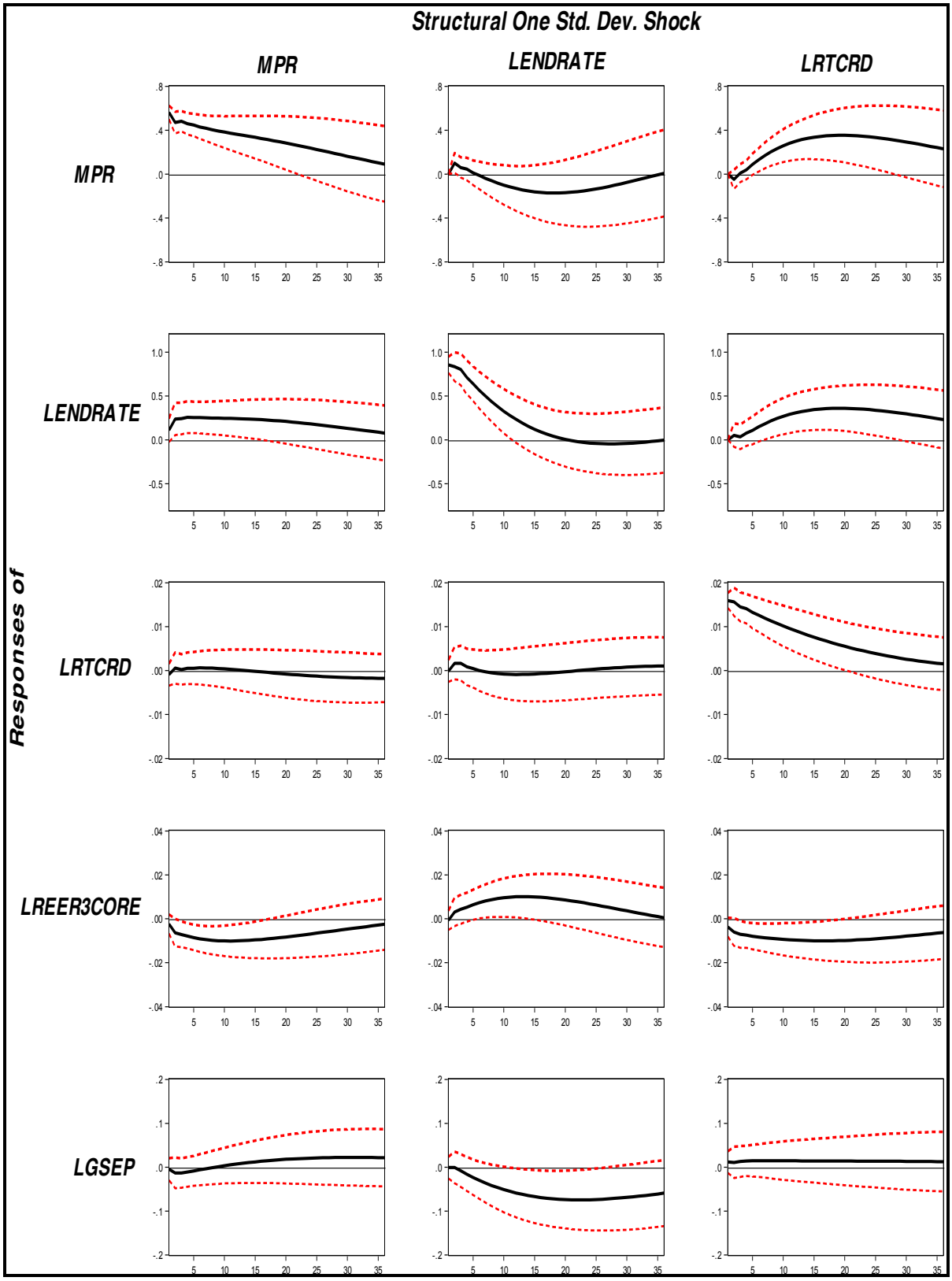
In the case of a positive shock to commercial bank's lending rate, exchange rate appreciates (and is significant) while credit declines (but is statistically insignificant)[21]. The appreciation in the domestic currency and credit declines following lending rate hike is very intuitive. In contrast, share price declines after lending rate increases and this is statistically significant, indicating that attractive money market rate tends to dampen stock market activities.

Following a positive shock to real credit, exchange rate depreciates and is statistically significant up to the 20th month. This is also consistent with economic theory. On the other hand, share price increases after a positive shock to credit but is statistically insignificant. As expected, commercial

[21] However, significant negative impact of contractionary monetary policy on real credit was observed when real lending rate was used (see Appendix E2).

bank's lending interest rate increases in response to real credit shock and this is statistically significant between the 7th and 29th months.

Figure 10: Responses to Interest Rate and Credit Shocks



Although not presented here, a positive shock to real exchange rate (appreciation) tends to increase both credit and share prices and this is intuitively plausible. By instinct, exchange rate depreciation often triggers interest rate hikes but real appreciation, on the other hand, already acts as a contractionary monetary policy. Therefore, the central bank tends to either adopt "policy neutral" by leaving interest rate unchanged or reduces policy rate in order to stimulate economy activity. The reduction in interest rate in turns stimulates growth in the quantity of loans (credit) and also makes investments in equities (assets) more attractive than that of money market instruments.

In synthesis, the impulse responses are in line with economic theory though some odd results do emerge in some cases. The overall behaviour of the variables confirms that our identification restrictions are very reasonable. It is essential to emphasize that the results (based on equation 3a) are robust as similar outcome was established from an alternative Cholesky ordering which assumes that MPR is only affected by other variables in the system with a lag (see Appendix E5). Among the intermediate variables, the response of output to credit shock is more pronounced and also statistically significant up to 15 months. This is followed by share price shock. In the case of inflation, both the interest rate and exchange rate shocks exert greater influences and are statistically significant. Thus, we establish that the monetary policy transmission to inflation in the case of Ghana is largely via both the interest rate and exchange rate channels. This is explored further in the subsequent section using forecast error variance decomposition (FEVD) analysis, espoused by Sims (1980).

E. Relative Contribution of Shocks using FEVD

Specifically, we gauged the relative importance of the shocks in the intermediate variables using FEVD. According to Amisano and Giannimi (1997), FEVD is a basic tool to provide complementary information for the better understanding of the dynamic relationship among the variables jointly analyzed in a VAR model. It determines the extent of the behaviour in the system affected by different structural innovations at certain horizons. Thus, FEVD allows the comparison of the role of different variables in explaining the changes in a certain variable in a system. We refer to this role as a relative importance and thus rank the shocks according to this role. Since output (RCIEA) and inflation (CPI) are the target variables, we assign relative importance to the four monetary transmission channel considered according to their share in the variations in the target variables.

Table 3 summarizes the FEVD of the composite index of economic activities (RCIEA) and consumer price index (CPI) due to the five shocks. Also, the time series of FEVD for RCIEA and CPI are reported in Appendix F1 and F2 respectively. We selected the contributions of each intermediate variable to the variations in the target variables at the end of 12^{th} months, 24^{th} months and 36^{th} months. The choice of time horizon is largely due to the fact that the central bank is forward looking and hence adopts a medium term inflation target[22]. The corresponding numerical values indicate the percentage changes in the RCIEA and CPI. In this case, the higher the fluctuations, the higher the relative importance of the shock for the interested variable.

[22] We think that 3-year period is reasonable enough to judge the efficiency of a channel as IT central bank oftentimes targets two-year ahead inflation. For instance, Tahir (2012) report the result for 36-months, Kim et al (2000) used 48 months, while Christiano and Eichenbaum (1992) used 10 quarters.

Table 3: Relative importance of shocks on the basis of variance decomposition

% Contribution at Different Time Horizon						
	RCIEA			CPI		
	12th-Month	24th-Month	36th-Month	12th-Month	24th-Month	36th-Month
ER	0.6	0.7	0.6	8.3	11.1	9.9
LR	*1.1*	*1.8*	*2.3*	*3.2*	*15.1*	*22.9*
MPR	*0.5*	*1.5*	*2.4*	*2.2*	*3.8*	*4.7*
CREDIT	21.4	20.1	17.2	1.2	6.5	11.3
SP	8.1	9.3	7.9	3.9	2.8	2.3

Note: The choice of 36 months is mainly due to the fact a forward-looking IT central bank has medium term target for inflation.
Source: Author's calculation

(i) Contribution to Innovations in Output

On a whole, credit shock assumes the first ranking for output, followed by share price (SP), commercial bank's lending interest rate (LR), monetary policy rate (MPR) and then exchange rate (ER). The first ranking of credit shock may be due to the fact that most companies (especially the small scale enterprises) heavily rely on the commercial bank for needed capital for expansion and also only few companies are listed on Ghana stock exchange. However, the second place of share price is also comprehensible as increases in share price could be due to capital inflows (either portfolio or foreign direct investments) on the back of global financial integration. In terms of proportion, credit explains about 21% of the variations in output at the 12th month which however moderates to 17% by the 36th months. Explanation of share price to variations in output increases to about 9.3% by 24th months. Commercial bank's lending rate, MPR and exchange rate shocks explain about 1.8%, 1.5% and 0.7% respectively of the variations in output. The relative smaller explanations of interest rate and exchange rate to changes in output are not surprising as they are largely second round effects. For instance, assuming relative price constant, real exchange rate depreciation would also imply nominal exchange rate depreciation. This in turn triggers an increase in commercial banks' lending rate which dampens credit growth, and hence decelerates output growth. Thus, although exchange rate depreciation can affect output via competitive gains, exchange rate movements can also affect output via the credit channel as indicated by the structural IRFs.

(ii) Contribution to Innovations in Prices (CPI)

In the case of CPI, commercial bank's lending interest rate shock (LR), on average, assumed the first ranking as its explanation to variation in CPI dominates the other shocks after 12th-month horizon. On aggregate, lending interest rate explains about 15.1% of the variations in CPI (inflation) by 24th month compared with 11.1% explanation from exchange rate (ER). As expected, we observed that the commercial banks' lending rate provides relatively higher explanation to variation in CPI than that emanating from MPR. However, the exchange rate shock is higher in ranking for the 12th month horizon with 8.3% explanation to variations in CPI compared with 5.4% explanation from lending rate. This is consistent with our expectation due to the peculiar characteristics of the Ghanaian economy as well as the results from IRFs. For instance, statistically

significant negative impact of shock to lending rate on CPI is observed after 15 months. In contrast, statistically significant disinflationary effects due to a positive shock to real exchange rate are observed after 5 months (see figure 10 above). Also, the results in Appendix F2 clearly exhibit larger influence of exchange rate on CPI (compared to that emanating from lending rate) from the 2nd to the 19th month. On the other hand, share price shock is observed to be the least important in explaining the variation in CPI in Ghana.

In all, the results suggest that the interest rate and credit shocks presume relatively higher importance for inflation and output respectively in Ghana over the medium to long term than shocks emanating from share price and exchange rate. However, exchange rate shock has a relatively larger influence on inflation in the short term.

6. Conclusion and Policy Suggestions

We examine the effectiveness of monetary policy transmission mechanism in Ghana, especially during the inflation targeting regime (2002-2014). As an IT economy with a more flexible exchange regime but pummeled by persistent fiscal dominance (and overruns) and high import contents in economic growth process, we analyze the potency of monetary policy transmission mechanism using two main approaches. First, we evaluate the short and long run signaling ability of monetary policy rate (MPR) to other market interest rates (such as interbank market rate, 91-day Treasury bill rate, lending rate and time deposits rate). Second, we assess monetary policy influences on the real sector (i.e. output and inflation) by developing a structural VAR framework at levels that also incorporates four main monetary transmission channels documented in the literature. In this regard, we exploit structural forecast error variance decomposition to rank the shocks. In particular, commercial bank's lending rate, real total credit, real effective exchange rate and GSE share index were used as intermediate variables to represent interest rate channel, credit channel, exchange rate channel and asset price channel respectively. The study employs monthly data for the period 2002M1-2014M12, although quarterly dataset (2002Q1-2014Q4) was also used to validate our results.

We observe that although the MPR effectively signaled other market interest rates, the pass through is incomplete both in the short run and long run. That is, the transmission of MPR to the wholesale market interest rate (i.e. overnight interbank rate and 91-day Treasury bill rate) is not one-to-one, consistent with Kovanen (2012) and Fukac et al (2013). In terms of hierarchy of interest rates in Ghana, we observe that 91-day Treasury bill rate has strong link with the MPR and also possesses a dominant influence on the retail interest rates (such as the lending and time deposit interest rates). This confirms that the central bank also uses government securities as a policy tool for liquidity management as well as stemming the depreciation of the domestic currency. We thus observe the following hierarchy of interest rates in Ghana: ***MPR, 91-Day Treasury bill, Overnight Interbank rate and commercial bank's average lending rate.*** In addition, the results also indicate that money market interest rates are not sticky downwards, consistent with the findings of Acheampong (2005).

Regarding macroeconomic impact of monetary policy, we established a well-functioning macroeconomic link between interest rate, exchange rate, credit, share price, inflation and output growth in Ghana. First, monetary authority responds appropriately (positively) and contemporaneously to output and inflationary pressures. We establish that the monetary policy

transmission to inflation in the case of Ghana is largely via the interest rate and exchange rate channels. Second, output and inflation decline in response to an increase in commercial banks' lending rate, while shock to credit increases both output and inflation, consistent with economic theory. We also observed that output picks up while inflationary pressures ease in response to a positive one standard deviation shock to real exchange rate (appreciation). Consistent with the IRFs, utilizing forecast error variance decomposition also confirms that the interest rate and credit shocks presume relatively higher importance for inflation and output respectively in Ghana over the medium to long term than shocks emanating from share price and exchange rate. In the short term, however, exchange rate shock has relatively higher influence on inflation than that emanating from the interest rate shock.

The findings have a key policy message within a domain of a small-opened economy with a flexible exchange rate regime like Ghana where considerable portion of inputs for production processes are imported alongside a shallow export base and rapid accumulation of external debt. Against this background, any deliberate attempt to depreciate the domestic currency in a bid to achieve trade competitiveness may be counterproductive in the short-to-medium term. The dominance of the exchange rate shock in the short term and its observed macroeconomic implications suggest that monetary policy should aim at either ensuring exchange rate stability or strengthening the value of the domestic currency to inure desirable macroeconomic outcomes. That is, monetary policy should be proactive in dampening excessive oscillations in domestic currency in order to soothe inflationary pressures and in tandem promote sustained economic growth. The result also suggests that financial (and macroeconomic) stability remains paramount for the effective transmission of monetary policy in Ghana. This paper therefore supports strong policy coordination between monetary and fiscal policy to avert persistent fiscal slippages and dominance that plunge the economy into disarray.

We observe that exchange rate play larger role in inflation developments in Ghana over the short term. Coupled with this, exchange rate depreciation in Ghana remains a perennial issue in policy, political, academia and international discourses. Therefore, we suggest that new research can focus on outlining the key determinants of exchange rate in Ghana and also providing concrete measures to tame the persistent depreciation of Ghana Cedi against the major trading currencies.

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8. Appendix

Appendix A:

Box 1: Bank of Ghana Act, 2002 (Act 612)

Objects of the Central Bank

3. (1) the primary objective of Bank of Ghana is to maintain stability in the general level of prices

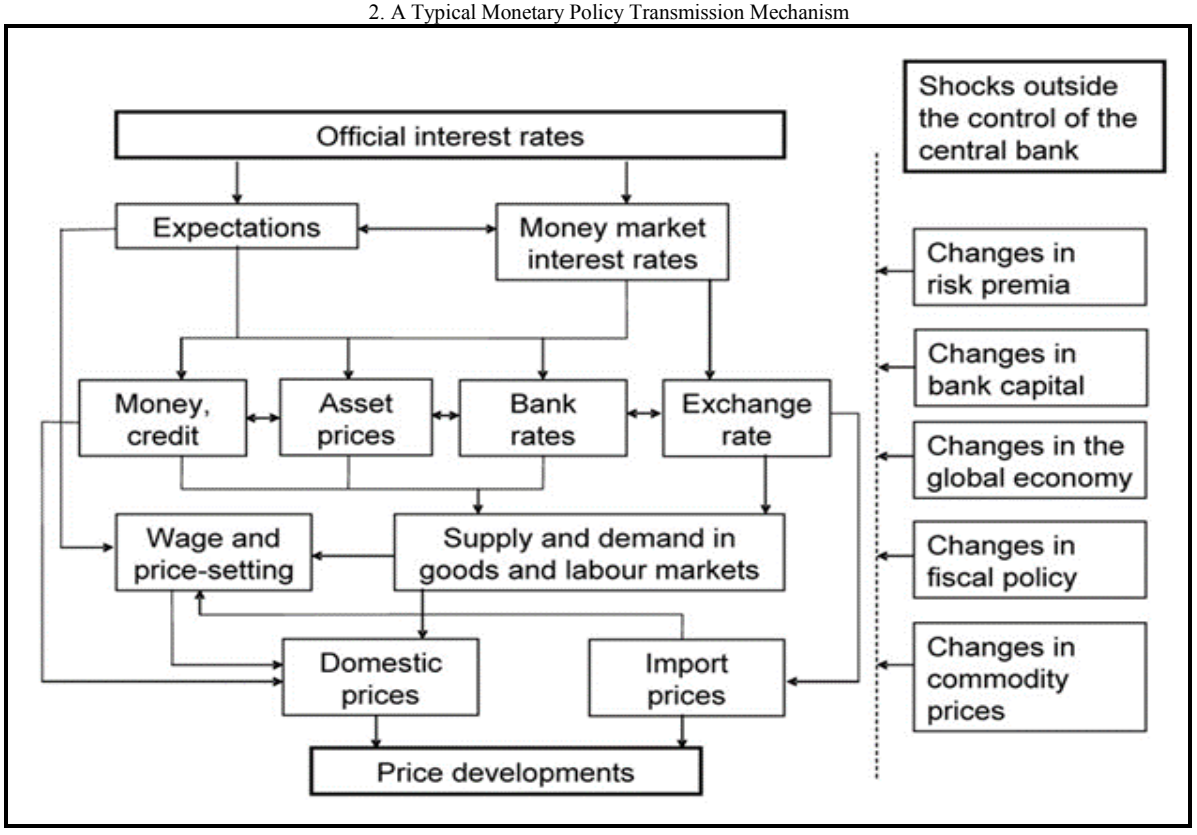
(2) Without prejudice to subsection (1) the Bank shall support the general economic policy of Government and promote economic growth and effective and efficient operation of banking and credit systems in the country, independent of instructions from the Government or any other authority.

Function of the Central Bank

4. (1) The Bank shall for the purposes of section 3 perform the following functions:

1 Formulate and implement monetary policy aimed at achieving the price stability and creating an enabling environment for sustainable economic growth.
2 Promote by monetary measures, the stabilization of the value of the currency within and outside Ghana.
3 Institute measures which are likely to have a favourable effect on the Balance of Payments.
4 Regulate, supervise and direct the banking and credit system and ensure the smooth operation of the financial sector.
5 Promote, regulate and supervise payment and settlement systems.
6 Issue and redeem the currency notes and coins.
7 Ensure effective maintenance and management of Gross external reserves of banks.
8 License, regulate, promote and supervise non-bank financial institutions.
9 Act as banker and financial adviser to the Government.
10 Promote and maintain relations with international banking and financial institutions.

2. A Typical Monetary Policy Transmission Mechanism



Source: European Central Bank

Appendix B

1. Descriptive Statistics of MPR and other Money Market Rates

	Monetary Policy Rate	91-Day Treasury Bill Rate	Interbank Rate	Lending Rate	Savings Rate	Time Deposits Rate
Mean	16.7	18.0	16.0	28.2	7.1	11.9
Median	16.0	17.1	15.9	27.3	6.4	12.3
Maximum	27.5	39.3	27.2	38.5	13.0	19.0
Minimum	12.5	9.1	6.4	24.1	4.1	7.3
Standard Deviation	3.7	6.8	4.7	3.5	2.3	3.0

2. Correlation Coefficients of Domestic Interest Rates since November 2002 (the 62 MPC Meetings)

	Monetary Policy Rate	91-Day Treasury Bill Rate	Interbank Rate	3-Month Time Deposit Rate	Savings Rate	Lending Rate
Monetary Policy Rate	1					

91- Day Treasury Bill Rate	0.83(0.86)	1				
	[0.00]*	-----				
Interbank Rate	0.83(0.90)	0.94(0.92)	1			
	[0.00]*	[0.00]*	-----			
3-Month Time Deposit Rate	0.79(0.35)	0.64(0.31)	0.65(0.40)	1		
	[0.00]*	[0.00]*	[0.00]*	-----		
Savings Rate	0.75(0.41)	0.53(0.37)	0.56(0.44)	0.89(0.89)	1	
	[0.00]*	[0.00]*	[0.00]*	[0.00]*	-----	
Lending Rate	0.64(0.70)	0.74(0.73)	0.75(0.76)	0.74(0.78)	0.69(0.84)	1
	[0.00]*	[0.00]*	[0.00]*	[0.00]*	[0.00]*	-----

Note: ( ) denote correlation coefficient for data series since 2008; *, ** & *** denote 1%, 5% & 10% significant levels respectively

3. Unit Root Test results

	Augmented Dickey-Fuller (ADF) Test			Philip & Perron (PP) Test		
	Intercept	Intercept & Trend	First Difference	Intercept	Intercept & Trend	First Difference
MPR	0.371	0.976	0.000*	0.467	0.847	0.000*
Interbank Rate	0.192	0.490	0.000*	0.053***	0.422	0.000*
Tbill Rate	0.306	0.609	0.000*	0.150	0.649	0.000*
Lending Rate	0.147	0.658	0.000*	0.134	0.635	0.000*
Savings Rate	0.401	0.585	0.000*	0.165	0.565	0.000*
Time Deposit Rate	0.042**	0.352	0.000*	0.045**	0.439	0.000*
LCPI	0.307	0.300	0.000*	0.191	0.313	0.000*
LRCIEA	0.951	0.165	0.000*	0.973	0.000*	0.000*
LRTCRD	0.985	0.403	0.000*	0.980	0.317	0.000*
LREER3CORE	0.422	0.792	0.000*	0.243	0.643	0.000*
LGSEP	0.418	0.750	0.000*	0.376	0.724	0.000*

4. VAR lags order selection for VAR and VECM Analysis

VAR Lag Order Selection Criteria						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1376.074	NA	842.167	20.925	21.035	20.970
1	-658.119	1370.642	0.023	10.426	**11.081***	10.692
2	-611.953	84.637	**0.016***	**10.105***	11.307	**10.593***
3	-594.297	31.033	0.019	10.217	11.964	10.927
4	-583.521	18.122	0.024	10.432	12.725	11.364
5	-557.722	**41.434***	0.024	10.420	13.259	11.574
6	-538.552	29.336	0.026	10.508	13.893	11.884
7	-525.741	18.635	0.033	10.693	14.624	12.290
8	-505.442	27.987	0.036	10.764	15.241	12.584
9	-489.136	21.247	0.043	10.896	15.919	12.937
10	-460.818	34.754	0.044	10.846	16.415	13.109
11	-441.491	22.255	0.051	10.932	17.047	13.417
12	-409.301	34.629	0.050	10.823	17.484	13.529
13	-381.886	27.415	0.054	10.786	17.993	13.715
14	-350.670	28.851	0.057	10.692	18.445	13.842

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

5. VAR Stability Test

Roots of Characteristic Polynomial Endogenous variables: MPR TBR91 INTBANK LENDING SAVINGS Exogenous variables: C Lag specification: 1 14	
Root	Modulus
0.990321 - 0.042409i	0.991229
0.990321 + 0.042409i	0.991229
0.978529 - 0.145906i	0.989347
0.978529 + 0.145906i	0.989347
0.978481 - 0.084475i	0.982121
0.978481 + 0.084475i	0.982121
0.927375 - 0.291975i	0.972252
0.927375 + 0.291975i	0.972252
…	…
-0.201693 - 0.507667i	0.546265
-0.201693 + 0.507667i	0.546265
No root lies outside the unit circle. VAR satisfies the stability condition.	

Appendix C

1. Short Run and Long run Estimates of 91-day Treasury bill (Tbill) and Interbank Market Interest Rates

	$Tbill_t$	$INTERBANK_t$	
	VECM 1	**VECM 2**	**VECM 3**
	2002M11 - 2014M12	***2002M11- 2014M12***	***2007M01 - 2014M12***
	Long Run Cointegrating Equations		
INTERBANK $_{t-1}$	0.87[8.19]*		
MPR $_{t-1}$	0.48[2.68]**	0.51[3.10]*	0.59[1.62]***
Tbill $_{t-1}$		0.38[4.25]*	0.29[2.16]**
Intercept	-4.79	0.68	-0.64
	Parsimonuous Short Run Equations		
ECM $_{t-1}$	***-0.16[-2.70]****	***-0.17[-3.71]****	***-0.18[-3.25]****
ΔINTERBANK $_{t-1}$	-0.001[-0.02]	0.37[4.42]*	0.46[4.23]*
ΔINTERBANK $_{t-2}$	-0.03[-0.46]	-0.04[-0.51]	-0.21[-1.82]***
ΔINTERBANK $_{t-3}$	-0.02[-0.37]		0.12[1.12]
ΔMPR $_{t-1}$	0.84[3.78]*	0.38[3.34]*	0.31[1.94]***
ΔMPR $_{t-2}$	0.14[0.64]	0.26[2.00]**	0.21[1.21]
ΔMPR $_{t-3}$	0.09[0.43]		0.11[0.64]
ΔTbill $_{t-1}$	0.32[3.45]*	0.02[0.51]	0.04[0.49]
ΔTbill $_{t-2}$	0.10[1.05]	0.06[1.20]	0.04[0.49]
ΔTbill $_{t-3}$	0.18[2.00]**		0.03[0.44]
Intercept	0.03[0.27]	0.02[0.40]	0.02[0.21]
Adj. R-squared	*0.28*	*0.40*	*0.42*
S.E. equation	*1.46*	*0.83*	*0.75*
F-statistic	*6.60*	*14.31*	*7.93*
Log likelihood	*-256.27*	*-171.57*	*-102.29*

Note: The VAR order was based on information criterion for the respective sample size; *,**&*** denote 1%, 5% & 10% significant levels respectively.

2. Short Run and Long Run Estimates of Retail Market Interest Rates

	Lending Rate $_t$					***Time Deposits Rate $_t$***		
	LR1	LR2	LR3	LR4	LR5	DR1	DR2	DR3
	Long Run Cointegrating Equations							
Tbill Rate $_{t-1}$	0.51 [4.90]*			0.27 [3.93]*		0.37 [5.08]*		0.38 [6.46]*
Interbank Rate $_{t-1}$		0.72 [4.44]*	0.30 [2.97]**		0.17 [1.52]		0.50 [4.70]*	
Time deposit Rate $_{t-1}$					0.29 [1.48]			
Savings Rate $_{t-1}$			1.02 [5.03]*	0.91 [4.41]*	0.87 [4.08]*	0.06 [0.29]	0.12 [0.57]	
Intercept	19.22	16.68	16.19	16.91	15.74	4.68	2.98	4.91
	Parsimonious Short Run Equations							
ECM $_{t-1}$	***-0.09 [-3.92]******	***-0.09 [-3.45]******	***-0.15 [-3.45]******	***-0.17 [-4.35]******	***-0.16 [-3.50]******	***-0.17 [-4.22]******	***-0.16 [-4.11]******	***-0.17 [-4.29]******
Δ Lending Rate $_{t-1}$	-0.03 [-0.48]	-0.01 [-0.15]	0.12 [1.47]	0.05 [0.63]	0.06 [0.65]			
Δ Lending Rate $_{t-2}$	-0.03 [-0.47]	-0.03 [-0.38]	0.02 [0.28]	0.02 [0.25]	0.02 [0.22]			
ΔTbill Rate $_{t-1}$	0.02 [0.54]					0.00 [-0.22]		0.00 [-0.04]
ΔTbill Rate $_{t-2}$	0.01 [0.29]					0.23 [3.35]*		0.03 [0.75]
ΔInterbank Rate $_{t-1}$		-0.03 [-0.47]	-0.01 [-0.11]	0.04 [1.11]	0.00 [-0.04]		-0.07 [-1.13]	
ΔInterbank Rate $_{t-2}$		0.04 [0.55]	0.07 [1.23]	0.03 [0.82]	0.09 [1.39]		0.03 [0.61]	
ΔTime deposit Rate $_{t-1}$					0.03 [0.41]	-0.02 [-0.22]	0.02 [0.32]	-0.02 [-0.24]
ΔTime deposit Rate $_{t-2}$					-0.06 [-0.78]	0.23 [3.35]*	0.25 [3.39]**	0.23 [3.11]*
ΔSavings Rate $_{t-1}$			-0.26 [-2.15]**	-0.27 [-2.26]**	-0.21 [-1.59]	0.03 [0.20]	0.07 [0.61]	
ΔSavings Rate $_{t-2}$			-0.02 [-0.12]	-0.12 [-0.93]	-0.03 [-0.23]	-0.14 [-0.17]	-0.07 [-0.57]	
Intercept	-0.07 [-1.10]	-0.06 [-1.05]	-0.07 [-1.11]	-0.07 [-1.16]	-0.07 [-1.07]	-0.01 [-0.17]	0.00 [-0.01]	-0.01 [-0.21]
Adj. R-squared	*0.12*	*0.08*	*0.09*	*0.14*	*0.07*	*0.22*	*0.16*	*0.21*
S.E. equation	*0.76*	*0.78*	*0.80*	*0.75*	*0.78*	*0.81*	*0.83*	*0.82*
F-statistic	*5.04*	*3.61*	*3.22*	*4.42*	*2.24*	*6.91*	*5.34*	*8.85*
Log likelihood	*-162.98*	*-166.21*	*-177.25*	*-160.29*	*-164.94*	*-179.39*	*-183.88*	*-174.05*

Note: VAR order was based on information criterion for the respective sample size; *,**&*** denote 1%, 5% & 10% significant levels respectively.

Appendix D:

1. Lag Order Selection Criteria for Johansen Cointegration Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-358.624	NA	2.21E-07	4.541914	4.675888	4.596313
1	1414.228	3369.521	1.11E-16	-16.8724	-15.80061*	-16.43721*
2	1485.435	129.1449	8.45e-17*	-17.14826*	-15.13865	-16.33227
3	1524.969	68.26378	9.58E-17	-17.03067	-14.08324	-15.83389
4	1558.05	54.24453	1.19E-16	-16.83292	-12.94767	-15.25535
5	1603.876	71.15939	1.27E-16	-16.7935	-11.97043	-14.83514
6	1647.222	63.53793	1.41E-16	-16.72326	-10.96237	-14.3841
7	1696.084	67.37472*	1.50E-16	-16.72154	-10.02284	-14.0016
8	1727.432	40.49922	2.01E-16	-16.50226	-8.865738	-13.40152

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

2. Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	ritical Valu	Prob.**
None *	0.368	189.690	134.678	0.000
At most 1 *	0.212	113.410	103.847	0.010
At most 2	0.161	73.859	76.973	0.084
At most 3	0.096	44.786	54.079	0.258
At most 4	0.082	28.057	35.193	0.239
At most 5	0.060	13.944	20.262	0.293
At most 6	0.022	3.671	9.165	0.463
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	ritical Valu	Prob.**
None *	0.368	76.280	47.079	0.000
At most 1	0.212	39.551	40.957	0.071
At most 2	0.161	29.073	34.806	0.206
At most 3	0.096	16.729	28.588	0.683
At most 4	0.082	14.113	22.300	0.452
At most 5	0.060	10.273	15.892	0.310
At most 6	0.022	3.671	9.165	0.463
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

3. Quarterly Contemporaneous Coefficients from Structural VAR (2002Q1-2014Q4)

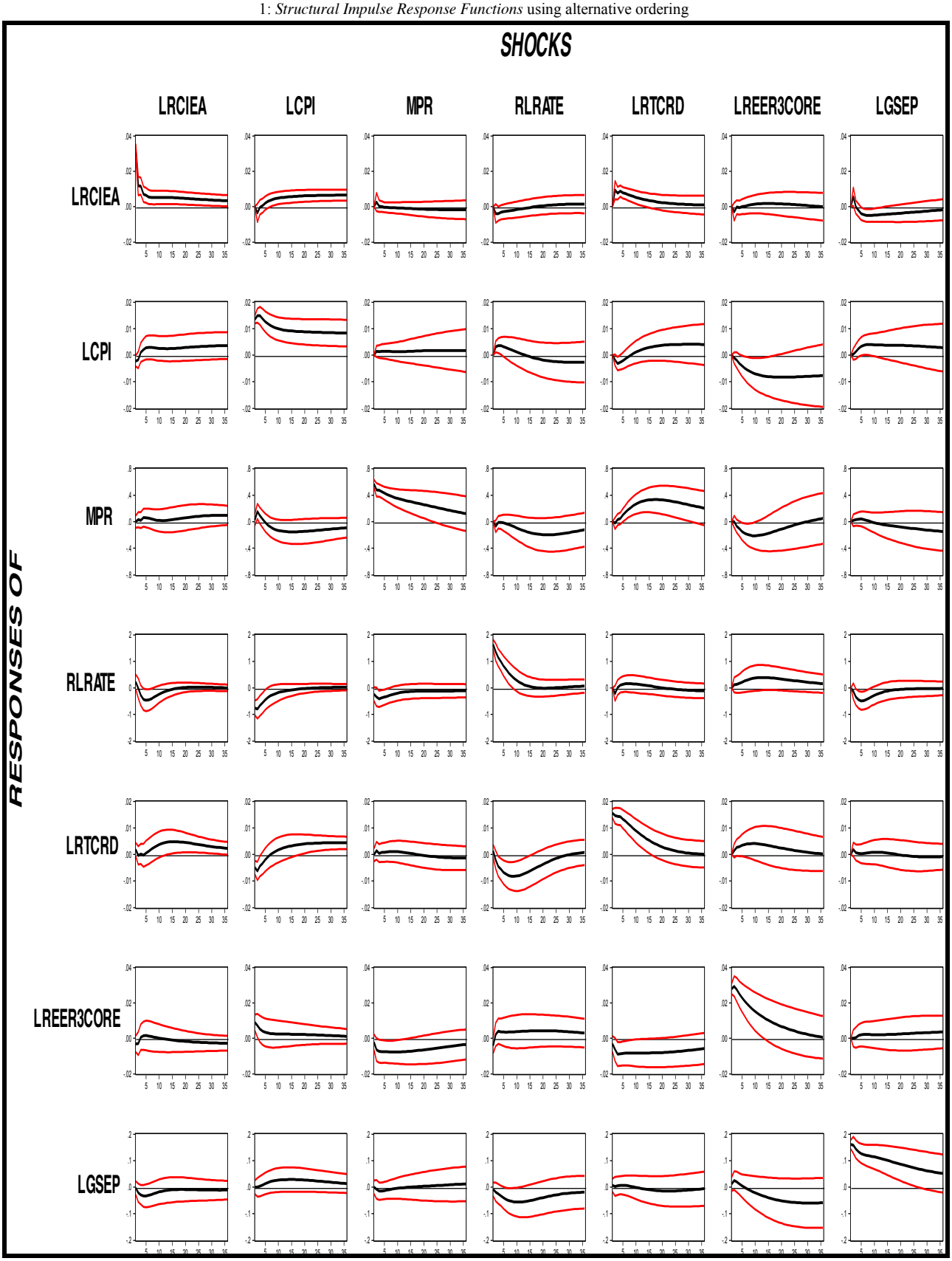
		Shocks						
		Real GDP	CPI	MPR	Lending Rate	Credit	Nominal Exchange Rate	Share Price
Contemporaneous Responses	Real GDP	0.02[10.09]*						
	CPI	-14.04-1.14]	2.07[1009]*					
	MPR	10.89[2.39]**	0.16[3.24]*	0.75[10.09]*				
	Lending Rate	-12.38[-1.97]**	-0.42[-5.84]*	0.35[1.94]***	0.98[10.09]*			
	Credit	0.37[3.06]*	0.01[5.03]*	-0.01[-4.31]*	0.01[5.70]*	0.02[10.09]*		
	Moninal Exchange Rate	0.03[0.49]	-0.01[-1.65]***	0.01[4.95]*	0.00[0.54]	-0.04[-0.56]	0.01[10.09]*	
	Share Price	-2.16[-2.45]**	0.01[0.83]	-0.05[-1.51]	-0.02[-0.87]	0.07[0.08]	4.81[2.71]*	0.12[10.09]*
		Real GDP	CPI	Credit	Lending Rate	Nominal Exchange Rate	Share Price	MPR
Contemporaneous Responses	Real GDP	0.02[10.09]*						
	CPI	-14.04[-1.14]	2.07[10.09]*					
	Credit	0.07[0.52]	0.001[0.51]	0.02[10.09]*				
	Lending Rate	-10.11[-1.89]***	-0.38[-6.42]*	20.36[4.06]*	0.88[10.09]*			
	Nominal Exchange Rate	0.20[2.75]*	0.001[1.56]	-0.23-2.99]*	0.01[2.86]*	0.01[10.09]*		
	Share Price	-2.65[-3.15]*	-0.002[-0.15]	0.62[0.69]	-0.03[-1.49]	3.27[2.19]**	0.13[10.09]*	
	MPR	7.34[1.99]**	0.27[5.93]*	-10.06[-2.82]*	0.22[2.48]*	32.89[5.28]*	-0.84[-1.51]	0.50[10.09]*

Note: columns are impulses, while rows are responses. Also *, **&*** denote 1%, 5% & 10% significant levels respectively. Here, real GDP and nominal exchange rate of Ghana Cedi per US dollar (+ denote depreciation and – denotes appreciation) were used rather than real CIEA and real effective exchange rate. The results confirm that monetary authority responses positively and contemporaneously to shocks to both inflation and output.

Source: Author's calculation.

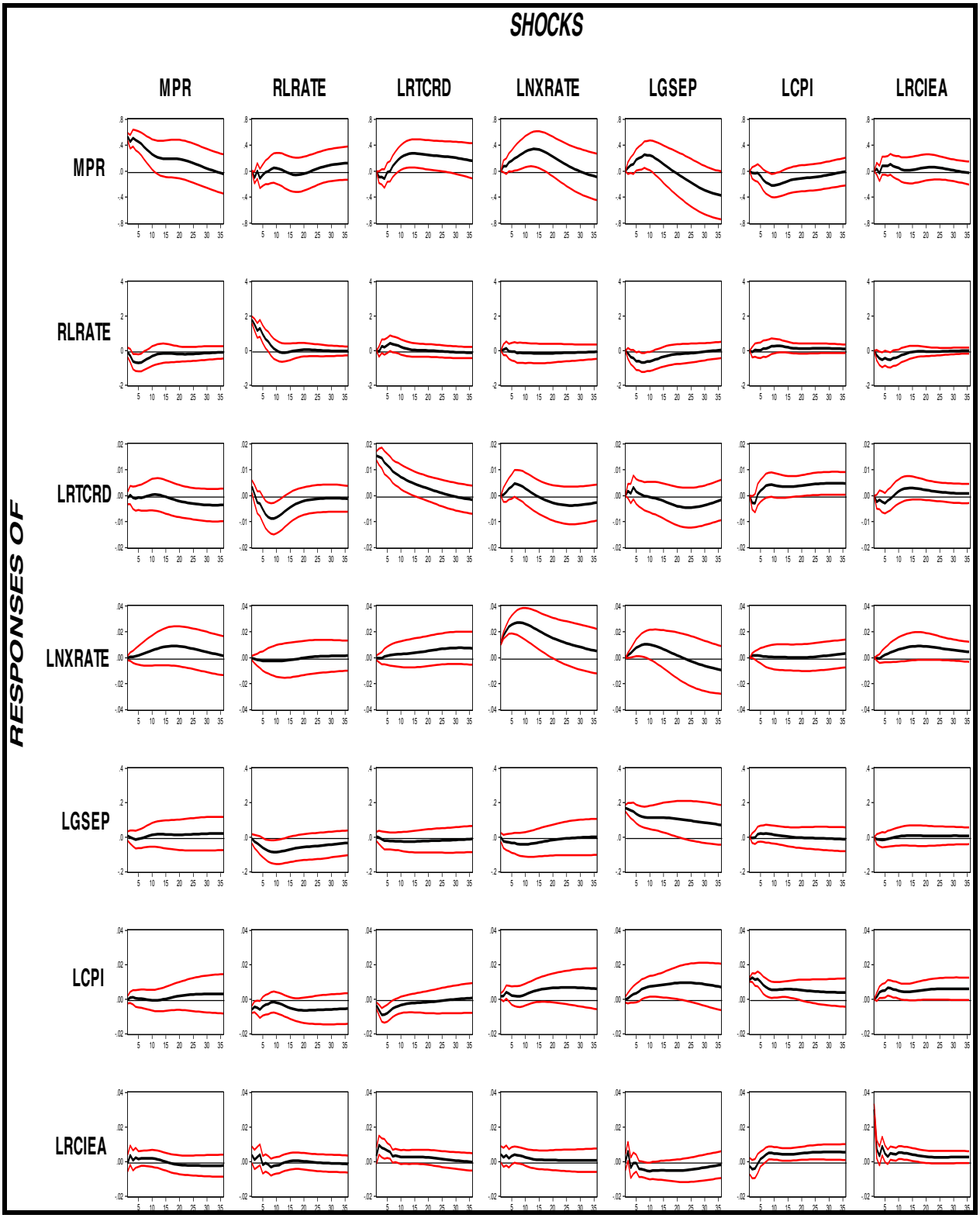
Appendix E

1: *Structural Impulse Response Functions* using alternative ordering



Note: Here, we used real lending rate.

2. Structural Impulse Response Functions with Oil Price as Exogenous Variable



Note: Here, international crude oil price was included as an exogenous variable, even though its exclusion does not alter the result. Nominal exchange rate is used instead of real effective exchange rate. In this case, + denotes depreciation, while – denotes appreciation. We assumed a Cholesky identification restriction that monetary policy rate (MPR) is contemporaneously exogenous to all the selected macroeconomic variables but is only affected with a lag.

Appendix F

1. Variance Decomposition of LRCIEA

Period	S.E.	LRCIEA	LCPI	MPR	LENDRATE	LRTCRD	LREER3CORE	LGSEP
1	0.03	100.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	87.21	1.18	0.22	1.73	6.60	0.55	2.52
3	0.04	85.98	1.07	0.28	1.51	8.42	0.54	2.20
4	0.04	82.57	1.01	0.27	1.52	11.89	0.50	2.24
5	0.04	79.78	0.99	0.31	1.43	14.16	0.48	2.86
6	0.04	76.85	1.07	0.32	1.36	16.27	0.45	3.68
7	0.05	74.20	1.29	0.35	1.29	17.81	0.45	4.60
8	0.05	71.79	1.62	0.37	1.23	19.04	0.45	5.49
9	0.05	69.65	2.05	0.40	1.19	19.95	0.47	6.29
10	0.05	67.75	2.56	0.44	1.15	20.63	0.49	6.98
11	0.05	66.06	3.13	0.48	1.13	21.11	0.52	7.57
12	0.05	64.54	3.76	0.53	1.13	21.44	0.55	8.06
13	0.05	63.17	4.43	0.58	1.13	21.64	0.58	8.46
14	0.05	61.92	5.15	0.64	1.15	21.75	0.61	8.78
15	0.05	60.77	5.90	0.71	1.18	21.77	0.63	9.04
16	0.05	59.70	6.68	0.78	1.23	21.72	0.65	9.23
17	0.05	58.71	7.49	0.86	1.28	21.63	0.67	9.37
18	0.05	57.78	8.31	0.94	1.34	21.48	0.68	9.46
19	0.06	56.90	9.16	1.03	1.41	21.31	0.68	9.51
20	0.06	56.06	10.01	1.12	1.49	21.11	0.69	9.53
21	0.06	55.26	10.88	1.21	1.57	20.88	0.68	9.51
22	0.06	54.50	11.75	1.30	1.64	20.65	0.68	9.48
23	0.06	53.77	12.63	1.40	1.72	20.40	0.67	9.42
24	0.06	53.06	13.50	1.49	1.80	20.14	0.66	9.34
25	0.06	52.38	14.38	1.58	1.88	19.88	0.65	9.25
26	0.06	51.73	15.25	1.67	1.95	19.62	0.63	9.15
27	0.06	51.09	16.12	1.76	2.01	19.36	0.62	9.03
28	0.06	50.48	16.98	1.85	2.07	19.10	0.61	8.92
29	0.06	49.89	17.83	1.93	2.12	18.84	0.60	8.79
30	0.06	49.31	18.66	2.01	2.17	18.59	0.59	8.67
31	0.06	48.76	19.49	2.08	2.21	18.34	0.58	8.54
32	0.06	48.22	20.31	2.15	2.24	18.10	0.58	8.41
33	0.06	47.69	21.11	2.22	2.26	17.86	0.57	8.29
34	0.06	47.19	21.89	2.28	2.27	17.64	0.57	8.16
35	0.06	46.69	22.66	2.33	2.28	17.42	0.57	8.04
36	0.07	46.22	23.41	2.38	2.28	17.20	0.58	7.92

2. Variance Decomposition of LCPI

Period	S.E.	LRCIEA	LCPI	MPR	LENDRATE	LRTCRD	LREER3CORE	LGSEP
1	0.01	3.44	96.56	0.00	0.00	0.00	0.00	0.00
2	0.02	2.96	95.39	0.58	0.14	0.60	0.32	0.01
3	0.03	1.90	95.00	0.85	0.14	1.12	0.83	0.15
4	0.03	1.67	93.60	1.13	0.11	1.17	1.64	0.68
5	0.03	1.90	91.75	1.30	0.15	1.10	2.46	1.35
6	0.04	2.22	89.71	1.44	0.28	0.97	3.34	2.04
7	0.04	2.56	87.66	1.56	0.50	0.86	4.24	2.62
8	0.04	2.84	85.63	1.67	0.84	0.79	5.14	3.09
9	0.04	3.06	83.64	1.79	1.27	0.79	6.01	3.44
10	0.04	3.22	81.68	1.91	1.82	0.87	6.83	3.68
11	0.05	3.34	79.73	2.03	2.46	1.02	7.59	3.83
12	0.05	3.42	77.80	2.16	3.20	1.23	8.27	3.91
13	0.05	3.48	75.88	2.30	4.02	1.51	8.87	3.94
14	0.05	3.52	73.97	2.44	4.91	1.85	9.40	3.91
15	0.05	3.54	72.08	2.59	5.87	2.23	9.84	3.85
16	0.05	3.55	70.22	2.74	6.87	2.65	10.21	3.77
17	0.05	3.56	68.39	2.88	7.90	3.10	10.50	3.67
18	0.06	3.56	66.60	3.03	8.96	3.57	10.73	3.55
19	0.06	3.56	64.85	3.18	10.02	4.05	10.91	3.42
20	0.06	3.56	63.16	3.32	11.08	4.55	11.03	3.29
21	0.06	3.56	61.53	3.46	12.13	5.05	11.11	3.17
22	0.06	3.56	59.96	3.60	13.15	5.54	11.15	3.04
23	0.06	3.56	58.46	3.72	14.15	6.04	11.15	2.92
24	0.06	3.57	57.02	3.84	15.11	6.52	11.13	2.81
25	0.06	3.58	55.65	3.96	16.02	7.00	11.09	2.71
26	0.07	3.59	54.35	4.06	16.90	7.47	11.02	2.62
27	0.07	3.60	53.11	4.16	17.72	7.92	10.94	2.54
28	0.07	3.62	51.95	4.25	18.50	8.36	10.85	2.47
29	0.07	3.64	50.85	4.33	19.23	8.78	10.75	2.41
30	0.07	3.67	49.81	4.41	19.91	9.19	10.65	2.37
31	0.07	3.70	48.84	4.47	20.53	9.58	10.53	2.33
32	0.07	3.74	47.93	4.53	21.11	9.96	10.42	2.31
33	0.07	3.78	47.08	4.58	21.64	10.32	10.30	2.31
34	0.07	3.82	46.28	4.62	22.12	10.67	10.18	2.31
35	0.08	3.87	45.54	4.66	22.56	10.99	10.07	2.32
36	0.08	3.92	44.84	4.69	22.95	11.31	9.95	2.34