INTEREST RATE PASS-THROUGH: A CASE STUDY OF GHANA

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Abstract

Inflation targeting has been the main policy objective for most central banks around the world and thus the importance of interest rate channel of monetary policy transmission has resurfaced. The success of monetary policy in inflation targeting depends largely on the effectiveness of the interest rate channel in the economy, which is quantified by the magnitude of the pass-through. Understanding the interest rate channel is crucial to uncover the monetary policy transmission mechanism hence this study.

This study investigates interest rate pass-through in Ghana by examining the extent to which changes in the policy rate transmits to market interest rates between 2002 and 2009. In addition, the study estimated the speed of adjustment of these market interest rates with respect to changes in the policy rate. The market interest rates used for the analysis were 91-day treasury bill rates, interbank rates; savings deposit rates, and lending rates. Using the ARDL technique, the study found that (1) the long run pass-through estimates were greater than one (unity) for all the retail interest rates; (2) The speed of adjustment varied across the retail interest rates but overall they were very small; (3) Retail interest rates responded sluggishly to changes in the policy rate in the short run.

Keywords: Interest Rate Pass-through, ARDL, Monetary Policy, Central Bank, Ghana

JEL Classification: E58, E52

INTRODUCTION

Inflation targeting has been the main policy objective for the Bank of Ghana in the last decade and the interest rate mechanism, which is an important link in the monetary policy transmission mechanism, has attracted more attention from policymakers since the understanding of the interest rate channel is crucial to effective monetary policy transmission.

In order to ensure price stability for inflation targeting monetary policies, it is essential for central banks to have a precise understanding of how fast and to what extent a change in their interest rate instrument affects inflation. The success and failure of monetary policy in achieving its objectives depend on how interest rates respond to the policy instrument. That is, to assess whether or not the pass-through from monetary policy rate to long-term

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market rates is complete, is the first building block for monetary policy transmission. This is because a complete interest rate pass-through ensures a determinate (stable) equilibrium for which the Taylor principle is applicable. If the pass-through is incomplete, monetary policy results in indeterminate (unstable) equilibrium. Hence, lack of knowledge about the pass-through will make it difficult to ascertain what the echelon interest instrument should be for effective monetary policy. This has consequential effect on effective monetary policy transmission to its target.

An incomplete interest rate pass-through distorts the transmission process through the credit, the interest rate, or the exchange rate channels enormously. Therefore, it is necessary to estimate the interest rate pass-through in monetary policy. As a result many monetary policy studies are concentrated on this theme. Despite its importance, the interest rate pass-through has however, been given little attention in Ghana, hence the need for this study.

This current paper is largely driven by the absence of adequate literature on interest rate pass-through in Ghana. Though, enormous literatures on interest rate in Ghana exist for its behaviour, determinants, structure and spread, there are few literatures on interest rate responsiveness to monetary policy. The existing literature Acheampong (2005), is inconclusive and do not give the state of pass-through in Ghana. Rather than the prime rate, which the central bank uses to communicate its policy stance, the study used treasury bill rate as proxy for policy rate. To investigate BoG’s action on interest rate, it suffices to use the prime rate. In addition, this study broadens the spectrum of the market rates to include treasury bill rates and interbank rate.

The objective of this study is to investigate interest rate pass-through in Ghana, particularly estimating the pass-through from the policy rate to market interest rates for the period 2002 to 2009 and determine the speed of adjustment from the short run to the long run. The interest rates used included the treasury bill rate, interbank rates, deposit rates, and lending rates. The prime rate is used as the monetary policy rate. Results from this study have implications for monetary authorities because knowledge about interest pass-through is important for monetary authorities to know how their actions are transmitted to the economy in order to achieve their objectives. In addition, this study adds to the existing knowledge on interest rates in Ghana by tracing how the policy instrument affects the market interest rates.

The rest of the paper is structured as follows. Section 2 presents the overview of the financial sector in Ghana and highlights various monetary policy frameworks the central has adopted so far. Section 3 presents both theoretical and empirical literature on the

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3 The only notable study on Ghana is by Acheampong (2005).

4 This is the only notable study on interest rate pass-through in Ghana per my search
subject matter. Section 4 discusses the research methodology used to unearth pass-through in Ghana and section 5 discusses the empirical results by applying the econometric model to the data.

OVERVIEW OF THE FINANCIAL SECTOR IN GHANA

Ghana financial sector is categorized into three main sectors: banking and finance (including non-bank financial services and forex bureaux), insurance and financial or capital market. The banking and finance sector constitute the largest sector as it has the highest number of institution as shown in Table A in appendix A.

Over the years the sector has witnessed tremendous changes in respect to institutional composition and regulations. Regarding regulations, post-independence banking sector was characterized by direct controls, which led to the repression of the financial sector. Following the abysmal performance of the economy in the 1970s and early 1980s, the country subscribe to Structural Adjustment Program (SAP). The FINSAP, a branch of SAP, which is responsible for the financial sector aimed at liberalize the financial environment in the sense of McKinnon-Shaw. Specifically, for the banking system, the exercise aimed at enhancing the soundness through improved regulatory framework; strengthening banking supervision; restructuring financially distressed banks; improving deposit mobilization; increasing efficiency in credit mobilization; and strengthening competition and efficiency within the banking sector. The aftermath of the FINSAP witnessed the emergence of various financial intermediaries including deposit money banks (DMBs), life and general insurance companies, discount houses, finance houses, leasing companies, savings and loan associations, credit unions, a stock exchange, brokerage houses and rural banks (refer to table A for current institutional composition).

As part of the policy description of FINSAP, the conduct of monetary policy in Ghana changed from the era of direct controls to indirect monetary policy through monetary targeting. Within the monetary targeting framework the Bank of Ghana implements monetary policy by using the open market operation to maintain a desire level of bank rate. The bank rate is kept unchanged in periods of economic sanity. However, during periods of stronger economic activities and higher prices, the Bank of Ghana tightens policy by reducing reserves to push up the bank rate to the desired level.

From the year 2002, the Bank of Ghana adopted the inflation targeting framework. Within this framework the central bank estimates and makes public a projected or target inflation rate and then attempt to steer actual inflation towards the target using interest rate changes and other monetary tools. Interest rates are important tools in this framework. They are used as the instruments through which the Bank of Ghana modifies macro variables such as investment and money demand to achieve its objectives.
Thus, the success of inflation targeting is deeply rooted in a complete interest rate pass-through. Therefore, an understanding of the pass-through is important for effective implementation of inflation targeting policies. As a result, this study is to estimate the pass-through that is required for smooth implementation of inflation targeting.

**Monetary Policy and the Term Structure of Interest Rate**

Monetary policy transmission mechanism suggests a close relationship between central bank’s policy actions and the market interest rates. The transmission mechanism relies on a simple version of expectation theory of the term structure of interest rates\(^5\), by which monetary policy affects the long term rate. In the transmission process, an increase in the desired level of bank rate causes both current and expected future rate to rise, which pushes up interest rates across all maturities. Similarly, a decrease in the desired bank rate causes both current and future short-term rates to fall resulting in a lower short and long term rates.

Following the disinflation process, the prime rate has been reduced systematically within the period 2002-2009. As a result interest rates have change reflecting trends in the prime rate as shown in figure A in appendix A. In April 2004, the prime rate dropped from 20 per cent to 18.5 per cent. Deposit rates declined from 13.75 per cent to 13.25 per cent and average lending rates declined by 10.98 basis points. Interest rates respond differently to the prime rate depending on the direction of change. Whiles interest rates respond sluggishly to declining prime rates, they respond nimbly when the prime rate is increased. Responding to the increase in prime rate from 12.5 per cent to 13.5 per cent in October 2007, the benchmark 91-day, and 182-day Treasury bill rates went up by 15 basis points and 30 basis points respectively to 10.77 per cent and 11.10 per cent respectively at the end of February 2008. The interbank market rates moved within a narrow band in the money market ranging between 11.5 per cent and 13.5 per cent during this period. Similarly, the benchmark 91-day Treasury bill rates increased to 24.58 per cent in the third quarter of 2008 from 16.32 per cent in the second quarter of the same year. Within this same period, the overnight interbank rate firmed-up significantly by 504 basis points to 19.52 per cent. In addition, the average base rates of the banks were revised upward by 337 basis point to 25.63 per cent in the third quarter in the range of 19.5 – 27.8 per cent, on top of the 258 basis points revision in the second quarter of 2008\(^6\). The forgoing discussions show that the policy rate serves as a leading indicator for interest rates in the economy. Thus, it is imperative to investigate BoG’s action on the interest rate through the pass-through.

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\(^5\) The expectation theory argues that long term rates are an average of current and expected future rates. \(^6\) Issues discussed were extras from various monetary policy reports
LITERATURE REVIEW

Theoretical literature

Interest Rate Pass-through and Adjustment⁷ (Conceptual Definition)

Interest rate pass-through, which is generally, defined as the extent to which changes in central bank policy interest rates and/or money market interest rates are reflected in changes in commercial banks' interest rates, in both the short-run and the long run involves two stages. The first stage describes how changes in the monetary policy rate is transmitted to short and long term market rates, while the second stage measures how changes in the market rates influence bank lending and deposit rates. Based on this, the literature on interest rate pass-through, distinguishes between the “cost of funds approach” and “monetary policy approach” (Sander & Kleimeier, 2003) as two distinct stages of interest rate pass-through.

The “Cost of funds” approach focuses on the price setting decisions of banks and it reflects the real cost arising from banks issuing loans and financing banks deposit and lending rates (De Bondt, 2005; Kwapil & Scharler, 2006). It describes the connection between market rates on one hand, and bank deposit and lending rates of comparable maturity on the other. The “cost of funds approach” indicates how changes in the market interest rates influence bank deposit and lending rates and it is the best way to describe the second stage of interest rate pass-through. The equalization of market interest rates and deposit rates is possible because of central banks’ role as lender of last resort for commercial banks, which ensure that short and/or long-term market rates transmit onto retail interest rates. Further, households and the non-financial entities do hold their financial assets in not only bank deposit but also government securities of comparable maturity. In addition, banks do not only depend on deposits for funding loans, rather, sometimes depend on the money markets.

The “Monetary policy” approach on the other hand best describes the first stage of interest rate pass-through. It measures how monetary policy affects short and long-term market rates. It focuses on how changes in policy rates warrant changes in money market rates. This stage is largely influenced by the stability of the yield curve: If the term structure, whatever its form may be, remains stable over time, the pass-through from policy rates to

⁷ Interest rate adjustment has two meaning in the banking industry. It indicates how bank rates are relatively not responsive to either a shift in the demand for banks loans and deposit or change in money market rates. This study focuses on bank rates responsiveness to official rates, thus market interest rate adjustment or stickiness can be used to describe the responsiveness of market interest rates to changes in another interest rate, such as the official interest rate (this is the definition employed in this study).
market rates is said to be proportionate. However, any twist in the yield curve can change the size of the pass-through. The assumption of a stable yield curve makes it possible to take a shortcut by looking directly at the relationship between policy rates and retail (deposit and loan) rates i.e. focusing on how changes in policy rates affect retail interest rates.

**Factors Affecting Interest Rate Adjustments**

Several factors are responsible for market interest rates stickiness, which include information asymmetric, level of reliance of the financial institution on the central bank accommodating their liquidity needs, level of competition in the financial sector and the level of financial development. These factors are country specific and vary from one situation to the other. In addition, market interest rates adjustments within a country vary to financial environment changes overtime. These changes in a country’s financial environment affect the smooth implementation of monetary policy. These dynamics are critical to the execution of monetary policy. Due to this, the empirical literature on the relationship between official interest rates and market interest rates has grown enormously, thus, giving rise to this study on the Ghanaian economy.

**Empirical evidence**

The empirical literature on interest rate pass-through has grown enormously with its major focus on the advanced countries though few recent studies have been undertaken on some emerging economies. However, there is only one notable Ghanaian study on the subject matter by Acheampong (2005). Studies on interest rate pass-through either examine individual country behaviour or cross country behaviour with a common aim of discovering the degree and speed of adjustment of interest rate to changes in the policy rate.

Differences in the empirical literature of interest rate pass-through arise in the choice of policy rate proxy, time period and the use of econometric methods. The conventional techniques such as Johansen multivariate co-integration methodology or Autoregressive Distributed lag (ARDL) model are used to estimate the pass-through. Cottarelli & Kourelis (1994) used the vector autoregressive (VAR) model in an international context. Following this study, various studies in the Euro area have adopted this approach (see BIS, 1994; Borio & Fritz, 1995; Cottarelli et al, 1995). Recent studies on pass-through are regularly based on autoregressive-distributed lag (ARDL) model or on error correction model (see e.g. Aziakpono & Wilson, 2010; Samba & Yan, 2010; Mojon, 2000).

Despite the differences in the approach to understand interest rate pass-through, previous research concluded that retail interest rates adjustment to market interest rate changes are incomplete, the degree and speed of pass-through are different among different retail rates,
significant cross country differences exist and whiles enterprise loans and time deposits adjust quickly, household loans and saving deposits are sticky\textsuperscript{8}, though these studies are silent on the magnitude of the pass-through estimates.

Regarding the cross-country studies, it is evident that the pass-through of policy rates to retail rates is incomplete and the degree of pass-through is different across retail rates and across time. In addition, most studies found significant differences across countries, which researchers attribute to different macroeconomic conditions in the economies and other country specific factors including financial structure and banking competition among others. Irrespective of the methodology employed, time span, and the interest rate used, the size of interest pass-through both in the short and long run are consistent in showing cross-country differences. Studies on European countries confirm these findings. Irrespective of the approach used, euro area studies indicate that short run pass-through is incomplete across banking products as well as across countries. De Bondt et al (2002) confirmed earlier findings that retail bank rates adjust sluggishly to market rates in Euro area countries using linear and state dependent error correction models. They also found out that the introduction of the euro has sped up the adjustment of retail bank interest rates to market interest rates, due to the evolution of competitive forces in the retail bank market.

Across time, studies show that the interest rate pass-through is higher in the long run than the short run. Comparing the pass-through from policy rate to retail interest rate in the euro area and the United States, Kwapil & Scharler (2009), found the long run pass-through to be lower in the euro area than the United States. Analysing data from January 1995 to September 2003 for various deposit and lending rates, they observed that most categories of deposit rates were nearly complete (i.e. one-to-one) in the United States whereas that of the Euro area range between 0.32 and 0.58. This means that whiles policy change transmit proportionally to deposit rates in the United States, only between 32 and 58 per cent transmit to deposit rates in the euro area. The long run pass-through to lending rates was also lower in the Euro area compared to the United States ranging between 0.48 and 0.73.

Though, most studies indicate incomplete short run pass-through, the evidence of full pass-through in the long-term is scattered and there is no clear consensus. Whiles some studies found complete long run pass-through\textsuperscript{9}, others found otherwise\textsuperscript{10}. Nevertheless, studies that aimed at investigating heterogeneity concluded that there exists substantial heterogeneity in the pass-through mechanism across countries and across bank products. Concerning bank product heterogeneity, some studies suggest that rates on loans to

\textsuperscript{8} See Sorensen & Werner,2006
\textsuperscript{10} Refer Aydin (2007)
households and rates on overnight and savings deposits are relatively sluggish. For example, according to Lowe & Rohling (1992), there exist large differences in the pass-through in Australia across different types of loans. The study reports complete pass-through of changes in banks’ marginal cost of funds only for overdraft rates for business borrowers. However, other product rates for credit cards, personal loans, standard overdraft and mortgages do not translate one to one in changes in banks’ marginal cost of funds. Just as several studies have concentrated on analysing the pass-through across and around the euro area and analysing it in a comparative form, some have focused on individual countries in the euro area and around the world. Cottarelli et al (1995), using individual data for 63 local Italian banks in a variety of financial environment, noted a high degree of stickiness of bank lending rates observed in Italy in the past is related to constraints on competition within the banking and financial markets.

The literature on interest rate pass-through in emerging economies seems to confirm results from the advanced economies of incomplete pass-through in the short run even though the results are inconclusive. Betancourt et al (2008) analysed interest rate pass-through in Columbia in a micro banking perspective. The study used a uni-equational error correction and VARX model for the Columbian data, which resulted in a confirmation of incomplete short run pass-through whereas that of the long run is complete. Espinosa-Vega & Rebucci (2003) investigated empirically the pass-through of money market interest rates to retail banking interest rates in Chile, United States, Canada, Australia, New Zealand and five European counties. Using standard error correction model, Chile had incomplete pass-through. In addition, Chile’s pass-through was faster than in many other countries considered and was comparable to estimates in the United States. In addition, they found no significant evidence of asymmetry in Chile’s pass-through across states of the interest rate or monetary policy cycle.

Whereas several literatures exist on the pass-through in other parts of the world, there are few notable studies on the subject matter in Africa. These studies include Acheampong (2005) for Ghana; Junkee (2004) for Mauritius; De Angelis et al (2005), Aziakpono et al (2007) and Aziakpono & Wilson (2010) for South Africa; and Samba & Yan (2010) for Central Africa Economic and Monetary Community states. Junkee (2004) used quarterly data from September 1988 to September 2003 and employed Johansen co-integration, TAR and M-TAR modelling techniques to estimate the pass-through for Mauritius. His study found out that the pass-through for deposit rates was higher than lending rates. Deposit rates had a pass-through of 0.413 whereas lending pass-through was estimated to be 0.242. Exploring the possibility of asymmetric adjustment in the interest rates, the study found asymmetry to exist only in the lending rates. In addition, lending rates tend to adjust sluggishly to an increase in policy rate than a decrease.

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In South Africa, De Angelis et al (2005) and Aziakpono et al (2007), studies focused on the pass-through for wholesale interest rates (the prime interbank lending rate, the prime lending rate, and money market rate i.e. money market negotiable certificate of deposit). De Angelis et al (2005) study focused on the relationship between the repo rate and wholesale interest rates for two periods: March 1998 to September 2001 when the repo system was first introduced and September 2001 to November 2004 when the adjustment was made to the repo system. Aziakpono et al (2007) on the other hand examined the interest rate pass-through for the period 1973 to 2004 divided into six sub periods corresponding to different monetary regimes. De Angelis et al (2005) found that the pass-through to the whole rates was higher during the first repo system than the second repo system. Aziakpono et al (2007) result shows that the wholesale interest rates record a high speed of adjustment throughout the period suggesting effective monetary transmission mechanism to wholesale rates. The result further indicated a high speed of adjustment during more market oriented policy regimes than less market-oriented periods. The paper also explored the possibility of asymmetric adjustment in the interest rates and found very weak evidence of asymmetric adjustment.

To evaluate the dynamics of interest rate pass-through across a wide period, Aziakpono & Wilson (2010), examined interest rate pass-through across monetary regimes in South Africa. They used rolling window analysis, which is the sequential increase in time span in regression. A rolling window analysis helps evaluate the dynamics in the estimates. Using rolling window and symmetric and asymmetric error correction modelling techniques for interest rate data covering the period 1980 to 2007, they found that the speed of adjustment of market interest rates varies across the rates. The study indicated that lending rates had the highest speed of adjustment, followed by Treasury bill rate and money market rates and closely followed by commercial bank deposit rates, while the government bond yield has the least speed of adjustment. In conformity with other studies exploring asymmetry in adjustment, the paper found evidence of asymmetric adjustment among commercial banks lending rates. In addition, there was evidence of rigidity in commercial banks’ lending rates responding upwardly to a positive shock in the official rate.

Samba & Yan (2010) examined the monetary transmission mechanism in the countries of the Central Africa Economic and Monetary Community (CAEMC) focusing on the interest rates pass-through from short-term interest rates towards long-term rates. The study, employed an autoregressive distribute lag (ARDL) model in a panel setting and found a very low and incomplete long run pass-through from the policy rate to deposit rate. In addition, there was evidence of overshooting effect of lending rate reaction to changes in the policy rate. In conformity with Aziakpono et al (2010) study in South Africa,  

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12 See for instance, Hannan & Berger, 1991 and Neumark & Sharpe, 1992 for USA; Scholnick, 1996 for Singapore and Malaysia; Samba & Yan, 2010 for countries in CAEMC for studies that explore asymmetric in adjustment.
the paper recorded asymmetry adjustment in retail interest rates. In the case of Samba & Yan (2010) study, they split the time span into two-sub periods; a phenomenon termed “the interest rate cycle asymmetry” by Mojon (2000). There was evidence of “interest rate cycle asymmetry” among the countries of CAEMC. According to Samba & Yan (2010), “interest rate cycle asymmetry” might result from the collusive behaviour of commercial banks, since retail rates adjustments induce supporting extra cost.

In Ghana, the only notable literature on interest rate pass-through is by Acheampong (2005). The study used both symmetric and asymmetric error correction models to estimate the pass-through for only deposit and lending rates. Overall, the study found the pass-through estimates to be very low, both for the short and long term. In the short-run, the study estimated the pass-through to be 0.26 and 0.22 for lending and deposit rates respectively. For the long run, the pass-through estimates were estimated to be 0.55 and 0.69 for lending and deposit rates respectively. The study further tested for asymmetry adjustment and found no support for asymmetry adjustment in bank rates but rather support symmetry adjustment. Whereas Acheampong (2005) study aimed at investigating how government bond rates translates to commercial banks product rates, the objective of this study is to investigate how monetary actions affect the major interest rates in Ghana. Thus, the study investigates the effect of policy rate (prime rate) on treasury bill rate, interbank rate, deposit and lending rate.

**Stylized facts about interest rate pass-through**

Over the years and across countries, various empirical studies have been conducted on interest rate pass-through. These studies have established some properties of interest rate pass-through. These include:

- Policy rates influence the behaviour of market and retail rates in every economy though there is no systematic trend in the bank rates and retail rates
- The pass-through estimates are within the range of zero and one.
- The short run pass-through estimates are always lower than the long run estimates and are mostly below 0.5. However, there is no evidence of complete pass-through in the long-run.

**THEORETICAL FRAMEWORK AND METHODOLOGY**

The pass-through of official rates to individual retail rates parallels the industrial organization literature in that the official rate is effectively the determinant of financial institutions’ cost of funds and the retail rate is the price of its product. Banks products prices (interest rates) determination is based on the papers of Klein (1971) and Monti (1972). The Monti-Klein model is adopted because it prescribes how financial institutions set the prices of their product in imperfect condition (e.g. monopolistic and oligopoly),
which characterize Ghana banking sector. The Monti-Klein model\(^{13}\) views banks as profit maximizing entities that have the capacity to set the price in both the loans and deposit market. The individual bank faces a downward sloping demand for loans \( r_L(L) \) and upward sloping supply of deposit \( r_D(D) \). The profit of the bank is given by

\[
\Pi = r_L(L) + rM - r_D(D) - c(D, L) \tag{1}
\]

Where, \((1 - \alpha)\) - 

Equation (2) gives the position of the bank on the interbank market.

\[ L = \text{Loans}, \quad D = \text{Deposit}, \quad r = \text{interest rate in the interbank market}, \quad M = \text{money reserves}, \]

\[ = \text{rate paid on loans}, \quad = \text{rate paid to deposit}, \quad c = \text{cost of operation} \]

The profit of the bank is given by the difference between return accrued on loan advances and interest paid on deposits and the cost of operation. Combining equation (1) and (2) gives

\[
\Pi = (r_L - r)L + \{r(1 - \alpha) - r_D\}D - c(D, L) \tag{3}
\]

Hence, the profit of the bank is the sum of intermediation margins of loans and deposits, net of management cost. Maximization requires the first derivative be equal to zero yielding

\[
\frac{\partial \Pi}{\partial L} = r^i_L(L)L + r - r - c^i_L(D, L) = 0 \tag{4}
\]

\[
\frac{\partial \Pi}{\partial D} = -r^i_D(D)D + r(1 - \alpha) - r - c^i_D(D, L) = 0 \tag{5}
\]

The solution \( r^*_L, r^*_D \) of equation (4) and (5) is characterize by

\[
\frac{r^*_L}{L} - (r^*_L + c^i_L) = \frac{1}{\varepsilon\left(\frac{r^*_L}{L}\right)} \tag{6}
\]

\(^{13}\) Refer to Freixas & Rochet (1997; p.57), "Microeconomics of Banking" for detail discussion
The pricing rule for the bank assets market \( i (i = \text{deposits, various loans}) \) for given inverse demand and supply functions \( r_L(L) \) and \( r_D(D) \) is given by

\[
 r_i = \left[ r - c_i \right] \frac{1}{1 - \varepsilon_i} \tag{8}
\]

Where \( \varepsilon_i \) and \( \varepsilon_D \) indicate elasticity of the demand for loans and supply of deposit. In addition, represents the price elasticity of the demand for loans \( (i=\text{loans}) \) and the supply of deposits \( (i=\text{deposits}) \).

In a perfect competitive banking industry with complete information, the elasticity approaches infinity \( (\rightarrow \infty) \). With an infinite elasticity, price equals marginal cost and its derivative with respect to marginal cost equals one. The derivative falls below one when the demand for loans (supply of deposit) is inelastic with respect to the bank lending (deposit) rate, or if the banks have some degree of market power. The market power in the banking industry arises from regulatory agencies that create room for monopoly power and administrated pricing. In addition, market power is created by the existence of switching and asymmetric information cost.

The pricing equation (8) states that retail rates are set as a weighted average of market interest rates, corrected for market structure and banking cost. Deposit and lending activities of universal banks relate through the cost structure of banking activities. If the deposits or loans markets are segmented, the properties of the cost function determine whether activities in one market have an impact on retail rates in other markets. Since banks engage simultaneously in deposit and lending activities, the cost functions defined on both deposits and lending should not be separable. Thus, the equilibrium volume of deposits chosen by the bank will depend on the prevailing rate in that market, so that the resulting marginal cost of loans is in general non-linear. The relationship between lending rates and the market rates, on the other hand, are linear in nature. Deposit rates \( (\ddot{c}) \) and market rates \( (\ddot{r}) \) will be linear only in a special case where is itself a linear function. As a result, the study concentrates on a linear specification including both market rates but excludes deposit rates out of the information set. This is consistent with the fact that Monti-Klein considers retail interest rates to be independent from each other across markets.

This analysis yields a marginal cost model that postulates a connection between retail interest rates and official rate given by

\[
 r(1 - \alpha) - c_i \frac{i}{D} \frac{r^*}{r^*_D} = \frac{1}{\varepsilon_D(r^*_D)} \tag{7}
\]
Equation 9 implies that in a monopolistic competitive environment, the bank lending rate should be, in the longer term, related to the level of the official rate that reflects the marginal yield of a risk-free investment. Assuming that the determinants of the equilibrium mark-up, particularly the borrower structure and the risk structure of the bank, do not change during the period under review, then the long term relationship between the policy rate and the market interest rates is given by equation (9).

Where are the market interest rates comprising of deposit rates, lending rates, Treasury bill rates, and interbank lending rates. is Bank of Ghana policy instrument (prime rate), is the random error term whiles and indicate the long run parameters. The long run parameter indicates the responsiveness of the market interest rate to the prime rate. The long run pass-through is expected to be between zero and one. The pass-through is incomplete if the value of is zero and complete if it is equal to one. However, over pass-through will make the value of to be greater than one. A complete pass-through (instance where equal one) means changes in policy rates are transmitted in equal proportion to retail interest rate. That is, a ten per cent change in policy rate will cause retail interest rate to change ten per cent all things being equal.

The short-run relationship between lending and market rates is subject to lags, relating to lending rate rigidities. The study uses an ARDL technique that follows the following specification

\[
\Delta IR = \alpha + \alpha \Delta PR + \beta \Delta IR + \varepsilon \\
\]

\[
_i \sum_j ^n - i + ^m i \sum_j - i = \eta \]

(11)

\(\Delta\) represent the first difference in the variables it accompanies. and are the short run parameters and \(\delta\) indicates the short run pass-through. From the literature above, the short run pass-through \(\delta\) will be different from the long run pass-through \(\beta\). The gap between these parameters indicates how interest rates are sticky in the economy. If the series are not co-integrated, the long run pass-through parameter is estimated from equation (11) as follows

\[
\beta = \frac{\sum_i ^\alpha - \sum_i ^\beta}{i}
\]

(12)

If the series are co-integrated, an error correction model is specified as

\[14 \text{ This follows the specification by Kwapi\l & Scharler (2009)}\]
\[ \Delta IR = \alpha + \alpha \Delta PR + \alpha \Delta PR + \beta \Delta IR + \eta \mu + \zeta t - 1 \]

Where \( \mu_{t-1} = IR_{t-1} - a - bPR_{t-1} \) is the lagged disequilibrium error. The error correction model distinguishes clearly between short run and long run effects. \( \eta \) is the coefficient of the lagged error that measures the speed of adjustment to equilibrium. If the series are co-integrated, then the error correction term enters the model so that \( \eta < 0 \). If the series are not co-integrated, then \( \eta = 0 \). Therefore, we can detect co-integration hypothesis implies there exists a long run equilibrium relationship between the interest rates under consideration.

The asymmetric responsiveness among the interest rate is determined using the mean lag. The mean lag\(^{16}\) is given by

\[ ML = \frac{(1 - \alpha)}{\eta} \]

\(^{15}\) The distribution of the test statistic is non-standard. See Banerjee et al (1993) for critical values constructed for various significant level.

\(^{16}\) See also Doornik & Hendry (1994), Scholnick (1996) and Azikpomo et al (2010).

Data

The study used monthly data on interest rates covering the period 2002:1 to 2009:12 from the Bank of Ghana database for the analysis. Bank of Ghana provides two kinds of data on interest rates: end of month data and the average monthly data. The end of month data is the interest rate prevailing in the economy at the end of month whiles the average
monthly data is constructed by taking the un-weighted average of all the values of the range of rates offered by deposit money banks (DMB’s) in a particular month. The study used the average monthly data. The index of interest rates used for the study were the prime rate-PRATE, savings (deposit) rates-D RATE, treasury bill rates-TBRATE, interbank rates-IBRATE and the lending (base) rates-L RATE. The prime rate is the policy rate used for the analysis. The prime rate is the rate that the Bank of Ghana uses to communicate its stance on policy directions.

**DISCUSSION OF EMPIRICAL RESULTS**

**Causality Tests**

For inflation-targeting monetary policy orientation, the Bank of Ghana policy rate is the key monetary policy instrument, particularly, influencing the behaviour of the market interest rates. Therefore, this study test whether the policy rate sets the direction for the behaviour of market interest rates or whether Bank of Ghana follow the behaviour of market interest rates by changing policy rates after market interest rates are adjusted automatically to suit economic and financial conditions. The Granger causality tests were carried out to test these competing hypotheses.

From Table A1 in appendix A, the Granger causality tests show that at five per cent critical value there is unidirectional causality from PRATE to DRATE, LRATE, TBRATE, and IBRATE. It can then be concluded that the policy rate sets the direction for the behaviour of market interest rates used in this study.

**Unit Root Tests**

The study begins by testing the time series property of the data to check their level of stationary. A unit root test is thus conducted on all the series. The unit root tests determine the root that characterizes the data, which help choose the appropriate estimation technique to prevent spurious results. Using ADF, KPSS and Phillip-Peron test statistics, the study found out that all the series are non-stationary at level but are stationary at first differenced indicating the presence of unit root in all the series. TablesA2 and A3 in appendix A present the unit root test in all the variables used for the analysis.

**Co-integration Test**

Following the evidence of unit root in series as determined above, the study further conducted the test of co-integration. Among the numerous available co-integration tests, the study favoured the ARDL technique because of its flexibility in application even when the variables are of different order of integration. In addition, the ARDL takes sufficient lags to capture the data generating process.
Table 1 shows the ARDL bound test for co-integration. The rates indicate the ARDL modelling of the prime rate and the particular rates. The F-statistic of all the regression is greater than the upper bound critical value indicating a level relationship (co-integration) between the market rates and the policy rate. This implies that there exist long run relationship between various interest rates and the policy rate. It also indicates that the series at level can be used for the estimation without resulting in spurious estimations.

Table 1: ARDL Bound Test for Co-integration

<table>
<thead>
<tr>
<th>RATES</th>
<th>F-STATISTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRATE</td>
<td>6.4113</td>
</tr>
<tr>
<td>LRATE</td>
<td>10.4426</td>
</tr>
<tr>
<td>IBRATE</td>
<td>12.9785</td>
</tr>
<tr>
<td>TBRATE</td>
<td>28.2987</td>
</tr>
</tbody>
</table>

SOURCE: Estimates from Micro fit 5.0. N.B: The rates indicate the ARDL modelling of the prime rate and the particular rates. If the statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect cannot be rejected. The critical value bounds computed by stochastic simulations using 20000 replications are for 5 per cent 6.7162 (7.5870) for lower bound (upper bound) and for 10 per cent 5.6842 (6.4024) for lower bound (upper bound).

Short and long run pass-through estimates

The study employed the ARDL technique and its re-parameterisation into error correction model to obtain the estimates for both long run and short run pass-through for the interest rates. Using the Akaike information criteria (AIC) to select the maximum lag for all the series, the maximum lags used were based on regression estimates with the lowest Akaike value. The AIC is proven to be the most parsimonious in infinite sample. The study favoured the AIC because the study’s sample size is more than ninety, which can be approximated to infinite. Also, the standard error is well behaved in the estimation with AIC than the other criteria such as the Swartz Bayesian criteria (SBC).

Table 2 below records the long run pass-through estimates and their associated Wald test. As per the empirical analysis, the pass-through process in the Ghanaian sector differs across the instruments used. The study found that the long run pass-through varies from a high value of 2.0753 (TBRATE) to a low value of 1.1439 (DRATE). The long run adjustment of TBRATE, IBRATE, DRATE, and LRATE to a percentage change in the policy rate is 2.0753, 1.3770, 1.1439, and 1.5196 respectively. This indicates that all the
series have a pass-through greater than unity. The Wald test\textsuperscript{17} is formally used to test whether the long-term impact or elasticity is greater than or equal to one ($\beta \geq 1$). With a P-value of 0.495 associated with a Wald statistic of 0.46533, the long run pass-through of DRATE is not statistically different from one. This shows that DRATE have a complete long run pass-through. On the other hand, the P-value associated with the Wald statistic of the long run pass-through of TBRATE, LRATE, and IBRATE is statistically different from one. From the Wald tests, it can be concluded that lending rate, interbank rate, and Treasury bill rate have over pass-through\textsuperscript{18}.

### Table 2: Wald Test for complete pass-through

<table>
<thead>
<tr>
<th>SERIES</th>
<th>LONG RUN (b)</th>
<th>WALD TEST</th>
<th>SERIES</th>
<th>LONG RUN (b)</th>
<th>WALD TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRATE</td>
<td>1.1439</td>
<td>0.46533</td>
<td>TBRATE</td>
<td>2.0753</td>
<td>181.7881</td>
</tr>
<tr>
<td></td>
<td>[0.495]</td>
<td></td>
<td></td>
<td>[0.000]</td>
<td></td>
</tr>
<tr>
<td>LRATE</td>
<td>1.5196</td>
<td>15.0959</td>
<td>IBRATE</td>
<td>1.3770</td>
<td>10.1838</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td></td>
<td></td>
<td>[0.001]</td>
<td></td>
</tr>
</tbody>
</table>

*Sources: compile from micro fit five estimates. [] contain p-value of the estimates Short run pass-through estimates*

The study found that the short run pass-through estimates are very low for Ghana. Table 3 provides the estimates for short run pass-through. As expected, the short run pass-through estimates are lower than the long run pass-through estimates. From Table 3, IBRATE has the highest short run pass-through with a value of 0.50565. The reason for this high short-run pass-through could be its relatively elastic demand. A relatively elastic demand means a greater percentage change in price (rates) required a smaller percentage change in quantity demand. Since most of the banks have a high pool of resources and alternatives source of finance, it makes them independent of the interbank markets. Therefore, a small demand pressure from banks on the interbank market will cause the interest rate to change by greater margin. This causes the interbank rates to respond enormously to policy change hence its relatively high pass-through estimates.

\textsuperscript{17} The Wald test is used to test whether the estimates equal one. If the test fail to reject the hypothesis of the estimates equal one, it implies that the estimates are greater than one hence overpass-through. The opposite meant there is complete pass-through.

\textsuperscript{18} By over pass-through, we mean change in market rates due to change in policy rate is more than 100 per cent.
<table>
<thead>
<tr>
<th>SERIES</th>
<th>LONG RUN</th>
<th>SHORT RUN</th>
<th>SPEED OF ADJUSTMENT</th>
<th>MEAN LAG</th>
<th>GAP between long and short run</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRATE</td>
<td>1.1439</td>
<td>0.217</td>
<td>0.163</td>
<td>4.818</td>
<td>0.9269</td>
</tr>
<tr>
<td>IBRATE</td>
<td>1.377</td>
<td>0.506</td>
<td>0.367</td>
<td>1.3462</td>
<td>0.871</td>
</tr>
<tr>
<td>LRATE</td>
<td>1.5196</td>
<td>0.011</td>
<td>0.162</td>
<td>6.1110</td>
<td>1.5086</td>
</tr>
<tr>
<td>TBRATE</td>
<td>2.0753</td>
<td>0.276</td>
<td>0.421</td>
<td>1.7195</td>
<td>1.7993</td>
</tr>
</tbody>
</table>

Source: Author compilations of estimates from micro fit five.

Discussion of results

The objective of the study is to estimate the pass-through for the various interest rates under consideration. The coefficient $\beta$ in equation (9) gives the long run pass-through of each particular interest rate with respect to changes in the prime rate. If the pass-through equals one, it implies there is complete pass-through from changes in prime rate to the retail rates in question. The long run over pass-through indicates that all the interest rates under consideration are very much responsive to monetary policy rates in the long term. In order of magnitude, treasury bill rate has the highest pass-through followed by lending rate, interbank rate and deposit rate. The long run pass-through estimates highlight which interest rate responds most to policy rate.

The estimates of pass-through in this study seems not surprising taking into account the role various interest rates play in the implementation of monetary policy in the Ghana. When the Bank of Ghana communicates its stance using the prime rate, it uses the open market operation to steer the demand and supply of credit facilities. Therefore, a high pass-through in treasury bill rates seems in conformity with the real implementation of monetary policy in Ghana since treasury bill is the main tool used for implementing open market operation. The rate-setting behaviour of treasury bills is undertaken through the open market operation in a competitive mechanism. As predicted by theory, a competitive environment reduces the sluggishness in interest rate pass-through. Thus, the high long run pass-through in treasury bill rates can be attributed to competition in the price setting.

The high long-term interest rate pass-through evident in this study is consistent with the findings of other developing economies study on interest rate pass-through. However, this study’s findings are in contrast with the study by Acheampong (2005). While the study by Acheampong (2005) found incomplete long run pass-through in deposit and lending rates, this study found complete pass-through for deposit rate and over pass-through for

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The difference in the pass-through could be because of the different periods considered or policy rate proxy. While this study used the prime rate as the policy rate, the study by Acheampong (2005) used the 91-day Treasury bill as the policy rate. The difference in the estimates could also emanate from differences in methodology used.

The study also found that the speed of adjustment of the short run pass-through towards its long run pass-through is relatively low. The coefficient on the error correction term (ECT) describes the speed at which any disequilibrium (emanating from policy change) from the long-run relationship between the prime rate and retail rates converges. The low speed of adjustment makes banks' interest rates very inflexible to changes in the policy rate. For example, the coefficient associated with ECT for DRATE is 0.16. This means that 16 per cent of any policy rate change is transmitted to the deposit rate within a one-month period. For example, if policy rate change by 100 per cent, deposit rate will only change by 16 per cent within the first month. Overall, the speed of adjustment varies between a high value of 0.42125 (TBRATE), to a low value of 0.16189 (LRATE). The treasury bill rates adjust faster followed by the interbank rate, the deposit rate, and the lending rate in that order of magnitude. The magnitude of the speed of adjustment shows that the speed of pass-through is very low in the Ghanaian economy. The low response implies that interest rate channel of monetary policy is weak.

The speed of adjustment mimics the level of competition existing in the setting of various interest rates in the Ghanaian economy. Treasury bill rate setting is highly competitive than any other interest rates under consideration in this study since it adjusts 42 per cent a month. This is supported by the argument that in Ghana the rates on treasury bill are determined through competitive bidding. Comparatively, the price setting of lending and deposit rates are less competitive since they have the lowest speed of adjustment of 16.19 per cent and 16.25 per cent a month respectively. These seem to support the existence of market power in the pricing setting behaviour in the Ghanaian banking industry (Aboagye et al, 2007). Economic theory argues that market power does not allow banks to respond to market condition in determining their prices for their product, hence, causing deposit and lending rates to be less responsive to market signal (i.e. the policy rate influencing market rates) in the determination of deposit money banks product prices.

The gap between the long run and the short run pass-through indicates whether interest rates are sticky or not in the short run. The difference between the long run and short-run estimates confirms high stickiness among the interest rates used for this study. The gap for all interest rates is greater than one except IBRATE (0.8785) and DRATE (0.9269). These gaps indicate that lending and treasury bill rates are not responsive to monetary policy rate in the short run since their values are greater than one.
Mean adjustment lags

Policy makers seek to reduce the numerous lags in the transmission process to make monetary policy very effective in achieving its objectives. Therefore, a major concern for policy makers is the speed of the transmission, whether it is quick or sluggish, beside the magnitude of the adjustment in the long--run. Mean adjustment lags determine how long does interest rates take for the full adjustment in the long term to be realized. The penultimate column of Table 3 records the mean lags for the series. A critical look at the values shows that LRATE has the highest mean lag of approximately six months. The high mean lag of LRATE mirrors its low speed of adjustment of 0.16189 for one-month period. Following LRATE in order of magnitude are DRATE, which takes five months, TBRATE, which takes two months and IBRATE, which takes approximately one month. As explained above, treasury bill rates and interbank rates are the two interest rates that play key role in monetary policy in Ghana; hence, it is not surprising they take smaller time to adjust fully in the long term.

CONCLUSION AND POLICY RECOMMENDATION

Conclusion

In conclusion, the pass-through process clearly differs across retail bank interest rates in Ghana. The study recorded two major findings. First, there is a long run equilibrium relationship between retail bank interest rates and monetary policy rate (prime rate). The bank interest rates almost adjust to changes in prime rates with an overshooting rate in all the interest rates in the long term. Second, it takes on average one to six months for the policies of the central bank to be transmitted to retail interest rates. One implication is that if the Bank of Ghana desires the transmission to be instantaneous, that is, if the Bank of Ghana wants to see the retail rates increase (decrease) by 100 basis points during the month the prime rate changes, the prime rate must be increased (decreased) above 100 basis points.

Generally, interest rates in Ghana exhibit high inflexibility. Compared to interest rate pass-through from other countries, interest rate pass-through in Ghana is among the lowest in the short-run, but very high in the long run. In conformity with other studies on the Ghanaian economy, the interest rate pass-through estimates are very low in the short run. Nevertheless, having made such comparison, it is worth noting that the period, methodology and data frequency are different for the studies. For example in the study by Acheampong (2005), the treasury bill rates was used to represent the policy rate whereas this study used the policy rate. In addition, whereas this study used the base rate to represent lending rate, the study by Acheampong (2005) estimated the pass-through using the lending rates to the manufacturing sector.
Policy Recommendation

The findings of this study have a number of implications for monetary and financial policies. First, the low speed of adjustment of market interest rates to monetary action during this period of inflation targeting suggests interference with the market forces. This suggests that market interest rates setting behaviour are uncompetitive in nature. Therefore, regulations should increase the level of transparency and accountability in executing monetary policy so as not to further slowdown the pass-through process. This will increase the effectiveness of monetary policy.

Secondly, the overshooting long run pass-through could be because of asymmetric information cost. As noted by De Bondt (2005), commercial banks will charge higher interest rates in an attempt to offset the higher risks resulting from asymmetry information rather than reducing the supply of loans. In other words, if banks increase their lending rates exactly one to one with monetary policy rates, they will attract a more risky class of borrowers. Consequently, banks will have to increase their lending rate further to offset this risk. Policy makers should therefore develop strategies to curb or reduce the level of information asymmetry prevalent in the financial sector.

Thirdly, there is evident of commercial banks behaving in a collusive manner in the deposit market. This necessitates appropriate interventions by authorities to ensure that depositors are protected against exploitation by the banks. Exploitation in the form of low interest earning on deposits may worsen the low saving habits of the Ghanaian population. The short run pass-through is very small suggesting a low level of competition in the banking industry. Though there are 28 banks in Ghana, deposits are concentrated among the four major banks20 (Ghana commercial bank, Barclays bank, Standard Chartered bank and Eco bank Ghana limited) which set the tone for the other banks. Regulations may target transparent banking operations to ensure that banks do not extract unnecessary surplus from depositors.

Given the size of the mean lag adjustment, there is the need to make various interest rates fully effective in the short-run. According to the results of the study, in order to increase (decrease) the deposit rate, treasury bill rate and interbank rate by about 100 per cent, the policy rate must be increased (decreased) by almost 200, 100, and 400 per cent respectively. The reasons for the high cost of adjustments must be carefully examined. Market power, demand elasticity of loans, switching cost and asymmetric information cost among others could be the elements to check to boost the effectiveness of interest rate policy.

The methods and rates through which the central bank communicates its policy to the public is a possible determining factor of the effectiveness of monetary policy. According

\[20\text{Ghana Banking survey,2010}\]
to Blinder et al (2008), a central bank communication matter in smoothing transmission of monetary policy shocks. Communications help shape public expectations, hence effective policy transmission. Therefore, to enhance signalling and effective pass-through, the Bank of Ghana should frequently communicate on future directions. The study covered only the inflation-targeting regime. Future studies, can however, extend to other monetary policy regimes by tracing the dynamics in the interest rate pass-through as the country has evolved in its monetary policy administration.
REFERENCES


Freixas, X. & Rochet, J. C. 1997, Microeconomics of Banking, the MIT Press, Cambridge, Massachusetts.


Marotta, G. 2009, ‘Structural breaks in the lending interest rate pass-through and the Euro’, Economic Modelling, 26: 191-205


Williamson, S.D. 1987, ‘Costly monitoring, loan contracts, and equilibrium credit rationing’, Quarterly Journal of Economics, Vo. 102 (February), 135-145


APPENDIX A

Table A: Sectorial Composition of the Financial Sector of Ghana as at April 2008

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banks</td>
<td>28</td>
</tr>
<tr>
<td>Rural Community Banks</td>
<td>129</td>
</tr>
<tr>
<td>Non-Bank financial institution</td>
<td>44</td>
</tr>
<tr>
<td>Forex bureau</td>
<td>273</td>
</tr>
<tr>
<td>Insurance company</td>
<td>17</td>
</tr>
<tr>
<td>Re-insurance company</td>
<td>2</td>
</tr>
<tr>
<td>Insurance brokers</td>
<td>35</td>
</tr>
<tr>
<td>GSE listed company</td>
<td>35</td>
</tr>
<tr>
<td>GSE licensed stockbroker</td>
<td>16</td>
</tr>
</tbody>
</table>

Source: BoG website

Table A1: Granger Causality Tests
Sample: 2002:01 2009:12

<table>
<thead>
<tr>
<th>NULL HYPOTHESES</th>
<th>OBS</th>
<th>F-STAT</th>
<th>PROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRATE does not Granger cause LRATE</td>
<td>86</td>
<td>4.32482</td>
<td>0.00012</td>
</tr>
<tr>
<td>LRATE does not Granger cause PRATE</td>
<td>86</td>
<td>0.60287</td>
<td>0.80574</td>
</tr>
<tr>
<td>PRATE does not Granger cause TBRATE</td>
<td>86</td>
<td>3.66177</td>
<td>0.0000</td>
</tr>
<tr>
<td>TBRATE does not Granger cause PRATE</td>
<td>86</td>
<td>0.77228</td>
<td>0.6546</td>
</tr>
<tr>
<td>PRATE does not Granger cause IBRATE</td>
<td>86</td>
<td>2.482</td>
<td>0.0138</td>
</tr>
<tr>
<td>IBRATE does not Granger cause PRATE</td>
<td>86</td>
<td>0.59167</td>
<td>0.815</td>
</tr>
<tr>
<td>PRATE does not Granger cause DRATE</td>
<td>76</td>
<td>2.3538</td>
<td>0.0129</td>
</tr>
<tr>
<td>DRATE does not Granger cause PRATE</td>
<td>76</td>
<td>0.90202</td>
<td>0.58714</td>
</tr>
</tbody>
</table>

Source: Author computations of estimates from E-views
### Table A2: Unit Root Test for series at level

<table>
<thead>
<tr>
<th>SERIES</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
<th>DECISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRATE</td>
<td>-0.934555 (0.3094)</td>
<td>-0.933448 (0.3098)</td>
<td>0.280128</td>
<td>Non Stationary</td>
</tr>
<tr>
<td>LRATE</td>
<td>-0.335538 (0.5618)</td>
<td>-0.805189 (0.3647)</td>
<td>0.263416</td>
<td>Non stationary</td>
</tr>
<tr>
<td>IBRATE</td>
<td>-1.823417 (0.6857)</td>
<td>-1.976640 (0.6062)</td>
<td>0.263161</td>
<td>Non stationary</td>
</tr>
<tr>
<td>TBRATE</td>
<td>-0.541953 (0.4797)</td>
<td>-0.901602 (0.3232)</td>
<td>0.266401</td>
<td>Non stationary</td>
</tr>
<tr>
<td>PRATE</td>
<td>-0.923266 (0.3140)</td>
<td>-1.505223 (0.1233)</td>
<td>0.275889</td>
<td>Non stationary</td>
</tr>
</tbody>
</table>

*Note: The asymptotic critical values for KPSS are 1% (0.21600), 5% (0.14600), and 10% (0.11900). For ADF and PP, value in parenthesis is the p-value, which is compared to 5% critical values. Source: Estimates from E-views.*

### Table A3: Unit Root Test for series at first difference

<table>
<thead>
<tr>
<th>SERIES</th>
<th>ADF STAT</th>
<th>P-VALUE</th>
<th>KPSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(DRATE)</td>
<td>-12.21722</td>
<td>0.0000***</td>
<td>0.046575+++</td>
</tr>
<tr>
<td>D(LRATE)</td>
<td>-6.915336</td>
<td>0.0000***</td>
<td>0.072420+++</td>
</tr>
<tr>
<td>D(IBRATE)</td>
<td>-6.396535</td>
<td>0.0000***</td>
<td>0.054382+++</td>
</tr>
<tr>
<td>D(TBRATE)</td>
<td>-6.280735</td>
<td>0.0000***</td>
<td>0.064298+++</td>
</tr>
<tr>
<td>D(PRATE)</td>
<td>-5.270915</td>
<td>0.0000***</td>
<td>0.077824+++</td>
</tr>
</tbody>
</table>

*Note: D denotes the first difference of the variable it precedes, *** denote significant at 1% critical value, +++ denote non-rejection of null hypothesis of stationary. Source: Estimates from E-views.*
Figure 2: Interest Rate Structure

Source: Author compilation using data from Bank of Ghana