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Excess Liquidity and Rwanda's Monetary Policy

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Preface

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ABSTRACT

This study examines the potential determinants of precautionary excess liquidity in the Rwandan banking system during the period 2004-16 and its optimal level above or below which excess liquidity becomes a constraint in monetary policy transmission. The study uses the FMOLS autoregression approach to estimate the determinants of precautionary excess reserves. However, for ease in interpreting the coefficients, the study also estimates the sum of coefficients using the dynamic least squares (DOLS) method with the lag operator set to 1. For the optimal excess liquidity level it uses the Kernel density estimation to estimate the probability density of the estimated precautionary excess liquidity. To avoid sample dependence on the optimal level obtained it uses the bootstrap method to obtain a confidence interval of the values computed. The results obtained from the regressions suggest that the reserve requirement, change in demand for cash proxied by the output gap and the lagged value of excess liquidity are important determinants of precautionary excess liquidity in the Rwandan banking system. Using the summation of coefficients, the lagged values of the cash-to-deposit ratio, discount rate and foreign exchange exposure are also found with significant positive relationships. Considering the first and second conditions of liquidity minimization, the study finds the optimal level of excess liquidity at around Frw 34 billion. On an average of five years, the excess reserves should be around Frw 14.3 billion. The estimations are based on the assumption that the existing reserve requirement is optimum. The findings can be used as a base for the central bank to improve its liquidity management for an effective monetary policy.

Keywords: Excess liquidity, monetary policy, Rwanda.

JEL Classification Codes: E51; E52; O55.

1. INTRODUCTION

In the last decade Rwanda achieved high economic growth averaging around 7.5 per cent in a stable macroeconomic environment characterized by low levels of inflation and a stable exchange. Economic stability, improvements in the business environment and significant budget support from international partners contributed in creating excess liquidity in the banking sector leading to high growth of broad money (M3) by 18 per cent on average between 2000 and 2016. Banking reserves exceeding the statutory requirements increased from 17 per cent between 2004-08 to 38 per cent in 2009-12 and 46 per cent in 2013-16.

There is consensus among central bankers and academicians about the impact of high liquidity in the banking sector on the effectiveness of monetary policy. First, improvements in demand conditions may lead banks to expend their lending to the private sector, which may create inflationary pressures. Second, significant banking liquidity may limit the monetary policy's ability to influence aggregate demand in the economy. If banks hold liquidity in excess of requirement, the central bank's actions aimed at stimulating aggregate demand (by lowering the central bank rate or increasing reserve money) by increasing liquidity will be ineffective. In other words, excess bank liquidity weakens the monetary policy transmission mechanism (see, for example, Agénor et al., 2004; Nissanke and Aryeetey, 1998). Another way in which excess liquidity limits the effectiveness of monetary policy is linked to its impact on the good functioning of the interbank market, which is key for a price based monetary policy.

In Rwanda, the banking sector has been characterized by high excess reserves. This has contributed to weakening the interbank market and making the BNR rate an opportunity cost of holding reserves rather than a cost of central bank funds. A shallow or non-liquid interbank market has contributed to limiting the effectiveness of money market operations in Rwanda by distorting a key aspect of the interest rate transmission channel.

Two categories of excess liquidity can be distinguished: excess bank liquidity held for precautionary purposes and reserves held above that level (called involuntary excess reserves) which could limit transactions between commercial banks and the central bank and weaken the central bank's ability to influence the interest rate and credit growth in the market.

Gichondo and Nizeyimana (2010) were the first to identify the causes of the observed excess liquidity during 2004-08 and its impact on the effectiveness of monetary policy in Rwanda.

Our study has two objectives. First, we identify the potential determinants of precautionary excess liquidity in the Rwandan banking system extending the period used by Gichondo and Nizeyimana up to 2016. Second, we estimate the optimal level above which excess liquidity becomes a constraint in the transmission of monetary policy. This is very important as BNR is planning to move from a monetary aggregate framework to a more price based monetary policy. The new framework requires a liquid interbank market and a strong interest rate pass-through which will depend on proper banking liquidity management by BNR using open market operations. The

findings of our study can guide BNR's daily money market interventions to influence liquidity in the banking system.

2. LITERATURE REVIEW

Different studies have analyzed the implications of excess liquidity on central banks' capacity to impact aggregate demand in economies (Arestis and Demetriades, 1999; Caprio and Honohan, 1993; Freedman and Click, 2006; Gentil and Fatima, 2012; Nketcha and Samson, 2014; Saxegaard, 2006). Gentil and Fatima (2012) show that the persistence of excess liquidity for both precautionary and involuntary purposes is due to the inadequate development of financial markets, high level of risk aversion and high capital inflows. In such an economic environment, the accumulation of excess reserves raise distress on banks' profitability, lead to inflationary pressures and impact the monetary policy's transmission mechanism as also its effectiveness. Arestis and Demetriades (1999) show that low competition in the banking system can lead to the building up of excess liquidity in the banking sector. They show that under a perfect loan market, excess liquidity and bank loans become substitutes at a zero loan rate and that in developing economies, the substitution is at higher loan rates because of low competition in the banking system.

This build-up of excess liquidity in developing countries has been the subject of several studies such as those by Fielding and Shortland (2002, 2005) for Egypt; Aikaeli (2006) for Tanzania; Khemraj (2006) for Guiana; Saxegaard (2006) for CEMAC, Nigeria and Uganda; Moumni and Nahhal (2014) for Morocco; Gichondo and Nizeyimana (2010) for Rwanda.

Different studies, including Agénor et al., (2004) and Agénor and Aynaoui (2010) have identified two motives for banks holding excess liquidity: precautionary and involuntary. Existing literature classifies determinants of involuntary excess liquidity into structural and cyclical factors. Regarding structural determinants, Saxegaard (2006) and Agénor and Aynaoui (2010) assert that banks' demand for involuntary balances is a result of a low developed interbank market, high operational costs, an underdeveloped public bonds market and absence of remunerative alternatives for excess balances.

According to Mishkin (2001), banks decide to accumulate excess reserves for reasons related to safety measures against operational costs. He notes that the higher the costs related to deposit outflows, the more the excess reserves that are held. Other determinants of excess liquidity include huge capital inflows, rising inflation and an uncertain economic environment (Agénor and Aynaoui, 2010).

Empirically, different models have been used to estimate the level of excess liquidity for both precautionary and involuntary purposes and their consequences on the effectiveness of monetary policy. These models include the GMM estimator, TSLS, ARDL and VAR. Saxegaard (2006) used a non-linear structural VAR model to investigate the consequence of banks holding excess liquidity on the effectiveness of monetary policy in the CEMAC region, Nigeria and Uganda as an extension of the model developed by Agénor et al., (2004). His findings suggest that excess liquidity

limited the effectiveness of monetary policy transmission leading monetary authorities to lose their ability to influence demand conditions in the economy.

Using the same model for Morocco, Moumni and Nahhal (2014) obtained the same findings. The particularity of this study is that for Morocco the effect was manifested in the long run. Gichondo and Nizeyimana's study (2010) on Rwanda found the same results indicating that excess liquidity was one of the key factors limiting the impact of monetary policy authorities on banks' behavior in terms of lending to the private sector.

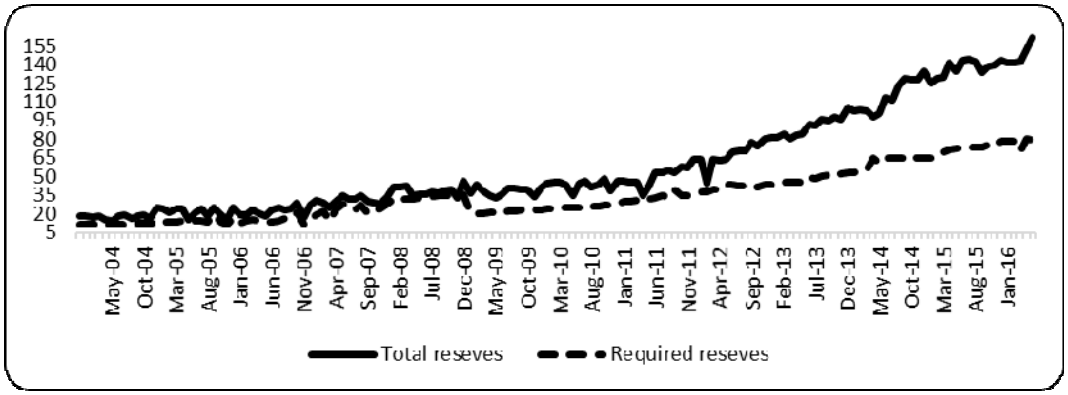
Using the same methodology, Gouteron and Szpiro (2005) found that liquidity did not explain variations in asset prices which complicate the role of monetary authorities as they cannot predict the changes in asset prices which in turn may affect the transmission of monetary policy.

Khemraj (2006) proposes two different hypotheses that work simultaneously to explain why non-regulated commercial banks in Guyana demanded large quantities of excess liquidity. One is the banks' desire for a minimum rate of interest at which loans and government securities are perfect substitutes and the second is the banks' intentions not to invest all excess reserves in safe foreign assets because the central bank creates foreign currency constraints by accumulating foreign exchange reserves.

3. Liquidity trends in the RWANDAN BANKING SYSTEM

The Rwandan banking sector has been characterized by increasing excess reserves -- from 17 per cent of the required reserves between 2004-08 to 38 per cent in 2009-12 and 46 per cent in 2013-16 -- mainly due to foreign aid, foreign direct investments (FDI) and less developed financial markets (Figure 1). Total disbursements for both budget and project support increased by 131.9 per cent between 2004 and 2015 and stood at US$ 518.5 million in 2015 against US$ 223.6 million in 2004. This contributed to significantly increasing the share of net foreign assets in broad money (M3) which averaged around 74.5 per cent during the period under review. Increasing remittances, FDI, debt relief under the highly indebted poor countries' (HIPC) initiatives in 2005, foreign aid and the country's privatization program for state-owned enterprises contributed to money creation through domestic government and household expenditure and played a major role in building high banking liquidity.

Figure 1: Total reserves and required reserves (in Frw billion)



Source: BNR (Financial Markets Department).

In the same period, deposits in the banking sector increased significantly and were dominated by demand deposits, averaging 41.6 per cent of the total deposits. This pushed banks to hold more precautionary cash deposits to withstand any unexpected withdrawals by their clients (Table 1).

Table 1: Development of monetary aggregates

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Share of Total M3													
NFA	84.6	90.4	88.8	82.6	86.6	84.1	84.3	86.2	62.4	72.3	56.4	43.4	46.4
NDA	15.4	9.6	11.2	17.4	13.4	15.9	15.7	13.7	37.6	27.7	43.6	56.6	53.6
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Share of Total Deposits													
Demand deposits	36.3	41.6	38.0	41.9	43.5	42.5	45.7	41.1	40.7	41.5	41.3	45.9	40.6
Time deposits	32.9	36.4	39.9	39.2	35.1	36.3	35.4	38.9	38.3	37.2	36.8	35.0	36.7
FX deposits	30.8	21.9	22.1	18.9	21.3	21.7	18.9	20.0	21.0	21.3	21.9	19.1	22.7
Total	**100**	**100**	**100**	**100**	**100**	**100.4**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: BNR (Statistics Department).

Since the 1990s, BNR has started using open market operations to implement its monetary policy: weekly tenders for liquidity injection or mop up and issuance of treasury bills. However, the management of liquidity in the banking system has become challenging over time, particularly after the 2003 presidential elections when business confidence and aid inflows increased significantly. This was further intensified by a US$ 1.4 billion debt relief in 2005 under the HIPC initiative. BNR reduced the reserve requirement ratio in 2000 to 8 per cent from 10 per cent and the reserve requirement maintenance period was revised from one week to one month in 2001. The objective of these policy measures was to allow banks to finance the private sector and support the government's economic policies.

Owing to sound economic policies, sizable donor support and important economic financing by commercial banks, the Rwandan economy recorded good performance with real GDP rates ranging between 7.4 per cent in 2004 to 11.2 per cent in 2008 and 7.5 per cent on average in the last decade. The external position strengthened as foreign capital inflows offset the trade deficit allowing a build-up of international reserves to comfortable levels. Recent macroeconomic developments are given in Table 2.

Table 2: Recent economic developments

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Real GDP Growth (in per cent)	7.4	9.4	9.2	7.6	11.2	6.2	7.3	7.8	8.8	4.7	7.0	6.9
Exports (YoY, per cent change)	55.4	27.6	14.0	24.1	51.5	-28.0	32.0	52.4	24.5	18.7	4.7	-6.8
Imports (YoY, per cent change)	19.4	29.9	35.2	35.8	54.0	9.9	11.4	36.1	16.3	2.2	6.6	-3.2
Export cover	31.7	31.1	26.3	24.0	23.6	15.5	18.3	20.5	22.0	25.5	25.1	24.2
Months of imports	7.6	6.8	7.0	5.1	6.3	7.2	7.0	6.7	4.8	4.5	4.4	4.6
Total Grants (YoY, per cent change)	68.9	27.8	2.8	22.6	35.0	24.2	14.4	11.5	-22.0	32.9	-8.1	-11.2
Budgetary grants (YoY, per cent change)	77.6	20.2	-34.0	82.1	39.3	25.8	18.1	9.1	-49.8	52.2	-34.6	2.7
Capital grants (YoY, per cent change)	50.3	47.1	78.9	-22.8	27.2	20.9	6.8	16.9	36.9	18.0	18.3	-21.8
Public debt (y-o-y % change)	15.0	-10.3	-56.9	20.4	4.5	12.7	10.2	21.1	9.8	33.2	16.0	16.8

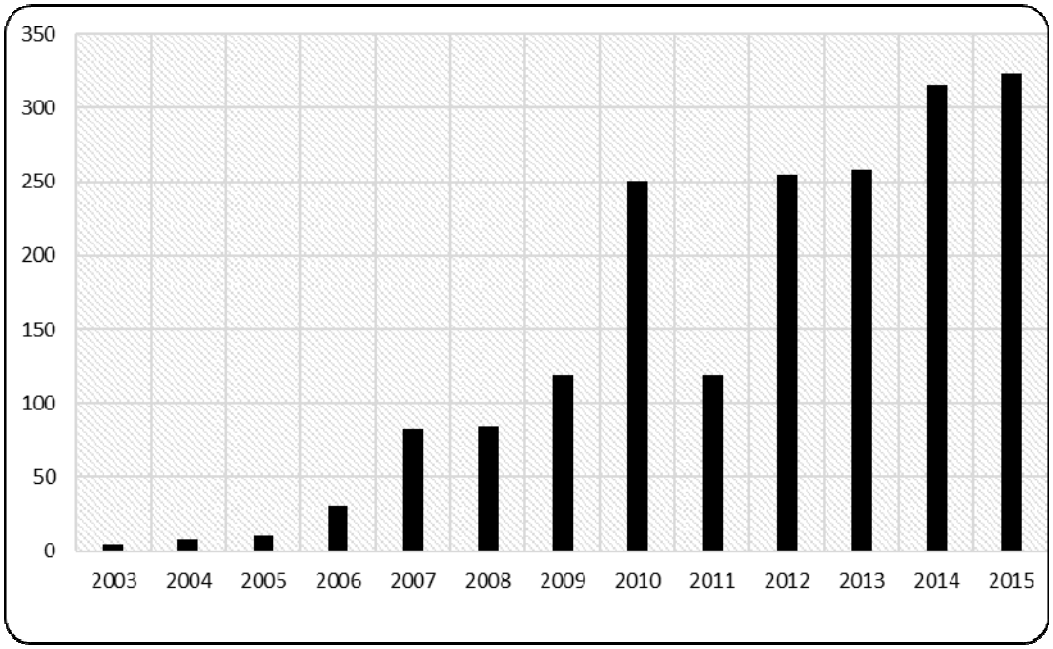
Public debt (% of GDP)	92.7	67.3	24.1	23.9	19.6	20.0	20.5	22.1	21.5	27.5	30.4	34.5
Inflation	10.2	5.6	12.1	6.6	22.3	5.7	0.2	8.3	3.9	3.6	2.1	4.5

Source: Monetary Policy Directorate.

In end-2008, a number of factors plunged the banking system into a liquidity crunch which lasted for a few months. These include huge investments by the Rwanda Social Security Board (RSSB) in different projects and the global financial crisis. As a result, deposits in the banking sector declined from Frw 400.5 billion in November 2008 to Frw 358.9 billion in February 2009 and some banks under stress used BNR's lender-of last resort facilities for the first time.

Different policy responses were implemented including a reduction in the reserve requirement from 8 per cent to 5 per cent in February 2009, introduction of a 3 to 12 month BNR liquidity facility while all T-bills were not rolled over at their maturities. In addition, a Frw 22.4 billion long term government facility for five years was given to seven banks to increase their capacities to finance long-term projects. As a result, the liquidity situation in the banking sector improved. Total deposits of commercial banks increased from Frw 366.6 billion in end March 2009 to Frw 783.1 billion in end December 2012. See Figure 2.

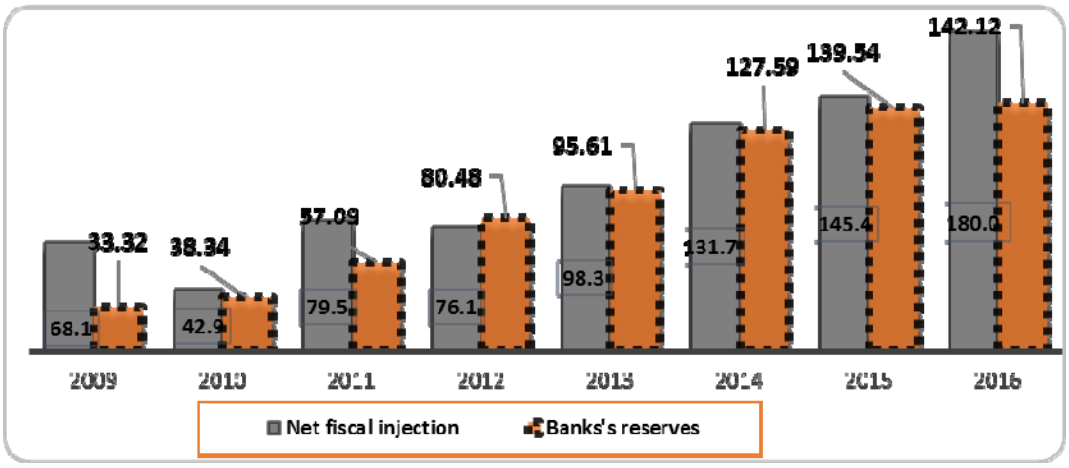
Figure 2: Evolution of Foreign Direct Investment (in USD million)



Source: BNR (Statistics Department).

During the second half of 2012, the suspension and delays in budget support led the total grants to contract by 22 per cent from an increase of 11.5 per cent in the previous year of which budgetary grants plunged by 50 per cent from a 9 per cent growth. Fiscal and monetary authorities responded to the aid shock by tightening policies and drawing reserves to mitigate the impact of aid suspension and cuts on the economy. This contributed to maintaining excess liquidity in the banking sector through government expenditure which was partly financed by increased domestic borrowings. Figure 3 shows how the net fiscal injection has been increasing over time.

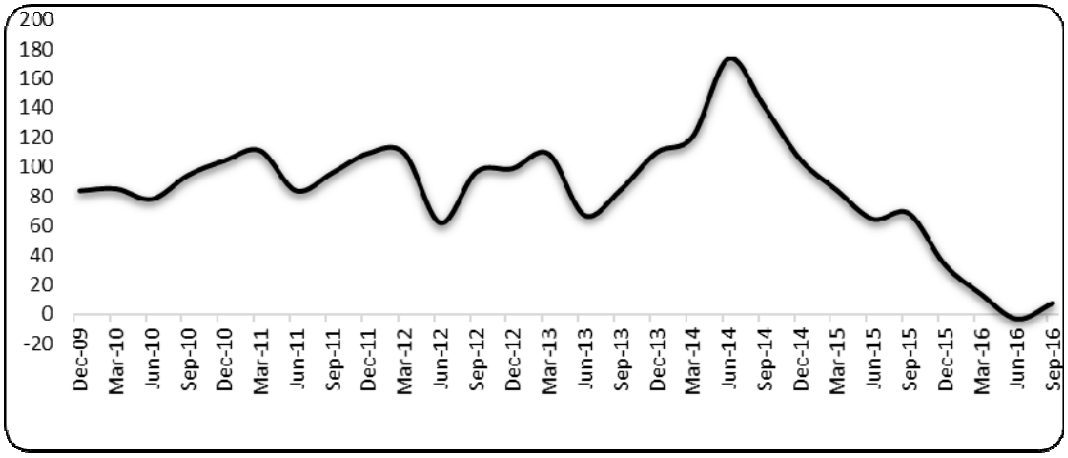
Figure 3: Net fiscal injections (in Frw billion)



Source: BNR (Statistics and Currency and Banking Operations Departments).

Increased domestic borrowings led to an increase in market interest rates and the use of reserves to mitigate growing pressures in the foreign exchange market contributed to a reduction of the reserve cover to 3.4 months of potential imports by end 2012. In addition, the slowdown in the global economy with a fall in commodity prices continued to exacerbate the trade deficit resulting in a progressive decline in forex inflows. This in turn intensified pressures on the domestic foreign exchange market. Further, commercial banks' net foreign assets fell by 92 per cent between December 2012 and September 2016 and banks were forced to hoard excess liquid assets large enough for safety measures against foreign exchange risks (Figure 4).

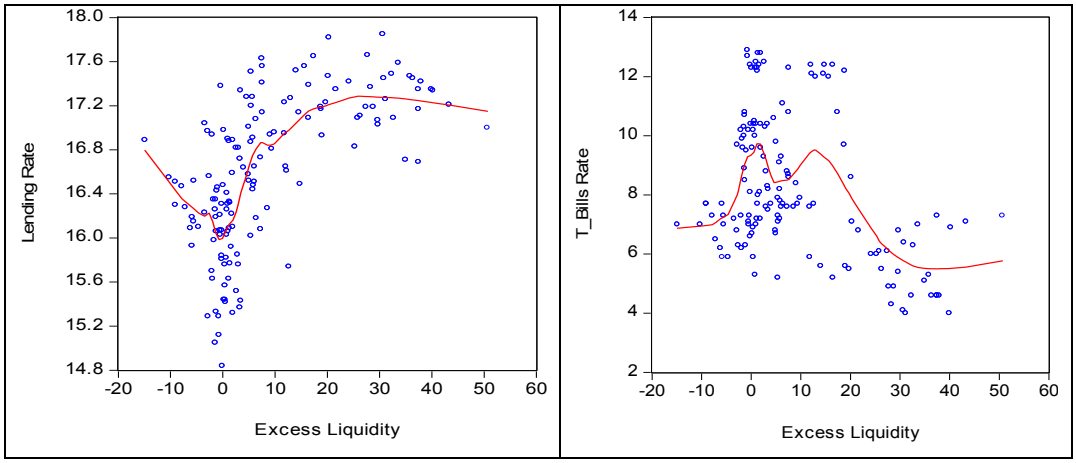
Figure 4: Trends in Commercial banks' net foreign assets (in Frw billion)



Source: BNR (Statistics Department).

In addition to these drivers of banking liquidity in Rwanda, weak completion in the banking sector also contributed to the build-up of excess liquidity. Using locally weighted polynomial regressions (LOESS) of degree one on monthly data ranging from 2004 to 2016, the liquidity preference against the lending and T-bill rates became flat at approximately 17.2 per cent for lending rate and 5.6 per cent for T-bills (Figure 5).

Figure 5: Excess reserves and the lending /T-bills rates LOESS fit (degree = 1 and span = 0.3)



Source: Authors' estimation using BNR data.

Figure 5 shows that excess reserves and lending rate as well as T-bills in Rwanda became substitutes at a high rate of interest, which is an indication of lack of competition in the banking sector. In competitive and pure concurrence loan markets, excess liquidity and loans are substitutes at a zero loan rate.

In the T-bills market, the substitute is at around 5.6 per cent, the minimum rate which banks demand before they bid for T-bills. This indicates the absence of a liquidity trap situation in which securities fall to zero and as a result money and government securities become perfect substitutes.

4. METHODOLOGY

We identified the determinants of precautionary excess liquidity in the banking sector in Rwanda before estimating its optimal level above which the banks' excess reserves become excessive.

4.1 Determinants of precautionary demand for excess liquidity

Following Agénor et al. (2004) we estimated demand for precautionary excess reserves by regressing excess liquidity on its hypothesized determinants. The conceptual framework is as follows: A bank has to decide the level of non-interest bearing reserve assets R and non-reserve assets which take the form of illiquid loans, L that are consistent for sustaining its profitability for a given level of deposits, D. The bank balance sheet is therefore given by:

(1) $R + L = D$

where, reserves, R, are prerequisite as the bank is exposed to liquidity risks and deposit flows, u, occur randomly.[1]

When net cash outflows surpass its reserves, a bank is exposed to illiquidity costs which are proportional to the reserve deficiency *max (0,u-R)*. In such circumstances, the bank is obliged to borrow the missing reserves at a penalty rate q. In this case, the bank's profit is given by:

(2) $$\Pi = r_L L - r_D D - q\max(0, u - R)$$

where, rL is the interest rate on loans and rD is the deposit rate.

Therefore, the bank's expected profit is:

(2A) $$E(\Pi) = r_L L - r_D D - q\int_R^{U_H} (u - R)\phi(u)du$$

Using Equation 1 to eliminate *L*, Equation 2A becomes:

(3) $$E(\Pi) = (r_L - r_D)D - r_L R - q\int_R^{U_H} (u - R)\phi(u)du$$

So, the optimal level of reserves is determined by maximizing the expected profits $E(\Pi)$ and the necessary condition is given by:

(4) $$\frac{\partial E(\Pi)}{\partial R} = 0 \Leftrightarrow -r_L + q[1 - \Phi(R)] = 0$$

(5) $$R^* = \Phi^{-1}\left(\frac{q - r_L}{q}\right)$$

This equation shows that the marginal opportunity cost, r_L, of holding an extra unit of reserves is associated with a marginal reduction in liquidity costs. Hence, the optimal reserves are negatively related to the lending rate r_L but positively related to the penalty rate q.

By considering that the demand for loans L is negatively related to the lending rate r_L and positively related to the expected output Y^e while the supply of deposits *D* by the public is positively related to the deposit rate r_D as well as to the expected output Y^e, Equation 2 can be rewritten as:

(6) $$\Pi = [r_L f(r_L) - r_D g(r_D)]Y^e + r_L R - q\max(0, u - R)$$

where, $L = f(r_L)Y^e$ and $D = g(r_D)Y^e$

To meet an unexpected demand for cash, a bank has two possible ways: borrow at a penalty rate, *q*, or use its excess reserves. So, the expected reserve deficiency may be written as $E\max[0, C - ((1-\theta)D - L)]$ and this allows us to define the bank's expected profits as:

(7) $$\Pi = [r_L f(r_L) - r_D g(r_D)]Y^e + r_L R - qE\max(0, ((1-\theta)D - L)]$$

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[1] *U* is a random variable which captures the net withdrawal of liquidity and its probability $Pu \in [u_L, u_H] = \int_{U_L}^{U_H} u\phi(u)du$.

Among the developments which express commercial banks' behavior, Agénor et al. (2004), provides three essential propositions:

Firstly, a penalty rate has a positive relationship with deposits, lending rates and excess reserves held by commercial banks. This implies that for a high enough level of the penalty rate, excess reserves exceed expected withdrawals $(Z - u > 0)$.

Secondly, the effect of volatility of output and liquidity shocks is ambiguous on the deposit rate, lending rate and excess reserves. But if the initial level of the penalty rate is high enough, a positive change in volatility positively impacts all the three variables.

Lastly, an increase in the reserve requirement rate has a positive effect on the lending rate and a negative impact on excess reserves. According to Agénor et al. (2004) combining the three assumptions the following demand function for precautionary excess reserves is derived:

(8) $$\ln\left(\frac{EL}{D}\right) = a_1(L)\ln\left(\frac{EL}{D}\right) + a_2(L)\ln\left(\frac{RR}{D}\right) + a_3(L)CV_{C/D} + a_4(L)CV_{Y/YT} + a_5(L)\ln\left(\frac{Y}{Y_T}\right) + a_6(L)r + a_7(L)EXPO + v_t$$

where, v_t denotes the error term and L is the lag operator. The dependent variable is the ratio of the logarithm of excess liquidity held by banks, *EL* to total deposits, *D*. The explanatory variables are current and lagged values of the logarithm of the dependent variable, logarithm of the ratio of required reserve assets, *RR*, to total bank deposits, *D*, coefficient of variation of the cash-to-deposit ratio, *C/D* and the deviation of output from trend, *Y/YT*; discount rate, r, which corresponds to the penalty rate; and exchange rate exposure. In particular, the dynamics of adjustment of *EL/D* demand is captured by the lagged values of *ln(EL/D)* in the regression:

- *Ln(RR/D)* captures the impact of the reserve requirement set by the central bank.
- $CV_{C/D}$ and CV_{Y/Y_T} account for the impact of volatility and liquidity risk.

- The penalty rate, *r*, is proxied by two interest rates: the discount rate and the money market rate. The first accounts for the cost of the last resort facility for banks while the second captures the cost of liquidity in the market.
- *Ln(Y/YT*) is used as a proxy for changes in banks' demand for cash. This implies that any cyclical positive shock will expect banks to anticipate high demand for currency by the public. This will therefore lead to an accumulation of their holdings of excess reserves. The lags account for the possibility of a gradual impact of funding costs and cyclical movements in output on the demand for excess reserves.
- *EXPO* is used to capture the fact that banks that are exposed to currency depreciation may be tempted to hold more cash than required in anticipation of unexpected withdrawals to respond to the increase in the domestic-currency value of debt service payments. To capture this effect, EXPO is defined as the difference between foreign-currency liabilities and assets over the total bank deposits times the rate of nominal depreciation.

4.2. Determining the banks' optimal level of liquidity

To estimate the optimal level of precautionary excess liquidity, we adopted the approach that Tinang-Nzesseu (2012) developed and applied to the CEMAC region to estimate the banks' optimal level of excess reserves desired by minimizing the cost function of each commercial bank as well as of the entire banking system.

Considering a financial system mainly dominated by commercial banks and under the control of the central bank, a commercial bank faces a net withdrawal of liquidity *u* from its customers which is a random variable with density function *f* and it holds a liquidity reserve stock (*R)* and security stock in the form of bonds (*S)*.

By choosing an approach for cost minimization, Tinang- Nzesseu (2012) pointed out four scenarios that arise as a result of a change in net withdrawals of liquidity *u* during a given period:

- First, the net withdrawal of liquidity is negative, which is a net deposit of cash by customers. This deposit is then distributed by the bank between new loans, a fraction β is placed at the central bank in the form of bonds and another fraction α is kept as excess reserves, all with an opportunity cost $(\alpha r_c + \beta(r_c - \beta(r_c - r_s)u)$ which will be added to the initial opportunity cost $r_c R + (r_c - r_s)S$.
- Second, the net withdrawal of liquidity is positive but less than the amount of reserves held by a bank. In this case, a bank's reserves are used to meet customer demand, which reduces the opportunity cost incurred by the bank when holding such reserves $r_c(R-u)$. The opportunity cost of holding securities remains the same $(r_c - r_s)S$.
- Third, the amount of net withdrawals is positive, higher than the bank reserves but less than the sum of reserves and bank securities. The bank then sells its securities to meet customers' liquidity demands by undergoing an adjustment cost *m* which should be less than or equal to the cost of refinancing on the interbank market, otherwise it is better for the bank to use the interbank market. The total cost of this operation is *m(u-R)*.
- In the last case, net withdrawals are greater than a bank's sum of reserves and securities. The bank then uses all its reserves, sells all its shares and uses the central bank's facilities to meet customers' liquidity demands. The opportunity cost of holding reserves is then zero, but the adjustment costs associated with the sale of securities and loans with penalty from the central bank are added: $mS + r_p(u - R - S)$.

Thus, the total expected cost (*TC*) of a bank which accounts for opportunity and adjustment costs can be expressed as:

$$E(TC) = \int_{-\infty}^{0} [r_c R + (r_c - r_s)S - (\alpha r_c + \beta(r_c - \beta(r_c - r_s)u]\, f(u)du + \int_{0}^{R} [r_c(R-u) + (r_c - r_s)S]\, f(u)du + \int_{R}^{R+S} m(u-R)\, f(u)du \quad (9)$$

$$+\int_{R+S}^{+\infty}[mS + r_p(u - R - S)]f(u)du$$

The first order condition where the opportunity cost equals the adjustment cost is given by:

$$(10) \qquad r_c P(u \le R) + (r_c - r_s)sf(R) = mP(R < u \le R + S) + r_p P(u > R + S)$$

Thus, the optimal level of reserves that a bank needs to hold in order to minimize the cost holding liquidity is that value of reserves which balance the opportunity cost of holding reserves to the adjustment cost incurred by the bank's demand for liquidity to cover customers' demand for cash.

To determine the optimal level of reserves, the estimation importantly adopts the probability function of the random variable of net withdrawal of liquidity by users, $(f(u))$. As mentioned by Tinang- Nzesseu (2012), to estimate the density function we also opted for a non-parametric approach to estimate an empirical density function as:

$$(11) \qquad \hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

where, h is the smoothing parameter or bandwidth and K is the Kernel estimator which gives the sum of individual bumps placed at the observations.

Using this approach we can derive the optimal level of excess reserves of the entire banking system by adding up all the individual commercial banks' optimal levels of excess reserves. Consequently, the amount of reserves held involuntarily by commercial banks can also be obtained by dividing the total reserves of each bank into three categories: the reserves required by regulation, precautionary excess reserves and involuntary excess reserves imposed through external shocks such as large capital inflows, government borrowings from the central bank and the undeveloped financial system.

5. EMPIRICAL RESULTS

5.1. Data and unit root test

We used monthly data from January 2004 to September 2016. Using the KPSS test, we accepted the null hypothesis of stationarity for all variables.

5.2. Estimating the demand function for precautionary excess liquidity

To estimate the demand for excess reserves we used the FMOLS approach and estimated the sum of coefficients by using the dynamic least squares (DOLS) method with lag one.

Tables 3and 4 summarize the estimations of excess liquidity with results of the sum of coefficients and their probabilities using two measures of penalty rates: discount rates and interbank rates. In the two regressions, the estimated results are not different.

Table 3: Determinants of excess liquidity

		Estimation using	
		Discount rate	**Interbank rate**
LNELD(-1)	Coefficient	0.402059	0.488082
	Probability	0.0197	0.0004
LNRRD	Coefficient	-0.967941	-0.539797
	Probability	0.0490	0.0765
LNCD	Coefficient	-0.317147	-0.116556
	Probability	0.3120	0.5818
LNYC	Coefficient	-1.467120	-1.632213
	Probability	0.0054	0.0038
YGAP	Coefficient	0.018048	0.020210
	Probability	0.0349	0.0049
Penalty: DISC_RATE/Interbank rates	Coefficient	0.099925	0.019843
	Probability	0.3107	0.3777
EXPO	Coefficient	2.772586	0.781119
	Probability	0.6979	0.9174
C	Coefficient	-8.368315	-5.693429
	Probability	0.0206	0.0005

Source: Authors' computations, using data from BNR (Monetary Policy Directorate).

As expected, the reserve requirement (LNRRD) had a significant and negative impact on excess liquidity while the effect of lagged excess reserves (*lnELD(-1)*) and the volatility of output gap (*YGAP*) had a significant and positive effect.

The effect of volatility of *lnYC* as proxy of liquidity risk is significant and incorrectly signed. As pointed out by Agénor (2004), an increase in volatility of output and liquidity shocks has ambiguous effects on excess reserves. However, if the initial level of the penalty rate is sufficiently high, an increase in volatility has a positive effect on excess reserves.

Variation of the cash-to-deposit ratio *(LnCD*) and *EXPO* have expected signs but are not statistically significant. In an environment of persistent excess liquidity, the impact of liquidity risks on reserves is not very important and this can explain why the effect of these variables is not significant statistically. However, using the sum of coefficients and estimating an autoregression equation we found that coefficients of lagged variations of the cash-to-deposit ratio *(LnCD(-1))*, the lagged discount rate *(DISC_RATE(-1))* and the exchange rate exposure (*Expo*) were statistically significant and positively related to excess liquidity.

Table 4: Determinants of excess liquidity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNELD(-1)	0.433005	0.058887	7.353104	0.0000
LNRRD	-0.605881	0.210048	-2.884487	0.0046
LNRRD(-1)	-0.478544	0.208308	-2.297292	0.0231
LNCD	-3.409041	0.639835	-5.328004	0.0000
LNCD(-1)	2.876400	0.631820	4.552564	0.0000
LNCY	-0.746923	0.572782	-1.304027	0.1944
LNCY(-1)	-0.397785	0.558858	-0.711782	0.4778
YGAP	-0.011898	0.006037	-1.970936	0.0507
YGAP(-1)	0.010634	0.006068	1.752454	0.0819
DISC_RATE	-0.105502	0.085448	-1.234703	0.2191
DISC_RATE(-1)	0.279258	0.083369	3.349669	0.0010

EXPO	47.87552	18.36249	2.607246	0.0101
EXPO(-1)	-47.71602	17.23882	-2.767940	0.0064
C	-9.432783	1.407102	-6.703695	0.0000

Source: Authors' computations using data from BNR (Monetary Policy Directorate).

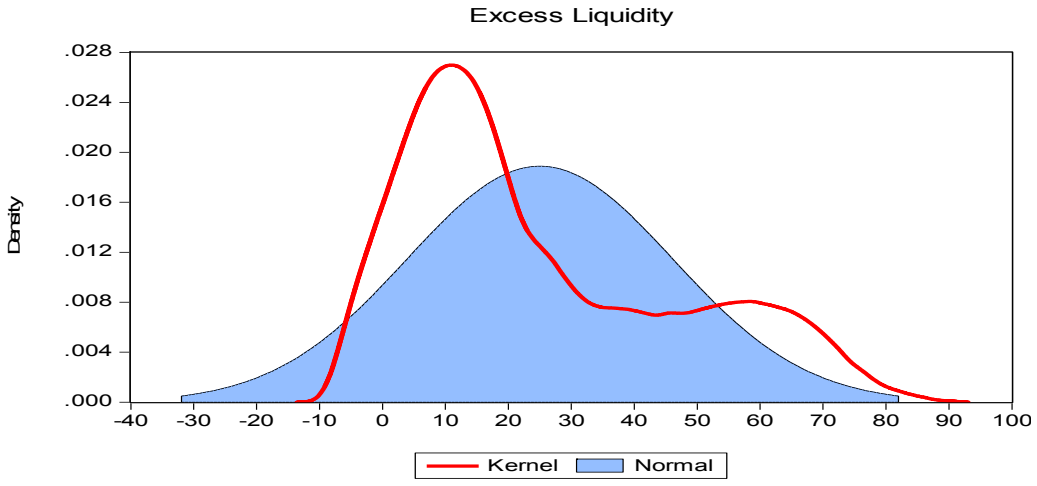
In brief, the results obtained from the two regressions suggest that the reserve requirement (*LnRR*), change in demand for cash proxied by the output gap (*YGAP*) and the lagged value of excess liquidity (*lnELD(-1)*) are important determinants of precautionary excess liquidity. The effect of volatility as proxy of liquidity risk (*LnYC*) is ambiguous with an incorrect sign. While using the summation of coefficients, the lagged values of the cash-to-deposit ratio (lnCD (-1)), discount rate (DISC_RATE (-1)) and foreign exchange exposure (EXPO) are also positive and significantly related to excess liquidity.

5.3. Estimating the optimal level of precautionary excess liquidity

As pointed out by Saxegaard (2006) and Tinang-Nzesseu (2012) all the liquidity held by commercial banks beyond the reserve requirements cannot be considered as excessive and detrimental to the effectiveness of monetary policy especially if it is for transaction and precautionary purposes rather than for speculative or involuntary motives. So, for the effectiveness of monetary policy, monetary authorities need to measure the optimal level necessary for transactional and precautionary motives.

The key element for determining the optimal level of reserves as pointed out by Tinang- Nzesseu (2012) is the probability function of the random variable (*f(u)*) which captures the net withdrawal of liquidity. We implemented the proposed model using the estimated precautionary excess liquidity. To avoid the optimal level obtained by largely depending on the sample we simulated bootstrap samples to get a good approximation of the distribution of the test statistics and accurate inferences and confidence intervals for values computed. See Figure 6.

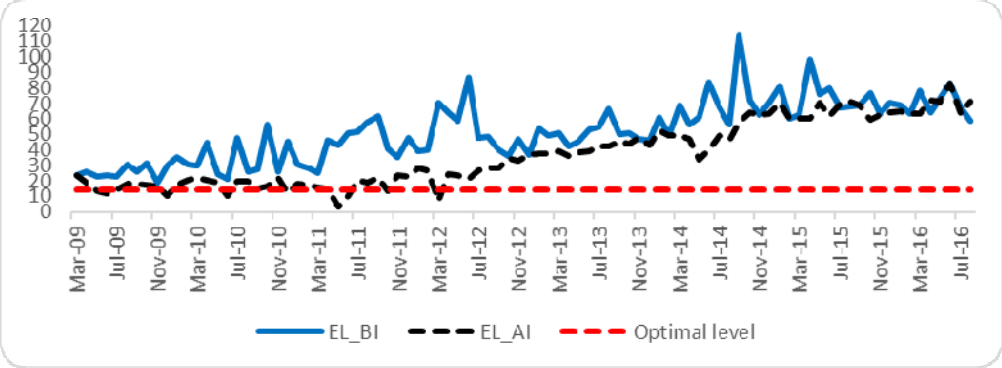
Figure 6: Kernel and normal distributions



Source: Authors' computations using data from BNR (Monetary Policy Directorate).

Taking into account the first and second conditions of the minimization of the function, the monthly optimal level of excess liquidity in the Rwandan banking system is estimated at around Frw 34 billion but not exceeding Frw 61 billion. This optimal level of excess liquidity includes cash in vault which on average represents around 58 per cent of the total excess liquidity during the last five years. Therefore, the optimal required excess reserves by commercial banks at BNR which balance the opportunity costs of holding reserves to the adjustment cost incurred by the banks' demand for liquidity to cover customers' demand for cash should lie between Frw 14.3 billion and Frw 25.6 billion. As indicated in Figure 7 excess liquidity was significantly above the estimated optimal level. Persistent excess liquidity contributed to reducing transactions in the interbank market and also limited the BNR interest rate (KRR) to an opportunity cost for banks to hold excess liquidity rather than playing the role of cost of funds for commercial banks. For the central bank to influence the liquidity conditions in the economy, banks must borrow funds from it.

Figure 7: Net fiscal injections (in Frw billion)



Source: Authors' computations using data from BNR (Monetary Policy Directorate).

This situation was amplified by limited demand for government securities as indicated by high levels of subscription, averaging 187.3 per cent of the demand for T-bills between 2010 and 2016. This is an indication that banks in Rwanda need more opportunities to invest their short-term liquidity (Table 5).

Table 5: Levels of subscription in T-bills

	Subscription level in T-Bills
2010	313.4%
2011	275.6%
2013	175.5%
2014	167.1%
2017	165.3%
2012	144.8%
2015	138.1%
2016	118.3%

Source: BNR (Financial Market Department).

6. CONCLUSION AND POLICY IMPLICATIONS

Excess liquidity has been an important feature of the banking system in most developing economies. We examined the potential determinants of precautionary excess liquidity in the Rwandan banking system during 2004-16 and its optimal level above which the excess liquidity becomes a constraint to monetary policy transmission. We used two separate econometric models. First, we used the FMOLS autoregression approach to estimate the determinants of precautionary excess reserves. However for ease in interpreting coefficients, the sum of coefficients was also estimated using the dynamic least squares (DOLS) method. For the optimal excess liquidity level, we used the Kernel density estimation to estimate the probability density of the estimated precautionary excess liquidity. To avoid sample dependence on the optimal level obtained we also used the bootstrap method to obtain the confidence interval of the computed values.

Our results suggest that the reserve requirements, change in demand for cash proxied by the output gap and the lagged value of excess liquidity are important determinants of precautionary excess liquidity. While using the summation of coefficients, the lagged values of the cash-to-deposit ratio, discount rate and foreign exchange exposure were also found to be positively related to excess liquidity. The effects of volatility as a proxy of liquidity risk were ambiguous. This is consistent with the proposition of persistent excess liquidity as stipulated by Agénor (2004), unless the initial level of the penalty rate is sufficiently high.

Secondly, taking into account the first and second conditions of liquidity minimization, our results show that the monthly optimal level of excess liquidity in Rwanda was around Frw 34 billion. This optimal level of excess liquidity includes cash in vault which on average represented around 58 per cent of the total excess liquidity during the last five years. Therefore, on average the excess reserves should be around Frw 14.3 billion which is far below the observed excess liquidity held by banks in Rwanda in the last eight years. This has important policy implications, particularly during this period of transition from a monetary aggregate to a more price based monetary policy. In this new monetary framework, BNR's objective should be influencing liquidity conditions in the economy through impacting market rates. This requires proper liquidity management for banks to borrow funds from BNR or from the interbank market.

The newly created Financial Market Operations Committee (FMOC) which meets every day to decide on BNR's interventions in the money market has been targeting excess reserves close to (but still above) the optimal level estimated by us. However, there is a need for improving the use of existing monetary policy instruments to keep minimum excess liquidity in the banking sector with the objective of supporting the development of the interbank market. In addition, the government treasury and BNR need to increase demand for T-bills and BNR bills to absorb unnecessary excess liquidity in the banking sector. High levels of subscriptions in investments in T-bills (averaging 187.3 per cent between 2010 and 2016) is an indication that banks in Rwanda need more opportunities to invest their short-term liquidity. Developing the government securities market will contribute to increasing the interest rate pass-through in Rwanda which is a key component in the monetary transmission mechanism.

REFERENCES

Agénor, P., J. Aizenman, and A. Hoffmaister (2004). The Credit Crunch in East Asia: What Can Bank Excess Liquid Assets Tell Us? *Journal of International Money and Finance*, 23: 27-49.

Agénor, P.R. and K.El. Aynaoui (2010). Excess Liquidity, Bank Pricing Rules, and Monetary Policy. *Journal of Banking & Finance*, 34: 923–933.

Aikaeli, J. (2006). Determinants of Excess Liquidity in Tanzanian Commercial Banks, *SSRN Electronic Journal*.

Allen, D.S. (1998). How closely do banks manage vault cash? *Federal Reserve Bank of St. Louis Review:* 43–54.

Anderson-Reid, K. (2011). *Excess reserves in Jamaican Commercial Banks: The implications for Monetary Policy*. Bank of Jamaica.

Arestis, P. and P. Demetriades (1999). Financial liberalization: the experience of developing countries. *Eastern Economic Journal*, 25(4): 441-457.

Caprio, G. and P. Honohan (1993). Excess liquidity and monetary overhangs. *World Development,* 21(4): 523–533.

Fielding, D. and A. Shorthand (2002). *Political Violence and Excess Liquidity in Egypt*. University of Leicester, Discussion Papers in Economics. 02/5, 1-15.

Fielding, D. and A. Shorthand (2005). Political violence and excess liquidity in Egypt. *Journal of Development Studies*, 41(4): 542-557.

Freedman, P.L. and R.W. Click (2006). Banks that don't lend? Unlocking credit to spur growth in developing countries. *Development Policy Review,* 24(3): 279–302.

Gichondo, P.M. and X. Nizeyimana (2010). Banking liquidity and monetary policy effectiveness: the case of Rwanda, *BNR Economic Review*, 4.

Gouteron, S. and D. Szpiro (2005). Excès de liquidité monétaire et prix des actifs, Banque de France, Notes d'études et de recherché.

Khemraj, T. (2006). Excess Liquidity, Oligopoly Banking and Monetary Policy in a Small Open Economy, PhD Dissertation. New York: New School for Social Research.

Mishkin, F.S. (2001). *The Economics of Money, Banking and Financial Markets* (6th ed.). Addison Wesley Publishing Company.

Moumni, N. and B. Nahhal (2014). Impact of Liquidity Level on the Monetary Policy Transmission Effectiveness of the Moroccan Central Bank (Bank Al Maghrib). *International Journal of Economics and Financial Issues*, 4(4): 801-818.

Nissanke, M. and E. Aryeetey (1998). *Financial Integration and Development: Liberalization and Reforms in Sub-Saharan Africa*. London: Routledge.

Nketcha-Nana, P.V. and L. Samson (2014). Why are banks in Africa hoarding reserves? An empirical investigation of the precautionary motive. *Review of Development Finance* 4(1), 29-37.

Saxegaard, M. (2006). Excess liquidity and effectiveness of monetary policy: evidence from Sub-Saharan Africa. *IMF Working Paper No. 115*.

Tinang-Nzesseu, J. (2012). Optimal Bank's Liquidity Supply by the Central Bank: A Microeconomic Approach. Unpublished.