OPTIMAL BANK'S LIQUIDITY SUPPLY BY THE CENTRAL BANK: A MICROECONOMIC APPROACH

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ABSTRACT:

Many observers focus on the Central Bank balance sheet in order to point out the excess of liquidity in the banking system as a failure to finance the economy, while banks may also decide to voluntarily hold liquidity above the level required in order to maximize their profit in an uncertain environment. In this paper, we tried to address excess reserves in the CEMAC banking system by looking from the point of view of commercial banks. By minimising the cost function of each commercial bank, we derived the optimal level of excess liquidity desired by it and consequently for the entire banking system. The result we obtained does not support the existence of excess liquidity in the banking system; furthermore, it approved the country approach implemented by the Central Bank concerning the required reserve coefficient. It is also helpful for the central bank in improving its liquidity supply to the banking system by anticipating the demands of liquidity by commercial banks during open market operations.

Keywords: Excess reserves, optimization, kernel density

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1. Introduction

The banking sector is the main source of external financing for firms in developing countries, making the bank lending channel the predominant mean of transmission of the monetary policy in these countries (Khemraj, 2007; Juks, 2002). According to Bernanke and Blinder (1988), Kashyap and Stein (1994), four conditions are required to make the bank lending channel effective as a mean of transmission of the monetary policy: a) bank loans should be the main source of funding for the majority of businesses and other economic agents; b) bank loans and the issuance of government securities should not be perfect substitutes in the company liabilities c) the Central Bank must be able to influence the supply of credit by changing the amount of available liquidity in commercial banks; d) There must be an imperfect adjustment of prices avoiding the neutrality of monetary policy. The third condition seems to be challenged by the presence of excess liquidity in commercial banks[2].

However, all the liquidity held by commercial banks beyond the minimum level of reserves required by the Central Bank can not be considered as excessive and detrimental to the effectiveness of monetary policy. Indeed, commercial banks hold liquidity for various reasons which can be summarized by motives of holding the cash defined by Keynes: the transaction motives, precautionary reasons and speculative purposes (Ganley, 2004). If the first two reasons are justified for the fulfilment of the intermediation role of commercial banks and the need to satisfy customers, the last reason may cause malfunction[3]. Beyond the level of liquidity deemed necessary and that could be seen as the reserve requirement at large, the holding of excess liquidity by commercial banks leads to a reduction in the effectiveness of monetary policy[4], notably through the rigidity of the interest rate to rise (Agenor and El Anyoui, 2009) or the ineffectiveness of expansionary monetary policy (Agenor, Aizenman and Hoffmaister, 2004).

Most central banks have now opted for an indirect intervention based on incentives through monetary policy instruments such as interest rates or reserve requirements to allow the operation of market forces. In this context, the estimated level of excess liquidity or involuntarily detained by commercial banks must be guided by their needs to minimize adjustment costs that may result from the need to avoid a situation of illiquidity but also to minimize opportunity costs resulting from the holding of this lowly or not remunerated liquidity.

2. Model description

The main idea pushing banks to hold reserves is the minimization of certain costs related to the management of liquidity. Baltensperger and Milde (1976) have divided those costs into three categories[5]: The opportunity cost caused by holding reserves that could be invested in other assets and generate income; the cost of adjustment that might result from a demand[6] for liquidity that exceeds the amount of

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[2] In the presence of excess liquidity in banks, the transmission of the monetary policy through the interest rate channel becomes uncertain (Kierzenkowski, 2001)

3 This dysfunction is reflected by the fact that below a relatively high interest rates, commercial banks, which usually constitute an oligopoly in developing countries, no longer react to the impulses of central banks, become "price maker" and practice of high interest rates holding back investment and production (Khemraj, 2007).

4 Especially when it is implemented by the use of indirect instruments to influence the market rather than to compel.

[5] These three costs are not positively correlated; reducing one would increase the other. Hence the need for the bank to search for the optimal reserve to minimize overall costs.

6 Assuming that the needs of households, or more generally applicants are not perfectly correlated, the bank expects only a fraction of depositors demanding liquidity (Freixas and Rochet, 2008).

reserves held by the bank; the cost of information[7] that would result from seeking a better understanding of customer behaviour to predict the withdrawals and deposits.

We consider a financial system mainly dominated by commercial banks and under the control of the Central Bank. Commercial banks have two funding sources: first the customer deposits paid at a rate r_D, secondly the refinancing from the Central Bank that can be done in a regular track at the interest rate r_R or at a penalty rate r_P if requested at the initiative of the commercial bank. The Central Bank charges a fee on deposits received by banks through the reserve requirement at the rate q. The bank faces a net withdrawal of liquidity u from its customers which is a random variable with density function f. Early in the period, the bank holds a liquidity reserve stock R[8]and a security stock in the form of Central Bank bonds S.

We have chosen here to present an approach for cost minimization. Four scenarios then arise as a result of a change in net withdrawals of liquidity u during the 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 reserves, all with an opportunity cost $(\alpha r_C + \beta(r_C - r_S)$u to 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 the bank. In this case, the bank 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 up with liquidity demand of the customer; this by undergoing an adjustment cost that is m should be less than or equal to the cost of refinancing on the interbank market, otherwise it is better for the bank to go on the interbank market. The total cost of this operation is $m(u-R)$.
- In the last case, the net withdrawals are greater than the sum of reserves and securities of the bank. The bank then uses all its reserves, sells all its shares and uses the Central Bank facilities to meet the liquidity demand of customers. 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: $mS + r_P(u - R - S)$

The total expected cost (opportunity and adjustment costs) by the bank is then:

$$E(TC) = \int_{-\infty}^{0} [r_C R + (r_C - r_S)\mathrm{S} - (\alpha r_C + \beta(r_C - r_S)\,u]f(u)du + \int_{0}^{R} [r_C(R-u) + (r_C - r_S)S]f(u)du + \int_{R}^{R+S} m(u-R)f(u)du + \int_{R+S}^{+\infty} [mS + r_P(u-R-S)]f(u)du$$

First order condition:

7 Indeed, the costs of information processing, project evaluation and monitoring borrowers are high enough, make it difficult to manage liquidity and lead to an accumulation of reserves beyond the desired level (Agenor and El Anyoui , 2009).

8 Liquid reserves that we consider here are excess reserves held in excess of regulatory levels required by the monetary authority.

$$\leftrightarrow \underbrace{r_C P(u \leq R) + (r_C - r_S) S f(R)}_{opportunity\ cost} = \underbrace{mP(R < u \leq R + S) + r_P P(u > R + S)}_{ajustement\ cost} (\boldsymbol{Eq.\ 1})$$

Thus, the optimal level of reserves to be held by the bank to minimize the cost of holding liquidity is the value of reserves that equalize the opportunity cost of holding reserve to the adjustment cost incurred by the bank when it has just run out of reserves and must find some cash to meet the customers' demand.

The key element in determining the optimal level of reserves is the probability function of the random variable of net withdrawals of liquidity by the users ($f(u)$).

3. Data and computation

The database used for this study comes from COBAC and contains monthly information on commercial banks[9] in the CEMAC region (32 banks) from 31/01/2001 to 31/12/2005. Some Banks have missing data for the variable of net withdrawal of liquidity, but they have also been taken into account (08 banks). The parameters were derived from online data from the World Bank and BEAC, and are summarized in the table below:

Interest rates on loans	Interest rates on securities of banks at the Central Bank	Average amount of securities held by commercial banks at the central bank's	refinancing cost by selling securities	refinancing cost at the penalty rate
r_C	r_S	S (in million CFA)	m	r_p
18.50%	2.45%	23,062	5.25%	15%

The variable that captures the net withdrawal of liquidity is the cash surplus of commercial banks. The observation of this variable's histograms for different banks and statistical tests, made it difficult to rank their probability densities in a predefined parametric probability distribution such as the normal distribution ($N(m, \sigma^2)$. We therefore opted for a non-parametric approach to estimate an empirical density function for each bank on the basis of existing data. The estimated density function is given by the function (Silverman, 1986):

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

Where K commonly called Kernel density is a probability density function with $\int_{-\infty}^{+\infty} \mathrm{K(x)dx} = 1$

The calculation of the optimal level of excess reserves being made on the basis of a data sample, is highly dependent this sample. To obtain a confidence interval, we used the bootstrap method.

4. Results and comments

At first glance, the results allow classifying the banks of the CEMAC zone into two categories depending on the level of excess reserves held to minimize their costs: those who need a certain amount of excess liquidity (21 banks), and those for which holding excessive liquidity is detrimental and they don't need it (11 banks). Moreover, for banks in need of reserves beyond the level required by regulation, the optimal values and their standard deviations are provided. The Central Bank may well know

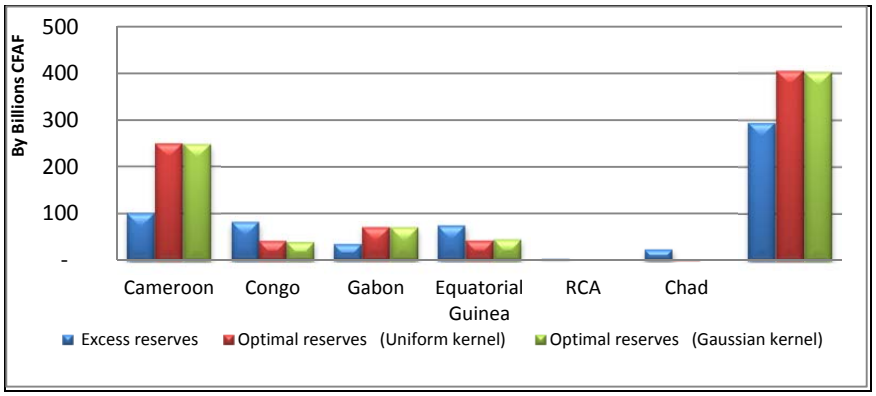
9 The database is anonymous and banks are represented by only codes indicating their country of residence.

who are the potential applicants to liquidity offers in its open market operations and anticipate the quantities requested.

Secondly, we can also derive from the optimal level of excess reserves, the amount of reserves held involuntary by commercial banks. Thus, the total reserves of each bank can be divided into three subgroups of statistics: the reserve required by regulations, voluntary excess reserves for purposes of minimizing the costs of liquidity management, and finally the excess reserves held involuntarily by banks that could be justified by external shocks such as capital inflows and rising oil prices for a country engaged in that production.

Finally, summing all the optimal reserve levels obtained for each commercial bank, the optimal level of excess reserves of the entire banking system would be around 403,467.461 million FCFA (with a standard deviation 10688.7068 Million FCFA). But the reserves of commercial banks in 2005 were 903,292 million CFA francs. By applying the required reserve ratio, the required reserves would be about 247,502 million CFA francs in 2005. The banks' free reserves including investments in central bank securities during open market operations would be about 655,790 million CFA francs. Subtracting investments in central bank securities from this amount, the excess reserves of commercial banks amounted then to 295,105 Million FCFA. It becomes apparent that this amount of excess reserves in the banking system is below the one that represents the optimum level (403,467.461million FCFA). Thus, from the point of view of commercial banks, the banking system could not be considered as over-liquid in 2005.

Graph 1: Excess reserves (observed) and optimal reserves (computed) by country



Moreover, by repeating the same exercise, this time by country, we find as shown in the graph above, that in some countries (CAR, Chad, Congo, Equatorial Guinea), banks hold more liquidity than they need. While in Cameroon and Gabon, the level of reserves held by banks would be insufficient.

Table 1: Situation of excess reserves (compare to the optimal level) and required reserve ratio by country

Country	required reserve ratio on demand deposit	Required reserve ratio on term deposit	Situation of excess liquidity
Cameroon	11.75%	9.25%	Deficit
Congo	14.00%	10.50%	Excess
Gabon	11.75%	9.25%	Deficit
Eq. Guinea	14.00%	10.50%	Excess
RCA	5.00%	3.00%	Excess
Chad	7.75%	5.25%	Excess

5. Conclusion

We proposed in this paper to take a look on the excess reserves held by commercial banks by putting ourselves on the same side of commercial banks. We have determined through the minimization of cost functions, the optimal level of excess reserves. The implementation of our model for determining the optimal level of reserves in surplus, led us to estimate the probability density of the net withdrawal of liquidity. We have done it using a non-parametric approach. The optimal level obtained depend heavily on sample of net withdrawals used; we then used the bootstrap method to obtain confidence intervals for the values computed.

The results obtained allow the Central Bank to distribute commercial banks into two categories according to their needs or not in excess liquidity, and then to anticipate the demands of banks' liquidity during open market operations. The Central Bank can use those results to improve its liquidity management by supplying more efficiently the liquidity to commercial banks. We have obtained a new criterion to describe the liquidity situation of the overall banking system as over-liquid or not, looking at it from the point of view of commercial banks which are the main actors. We have also derived new statistics which can be publish recurrently to follow the evolution of different compartment of reserves held by commercial banks, by country in the sub-region.

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