CAPITALIZATION AND EFFICIENCY OF CEMAC BANKS : AN INTERMEDIATION APPROACH

Abstract

This study assesses the effect of increased equity capital on the technical efficiency of CEMAC banks. With this end in view, we use panel data from seventeen banks extracted from Bankscope database (2017). The study period runs from 2014 to 2016 and the analysis is carried out in two steps. In the first step, the intermediation approach and the Data Envelopment Analysis are used respectively to choose the inputs and outputs (variables) and measure the technical efficiency of the banks. In the second step, the technical efficiency scores obtained in the first step are estimated using the Tobit model and the Maximum Likelihood estimator. The results obtained show that the fact that banks in the CEMAC sub-region increase their equity capital negatively and significantly affects their pure technical efficiency and their efficiency of scale. For this reason, our recommendations relate to the definition of prudential capital ratios, capable not only of ensuring financial security and stability but also of reducing at best the problems of information asymmetries between shareholders, managers and the creditors.

Key words: Banking capitalization, Technical efficiency, Scale efficiency.

Classification JEL: G21, G32, G38, E42, E43

1. Introduction

The intermediation theory recognizes, in one of its approaches, the bank as a firm that uses factors of production (deposits, investment and transaction securities) to produce a good that is crucial to any economy: credit (Hellwig, 2015; Eggoh et al., 2021). It is this approach that guides our choice of inputs and outputs in this article, in order to analyse the efficiency of banks in the CEMAC[1] zone in relation to the considerable increase in their capital observed in recent decades.

As a reminder, after the promotion of financial liberalization at the end of the 1980s and the success of the new information and communication technologies (NICT) that followed in the early 1990s, competition became intense between banks of the same system on the one hand, and those operating in different systems on the other hand. For this reason, we believe with Nodjitidjé (2009) that our banks today must operate efficiently in order to survive in this

[1] The Economic and Monetary Community of Central Africa which includes Cameroon, Chad, Congo, Gabon and the Central African Republic.

increasingly competitive environment; and that the banks in the CEMAC zone, the main pioneers of the financial system in this sub-region, are not exempted from this reality.

As stylized facts, various structural and organizational reforms have been made since the early 1990s in the CEMAC zone such as: financial liberalization, the creation of the regulatory and supervisory body (COBAC[2]), the reorganization of the financial system planned by BEAC to improve the efficiency and stability of banks, etc. Following the reform of regulatory capital standards, the CEMAC banking system recorded a considerable capital surplus of §224 billion between 2006 and 2010[3] (COBAC Report, 2010). In addition, it should be noted that in 2010, several banks had not even reached the minimum regulatory capital of 10 billion set by COBAC and had to comply by June 30th, 2014 at the latest. Thus, the paradox that emerges from this considerable increase in bank equity in the CEMAC zone is that the banks are being forced to increase their capital when, theoretically, they would prefer less equity because they consider it to be more costly than debt (Kusi et al., 2017).

Based on this observation, our research question is: What is the effect of increased capital on the efficiency of banks in the CEMAC? This issue is in our opinion, neglected or vaguely treated by existential studies focused on the CEMAC zone. In the existential literature, the beginnings of this problem date back to Modigliani and Miller (1958) who demonstrated that the sources of financing do not influence the value of a company in any way. However, the banking literature presents two groups of authors with opposing positions. The first group believes that capitalization is much more beneficial for banking efficiency (Holmstrom and Tirole, 1997; Kumbahakar and Lovell, 2000; Martinez-Miera and Suarez, 2012; Klimenko and Rochet, 2015; Tadesse, 2016; Banyen and Biekpe, 2020)., while the second group rejects this logic and points out its negative effects (Stiglitz and Weiss, 1981; Berger and Bonaccorsi, 2006; Adusei, 2016). To answer our question, we have structured our analysis in five parts. After this introduction (1), we have the literature review (2), the methodological approach (3), results and discussions (4) and finally the conclusion and recommendations (5).

2. Literature Review

In this section we review the theoretical and empirical aspects of the link between capital and banking efficiency. Before doing so, we first look at the literature on the measurement of firm efficiency.

2.1. Literature on the measurement of firm efficiency

In order to overcome the limitations[4] of classical performance indicators (profitability ratios), Koopmans (1951) and Farell (1957) innovated with other indicators, namely technical

[2] Banking Commission of Central Africa.
[3] Calculations made using statistics from the COBAC Report (2010).
[4] Among the limitations of classical indicators of firm performance are: the difficulty of comparing banks or making a decision when the number of ratios is high; the difficulty of interpreting partial productivity indicators that do not include other variables; the difficulty of taking into account economies of scale; the difficulty of detecting sources of efficiency; the difficulty of taking into account the firm's environmental context; and the difficulty of making long-term forecasts (Sherman and Gold, 1985).

efficiency and allocative efficiency, which can be measured using the parametric and non-parametric approaches.

2.1.1. The parametric approach

It is based on a parametric specification of the production function which can take the usual Translog or Cobb-Douglas form. Here, the functional form of the efficient frontier is imposed a priori. It is based on the specification of the empirical production frontier of the actual input and output data for each unit of observation. Thus, efficiency is measured using three methods: the stochastic frontier method, the thick frontier method and the free distribution method.

In the first method, producers use inputs to produce outputs efficiently. Inefficiencies arise from statistical errors, costs, resource allocation and profit (Kumbahakar and Lovell, 2000). According to these authors, the three efficiency models share the same compound error principle and differ in the production frontier whose initial function is: $= f(x.\beta).exp\{v - u\}$; with y being the input, x is the vector of outputs; β is the technical parameter and $(v - u)$ is the error term of v, the first error term which indicates the effects of statistical errors and follows the standard normal distribution; u the second error term greater than or equal to zero representing the effects of technical inefficiency.

The second method developed by Berger and Humphrey (1992) estimates the two "thick boundaries" after classifying the data according to average costs. It allows for an efficient comparison between firms provided that the variables follow a normal distribution. These conditions are difficult to meet by production functions (Wagenvoort and Schure, 1999).

The third method is characterised by the fact that it does not impose any particular distribution on inefficiency. In practice, marginal inefficiency is assumed to be constant over time and the appropriate data is panel data. The econometric model is: : $lnTC_{it} = lnC_t(Y_{it}, W_{it}) + lnu_i + lnv_{it}$, where: TC_{it} is the total cost of production unit i at time t; C, its cost function at time t; Y_{it} the output vector and W_{it} the input price vector; ln the natural logarithm and the remainder, the compound error term.

2.1.2. The non-parametric approach

Unlike the parametric approach, this one does not impose a functional form, nor an error term. The efficiency frontier is constructed from linear programming (primal, dual) for the inputs and outputs of the production units. Efficiency is measured by two methods: the Data Envelopment Method (DEA) and the Free Disposal Hull (FDH) method.

The data envelopment method measures the efficiency of the set of homogeneous production units (hospitals, banks, companies etc.). It is the most widely used in literature. Efficiency is measured using two models: the Charnes, Cooper and Rhodes model (1978) and the Banker et al model (1984). The former assumes that homogeneous production units use the same inputs and produce the same outputs in different quantities. This allows each unit to be compared with the best. The programme amounts to, $\boldsymbol{Min\,\theta_i}$ under the constraints of: $-y_{jk} + \sum_{j=1}^{n} \lambda_i y_{jk} \geq 0, k = 1, 2, \ldots, s$ and

$\theta_i x_{ij} - y_{jk} + \sum_{j=1}^{n} \lambda_i y_{jk} \geq 0,\ k = 1, 2, \dots, m\ ; \lambda_i \geq 0$ with λ the vector of constant terms; θ_j the scalar that represents the efficiency score for production unit j (Charnes et al., 1978).

The second model rejects the assumption of constant returns to scale of the previous model (which assumes that production units produce optimally) since it does not incorporate imperfections related to the environment of the production units. Thus, the authors have added a convexity constraint and the program consists in: $\boldsymbol{Min\ \theta_i}$ under the constraint of: $-y_{jk} + \sum_{j=1}^{n} \lambda_i y_{jk} \geq 0, k = 1, \dots, s\ ; \theta_i x_{ij} - y_{jk} + \sum_{j=1}^{n} \lambda_i y_{jk} \geq 0,\ k = 1, 2, \dots m\ ;\ \lambda_i \geq 0$ and $\sum_{\lambda_i}^{n} \lambda_i = 1$. It is this last constraint that transforms constant returns to scale into variable returns to scale and the efficiency scores are those of pure technical efficiency (Banker et al., 1984).

In the case of the Free Disposal Hull method, it simply assumes the free disposal of inputs and outputs without a specification of the functional form as in the case of DEA[5]. Initially, it was assumed to have variable returns to scale. Later, the authors developed models with non-increasing, non-decreasing and constant returns to scale. The possibility of boundaries are represented only by the peak vertices of the boundary obtained in the DEA method. As the points are located inside the peaks, the average efficiency obtained is higher than that of DEA (Daraio and Simar, 2007).

2.2. Theoretical review on the link between capital and banking efficiency

Based on the intermediation approach, where the bank is seen as a firm that collects deposits to produce loans, two theories oppose the nature of the link between capital and banking efficiency. These are the incentive theory, which demonstrates a positive link, and the agency cost theory, which highlights a negative link.

2.2.1. The incentive theory

The basic idea here is that capitalisation disciplines the bank's shareholder/manager couple by imposing a more rigorous and rational management of resources and a more rational distribution of products. This consequently allows for an improvement in the bank's efficiency, as inefficiencies arise from statistical errors, costs, resource allocation and profit (Holmstrom and Tirole, 1997; Kumbahakar and Lovell, 2000).

To illustrate the same point, Klimenko and Rochet (2015) point out that capital determines the shareholders' stake and the bank's survival. If the value of capital is high, shareholders will be risk averse and will encourage their managers to take fewer risks. This risk discipline is well characterised by the rigorous management of the liabilities and assets of the bank's balance sheet for the benefit of efficiency.

Passionate about this debate, Martinez-Miera and Suarez (2012) use a general equilibrium model in which they consider two groups of firms (systemic risk and non-systemic risk groups) financed by banks. Assuming that the bank that finances a systemically risky firm becomes a systemically risky bank itself, they find that capitalisation reduces systemic risk by

[5]In addition to the free disposal of inputs and outputs, DEA assumes a convex functional form.

reducing the risk of loans, thus allowing for an efficient distribution of these loans. In a similar vein, Nguyen (2015) developed a general equilibrium model that takes into account the "too big to fail" problem and the friction of the cost of capital. Thus, he finds that an increase in capital forces banks to reduce their leverage and thereby the risk of default. Once again, capital disciplines banks and this can be beneficial for their efficiency.

In contrast to these asset-based analyses, Hellwig (2015) instead demonstrates the positive link between equity and efficiency by relying on deposits as a necessary liability resource in loan production. Thus, this author puts forward the idea that high equity is essential to collecting risk-free liquid deposits at lower costs. This lowering of funding costs is arguably in favour of banking efficiency.

Incorporating Hellwig's (2015) idea and the ability of equity to absorb bank losses into their analysis, Klimenko and Rochet (2015) develop a dynamic general equilibrium model considering that banks fund themselves with deposits and equity to lend to SMEs excluded from the financial market. Thus, they find that the total capitalization of banks plays an important role in the dynamics of interest rates and bank lending. However, the continuous-time version of the model and the numerical analysis of these show that the inconvenience caused by an increase in capital in the short run will be recovered in the long run due to high stability.

2.2.2. The agency theory

In this approach, the idea is that an increase in equity capital increases the moral hazard between financial partners (creditors, managers, shareholders). Indeed, managers may misuse the bank's resources to the detriment of its efficiency. Such reasoning is based on the conflicts of interest between managers and shareholders on the one hand, and between managers and creditors on the other.

Thus, the first conflict of interest concerns shareholders and managers. When equity rises, free resources (which are not constrained by creditors) rise and managers who receive, for example, the smallest share of the bank's residual value (mismatch between effort and reward) may take advantage of moral hazards and devote their efforts and talents to self-interested activities rather than the bank's productive activities. These are the managers who use the banks' resources for their own benefit. This diversion of funds is counterproductive and inevitably undermines the efficiency of the bank.

Assuming the case of an increase in equity capital obliging shareholders to carry out permanent controls to minimise moral hazard, we can note, like Berger and Bonaccorsi (2006), an increase in financing costs. Indeed, the cost of permanent shareholder controls is added to those that can be observed in the absence of information asymmetries. We agree with these authors that this excess cost of capital is likely to compromise the bank's level of efficiency.

The second type of conflict is between managers and creditors. Indeed, banks that prefer debt financing benefit from limited liability and have an incentive to finance projects that are too risky once the debt is raised (Stiglitz and Weiss, 1981). In the presence of ex-ante asymmetric information on the level of bank risk, creditors can anticipate the risk-averse behaviour of banks by limiting lending or by demanding a much higher return on loans. This leads to higher agency costs for the bank that is soliciting the debt. This problem is known as "managerial risk seeking" (Jensen, 1986).

2.3 Empirical review of the link between capitalisation and bank efficiency

The divergences concerning the effects of capitalisation on bank efficiency are not only theoretical. There are also empirical divergences which we classify here according to the methodological approaches adopted by the authors.

2.3.1. Work based on parametric approaches

Berger and Bonaccorsi (2006) studied the link between capital requirements and the efficiency of American banks between 1990 and 1995. They measured bank efficiency by cost efficiency and profit efficiency. They also used a parametric free distribution approach. At the end of the study, they found that high equity capital negatively affects bank efficiency.

Analysing the relationship between capital and efficiency for a large sample of European banks, Altunbas et al. (2007) use a parametric approach and find that high capital positively affects bank efficiency. And that banks with high levels of capital are more efficient than those with low levels of capital.

Pessarossi and Weill (2015) equally analysed the relationship between capital and efficiency of 100 large Chinese commercial banks. They measured the efficiency of these banks by one of the variants that is the cost utility and used a parametric approach with the stochastic frontier method. At the end of the study, they find that high capital levels play positively with bank efficiency. In addition, they find that banks with high capital levels perform better than those with low capital levels.

Finally, Cyrille and Christophe (2022) evaluated the nature of the money supply in the CEMAC zone through a direct test of the endogeneity of money. Quarterly data from 1990 to 2017 were used and the results show that the money supply is endogenous in the CEMAC zone.

2.3.2. Works using non-parametric approaches

Jackson and Fethi (2000) found in their 1998 study a positive influence of capital on the efficiency of Turkish banks. They used the non-parametric DEA method in combination with Tobit regression.

Also, in their analysis of transition banks between 1995 and 1998, Grigorian and Manole (2002) use the non-parametric approach and a Tobit regression to detect the determinants of bank efficiency. In the end, their results indicate a positive effect of capitalisation on the efficiency of the banking system.

Working on Greek banks between 1982 and 1997, Rezistis (2008) attempts to detect the determinants of banking efficiency (pure technical efficiency and scale efficiency). Using the data envelopment method and the Tobit method, the author finds no significant relationship between capitalization and bank efficiency. In,

In assessing the efficiency of Malaysian banks during the 1997 Asian crisis period using the data envelopment method, and using the Tobit model over the 1995-1999 period, Sufian (2009) finds that the technical efficiency of Malaysian banks deteriorated rapidly one year after the crisis. Also, better capitalised foreign banks have higher technical efficiency than domestic banks.

Furthermore, in 2011, a sample of 206 banks from the Mediterranean basin countries allowed Femise to conduct its study on the convergence of banking regulations. Using the data envelopment method and the Tobit model, it finds that better capitalised banks improve their efficiency more.

Selecting a sample of 17 Libyan banks over the 2004-2010 period, Alrafadi et al. (2014) measure banking efficiency by technical efficiency and scale efficiency. They use the non-parametric approach and Tobit regression and find that high capitalization has a positive effect on banking efficiency.

Looking at banks in Ethiopia to identify the determinants of their efficiency over the 2011-2014 period, Tadesse (2016) uses the data envelopment method and Tobit model. He finds that capitalization positively affects the technical efficiency of banks.

Work by Eggoh et al. (2021) on the relationship between market power and cost efficiency for a sample of 63 West African Economic and Monetary Union (WAEMU) banks from seven countries over the period 2004-2016 shows that an increase in market power reduces banking efficiency in WAEMU countries, and thus suggests that competition in the banking sector improves cost efficiency.

In 2022 Van evaluated the dynamic causal relationships between bank risk, capital, and efficiency. Using a panel dataset of commercial banks in five ASEAN countries from 2005 to 2015. the vector autoregression analysis shows that better capitalized banks in these countries are more efficient and take less credit risk. However, high efficiency banks tend to maintain low levels of capital, while low efficiency banks have higher capital ratios.

2.3.3. Works focusing on other techniques

Fiordelisi et al. (2011) addresses the issue of the effects of capital on banking efficiency in a more risk-informed sense. Considering cost, profit and income efficiency, and using the Granger causality tests associated with dynamic panel generalized methods of moments, they find that high capital has a positive effect on bank efficiency.

Adusei (2016) took it upon himself to examine the determinants concerning the technical efficiency of rural and urban banks in Ghana. Given the multi-colinearity between size and capital quality, the author preferred to estimate two models to correct for the multi-colinearity problem. Using a binary logit model, he finds that capitalization plays negatively with the efficiency of both groups of banks.

Andrieș et al. (2018) studied the impact of corporate governance on bank efficiency through a sample of 139 commercial banks from 17 Central and Eastern European countries during the period 2005-2012. The results show that the implementation of strong corporate governance structures is associated with higher costs for banks and lower efficiency. But during the crisis, a rigorous governance mechanism significantly increases banks' costs and technical efficiency.

More recently, Banyen and Biekpe (2020) examine the convergence properties as well as the causality between competition and bank efficiency in five African regional economic communities over the period 2007-2014. Through the stochastic frontier analysis approach, they show that there is a relationship between a steady increase in competition and bank efficiency in Africa and the five subregional markets over time.

3. Methodology

We perform a two-step analysis. In the first step, we measure the technical efficiency of CEMAC banks. In the second step, we assess the effect of the increase in capital on the technical efficiency scores obtained in the first step.

3.1. Measuring the technical efficiency of CEMAC banks

We use a sample of seventeen banks in the CEMAC sub-region (see table 1 below). The absence of Central African and Chadian banks in this sample is justified by the non-publication of their data for the three years under consideration. The study period runs from 2014 to 2016. The data used are panel data from the Bankscope database (2017).

Table 1: Names of banks in the sample by country

Pays	**Name of Bank**	**Number of banks by country**
Cameroun	AFRILAND FIRST BANK, BICEC, BGFI, SCB COMMERCIAL BANK, ECOBANK, SGBC	7 banks
Congo	BANK OF AFRICA, ECOBANK, SB, SFB, FBN CITI BANK, PBC	7 banks
Gabon	BGFI, ECOBANK	2 banks
Guinea	BCRG	1 bank

Source: Authors from Bankscope database (2017).

To measure efficiency, we use the data envelopment technique (DEA) which is a variant of the non-parametric approach. It is a method that allows to determine the efficient production units, to construct the production frontier from them and to measure for each production unit the distance to the frontier. The problem to be solved is: Given a sample of (n) production units with (s) inputs (x) and (m) outputs (y), the efficiency of a production unit (ho) is obtained by solving the following linear program (Charnes et al., 1978): $\underset{u_r, v_i}{Max}\, \boldsymbol{h_0} = \frac{\sum_{r=1}^{s} u_r y_{r_0}}{\sum_{i=1}^{m} v_i x_0}$

under the constraints of $\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, j = 1 \dots n \,; u_r \,, v_i \geq 0 \,; \, r = 1 \dots s \,; i = 1 \dots m$. Since this program is not linear, Charnes and Cooper (1962,) showed how it can be transformed into linear programming. Once this transformation is done, the solution can be done using Primal or Dual programming from the table 2 below.

Table 2: Primal and Dual programming

Primal programming	Dual programming
${}^{max}_{UV} V'_m Y_m$ Under the constraint: $U'_m X_m = 1 \,; \; V'_m Y - U'_m X \leq 0$ $V'_m U'_m \geq 0$	${}^{min}_{\theta} \theta_m$ Under the constraint: $Y \quad \geq Y_m X \leq 0 \quad ; \quad X\gamma \leq \theta_m X_m$ ≥ 0

Source: Ramanathan (2007).

The solution of the Primal program can be difficult if the number of production units is very high because there are as many constraints as production units. In this case, the Dual program can be used, where the number of constraints depends only on the number of inputs. This model is known as CCR (Charles et al., 1978) after the authors. One limitation is that it does not take into account the production scale and this shortcoming can be overcome by adding to the Dual programming the constraint $\sum_{i=1}^{n} \gamma_i = 1$(Banker et al., 1984). This refers to the model of (Banker et al., 1984) in short BCC model.

For the choice of inputs and outputs, we opt for the intermediation approach because of the importance of the banking intermediation function in the CEMAC zone. While inspired by the work of Takor and Boot (2008), the selected inputs are: equity, deposits and operating expenses and the outputs are: loans and other investment and transaction securities. Using the Max DEA pro program and Stata software, we have technical efficiency, technical pure efficiency and scale efficiency scores as explained variables in the second step below.

3.2. Methodology for evaluating the effects of capitalisation on technical efficiency

In this second stage, the different efficiency scores obtained in the first stage are used as explained variables, drawing on the work of Coelli et al. (1998). The explanatory variables are those in the table 3 below. The data comes from Bankscope database (2017) for the internal variables and from WDI of the World Bank (2017) for the macroeconomic control variables.

Table 3: Explanatory variables selected for the econometric analysis

NAME	VARIABLE (CODE)	MEASURE	SIGN
INTERNAL FACTORS OF THE BANK	Capitalisation (FPTA)	Equity to total assets ratio	+ ou -
	Size (L_nTA)	Logarithm of total assets	+ ou -
	Liquidity (LIQ)	Ratio of liquid assets to customer deposits	+ ou -
	Risk of credits (RDC)	Ratio of total loans to total assets	+ ou -
	Printability (ROE)	Net income to equity ratio	+ ou -
SECTORIAL FACTORS	Concentration (CON)	Herfindhal-Hirschman index	+ ou -
MACROECONOMIC FACTORS	Inflation (INF)	Consumer price index	+ ou -
	Economic activity (PIBH)	GDP growth per head	+ ou -

Source: Authors based on Takor and Boot (2008) and Altunbas et al. (2007).

As our explained variables are bounded (between 0 and 1), Cadoret et al. (2004) advise us to use a Tobit model as follows: $Y_{it} = \max(1, X_{it}\beta + C_i + \varepsilon_{it})$. Y_{it}, efficiency income of bank i at time; Xit, explanatory variables matrix of bank i at time t; β the vector of fixed coefficients; $C_i/X_{it} \sim N\ (0, \sigma_C^2)$ the random effect that takes into account all the qualified unspecified effects of bank i, $\varepsilon_{it}/X_{it}\, C_i \sim N\ (0, \sigma_\epsilon^2)$ the random residual. Hence our model to be tested:

$$\boldsymbol{EFF_{it} = \alpha + \beta_1 FPTA_{it} + \beta_2 L_n TA_{it} + \beta_3 LIQ_{it} + \beta_4 RDC_{it} + \beta_5 ROE_{it} + \beta_6 CON_{it} + \beta_7 INF_{it} + \beta_8 PIBH_{it} + \varepsilon_{it}}$$

With: EFF_{it} the technical efficiency for the first model, the pure technical efficiency for the second model and finally, the scale efficiency for the third model; α is the constant term; $\beta_1 \ldots . \beta_8$ are the coefficients of the explanatory variables of the model. ε_{it} is the error term. Specifically, via the Maximum Likelihood method, we estimate the following three models:

$$\boldsymbol{CRS_{it} = \alpha + \beta_1 FPTA_{it} + \beta_2 L_n TA_{it} + \beta_3 LIQ_{it} + \beta_4 RDC_{it} + \beta_5 ROE_{it} + \beta_6 CON_{it} + \beta_7 INF_{it} + \beta_8 PIBH_{it} + \varepsilon_{it}}$$

$$\boldsymbol{VRS_{it} = \alpha + \beta_1 FPTA_{it} + \beta_2 L_n TA_{it} + \beta_3 LIQ_{it} + \beta_4 RDC_{it} + \beta_5 ROE_{it} + \beta_6 CON_{it} + \beta_7 INF_{it} + \beta_8 PIBH_{it} + \varepsilon_{it}}$$

$$\boldsymbol{SCALE_{it} = \alpha + \beta_1 FPTA_{it} + \beta_2 L_n TA_{it} + \beta_3 LIQ_{it} + \beta_4 RDC_{it} + \beta_5 ROE_{it} + \beta_6 CON_{it} + \beta_7 INF_{it} + \beta_8 PIBH_{it} + \varepsilon_{it}}$$

Where, CRS_{it}, VRS_{it} and $SCALE_{it}$ represent technical efficiency, pure technical efficiency and scale efficiency respectively.

4. Results and Discussion

4.1. Technical efficiency level of the banks

The individual bank efficiency scores in Tables (4) (5) and (6) belows indicate that two out of seventeen banks are 100% technically efficient over the whole study period, five banks for pure technical efficiency and two banks for scale efficiency. On the other hand, six banks have efficiencies (technical and pure technical) below 50% while all seventeen banks are highly efficient in terms of scale of production.

Table 4: Average technical efficiency scores for each bank in the sample

	CRS_TE	VRS_TE	NIRS_TE	SCALE	RTS
dmu:1	0.674719	0.853661	1.000000	0.790384	1.000000
dmu:2	0.988459	1.000000	1.000000	0.988459	1.000000
dmu:3	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:4	0.656003	0.705434	0.752303	0.929928	1.000000
dmu:5	0.828670	1.000000	1.000000	0.828670	1.000000
dmu:6	0.996860	1.000000	1.000000	0.996860	1.000000
dmu:7	0.357262	0.359412	0.506664	0.994018	1.000000
dmu:8	0.806108	0.876158	1.000000	0.920048	1.000000
dmu:9	0.672678	0.673615	1.000000	0.998609	1.000000
dmu:10	0.550888	0.550917	1.000000	0.999947	1.000000
dmu:11	0.407522	0.408675	1.000000	0.997179	1.000000
dmu:12	0.477360	0.478157	1.000000	0.998333	1.000000
dmu:13	0.420213	0.421816	1.000000	0.996199	1.000000
dmu:14	1.000000	1.000000	1.000000	1.000000	0.000000
dmu:15	0.457168	0.459591	1.000000	0.994728	1.000000
dmu:16	0.752013	0.796336	1.000000	0.944341	1.000000
dmu:17	0.170513	0.170669	1.000000	0.999086	1.000000

Source: Authors, using Max DEA pro and Stata.

Table 5: Technical efficiency scores for all banks in the sample

Year	2014	2015	2016	NBE_P
Mean	0.6914377	0.7323799	0.8056924	
Max	1.0000	1.0000	1.0000	
Min	0.170669	0.184411	0.224803	
Standard deviation	0.2739854	0.2841524	0.2690522	
NBE	2	4	5	2

Source: Authors, using the Max DEA pro program and Stata. Max: refers to the highest efficiency score in the sample per year; Min: refers to the minimum efficiency score in the sample per year. NBE: denotes the number of 100% efficient banks per year, NBE_P is the number of 100% efficient banks over the whole period.

Table 6: Pure technical efficiency and scale scores for all banks

year	2014	2015	2016	NBE_P
Technical efficiency	0.6914377	0.7323799	0.8056924	2

Pure technical efficiency	0.6597904	0.6434406	0.7548761	5
Scale efficiency	0.9633405	0.8936766	0.9413582	2

Source: Authors, using the Max DEA pro program and Stata software.

The efficiency scores for the whole sample indicate that, over the period 2014-2016, the 17 banks in our sample are only 74.32% efficient, i.e. an inefficiency of about 25.68%. In other words, they efficiently used 74.32% of inputs (deposits, equity and operating expenses) to produce loans and investment and trading securities. They however wasted 25.68% of inputs.

In contrast to the technical efficiency of all banks, which is increasing over the entire study period, pure technical efficiency decreased slightly in 2015 and increased in 2016. This is the same trend for scale efficiency except that its level in 2016 did not match that of 2014.

4.2. The effect of capital on the technical efficiency of banks in the CEMAC zone

The results of table (7) show that, capital positively affects the technical efficiency of CEMAC banks. However, this effect is not significant. On the other hand, it plays negatively with the pure technical efficiency and the scale efficiency. Theoretically, a high level of equity can have a positive effect on banking efficiency by encouraging the shareholders/managers to minimise risks and to manage the resources of deposits and equity in an optimal way. However, this study shows a non-significant positive effect. On the other hand, high equity can negatively affect banking efficiency by increasing agency costs due to the relaxation of the constraint of managers towards creditors and the increase in moral hazard between managers and shareholders. It is therefore the latter approach that better justifies the negative link between equity, pure technical efficiency and scale efficiency found in this study. This result corroborates that of Adusei (2016) who instead uses the binary Logit model for the case of Ghanaian banks.

Table 7: Tobit model regression results

Different models	**Technical efficiency**		**Pure technical efficiency**		**Scale efficiency**	
Explanatory Variables	dy/dx	P > | z |	dy/dx	P > | z |	dy/dx	P > | z |
FPTA	0.0080825	0.676	-0.0097393**	0.053	-0.0092761**	0.033
L_nTA	0.2007312*	0.089	0.0823333	0.205	-0.0228481	0.246
LIQ	-4.55e-06	0.306	-3.78e-06	0.261	1.75e-06	0.133
RDC	0.222831	0.706	0.0083466	0.847	-0.0135877	0.284
ROE	0.0046751	0.321	0.0023726	0.486	0.0003236	0.815
CON	0.0003609	0.289	0.0005419*	0.082	0.0001473	0.339
INFL	0.0076307	0.797	0.0035646	0.866	0.0049811	0.606
PIBH	-0.0907479**	0.017	-0.0610719**	0.050	0.0218083	0.152
Likelihood-ratio test	Chibar2=7.63; Prob=0.003		Chibar2=7.14 ; Prob=0.004		Chibar2=0.00; Prob=1.000	
Wald test	Chi2(8)=16.25;Prob=0.039		Chi2(8)=15.63;Prob=0.069		Chi2(8)=16.03;Prob=0.042	

Source: Authors (Stata output). The symbols *, ** indicate significance at 10% and 5%.

Also, our results present a negative and significant effect of economic development on technical and pure technical efficiency. In a situation of economic prosperity, banks tend to underestimate the problems related to asymmetric information and grant for example loans and other securities to the detriment of technical efficiency in the sense of Koopmans (1951). In contrast, bank size and concentration positively and significantly affect technical efficiency. For the simple reason that some inefficiencies stem from costs (resource costs, agency costs), our positive result of the volume of assets on the technical efficiency of banks is justified by the confidence that large banks enjoy with respect to depositors and other creditors which provides them with less expensive sources of funds (Bourke, 1989). For bank concentration, its positive effect is rather explained by the development of new information and communication techniques for the benefit of the bank credit market.

5. Conclusion and recommendations

In order to cope with the bank recapitalisation introduced in the CEMAC zone in 1992 by the states, banks are obliged to increase their capital to the minimum level provided for by the regulations. Between 2006 and 2010, the banking system recorded a surplus of 224 billion in equity. Therefore, we considered it appropriate to assess the link between this increase in capital and the technical efficiency of banks. With this in mind, the study period is from 2014 to 2016 and the analysis was in two stages. In the first stage, we used panel data from 17 CEMAC banks, the intermediation approach and the data envelope method to measure bank efficiency. In the second step, we used the Tobit model and the Maximum Likelihood method to assess the effect of an increase in capital on technical efficiency, pure technical efficiency and scale efficiency.

The results showed that an increase in capital negatively and significantly affected the pure technical efficiency and the scale efficiency of banks in the CEMAC zone. The level of assets and bank concentration positively affected technical efficiency while economic development negatively affected it. In view of these results, our recommendations concern prudential regulation of the banking system with capital requirements capable of reducing not only risks, but also information asymmetries and agency costs. For banks, they need to improve deposit and capital management as well as risk management of loans and other investment and trading securities.

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