

Ownership type and technical efficiency of banks in Côte d'Ivoire: parametric and non-parametric evidence

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Abstract. *This study evaluates the technical efficacy of Côte d'Ivoire's banks from 2005 to 2019, accounting for the effect of shareholding. The technical efficiency of the Ivorian banking system became much more efficient after 2012, according to the results of a Tobit random-effects model using the DEA and SFA methods. Additionally, private and foreign shareholding significantly and favorably influences technical efficiency, according to the study. We suggest that actions be taken to allow local and foreign private partners to purchase shares in Ivorian public banks, based on these findings.*

Keywords: technical efficiency, shareholding, DEA, SFA, Tobit model, Bank.

JEL Classification: G21, G32, D20, C60, C61.

1. Introduction

Financial institutions are being forced to increase their governance and competitiveness due to the funding needs of national economies. Banks must increase their performance and efficiency in order to maintain their long-term viability since they operate in an uncertain environment and are increasingly susceptible to the pressures of globalisation. Ivorian banks are currently up against more intense competition on a national and worldwide level. Therefore, the level of efficiency of the Ivorian banking sector determines its long-term viability. Furthermore, banks are the primary source of funding for the economy in developing African nations like C te d'Ivoire. To finance the economy adequately, banks need to be efficient. In fact, the objective of any business is to maximize profit, so it's only natural that it should ask questions about the efficiency of its factors of production. With a given quantity of available inputs, the company must produce the maximum number of goods, or achieve the highest level of profit per unit of goods produced, in accordance with the strategies of economic calculation. It is considered to be technically efficient if this is the case.

According to Weill (2006), technical efficiency refers to the production frontier. In other words, a company is technically efficient if its activities place it exactly on the frontier. This efficiency is "the ability to avoid losses by producing as much output as the use of inputs will allow, or by using as few inputs as the production of outputs will allow" (Harold et al., 1993). Similarly, a company can minimize its factor costs in order to maintain or obtain a given level of output. In this configuration, the company operates at allocative efficiency. Efficiency of scale, on the other hand, refers to the fact that the company must ensure a perfect match between its marginal cost and the selling price of its product on the market, in a situation of pure and perfect competition. With these different definitions, it is clear that the search for efficiency is important for a bank. Indeed, according to Allen et al (2007), an efficient bank contributes to the reliability and soundness of the financial system. An operationally efficient bank contributes to shareholder wealth by offering market shares to its investors.

Banks have the onerous task of providing the capital needed to finance the most profitable and secure investment projects. According to the authors, without an efficient allocation of capital, profitable projects cannot be undertaken, thereby reducing economic growth. Efficiency also makes it possible to anticipate banking crises (De Lima, 2012). Conversely, an inefficient bank can have a number of consequences for both the bank and the economy. For Sufian and Kamarudin (2013), one of the main reasons for bank failure is the decline in efficiency. As well as making the bank unstable, inefficiency also limits their production capacity (Gentier, 2003). In the economic literature, studies have highlighted the factors likely to influence bank efficiency. Some people believe that internal bank characteristics like profitability, size, liquidity, and ownership affect how efficient a bank is (Berger et al., 1993; Gunes and Yilmaz, 2016). For others, however, outside influences like inflation and the pace of GDP development might affect how efficient banks are (Demirgu -Kunt and Detragiache, 1998).

Recent research suggests that both internal and external factors can explain banking efficiency (Pasiouras, 2008). Taktak (2010) conducted a study on the particularities of bank governance and the effect of internal governance mechanisms of listed Tunisian banks on their efficiency during the period 2002-2006. The study revealed that listed Tunisian banks, whether small, medium or large, had an average efficiency level of 79.30% over the study period. Similarly, the analyses also show that the deterioration in the efficiency level of Tunisian banks is mainly due to the failures of the large public banks. Indeed, ever since the theory of property rights (Coase, 1960), economic analyses that have examined the performance criteria of firms agree that publicly-owned organizations are less efficient than privately-owned ones. These theories are supported by the fact that company owners and managers pursue objectives that can be very divergent, depending on the personal interests they each pursue. Indeed, when the firm's director or manager is not the owner (which is particularly true of public companies), he or she may be led to take actions that are not in line with the shareholders' wishes. This creates an asymmetry of information between the agent and the principal, which has the effect of altering firm performance (Alchian, 1969; Demsetz, 1967).

The numerous privatization operations observed around the world have focused on these theories and attributed the poor performance of public companies to the mere fact that their shareholders are public. However, empirical work carried out to verify this hypothesis in a number of fields has produced varied and sometimes contradictory results. In the banking sector, in particular, research shows that the relationship between shareholding and performance is not systematic. This has led to renewed interest in the debate on the link between shareholder structure and bank efficiency. The first category of studies shows that in CFA franc zones, public banks are technically less efficient than local private banks or foreign banking groups. Indeed, while public banks showed an efficiency level of 79.37%, domestic private banks and foreign banks recorded average levels of 86.92% and 84.84% respectively (Andriamasy and Paget-Blanc, 2016).

In the West African Economic and Monetary Union (WAEMU), Kablan (2009) estimated the efficiency level of public banks at 56%, compared with 85% for local private banks and 72% for foreign banks.

However, more recent research, such that done by Diop and Ka (2020), has demonstrated that public banks operating in the WAEMU region have a 4% higher cost-efficiency than private banks. This demonstrates the lack of a clear relationship between shareholding and technical efficiency, made further evident by the inconsistent findings of research conducted in the same region. In Côte d'Ivoire, this paradox is much more apparent. Between 2012 and 2015, the share of foreign ownership in the Ivorian banking sector rose from 41.1% to 56.6%, an increase of 15.5 percentage points. At the same time, banks' average interest margin also increased by 10.57%. From 2016 to 2019, the share of foreign capital began to decline by around 8.2 percentage points, from 59.6% to 51.4%, while the sector's average interest margin continued to grow at an accelerated rate of 32.1% over the same period.

Thus, we can see from the data that in Côte d'Ivoire, there was a positive relationship between foreign shareholding and banks' interest margin over the 2012-2015 period, whereas this relationship became negative over the 2016-2019 period. More specifically, we note that over the 2012-2015 period, Ivorian domestic banks (local public and private) recorded a lower average interest margin than foreign banks (8,273.1 million FCFA versus 10,973.6 million FCFA), whereas over the 2016-2019 period, the interest margin level of local banks was higher than that of foreign banks. Given that the financial intermediation function characterises banking activity in Côte d'Ivoire and that interest margins on financial operations serve as a proxy for bank efficiency, previous analysis has led us to conclude that, in terms of technical efficiency, Ivorian domestic banks were less efficient than foreign banks from 2012 to 2015, with the trend reversing between 2016 and 2019.

Thus, based on this illustration of the data, the question of the role of ownership type on the technical efficiency of banks deserves to be re-examined, particularly for the case of the Ivorian banking system, which has undergone significant change in recent years. Given that Côte d'Ivoire has the biggest financial system in the WAEMU area, the case study of the nation is particularly intriguing. The fundamental question we seek to analyze is: What influence does the type of shareholding have on the technical efficiency of banks in Côte d'Ivoire?

From this central question flow two questions that can help us to better define it. These are: What is the level of technical efficiency of banks in Côte d'Ivoire? Are Ivorian public banks less efficient than their competitors? In an attempt to answer the above question, the general objective of our study will be to analyze the technical efficiency of banks in Côte d'Ivoire, taking into account the influence of the type of shareholding. The specific objectives are: *Specific objective 1*: Evaluate the level of technical efficiency of banks in Côte d'Ivoire; *Specific objective 2*: Identify the influence of shareholding on the level of technical efficiency of banks in Côte d'Ivoire.

In relation to our objectives, we postulate the following hypotheses:

Hypothesis 1: The average technical efficiency level of banks is improving in Côte d'Ivoire.

Hypothesis 2: In Côte d'Ivoire, public banks are technically less efficient than domestic private banks and foreign banks.

Our study is of twofold interest. At the scientific level, it contributes to the debate on the relationship between ownership type and bank performance. At the political level, on the one hand, it sheds light on the factors explaining the differences in performance that can arise between public banks and other banks, and on the other, it guides their decision on the key factors for the success of banking sector development policies.

Methodologically, this study is based on a two-stage procedure. The first stage mobilizes a dual non-parametric and parametric approach to measuring the technical efficiency of banks in Côte d'Ivoire through data envelopment analysis (DEA) and the stochastic frontier approach (SFA). The second stage uses econometric methods on panel data, in this case the Tobit random-effects model, to assess the influence of ownership type and other control variables on the level of technical efficiency of the Ivorian banking sector.

This is how the rest of the article is structured: A summary of the research on the relationship between bank shareholding and technical efficiency is covered in section 2. The methodology for evaluating the technical efficiency of Côte d'Ivoire's banks and how ownership type affects it are presented in Section 3. The data source and variable descriptions are shown in Section 4. The empirical data obtained are presented and discussed in Section 5. The study is concluded in Section 6.

2. Literature review

The literature review breaks down into a theoretical review and an empirical review of the relationship between shareholder structure and technical efficiency.

2.1. Theoretical contributions on the link between bank shareholding and technical efficiency

Agency, property rights, public choice, and efficiency-X theories provide the theoretical basis for examining the connection between ownership type and banking performance. The work of Berle and Means (1932), who proposed an inverse link between dispersed ownership and company performance, is where the analysis of the impact of ownership mix on performance began. In other words, according to the author, shareholder concentration promotes performance. In a similar vein, Jensen and Meckling (1976) have highlighted the problems that can arise when ownership and control are separated. According to them, when ownership is widely dispersed, conflicts can arise between managers and shareholders, as the former may seek to satisfy their own interests to the detriment of those of the owners. Agency theory suggests that a concentration of ownership favors a reduction in agency costs, thus improving firm performance. Fama and Jensen (1983) also point out that ownership unbundling is a major source of costs for shareholders.

Because a bank failure can upset the stability of the entire financial system and have an impact on economic activity, shareholder structure is particularly crucial in the banking industry (Chebri and Bahoussa, 2020). The concentration of bank ownership around a majority shareholder results in the latter having more influence over management. This strengthens the flow of information between shareholders and managers, which lowers the danger of moral hazard (Abdul Rahman and Reja, 2015). Efficiency is therefore favoured by the structure of private banking capital, both local and foreign, which is typically defined by a concentration of equity shares around a dominating majority shareholder.

On the other hand, this close link between management and shareholder interests is not always perceptible in state-owned banks. In fact, the delegation of powers within state-owned companies comprises a relatively high number of hierarchical levels, making it difficult for the ultimate owner to control.

Property rights theory (Coase, 1960; Demsetz, 1967; Alchian, 1969; Alchian and Woodward, 1987) discusses how different property rights types and systems affect how each individual agent behaves as well as how efficiently a corporation operates. It also looks at how property rights are distributed and what kinds of rights often predominate in

an economy. Two things set property rights theory apart from the traditional theory of pure and perfect competition: transaction costs are not minimal and there are significant knowledge asymmetries. According to this theory, the inefficiency of the public firm compared to the private firm is due to the weakness of the public firm's property rights and the risk of bankruptcy. Indeed, the risk of bankruptcy is virtually non-existent in the public firm, due to state support through subsidies, whereas the private firm integrates this risk into its management strategy. What's more, the company is seen as a nexus of contracts in which each agent acts in his or her own interest.

The public choice theory (Buchanan and Tollison, 1973) attributes the inefficiencies of public enterprises primarily to the political games and interest groups that make up public organisations. Public choice theorists contend that those who make decisions on behalf of the public, such as politicians, public enterprise directors, and civil servants, do so by putting their personal interests ahead of those of society at large. Furthermore, they contend that elected politicians regularly meddle in public administration, giving favours and benefits to particular groups in order to win reelection; this is an approach that is unquestionably opposed to the prudent and effective management of public institutions (Vickers and Yarrow, 1988).

For Leibenstein (1978), several factors are at the root of inefficiency in state-owned enterprises: the monopoly situation, the State's permanent coverage of deficits and cash-flow crises, and the multiplicity of economic and social objectives, which encourage managers to shirk their responsibilities. These inefficiency-X factors lead to a certain slackness in the way managers run their companies, a flight from responsibility and a strong bureaucratic culture (Lesueur and Plane, 1997). These inefficiency-X factors explain the superior efficiency of private enterprise, providing arguments for the privatization of public enterprises.

2.2. Empirical work on banking efficiency

Both developed and developing nations are addressed in this review of empirical research on the relationship between ownership type and technical efficiency. Research generally indicates that domestic banks are more efficient than foreign banks in industrialised nations. Chang et al. (1998), for instance, conducted a comparative study of the productive efficiency of banks in the United States. They employed a two-step process: first, they examined their determinants before determining efficiency scores using the SFA approach.

Foreign banks created in the United States are less efficient than domestic banks, according to the findings of Tobit and ordinary least squares (OLS) regressions. Based on banking data from the UK, France, Germany, and Spain between 1993 and 1998, Berger et al. (2000) demonstrate that local banks are generally more efficient than international banks. However, Manole and Grigorian (2002) demonstrate that foreign banks operating in these countries are technically more efficient than local banks based on a sample of 1,074 observations gathered on banks in 16 Eastern European transition countries. For Poland and the Czech Republic, based on a sample of 31 banks, Weill (2006) indicates that foreign banks have higher efficiency scores than domestic banks. The high level of overall

technical efficiency of foreign banks compared to domestic banks stems from their advantage in terms of pure technical efficiency, i.e. a better-adapted managerial and production system.

In emerging and middle-income countries, particularly in Asia, the majority of empirical studies reveal that foreign-owned banks are more efficient than domestic private and public banks. Using a non-parametric DEA approach, Sanjeev (2006) finds that foreign-owned banks operating in India are far more efficient than their domestic competitors. Using parametric methods, Bhattacharyya and Pal (2013) also conclude that foreign banks are more efficient in India. In Malaysia and Vietnam, Sufian et al (2016) and To and Le (2020) reach the same conclusions. The performance of foreign banks is said to be due to economies of scale, an efficient management system and better bad debt and risk management. However, a number of studies point to contrary results. Indeed, using the Olley-Pakes procedure, with a production approach to banking activity, Sanyal and Shankar (2011) indicate that Indian private banks dominate public banks and foreign banks, in terms of productivity level and productivity change.

In Africa, the results of research into the relationship between ownership type and banking performance do not appear to converge. Kablan (2009) assessed the technical and cost efficiency levels of WAEMU banks after the period of financial liberalization, using a mixed method: the DEA method for measuring technical efficiency and the SFA method for measuring cost efficiency. Over the period from 1996 to 2004, the results show that local private banks were the most technically efficient under both constant and variable returns to scale assumptions, with efficiency scores of 0.85 and 0.92 respectively. They are followed by foreign banks, with scores of 0.72 for constant return on scale and 0.83 for variable return on scale. Public banks are the least efficient, with efficiency scores of 0.56 for constant return on scale and 0.64 for variable return on scale. Andriamasy and Paget-Blanc (2016) also looked at the WAEMU zone, extending their study area to the Central African Economic and Monetary Community (CEMAC). Using a DEA method with the B-convex model, they find that domestic private banks in these two community areas are technically the most efficient, for all three efficiency measures. They are followed by foreign banks, with public banks being the least efficient. Still in the WAEMU zone, over the period 1996-2015, Diop and Ka (2020) show that public ownership positively affects the cost-efficiency of WAEMU banks. For the specific case of Côte d'Ivoire, Gahé et al. (2016) sought to assess the technical efficiency of Ivorian banks, using the DEA method, on data covering the period 2008-2010. They conclude that foreign banks operating in the country, are more efficient in intermediation activities compared to domestic private banks and state-owned banks. The results show an average efficiency level of 47.64%, a level of 79.49 for pure technical efficiency and 61.51% for scale efficiency.

3. Research methodology

We first outline the process for calculating banks' technical efficiency scores in this section. Second, a technique for calculating the correlation between shareholding and technical efficiency is described.

3.1. Estimating technical efficiency scores

The most commonly used methods for estimating technical efficiency are the non-parametric DEA approach and the parametric SFA approach.

3.1.1. Presentation of the DEA method

The DEA method was developed by Charnes et al (1978) under the assumption of constant returns to scale, then by Banker et al (1984) under the assumption of variable returns to scale. It is a linear programming model whose objective is to maximize output or minimize inputs (depending on whether it is output- or input-oriented) under a certain number of constraints. The idea of the DEA model is to estimate a unit production frontier from the sample. This frontier is located at the top of the observations and corresponds to the best-performing units, all other units being located below the frontier (Kablan, 2009). Following the example of Kamgna and Dimou (2008) and Gah  et al. (2016), we apply the DEA method to assess the technical efficiency of the Ivorian banking system. More specifically, the approaches of Charnes et al. (1978) and Banker et al. (1984) will be simultaneously deployed to obtain overall efficiency scores, as well as their decomposition into pure technical efficiency and scale efficiency. The form adopted is input-oriented rather than output-oriented, particularly under the assumption of constant returns to scale (F re and Lovell, 1978).

a) The DEA approach, assuming constant returns to scale

The Charnes et al. (1978) model is based on maximizing the ratio between the weighted sum of outputs and the weighted sum of inputs of a unit (DMU₀), relative to the ratio of all DMUs. In the notations, we assign index 0 to the DMU for which the efficiency score is evaluated and index j for all DMUs. Mathematically, it is as follows:

$$\left\{ \begin{array}{l} \text{Max } h_0(u, v) = \frac{\sum_{r=1}^s u_r y_{r0}}{\sum_{i=1}^m v_i x_{i0}} \\ \text{s.c.} \\ \frac{\sum_{r=1}^s u_r y_{rj}}{\sum_{i=1}^m v_i x_{ij}} \leq 1; \quad j = 1 \dots n \\ u_r, v_i \geq 0; \quad r = 1 \dots s; \quad i = 1 \dots m \end{array} \right. \quad (1)$$

Where: y_{ij} and x_{ij} represent the r^{th} output and i^{th} input of DMU j respectively. r and i are the indices associated with the outputs and inputs respectively. u_r and v_i are the input and output weighting variables. The variables u_r , v_i are to be determined by the problem solution. Solving such a program leads to an infinite number of possible solutions. To circumvent the difficulty, a transformation of system (1) has been proposed by positing $\sum_{i=1}^m v_i x_{i0} = 1$.

Thus, solving system (1) is equivalent to solving the following equivalent program:

$$\left\{ \begin{array}{l} \text{Max} \quad z = \sum_{r=1}^s \mu_r y_{r0} \\ \text{s.c.} \\ \sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} \leq 0; \quad j = 1 \dots n \\ \sum_{i=1}^m v_i x_{i0} = 1 \\ u_r, v_i \geq 0; \quad r = 1 \dots s; \quad i = 1 \dots m \end{array} \right. \quad (2)$$

The dual form resulting from problem (2) is:

$$\left\{ \begin{array}{l} \text{Min} \quad \theta \\ \text{s.c.} \\ \theta x_{i0} - \sum_{j=1}^n \lambda_j x_{ij} \geq 0; \\ -y_{r0} + \sum_{j=1}^n \lambda_j y_{rj} \geq 0; \\ \lambda_j \geq 0; \quad i = 1 \dots m; \quad r = 1 \dots s; \quad j = 1 \dots n \end{array} \right. \quad (3)$$

Where λ is a vector of dimension n to be estimated and θ a scalar between 0 and 1. θ takes the value 1 for DMUs located on the border. It represents, for the DMU, the fraction of its resources that it uses optimally. In the dual program (system 3), the first constraint means that the coefficients λ_j are determined in such a way that the weighted sum of the input quantities used by all DMUs is at most equal to the input quantity of the DMU under study. As for the second constraint, it assumes that the weighted sum of the outputs of all the production units in the sample is at least equal to the quantity of output of the unit under consideration. The value θ represents the measure of the technical efficiency of the DMU studied in the input-oriented case. Note that program (3) must be solved n times to obtain the efficiency scores of all n DMUs in the sample.

b) The DEA approach under the hypothesis of variable returns to scale

According to Coelli et al. (1998), measuring technical efficiency under the constant returns on magnitude hypothesis is appropriate only if all DMU operate at an ideal scale. A DEA (oriented input) approach was developed by Banker et al. (1984) to account for varied scale results. To obtain the effectiveness measure in variable scale returns, just add the non-convexity constraint: $\sum_{i=1}^n \lambda_j$ to the system of equations (3). The following system is then available:

$$\begin{cases}
\text{Min } \theta \\
\text{s.t.} \\
\theta x_{i0} - \sum_{j=1}^n \lambda_j x_{ij} \geq 0; \\
-y_{r0} + \sum_{j=1}^n \lambda_j y_{rj} \geq 0; \\
\sum_{j=1}^n \lambda_j = 1 \\
\lambda_j \geq 0; \quad i = 1 \dots m; \quad r = 1 \dots s; \quad j = 1 \dots n
\end{cases} \quad (4)$$

The values θ obtained by solving problem (4) represent the pure technical effectiveness scores. These results are contrasted with the ones obtained with constant returns to scale. If there is equality, the DMU operates on an optimal scale; if not, it operates on a sub-optimal scale. The ratio of the two effectiveness ratings is used to calculate the scalar efficiency.

3.1.2. Presentation of the SFA method

The stochastic frontier approach was introduced separately by Aigner et al. (1977) and Meeusen and Broeck (1977). Unlike the DEA method, the SFA approach estimates the production frontier using econometric regression techniques and first requires knowing the functional form of the production, cost or profit function. The SFA method derives its stochastic nature from the fact that any deviation between the actual production level and the production frontier is not entirely due to inefficiency. It separates the error term into two components. The first represents the random statistical error linked to errors of measurement, observations and uncontrollable exogenous shocks, while the second represents the inefficiency of the firm. In addition to the DEA method, we estimate a stochastic production frontier from panel data by considering a temporal evolution of the inefficiency component. This consideration finds its justification in the fact that our data covers a period that we consider relatively long in addition to technological changes in the productive systems of banks in C te d'Ivoire. Authors like Chen (2002) and Weill (2004) predict that the efficiency ratings achieved with the DEA approach can differ significantly from those obtained with the SFA method in the banking industry, which is why these two methodologies were chosen. As a result, the SFA model's fundamental theoretical specification is:

$$Y_{it} = \alpha + \beta X_{it} + v_{it} - u_{it} \quad (5)$$

Where X represents the vector of inputs and β the associated coefficients. The error term is represented by $v_{it} - u_{it}$ where i and t being the individual and temporal dimensions respectively. The u_{it} or error term component reflects the inefficiency of the firm and is the remainder of the disturbance. The assumptions on v_{it} and u_{it} are such that v_{it} and u_{it} are independent, $v_{it} \sim IID N(0, \sigma_v^2)$ and $u_{it} \sim IID N(0, \sigma_u^2)$. In equation (5), the inefficiency

of the firm is summarized by the unobservable individual specific effects, that is to say the u_{it} . However, in reality the differences between firms are not only due to inefficiency. Indeed, as Greene (2004) points out, these differences can come from the heterogeneity between firms when they use different technologies and operate in different internal or external environments. Thus, to take heterogeneity into account, we will use the True Random Effect (TRE) model proposed by Greene (2004, 2005) in order to distinguish heterogeneity and inefficiency. Additionally, the stochastic production frontier can be specified by a Cobb-Douglas function, a translogarithmic function, or a Fourier function. We opt for a Cobb-Douglas specification which seems suitable for our data. Thus, the specification of the production function is as follows:

$$\ln Y_{it} = (\alpha + \omega_i) + \sum_{k=1}^K \beta_k \ln X_{it} + v_{it} - u_{it} \quad (6)$$

Where ω_i summarizes individual heterogeneity. The u_{it} component can be obtained following the formula of Jondrow et al. (1982):

$$E[u_i | \varepsilon_i] = \frac{\sigma\lambda}{1 + \lambda^2} \left[\frac{\phi(z_i)}{1 - \Phi(z_i)} - z_i \right]; \quad z_i = \frac{\varepsilon_i \lambda}{\sigma} \quad (7)$$

The technical efficiency score of firm i at date t is then written as: $TE_{it} = \exp [E(-\frac{u_{it}}{\varepsilon_{it}})]$

The choice of banking inputs and outputs is determined by the way in which banking activity is understood. In the literature, the debate on the identification of banking inputs and outputs is not settled. There are mainly two approaches: the production approach and the intermediation approach. According to the production approach, the banking firm is seen as a company that produces deposits and credits using capital and labor and of course other factors. In this approach, production is represented by deposits and credits. As for the factors of production, they are represented by labor and capital. A second trend considers that the bank plays the role of financial intermediary. Its function is to collect deposits from economic agents with financing capacity, then to recycle them by granting credit to agents expressing financing needs. According to this approach, credits are produced from deposits and other usual factors of production such as capital and labor. As output, we have outstanding loans and as input, we have deposits, labor and capital. Following Kamgna and Dimou (2008) as well as Gahé et al. (2016), we use the intermediation approach in our study due to the relatively low level of financial markets.

3.2. Empirical analysis of the relationship between technical efficiency and shareholding

This section describes the second step of our procedure which consists of regressing technical efficiency on a set of explanatory variables. It justifies the choice of model and presents its specification.

3.2.1. Choice and presentation of the model

In the literature, there are mainly two methods for modeling the determinants of technical efficiency, namely OLS regression and the Tobit model. Linear regression considers that

the dependent variable is observed for all individuals while the Tobit model is appropriate the dependent variable is continuous in an interval with a non-zero probability of taking the value 0 (Fouopi and Song, 2016). Since the technical efficiency scores estimated using the DEA and SFA approaches vary continuously in the interval between 0 and 1, the Tobit model would be best suited in our case. More precisely, in our data, efficiency scores take the value 1 for banks located on the production frontier and take values less than 1 (but strictly positive) for banks below this frontier. Thus, we are in the presence of a right-censored Tobit model (the most efficient banks have an efficiency score increased to 1). Furthermore, according to Pamphile (2020), the basic Tobit model only makes sense if censoring occurs in a linear regression model with normally distributed error, when only positive results are observed. However, in the case of panel data, observations are repeated for each group of individuals in the panel and consequently, correlations may exist between these repeated observations. Thus, for panel data with censored dependent variables, the random effects Tobit model would be best suited (Chen and Chen, 2014). This model is applied to account not only for correlations between observations, but also for censoring and truncation effects as well as unobserved heterogeneity.

3.2.2. Specification and estimation technique of the random effects Tobit model

Following Cameron and Trivedi (2005), the panel specification of the basic Tobit model is est $y_{it}^* = X'_{it}\beta + \varepsilon_{it}$ where y_{it}^* represents a latent variable which is only observable when it is positive. Above, we indicated that in panel data, correlations can exist between repeated observations and that the random effects model would be more suitable than that developed by Tobin (1958). The random effects Tobit model with censored data is based on the same latent regression, but with a different treatment of the common effect. This model is obtained by decomposing the error term in the form of a one-factor compound error model. A basic structure of this type of model can be written:

$$y_{it}^* = X'_{it}\beta + \eta_i + v_{it} \quad (8)$$

Where η_i is the random effect of the individual which follows a centered normal distribution and variance σ_η^2 and v_{it} is the remainder of the disturbance distributed following a centered normal distribution with variance σ_v^2 . According to Cameron and

Trivedi (2005), when data are right-censored, completely unobserved observations y_{it}^* are based on a certain U_{it} value. Thus, from the basic specification translated by relation (8), we arrive at the specification specific to the Tobit model with random effects with right censoring. This final theoretical model is as follows:

$$y_{it} = \begin{cases} y_{it}^* = x'_{it}\beta + \eta_i + v_{it}, & \text{si } y_{it}^* < U_{it} \\ U_{it}, & \text{si } y_{it}^* \geq U_{it} \end{cases} \quad (9)$$

The parameters of the random effects Tobit model are estimated using the maximum likelihood technique. The log-likelihood function is written:

$$LL = \sum_{i=1}^N \log \left\{ \int_{-\infty}^{+\infty} \frac{1}{\sigma_{\eta} \sqrt{2\pi}} \exp \left(-\frac{\eta_i^2}{2\sigma_{\eta}^2} \right) \prod_{i=1}^{T_i} \left[\frac{1}{\sigma_v} \phi \left(\frac{U_{it} - x'_{it} \beta - \eta_i}{\sigma_v} \right) \right]^{1-d_{it}} \cdot \left[\Phi \left(\frac{y_{it} - x'_{it} \beta - \eta_i}{\sigma_v} \right) \right]^{d_{it}} d\eta_i \right\} \quad (10)$$

Où $\phi(\cdot)$ et $\Phi(\cdot)$ sont respectivement la fonction de densité et la fonction de répartition de la loi normale. d_{it} est une variable indicatrice prenant la valeur 0 si $y_{it}^* \geq U_{it}$ et vaut 1 si $y_{it}^* < U_{it}$.

Where $\phi(\cdot)$ and $\Phi(\cdot)$ are respectively the density function and the distribution function of the normal law. d_{it} is an indicator variable taking the value 0 if $y_{it}^* \geq U_{it}$ and value 1 if $y_{it}^* < U_{it}$.

Explicitly and formally, the Tobit regression model can be presented as follows. A variable called $Effic^*$ is presumed to depend on a certain number of independent variables grouped in the vector X , whose effects are grouped in the vector β . We assume that the observed values of $Effic^*$, the $Effic_i^*$, are the combination of the value predicted by the deterministic component of the model $X_i' \beta$, and a residue, ε_i , whose value varies randomly for each individual. However, we assume that the variable $Effic^*$ is not directly observable, but rather that we observe the variable $Effic$. The Tobit model can be written:

$$Effic_i^* = \alpha + X_i \beta + \varepsilon_i \quad (11)$$

Where $Effic_i^*$ is the latent variable of efficiency scores and X_i is the vector of explanatory variables.

$$Effic_i = 0 \text{ si } Effic_i^* \leq 0$$

$$Effic_i = Effic_i^* \text{ si } 0 \leq Effic_i^* \leq 1$$

$$Effic_i = 1 \text{ si } Effic_i^* \geq 1$$

The random effects Tobit model first includes an equation that relates the dependent variable of the model, $Effic_{it}^*$, to the independent variables, to which are added both a random effect and a residual:

$$Effic_{it}^* = \alpha + X_{it} \beta + v_i + \varepsilon_{it} \quad (12)$$

$$\forall i = 1, \dots, N, \forall t = 1, \dots, n_i$$

In equation (12), $Effic_{it}^*$ represents the value that the continuous latent variable can take for the observation of individual i at time t , α represents the value of the ordinate at the origin, X_{it} designates all the independent variables as measured at time t for individual i , β is the vector of coefficients affecting these variables to be estimated, v_i represents the value of the random effect associated with individual i and ε_{it} constitutes the error of the model, which differs for each observation. Note also that v_i is distributed according to the

law $N(0, \sigma_v^2)$ and ε_i also follows a law $N(0, \sigma_\varepsilon^2)$. From the above, our model can therefore be written as follows:

$$Effic_{it}^* = \alpha + \beta_1 private_{it} + \beta_2 foreign_{it} + \beta_3 old_{it} + \beta_4 car_{it} + \beta_5 rnpl_{it} + \beta_6 principal_{it} + \beta_7 ln bilan_{it} + \beta_8 rcredit_{it} + \beta_9 rdepot_{it} + \beta_{10} coexp_{it} + \beta_{11} icb_{it} + \beta_{12} regul_{it} + \beta_{13} inflation_{it} + \beta_{14} d1216 + \beta_{15} d1719 + \varepsilon_{it} \quad (13)$$

$Effic_{it}^*$ is the series of technical efficiency scores obtained by the DEA and SFA methods. Our variable of interest is the type of bank ownership, captured by three dummy variables: *public*, *private* and *foreign*. When the bank is a public bank, the *public* variable takes the value 1 and the two other variables take the value 0. If, on the contrary, the bank is of the domestic private type, the *private* variable then takes the value 1 and the *public* and *foreign* take the value 0. Finally, when the bank is of foreign origin, the variable *foreign* is coded with the value 1 and the variables *public* and *private* are coded with the value 0. The public, private domestic or foreign type of the property of the bank is determined by the fact that the cumulative share of shares held by the State or its branches in the share capital of the bank is higher than that of other categories of shareholders. Likewise, a bank is considered as domestic private if the share of shares accumulated by natural and legal persons under Ivorian private law is higher than that held by the State and its branches on the one hand, and higher than that held by the State and its branches on the one hand, and higher than that foreign natural and legal persons on the other hand. The same logic guides the identification of foreign banks. To avoid the trap of misleading regressions due to multicollinearity, we only retained the *private* and *foreign* variables in the model. The coefficients of these variables are therefore interpreted with reference to the *public* variable.

We also want to capture the effect of time on technical efficiency. To do this, we construct two dummy variables representing the sub-periods, 2012-2016 and 2017-2019. These last two sub-periods correspond to the implementation of national development plans marked by structural reforms in the Ivorian banking landscape. To the variable of interest, we add control variables which are of three orders: bank-specific variables, banking environment variables and macroeconomic variables. At the level of internal bank variables, we retain the seniority of the bank (*old*), the ratio of equity / total assets (*car*), the rate of doubtful debts (*rnpl*), the share of capital of the majority shareholder (main), the logarithm of the balance sheet (*ln bilan*), the ratio of outstanding loans to total balance sheet (*rcredit*), the ratio of outstanding deposits / total balance sheet (*rdepot*) and the operating coefficient (*coexp*). Concerning the banking environment variables, we use the banking concentration index (*icb*) and the public authority regulation index (*regul*). At the level of macroeconomic variables, only inflation (*inflation*) is retained. The expected signs of the coefficients of the explanatory variables are presented in Table 1.

Table 1. Summary of explanatory variables of the Tobit model

| Variable category | Notation | Description | Expected sign on technical efficiency (*) |
|--------------------|----------------|---|---|
| Temporal evolution | <i>d1216</i> | Dummy variable taking the value 1 over the period 2012-2016 | + |
| | <i>d1719</i> | Dummy variable taking the value 1 over the period 2017-2019 | + |
| Property Type | <i>Private</i> | Dummy variable indicating a domestic private bank | + |

| Variable category | Notation | Description | Expected sign on technical efficiency (*) |
|-------------------------|------------------|---|---|
| | <i>Foreign</i> | Dummy variable indicating a foreign bank | + |
| Shareholder structure | <i>Principal</i> | Share of shares held by the main shareholder | + |
| Seniority in the sector | <i>Old</i> | Number of years of existence in the Ivorian banking sector | + |
| Portfolio quality | <i>Car</i> | Capital adequacy ratio | + |
| | <i>Rnpl</i> | Bad debt rate as a proportion of assets | - |
| Bank size | <i>Ln bilan</i> | Logarithm of balance sheet total | ND |
| Importance of charges | <i>Coexp</i> | Operating ratio (in percentage) | - |
| Balance sheet structure | <i>Rcredit</i> | Ratio of outstanding loans / total balance sheet (as a percentage) | + |
| | <i>Rdepot</i> | Ratio of outstanding deposits/total balance sheet (as a percentage) | + |
| Environmental variables | <i>Icb</i> | Banking concentration index | ND |
| | <i>Inflation</i> | Inflation rate | + |
| | <i>Regul</i> | Quality of regulation by public authorities | + |

Source: Author, from the literature review; ND = not determined.

4. Analysis data

In this section, we present, firstly, the source of the data and the definition of the variables and indicators, and secondly, the descriptive statistics of the variables.

4.1. Data sources

Concerning individual data on banks, we used the directory of WAMU banks and financial institutions as well as the balance sheets and their income statements, published on the official BCEAO website. Concerning macroeconomic and banking environment data, we used the World Development Indicators (WDI) database of the World Bank. In order to ensure the convergence of the estimators, during the parametric tests, we chose the longest series of data available. The data series thus retained cover the period 2005-2019, i.e. 15 years. At the individual level, our data consists of a sample of banks with information available over the entire above-mentioned period. Banks which joined or left the Ivorian banking system during the period concerned are excluded from the sample. Finally, we retain a sample of 14 banks over the period 2005-2019, for a total of 210 observations. The distribution of the banks in the sample is as follows: 3 public banks (BHCI, BNI and VERSUS BANK), 3 domestic private banks (BACI, BOA and NSIA Bank) and 8 foreign private banks (BICICI, CITIBANK, ECOBANK, AFRILAND FIRST BANK, ORABANK, SCB, SGCI and SIB). In the following lines, we will carry out the descriptive analysis of the variables.

4.2. Descriptive statistics of variables and effectiveness scores

This analysis consists of carrying out a synthetic and explicit description of the observed data. Thus, for this work, the study of the variables will focus on their mean, their standard deviation, their minimum and maximum. Furthermore, classic comparison tests such as the analysis of variance test (ANOVA) and the Kruskal-Wallis test are used to analyze the correlation between technical efficiency scores and the type of shareholding. Descriptive statistics of the data are reported in Table 2.

Table 2. Statistical summary of variables

| Variable | Mean | Standard deviation | Minimum | Maximum |
|------------------------------|---------|--------------------|---------|---------|
| <i>Dependent variables</i> | | | | |
| <i>VRS pct</i> | 0.855 | 0.191 | 0.117 | 1 |
| <i>SFA pct</i> | 0.755 | 0.199 | 0.086 | 0.971 |
| <i>Independent variables</i> | | | | |
| <i>d1216</i> | 0.333 | 0.473 | 0 | 1 |
| <i>d1719</i> | 0.2 | 0.401 | 0 | 1 |
| <i>Private</i> | 0.224 | 0.418 | 0 | 1 |
| <i>Foreign</i> | 0.6 | 0.491 | 0 | 1 |
| <i>Old</i> | 36.8 | 14.926 | 15 | 61 |
| <i>Car</i> | 4.146 | 22.466 | -148.22 | 90.736 |
| <i>Rnpl</i> | 1.679 | 2.712 | 0 | 17.185 |
| <i>Principal</i> | 87.088 | 16.838 | 51 | 125.397 |
| <i>Ln bilan</i> | 12.182 | 1.314 | 7.697 | 14.582 |
| <i>Rcredit</i> | 55.902 | 16.268 | 2.359 | 87.321 |
| <i>Rdepot</i> | 77.815 | 15.127 | 36.704 | 169.844 |
| <i>Coexp</i> | 82.561 | 82.267 | -86.24 | 767.544 |
| <i>lcb</i> | 464.666 | 19.36 | 424.995 | 497.36 |
| <i>Regul</i> | 27.815 | 9.569 | 17.703 | 45.673 |
| <i>Inflation</i> | 1.864 | 1.859 | -1.107 | 6.309 |

Source: Author, based on data from the BCEAO (2020) and WDI (2021).

The average technical efficiency in constant return to scale or overall technical efficiency of the 14 banks in our sample, obtained with the DEA method, is estimated at 77.95% over the period 2005-2019, with a standard deviation of 21%. Thus, there is an inefficiency of around 22.05% in the transformation of deposits into credits by the Ivorian banking system. It follows that for the production of a given quantity of output (in this case outstanding loans), banks established in Côte d'Ivoire use an excess of inputs which corresponds to 22.05% more than what is technically necessary. The analysis reveals that the inefficiency of banks in Côte d'Ivoire is due to the fact that they operate at non-optimal returns to scale. Indeed, the average scale efficiency over the study period is 91.06% compared to 85.54% efficiency in variable return of scale. Seven banks have above-average efficiency levels over the entire period with scores of more than 83%. These are CITIBANK-CI, ECOBANK-CI, BICICI, NSIA-BANK, SGCI, SIB and VERSUS BANK. Table 3 shows that the technical efficiency of the Ivorian banking sector has experienced four phases of evolution: 2005-2009, 2010-2011, 2012-2017 and 2018-2019. The first phase is marked by a slight increase in performance between 2005 and 2009, where the average efficiency of the sector increased from 80.37% to 85.27%. Efficiency subsequently fell to reach its lowest level in 2011 (67.44%) under the effect of the post-electoral crisis of 2010, which degraded the political, economic and social environment.

Table 3. Breakdown of technical efficiency

| Année | ETG | | ETP | | | EE | | SFA | |
|-------|--------|--------|--------|--------|--|--------|--------|--------|--------|
| | moy. | sd. | moy. | sd. | | moy. | sd. | moy. | sd. |
| 2005 | 0.8037 | 0.1718 | 0.9011 | 0.1070 | | 0.8970 | 0.1708 | 0.8354 | 0.1719 |
| 2006 | 0.8120 | 0.2135 | 0.8686 | 0.1812 | | 0.9400 | 0.1525 | 0.7586 | 0.1987 |
| 2007 | 0.8308 | 0.1797 | 0.8906 | 0.1734 | | 0.9344 | 0.0870 | 0.7875 | 0.1650 |
| 2008 | 0.8161 | 0.1735 | 0.8835 | 0.1574 | | 0.9225 | 0.0946 | 0.7873 | 0.1672 |
| 2009 | 0.8521 | 0.1588 | 0.9069 | 0.1606 | | 0.9431 | 0.0862 | 0.8048 | 0.1440 |
| 2010 | 0.7798 | 0.1884 | 0.8393 | 0.1914 | | 0.9293 | 0.0730 | 0.7462 | 0.1672 |
| 2011 | 0.6744 | 0.1971 | 0.7795 | 0.2037 | | 0.8751 | 0.1453 | 0.6097 | 0.1710 |
| 2012 | 0.7212 | 0.2072 | 0.8696 | 0.1878 | | 0.8388 | 0.1782 | 0.6204 | 0.1735 |

| | ETG | | ETP | | | EE | | SFA | |
|--------------|--------|--------|--------|--------|--|--------|--------|--------|--------|
| Année | moy. | sd. | moy. | sd. | | moy. | sd. | moy. | sd. |
| 2013 | 0.7554 | 0.2282 | 0.8373 | 0.1628 | | 0.9067 | 0.1971 | 0.7141 | 0.2029 |
| 2014 | 0.7672 | 0.2021 | 0.8874 | 0.1381 | | 0.8698 | 0.1882 | 0.7340 | 0.1600 |
| 2015 | 0.7723 | 0.1512 | 0.8891 | 0.1294 | | 0.8672 | 0.0949 | 0.8235 | 0.0829 |
| 2016 | 0.8531 | 0.1456 | 0.8907 | 0.1386 | | 0.9569 | 0.0537 | 0.8353 | 0.1185 |
| 2017 | 0.8622 | 0.1703 | 0.8821 | 0.1593 | | 0.9737 | 0.0392 | 0.8167 | 0.1544 |
| 2018 | 0.7052 | 0.3190 | 0.7659 | 0.3157 | | 0.9057 | 0.1558 | 0.7427 | 0.3292 |
| 2019 | 0.6871 | 0.3329 | 0.7397 | 0.3107 | | 0.8986 | 0.1992 | 0.7055 | 0.3325 |
| Whole period | 0.7795 | 0.2109 | 0.8554 | 0.1905 | | 0.9106 | 0.1382 | 0.7548 | 0.1992 |

Note: ETG: Overall technical efficiency; FTE: Pure technical efficiency; EE: Scale efficiency and SFA: Technical efficiency score obtained with the SFA approach.

Source: Author, based on data from the BCEAO (2020) and WDI (2021).

The economic recovery from 2012, supported by the consolidation of the banking sector, favored a resumption of banking activities and an improvement in performance supported by an increasing technical efficiency to reach 88.21% in 2017. In 2018 and 2019, we once again records a decline in the efficiency of the sector.

Table 4. Comparison tests of average technical efficiencies (DEA and SFA) according to sub-periods

| Dependent variable | Test de Kruskal-Wallis | | ANOVA | |
|---|---------------------------|---------|-----------------------------|---------|
| | Test statistics; Chi 2(3) | p-value | Test statistics; F (3, 206) | p-value |
| Technical efficiency in REC | 5.158 | 0.1606 | 3.17 | 0.0253 |
| Technical efficiency in REV | 5.196 | 0.1580 | 5.58 | 0.0040 |
| Technical efficiency calculated with the SFA method | 12.753 | 0.0052 | 2.61 | 0.0526 |

Source: Authors, based on BCEAO (2020) and WDI (2021) data.

The average technical efficiency is 82.29% over the 2005-2009 sub-period, 72.71% over the 2010-2011 sub-period, 78.86% over the 2012-2017 sub-period and 69.61% over the 2018-2019 sub-period. However, the comparison test of means, in particular the non-parametric Kruskal-Wallis test, indicates that the average level of technical efficiency is not significantly different between these four sub-periods. Indeed, the Chi2 (3) statistic associated with the test displays a value of 5.196 with a p-value of 0.1580 (table 4). The scores calculated with both the DEA method and the SFA method record the same trend developments.

In the following, we make a comparative analysis of efficiency according to shareholding. According to the DEA approach, public banks appear to be less efficient than their domestic and foreign private competitors. Indeed, the average level of technical efficiency of public banks over the period 2005-2019 is 70.94% in constant return to scale including 76.27% technical efficiency in variable return to scale and 93.37% scale efficiency. Regarding domestic private banks and foreign banks, the average efficiency scores in constant return to scale over the period are 78.21% and 79.92% respectively. The overall technical inefficiency of public banks compared to other banks is due to inefficiency linked to production technique rather than to the scale of production.

Among the 5 most efficient banks both in terms of constant and variable returns to scale, we find four foreign banks (CITIBANK-CI, ECOBANK-CI, BICICI and SGCI), a domestic private bank (NSIA BANK) and no public bank.

Table 5. Comparison tests of average technical efficiencies (DEA) according to shareholding

| Dependent variable | Kruskal-Wallis test | | ANOVA | |
|-----------------------------|---------------------------|---------|-----------------------------|---------|
| | Test statistics: Chi 2(2) | p-value | Test statistics: F (2, 207) | p-value |
| Technical efficiency in REC | 11.948 | 0.0025 | 2.67 | 0.0740 |
| Technical efficiency in REV | 27.477 | 0.0001 | 7.52 | 0.0007 |

Source: Author, based on data from the BCEAO (2020) and WDI (2021).

From Table 5, it appears that public banks performed less during the period and more particularly, between 2005 and 2010, where the efficiency of public banks evolved below that of domestic private banks and foreign banks. Classic hypothesis tests comparing average technical efficiencies in constant returns to scale and variable returns to scale are all significant at the 1% level, thus confirming that banks display significantly different levels of efficiency depending on the type of shareholding.

The comparative analysis of the scores of the SFA model according to shareholding gives different results from those of the DEA model. Indeed, it appears that the level of efficiency of public banks remained below that of domestic private banks and foreign private banks during the period 2005-2010 with a low reached in 2006. Between 2005 and 2010, public banks had an average efficiency level of 64.64% while those of private banks and foreign banks were 86.19% and 78.24% respectively over the same period. But, between 2011 and 2019, public banks recorded an above-average level of efficiency with an average score of 77.11% compared to 77.31% for domestic private banks and 70.27% for foreign banks.

Table 6. Comparison tests of average technical efficiencies (SFA) according to shareholding

| Dependent variable | Kruskal-Wallis test | | ANOVA | |
|----------------------------------|---------------------------|---------|-----------------------------|---------|
| | Test statistics: Chi 2(2) | p-value | Test statistics: F (2, 207) | p-value |
| Technical efficiency (SFA score) | 3.541 | 0.1702 | 2.21 | 0.1127 |

Source: Author, based on data from the BCEAO (2020) and WDI (2021).

Comparison tests revealed that there was no significant difference in efficiency between banks over the entire period 2005-2019, due to the improvement in technical efficiency of public banks which reached the level of private banks and foreign banks between 2011 and 2019. Indeed, the Kruskal-Wallis test displays a statistic of 3.541 with a probability of 0.1702 and the ANOVA test gives a statistic of 2.21 with a probability of 0.1127 (Table 6). Both probabilities being greater than 0.05, we conclude that the efficiency levels are not significantly different depending on the shareholding. Among the 5 most efficient banks according to the SFA approach, there are three foreign banks (ECOBANK-CI, BICICI and SGCI), a domestic private bank (NSIA BANK) and a public bank (VERSUS BANK). In this section, we described the technical efficiency scores and conducted a comparative analysis of these scores according to shareholding using classic hypothesis tests. The scores obtained with the DEA approach seem to indicate that public banks are less efficient than other banks. Conversely, the comparative analysis with the SFA scores suggests that there is no significant difference between banks in terms of technical efficiency. The results of the econometric tests will help to better clarify this relationship.

5. Analysis and discussion of econometric results

In this section, we present and interpret the results of the second stage of our work which consists, using econometric regressions, in identifying the influence of shareholders on the technical efficiency of banks by taking into account the variables of control.

5.1. Tobit model estimation results

The model whose dependent variable is the DEA scores is called “model 1” and the one in which the dependent variable is represented by the SFA scores, “model 2”. The results and comments relate successively to each of these two models. When we have panel data, before proceeding with the estimation and interpretation of the results, it is essential to verify a certain number of tests, in particular on the structure of the data and the stationarity of the series available to us. We therefore carried out the homogeneity test of Hsiao (1986) and the independence test of Breusch-Pagan (1980) before carrying out the appropriate unit root differences on the series. The Hsiao test (1986) indicates that the two panels available to us are heterogeneous. Indeed, the p-values of the Hsiao test applied to the two panels are all less than 5%. As for the Breusch-Pagan dependence test (1980), it gives p-values greater than 5%. There is therefore independence between the individuals on the panel. This allows us to perform first generation unit root tests. The IPS tests indicate that all the series are stationary at the 5% threshold, because the null hypothesis of the presence of a unit root is rejected for each of the series. Since the series are all stationary at level, we can use them in the model. The homogeneity test displays a statistic with a value of 479.22 for model 1 and 3771.52 for model 2. This statistic is distributed according to a Chi 2 with 15 degrees of freedom for model 1 and a Chi 2 at 14 degrees of freedom for model 2. The associated p-value is less than 1% in both models. The null hypothesis of panel homogeneity can be rejected in both cases. Thus, the two panels are heterogeneous and we must take into account the heterogeneity in the estimation of the Tobit model. The estimation results are reported in Table 7.

Table 7. Result of Tobit model estimations

| Variable | Model 1 | | Model 2 | |
|------------------------|-------------|--------------------|-------------|--------------------|
| | Coefficient | Standard deviation | Coefficient | Standard deviation |
| <i>d1216</i> | 0.134*** | 0.033 | 0.023** | 0.009 |
| <i>d1719</i> | 0.114** | 0.057 | 0.034*** | 0.013 |
| <i>Private</i> | 0.085* | 0.044 | 0.004 | 0.019 |
| <i>Foreign</i> | 0.142*** | 0.049 | 0.005 | 0.019 |
| <i>Old</i> | 0.006*** | 0.001 | 0.001* | 0.001 |
| <i>Car</i> | 0.001 | 0.001 | 0.001*** | 0.000 |
| <i>Rnpl</i> | -0.008* | 0.004 | -0.003* | 0.002 |
| <i>Principal</i> | 0.001 | 0.001 | 16e-5 | 31e-5 |
| <i>Ln bilan</i> | -0.103*** | 0.022 | 0.015** | 0.007 |
| <i>Rcredit</i> | 0.012*** | 0.001 | 0.012*** | 28.5e-5 |
| <i>Rdepot</i> | -0.008*** | 0.001 | -0.006*** | 33e-5 |
| <i>Coexp</i> | 0.001*** | 0 | 2.6e-5 | 5.4e-5 |
| <i>lcb</i> | -0.002*** | 0.001 | 23.7e-5 | 17.8e-5 |
| <i>Regul</i> | 0.002 | 0.002 | | |
| <i>Inflation</i> | -0.007 | 0.006 | -0.002 | 0.002 |
| <i>Constant</i> | 2.302*** | 0.458 | 0.452*** | 0.147 |
| <i>sigma_u</i> | 0.061*** | 0.023 | 0.047*** | 0.01 |
| <i>sigma_e</i> | 0.104*** | 0.007 | 0.041*** | 0.002 |
| <i>Rho</i> | 0.2516*** | 0.1473 | 0.576*** | 0.109 |
| Number of observations | 210 | | 210 | |
| Prob > chi2 | 0.000 | | 0.000 | |
| Chi 2 of Wald | 479.216 | | 3771.525 | |
| AIC | -62.333 | | -671.933 | |

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Author, based on data from the BCEAO (2020) and WDI (2021).

5.2. Economic interpretations and discussion of results

The estimation of technical efficiency by the DEA and SFA approaches, over the period 2005-2019, indicates that the efficiency of banks in C te d'Ivoire is on average at 77.95% (with the DEA approach) and 75.48% (with the SFA approach). These levels of efficiency are higher than those found by Gah  et al. (2016) who obtained an average score of 47.64% over the period 2008-2010. These differences are justified in particular by the differences between the methodological approaches as well as the study period. Indeed, the study by Gah  et al. (2016) covers a relatively short period (2008-2010) and the only variables used for the estimation of technical efficiency scores are the outstanding deposits (input) and the outstanding loans (output) while our study uses multiple inputs and outputs.

Considering the results indicating the overall performance of the banks in the sample, in terms of technical efficiency, significantly improved after the period 2005-2011, it follows that the first hypothesis of our study is verified. The improvement in the technical efficiency of banks over time can be seen as a reflection of the measures and reforms put in place for the development of the financial sector in C te d'Ivoire. Indeed, the economic context reinforced by the implementation of vast reforms included in the national development plans over the periods 2012-2016 and 2017-2019 have strengthened the development of the country's banking sector.

The results also indicate that public banks are technically less efficient than domestic private banks and foreign banks in the activity of transforming deposits into credits. More precisely, the effect of foreign ownership on improving technical efficiency is the same as that of domestic private ownership. Our second hypothesis is therefore verified. Our results are similar to those of Gah  et al. (2016) who showed that foreign banks operating in C te d'Ivoire are more efficient than public banks and domestic private banks. On the other hand, our results are in contradiction with those of Diop and Ka (2020), on the WAEMU countries or even of Ntchabet et al., (2020), on Cameroon.

The outperformance of foreign banks and domestic private banks in terms of technical efficiency could be justified by the fact that they are generally subsidiaries of large international groups, enjoying long-term expertise in the banking profession, in 'other countries. They benefit from cutting-edge technologies and expertise allowing them to reduce banking risks.

Beyond the relationship between shareholding and banking technical efficiency, we focus our attention on a few control variables. Our results highlight an inverse relationship between the bad debt rate and technical efficiency. Indeed, a high rate of doubtful debts degrades the quality of the credit portfolio, causing losses in the credit granting process. Kamgna and Dimou (2008) and Bhatia and Mahendru (2015) have shown through their studies carried out respectively on CEMAC and India that, the more the rate of bad debts increases, the less efficient banks are in intermediation activity. , that is to say, the transformation of deposits into credits.

Furthermore, our results are among those which do not find a clearly established relationship between size and efficiency. Indeed, with model 1, we find that size has a negative influence on the technical efficiency obtained with the DEA approach, while with

model 2, we find that it has a positive influence on the SFA scores. Such a result indicates that the question of the link between the size of banks and technical efficiency is not clearly established. On the one hand, under certain conditions, too large a size can be a source of inefficiency, to the extent that the bank must bear significant costs linked to its operation and maintenance of the network (Abida and Gargouri, 2019; Srairi and Sahut, 2015). On the other hand, if banks benefit from economies of scale, then a large size favors the reduction of unit costs, and therefore, the improvement of performance. Dem (2003) showed that small banks operating in the WAMU space have increasing returns to scale, which should allow them to increase their size. The relationship between bank size and efficiency level appears to be non-linear.

6. Conclusion

Our goal in conducting this study was to assess the technical efficacy of Côte d'Ivoire's banks while accounting for the interests of shareholders. In order to do this, we applied a two-step process using panel data that included a selection of 14 commercial banks that were active in Côte d'Ivoire between 2005 and 2019. Initially, the task involved calculating the technical efficiency scores by utilising both the stochastic frontiers approach (SFA) and the data envelopment analysis (DEA) method. Banking inputs and outputs were selected using the intermediation technique in mind. Using a random effects Tobit model with right censoring, the second step of the approach measured the impact of ownership type on technical efficiency.

Our findings demonstrated that the Ivorian financial sector typically functions at a level of scale that is less than ideal. Over the years 2005 to 2019, the average technical efficiency in constant return to scale is 77.95%, with 85.54% efficiency in variable return to scale and 91.06% efficiency of scale. The average score attained using the SFA technique is 75.48%. The level of efficiency of banks in Côte d'Ivoire is still influenced by shareholding, as demonstrated by the examination of the coefficients of the explanatory variables under the influence of the control variables. In fact, there is a considerable positive correlation between the coefficients for foreign banks and domestic private banks. Furthermore, during the study period, banks' efficiency increased dramatically, especially during the two sub-periods that corresponded with the implementation of national development plans: 2012-2016 and 2017-2019. Ultimately, our findings show that excessively high deposit percentages on the overall balance sheet and a high percentage of dubious debts do not improve banks' technical efficiency.

These findings provide two important lessons. First, the financial sector's changes between 2005 and 2019 greatly increased the Ivorian banking system's efficiency. Secondly, Ivorian public banks convert deposits into loans with much less efficiency.

Regarding the implications for economic policy, our findings first imply that efforts to further enhance the efficiency of Côte d'Ivoire's banks are driving the financial sector development agenda. Second, we support the ongoing changes to public banks' shareholder structures that aim to provide private partners with access to capital.

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