

Custo x-eficiência e eficiência de escala no sector bancário angolano

Cost x-efficiency and scale efficiency in the angolan banking sector

Eficiencia de costes y eficiencia de escala en el sector bancario angoleño

Efficacité des coûts et efficacité d'échelle dans le secteur bancaire angolais

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Resumo

O objectivo deste documento é analisar o custo X-eficiência e eficiência de escala no sector bancário angolano durante o período 2007-2017. Para este efeito, foi aplicado o método da abordagem de Fronteira Estocástica (SFA), com a distribuição da ineficiência sob duas formas, nomeadamente Distribuições seminormal e Truncado-Normal. A amostra é composta por 22 bancos comerciais, que compreende 184 observações. Os resultados mostram que os modelos Semi-Normal e Truncado-Normal têm um custo X-eficiente de 83%, respectivamente. Os resultados revelam também que os bancos privados estrangeiros são os mais eficientes e os menos eficientes são os bancos estatais. Na segunda fase, foi analisado o efeito das variáveis de controlo e de mercado sobre o Custo X-eficiência e os resultados mostram que os empréstimos sem desempenho, o risco de liquidez, as exportações de petróleo, o GDPpc e a nacionalização dos bancos influenciam o Custo X-eficiência. Os resultados mostram que, numa análise global, os bancos angolanos operam à escala óptima, representando uma Escala Global Eficiente de um (1). Quando a amostra é dividida em grupos, observou-se que os pequenos bancos operam numa Escala Eficiente de um (1). Quanto à banca accionista, os bancos domésticos privados operam a uma escala de retorno constante.

Palavras-chave: Custo X-eficiente; Eficiente em Escala; Abordagem de Fronteira Estocástica; Bancos Angolanos

Abstract

The objective of this paper is to analyse the Cost X-efficiency and Scale efficiency in the Angolan banking sector over the period 2007-2017. For this purpose, it was applied the Stochastic Frontier Approach (SFA) method, with the distribution of inefficiency in two forms, namely: Half-Normal and Truncated-Normal distributions. The sample consists of 22 commercial banks, which comprises of 184 observations. The results show that the Half-Normal and Truncated-Normal models have a Cost X-efficient of 83%, respectively. The results also reveal that foreign private banks are the most efficient and the least efficient are state-owned banks. In the second stage, it was analysed the effect of control and market variables on Cost X-efficiency and the results shows that non-performance loans, liquidity risk, oil exports, GDPpc and bank nationalization influences the Cost X-efficiency. The results shows that in a global analysis, Angolan banks operate at the optimal scale, representing an overall Scale Efficient of one (1). When the sample is divided into groups, it was observed that small banks operate on a Scale Efficient of one (1). As for shareholder ownership banking, private domestic banks operate at a constant return to scale.

Keywords: Cost X-efficient; Scale Efficient; Stochastic Frontier Approach; Angolan Banks

Resumen

El objetivo de este trabajo es analizar la eficiencia de costes X y la eficiencia de escala en el sector bancario angoleño durante el período 2007-2017. Para ello, se aplicó el método del Enfoque de la Frontera Estocástica (SFA), con la distribución de la ineficiencia en dos formas, a saber: Distribuciones Seminormales y Truncadas-Normales. La muestra se compone de 22 bancos comerciales, que incluyen 184 observaciones. Los resultados muestran que los modelos Half-Normal y Truncated-Normal tienen un coste X-eficiente del 83%, respectivamente. Los resultados también revelan que los bancos privados extranjeros son los más eficientes y los menos eficientes son los bancos estatales. En la segunda etapa, se analizó el efecto de las variables de control y de mercado sobre el Coste X-eficiente y los resultados muestran que los préstamos no rentables, el riesgo de liquidez, las exportaciones de petróleo, el PIBpc y la nacionalización bancaria influyen en el Coste X-eficiente. Los resultados muestran que en un análisis global, los bancos angoleños operan a la escala óptima, representando una Eficiencia de Escala global de uno (1). Cuando la

muestra se divide en grupos, se observa que los bancos pequeños operan a una Escala Eficiente de uno (1). En cuanto a la banca de propiedad de los accionistas, los bancos privados nacionales operan con un rendimiento de escala constante.

Palabras clave: Costo X-eficiente; Escala eficiente; Enfoque de frontera estocástica; Bancos angoleños

Résumé

L'objectif de cet article est d'analyser l'efficience du coût X et l'efficience de l'échelle dans le secteur bancaire angolais sur la période 2007-2017. À cette fin, il a été appliqué la méthode de l'approche de frontière stochastique (SFA), avec la distribution de l'inefficacité sous deux formes, à savoir : Les distributions semi-normales et tronconormales. L'échantillon est composé de 22 banques commerciales, qui comprennent 184 observations. Les résultats montrent que les modèles Half-Normal et Truncated-Normal ont un coût X efficace de 83%, respectivement. Les résultats révèlent également que les banques privées étrangères sont les plus efficaces et que les banques publiques sont les moins efficaces. Dans la deuxième étape, l'effet des variables de contrôle et de marché sur l'efficience du coût X a été analysé et les résultats montrent que les prêts non performants, le risque de liquidité, les exportations de pétrole, le PIBpc et la nationalisation des banques influencent l'efficience du coût X. Les résultats montrent que dans une analyse globale, les banques privées étrangères sont les plus efficaces et les banques publiques les moins efficaces. Les résultats montrent que dans une analyse globale, les banques angolaises opèrent à l'échelle optimale, ce qui représente un Scale Efficient global de un (1). Lorsque l'échantillon est divisé en groupes, il a été observé que les petites banques opèrent à une échelle efficace de un (1). Quant à l'actionnariat bancaire, les banques privées nationales opèrent à un rendement d'échelle constant.

Mots-clés : Cost X-efficient ; Scale Efficient ; Stochastic Frontier Approach ; Angolan Banks

Introduction

The efficiency of commercial banks has been subject to academic research for many years. The evidences show that initially most banking efficiency studies were conducted in the US and Europe. Nowadays the banking systems of the developing countries have started to be conducted

by several researchers, this is justified by the concern that the growth of the economy cannot be carried on without the reformulation of the banking sectors, the legal and financial structures.

In Angola the credit is the main financing instrument of the economy and this sector has been growing quickly, since 2002 after the end of the civil war, but in real terms its impact is hardly visible. The bureaucratic situation, public sector culture and strict compliance with banking rules have been to contribute to the poor performance of this sector (Ferreira & Oliveira, 2015; 2018). On the other hand, it is highlighted the effect of the economic and financial crises, especially the one that started in 2014, and made banks stop exercising their true role, which is the sale of money, focusing on foreign currency buying and selling business (foreign exchange). As consequence, the gross interest margins slowed down its positive effect on the formation of net income for the year. Also within this period, we highlight the years 2015-2016, where banks had high deposit levels, on average 60% and 73.2%, respectively and low levels of loans, on average 28.9% and 35,1%, respectively and as a result of high liquidity levels, estimated at 19.6% and 16.1%, respectively, which is not normal for banking activity¹.

To this situation of the Angolan banking sector, the following hypotheses were raised: how to characterize the Cost X-efficient and Scale Efficient of Angolan banks? What is the behaviour of Cost X-efficient and Scale Efficient in the period 2007-2017? What are factors influence the Cost X-efficient of Angolan banking?

In order to respond to the questions above, the following objective was set as to analyse the Cost X-efficiency and the Scale efficient in the Angolan banking sector.

This paper has three originals contributions: i) It is the first paper that measures the Cost X-efficiency and the Scale Efficient in Angolan banking; ii) It is the first applies the SFA model to Angolan bank data and iii) It is uses the most recent data Angolan banking sector.

After the introduction, this paper presents in section 2: Describes the main theoretical contributions of Cost X-efficient and Scale Efficient in Angolan banking; section 3 presents the applied methodology and data selection process; section 5: main findings and section 6: conclusions, policy implications and suggestions for future studies.

¹ Report of the Association of Angolan Banks 2016. Retrieved October 20, 2018 at <https://www.bancosdeangola.co.ao/banks>.

2.1 Concept of efficiency and its applicability in banking

The economic and financial efficiency of firms has been a research area since early times by various investigators and managers. In the 1950s, the first definition of technical efficiency was made by Koopmans (1951). Ferrell (1957) empirically developed efficiency measures from the concept defined by Koopmans. The combination of technical efficiency and allocative efficiency provides the measure of economic efficiency (Coelli et al., 1998) and Leibenstein (1966) introduced for the first time in the literature the concept of Cost X-efficiency.

Likewise, the efficiency of banks has been subject to academic research for several years. The vast majority of banking studies have been conducted in the US and Europe (Kwan, 2006) and recently in developing countries. Thus, the applicability of the banking efficiency concept is notable (see: Martins, 2012; Maudos et al., 2002; Berger & Mester, 1997; Aboagye-Debrah, 2007 and Adjei-Frimpong, 2013). The author's further state that the definition of cost and profitable efficient and banking respectively corresponds to two important economic objectives: cost minimization and profit maximization. Banking efficiency is usually defined in three measures, namely: efficient profit, alternative efficient profit and Cost X-efficient.

In this study, the Cost X-efficient measurement is developed, being the main variable that is used to measure efficiency in most studies that report efficiency in the banking sectors.

In the banking context, Cost X-efficiency measures the distance between a given bank's spending against best practices industry or the minimum cost of production that would be spent if the bank were efficient against the sample best practices and some exogenous variables to predict the current cost adjusted for random error (Berger & Mater 1997; Martins, 2012).

Cost X-efficient is the proportion of costs or resources that are used efficiently: A ratio 80% Cost X-efficient indicates that the bank is 20% less efficient than best banking practice, operating under the same conditions of the sample banks. The Cost X-efficiency theoretically ranges from (0 to 1), where 1 is equal to best banking practice within the observed data. One of the limitations of Cost X-efficiency is that its estimation simply measures best practice from all banks in the sample. Best banking practices alone may not be efficient compared to out-of-sample banks (Sokic, 2015: Fu & Heffernan, 2007; Berger & Mester, 1997).

Cost X-efficiency differs from Scale Efficient in that it is limited to a given output level, while Scale Efficient attempts to determine a lower cost scale and the boundary mix of a given output by considering the firm as if it were operate within the optimal efficient frontier (Berger & Humphrey, 1993).

2.2 Concept of Scale Efficient and its applicability in banking

The discussion of firm efficiency can be analysed according to the technological frontier and the price level of inputs and outputs. The analysis assumes that a firm is technically and allocative efficient but may not operate at the optimal operational scale. There are two cases of Scale efficient analysis: the first is a small firm that has an increasing return scale and operates on the smallest operating scale. In this context, management could efficiently use resources to increase the unused return scale and the second case is for a larger firm and operates within the decreasing return scale (Ferrell, 1956; Coelli et al., 1998).

To Altunbas et al. (2000) and Mahajan et al. (1996), the measure of the Scale Efficient is given by the following cost elasticity, differentiating from the cost function. Economies of scale occur when a firm intends to expand production capacity, when the increase in the total quantity of products without in return increases the cost of production, as a consequence of the lower average cost (Martins, 2012).

The concept of Scale Efficient is also applicable in the banking context. In this sense, a bank is said to operate on an Scale Efficient if it has the ability to reduce the average cost of production against the increase in outputs, in other words, the Scale Efficient exists if an increase in all outputs leads to a less than proportional increase average cost (Yang, 2012; Margono et al., 2010).

The Scale Efficient of a bank is measured as follows: if the Scale Efficient (SE) is greater than one, the bank exhibits a decreasing return scale; if the SE is less than one, the bank exhibits increasing return scale, which implies diseconomies of scale and if SE equals one, the bank exhibits constant return scale (Margono et al., 2010; Altunbas et al., 2000). One of the major difficulties in measuring Scale Efficient banking result from the difference that the largest banks produce a variety of products that have different technologies or different degrees of cost dispersion compared to smaller banks, and this may create limitations in the analysis Scale Efficient measurements.

2.3 Review of methods used in efficiency studies

For several years, two main approaches to measuring efficiency have been developed: deterministic or nonparametric approach, that assumes that the banks use technology and costs common against the production frontier and all deviations in firm performance are attributed to the relative efficiency variation this common boundary and the econometric or parametric approximation that assumes that firms can deviate from the minimum cost attainable for exogenous reasons and through the effect of inefficiency (Al-jarrah et al., 2017; Erkoc, 2012). The notable difference between parametric and nonparametric approaches is that parametric methods assume the error component in boundary estimation frontier efficient, whereas nonparametric methods assume that random error does not exist, thus neglecting the importance of specifying best practice of the bank (Huljak, 2015).

The most used nonparametric model for analysis efficiency is Data Envelopment Analysis (DEA), and for parametric methods, the following stand out: Distribution Free Approach (DFA), Thick Frontier Approach (TFA) and Stochastic Frontier Approach (SFA)) (see: Fu, 2004; Berger & Mester, 1997; Berger & Humphrey, 1993; Coelli et al., 1998; Chen et al., 2014).

The Frontier Approach Analysis (SFA) method which is motivated by the theoretical ideas that economic agents can exceed the ideal frontier and the deviations to the extremes that represent individual inefficiency. From a stochastic point of view, this model has been implemented by means of regression models, characterized by the composition of the term error, in which the classic idiosyncratic disorder points to error capture and other noise, including the unilateral distribution representing inefficiency (Belotti et al., 2012). The SFA method generally assumes that inefficiency follows a somewhat normal asymmetric distribution and random error follows a normal symmetrical distribution. Both are orthogonal to the exogenous variables of the cost function (Berger & Humphrey, 1993). The model parameter can be used to estimate specific efficiency bank and error distribution mean and generally used for mean inefficiency (Berger & Mester, 1997).

The SFA method was developed by Aigner et al (1977) stimulated by works Ferrell in 1957. This new model involves the specification of error. The term error is the result of the two-component

effect, where the error component represents the symmetrical distribution assumed to be independently and identically distributed and the inefficiency component is assumed to be asymmetrically distributed and reflects the fact that each output of a firm can be positioned below or above the stochastic frontier. Still for the authors, some deviations are results of factors that are under the control of the firm, such as technical inefficiency, which is a consequence of less efforts of employees in the production process. But it must be emphasized that the frontier itself may vary randomly depending on the firm's inputs and outputs or over time.

Like the DEA, the SFA model is the most applied parametric model in banking efficiency studies (see: Nurboja & Kosák, 2017; Belotti et al., 2012; Barros & Williams, 2013; Fu, 2004; Brissimis et al., 2010; Maudos et al., 2002; Altumbas et al., 2000; Andries & Căparu, 2012; Weill, 2009; Pasiouras, 2009; Margono et al., 2010; Al-jarrah et al., 2017; Aiello & Bonanno 2016 ; Liadaki & Gaganis, 2010; Barros & Wanke, 2014; Nițoi & Spulbar, 2015; Vennet, 2000; DeYoung et al., 1998; Schmidt & Sickles, 1984).

Studies by various authors in the banking sector help to identify the advantages and disadvantages of each of the above methods. Berger & Humphrey (1993) state that there is no simple rule for determining which of these methods best develops the true nature of bank data. The problem would be if all methods came to the same conclusion. Fortunately, this is not the case. The choice of method measures seems to affect the level of inefficiency. Studies by the same authors conclude that studies applying SFA, TFA and DEA in banks usually find average inefficiency ranging from 20 to 25% of costs, while for authors using DEA their results indicate a range between 10% to 50%.

2.4 Review of empirical studies on banking efficiency

The evidence shows that initially most of the bank efficiency studies were done in the US and Europe. Nowadays the banking systems of developing countries have started to be researched by many investigators. This is justified by the concern that economic growth cannot be continued without the reformulation of the banking sectors, legal and financial structures.

Some studies on efficiency in developed countries show that the average level of efficiency in developed countries ranges from 49.6% to 94% and the average Scale Efficient is less than one (1) (See: Maudos et al., 2002; Huljak 2015; Tsionas et al., 2015; Karafolas & Mantakas, 1996;

Liadaki & Gaganis, 2010; San-Jose et al., 2014; Nurboja & Košak, 2017; Sokic, 2015; Tsionas et al., 2015; Williams, 2004; Řepková, 2015; Gunes & Yildirim, 2016; Aiello & Bonanno, 2016; Martins, 2012; Berger & Humphrey, 1993; Berger & Mester, 1997; Mahajan et al., 1996; Drake & Hall, 2003; Altunbas et al (2000; Tsionas & Mamatzakis, 2017; Wanke et al., 2016).

Some studies in emerging countries show that the average level of efficiency ranges from 30% to 89.7% (see: Bonin et al., 2005; Degl et al., 2017; Wanke et al., 2017; Nițoi & Spulbar, 2015; Fu, 2004; Berger et al., 2009; Yang, 2012; Fu & Heffernan, 2007; Kwan, 2006; Drake et al., 2006; Badunenko & Kumbhakar, 2017; Barros & Williams, 2013; Barros & Wanke, 2014; Tsionas & Mamatzakis, 2017).

Efficiency studies in developing countries show that the average level of efficiency ranges from 66% to 91% (see: Macanda, 2015; Tsionas & Mamatzakis, 2017; Huljak, 2015; Margono et al. , 2010; Al-Jarrah et al., 2017; Huang & Chung, 2017; Pasiouras et al., 2009; Doan et al., 2018; Miah & Uddin, 2017; Al-Gasaymeh, 2016; Macanda, 2015; Berger, 2007; Tsionas & Mamatzakis, 2017; Khan, et al., 2017).

The factors and variables affecting Cost X-efficiency in developed countries are as follows: asset risks, financial crisis, bad credit, bank size, credit risk, number of workers per branch, bank ownership, and the quality of credit. Studies in emerging and developing countries add: foreign banks, regulatory factors, privatization of banks, regulation and supervision, socioeconomic and demographic variables.

3. Methodology and Data

The bank cost measurement is determined through the approximation of the cost of the optimal frontier, given the best practices of the sample, in other words, the banks with the lowest market cost compared to the same amount of output produced under the same market conditions.

This concept is measured from a frontier, where a determined bank uses inputs and outputs. But the frontier outputs may exceed the value of the production function (called the deterministic frontier), because banking is associated with favourable conditions and, in this situation, the observed errors are positive. However, it may be the case that the inputs used by banks correspond to a potential output, which is less than the cost value of the deterministic function. In this condition, banking activity is associated with unfavourable conditions, which makes the random

errors observed in banking activity to be negative. In both cases, the observed frontier cost values would be positioned around the deterministic cost function of all banks in the sample (Battese, 1992).

3.1 Method of the Stochastic Frontier Approach

In general the version of the equation used to measure bank cost is as follows:

$$TC_{i,t} = C(y_{i,t}; w_{i,t}) + \varepsilon_{i,t}, \quad i = 1, 2, \dots, N; t = 1, \dots, T. \quad (3.1)$$

Or,

$$\ln TC_{i,t} = \ln C(\ln y_{i,t}; \ln w_{i,t}) + \ln \mu_{i,t} + \ln v_{i,t}, \quad i = 1, 2, \dots, N; t = 1, \dots, T. \quad (3.2)$$

This model derives from the independent studies proposed by Aigner et al. (1977) and Meeusen & van Den Broeck (1977). Where i represents a particular bank and t has a certain period. TC_{it} it is the Total Cost or the natural logarithm of the Total Cost of bank i at time t ; w_{it} it is the input price or logarithm of the input price of bank i at time t ; y_{it} it is the amount of output or logarithm of output from bank i at time t , and the term error (ε_{it}) of the cost function is assumed as follows:

$$\varepsilon_{i,t} = u_{i,t} + v_{i,t} \quad (3.3)$$

Where $\varepsilon_{i,t}$ is not correlated with $u_{i,t}$ and $v_{i,t}$, and $u_{i,t}$ represents inefficiency.

In this sense, the cost X-efficient is defined as the expected minimum cost that would be used if the bank were efficient against the best practices of the sample, having the same endogenous variables (w, y) for the current cost, adjusted for random error. Thus, following Solís & Maudos (2008), the following measure the Cost X-efficiency of a given bank:

$${}^c CEF_{i,t} = \frac{c_{\min}}{c_{i,t}} = \frac{\exp(f(y_{i,t}; w_{i,t})) \exp(\ln v_{i,t})}{\exp(f(y_{i,t}; w_{i,t})) \exp(\ln u_{i,t}) \exp(\ln v_{i,t})} = \exp(-\ln u_{i,t}). \quad (3.4)$$

Where: c^{min} is the minimum cost used by sample best practice banks; C_i is the current cost, v_{it} it is the minimum error of all banks in the sample, and u_i it is the current Cost X-inefficient cost of each bank i in the sample

The above model has been applied and modified in several studies and they give different treatment to the term inefficiency (u_{it}), in function its behaviour in time and its distribution. For example, some authors consider non-variation of time inefficiency (see: Kumbhakar, 1990; Battese & Coelli, 1992; Greene, 2005) and others consider variation of time inefficiency (see: Battese & Coelli, 1988; Pitt & Lee, 1981; Greene 2005). In this paper both ways of considering inefficiency in time were used. Thus it was used the model with the Truncated-Normal distribution by Battese & Coelli (1992) and the model the Kumbhar (1990), with Half-Normal distribution both models took into account the variation of inefficiency over time. We also used the model with the Truncated-Normal distribution by Battese & Coelli (1988) and the model with the Half-Normal distribution by Pitt & Lee (1981) both models considers inefficiency to be invariant in time.

3.2 Stochastic frontier Approach method specification

In accordance with the literature studied, Cost X-efficient estimation models have adopted two functions: the Fourier-flexible functional function and the translogo function. The former requires more degrees of freedom, but with few banks or with a short history, adopting this model the Angolan reality could make the analysis of efficiency difficult. For this, the translogo function was applied in this paper following (Fu & Heffernan 2007; 2009; Altunbas et al., 2000), as follows:

$$\ln TC_{i,t} = \alpha + \sum_{p=1}^3 \gamma_p \ln y_{p,i,t} + \sum_{n=1}^3 \beta_n \ln \frac{w_{n,i,t}}{w_{3,i,t}} + \dots +$$

$$1 \frac{-\sum_{p=1}^{3q} \phi_{pq} \ln y_{p,i,t} \ln y_{q,i,t}}{2 \sum_{p=1}^{3q} \phi_{pq}} + \frac{1}{2} \sum_{n=1}^{3q} \theta_{nm} \ln \frac{w_{n,i,t}}{w_{3,i,t}} \ln \frac{w_{m,i,t}}{w_{3,i,t}} + \ln u_{i,t} + \ln v_{i,t}$$

(3.8)

Where: CT_{it} it is the natural logarithm of the total cost of bank i at time t ; y_1 , y_2 and y_3 are the natural logarithms of the three outputs obtained by bank i at time t ; w_1 , w_2 and w_3 are natural logarithms of the three price factors of bank i at time t ; and α , β , ϕ , θ and γ are the parameters to be estimated.

To homogenize input price factors using the wage price factor of employees (w_3), this normalization is necessary to ensure that the costs used by various banks with different dimensions do not vary.

The literature also presents two different approaches to measuring banking services, such as: production approach that employs capital and labour to produce both deposits and loans. The intermediate approach considers banks to be financial intermediaries that receive deposits to offer to borrowers in the form of loans. In this sense, outputs are treated as stock and measured by the value of loans and total costs include operating costs. In this paper an intermediate approach was applied, following (Fu & Heffernan, 2007; Altunbas et al., 2000; Berger, 1993).

To determine the effect of control and market variables on efficiency, in second stage estimation the equation was presented below:

$$\begin{aligned}
 CEF_{i,t} = & \alpha + \rho_1 EMP_{i,t} + \rho_2 Rliq_{i,t} + \gamma \frac{y_{2,t}}{z_{i,t}} + \phi_1 EXPORT_{petr_{i,t}} + \dots + \\
 & \phi_2 PIB_{pc_{i,t}} + \lambda BN_{i,t} + \pi_1 2008 + \pi_2 2014 + \varepsilon_{i,t}.
 \end{aligned}
 \tag{3.9}$$

Where CEF is Cost X-efficient; NPL is the Non-performance loan; Rliq is the liquidity risk; y_2/z is assets risk; BN is a dummy variable, where one (1) represents the nationalized banks and zero (0) others; $EXPORT_{petr}$ are petroleum exports; GDP_{perc} is the Gross Domestic Product per capita and $\alpha, \rho, \gamma, \phi$ and τ are parameters to be estimated.

3.3 Scale Efficient Measurement

The Scale Efficient (SE) is determined as a function of each bank's outputs and the respective input price factors. A Scale Efficient measure (SE) is given by the second derivative of the elasticity of the cost function, with respective input price factors presented in equation (13). For this, was followed the methodology used by Goldberg & Rai (1996); Fu & Heffernan (2009), where the Scale Efficient is determined as follows:

$$\begin{aligned}
 EEF_{i,t} = \sum_{i=1}^3 \frac{\partial \ln TC_{i,t}}{\partial \ln y_{i,t}} = & \alpha + \frac{1}{2} \sum_{p=1}^3 \sum_{q=1}^q \Phi_{pq} \ln y_{i,t} + \frac{1}{2} \sum_{n=1}^q \sum_{m=1}^m \theta_{nm} \ln \frac{w_{n,t}}{w_{m,t}} + \sigma \ln z_{i,t} = 1 \tag{3.10}
 \end{aligned}$$

Where $\partial \ln TC$ is the natural logarithm of the second derivative of the multiple output cost function; y is the vector of outputs; $\ln z$ is the natural logarithm of the size of bank i at time t ; and α , ϕ , and θ are parameters to be estimated and one (1) is a constraint of the Scale Efficient function, where: If SE is less than 1, then it is facing the increasing returns scale; if SE is equal to 1, then if it is before the constant returns scale and if SE is greater than 1, then it is before the decreasing return scale, thus implying diseconomies of scale.

3.4 Definition of variables in the study of Cost and Scale Efficient

In the model SFA the variables were used are following: Total costs (TC) - is the sum of the costs of deposits, personnel costs and depreciation costs. The outputs used are as follows:

Deposits (y_1) - is the sum of short and long term deposits; Loans (y_2) - is the sum total of loans granted to customers, companies and states, and Bank Income (y_3) - is the banking income before operating costs. The inputs used are as follows: staff cost (w_1) - is the ratio of the sum of staff cost to assets; Fixed asset cost (w_2) - is the ratio of total fixed asset expense to total fixed asset. Total assets equals gross assets minus depreciation or amortization and total fixed asset expenses equals depreciation in a given period and cost of funds (w_3) - is the ratio of total borrowing expenses to the total credit given to the economy.

The literature consulted presents several factors specific to the banking sector. In this paper, the following variables were selected: Nonperforming loans (NPL): is the ratio of loan provisioning to total loans. Liquidity risk (Rliq): it is the ratio of cash and total assets, this variable was used to contain liquidity risk, knowing that ensuring liquidity is a cost to banks as well as high volumes of cash represents high risk. It was also analysed the loan-to-asset ratio (E/z), which measures asset risk. The Nationalized Banks (BN): it was included for reasons of not registering in the previous studies the inclusion of this variable significant effect on Cost X-efficiency.

The banking dimension (z): is measured by the natural logarithm of total assets. Bank assets are included to contain the difference between banks, induced by bank size in Scale Efficient. Time (Tend): Included is the trend which is a time measure and serves to capture the technological and crisis effect on the Angolan banking sector.

This paper includes two market variables, namely: oil exports (EXPORToil): which is essential to study this variable, due to the excessive dependence of the Angolan economy on the oil sector

and the Gross Domestic Product per capita (GDPpc): it is measured by ratio of gross domestic product to millions of kwanzas divided by total population.

3.5 Data

Study analysis covers the period 2007-2011. The data used were evaluated according to each bank included in the sample. For this purpose, all banks that did not present data for three financial years were excluded and banks with insufficient data in a given year were considered as missing data in the data panel, with this treatment it was possible to obtain a sample of 22 banks and were excluded 8 banks that do not meet the pre-established requirement for the study.

The data panel treatment yielded 185 annual observations, representing approximately 85% of bank assets in the period under analysis. The data were taken from the accounts and management reports of the 22 banks published at the website of the Association of Angolan Banks. Data on macroeconomic variables were obtained from the Angolan State General Budgets for the periods under examination and from the Catholic University Economic Reports. The 22 banks studied in this which includes three (3) public banks, fifteen (15) national private banks and four (4) foreign private banks.

The table below presents the statistical description of all variables used in the econometric models developed above and measured in thousands of Kwanzas:

Table 1: Descriptive statistics of the variables used in the study of cost and scale efficient (measured in thousands of Kwanzas).

| Variable | Description | Mean | Standard-deviation | Min | Max |
|----------|-----------------------------------|---------|--------------------|---------|---------|
| CT | Total costs | 157.975 | 246.10 | 0 | 985 |
| | Deposits | 90.06 | 200.75 | 0 | 999 |
| | Loans | 82.83 | 188.79 | 0 | 988 |
| | Gross Margin | 134.24 | 245.25 | -284 | 997 |
| | Price of employees | 0.049 | 0.374 | 0 | 5.766 |
| | Price of funds | 0.393 | 1.606 | 0 | 16.90 |
| | Price of fixed assets | 0.310 | 1.864 | 0 | 27.20 |
| | Non-Performance loans | 0.437 | 4.371 | 0 | 66.14 |
| | Liquidity risk | 0.174 | 0.169 | 0 | 0.979 |
| | Asset risk | 0.04 | 1.81 | -5.6 | 6.5 |
| | Oil Exports | 0.236 | 1.130 | 3.237 | 8.516 |
| | Gross Domestic Product per capita | 19.318 | 91.31 | 241.713 | 535.921 |

Source: Angolan Banks Association (Angolan Bank Account Reports: 2007 – 2017)

4. Empirical Results of the Cost Efficient

The Cost X-efficient was estimated through the translogo functional form of the cost function frontier and four specifications with different distributions were applied, namely: Kumbhakar's (1990) Model I the Half-Normal distribution; Battese & Coelli (1992) model II the Truncated-Normal distribution; Battese & Coelli (1988) model III the Truncated-Normal distribution and Pitt & Lee (1981) model IV the Half-Normal distribution, in a sample of 22 Angolan banks in the period 2007-2017.

Models I and II assume time-varying inefficiencies and have a log likelihood of -289.4460 and -289.4418, which is superior to models III and IV, which assumes that inefficiencies are time-invariant, with a log likelihood of -289.36. Nevertheless, it appears that there is no significant difference in log likelihood between the models. Overall, the models have a

probability of x^2 less than 1%, which means that the input and output variables introduced into the models are statistically significant to explain the found levels of efficiency. The individual analysis of the inputs and outputs involved in the models shows that deposits, staff costs, difference in deposits, the cointegrated effect of deposits with banking income are the main explanatory variables of bank inefficiency in Angola, at a level of 5 and 10%, As shown in table 2.

Table 2: Estimated Parameters of the Stochastic Frontier Model

| Variable | Parameters | Model I | Model II | Model III | Model IV | |
|------------|------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|-------------------|
| | | Regression Coefficient and (P-Value) | Regression Coefficient and (P-Value) | Regression Coefficient and (P-Value) | Regression Coefficient and (P-Value) | |
| <i>LCT</i> | | -7.301*** (4.33) | 7.370*** (5.28) | 7.65*** (5.14) | 7.65*** (5.28) | |
| | | -1.312*** (-3.27) | -1.338*** (-3.35) | -1.34*** (-34) | -1.34*** (-3.40) | |
| | | -0.327 (-1.03) | -0.330 (-1.03) | -0.33 (-1.04) | -0.33 (1.04) | |
| | | 0.081 (0.45) | 0.069 (0.38) | 0.06 (0.34) | 0.06 (0.37) | |
| | | 0.583** (1.80) | 0.609** (1.94) | 0.61** (1.95) | 0.61** (1.95) | |
| | | -0.443 (-1.09) | -0.409 (-1.00) | -0.42 (-1.05) | -0.42 (-1.05) | |
| | <i>I</i> | | -0.112 (0.34) | 0.072 (-0.22) | -0.08 (-0.25) | -0.08 (-0.25) |
| | | | 0.145 (1.59) | 0.147* (1.69) | 0.15* (1.74) | 0.15 (1.74) |
| | | | 0.039 (1.01) | 0.039 (0.99) | 0.04 (1.02) | 0.04 (1.02) |
| | | | 0.141** (2.10) | 0.144** (2.14) | 0.014** (2.09) | 0.014** (2.09) |
| | | | -0.034 (-0.41) | -0.033 (-0.40) | -0.04 (-0.49) | -0.04 (-0.49) |
| | | | 0.049 (0.79) | 0.049 (0.79) | 0.05 (0.85) | 0.05 (0.85) |
| | | | 0.047 (0.58) | 0.045 (0.55) | 0.04 (0.54) | 0.04 (0.54) |
| | | | -0.067 (-0.85) | -0.064 (-0.80) | -0.06 (0.84) | -0.06 (0.84) |
| | | | -0.077 (0.87) | 0.087 (-0.98) | 0.08 (0.94) | 0.08 (0.94) |
| | | | 0.059 (-0.68) | -0.068 (-0.83) | -0.05 (-0.61) | -0.05 (-0.61) |
| | | 0.109 (-1.17) | -0.104 (-1.12) | -0.11 (-1.19) | -0.11 (-1.19) | |
| | | 0.050 (-1.39) | -0.05 (-1.43) | -0.04 (-1.36) | -0.04 (-1.36) | |
| | | 0.17 | 0.17 | 0.21 | 0.10 | |

| | | | | |
|-------------------------------|-----------|-----------|-----------|-----------|
| | 1.578 | 0.49 | 0.04 | |
| | 0.22 | 1.561 | 0.07 | 0.28 |
| | 1.25 | 1.599 | 1.57 | 1.57 |
| Estimação da eficiência média | | | | |
| Média | 0.83 | 0.83 | 0.79 | 0.90 |
| DP | 0.052 | 0.125 | 0.04 | 0.03 |
| Min | 0.72 | 0.33 | 0.61 | 0.83 |
| Max | 0.88 | 1.96 | 0.87 | 0.93 |
| log Likelihood | -289.4460 | -289.4418 | -289.36 | -289.36 |
| | 336.45*** | 339.63*** | 337.62*** | 337.65*** |
| Prob > | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Note: Model I is from Kumbhakar (1990); model II is by Battese & Coelli (1992); Model III is by Battese & Coelli (1988) and Model IV by Pitt & Lee (1981). Models I and III have a half-normal distribution and models II and IV have a half-truncated distribution. T-statistic in parentheses estimates *, ** and *** the significance level of 10%, 5% and 1% respectively. The following is the descriptive efficiency statistics for each model and finally model validation elements.

The $\hat{\mu}$ estimated represents the level of cost X-inefficient. For this purpose, models with the specification of the Half-Normal and Truncated-Normal distribution with time-varying inefficiency have an inefficient cost level of 17%. And when inefficiency is time-invariant, the Half-Normal model has an inefficient cost of 10% and the Half-Truncated model has an cost inefficient cost 21%.

Based on the estimation of inefficiency (μ), the cost X-efficient level of the Angolan banks was estimated and the results show that the average cost X-efficient level in the Half-Normal and Truncated-Normal distribution models with time-varying inefficiency is 83%. For models with invariant time inefficiency, the efficiency level is 90% for the Half-Normal model and 79% for the Truncated-Normal model.

The cost-efficient average found in the Half-Normal and Truncated-Normal models with time-varying inefficiency is acceptable and converge with the results found by (Nurboja & Košak, 2017; Macanda, 2015; Tsionas & Mamatzakis, 2017; Barros & Williams, 2013; Huljak, 2015; Fu & Heffernan, 2007) in the countries of eastern Europe, Angola, Mexico, China and Croatia and are below the average cost X-efficiency found by (Berger et al., 2009; Margono et al., 2010; Al-Jarrah et al., 2017; Huang & Chung, 2017; Pasiouras et al., 2009; Weill, 2009; Doan et al., 2018; Sokic, 2015; Andries & Cpraru, 2012;) on China, Indonesia; in East and North Africa; in Taiwan; Serbia and Montenegro and in the member and non-member countries of the European Union. In this case, it can be said that the average level of cost efficiency fits within those results found at the level of developing countries².

The concept of cost X-efficient is defined as a function of optimal cost. For the specific case, it can be said that the cost X-efficient average of Angolan banks varies from 79% to 90%, “depending on the form of variation or not inefficiency over time”. But here, we emphasize the Cost X-efficient average presented by models that consider the time-varying inefficiency,

² The differences between the results of this research and the other researches, which served as comparisons, are based on the different applied approaches and different studied periods.

which is 83%, which means that Angolan banks have to improve their cost application by 17% to achieve bank performance best practices, producing the same amount of goods and services provided under the same market conditions.

The results in the table below show the Cost X-efficient average in function of bank share ownership (publicly owned banks, national privately owned banks and foreign private owned banks) and for each year of study using the result of the model Truncated-Normal distribution of the Coelli & Battese (1992), who considers variant inefficiency in time.

Table 3: Average overall Cost X-efficiency by type of bank property and over Period

| Years | Cost X-efficient | | | | | | | |
|---------------------|------------------|------|--------------|------|----------------|------|---------------|------|
| | Overall Banks | | Public Banks | | Domestic Banks | | Foreign Banks | |
| Mean | SD | Mean | SD | Mean | SD | Mean | SD | |
| 2007 | 0,86 | 0,03 | 0,83 | 0,06 | 0,86 | 0,04 | 0,94 | - |
| 2008 | 0,80 | 0,04 | 0,77 | 0,08 | 0,79 | 0,05 | 0,9 | 0,02 |
| 2009 | 0,82 | 0,03 | 0,81 | 0,07 | 0,81 | 0,05 | 0,87 | 0,04 |
| 2010 | 0,85 | 0,02 | 0,84 | 0,05 | 0,84 | 0,03 | 0,89 | 0,03 |
| 2011 | 0,89 | 0,01 | 0,87 | 0,03 | 0,87 | 0,02 | 0,93 | 0,02 |
| 2012 | 0,9 | 0,01 | 0,88 | 0,02 | 0,89 | 0,01 | 0,94 | 0,01 |
| 2013 | 0,88 | 0,01 | 0,86 | 0,03 | 0,87 | 0,01 | 0,93 | 0,02 |
| 2014 | 0,89 | 0,01 | 0,88 | 0,02 | 0,88 | 0,02 | 0,94 | 0,01 |
| 2015 | 0,87 | 0,01 | 0,85 | 0,03 | 0,86 | 0,01 | 0,92 | 0,04 |
| 2016 | 0,72 | 0,03 | 0,64 | 0,08 | 0,7 | 0,04 | 0,82 | 0,04 |
| 2017 | 0,71 | 0,03 | 0,67 | 0,01 | 0,69 | 0,04 | 0,81 | 0,05 |
| Overall Mean | 0,83 | | 0,80 | | 0,82 | | 0,89 | |

Note: BP - Public Banks; BPN - National Private Banks and Foreign Private Banks.

The results show that the most efficient banks in the sample are foreign private banks, with an average Cost X-efficient of 89% and public banks are the least efficient, with an average Cost X-efficient of 80%. These results are in line with those found by Gunes & Yildirim (2016) in Turkia, Sokie (2015) in Montenegro and Serbia and Fu & Heffernan (2004; 2007) China; Berger et al. (2009) also in China.

Over the period under analysis, the results showed that the Cost X-efficient ranged from 0.71 to 0.90. To prevent this situation, the Angolan State has implemented a set of regulatory measures to bring banking sector standards into line with international standards and as result in 2019 the closure of some Angolan banks such as: the *Banco Angolano de Negócio e Comercial* (BANC); Banco Mais S.A and Banco Postal S.A.

In the second stage, sought to determine the effect of market and control variables, such as: Non-performance loans (NPL), liquidity risk (Rliq), asset risk (E/z), oil exports (Expotpetr), Gross Domestic Product per capita (GDPpc), the Dummy variable representing the nationalization of banks and the effects of economic and financial crises in 2008 and 2014 on cost X-efficiency, as reflected in the table below.

Table 3.4: Estimated econometric models in the second stage

| Variable | Parameters | Model I | Model II | Model III |
|----------------|------------|--------------------------------------|--------------------------------------|--------------------------------------|
| | | Regression Coefficient and (P-Value) | Regression Coefficient and (P-Value) | Regression Coefficient and (P-Value) |
| CEF | | 0.817*** (47.57) | 0.826*** (31.96) | 0.807*** (31.96) |
| EMP | | -0.0004 (-0.25) | -0.0007*** (-2.63) | -0.0006** (-1.67) |
| Rliq | | 0.099* (1.79) | 0.092*** (2.72) | 0.119*** (3.52) |
| E/z | | 0.0004 (0.50) | 0.00001 (0.72) | 0.0006 (0.12) |
| EXPORTpetr | | 0.055** (2.00) | 0.040 (1.25) | - |
| PIBpc | | -0.011*** (-3.25) | -0.0009** (-2.18) | - |
| BN | λ | 0.016 (0.71) | 0.01** (2.48) | 0.035*** (4.58) |
| 2008 | | -0.015 (-0.42) | - | - |
| 2014 | | 0.06** (2.47) | - | - |
| F-statistic | | 0.26 | 0.27 | 0.27 |
| Prob-F | | 51.99*** | 630.87*** | 630.87*** |
| Teste de Reset | | 0.0000 | 0.000 | 0.000 |
| F-statistic | | 49.66** | 73.05** | 73.05** |
| Prob-F | | 0.02 | 0.01 | 0.01 |

Note: In the second stage estimation, the efficient cost used results from the Battese & Coelli (1992) model, which considers the fixed efficiency over time. In model II, the temporal Dummies variables that measure economic crises were excluded, and in model III, besides the exclusion of the temporal Dummies variables, the market variables were also excluded. T-statistic in parentheses estimates *, ** and *** the significance level of 10%, 5% and 1% respectively. The reset test was performed on the first and second models to determine the effect of per capita Gross Domestic Product and Petroleum Exports on cost efficient banking.

Estimated models are statistically significant with F-statistic likelihoods below 1% for all estimated models. Robust random effect models were used, and those with the most consistent coefficients, in model II they were removed from the temporal dummy

variables related to economic crises and in model III, in addition to the dummies, we also removed the variables market. The coefficients of determination (R^2) are: 26% for model I and 27% for model II and III. This means that the independent variables included in the models have little explanatory power for the variation of efficiency in the three estimated models. A specification test was also performed to assess whether the GDPpc and Exportpetr variables are significant to explain the average efficient cost in the Angolan banking sector. For this

purpose, the following hypotheses were raised: $H_0: \varphi_1 = \varphi_2 = 0$; $H_1: \varphi_1 \neq \varphi_2 \neq 0$, at a significance level of 5%, hypothesis H_0 is rejected, which means that oil exports and GDPpc are statistically significant to explain the variation in Cost X-efficiency in Angolan banks.

Control and market variables are analysed using the Battese & Coelli (1992) Truncated-Normal model, which considers time-varying inefficiencies and the three other models were dispensed. The assessment of bank risk at the efficient average cost was made possible by including the variables Non-performance loans (NPL), liquidity risk (Rliq) and asset risk (y/z).

The results show that the NPL are statistically insignificant, when model I includes the temporal dummies and market variables and are statistically significant in models II and III, when excluding the variables specified in model I, at a level of confidence of 1 and 5% respectively. As for the Rliq, the three models have a positive and significant relationship at a confidence level of 1, 5 and 10%, respectively, which means that Angolan banks take less liquidity risks. Asset risk (y/z) is not statistically significant to explain the variation in the average Cost X-efficient in Angolan banking in the three estimated models.

The market variables included in the models are oil exports and gross domestic product per capita. Exportpetr has a positive and statistically significant effect on the average cost X-efficient in model I, at a confidence level of 5%. The GDPpc coefficient is statistically significant at a level of 1 and 5% respectively to explain the variation in average efficient cost.

It was sought to evaluate the effect of bank nationalization on cost X-efficiency. For this purpose, the dummy variable was defined, where the value one (1) represents the nationalized bank and zero (0) other non-nationalized banks. The results show that in model I the nationalization of a bank is not statistically significant to increase or decrease

the likelihood of Cost X-efficiency, while in models II and III there is a likelihood that when a bank is nationalized it becomes efficient at a level of 1 or 5% confidence respectively. The analysis of the financial crisis in cost X-efficient was made according to the years 2008 and 2014, years that marked the beginning of each economic and financial crisis worldwide. The crisis that started in 2008 had no effect on Cost efficiency. The crisis that started in 2014 had a positive and statistically significant effect at a confidence level of 5%.

4.1 Empirical Result of Scale Efficient

From the Cost X-efficient estimated by the Battese & Coelli (1992) SFA model, the Scale Efficient of the Angolan banks was determined. The Scale Efficient was analysed from two perspectives, in the first one the global Scale Efficient of the banks was determined and then the sample was divided into two groups, a sample group was estimated to determine the Scale Efficient of the small banks with a lower average or 110.17 and banks with assets in excess of these values in thousands of kwanzas are considered large banks, and the second part analysed the Scale Efficient as a function of private ownership of banks, or foreign private banks, domestic private banks and state-owned banks.

The table below summarizes the average Scale Efficient global, large banks, small banks and over the investigation period.

Table 4: Scale Efficient Analysis

| Years | Scale efficient | | | | | | | | | | | |
|---------------------|-----------------|-------|------------|-------|-------------|-------------|------|-------------|------|-------------|------|----|
| | All Banks | | GB | | PB | | BP | | BPN | | BPE | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 2007 | 1.22 | 0.11 | 0.68 | 0.013 | 1.20.14 | 1.42 | 0.37 | 1.21 | 0.21 | 1.09 | | |
| 2008 | 0.92 | 0.07 | 1.00 | 0.26 | 0.90.07 | 0.86 | 0.29 | 0.98 | 0.07 | 1.37 | 0.39 | |
| 2009 | 1.00 | 0.11 | 1.6 | 0.33 | 0.780.12 | 0.91 | 0.22 | 1.1 | 0.13 | 1.21 | 0.50 | |
| 2010 | 1.00 | 0.11 | 1.9 | 0.06 | 0.940.14 | 0.83 | 0.52 | 1.1 | 0.13 | 1.12 | 0.32 | |
| 2011 | 1.00 | 0.09 | 1.1 | 0.32 | 1.030.11 | 1.12 | 0.24 | 1.06 | 0.12 | 1.11 | 0.27 | |
| 2012 | 1.00 | 0.08 | 1.08 | 0.24 | 1.110.11 | 1.24 | 0.29 | 1.04 | 0.11 | 1.21 | 0.28 | |
| 2013 | 1.08 | 0.10 | 0.8 | 0.20 | 1.180.10 | 1.47 | 0.48 | 1.05 | 0.12 | 1.40 | 0.36 | |
| 2014 | 1.00 | 0.10 | 0.74 | 0.17 | 1.230.11 | 1.27 | 0.34 | 1.02 | 0.13 | 1.35 | 0.32 | |
| 2015 | 1.00 | 0.88 | 0.92 | 0.19 | 1.080.11 | 1.82 | 0.15 | 1.02 | 0.09 | 1.37 | 0.35 | |
| 2016 | 0.93 | 0.093 | 0.90 | 0.22 | 0.950.12 | 1.05 | 0.41 | 0.97 | 0.09 | 1.14 | 0.24 | |
| 2017 | 0.91 | 0.08 | 1.00 | 0.21 | 0.870.10 | 1.6 | 0.12 | 0.85 | 0.10 | 1.29 | 0.22 | |
| Overall Mean | 1.00 | | 1.1 | | 1.00 | 1.26 | | 1.00 | | 1.25 | | |

Note: Large banks are those with an average of assets above 110.17 thousand Kuanzas; PB - Small Banks with average assets below 110.17 thousand Kuanzas; BP- Public Banks; BPN - National Private Banks and BPE - Foreign Private Banks.

The results show that Angolan banks in a global analysis operate at the optimum scale, representing an overall Scale Efficient of 1, with a standard deviation of 0.39, this is,

they operate at a constant return scale, meaning that these banks can increase one unit (1) on outputs without necessarily increasing production costs. Over the period under analysis it was already found that in 2007, banks operated on a rising return scale and in 2008 a decreasing return on scale, here draws attention to the economic crisis that affected the world and in particular Angola. From 2009, banks begin to operate at a constant return to scale until 2015, except 2013. Already in recent years banks are exploring an increasing return to scale. This is due to the economic crisis that began in 2014 and had a major impact on the Angolan economy.

The result shows that large banks have an Scale Efficient of 1.1, with a standard deviation of 0.40, that is, a decreasing scale return. Small banks have an scale efficient of 1.0, with a standard deviation of 0.409. The result of the Scale Efficient is consistent with the results of the studies by Karafolas & Mantakas (1996); Margono et al. (2010); Martins (2012); Drake & Hall (2003) and divergent from the studies by Altunbas et al. (2000), which concludes that all banks in Japan operated at scale inefficient during the period under study.

As for bank share ownership, the results show the declining return to scale for state and private foreign banks, while private domestic banks operate at a steady return to scale.

5. Conclusion

The analysis of Cost and Scale efficient in the Angolan banking sector in the period 2007-2017, was carried out using the Stochastic Frontier Approach method in Angolan banking data to determine the Cost and Scale efficient with two ways of distributing inefficiency in function of the variation of inefficiency in time, namely: the models with the Kumbher (1990) Half-Normal and the Battese & Coelli (1992) Truncated-Normal distribution. Both consider variant inefficiency over time. On the other hand, it used the models that consider the time-invariant inefficiency of Pitt & Lee (1981) with the Half-Normal distribution and Battese & Coelli (1988), with the Truncated-Normal distribution.

The results show that the Cost X-efficiency in Angolan banks is 83% for the Half-Normal and Truncated-Normal models, when inefficiency is variant over time. When inefficiency is time-invariant, the Cost X-efficiency is 79% for the Truncated-Normal model and 90% for the model with the Half-Normal distribution. The most efficient banks in the sample

are foreign private banks, with an Cost X-efficient average of 89% and public banks are the least efficient, with an average Cost X-efficient of 80%. Over the period under assessment, the results showed that the Cost X-efficient ranged from 71% to 90%.

In the second stage, it was analysed the effect of control and market variables on Cost X-efficiency and the results show that variables that measure bank risk, such as Non-performance loan and liquidity risk, have a positive and significant effect on cost. while asset risk has no effect on bank cost. As for market variables, oil exports have positive and statistically significant effects on Cost efficiency and GDPpc has a positive effect on Cost X-efficiency. The Dummy variable introduced measures the effect of nationalization of foreign private banks and the results show that when a bank is nationalized, its Cost X-efficiency increases, this is, the likelihood of operating at a more Cost X-efficient remains.

From the Cost X-efficient estimated by the Battese & Coelli (1992) SFA model, the Scale Efficient of the Angolan banks was determined. In a global analysis, Angolan banks operate at the optimum scale, representing an overall efficient scale of 1, that is, they operate at a constant return to scale. When the sample is divided into groups, it was observed that large banks operate on an inefficient scale of 1.1, while small banks operate on an efficient scale of 1.0. As for bank share ownership, the results show a diminishing return to scale for foreign state and private banks state, while domestic privately owned banks operate at a constant return to scale.

These results have political implications for Angolan banking, both in terms of bank regulation, as well as for managers and policymakers, and the banks in the sample studied are all inefficient and the Cost X-efficiency decreasing in recent years. It requires better performance of managers and optimization of the resources invested in the operational activity of banks and decision makers, exhaustively reviewing regulatory mechanisms and creating incentives to improve bank efficiency.

Two suggestions for future studies are presented in this paper: the first to evaluate the effect of competition on cost X-efficiency and vice versa and second to test the various hypotheses that relate market concentration and efficiency in Angolan banking.

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