

Efficiency of the Brazilian Banking System in 2014: A DEA-SBM Analysis

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Abstract

This study used the DEA-SBM technique to evaluate the efficiency of Brazilian banks in 2014 from the perspective of the three most recurring approaches in this evaluation type: intermediation, production, and profitability. The efficiency scores were evaluated by quintile and the Mann-Whitney test according to (1) capital origin; (2) public vs. private; (3) size; (4) operating segment (5) ratings. The analysis led to ten conclusions and demonstrated that federal public capital banks, micro-sized banks, the banks of the Retail segment (except for the intermediation approach) and AAA-rating banks were the most efficient institutions.

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1 Introduction

The economic performance of a country is influenced by its financial and banking system; given that the banking system performance directly interferes with the decisions of economic agents and, consequently, affecting the lives of the entire population (Wu, Yang, & Liang, 2006). Banks play an essential role in the economy by maintaining public and private savings and their intermediation activities to allocate investments that contribute to the development of a country (Oliveira, 2008).

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Efficiency is utilized as an indicator of the level of banking competition. In this scenario, only the most efficient banks would be capable of maintaining their activity (D. Wu, Yang, & Liang, 2006).

After 1994, the inflation control in Brazil resulting from the Real Plan demanded a sound management from banks on their operating performance to maintain profitability levels and ensure sustainability. The transition from high to low inflation rates required a better performance control from the banking sector to dynamically respond to the monetary stability scenario.

Metzner & Matias (2015) point out the changes in the banking sector from 1990 to 2010 as being significant for the competition increase. The impact of market opening to foreign banks, the reduction of the basic interest rate, the advent of the Real Plan and reducing inflation stand out as the main component to force managers to increase the efficiency of their operations.

However, despite the evolution after the Real Plan, the inefficiency of the Brazilian banking system still has been appointed as one of the factors for poor development and financial instability (Tecles & Tabak, 2010). Studies also suggest that the Brazilian banking system is less efficient when compared to other countries (Roberta B. Staub et al., 2010).

The evaluation of efficiency of banking institutions requires the performance leveling of those the banks that successfully carry out such activity in relation to the other banks. (Macoris; Salgado Junior & Falsarella Junior, 2015). The aim is to identify the banks considered efficient, serving as performance benchmarks for other institutions. That evaluation can be executed via parametric or non-parametric tests.

The non-parametric technique Data Envelopment Analysis (DEA) stands out as one of the most used techniques used in banking efficiency rating (Fethi & Pasiouras, 2010). Its implementation and bank evaluation can be performed according to three distinct points of view.

The first one evaluates banks focusing on intermediation capacity, that is, according to the efficiency of banks in obtaining resources from agents with surplus funds and transferring them to the other agents (Sealey & Lindley, 1977). The second approach refers to production, with the evaluation of the ability to provide services such as account opening, deposits, and check clearing (EPURE et al., 2011). The third approach consists of profitability, to evaluate the reduction of expenses and costs to increase profitability, and the profitability of the institution (Drake, Hall, & Simper, 2006; Fethi & Pasiouras, 2010). The comparison of the three approaches exposes evidence that there are efficiency determinants that, from a particular perspective, do not necessarily contribute to the effectiveness of other methods (Macoris, Salgado Junior & Falsarella junior, 2015)

The efficiency analysis contributes to (1) evaluate government policies, and the effects of regulation, mergers, and market competitiveness; (2) describe the sector's efficiency and verify how efficiency relates to the management techniques used to improve and develop management practices; (3) assist in investment allocation decisions; and 4) gather objective information to improve bank management (Berger & Humphrey, 1997).

Given the above, the present study aimed to evaluate the banking efficiency under the Intermediation, Production And Profitability approaches of the banks that operated in Brazil in 2014. To this end, the DEA scores were obtained using the DEA-SBM technique (slacks-based measure) proposed by Tone (2001). The results were descriptively investigated to achieve patterns about (1) capital origin; (2) public or private capital; (3) the size of the banks; (4) the operating segment of the banks; and (5) and ratings of these institutions.

2 DEA and Banking Application

A priori, Charnes, Cooper, and Rhodes (1978) officially coined the term Data Envelopment Analysis in a non-parametric study used to evaluate public education programs in the United States. This methodology was known as CCR. (Initials of the authors) or CRS (constant returns to scale) and brought the concept of Decision Making Units (DMU).

Later, Banker, Charnes, and Cooper (1984) extended the DEA technique, developing the BCC method. The major alteration consisted of considering the variations, that is, DMUs are subject to gains and reductions at scale also being referred to as variable returns to scale (VRS).

By improving the technique, Tone (2001) proposed the DEA-SBM model (Slack-Based Measure), used in this study. The DEA-SBM brings a fundamental breakthrough to the DEA technique for incorporating the intrinsic clearance of each DMU, avoiding weakly efficient DMUs classification, as in previous models. Tone (2001) claims that his method (SBM) is the most suitable to evaluate DMUs with differences between sizes; a situation in which previous models would have difficulty to consider the DMUs efficiency within an environment with scale gains exactly as in the banking sector in Brazil.

DEA-SBM mathematical proposition is represented by:

$$\text{Min } \rho = t - \frac{1}{m} \sum_{i=1}^m S_i^- / x_{i0}$$

Subject to:

$$1 = t + \frac{1}{s} \sum_{r=1}^s S_r^+ / y_{r0}$$

$$x_0 = X\Lambda + S^-$$

$$y_0 = Y\Lambda - S^+$$

$$\Lambda \geq 0, \quad S^- \geq 0, \quad S^+ \geq 0, \quad t > 0$$

DEA-SBM is considered the most suitable technique available to assess the banking DMUs efficiency (Avkiran, 2011). Considering all aspects, DEA is the method most commonly used for analysis of the banking sector efficiency. From among 191 papers reviewed in publications and several countries, Fethi and Pasiouras (2010) found that 151 out of them used some variations of DEA to estimate operational efficiency measures for banks, having cost efficiency as the concept used in 35 studies (Fethi & Pasiouras, 2010).

Liu (2009) used the intermediation approach for the evaluation of resource transfer efficiency via short-term and long-term loans, considering that banks are mainly engaged in acting as financial intermediaries, whose core activity is to attract depositors funds to lend to others (Liu, 2009).

In another study of Asian banks, Avkiran (2011) evaluated the efficiency of Chinese banks after economic liberalization, marked by China's entry into the World Trade Organization in 2001. The author presents the usefulness of DEA scores as a benchmark for investors, regulators, and society. DEA-SBM was also used to evaluate the efficiency of 130 banks in Indonesia between 2003 and 2007 (HADAD et al., 2012). The same technique was used to assess the effectiveness of one thousand bank agencies in Canada in light of the production approach ((PARADI; ZHU; EDELSTEIN, 2012). DEA-SBM proved an appropriate efficiency evaluation technique for all the studies as mentioned earlier (Avkiran, 2011).

The banking efficiency results depend on the Input and Output variables selected for inclusion in the DEA model. Consequently, understanding the approach used is crucial; that will determine the model's input and output configuration.

Table 1: highlights major approaches and their definitions for efficiency analysis.

APPROACH	DEFINITION	STUDIES CARRIED OUT
PRODUCTION	Capacity to provide banking services, considering the constraints of physical inputs.	Berger, Humphrey (1997), Kuussaari (1993), Epure, Kerstens, Prior (2011), Yang et al., (2010)
INTERMEDIATION	Capacity of raising and lending financial resources.	Liu (2009, 2010, 2011), Tecles and Tabak(2010); Puri and Yadav(2013).
PROFITABILITY	Capacity to maximize return on investment while minimizing expenses and increasing profits.	Avkiran (2011), Drake, Hall e Simper (2006), Liu (2011) Puri and Yadav (2013).
OTHER APPROACHES	- Value (EVA) - Market (shares) - Risk ; - Sales (Commercial)	Bergendahl (1998), Eskelinen, Halme and Kallio (2014)

Source: Macoris, Salgado Junior and Falsarella Junior (2015), adapted.

This study uses the production, intermediation and profitability approaches, described in Table 1 since they are the most common approaches and allow the use of the information provided by the Central Bank of Brazil.

3 Efficiency of the Brazilian Banking System

Bank efficiency evaluations in Brazil are crucial due to the importance of that country to Latin America, as the country has the largest banking system in the region. Also, the corporate bond market is still incipient, which reinforces the banking system's relevance. In emerging economies, banks are of paramount importance for financial development, particularly when the stock and corporate bond market lacks development which is evident in Brazil (R B Staub, Souza, & Tabak, 2010).

As from 1994, the Brazilian banking sector has undergone extensive changes with the advent of the Real Plan; a reconstruction process of both the purchasing power structure and the economy of the Brazilian state. The measures adopted dismantled the historical hyperinflationary scenario, requiring a quick response from the banking system (Ianoni, 2009; LFR Paula, 1998); leading to fundamental alterations in the industry's composition. The abrupt drop in inflation led to negative impacts on bank results (especially with float revenues), causing many institutions to discontinue their activities in that period. For instance, from July of 1994 to March of 1995, sixteen banks had undergone liquidation or intervention of the Central Bank (Matias & Siqueira, 1996).

The privatization of state-owned banks contributed significantly to the banking consolidation phenomenon. In the international sphere in agreement with regulatory requirements of the Basel Agreements on behalf of the soundness of the financial system, new measures of capital requirement were adopted, highlighted the Brazilian strictness on this issue (LF de Paula & Marques, 2006). Amid the process of consolidation and growth of banks, performing their competitiveness assessment using efficiency evaluation towards the financial system's sustainability proved significant.

Among the evaluations carried out, several studies examined the impact of the size of the institution on the efficiency in the light of that factor to explain industry consolidation (Felicio, 2014; Périco; Rebelatto; Santana, 2008; Tecles; Tabak, 2010; Wanke; Barros; Faria, 2015). However, those studies differ as to the size influence on the efficiency of the evaluated banks. The relationship between size and performance appears to be higher in studies among agencies, not conglomerates. For example, Macedo and Cavalcante (2009) point to scale gains in banking operations of agencies; the performance of larger agencies was superior to the performance of smaller ones. Barbosa and Macedo (2008), and Barbosa and Macedo (2009) also showed that there was no direct relationship between the size of the institutions and the efficiency level.

The authors concluded that the size was not decisive to justify the efficiency, corroborating the results of Staub, Souza and Tabak (2010). However, Ceretta and Niederauer (2001) diverge from the relationship between size and efficiency. According to their study, the large-sized banks in Brazil demonstrated a much greater operational efficiency, while small and medium-sized banks showed similar levels of efficiency.

The public and private banks efficiency differences were also highlighted in the studies. Staub, Souza and Tabak (2010), and e Wolters, Couto and Felício (2014) point out state-owned banks demonstrated higher efficiency, while Becker, Lunardi and Maçada (2003) point out that the federal banks are more efficient than others. In contrast, Wanke and Barros (2014) described a positive impact on efficiency for private control.

Analyzes on capital origin also demonstrate significant divergence in studies conducted in Brazil. Becker, Lunardi and Maçada (2003) argue that foreign banks or banks with foreign sharing feature a better performance. Similarly, Assaf, Barros and Matousek (2011) describe evidence that foreign capital has improved the technical efficiency of Saudi banks. However, for Wolters, Couto and Felício (2014) and Staub, Souza and Tabak (2010), foreign banks have lower efficiency ratios. According to Barbosa and Macedo (2008), the most efficient banks comprise the foreign control institutions or banks with foreign sharing. The findings of Becker, Lunardi and Maçada (2003) showed similar results in identifying that public banks (especially federal banks), foreign and with foreign sharing were the most efficient institutions.

Studies evaluating the banks by operating segment did not show conclusive results (Mainetti Junior, Gramani, & Barros, 2014; R B Staub et al., 2010). The targeting studies revealed differences concerning the efficiency and performance of the niche banks; substantial differences were found about the size and segmentation of the bank (Roberta B. Staub et al., 2010). The results concerning the bank segmentation refer to sectoral performance or niche operations. For example, in the light of Barbosa and Macedo (2008) and Souza and Macedo (2009), wholesale banking and business (also classified as corporate) had the best performance, followed by retail banks.

4 Methodological Aspects

The present study involved the development of six stages. The first stage consisted of the individualized collection of financial information, consolidated and referring to the year 2014. The data were extracted from reports comprising Top 50, 4010, 4040 and IF.data at the Brazilian Central Bank website (2015).

In the second stage, the variables analyzed for each approach were selected, composing each of the models. The inputs and outputs were chosen based on the meta-analysis by Macoris, Salgado Junio & Falsarella Junior (2015), with the identification of most used variables per approach. In line with Macoris et al. (2015), whose study develops a reflection of the adequacy of the variables employed in DEA research in the world, Macoris et al. (2015) conclude with the configuration proposed for each approach.

This proposal was used to define the configuration employed in this thesis. Under Macoris et al. (2015), the variables used in the model are shown in Frame 1.

Frame 1: Inputs and outputs used in the study

	INTERMEDIATION APPROACH	PRODUCTION APPROACH	PROFITABILITY APPROACH
Input	Total Deposits	Number of employees	Total assets
Input	Total employees	Operating expenses (interest not included)	Operational expenses
Input			Financial liabilities
Output	Total credit	Total Deposits	Net profit
Output	Revenue from credit operations	Revenues not related to interest	ROA
Output	investments	-	ROE

The selection of variables is related to the purpose of the analysis. In the intermediation approach, the number of employees represents the work to generate loans or allocate resources. The total deposits represent the funds raised from the surplus agents, and the interest expenses account for the cost of deposits taken. The loan operations represent the capital lent to agents, and financial intermediation revenues are revenues generated by loans. The investments represent the amounts invested by the bank to generate revenue.

As regards the production approach, the number of employees represents the workforce that performs services. Operating expenses (interest not included) represent the expenses necessary for the provision of such services (Resource intermediation costs are not included) (WANKE; BARROS, FARIA, 2015). Total assets represent the assets used to provide services such as facilities, equipment, and the like. Total deposits represent deposit accounts and the service rendered to the customer. Revenues unrelated to interest refer to income from fees and services, i.e., the remuneration for service provision.

On profitability approach, total assets represent the resources the bank uses for its activities. Operating expenses refer to expenditures incurred to generate results. Net worth represents the resources invested by the partners or shareholders. Net income is the result produced, as well as ROA and ROE indicators, which measure the return on assets and return on investment, respectively.

The exclusions mentioned above were took place in the third stage. The Brazilian financial system totalized 136 institutions in 2014. However, all banks that presented losses and/or

displayed input or output variables with lacking information were excluded from the analyzed sample definition.

Exclusions occurred due to technical limitations of the system used to calculate the efficiency scores involving negative variables (in the case of loss).

After the exclusions, the obtained sample included 66 banks for all approaches. Although the sample represents 48% of the national financial system banks, it comprises 98% of the total assets of the banking system. The numerical difference between the banks concerning total assets is due to several banks - classified and authorized by the Central Bank - did not operate efficiently; therefore, lacking all the variables needed for the study. Additionally, the exclusion of banks registering losses eliminates plenty of banks. However, the sample is superior to all previous studies in Brazil, except for the study by Souza and Macedo (2009), which tested a 100-bank sample in Brazil but to one approach only.

The fourth stage consisted in bank classification. The total assets were used as classification criteria by size, by dividing the banks into quartiles. The first quartile comprises micro-sized banks; the second quartile contains small-sized the banks; the third quartile brings medium-sized the banks and finally, the fourth quartile comprises the large-sized banks.

As to capital origin, the banks were classified into four groups: 1) national private, 2) national private with foreign sharing or foreign control, 3) Public State and 4) Public Federal, according to the Central Bank classification. The banks classified as foreign-controlled refer to foreign bank subsidiaries and banks classified as national private with foreign control hold foreign sharing greater than or equal to 50% of the voting capital. The banks classified as national private with foreign sharing hold foreign sharing greater than 10% and less than 50% of the voting capital.

In addition to the classification by size and capital origin, banks were classified by operating segment and rating. Such classification was performed using the Visionarium system, one of the major systems used for corporate credit risk assessment in Brazil (LANGKAMP, 2014). The operating segments consist of Development Banks; Corporate; CDC / consumption; Car Maker/vehicles; Small and Medium Enterprises; Products, Services and Treasury; and Retail. As for the rating were obtained classifications for banks according to the score assigned by the Visionarium system: AAA, AA, A, BBB, BB and B. However, not all banks had ratings and those with no score were analyzed as a specific group: No rating.

The fifth stage consisted of identifying the efficiency scores. PIM-DEAsoft software was used to find the efficiency. The data evaluation occurred according to the DEA-SBM method. As previously described, the SBM tool (slacks-based measure) refers to a DEA approach that works with variable returns to the scale used based on the super-efficiency gain. This has been the most popular model of choice for banking analysis in the twenty-first century; capable of recognizing different dimensions across business units, and enabling the translation and comparison with distinct variances (Avkiran, 2011).

This gap-based measure is a DEA variation proposed by Tone (2001). DEA-SBM considers the gaps for efficiency gains by estimating possible scale gains. The mathematical model is represented by formula (4):

$$\min_{\lambda, s^-, s^+} \rho = \frac{1 - \frac{1}{m} \sum_{i=1}^m s_i^- / x_{io}}{1 - \frac{1}{s} \sum_{i=1}^s s_i^+ / y_{ro}}$$

Subject to

$$\begin{aligned} x_o &= X\lambda + s^- \\ y_o &= Y\lambda - s^+ \\ \lambda &\geq 0, s^- \geq 0, s^+ \geq 0 \end{aligned}$$

Where λ represents inputs, and s^- and s^+ represent possible gaps for scale gains. In agreement with the models applied in the studies examined, the formula below (5) represents that variation over its input orientation:

$$\begin{aligned} x_o &= X\lambda + s^- \\ y_o &= Y\lambda - s^+ \\ \lambda &\geq 0, s^- \geq 0, s^+ \geq 0 \end{aligned}$$

The sixth and final stage consists of analyzing the results obtained, which occurred after the scores had been obtained. The scores of the sample were analyzed through the use of two techniques. Initially, the Kolmogorov-Smirnov test was used to verify whether the distribution of medians for each approach followed a normal distribution. Considering a significance level of 0.05, the test indicated that the results did not follow a normal distribution. Thus, the median differences were analyzed according to the use of the non-parametric Mann-Whitney test.

The Mann-Whitney test was used to assess whether median scores, in each group and subgroup, were significantly different so that the results could be extrapolated to the entire Brazilian banking system. With a confidence interval of 95% and 5% significance, the median equality hypotheses were rejected; indicating that the medians obtained were statistically different. The analysis at the results presentation stage described when the median test pointed out differences between the average efficiency scores obtained.

The second technique used is a descriptive analysis related to the evolution of the bank's group sharing within the initial sample to the sharing of that same group within the efficient bank sample, considered within the quintile 1 with the highest scores DEA by DMU. That comparison is intended to verify if any group, among the classifications held, has a greater relevance among the efficient bank sample.

5 Discussion and Results

As described in the methodology, two analyses comprise the results of this paper. The former investigates the sharing of each profile/feature of the banks according to their distribution in the selected sample and their relative sharing within the efficient bank group. Graph 1 summarizes the result found for the three approaches presented in three dimensions. Also, the position of the leading and largest banks operating in Brazil was appointed to illustrate the relative performance identified in this study.

Table 2: Assessment of the DEA scores according to capital origin.

Capital Origin	INTERMEDIATION			PRODUCTION		PROFITABILITY	
	% Initial sample	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)
National Private (P.N.)	41%	29%*	0,18	36%	0.63	50%	0.28
P.N. with Foreign control (C.E)	42%	43%	0.18	29%**	0.22**	14%**	0.24**
State Public (P.E)	9%	7%	0.14	7%	0.58	7%	0.41
Federal Public (P.F)	8%	21%*	1.00	29%**	1.00**	29%**	0.91**
Total	100%	100%		100%		100%	

* Highlights for the comparison between the sharing in the sample and the sharing in the effective group only.

** Results confirmed by the KS test at significance level 0.05.

Initially, there is the analysis of descriptive statistics comparing the distribution of the groups in the initial sample to participate in the efficient bank sample, as shown in the first column of each approach. It is noted in Table 2 that the federal bank's sharing emerged from the initial sample from 8% to 21%, 29% and 29% in the approaches that included intermediation, production, and profitability, respectively. Therefore, based on this first analysis, it is noted that the federal banks had a positive highlight (highlighted in green). The opposite occurred with the banks classified as national private (in the intermediation approach) and banks with foreign control in the other approaches.

Staub, Souza, and Tabak (2010) obtained similar results; the authors noted that foreign banks were less efficient than the Brazilian banks, in line with the results observed in this study. The results may indicate that foreign banks failed to adapt to the peculiar characteristics of the Brazilian banking system; with few banks and low level of credit when compared to the international banking market. Also according to the median differences analysis of the Mann-Whitney test, considering a significance ≤ 0.05 to verify that the medians of the DEA scores were different, it was possible to see that the median score of federal public banks was significantly distinct from the other groups only in intermediation and profitability approaches.

5.2 Analysis by Capital Origin - Public or Private

Results supported by the median test for the difference between and the efficiency of public and private banks were not found. The only possible evaluation refers to the sharing of the public banks among banks considered efficient, increasing its relative sharing in the group, as highlighted in green in Table 3 below.

Table 3: Evaluation of DEA scores according to capital origin - public or private.

Capital Origin	INTERMEDIATION			PRODUCTION		PROFITABILITY	
	% Initial sample	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)
Public	21%	43%*	0.18	50%*	0.95	57%*	0.54
Private	79%	57%	0.18	50%	0.35	43%	0.28
Total	100%	100%		100%		100%	

* Highlights for the comparison between the sharing in the sample and the sharing in the effective group only.

Evidence shows that public banks have evolved from a sharing of 21% in the initial sample to 43%, 50% and 57% respectively in the three evaluated approaches. However, the impossibility to assert that public banks were more efficient, when compared to the averages from their groups, may indicate that the public capital per se does not influence the efficiency, but the federal capital only. This result corroborates the study and Paula Faria (2006).

According to the authors, federal banks obtain scale gains due to diversification and size, which does not occur with the state banks; these institutions are more targeted and focused on smaller niches. Moreover, public banks can also focus on economic and social development, especially regional and state banks, which appear to influence the efficiency of the model (R B Staub et al., 2010). That is a specific feature of the Brazilian market; among the public banks assevaluated, eight of them operate regionally only. Most of those institutions focus on development (for example Development Bank of Minas Gerais, Development Bank of Espirito Santo; Development Bank of Pará; Development Bank of Northeast and Amazonia). It is worth noting that state banks, particularly development banks, have no funding subsidized by the National Treasury - such as BNDES - but they usually offer special rates and credit lines, which directly affects the calculation of the efficiency of those banks.

5.3 Analysis by Size

The evaluation by size investigates the relationship between the bank's efficiency to its size, classified as (Mi) Micro (Pe) Small, (Me) or Medium (Gr) Large. The size segmentation was carried out by allocating banks into quartiles according to the total assets of the institution, adapting the classification by the Central Bank of Brazil (2015). On the relationship between size and efficiency, the literature is not about the effect of the size consensus on banking efficiency gains in Brazil. Some authors claim there are no scale gains (Mainetti Junior et al., 2014).

The group of banks classified as micro was considered more efficient concerning its proportion in the sample of banks. Those institutions also had significantly different median from the other groups, as opposed to smaller banks, which had the worst results. This verification is consistent with previous studies, according to which, the bank efficiency relates more to the operating segment than the size of the institution (Mainetti Junior et al., 2014).

Table 4: presents the results regarding all three approaches.

Group	Porte	INTERMEDIATION			PRODUCTION		PROFITABILITY	
		% Initial sample	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)
1	Micro	11%	14%	0.35**	21%**	0.82**	21%**	0.53**
2	Small	18%	7%**	0.12**	7%**	0.35**	0%**	0.16**
3	Medium	33%	29%	0.15	14%	0.31**	21%	0.22
4	Large	38%	50%*	0.19	57%	0.52	57%	0.56
	Total	100%	100%		100%		100%	

* Highlights for the comparison between the sharing in the sample and the sharing in the effective group only.

** Results confirmed by the KS test at significance level 0.05.

Table 4 shows that the negative highlight to size refers to the small-sized banks. That suggests that middle-sized banks have higher cost components, but without the benefits of increased revenue. It is also considered a matter of transition and adaptation after size expansion and classification change.

However, the large banks had a positive highlight in the intermediation approach due to the share enhancement at the efficiency sample; rising to 50% of the group DMUs. The growth also occurred in other approaches, especially the micro-sized banks, with the greatest increase in the composition ratio of the efficient group. The relationship demonstrated between the large-sized banks and efficiency may result from the gain arising from financial leverage (Ceretta & Niederauer, 2001). That finding could mirror the consolidation scenario after the Real Plan; it contributed for major banks to be formed and remain in the market, in contrast to small and medium sized banks, which faced mergers and acquisitions (Périco et al., 2008)

The Mann-Whitney median difference test, at the significance level of 0.05, confirmed that the micro-sized banks (Mi) exhibited significantly higher median in this study. The result of this analysis is supported by the studies of Macedo and Barbosa (2009), Macedo, Santos and Silva (2008), Périco, Rebelato and Santana (2008) and Staub, Souza and Tabak (2010); which also identified no direct proportionality between size and efficiency.

5.4 Analysis by Operating Segment

The analysis of the bank's operation niche proves to be a major component to determine bank efficiency in Brazil (Macedo & Barbosa, 2009). According to Mainetti Junior, Gramani and Barros (2014), banking efficiency is more closely related to operating segmentation than to the size of the institution per se. Similarly, Périco, Rebelatto and Santana (2008, p.428) argue that "the managerial aspects (resource allocation decisions) are more important than the size regarding the DEA analysis."

Given the above, this analysis was performed to investigate possible links between segmentation decisions (strategic decision) and the efficiency score. To this end, banks were evaluated according to seven potential segments extracted from Visionarium system. Namely, the segments are:

- (Bd) Development Bank: Represent the activities of Banks focused on loans to generate economic, social, environmental or technological development;

- (Cd) CDC / consumption: Includes banks that act directly on lending for consumption, especially of individuals, also expressed as CDC - Direct Consumer Credit;
- (Co) Corporate: Includes the segment of banks that operate mainly in the corporate sector, specifically with large companies.
- (Mo): Car maker / Vehicles: Represents the segment of banks operating in loans for vehicle sales in Brazil;
- (SMEs) Small & Medium Enterprises: Refers to the niche market of banks that operate in small and medium enterprises, also in the corporate segment;
- (PST) Products, Services and Treasury - Includes the banks that focus on providing differentiated services and financial investment activities (treasury), constituting a performance focused on fund establishment, business participation, and other investment services;
- (Vr) Retail: Retail banks have diversified operations with no focus on a defined segment. These institutions provide basic services such as checking accounts and work with companies at different levels.

Table 5: Evaluation of the DEA scores according to operating segments.

Grupo	Segmento	INTERMEDIATION			PRODUCTION		PROFITABILITY	
		% Initial sample	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)
1	Development Bank (Bd)	5%	14%**	1.00**	0%**	0.22**	7%	0.42
2	CDC / Consumption (Cd)	14%	14%	0.94**	14%	0.33	21%	0.22
3	Corporate (Co)	17%	14%	0.18	14%	0.36	0%**	0.21**
4	Car Maker/vehicles (Mo)	15%	14%	0.18	14%	0.36	7%	0.21
5	Small and Medium Businesses (SME)	14%	7%	0.15	7%	0.41	0%**	0.20
6	Products, Services and Treasury (PST)	14%	7%	0.15	7%	0.17	14%	0.36
7	Retail (Vr)	23%	29%	0.18	43%**	0.94**	50%**	0.52**
Total		100%	100%		100%		100%	

* Highlights for the comparison between the sharing in the sample and the sharing in the effective group only.

** Results confirmed by the KS test at significance level 0.05.

A relationship between the result obtained and lived economic times can be established; the economy experienced a slowdown, which resulted in a decline compared to previous years, substantially affecting banks that operate exclusively in the corporate segment (SABOIA, 2014).

In turn, Table 5 shows the results found from the segment share of each bank within the effective sample, as well as the medians obtained.

The development banks were the most efficient institutions in the intermediation approach. The median test result supports the same conclusion, given the evolution of these banks towards the efficient banking group, from 5% in the initial sample to 14% among the efficient banks. That may be due to the low cost of funding with the National Treasury and the Brazilian institutional support during the year 2014. In addition, development banks consist of the single banking segment that offers long-term credit lines for investment in the country. That ensures a high demand often cost less than the market. By contrast, as these institutions do not have a structure dedicated to providing services, nor generate significant revenues from sales of services, no development bank was considered efficient in the production approach.

In the remaining approaches, the positive highlight belongs to the retail segment, both for displaying a higher DEA score median, but also for increasing its share among the banks considered efficient in this study. Retail banks had the highest levels of efficiency in average profitability and production approaches. That is in line with the findings of Camargo Jr. and Matias (2005), for whom retail banks are more efficient in using their costs and infrastructure for loans and funding, including deposits, leading them to levels considered efficient.

The remaining banks in the segments that include CDC, PST, corporate, SMEs and car makers/vehicles consist of banking institutions with a performance highly influenced by economic conditions. These banks are unable to obtain the level of diversification that retail banks can achieve. Except for CDC banks, all the other banks have suffered from the low level of investment in the economy in 2014. The negative focus is on the corporate segment, essentially dependent on business activity; those banks exhibit good performance when companies expand investments, as well as the demand for credit and services offered by them.

5.5 Analysis by Agency Ratings

The evaluation of the efficiency scores and their relationship with rating granted by agencies is not widespread in the literature. Hence, this analysis was carried out in this study to investigate whether credit risk ratings performed by specialized agencies relate to efficiency. Thus, we sought to determine whether the most efficient banks also hold the best ratings.

Accordingly, the banks that received the highest rating (AAA) were also the most efficient banks in all used approaches. In the production approach, the AAA-rated banks obtained a DEA mean score of 84%. In the opposite direction, the banks ranked with BBB and BB ratings were not represented among the efficient samples (except for the profitability approach regarding the BBB group), which may indicate that such ratings are not adequate to discriminate the banking efficiency level in the intermediate range.

The evaluation improves by observing Table 6, in which it is noted that the AAA-rated banks had highlights between banks efficiently, and also the higher DEA median score.

Table 6: Evaluation of the DEA scores according to agency ratings.

GROUP	Rating	INTERMEDIATION			PRODUCTION		PROFITABILITY	
		% Initial sample	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)	% Efficient banks	DEA Score (median)
1	AAA	15%	36%*	0.48	43%**	1.00**	43%**	0.85**
2	AA	18%	14%	0.17	7%	0.22**	7%	0.28
3	A	20%	7%	0.10	21%	0.54	0%	0.21
4	BBB	6%	0%**	0.06*	0%*	0.46	7%*	0.51
5	BB	2%	0%**	0.15	0%*	0.13	0%*	0.56
6	B	8%	7%	0.15	14%	0.58	0%	0.31
7	Sem Rating	32%	36%	0.20	14%	0.33	43%	0.30
	Total	100%	100%		100%		100%	

** Results confirmed by the KS test at significance level 0.05.

For the intermediate ranges, one can observe the same findings of several studies, according to which the methodologies employed by rating agencies are not entirely adequate to uniformly assess the credit risk in emerging market economies (GOMEZ-GONZALEZ; KIEFER, 2009).

The presented median test proved the superiority of the results that the AAA group obtained at the significance level of 0.05. Differences were not found in the intermediation approach only.

6 Conclusion

The analysis above gave rise to ten findings on the Brazilian banking segment's efficiency in 2014 as follows:

I) Banks considered efficient in the intermediation approach held lower profitability scores.

This result demonstrates the difficulty of banks to be effective in these two approaches. In evaluating the return on equity of banks (ROE), it is clear that banks in the intermediation approach had a much lower return of only 6.9%. However, efficient banks in profitability approach had an ROE of 16.9%. These indications have been identified as discriminant factors for the survival of banks in Brazil in the 1990-2010 period in the study by Metzner and Matias (2015).

II) The comparison featuring the Production and Profitability approaches encompasses the most efficient banks.

That observation raises evidence that the supply of services can overcome intermediation when it comes to bank profitability.

III) The Public Federal Banks were considered efficient in 2014

The results indicated that, for the year 2014, only the Public Federal banks were considered efficient. One of the factors that may explain this result is the lower risk of the bank, associated with sovereign risk, lower funding cost, being large-sized, the positive influence of scale gains, and the diversified operations.

IV) The Foreign banks had the worst performance.

In 2014, foreign banks obtained a negative highlight in the ratings in all the approaches used. That result was also found in studies conducted by Wolters, Couto & Felício (2014) and Staub, Souza and Tabak (2010), but in contrast to the conclusions of Barbosa and Macedo (2008) Becker, Lunardi and Maçada (2003).

It is possible that the differences are linked to the evaluation period, potentially strengthening the evidence of the difficulties faced by foreign banks to adapt to the market of emerging countries, as advocated by Sathye (2003).

V) No direct relationship between size and efficiency was detected.

During the period of the present study, micro-sized banks were considered efficient in the three approaches examined; there was no increasing direct relationship between size and efficiency. The good performance of those banks was also reported by Mitzener and Matias (2015). However, Macedo and Cavalcante (2009) demonstrate the existence of efficiencies because of the size in light of the effectiveness of bank agencies. On the contrary, Staub, Souza and Tabak (2010) state that the size is unable to determine bank efficiency in Brazil.

VI) The development banks were efficient on the intermediation approach.

As expected, it was possible to prove that, in 2014, the development banks were efficient, adequately meeting their reason for being, which is to provide financial resources to foster investment and development.

VII) Retail banks were efficient in the production and profitability approaches.

This result may be related to diversification in the activities of banks in this classification. As 2014 was a challenging year for many segments of the economy, as stated by Savoy (2014), niche banks underperformed. Also, Camargo Jr. and Matias (2005) and Souza and Macedo (2009) justify that retail banks are more efficient in operations cost control and infrastructure use.

VIII) The Banks of the corporate segment (Corporate and SMEs) had poor performance.

The efficiency of these banks is linked to the level of investment in the economy, and consequently of companies. As explained by Savoy (2014) low investment result in less movement for the demand for credit, goods and services of banking institutions focused on the corporate segment, which may explain the negative result of those banks.

XIX) The AAA-rated banks were highly efficient.

Despite the higher relationship between the production and the highest rating, efficient banks were also classified with the AAA rating, which reinforces the perception that the best rating can discriminate the banks with better performance.

X) The intermediate ratings did not determine banking efficiency.

In contrast, the other rank ratings showed no relation to the efficiency evaluated by the DEA in the three approaches. This finding may suggest that agency ratings are not able to uniformly evaluate the risk of bank credit in emerging countries (GOMEZ-GONZALEZ; KIEFER, 2009)

In conclusion, the features shared by efficient banks replicate at the three approaches, except for the operating segment in the intermediation approach, in which the development banks were the most efficient, as observed below in Frame 2

1

Frame 2: Characteristics of banks considered efficient in the analysis

CLASSIFICATION	INTERMEDIATION	PRODUCTION	PROFITABILITY
	Characteristic	Characteristic	Characteristic
(1) Origin of Capital	Public Federal**	Public Federal*	Public Federal*
(2) Public or Private	Inconclusive	Inconclusive	Inconclusive
(3) Size	Micro*	Micro*	Micro*
(4) Segment	Development Bank*	Retail*	Retail*
(5) Rating	AAA**	AAA*	AAA*

* Result (strong) confirmed by the Median test at a significance level of 5%

** Result (weak) verified through the comparison between the share in the sample and the 1st quintile (efficient banks) only

Therefore, this study concludes that in 2014, banks including Public federal, micro-sized, Retail (except for the intermediation approach), and AAA-rated were the most efficient.

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References

- [1] Avkiran, N. K. (2011). Association of DEA super-efficiency estimates with financial ratios: Investigating the case for Chinese banks. *Omega*, **39**(3), 323–334.
- [2] Banker, R., Charnes, A., & Cooper, W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, **30**(9), 1078–1092.
- [3] Becker, J. L., Lunardi, G. L., & Maçada, A. C. G. (2003). Análise de eficiência dos Bancos Brasileiros: um enfoque nos investimentos realizados em Tecnologia de Informação (TI). *Produção*, **13**(2).
- [4] Bergendahl, G. (1998). DEA and benchmarks – an application to Nordic banks, **82**, 233–249.
- [5] Berger, A. N., & Humphrey, D. B. (1997). Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, **98**(2), 175–212.
- [6] Ceretta, P. S., & Niederauer, C. A. P. (2001). Rentabilidade e eficiência no setor bancário brasileiro. *Revista de Administração Contemporânea*, **5**(3), 7–26.
- [7] Charnes, a., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, **2**(6), 429–444.

- [8] Charnes, a.; cooper, w. W.; rhodes, E. Measuring the efficiency of decision making units. *European Journal of Operational Research*, v. 2, n. 6, p. 429–444, nov. 1978.
- [9] Drake, L., Hall, M. J. B., & Simper, R. (2006). The impact of macroeconomic and regulatory factors on bank efficiency: A non-parametric analysis of Hong Kong's banking system. *Journal of Banking & Finance*, 30(5), 1443–1466.
- [10] Epure, M., Kerstens, K., & Prior, D. (2011). Bank productivity and performance groups: A decomposition approach based upon the Luenberger productivity indicator. *European Journal of Operational Research*, 211(3), 630–641.
- [11] Eskelinen, J., Halme, M., & Kallio, M. (2014). Bank branch sales evaluation using extended value efficiency analysis. *European Journal of Operational Research*, 232(3), 654–663.
- [12] Fethi, M. D., & Pasiouras, F. (2010). Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey. *European Journal of Operational Research*, 204(2), 189–198. <http://doi.org/10.1016/j.ejor.2009.08.003>
- [13] Freaza, F. P., Madeiro, G. L. E., & Gomes, L. F. A. M. (2004). Análise de eficiência do mercado bancário brasileiro, utilizando a metodologia da análise envoltória de dados. In *XXXVIII SIMPÓSIO BRASILEIRO PESQUISA OPERACIONAL* (pp. 244–257).
- [14] Hadad, M. D., Hall, M. J. B., Kenjegalieva, K. a., Santoso, W., & Simper, R. (2012). A new approach to dealing with negative numbers in efficiency analysis: An application to the Indonesian banking sector. *Expert Systems with Applications*, 39(9), 8212–8219. <http://doi.org/10.1016/j.eswa.2012.01.145>
- [15] Ianoni, M. (2009). Políticas Públicas e Estado: o Plano Real. *Lua Nova: Revista de Cultura E Política*, (78), 143–183.
- [16] Liu, S.-T. (2009). Slacks-based efficiency measures for predicting bank performance. *Expert Systems with Applications*, 36(2), 2813–2818.
- [17] Macedo, M. A. da S., & Barbosa, A. C. T. de A. M. (2009). Eficiência no sistema bancário brasileiro: uma análise do desempenho de bancos de varejo, atacado, middle-market e financiamento utilizando DEA: a performance analysis of retail , wholesale , middle- market and financing banks using dea. *Revista de Informação Contábil*, 3(3), 1–24.
- [18] Macoris, I. S; salgado junior, a. P; falsarella junior, e. the different approaches of banking efficiency: a meta-analysis. in: international conference on data envelopment analysis. 13th edition, 2015, Braunschweig, Germany.
- [19] Mainetti Junior, S., Gramani, M. C. N., & Barros, H. M. (2014). Despesas com tecnologia da informação e eficiência organizacional: novas evidências do setor bancário brasileiro. *Revista de Administração E Inovação*, 11(1), 138.
- [20] Matias, A., & Siqueira, J. de O. (1996). Risco bancário: modelo de previsão de insolvência de bancos no Brasil. *Revista de Administração*, 31(2), 19–28.
- [21] Mostafa, M. (2009). Modeling the efficiency of top Arab banks: A DEA–neural network approach. *Expert Systems with Applications*, 36(1), 309–320.
- [22] Oliveira, G. C. de. (2008). Sistema financeiro: uma análise do setor bancário brasileiro. *Revista de Economia Política*, 28(1), 178–180.
- [23] Paradi, J. C., Zhu, H., & Edelstein, B. (2012). Identifying managerial groups in a large Canadian bank branch network with a DEA approach. *European Journal of Operational Research*, 219(1), 178–187.

- [24] Paula, L. de, & Marques, M. (2006). Tendências recentes da consolidação bancária no Brasil. *Análise Econômica*, **24**(45), 235–263.
- [25] Paula, L. (1998). Tamanho, dimensão e concentração do sistema bancário no contexto de alta e baixa inflação no Brasil. *Nova Economia*, **8**(1), 87–116.
- [26] Périco, A. E., Rebelatto, D. A. do N., & Santana, N. B. (2008). Eficiência bancária: os maiores bancos são os mais eficientes? Uma análise por envoltória de dados. *Gestão & Produção*, **15**(2), 421–431.
- [27] Sealey, C., & Lindley, J. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *The Journal of Finance*, **32**(4), 1251–1266.
- [28] Staub, R. B., Souza, G., & Tabak, B. M. (2010). Evolution of bank efficiency in Brazil: A DEA approach. *European Journal of Operational Research*, **202**(1), 204–213. Staub, R. B., Souza, G. da S. e, & Tabak, B. M. (2010). Evolution of bank efficiency in Brazil: A DEA approach. *European Journal of Operational Research*, **202**(1), 204–213.
- [29] Tecles, P. L., & Tabak, B. M. (2010). Determinants of bank efficiency: The case of Brazil. *European Journal of Operational Research*, **207**(3), 1587–1598. <http://doi.org/10.1016/j.ejor.2010.06.007>
- [30] Tone, K. (2001). A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research*, **130**, 498–509. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0377221799004075>
- [31] Wanke, P., Barros, C. P., & Faria, J. R. (2015). Financial distress drivers in Brazilian banks: A dynamic slacks approach. *European Journal of Operational Research*, **240**(1), 258–268.
- [32] Wolters, M. E.; Couto, e. B; Felício, j. E. . (2014). The effects of the global financial crisis on Brazilian banking efficiency. *Revista Innovar Journal*, **24**, 23–39.
- [33] Wu, D. (Dash), Yang, Z., & Liang, L. (2006). Efficiency analysis of cross-region bank branches using fuzzy data envelopment analysis. *Applied Mathematics and Computation*, **181**(1), 271–281.
- [34] Wu, D., Yang, Z., & Liang, L. (2006). Using DEA-neural network approach to evaluate branch efficiency of a large Canadian bank. *Expert Systems with Applications*, **31**(1), 108–115.