Efficiency of the Brazilian Banking System: An Assessment Using DEA under Three Approaches

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Abstract

This study has used the DEA-BCC (VRS) technique to assess the efficiency of Brazilian banks in the year of 2013 under three most used approaches. Then the differences of the results of each classification were evaluated according to the Mann-Whitney's test. The efficiency scores were assessed according to 1) capital origin, 2) bank size, 3) market niche, and 4) rating. The study demonstrates that public banks are more efficient and that bank size is relevant for production approach, but without impacting profitability and intermediation as bank market niche is a more relevant feature for explaining bank efficiency. Was observed that bank ratings can discriminate all the approaches based on the highest scale (AAA), highlighting the profitability.

1   Introduction

The economic performance of a country is influenced by its financial and banking systems. The performance of the banking system interferes directly with economic agents and, consequently, affects the whole life of the population (Wu; Yang and Liang [1]). Banks play a key role in the economy as they hold both public and private savings as well as they finance investments which contribute to the country's development. For this reason, the assessment of bank efficiency has been object of interest for investors, regulators, managers,

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clients, and society (Fethi and Pasiouras [2]). According to Staub et al. [3] the development of the banking system and the increase of its efficiency are related to a higher economic growth. Also, Tabak et al. [4] emphasise that institutions with low levels of efficiency might become insolvent, which would result in damage to depositors as well as to the strength of the financial system.

In Brazil, the inflation control resulting from the Real Plan required the banks to better manage their operational performance in order to keep the profitability levels and ensure sustainability. Moreover, there was an increase in the foreign participation in the national market in the 1990s, including mergers, acquisitions and privatisation of state banks.

These transformations contributed to increasing the competitiveness in the banking sector, resulting in a more competitive environment where the banks were impelled to assess their efficiency (Périco et al. [5]). According to Wu, Yang and Liang [1], efficiency is also used to indicate the level of competitiveness of the banking system. In this scenario, only the most efficient banks have managed to keep their activities. In this way, as major financing agents, it is indispensable that banks use reliable performance measurement tools as management mechanisms (Barbosa and Macedo [6]). However, the inefficiency of the Brazilian banking system has still been pointed as one of the factors for the low development and financial instability (Tecles and Tabak [7]). Studies also suggest that the Brazilian banking system is less efficient compared to other countries (Staub et al. [3])

To assess the efficiency of a bank it is necessary to compare its performance in relation to those carrying out their activities efficiently (Macoris et al [8]). The efficiency measurement sets out the generation of outputs for a given amount of inputs, which is a concept often applied for assessment of banks (Saha and Ravisankar [9]). In this way, it is possible to rate the efficient bank based on its capacity to achieve a higher level of output for a given level of input. It is also possible to assess the efficiency by decreasing the amount of inputs used (Hasan et al. [11]). The purpose of the efficiency analysis is to find out efficient banks in order to use them as benchmarks for other financial institutions. This analysis can be performed by employing either parametric or non-parametric techniques. The results of such an investigation can be productive for 1) assessing the government policy and the effects of regulations, mergers and market competitiveness, 2) describing the sector efficiency and verifying how efficiency is related to management techniques employed to improve and develop managerial practices, and 3) assisting the decision-making on allocation of investments (Berger and Humphrey [12]).

Banking efficiency can be measured under three main approaches, namely, intermediation, production and profitability (Macoris et al [8]). The first approach addresses the assessment of banks by focusing on their intermediation capacity, that is, capturing resources from surplus agents and relocating them to other agents (Sealy and Lindley [12]). The production approach assesses the bank efficiency in providing services, such as account opening, deposits and cheque clearing. This approach is usually employed for assessing bank branches (Epure et al. [13]). The third approach addresses the profitability, which is of interest of the shareholders, and as such the main objective is to maximise wealth by reducing expenditures and costs in order to increase profit and income.

Although there are several parametric and non-parametric techniques for efficiency assessment, the data envelopment analysis (DEA) is the most used non-parametric technique for measuring the bank efficacy (Assaf and Barros [14] and Pasiouras [15]), including in Brazil Macoris et al [8] also emphasise that the DEA technique has been widely used for assessment of banks, being one of the main fields for its application

From that, the present study aims to assess bank efficiency according to intermediate,

production and profitability approaches of the banks operating in Brazil in the year of 2013. The purpose of such analysis is to compare the performance of Brazilian banking institutions under different approaches. To assess the bank efficacy, the DEA technique was used and data on banking institutions were obtained from the Brazilian Central Bank (BACEN). The results found were complementarily evaluated for standardising 1) capital origin, 2) bank size, 3) bank market niche, and 4) rating of these institutions. The present study contributes to the literature on banking by relating the bank characteristics, such as capital origin, size, market niche and efficiency. Moreover, the comparison between three approaches reveals evidence that there are factors determining efficiency according to a given approach, which does not necessarily contribute to the efficiency in other approaches.

2   Data Envelopment Analysis applied to Banks

The DEA technique has been widely employed to measure the bank efficiency. Avkiran [16] proposes that there are more than 170 studies available on the Web of Science database, all applying the technique to banks. Fethi and Pasiouras [15], also report that among the 191 articles assessing bank efficiency in various countries, 151 of them conducted analysis by employing DEA variations.

Originally developed by Charnes, Cooper and Rhoder [17] the DEA technique was used to assess public education programs in the United States. This technique is a mathematical programming model to assess the relative efficiency of decision-making units (DMUs). These units need to be homogeneous, which means to perform similar activities in order to enable a comparison between them (Périco et al. [5]). The DEA technique has a score for each DMU and the benchmarks have score of 1, meaning that they are efficient. DMUs scoring less than 1 are considered inefficient. Inputs and outputs, which are determined by the manager or researcher depending on the study's objective, are equated in order to determine such a score.

The first DEA model has become known as CCR, which are the author's initials, or CRS (constant returns to scale). The CCR method assumes that input and output returns occur on a constant scale, searching for a non-stochastic and non-parametric linear programming solution to determine the efficiency frontier between the pairs of DMUs (Mostafa [18]). The DEA technique was then unfolded by Banker, Charnes and Cooper [19]) to give rise to the so-called BCC method, also termed as VRS (variable returns to scale). The main modification is that DMUs are thought to be subject to gains and reductions to scale, which is applicable to the banking sector as there are great differences in both bank size and possible gains to scale.

The BCC model redefines the CCR model into two measurements: technical efficiency and scale efficiency. The former identifies the correct usage of resources depending on the scale level of a given DMU.   In one of the first studies applying the DEA technique to banks of emerging countries, Sathye [20] analysed the efficiency of Indian banks in the period from 1997 to 1998 by segmenting them into public, private and foreign banks. The concept of efficiency used by Sathye [20] was the operational one, such as capacity to reduce capture costs and increase revenues with financial application.

In addition to the comparison between banks, there are studies assessing the efficiency of bank branches. One can highlight a study by Pastor et al. [21], who evaluated the efficiency of 573 branches of a major European saving bank by using the concept of intermediation efficiency with focus on costs, including cost indicators as assessment metrics. It was found

that the bank's indicators were not necessary and that some branches would have the capacity to reduce their costs without affecting the level of services offered. In a similar study, Wu, Yang and Liang [1] analysed the efficiency of 805 branches across three Canadian cities. The DEA model was oriented towards reducing costs (inputs) while disregarding environmental and geographical variables.

In the DEA technique, efficient DMUs are those having the best relationship between inputs and outputs. It is possible, therefore, that DMUs show high levels of output for a given level of input, or that they show low levels of input for a given level of output. The input-oriented model seeks to minimise the level of inputs as much as possible while keeping the outputs constant, whereas the output-oriented model seeks to maximise the outputs while keeping the inputs constant.

3   Performance of the Brazilian Banking Σector

The DEA technique was developed in the 1970s, but studies on bank efficiency by using such a technique began by the 1990s, whereas in Brazil they emerged in the 2000s. This analysis verifies bank efficiency under specific approaches, such as efficiency in costs or intermediation.

Although several approaches are cited in the literature, three major ones can be presented, namely, intermediation, production and profitability (Paradi, Zhu and Eldeltein [22]). In addition to the study's objective, what differentiates one approach from another is the set of inputs and outputs, since their choice reflects the features to be measured.

The intermediation approach, proposed by (Sealy and Lindley [12], treats banks like financial intermediaries. In this way, they capture funds from surplus agents and loan resources to deficit agents by using their structures and thus achieving remuneration. Studies use different inputs and outputs to measure efficiency under the intermediation approach, but in general, resources can be used as either inputs or outputs depending on being captured or lent, respectively. The efficiency analysis based on a production approach assesses banks as providers of services to their current account holders (Epure et al. [13])

In this approach, banks would have the function of producing services, such as account openings, deposits, payments, and so on. In order to provide these services, capital and labour are used, with the former being often represented by assets (e.g. realties, machines, equipment) and the latter represented by the number of employees or work costs.

The profitability approach assesses the relationship between costs and profit obtained by banks. From this point of view, efficient banks are those presenting the lowest costs for generation of revenues or the highest profits (Drake, Hall and Simper [23]). In general, inputs are used as costs with personnel, operations and capture of resources, whereas outputs can be represented by revenues and profits.

The literature shows studies in which the impact of bank size on efficiency was assessed, but their results are divergent (Ceretta and Niederauer [24]; Périco et al. [5]; Staub et al. [3]; Tecles and Tabak [7]; Wanke and Barros [25]; Wolters et al., [26]). Ceretta and Niederauer [24] found evidence that large-sized banks in Brazil had an operational efficiency much greater than the others, whereas small and medium-sized banks had equivalent levels of efficiency. The works by Wanke and Barros [25], Wolters et al., [26] and Tecles and Tabak [7] show that large-sized banks are more efficient based on their gains to scale, but not all banks have gains to scale as there are smaller institutions providing specific services.

The study by Périco et al. [5) evaluated the relationship between size and efficiency in Brazilian banks, but the results indicated that bank size was not determinant to explain efficiency, which corroborates the study by Staub et al. [3]. The relationship between size and efficiency seems to be greater in the studies comparing branches to non-conglomerates. In fact, Macedo and Cavalcante [27] demonstrated that bank branches have gains to scale in their operations, since the performance of large-sized banks was superior to that of small-sized ones. However, as for the conglomerate size, Barbosa and Macedo [6] showed evidence that there was no direct relationship between institution's size and level of efficiency.

The influence of capital origin on bank efficacy was analysed by several studies, but there is no consensus regarding the results. In the study by Barbosa and Macedo [6] the most efficient banks were those with foreign control or participation. In this sense, Becker et al. [28] observed better indicators of efficiency in banks with foreign capital, whereas studies by Staub et al. [3] and Wolters et al., [26] found that these banks are less efficient. Although differences in efficiency were observed between public and private banks, the majority of the studies found similar results, with public banks being considered more efficient than both private and foreign ones Becker et al. [28], Staub et al. [3] and Wolters et al., [26]. The study by Wanke and Barros [25] however, found a positive impact of private property on productive efficiency.

Studies have also categorised banks by segment or market niche, but with no conclusive results (Mainetti Junior, Gramani and Barros [29]; Staub et al. [3]).

Of course, the results on banking segmentation are reflected by the sector performance or operating niche. In the study by (Barbosa and Macedo [6] and Souza and Macedo [30] , corporate and whosale banks had a better performance, followed by the retail banks. In the study by Mainetti Junior, Gramani and Barros [29] investigating the impact of IT investments on efficiency, the authors warn that such investments have a distinct impact on banks from different segments, with retail banks benefiting most. However, no significant differences in efficacy were found in wholesale and credit banks as a result of IT investments.

4 Methodological Aspects

The present study can be rated as an empirical research with descriptive and explanatory objectives in which one seeks to describe the characteristics of banks considered efficient. The study can also be rated as an explanatory research aimed to indentify factors contributing to the results found, especially by describing possible causes of bank efficiency. With regard to the approach, this is a quantitative and qualitative research conducted by surveying data, by using mathematical method to measure results and by interpreting information.

4.1 Variables and Methods

The sample of the present study consisted of accounting information from banks operating in Brazil in the year of 2013. This annual information was obtained from the Brazilian Central Bank (BACEN). The initial population of banks had 135 banks, but those presenting any input or output with no related information were excluded from the study

based on analyses of the variables needed for each approach.

After exclusion, the resulting samples consisted of 99 banks with intermediation approach, 110 banks with production approach, and 95 banks with profitability approach. The option to use different quantities of banks for each approach is explained by the necessity to obtain the highest number of DMUs as possible.

Net assets were used as criterion to rank the banks by size and then dividing them into four groups according to a quartile division as follows: micro-sized banks are in the first quartile; small-sized banks are in the second quartile; medium-sized banks are in the third quartile; and large-sized banks are in the fourth quartile.

With regard to the origin of capital, the banks were ranked into four categories: a) national private banks, b) national private banks with foreign control or participation, c) federal public banks, and d) state public banks. Information for this ranking was obtained from the Brazilian Central Bank. Institutions ranked as national private banks with foreign control or participation are branches of foreign banks or have foreign capital comprising the social capital of the bank operating in Brazil.

Besides the ranking by size and origin of capital, the banks were also ranked by segment of market and bank rating. This ranking was performed based on data obtained from a credit risk analysis system (Visionarium), one of the major web systems used for assessment of corporate credit risk in Brazil (Langkamp [31]). The segments of market are: development, corporate, exchange, CDC/consumption, vehicle manufacturers, small- and medium-sized companies, products & services, treasury, and retail. With regard to the bank rating, the ranking of the banks were obtained according to the grades set by the Visionarium system as follows: AAA, AA, A, BBB, BB, and B.

The DEA technique using the Frontier® software was used to obtain the efficiency scores. After defining the database, the variables were selected depending on the approach to be used. The variables of each approach are listed in Table 1.

The variables of each approach were selected according to recommendation by Macoris et al [8]). These variables are described in Table 1.

Table 1: Inputs and outputs used in the study.

	INTERMEDIATION APPROACH	PRODUCTION APPROACH	PROFITABILITY APPROACH
Input	Number of employees	Number of employees	Total assets
Input	Total of deposits	Operational expenditures (except interest rates)	Operational expenditures
Input	Expenditures with interest rates	Fixed assets	Net assets
Output	Credit operations	Total of deposits	Net profit
Output	Financial intermediation revenues	Revenues not related to interest rates	ROA
Output	Investments	-	ROE

In the intermediation approach, the number of employees represents the labour needed to generate loans or to allocate resources. The total of deposits represents the resources captured from surplus agents and expenditures with interest rates are the costs with deposits

captured. The credit operations represent the capital lent to agents and the financial intermediation revenues are the revenues generated by loans. Investments represent the resources invested by the bank to generate revenues.

In the production approach, the number of employees represents the labour needed to perform services and operational expenditures (except interest rates) are the spending needed to provide such services, excluding spending with resource intermediation (Wanke and Barros [25]). Fixed assets represent the assets used for provision of services, such as realties, equipment, etc. The total of deposits represents the deposit accounts, which is a service provided to clients, and the revenues not related to interest rates are revenues from tariffs and services, that is, the remuneration paid for the services provided.

In the profitability approach, the total assets represent the resources the bank uses for their activities, whereas operational expenditures are the spending to generate results and net assets are the money invested by partners or shareholders. The net profit is the result generated, as well as the indicators ROA (return on asset) and ROE (return on equity), which measure the returns on assets and investment, respectively.

These variables are used to measure the effort by the bank to lend more resources, generate more services and obtain returns depending on the approach, that is, intermediation, production and profitability, respectively. All outputs used are different, ranging based on the study's objective. However, one can observe the repetition of the variable "total of deposits" in both inputs (for intermediation approach) and outputs (for production approach). This conceptual difference is due to the distinct goals of these approaches. In the first case, deposits act as inputs (e.g. institution's funding) and, in the second case, deposits are seen as a metric to measure the extension of the services offered to clients.

Data were assessed according to the DEA-BCC method developed by Banker, Charnes and Cooper [19]) also known as VRS (variable returns to scale). This method allows each efficient DMU to be projected onto the frontier surface (envelopment) as determined by efficient DMUs of compatible size. The orientation was that of maximisation of outputs, according to the following mathematical formula:

$$Max \ \theta_o = \sum_{i=1}^{m} v_i X_{io} + v_0 \tag{1}$$

$$S.R.:$$

$$\sum u_r Y_{ro} = 1_{=1} \tag{2}$$

$$\sum_{r=1}^{s} u_r Y_{rj} \leq \sum_{i=1}^{m} v_i X_{ij} + v_0 \tag{3}$$

$$ur, vi \ \geq 0$$

$$j = 1, \dots, n$$

$$r = 1, \dots, si = 1, \dots, m$$

The choice for the DEA-BCC technique is the most suitable to assess bank efficiency when gains to scale are considered in the model, which allows the comparison of different-sized banks in the same analysis. This technique was also employed in studies conducted in Brazil to assess bank efficiency (Périco et al. [5]; Becker et al. [28]; Chabalgoity et al. [2007]; Mainetti Junior, Gramani and Barros [29]).

After obtaining the scores, the sample results were analysed by using the Kolmogorov-Smirnov's test in order to verify the distribution of the means for each approach.

Considering a significance level of 0.05, the test indicated that the samples did not follow a normal distribution and the differences of the means were analysed with the Mann-Whitney's test.

The Mann-Whitney's test was used to assess whether the mean scores in each group and sub-group were significantly different to allow the results to be extrapolated to the entire Brazilian banking system.

The null hypotheses were rejected at 95% confidence interval and 5% significance level, thus indicating that the means obtained were statistically different, which allowed extrapolation of the results to the Brazilian banking system.

The analyses throughout the present study indicate when the test of the means showed differences between the mean efficiency scores found.

5   Main Results

The DEA technique has shown that 66 banks are at the efficiency frontier, that is, 22 for intermediation approach, 26 for production approach and 18 for profitability approach. Table 2 lists the quantity and percentage of efficient banks.

Table 2: Efficient banks by approach.

	Intermediation Approach	Production Approach	Profitability approach
Quantity of efficient banks	22	26	18
(%)	22%	24%	19%

Therefore, 22%, 24% and 19% of the banks were considered efficient regarding the approaches of intermediation, production and profitability, respectively. Analyses of the bank rankings and segments available will be presented below.

5.1   Analysis by Origin of Capital

The analysis by origin of capital allowed us to identify that federal public banks are more efficient regardless of the approach studied, as listed in Figure 1. The fields with positive and negative highlights were painted in yellow and red, respectively.

These colours were used to allow for rapid visualisation and better understanding by the reader.

Origin of Capital	ABORDAGEM DE INTERMEDIAÇÃO			ABORDAGEM DE PRODUÇÃO			ABORDAGEM DE RENTABILIDADE		
	(%) in the Population	(%) of Efficient Banks	Mean DEA Score	(%) in the Population	(%) of Efficient Banks	Mean DEA Score	(%) in the Population	(%) of Efficient Banks	Mean DEA Score
National Private (P.N.)	41%	18%	0,34	41%	27%	0,43	39%	50%	0,58
P.N. With Foreign Control	46%	59%	0,54	44%	58%	0,5	44%	28%	0,47
State ublic	7%	9%	0,43	6%	4%	0,38	8%	6%	0,66
Federal Public	5%	14%	0,79	5%	12%	0,89	5%	17%	0,78
Total	100%	100%		100%	100%		97%	100%	

Figure 1: Efficient banks and capital of origin

The federal public banks represent 14%, 12% and 17% of the efficient banks, respectively, compared to 5% of the total sample. The federal public banks considered efficient in all

approaches were Banco do Brasil and Caixa Econômica Federal. The conclusion that federal public banks are more efficient was also demonstrated in the study by Becker et al. [28], whereas Staub et al. [3] reported that state public banks are more efficient than private banks. The explanation for such a result in the profitability approach can be related to the low capture costs in the federal public banks due to the decreased credit risk perception regarding these institutions, since such risks are naturally linked to the Brazil's sovereign risk.

With regard to the intermediation and production approaches, their better performance is explained by the fact that these banks are used as tools for intermediation of public or subsidised resources. In addition, under the production approach, these banks have more branches and offer more services (e.g. account openings) compared to the other banks.

This finding is also supported when one analyses the mean scores obtained in all approaches. The Mann-Whitney's test confirmed that the mean scores of the federal public banks can be considered higher.

In the comparison of the mean scores, the differences were validated by the test. With regard to the intermediation approach, the comparative assessment between federal public and national private banks using the Mann-Whitney's test allows us to state that the former are more efficient than the latter, since the result indicated significance level of 0.021.

The result was similar in the production approach, with federal public banks having higher mean scores, which was confirmed by the test of the mean that indicated significance levels of 0.011, 0.029 and 0.021 compared to national private banks, foreign-controlled banks and state public banks, respectively.

On the other hand, in the profitability approach, the test of the means indicated that only state public banks had a different efficiency score compared to the national private banks with foreign control at significance level of 0.012.

The national private banks also had good performance regarding the profitability approach, since they represent 38.9 percent of the population and 50 percent of the efficient banks. However, this characteristic is observed neither in the intermediation nor in the production approach, thus suggesting that Brazilian private banks are more oriented towards profits than intermediation of resources and production of banking services.

In considering only the division of banks into public and private institutions, it is possible to notice that the former are more efficient than the latter, as shown in Figure 2.

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Type of Capital	INTERMEDIATION APROACH			PRODUCTION APPROACH			PROFITABILITY APPROACH		
	(%) in the Population	(%) of Efficient Banks	Mean DEA Score	(%) in the Population	(%) of Efficient Banks	Mean DEA Score	(%) in the Population	(%) of Efficient Banks	Mean DEA Score
Public	12%	23%	0,58	11%	15%	0,59	14%	22%	0,71
Private	88%	77%	0,46	89%	85%	0,48	86%	78%	0,52
Total	100%	100%		100%	100%		100%	100%	

Figure 2: Public and private banks

In Figure 2, it is possible to verify that public banks increased their participation in the efficiency sample regarding all approaches, with intermediation representing the best performance, which shows the higher efficiency of public banks in this function.

In the assessment of the test of the means, only in the intermediate approach the mean efficiency score was considered higher in public banks at significance level of 0.027

5.2 Analysis by Size

In the literature, there is no consensus regarding the effect of bank size on efficiency gains among the banks in Brazil. There are authors who support that there are no gains to scale Mainetti Junior, Gramani and Barros [29], whereas studies by Ceretta and Niederauer[24], Tecles and Tabak [7], Wanke and Barros [25] and Wolters et al. [26] demonstrated that the most efficient banks regarding the intermediation and production approaches are the large-sized ones, as shown in Figure 3.

Market Sector	INTERMEDIATION APPROACH			PRODUCTION APPROACH			PROFITABILITY APPROACH		
	% in population	% of efficient banks	Mean DEA score	% in the population	% of efficient banks	Mean DEA score	% of efficient banks	% in the population	Mean DEA score
CDC/Consumption	19%	14%	0.42	20%	13%	0.43	11%	16%	0.41
Retail	14%	14%	0.45	14%	25%	0.6	28%	13%	0.68
Corporate	14%	5%	0.51	15%	13%	0.54	0%	12%	0.50
Small-medium sized companies	18%	0%	0.25	17%	8%	0.38	11%	18%	0.45
Products,, Services and Treasury	13%	27%	0.65	13,3%	17%	0.51	28%	19%	0.66
Exchange	4%	14%	0.83	5%	13%	0.68	11%	5%	0.61
Bank for development	3%	14%	1.00	3%	0%	0.39	6%	4%	0.75
Manufacture/ vehicles	14%	14%	0.44	12%	13%	0.,42	6%	14%	0.52
Total	100%	100%		100%	100%		100%	100%	

Figure 3: Bank efficiency and Bank Size.

It is possible that such divergent results can be explained by the different objectives of the approaches. In this way, larger banks would be more efficient in providing services and intermediating resources, but bank size would not be relevant to explain the profitability as micro-sized banks are highlighted in this approach. One can also notice that micro-sized banks are not necessarily influenced by the size factor, being slightly better than small-sized banks in the first two approaches. This finding can be explained by the fact that most of the micro-sized banks operate in the niche of products, services and treasury (PST), whose group achieved high rates of efficiency in the present study.

Small- and medium-sized banks were negatively highlighted, which suggests that banks of intermediate size have more cost components, but without the benefits of higher revenues. Perhaps this is due to the transition and adaptation from small to large sizes, making these banks less efficient than the others. This analysis allows us to conclude that it is impossible to confirm a positive relationship between efficiency and size in the banking industry as a whole (Macedo and Cavalcante [27]). This assessment will depend on the approach to be considered.

Considering the Mann-Whitney's tests for mean scores, only in the production approach we could verify that the mean score of large-sized banks is significantly higher than those observed among other banks, with significance levels of 0.019, 0.0 and 0.2, respectively, compared to micro, small and medium-sized banks.

5.3 Analysis by Market Niche

The analysis by market niche seems to be one of the main components for determining the bank efficiency in Brazil (Macedo and Cavalcante [27]). In fact, according to Mainetti Junior, Gramani and Barros [29], the bank efficiency would be more related to the market

segmentation than to the institution's size itself. Similarly, Périco et al. [5] support that managerial aspects (resource allocation decisions) are more relevant than size in the DEA analysis.

It is possible to establish a relationship between result obtained and the current economic situation in Brazil in 2013, when the economy slowed down compared to previous years, excessively affecting the entrepreneurial segment (Saboia, [33]). In Figure 4, small- and medium-sized banks (also termed as middle segment) are listed as negative highlights.

Market Sector	INTERMEDIATION APPROACH			PRODUCTION APPROACH			PROFITABILITY APPROACH		
	(%) of Efficient Banks	(%) in the Population	Mean DEA Score	(%) of Efficient Banks	(%) in the Population	Mean DEA Score	(%) of Efficient Banks	(%) in the Population	Mean DEA Score
CDC/Consumption	14%	19%	0.42	13%	20%	0.43	11%	16%	0.41
Retail	14%	14%	0.45	25%	14%	0.60	28%	13%	0.68
Corporate	5%	14%	0.51	13%	15%	0.54	0%	12%	0.50
Small and Medium-sized companies	0%	18%	0.25	8%	17%	0.38	11%	18%	0.45
Products, services and treasury	27%	13%	0.65	17%	13,3%	**0.51**	28%	19%	0.66
Exchange	14%	4%	0.83	13%	5%	0.68	11%	5%	0.61
Bank for development	14%	3%	1.00	0%	3%	0.39	6%	4%	0.75
Manufacturer/Vehicles	14%	14%	0.44	13%	12%	0.42	6%	14%	0.52
Total	**100%**	**100%**		**100%**	**100%**		**100%**	**100%**	

Figure 4: Bank efficiency and market niche.

The segments of banks operating along with companies showed significantly lower efficiency indicators because their performance depends on investments by Brazilian companies, since these banks are highly sensitive to demand for credit. This argument can be founded on the average efficiency of banks serving small- and medium-sized companies in terms of intermediation approach, but which is far below the overall average efficiency. In Brazil, the level of investment has been held close to 18 percent of the GNP, which is considered low compared to that of other countries. This fact affects these segments as the results are lower than those of other banking segments (Saboia, [33]).).

The banks for development were positively highlighted as they had the highest mean DEA score in the profitability and intermediation approaches. A possible cause is the low capture cost with the National Treasury, including the Brazilian institutional support during the year of 2013. Additionally, the banks for development are the only banking segment in Brazil offering long-term credit lines for investments, which ensures a high demand, often at lower costs than the market. On the other hand, because of the lack of structure for providing services, no bank for development was found to be efficient in the production approach.

The retail banks, in turn, achieved higher levels of average efficiency in the profitability

approach, which may evidence the same finding reported by Camargo Jr and Matias [34], to whom retail banks are more efficient in terms of costs and infrastructure for credit and capture operations, including deposits, as these are transformed into efficient levels of profitability (Barbosa and Macedo [6]).

Banks operating in the niche of products, services and treasury (PST) as well as the exchange banks also had positive results, with scores above the average and significant participation in the sample of efficient banks. These banks are focused on revenues from financial market operations, highlighting the treasury gains.

In the assessment of the mean scores, the test indicated differences in both intermediation and profitability approaches. In the former approach, the test confirmed that banks for development had a superior performance, which corroborates the hypothesis that these banks are efficient in the intermediation of resources.

In the profitability approach, one the other hand, it was found that banks rated as PST (i.e. focused on treasury activities) have greater efficiency as their mean score is statistically different compared to those of banks rated as CDC, corporate, manufactures/vehicles and small and medium-sized companies, with significance levels of 0.01, 0.013, 0.04 and 0.02, respectively.

5.4 Analysis by Credit Risk Rating

The analysis of efficiency scores and their relationship with grades given by rating agencies is not usual in the literature. For this reason, it was aimed to conduct an investigation on whether the credit risk rating by agencies is associated with efficiency, that is, whether more efficient banks are also holders of higher rating grades. The Figure 5 lists the efficiency indicators and their relationship with credit risk rating.

Rating	INTERMEDIATION APPROACH			PRODUCTION APPROACH			PROFITABILITY APPROACH		
	(%)Efficient Banks	(%) in the Population	Mean DEA Score	(%) of Efficient Banks	(%) in the Population	Mean DEA Score	(%) of Efficient Banks	(%) in the Population	Mean DEA Score
AAA	40%	14.14%	0.77	33%	13%	0.74	63%	12%	0.68
AA	20%	14.14%	0.48	17%	13%	0.52	13%	12%	0.43
A	27%	16.16%	0.50	39%	18%	0.61	13%	22%	0.45
BBB	0%	7.07%	0.24	0%	6%	0.30	0%	3%	0.32
BB	0%	4.04%	0.24	0%	4%	0.18	0%	5%	0.59
B	13%	13.13%	0.40	11%	13%	0.38	13%	7%	0.42
Without rating	0%	31%	0.45	0%	34%	0.55	0%	39%	0.19
Total	100%	100%		100%	100%		100%	100%	

Figure 5: Bank efficiency and credit risk rating.

The information in Figure 5 show evidence that banks rated with maximum grade (AAA) are also the most efficient ones in all approaches. The greatest discrimination occurs in the profitability approach as 63 percent of the efficient banks were rated AAA. On the other hand, banks rated BBB and BB were not represented among the sample of efficient banks, which may indicate that the grades given by rating agencies are not enough to discriminate

the level of risk for banks in intermediate position.

As for the intermediate positions, many studies have reported the same findings after evaluating the methodologies used by the rating agencies, since they are not completely suitable to regularly assess the credit risk in economies of the emerging markets (Gomez-Gonzalez and Kiefer [35]).

One can notice that there is evidence that the credit risk rating for Brazil would be strongly related to the efficiency of the banks in terms profitability. The fact that the non-rated banks had lower DEA scores contributes to this hypothesis, since they represented the group with the worst average score in the present study.

The test of the means confirms this result for both intermediation and production approaches as it was found that the mean score of AAA banks was significant different from the other ratings.

6 Conclusion

The present work was aimed to assess the banking efficiency of the banks operating in Brazil in 2013. This analysis was performed under the approaches of intermediation, production and profitability by using the DEA technique. The reason for comparing the results of three approaches is to investigate whether there are differences in bank efficacy depending on the changes in the point of view, and consequently, in the inputs and outputs used. The contribution of this work to the banking literature relied on the relationship between the characteristics of a bank (e.g. origin of capital, size and market niche) and efficiency. Moreover, the comparison between three approaches helped find out factors related to efficiency for a given point of view, but not necessarily for the others.

Therefore, based on the results obtained by using the DEA technique, the characteristic of efficient banks have been analysed. The results indicated that size is related to higher levels of efficiency only in the approaches of intermediation and production, but not in the profitability. One possible explanation for this would be the gains to scale achieved by large-sized banks to intermediate resources and provide services, but with regard to profitability, the micro-sized banks can operate in more profitable segments and present a leaner structure, thus explaining their higher efficiency in this approach.

The origin of capital of the banks seems to have some relation with efficiency. In all approaches, it was found that public banks are more efficient than private ones. Federal public banks had the highest average efficiency score in the approaches of profitability and production and the second highest score in the intermediation approach, suggesting that federal public banks would be more efficient than the other banks. However, state public banks had very low efficiency levels in the approaches of intermediation and production.

It was also found that foreign capital banks and banks with foreign participation had high average scores, mainly in the production approach. National private banks operated at very low levels of efficiency in the approaches of intermediation and production, but exhibited higher levels of efficiency in the profitability approach.

The market niche of the banks has also revealed important characteristics. The banks for development had high efficiency scores, except in the production approach, since they provide no service. As for other segments, evidence show that approach influences significantly the results, since a given segment can be very efficient under one approach and less efficient under another. Therefore, there seems to be no solid result for all approaches. With regard to the credit risk rating, banks rated as AAA had higher average

efficiency scores, although there is no pattern for all approaches regarding the other ratings..

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