EVALUATION OF BANK EFFICIENCY

IN BRAZIL: A DEA APPROACH

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ABSTRACT

Purpose: The research aims to evaluate the efficiency of banks that operated in the Brazilian market in 2013. To achieve this goal, efficient banks were identified according to the production approach. To detect and explain efficiency standards, additional analyses were carried out related to: 1. capital origin, 2. size, 3. business segment, and 4. risk rating.

Originality/gap/relevance/implications: The Brazilian literature on bank efficiency features several studies linking the efficiency of banks to capital origin and size. However, the relationship between efficiency and business segment has been poorly explored and the relationship between efficiency and risk rating is scarce. In this sense, this research contributes to the literature by exploring the relationship between efficiency and business segment, as well as the relationship between efficiency and risk rating.

Key methodological aspects: The research uses a quantitative approach and employs the Data Envelopment Analysis (DEA) technique to calculate efficiency scores. The data were obtained from the Central Bank of Brazil (Bacen).

Summary of key results: Federal public banks and large banks are, on average, more efficient. Banks operating in foreign exchange and retail, as well as banks with high credit ratings, also achieved high levels of efficiency.

Key considerations/conclusions: Efficient banks proved to be more profitable, lent less money in proportion to their total assets, and received fewer complaints filed with the Central Bank of Brazil in 2013.

KEYWORDS

Bank efficiency. Banks. Brazilian banks. Production approach. DEA.

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1 INTRODUCTION

The 1990s were a period of significant changes in the banking sector (Staub, Souza, & Tabak, 2010). This period marked the beginning of an increase in foreign participation in the domestic market with the entry of international banks, mergers and acquisitions, and privatization of state-owned banks. These changes contributed to increase competition in the banking sector, and, within a more competitive environment, these companies found themselves compelled to evaluate efficiency in meeting customer demands (Périco, Rebelatto, & Santana, 2008). The concept of efficiency is related to the measurement of an output for a given level of input, and this concept can be applied to banking operations (Saha & Ravisankar, 2000). In this sense, an efficient bank is one that obtains maximum levels of output for a given level of input, or one that is able to minimize the inputs used for a given level of output (Hasan, Kamil, Mustafa, & Baten, 2012).

The Brazilian banking sector plays an important role in the economy, since the stock and securities market is yet undeveloped, which emphasizes the participation of banks in financing investments that contribute to the country's development. Thus, the performance of the banking system is important not only to its managers, but also to customers, investors, regulators and society (Fethi & Pasiouras, 2010). According to Staub, Souza and Tabak (2010, p. 204), "the development of the banking system and the increase of its efficiency are related to greater economic growth." In this sense, Tabak, Krause and Portella (2005) stress that institutions with low levels of efficiency could become insolvent, causing losses to depositors and jeopardizing the solidity of the financial system.

Considering the importance of the banking system in the economy, studies on bank efficiency contribute to understand the determining factors for efficiency, to analyze the effects of new rules on the efficiency of banks, to identify good and bad management practices, and to support decisions in public policy (Tabak *et al.*, 2005). Regarding Brazilian banks, Staub *et al.* (2010) state that changes in average efficiency over time could indicate that such efficiency is influenced by macroeconomic and regulation changes.

Bank efficiency can be measured according to three main approaches: intermediation, production and profitability (Macoris, Salgado, & Falsarella, 2015). The intermediation approach is used to assess the efficiency of banks in intermediating funds between agents with surplus funds and other economic agents (Sealey & Lindley, 1977). The production approach analyzes the efficiency of banks in providing banking services, such as opening accounts, check clearing, reports and others (Epure, Kerstens, & Prior, 2011). The profitability approach, widely used in Brazil, considers the efficiency of banks to generate profit, given their costs (Drake, Hall, & Simper, 2006). In this research, the production

approach is used to evaluate the efficiency of banks, since the provision of good services is an important competitive factor and necessary to improve customer perception and acceptance (Périco *et al.*, 2008).

Although several parametric and nonparametric techniques are used to evaluate efficiency, the nonparametric technique Data Envelopment Analysis (DEA) is the most widely used to assess bank efficiency (Fethi & Pasiouras, 2010). According to Avkiran (2011), the Web of Science database contains more than 170 papers combining DEA and banks. The main advantage of DEA is not imposing a functional form for the efficiency frontier, which allows it to be constructed from the data (Macoris *et al.*, 2015).

Therefore, the aim of this research is to evaluate the production efficiency of banks operating in Brazil in 2013. The data used are available from the Central Bank of Brazil (BACEN), and the DEA technique was used to estimate efficiency. A further analysis was carried out to detect and explain efficiency standards regarding: 1. capital origin, 2. size, 3. business segment, and 4. risk rating. The study contributes to the literature by exploring the relationship between efficiency and business segment, as well as the relationship between efficiency and risk rating, aspects that are poorly investigated in the Brazilian literature.

2 BANK EFFICIENCY AND DATA ENVELOPMENT ANALYSIS

The literature addressing bank efficiency with the use of the DEA technique dates from the 1990s. In Brazil, however, studies on bank efficiency with this technique emerged in the early 2000s. This analysis measures bank efficiency in some specific aspect, such as cost efficiency or financial intermediation. Therefore, there are different approaches to measure efficiency in distinct aspects.

2.1 ANALYSIS OF BANK EFFICIENCY

Although studies show different approaches with different inputs and outputs, three main approaches can be cited: intermediation, production and profitability (Paradi, Yang & Zhu, 2011). In addition to the objective of the analysis, what distinguishes one approach from another is the set of inputs and outputs, as their choice reflects the aspect intended to be measured.

The intermediation approach was proposed by Sealey and Lindley (1977). The function of banks in this approach is to intermediate funds. This means that they raise funds from surplus spending agents and lend them to deficit spending agents, using their structure to this end and receiving a fee for their services.

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Studies differ as to the inputs and outputs used to measure efficiency in the intermediation approach. However, generally speaking, raised funds can be considered as inputs and funds to be lent as outputs. Among the studies that applied the intermediation approach to Brazilian banks, Staub *et al.* (2010) used raised funds, interest expenses, operating expenses (excluding staff expenses) and staff expenses as inputs, and the outputs were deposits, loans and investments.

The production approach analyzes banks as producers of services for their account holders (Epure *et al.*, 2011). From this perspective, the function of banks would be to generate services for customers, such as opening accounts, deposits, payments, provision of reports, check clearing and others. In this approach, banks use capital and labor to provide these services to customers. Capital can be represented by the assets used in the provision of services such as real estate, machinery and equipment, and labor can be represented by the number or cost of staff. Bergendahl (1998, p. 235) points out that, in the production approach, "the volume of services will be a significant output and the cost of producing these services an appropriate input." The author further states that the production approach "can be viewed as minimizing inputs related to personnel and materials to a desired level of services such as loans and deposits" (Bergendahl, 1998, p. 237). Becker, Lunardi and Maçada (2003) evaluated bank efficiency in the production approach in Brazilian banks, considering as inputs investments in information technology (IT), physical structure, staff expenses and other expenses, and as outputs net income from financial intermediation, net income from services, and net income from international operations.

Unlike the intermediation and production approaches, the profitability approach evaluates the relationship between the costs and profits of banks. From this perspective, efficient banks are those considered to have the lowest costs to generate revenue and the highest profits (Drake *et al.*, 2006). Potential inputs include staff costs, operating costs, and fundraising costs, and outputs can be represented by revenue and profit. The study of Souza and Macedo (2009) evaluated Brazilian banks from the perspective of profitability and considered as inputs leverage, deposit levels, credit operation levels, and operating costs, and outputs as immediate liquidity and operating profitability.

Bank efficiency analysis was used to measure the efficiency of IT investments (Becker, Lunardi, & Maçada, 2003; Maçada, Becker, & Lunardi, 2005; Mainetti, Gramani, & Barros, 2014). The studies concluded that banks which invest more in IT are more efficient. However, the study of Mainetti, Gramani and Barros (2014) warns that investments in IT have different impacts on different business segments, retail banks being the ones that most benefit from such investments. However, among commercial banks and those specializing in loans, IT investments do not generate significant differences in efficiency.

The literature features studies that assess the impact of bank size on efficiency (Périco *et al.*, 2008; Staub *et al.*, 2010; Tecles & Tabak, 2010; Wanke & Barros, 2014; Wolters, Barbosa, & Felicio, 2014). Although not all studies present evidence related to size. The works of Wanke and Barros (2014) and Wolters, Barbosa and Felicio (2014) indicate that larger banks are more efficient due to their economies of scale. Tecles and Tabak (2010) explain that large banks are more efficient, yet not all banks have economies of scale, as there are smaller institutions operating in specific services. The influence of capital origin on efficiency also presents dissimilar results. Becker *et al.* (2003) identified the best efficiency ratios in foreign banks and banks with foreign capital participation, while Assaf, Barros and Matousek (2011) found evidence that foreign capital has improved technical efficiency in Saudi banks. In the opposite direction, for Staub *et al.* (2010) and Wolters *et al.* (2014), foreign banks are less efficient. Another aspect analyzed includes differences in efficiency between public and private banks. The studies of Staub *et al.* (2010) and Wolters *et al.* (2014) indicate that public banks are more efficient than private banks, while Becker *et al.* (2003) point out that state-owned public banks had the lowest rates of efficiency and federal public banks had the highest. The study of Wanke and Barros (2014), however, found a positive impact of private ownership on production efficiency. Some studies categorize banks by business segment or market niche, without, however, presenting conclusive results (Mainetti *et al.*, 2014; Staub *et al.*, 2010).

The study of bank efficiency proved to be well suited to evaluate impacts of regulatory changes, mergers and acquisitions, privatizations and crisis (Costas & Panagiotis, 2010; Tecles & Tabak, 2010; Wanke & Barros, 2014; Wolters *et al.*, 2014). The research has found a negative impact on the average efficiency of banks in times of crisis, and Tecles and Tabak (2010) identified a drop in the cost efficiency of Brazilian banks in the periods of instability caused by the 2002 elections. The work of Wolters *et al.* (2014) on Brazilian banks found differences in the decline of efficiency by size and capital origin. Small banks showed the largest drop in efficiency following the 2008 financial crisis, as did foreign banks. The study of Costas and Panagiotis (2010) on Greek banks identified that the efficiency of banks was reduced in times of crisis, yet it recovered within two years of the event and surpassed the initial efficiency. Wanke and Barros (2014) found a positive impact of mergers and acquisitions on cost efficiency.

The literature review above comprises several studies on Brazilian banks. Its analysis indicates that evaluation of efficiency using the DEA technique in Brazil is at an early stage, and there are still many issues to be further explored, such as the relationship between efficiency and business segment, as well as risk rating.

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3   METHODOLOGICAL ASPECTS

This research can be classified, according to the definitions by Gil (2002), with regard to type, as empirical research, since it analyzes information about the reality of banks in Brazil. As for objectives, it can be classified as descriptive and explanatory, since it describes the characteristics of banks and aims to identify and understand the causes of bank efficiency. As for approach, it is quantitative, since it uses information from banks and a mathematical method to generate results, and also analyzes and interprets them based on economic and financial information.

3.1   VARIABLES

The approach used in this work to measure bank efficiency is the production approach. The data used in the analysis are from banks that operated in Brazil in 2013. This information was obtained from the Central Bank of Brazil and the data used are annual. The initial sample contained 136 banks; however, after the variables were defined, some banks were removed from the sample due to lack of necessary information. Thus, the efficiency analysis was carried out with 110 banks containing all information required.

The choice of variables required the identification of elements considered in the literature and the information available in the Accounting Plan for Institutions of the National Financial System (Cosif), used by Brazilian banks. Thus, based on the reviewed literature and the information available in Cosif, the input and output variables were selected. Table 1 summarizes the variables used in the study.

TABLE 1

VARIABLES USED TO ELABORATE THE MODEL

VARIABLE	IDENTIFICATION	MEANING
Number of staff	Input	Labor, people who provide the services
Operating expenses (excluding interest)	Input	Expenses with banking operations, excluding financial intermediation expenses
Fixed assets	Input	Capital, assets used to provide services such as real estate, equipment and machinery
Total deposits	Output	Deposit accounts
Revenue not related to interest	Output	Revenue obtained from providing services, such as bank fees and revenue from services

Source: Elaborated by the authors.

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Three variables were selected as inputs: number of staff, operating expenses (excluding interest), and fixed assets. Number of staff represents labor, the human resources providing services to customers (Macedo & Barbosa, 2009; Saha & Ravisankar, 2000; Sathye, 2003). Operating expenses (excluding interest) represent the cost of the bank's operations, excluding expenses related to financial intermediation (Liu, 2009; Sathye, 2003; Wanke, Barros, & Faria, 2015). The third input is fixed assets, representing the capital, i.e., the assets that the company uses to provide services (Becker *et al.*, 2003; Liu, 2010).

The outputs were represented by two variables: total deposits and income not related to interest. Total deposits represent deposit accounts, or the monetary value contained in such accounts (Bergendahl, 1998; Liu, 2010; Staub *et al.*, 2010). Income not related to interest includes revenue from fees and services and other revenue unrelated to financial intermediation (Liu, 2009; Saha & Ravisankar, 2000).

Bank efficiency in Brazil will be evaluated using the DEA technique with constant returns to scale, in the output-oriented BCC model. The reason for using the BCC model is that banking enables economies of scale, i.e., there are gains related to the amount of services produced by a bank.

3.2 DATA ENVELOPMENT ANALYSIS

The DEA technique has been widely used to assess relative efficiency (Fethi & Pasiouras, 2010). According to Becker *et al.* (2003, p. 72), "DEA is a mathematical programming technique, originally proposed by Charnes, Cooper and Rhodes (1978), which evaluates the relative efficiency of a number of homogeneous units." These homogeneous units are called Decision Making Units (DMUs), and they should perform similar activities in order to make the comparisons (Périco *et al.*, 2008). Thanassoulis (2003) explains that the DEA technique was developed to compare the relative efficiency of units that perform similar functions with regard to resources used and outputs produced, such as banks, schools and hospitals. DEA is a nonparametric test, which means that it does not require statistical assumptions. Therefore, there is no functional form for the frontier, such as linear or exponential one. It is constructed out of the data (Macoris *et al.*, 2015).

The DEA technique compares DMUs and presents a score for each one. DMUs that have a score of 1 are efficient, while those with a score lower than 1 are inefficient. This score is determined by analyzing inputs and outputs. The inputs and outputs are determined by the manager or researcher, but what influences their choice is the objective of the analysis. Using bank efficiency analysis as an

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example, if the objective of the analysis is to measure efficiency in terms of profitability, the set of inputs and outputs will be related to costs and profits. Similarly, if the objective is to measure efficiency in intermediating funds, the inputs will be related to raised funds and the outputs to loans. The seminal work that originated the DEA technique was carried out by Charnes *et al.* (1978). However, the method has been further explored, and two main application models can be cited: Charnes *et al.*, 1978 which considers constant returns to scale, and Banker, Charnes, & Cooper, 1984 which considers variable returns to scale.

In this technique, DMUs considered as efficient feature a better relationship between inputs and outputs. For inefficient units, there are two ways to improve efficiency: reducing inputs while maintaining the level of outputs, or increasing outputs while maintaining the same level of inputs. These two options are called model orientation. The input-oriented model seeks to reduce input levels to the minimum, keeping outputs constant, while the output-oriented model seeks to increase outputs, keeping input levels constant (Batista, 2009).

Efficiency can be measured in processes that generate intermediate products. In a bank, for example, assets and staff labor generate loans for account holders, and these loans generate revenue for the bank. Thus, a bank's efficiency can be evaluated by a two-stage DEA model. The first stage evaluates efficiency in transforming assets and labor into loans. Therefore, assets and labor are inputs, and they are used to generate loans, outputs. The second stage evaluates the efficiency of transforming loans into revenue. To this end, it uses loans, the output of the first stage, as input, and revenue as output. Zhu (2009) explains that the outputs of the first stage are the only inputs of the second stage. The two-stage model was used by Paradi *et al.* (2011) to assess Canadian banks; in Brazil, the work of Wanke and Barros (2014) also used a two-stage model.

There are two types of DEA model, radial and non-radial (Tone, 2011). Radial models consider proportional changes in inputs and outputs, such as CCR. This means that score measurement calculates the proportional maximum input reduction or the proportional maximum output expansion. However, not always do inputs and outputs feature proportional changes and, in this case, non-radial models can be used, such as slacks-based measure (SBM), which considers slacks to calculate the score. Slacks are abundant inputs or insufficient products. By using more inputs than necessary or generating fewer products than expected, DMUs with slacks are considered inefficient.

The SBM model, developed by Tone (2001), is a variation of the DEA technique. One aspect that distinguishes it from the traditional DEA models, CCR and BCC, is not requiring an orientation (input or output), since the slacks, from inputs and outputs, are considered simultaneously to generate the score. Thus, the model can be input-oriented, output-oriented, or have no orientation at all.

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This study uses the output-oriented BCC model, which can be mathematically represented as follows:

$$Max \ h_o = \Sigma_{i=1}^{n} \ v_i X_{io} + v_o \tag{1}$$

Subject to the constraints

$$\Sigma_{r=1}^{m} \ u_r Y_{ro} = 1 \tag{2}$$

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

$u_r, v_i \geq 0$
$j = 1, ..., s$
$r = 1, ..., m$
$i = 1, ..., n$

The mathematical representation indicates that the objective is to maximize the outputs for each bank, given the constraints. In the constraints, the sum of the inputs multiplied by their respective weights must be equal to 1. This is necessary for the problem to be solved by linear programming. In the second constraint, the outputs must be greater than or equal to 1.

3.3 SAMPLE DESCRIPTION

The analysis of the sample of Brazilian banks allowed a better understanding of their characteristics, such as size and capital origin. Table 2 features the classification of banks according to size.

TABLE 2

CLASSIFICATION OF BANKS BY SIZE

SIZE	NUMBER OF BANKS	PARTICIPATION (%)
Micro	24	21.8%
Small	26	23.6%
Medium	30	27.3%
Large	30	27.3%
Total	**110**	**100.0%**

Source: Elaborated by the authors.

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Classification by size was based on net equity, considering all banks in the financial system (136). The banks were later ordered and divided into quartiles. In the first quartile, micro-sized banks were gathered; in the second quartile, small banks; in the third quartile, medium-sized banks; and, in the fourth quartile, large banks. Although all banks were used in the classification, only the participating banks of the sample feature in Table 2, which shows that medium--sized and large banks, have a greater participation in the sample.

As for capital origin, the banks were classified into six categories: foreign, domestic private, domestic private with foreign control, domestic private with foreign participation, federal public and state-owned public. The information for this classification was obtained from the Central Bank of Brazil. Banks classified as foreign are subsidiaries of foreign banks. Banks classified as domestic private with foreign control are those in which foreign participation is greater than or equal to 50% of the voting capital stock. Banks classified as domestic private with foreign participation have foreign participation greater than 10% and lower than 50% of the voting capital stock. Table 3 features information of banks by capital origin.

TABLE 3

CLASSIFICATION OF BANKS BY CAPITAL ORIGIN

CAPITAL	PARTICIPATION	DEPOSITS ($)	%	LOANS ($)	%
Foreign	1.8%	15,933,565.00	0.9%	11,122,953.00	0.4%
Domestic private	40.9%	591,929,745.00	32.5%	843,174,356.00	31.9%
D.P. foreign control	43.6%	244,621,387.00	13.4%	357,509,070.00	13.5%
D.P. foreign particip.	2.7%	30,740,054.00	1.7%	25,569,133.00	1.0%
State-owned public	6.4%	52,937,519.00	2.9%	46,476,722.00	1.8%
Federal public	4.5%	886,188,374.00	48.6%	1,363,036,148.00	51.5%
Total	**100.0%**	**1,822,350,644.00**	**100.0%**	**2,646,888,382.00**	**100.0%**

Source: Elaborated by the authors.

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According to Table 3, out of the total (110 banks), the largest share in the sample is of domestic private capital banks with foreign control, 43.6%. Although banks with foreign control are the most numerous, they have only 13.4% of total deposits and 13.5% of loans.

The information in Table 3 shows that the Brazilian financial system has currently a large share of banks with domestic capital, about 80%, whether private or public. Federal public capital banks, however, have a share of approximately 50%, evidencing their large participation and importance in the national financial system.

In addition to classification by size and capital origin, banks were ranked by business segment and risk rating. This classification was based on information from the credit risk assessment system Visionarium, which is one of the main systems used for corporate credit risk assessment in Brazil (Langkamp, 2014). The business segments are: Development Banks, Corporate, Foreign Exchange, CDC/consumption, vehicle manufacturers, Small and Medium-Sized Businesses, Products, Services and Treasury, and Retail. As for rating, banks were classified as AAA, AA, A, BBB, BB and B.

Efficiency scores were obtained using Frontier® software.

4 ANALYSIS OF RESULTS

The efficiency analysis of selected banks showed 26 banks on the efficiency frontier. The mean efficiency of all 110 banks analyzed is 0.49. Banks on the frontier have an efficiency score equal to 1, and the 20% least efficient banks have a mean efficiency score of 0.11.

Table 4 presents the efficient banks in alphabetical order, as well as the origin of their capital, the business segment in which they operate and their size.

TABLE 4

EFFICIENT BANKS

INSTITUTIONS	CAPITAL ORIGIN	BUSINESS SEGMENT	SIZE[1]
Banco Fidis	Domestic private with foreign control	Auto manufacturing/sales	Me
Banco IBM S.A.	Domestic private with foreign control	–	S
Banco Vipal	Domestic private	Corporate	M

(continue)

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TABLE 4 (CONTINUATION)
EFFICIENT BANKS

INSTITUTIONS	CAPITAL ORIGIN	BUSINESS SEGMENT	SIZE[1]
Bancoob	Domestic private	Consumer rights consumer	Me
Banrisul	State-owned public	Retail	L
BB	Federal public	Retail	L
Banco BRJ S.A.	Domestic private	Small and medium-sized businesses	M
Banco Capital S.A.	Domestic private	Small and medium-sized businesses	M
Banco Cargill S.A.	Domestic private with foreign control	Products, services and treasury	S
Banco Cooperativo Sicredi S.A.	Domestic private with foreign control participation	Consumer rights consumer	Me
Banco do Nordeste do Brasil S.A.	Federal public	Retail	L
Banco KEB do Brasil S.A.	Domestic private with foreign control	Foreign exchange	M
Banco REP Oriental Uruguay BCE	Domestic private with foreign control	Foreign exchange	M
Banco Woori Bank do Brasil S.A.	Domestic private with foreign control	Foreign exchange	M
Banco Yamaha Motor S.A.	Domestic private with foreign control	Auto manufacturing/sales	M
BTG Pactual	Domestic private with foreign control participation	Products, services and treasury	L
Caixa Econômica Federal	Federal public	Retail	L
Credit Agricole	Domestic private with foreign control	Products, services and treasury	Me
Credit Suisse	Domestic private with foreign control	Products, services and treasury	G

(continue)

TABLE 4 (CONCLUSION)

EFFICIENT BANKS

INSTITUTIONS	CAPITAL ORIGIN	BUSINESS SEGMENT	SIZE[1]
Honda	Domestic private with foreign control	Auto manufacturing/sales	Me
ICBC do Brasil BM S.A.	Domestic private with foreign control	–	S
ING	Foreign	Corporate	Me
ITAU	Domestic private	Retail	L
Santander	Domestic private with foreign control	Retail	L
Votorantim	Domestic private	Corporate	L
VR	Domestic private	Consumer rights/consumer	S

1 – M (Micro); S (Small); Me (Medium); L (Large).

Source: Elaborated by the authors.

In the group of efficient banks, with regard to size, it is observed that there is greater participation of large banks, with a share of 34.6%. The mean score of large banks is 0.68, higher than the overall mean. Table 5 features information according to size.

TABLE 5

ANALYSIS OF BANKS BY SIZE

	EFFICIENT	%	SAMPLE	%	MEAN DEA SCORE
Micro	7	26.9%	24	21.8%	0.47
Small	4	15.4%	26	23.6%	0.35
Medium	6	23.1%	30	27.3%	0.44
Large	9	34.6%	30	27.3%	0.68
Total	**26**	**100.0%**	**110**	**100.0%**	**0.49**

Source: Elaborated by the authors.

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The first column lists the analyzed sizes. The second column features efficient banks by size, in absolute numbers, and the third column features the relative values of efficient banks. The fourth column features all banks in the analysis, in absolute numbers, and the fifth column features the relative values for all banks. Although large banks account only for 27.3% in the overall sample, they show greater participation among efficient banks, i.e. 34.6%. The last column features the mean scores for banks in each size. The information presented in Table 5 suggests that size may be a factor that contributes to increase bank efficiency, since the mean score of large banks is somewhat higher than the score of other categories. This result is similar to the evidence found in the studies of Ceretta and Niederauer (2001), Tecles and Tabak (2010), Wanke and Barros (2014) and Wolters *et al.* (2014), yet it goes in the opposite direction of the results obtained by Macedo and Barbosa (2009), Macedo, Santos and Silva (2008), Périco *et al.* (2008) and Staub *et al.* (2010), which did not identify the influence of size on efficiency. The justification for the contribution of size to efficiency is the possibility of economies of scale in banking activities.

Capital origin of banks also seems to have some influence on production efficiency. In the classification by capital origin, federal public banks have a fairly high mean score, 0.89. This value is considerably above the overall mean and suggests that federal banks are more efficient than the average. However, the same does not happen with state-owned public banks, which had a mean score of 0.38, below the overall mean, a result similar to that found by Becker *et al.* (2003). Federal banks include Banco do Brasil, Banco do Nordeste and Caixa Econômica Federal, all efficient banks operating in the retail segment and which together account for over 47% of total deposits. Table 6 features information organized by capital origin.

TABLE 6

ANALYSIS OF BANKS BY CAPITAL ORIGIN

	EFFICIENT	%	SAMPLE	%	MEAN DEA SCORE
Foreign	1	3.8%	2	1.8%	**0.86**
Domestic private	7	26.9%	45	40.9%	**0.43**
D. P. foreign control	12	46.2%	48	43.6%	**0.50**
D. P. foreign particip.	2	7.7%	3	2.7%	**0.70**

(continue)

TABLE 6 (CONCLUSION)

ANALYSIS OF BANKS BY CAPITAL ORIGIN

	EFFICIENT	%	SAMPLE	%	MEAN DEA SCORE
State-owned public	1	3.8%	7	6.4%	**0.38**
Federal public	3	11.5%	5	4.5%	**0.89**
Total	**26**	**100.0%**	**110**	**100.0%**	**0.49**

Source: Elaborated by the authors.

All federal public banks in the Table 6 are large banks. The explanation for this finding may be related to the fact that federal employees receive wages and social benefits through federal bank accounts. Thus, federal public banks have a large number of clients that carry out transactions. In addition, the cost of raising funds is low for federal public banks, since their credit risk rating is linked to the sovereign credit rating, which enables them to offer competitive rates on loans and other operations. These two features have helped federal public banks attract a large number of clients, thus obtaining economies of scale and greater efficiency.

Banks with foreign capital also had a high mean score, 0.86, similar to the result found by Assaf *et al.* (2011) and Becker *et al.* (2003), but different from the one found by Staub *et al.* (2010) and Wolters *et al.* (2014), for whom foreign banks had the worst levels of efficiency. Although the studies are conflicting, foreign capital may contribute to raise a bank's efficiency level. One possible explanation would be the transfer of management techniques and knowledge acquired abroad.

The analysis of business segments may be an important factor to distinguish the efficiency of banks in Brazil (Macedo & Barbosa, 2009). The findings indicate that banks operating in the foreign exchange segment are the most efficient in the sample, with a mean score of 0.68. Due to the characteristics of their segment, foreign exchange banks have a small share in total deposits and total loans. However, their revenue is basically comprised of commissions, gains on financial markets and treasury gains. Therefore, these banks obtain large revenues from services and have smaller structures compared to other segments, which could justify their high level of efficiency. Table 7 features the analysis of banks by business segment.

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ANALYSIS OF BANKS BY BUSINESS SEGMENT

	EFFICIENT	%	SAMPLE	%	MEAN DEA SCORE
Development bank	0	0.0%	3	2.9%	**0.39**
Foreign exchange	3	12.5%	5	4.8%	**0.68**
CDC/consumption	3	12.5%	21	20.0%	**0.43**
Corporate	3	12.5%	16	15.2%	**0.54**
Auto manufacturing/sales	3	12.5%	13	12.4%	**0.42**
Small and medium business	2	8.3%	18	17.1%	**0.38**
Products	4	16.7%	14	13.3%	**0.51**
Retail	6	25.0%	15	14.3%	**0.60**

Source: Elaborated by the authors.

Banks operating in the retail segment also have a high mean score, 0.60. Retail banks account for over 76% of total deposits and 65% of total loans and are, therefore, quite representative. Also noteworthy is the fact that approximately 50% of retail banks are large and have an AAA rating. Results of similar studies were not significant enough to analyze the effect of business segment on efficiency (Staub *et al.*, 2010). However, the work of Mainetti *et al.* (2014) indicates that IT investments may have an impact on efficiency only among retail banks. Retail banks perform several banking activities and have the advantage of sharing costs and structure, both in credit operations and deposits, investments and others. Therefore, these banks would have proportionally lower costs to provide their services, which would their advantage in terms of efficiency.

When analyzing the banks according to credit rating, it was identified that banks rated AAA, AA and A have the highest mean scores, with the AAA rating featuring the highest score, 0.74. Banks with BBB, BB and B ratings have lower mean scores. This information suggests that banks with better risk ratings are also more efficient.

The total number of banks analyzed in the research, as previously mentioned, is 110, and the DEA technique identified 26 efficient banks. For comparison purposes, the study analyzed some indicators among efficient banks, the sample as a whole, and the least efficient banks, composed of the 20% with the lowest score, i.e., 22 banks. Table 8 features these indicators.

INDICATORS FOR EFFICIENT AND LEAST EFFICIENT BANKS

	EFFICIENT	TOTAL SAMPLE	LEAST EFFICIENT
Services revenue/total revenue	3.43%	5.25%	2.59%
Fees revenue/total revenue	2.17%	2.17%	1.83%
Net profit/total revenue	2.88%	-0.01%	-4.36%
Financial interm. revenue/total revenue	34.80%	42.33%	48.44%
Loans/total assets	37.19%	41.11%	45.76%
Complaints/number of clients	91.8	1837.8	5666.7

Source: Elaborated by the authors.

Revenue from fees and services comprises revenue unrelated to interest, a model output. According to DEA logic, the greater the generation of outputs for a given level of inputs, the more efficient the bank. Thus, the more revenue a bank obtains from services and fees, the better. Revenue from services and fees represents 3.43% and 2.17% of the total revenue, respectively, for efficient banks. However, this is very close to the figures of these indicators for the sample as a whole and for the least efficient banks. This raises doubts as to whether revenue from fees and services are essential factors in determining the efficiency of a bank.

The indicator of net profit over total revenue shows interesting results. For efficient banks, net profit represents 2.88% of the total revenue. For the least efficient banks, however, this indicator is negative, indicating that the least efficient banks lost money in 2013. Therefore, being efficient can contribute to the profitability of a bank.

The indicator of revenue from financial intermediation over total revenue shows that, for efficient banks, financial intermediation revenue represents 34.8% of the total revenue. However, for the least efficient banks, this percentage is 48.4%. The indicator of loans over total assets shows that efficient banks lend less in proportion to total assets. Based on these two indicators, revenue from financial intermediation over total revenue, and loans over total assets, efficient banks lend less money than least efficient banks.

The indicator of number of complaints per client was based on the number of complaints to a specific bank in 2013. This information was obtained from the Central Bank of Brazil, as well as the number of clients of the bank. In order

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to use a methodology similar to the indicator published in the banks' ranking, the resulting number was multiplied by 10⁵. The indicator shows that efficient banks receive fewer complaints per client, which might be the result of providing better services.

5 CONCLUSION

This study aimed to evaluate the efficiency of banks operating in Brazil in 2013. The analysis used the production approach and the DEA technique. The inputs chosen were staff number, operating expenses (excluding interest) and fixed assets, which represent costs and investments for the provision of services to customers. The outputs selected were total deposits and revenue not related to interest, which represent services provided and the revenue from such services.

The results generated by the DEA technique were used to analyze the characteristics of efficient and inefficient banks. The results indicated that large banks have the highest mean score, suggesting that large banks are more efficient. One possible explanation would be the economies of scale achieved by large banks.

The classification of banks by capital origin revealed some important features. Federal public banks had the highest mean efficiency score, suggesting that federal public banks are more efficient than other banks. The analysis also found that banks with foreign capital and foreign participation had high mean scores. Thus, it is possible that foreign capital contributes to raise efficiency levels. One possible explanation would be the transfer of knowledge and management methods by foreign banks. The remaining banks with exclusively domestic capital, i.e. domestic private and state-owned public, had the worst mean efficiency levels.

The business segment also revealed important features. Banks operating in foreign exchange showed the best mean efficiency scores. It is believed that this results from the fact that foreign exchange banks have a small, well-defined scope of operation, and much of their revenue comes from commissions and services, as well as treasury services. Furthermore, these banks do not need large service structures, generating their results at lower costs when compared to other segments. As for rating, banks rated AAA had higher mean efficiency scores. This result suggests that banks with better services have more solid results and better risk classification.

The comparison of some indicators between efficient and least efficient banks revealed that, in the production approach, efficient banks seem to be more profitable. It was also noted that efficient banks lend less money in proportion to total assets, and receive fewer complaints per client. Based on DEA logic, effi-

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cient banks produce more outputs with a given level of inputs, which explains higher profits in efficient banks. The topic of loan levels, however, requires further study. In short, the results of this study indicate that efficient banks lend less, are more profitable, and receive fewer complaints.

AVALIAÇÃO DA EFICIÊNCIA BANCÁRIA BRASILEIRA: UMA ABORDAGEM DEA

RESUMO

Objetivo: A pesquisa tem como objetivo avaliar a eficiência de bancos que atuaram no mercado brasileiro no ano de 2013. Para atingir este objetivo, foram identificados os bancos eficientes sob a abordagem de produção. A fim de detectar e explicar padrões de eficiência, foram realizadas análises complementares relacionadas a: 1. origem de capital, 2. porte, 3. segmento de atuação, e 4. classificação de risco (*rating*) da instituição.

Originalidade/lacuna/relevância/implicações: A literatura brasileira sobre eficiência bancária apresenta diversos estudos relacionando a eficiência dos bancos à origem de seu capital e porte. Entretanto, a relação entre eficiência e segmento de atuação foi muito pouco explorada e a relação entre eficiência e classificação de risco é escassa. Neste sentido, a presente pesquisa contribui com a literatura ao explorar a relação entre eficiência e segmento de atuação, bem como a relação entre eficiência e classificação de risco.

Principais aspectos metodológicos: A pesquisa utiliza uma abordagem quantitativa e emprega a técnica *Data Envelopment Analysis* (DEA) para calcular os escores de eficiência. Os dados foram obtidos no Banco Central do Brasil (Bacen).

Síntese dos principais resultados: Bancos públicos federais e bancos de grande porte são, em média, mais eficientes. Bancos que atuam nos segmentos de câmbio e varejo, bem como bancos com elevada classificação de crédito também obtiveram altos níveis de eficiência.

Principais considerações/conclusões: Bancos eficientes apresentaram-se mais lucrativos, emprestaram menos, como proporção de seu ativo total, e receberam menos reclamações no Banco Central no ano de 2013.

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PALAVRAS-CHAVE

Eficiência bancária. Bancos. Bancos brasileiros. Abordagem de produção. DEA.

EVALUACIÓN DE LA EFICIENCIA BANCARIA BRASILEÑA: UN ENFOQUE DEA

RESUMEN

Objetivo: Una pesquisa tem como objetivo avaluar un eficiencia de bancos que aturaran no brasileiro mercado sin ano de 2013. Para atingir este objetivo foram identificados os bancos eficientes sob una abordaje de produção. A fim de detectar e explicar padrões de eficiencia, foram realizadas análises complementares relacionadas un: 1. origen de capitales, 2. porte, 3. segmento de atuação e 4. clasificación de risco da instituição.

Originalidad/laguna/relevancia/implicaciones: La literatura brasileña en la eficiencia bancaria presenta varios estudios que relacionan la eficiencia de los bancos a la fuente de su capital y el tamaño. Sin embargo, la relación entre la eficiencia y el rendimiento del segmento ha sido muy poco explorado y la relación entre la eficiencia y la calificación de riesgo es escaso. En este sentido, esta investigación contribuye a la literatura mediante la exploración de la relación entre la eficiencia.

Principales aspectos metodológicos: La investigación DA utiliza un enfoque cuantitativo y emplea la técnica de análisis envolvente de datos (DEA) para calcular los índices de eficiencia. Los datos se obtuvieron del Banco Central de Brasil (BCB).

Síntesis de los principales resultados: Los bancos federales y los bancos grandes son en promedio más eficiente. Los bancos que operan en divisas y los segmentos minoristas, así como los bancos con altas calificaciones de crédito también lograron altos niveles de eficiencia.

Principales consideraciones/conclusiones: Bancos eficientes se han vuelto más rentable, prestaron menos, como proporción de los activos totales, y recibieron menos quejas con el Banco Central en 2013.

PALABRAS CLAVE

Eficiencia bancaria. Bancos. Los bancos brasileños. Enfoque de la producción. DEA.

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