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Relationship between Efficiency and Profitability in Banks of Brazil

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Abstract: *This study aimed to investigate the relationship between efficiency, measured by two different methods (Data Envelopment Analysis and Stochastic Frontier Analysis), and profitability of banks from Brazil. We analyzed a total of 47 banks that operated between the years of 2008 and 2015. The efficiency of institutions was measured using the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) methodologies, based on economic and financial indicators. These indicators were calculated considering the approach of financial intermediation in order to measure the cost efficiency of banks. Subsequently, the scores found from the application of DEA and SFA were related to the ROA (return on assets) and ROE (return on equity) indicators, using the regression model with panel data. We identified the existence of a statistically significant relationship between the efficiency and the profitability of banks. Profitability measures are related in a direct and significant way with the efficiency measured by the DEA and SFA methods. The results show that the efficiency is associated with the profitability and evidence a greater impact on the ROE than on the ROA indicator. Thus, we concluded that efficiency significantly influences the return on total assets but has an even greater influence on return on invested capital.*

Keywords: Efficiency, profitability, bank, financial intermediation, costs.

Introduction

Banks play a fundamental role in the functioning of economic systems, especially by their function of financial intermediation (Belém & Gartner, 2016). In Brazil, the banking sector experienced a huge growth since the 1990s, in which major transformations (such as the opening to the greater share of foreign banks, the growth of the internationalization of Brazilian banks and the intensification of mergers and acquisitions). Since then, this sector has been increasing its relevance in the national and international economic scenario (Modro & dos Santos, 2015).

Globalization has arisen a new format in the activities performed by financial institutions operating in Brazil. The new market reality resulted in an expansion of the scope of banking activities that went beyond the traditional income source (from financial intermediation) to incorporate also the use of non-traditional income sources - including

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insurance, private pension and capitalization bonds, among others (Brighi & Venturelli, 2016).

The scientific literature in the management area has explored the relationship between efficiency and profitability. To evaluate the efficiency is extremely important once this evaluation assists decision-making and provides inputs that facilitate monitoring, comparison, and correction of organizational performance (Doumpos & Cohen, 2014). Gitman (2010) explained that efficiency in business management creates value and improves organizational performance while minimizing the use of resources. Therefore, that author argued that the efficient use of resources leads to reduced costs and increased quality of service, adding value and may represent an increase in the profitability of companies.

According to Dietrich and Wanzenried (2011), profitability is an important criterion for analyzing the result of financial institutions, since it allows identifying the success of competitive strategies of institutions operating in similar environments. Efficiency is a concept related to the way things are done, representing the relationship between the amount produced and the resources consumed; in this way, efficiency compares what was produced, given the available resources, with what could be produced with the same resources.

Efficiency in cost management is measured by estimating an optimal cost frontier. Once this frontier is estimated, it becomes the standard against which business efficiency is measured. The cost frontier indicates the minimum cost required to produce a set of products or services, given input prices, production level and existing technology (Nguyen, Nghiem, Roca, & Sharma, 2016). Thus, the companies considered as more efficient in the cost management are those incurring the lowest costs to produce a certain amount of products or services.

Ghroubi and Abaoub (2016) explain that there are two paradigms of how to construct efficiency frontiers: one considers mathematical programming techniques (nonparametric) and the other uses econometric techniques (parametric). Such approaches differ in the way they specify the frontier, in the way it is constructed (using statistical or programming techniques), and in the way frontier deviations are interpreted.

In front of the potential relationship between efficiency and profitability, as well as the different ways of calculating the optimal frontier to measure efficiency in cost management, this study aimed to investigate the relationship between efficiency in cost management measured by two different methods, data envelopment analysis (DEA) and stochastic frontier analysis (SFA), and the profitability of banks in Brazil. We have the research hypothesis that more cost-effective institutions tend to be more profitable. In this perspective, it is intended to answer the following question: what is the relationship between efficiency in cost management, measured by the DEA and SFA methods, and the profitability of banks in Brazil?

Based on the importance of banks for the Brazilian economy, it is relevant to understand whether efficiency is related to profitability. Several countries that have implemented new regulatory policies in the sector are experiencing a scenario with more competitive institutions. This is also the case in Brazil, since the Brazilian banking sector has shown an evolution in net profit and an expansion in the volume of credit operations, showing a huge growth (Modro & dos Santos, 2015).

According to Nguyen et al. (2016), an efficient banking sector can reflect an efficient economy, since the banks are the main financiers of the economy. In this sense, Philippon (2015) states that the efficiency in the cost management of financial institutions directly influences the development of the economy in the long term, reducing transfer rates and influencing the money flow.

The results of the present study may contribute to managers, investors and financial analysts, generating subsidies for decision-making, since it offers information relative to the financial sector structure and the importance of efficiency for profitability. The study also has the potential to contribute to the expansion of academic discussions on this theme.

This paper is divided into five sections. In the next section, the theoretical framework encompasses the theory of financial intermediation and banking business, methods of estimating efficiency and studies that investigated the relationship between efficiency and profitability in the banking sector. Afterwards, the used methodological procedures are described. Later, the results and discussion are presented, concluding with the final considerations of the study.

Theoretical Framework

Theory of Intermediation and the Banking Business

Financial intermediation is the process that uses the financial resources accumulated by savers and puts them back into the economy for borrowers in the form of loans. From this transaction, banks receive the spread, consisting in the gain of financial institutions, since they raise funds at a certain interest rate and lend them to a rate that is higher than the funding (Philippon, 2015). The intermediation results are measured by total intermediation income less the aggregate costs of the financial intermediation operation (cost of funding in the market, cost of operation, provision for losses, personnel expenses, among others). The intermediation result is the sum of all spreads from credit operations and fees paid by non-financial agents to financial intermediaries (Zaernjuk, Bokareva, Chernikova, & Kryukova, 2014).

The cost of financial intermediation directly affects the cost of external financing users, whether they are companies or families that use the services of intermediaries (Diamond, 1984). Philippon (2015) states that the cost management efficiency resulting from the financial intermediation operation directly affects the long-term development of the economy. The author emphasizes that efficient cost management can represent lower transfer rates, directly affecting the flow of money and contributing to a lower cost of money. Understanding the importance of financial intermediaries is related to characteristics of financial markets. The inexistence of a market with perfect and complete information and without friction makes possible the formation of financial intermediaries. Whether there was a complete market, savers and investors would perform the financial operations directly, without the need for an intermediary (Allen & Santomero, 2001).

Intermediation makes possible to supply the financing needs of economic agents (com-

panies, families and governments). Financing, when received by agents, are invested in the economy and can generate employment and income, making that the aggregate demand (consisting of the total demand for goods and services in an economy, i.e., the total of goods and services that will be acquired) tends to increase, opening opportunities for new investments (D'Oliveira, 2014).

Restructuring in the global banking business has altered the sources of revenues and the management model of banks. Institutions highly dependent on spread gains lost much of that gain with the sector regulation and the standardization of rates. In order to compensate for the loss of revenues with the spread, the provision of services (opening and maintenance of accounts, tariffs in general and administration of funds, among others) became more relevant in the total banking revenues (Brighi & Venturelli, 2016). Thus, banks have two main sources of revenues: financial intermediation and provision of services (Nguyen et al., 2016).

Frontier Methods for Measuring Efficiency

The concept of efficiency was presented initially by Farrell (1957), who elaborated the basic principles for measuring efficiency and for discussing efficiency frontiers. Econometrics and operational research have advanced greatly in the development of techniques for estimating the frontier of business efficiency. The estimated frontier is the standard against which the company's efficiency will be measured. Coelli and Battese (1996) explained the existence of two paradigms of how to construct efficiency frontiers: the non-parametric paradigm, considering mathematical programming techniques, and the parametric paradigm, using econometric techniques.

The parametric approach requires the specification of a production, cost, income or profit function, with the need for an error term. The non-parametric programming approach requires less specification in problem optimization, making the work less vulnerable to specifying errors that are common in the parametric approach (Khalil, Mehmood, & Nisar, 2015).

The SFA is a parametric and stochastic methodology proposed by Aigner, Lovell, and Schmidt (1977), designed to evaluate efficiency of production, costs or profits. In contrast to non-parametric approaches, which ignore the possibilities of measuring errors and the inaccurate effects associated with accounting data, the stochastic frontier decomposes the error term into two components. The first component results from measurement errors of external shocks, and the second measures the specific inefficiency for each entity to be evaluated (Khalil et al., 2015).

The DEA is a method that allows using multiple inputs and outputs without necessarily estimating a function to measure efficiency. Coelli and Battese (1996) explained that the DEA is a non-parametric and deterministic methodology, aiming to estimate a metric benchmarking (standard frontier) of the best practices among the analyzed companies and to determine the distance that each company is from the ideal.

It is possible to use two methods to estimate efficiency using the DEA. The CCR or CRS (constant returns to scale) method was proposed by Charnes (1979). This method presupposes that there is no significant relationship between the scale of operations and

efficiency, assuming the premise of constant returns to scale, i.e., any variation in inputs produces proportional variation in outputs. However, the BCC or VRS (variable returns to scale) method proposed by Banker, Charnes, and Cooper (1984) is used to evaluate the efficiency of companies that have variable returns to scale, i.e., this method considers the influence of scale economies of scale, allowing companies operating with low input values having increasing returns to scale and those operating with high values having decreasing returns to scale.

The two approaches (parametric and non-parametric) have advantages and disadvantages. Although they use different techniques, both use rigorous comparison analysis of efficiency according to radial distance functions in relation to the efficiency frontier (Silva, 2014).

Previous Studies

In this section we presented some national and international studies that sought to measure efficiency and related the efficiency scores obtained by the DEA and/or SFA method with the profitability of banks.

Kirkwood and Nahm (2006) analyzed the relationship between efficiency measured by DEA and the profitability of the 10 major banks in Australia between 1995 and 2002. The measure of profitability used by the authors was the stock returns. The results evidenced that the larger banks showed greater efficiency. The major and more efficient banks also showed higher profitability. The study by Majid, Zulkhibri and Fadzlan (2008) investigated which variables were decisive for the profitability of Chinese banks between 1997 and 2006. The authors used the DEA window analysis to estimate efficiency and the measure of profitability was also the stock returns. The study showed that efficiency was one of the determinants of profitability.

In the national literature on the theme, the study by Martin, Kimura, Kayo, and SANTOS (2011) aimed to identify the determining factors for the profitability of Brazilian banks between 1996 and 2010. The efficiency was measured by the DEA method and the measure of profitability was the ROA (return on assets) variable. The results indicated that the most efficient banks showed higher ROAs. However, the study by D'Oliveira (2014) examined which specific variables of banks, industry and macroeconomics determined the profitability of Brazilian banks from 1995 to 2013. To measure efficiency, the author used the SFA method and two variables to represent the profitability: ROA and ROE (return on equity). The results showed a significant and positive relationship between cost efficiency and profitability of banks.

Finally, the study by Mendonça et al. (2017) investigated the relationship between economic and financial efficiency and profitability in the Brazilian banking sector from 2011 to 2015. The efficiency was measured by the DEA method and the measure of profitability used was the net margin. The results showed that institutions with greater economic and financial efficiency also showed higher profitability.

In relation to the presented studies, it is emphasized that they used only one method to measure efficiency. Therefore, the present study advances the investigation of the relationship between efficiency and profitability, since it aims to investigate the efficiency

measured by two different methods, using the same indicators to estimate the efficiency in both methods, besides relating the obtained scores with profitability. Thus, it will be possible to identify whether different methods to estimate the efficiency generate a different relationship with the profitability.

Methodology

Type of Research and Sample

The research is characterized as a quantitative and descriptive study. According to Gil (2010), a research is considered as quantitative when it has a positivist perspective, using a statistical and mathematical analysis, translating the information into numbers to classify and analyze them. For Martins (2002), a descriptive research aims to describe the characteristics of a given population or phenomenon, establishing relationships between variables and facts.

We analyzed the data using the non-parametric methodology of DEA, parametric methodology of SFA and regression modeling with panel data. For the sample selection, the banks with data available for all the years analyzed in the study (between 2008 and 2015) were identified through the records of the Central Bank of Brazil (BCB). Institutions that did not have data available in any of the analyzed years were excluded. Thus, the final sample consisted of 47 banks.

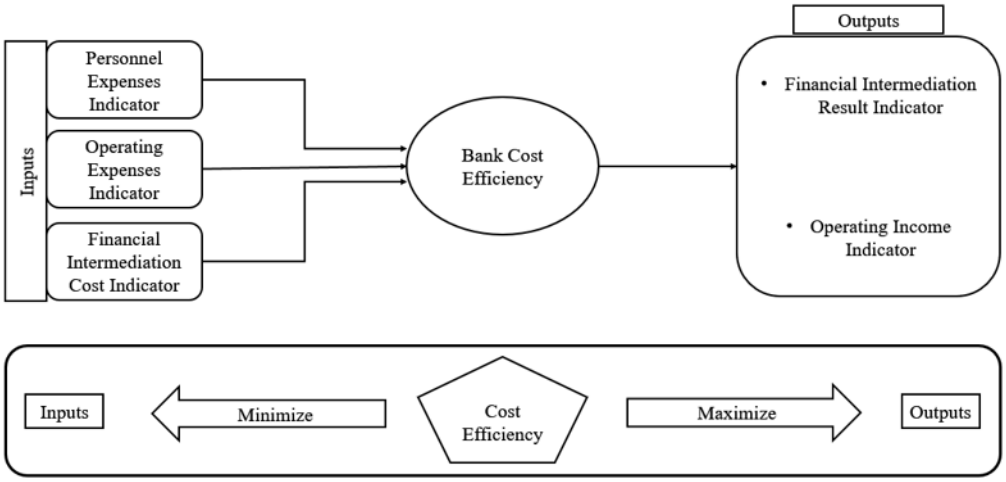
The survey used secondary data, obtained through the BCB annual report entitled "50 Largest Banks and the Consolidated National Financial System" available at the BCB website (2016). This report contains the consolidated data for all institutions that compose the Brazilian financial system.

Efficiency Measurement

In order to estimate the cost management efficiency of Brazilian banks, we used the intermediation approach, commonly used in the literature to measure efficiency. According to Jiang, Yao, and Feng (2013), the intermediation approach is considered more appropriate to measure the bank efficiency. Some international studies have used the intermediation approach in surveys aimed to measure bank efficiency, such as (Gaganis & Pasiouras, 2013; Duygun, Sena, & Shaban, 2013; Khalil et al., 2015).

In the intermediation approach, expenses incurred in raising funds for this process are considered generally as inputs, as well as personnel and operating resources. On the other hand, the resources borrowed and generated through investments are treated as outputs, divided into two distinct results: the intermediation itself and the operating income (Ghroubi & Abaoub, 2016). The inputs and outputs used to estimate the efficiency of financial institutions appears in Figure 01.

Figure 1
Input and output indicators used to measure cost efficiency



As shown in Figure 1, the cost efficiency term can be used in two ways: to maximize the results (outputs) or to minimize the cost (input). In order to measure cost efficiency with the SFA method, it becomes necessary to estimate a cost function. This function estimates the frontier of the minimum cost necessary to produce a given product based on the available inputs. Thus, to be efficient, an institution must keep producing the same volume of outputs or products using a smaller volume of inputs. Therefore, the SFA cost method is oriented to minimize the level of inputs to estimate the institution with the greatest efficiency level (Khalil et al., 2015).

With the objective of using the same logic to estimate the efficiency for both models, the DEA followed the same orientation to minimize the inputs, using the same indicators as in the SFA method. The DEA model that is closest to the SFA efficiency measurement way is the input-oriented CCR. The input-oriented CCR has as its central objective to measure efficiency through changes (reductions) in input levels, keeping product constant (output), considering the constant returns to scale.

In this study, the calculations of indicators were adapted to the reality of the Brazilian banking financial statements that follow the COSIF standard. The following is a brief description of each indicator used to measure efficiency through DEA and SFA methods. - Personnel expenses indicator (PEI): identifies the cost with personnel necessary for the bank to perform the banking activity, whether of intermediation or provision of services. It is calculated by dividing personnel expenses by total assets.

- Operating expenses indicator (OEI): measures the expenses that the institution has to provide services other than financial intermediation. The indicator is calculated by dividing the operating expense by total assets.

- Financial intermediation cost indicator (FICT): measures the cost of the banking institution to render the financial intermediation service. The indicator is calculated by dividing financial intermediation costs by total assets.
- Financial intermediation result indicator (FIRT): Indicates how much the financial institution was able to ascertain from the result of financial intermediation operations. The indicator is calculated by dividing financial intermediation results by total assets.
- Operating income indicator (OII): represents how much the financial institution was able to ascertain incomes not derived from financial intermediation. The indicator is calculated by dividing the operating income by total assets.

The input and output indicators and their respective calculation formulas are presented in Table 1.

Table 1
Calculation of inputs and outputs used in the DEA and SFA models to measure efficiency

NAME/ACRONYM	CALCULATION FORMULAS	INDICATOR OF TYPE (reference for interpretation)
	INPUTS	
Personnel expenses indicator (PEI)	PEI= (Personnel Expenses)/(Total Assets)	The lower the better
Operating expenses indicator (OEI)	OEI= (Operating Expenses)/(Total Assets)	The lower the better
Financial intermediation cost indicator (FICT)	FICT= (Intermediation Expenses)/(Total Assets)	The lower the better
	OUTPUTS	
Financial intermediation result indicator (FIRT)	FIRT= (Profit from Intermediation)/(Total Assets)	The higher the better
Operating income indicator (OII)	OII= (Operating Profit)/(Total Assets)	The higher the better

The indicators presented in Table 1 were calculated based on the assumption that the financial institutions that compose the sample have different structures; thus, all indicators were divided by total assets. This division aims to demonstrate the representativeness of accounts in relation to the total assets invested in each of the analyzed financial institutions. It should be mentioned that the input and output indicators presented in Table 1 were used to measure the efficiency of intermediation costs of financial institutions in the studies of Lensink, Meesters, and Naaborg (2008); Gaganis and Pasiouras (2013); Ghroubi and Abaoub (2016).

In order to measure efficiency by the stochastic frontier method, a transcendental logarithmic function (translog), which is a second-order approximation of any functional form, was estimated based on the model proposed by Battese and Coelli (1995). This model is represented by Equation 1.

$$Ln(TC)_{it} = \beta_0 + \beta_1 LnFIRT_{it} + \beta_2 LnOII_{it} + \beta_3 LnPEI_{it} + \beta_4 LnOEI_{it} + \beta_5 LnFICT_{it} + \beta_6 Ln(FIRT_{it})^2 + \beta_7 Ln(OII_{it})^2 + \beta_8 Ln(PEI_{it})^2 + \beta_9 Ln(OEI_{it})^2 + \beta_{10} Ln(FICT_{it})^2 + \beta_{11} LnFIRT_{it} LnOII_{it} + \beta_{12} LnFIRT_{it} LnPEI_{it} + \beta_{13} LnFIRT_{it} LnOEI_{it} + \beta_{14} LnFIRT_{it} LnFICT_{it} + \beta_{15} LnOII_{it} LnPEI_{it} + \beta_{16} LnOII_{it} LnOEI_{it} + \beta_{17} LnOII_{it} LnFICT_{it} + \upsilon_{it} + \nu_{it} \quad (1)$$

Where: i indicates the observation of the $i-th$ financial institution in the sample; t indicates the $t-th$ period; $Ln(TC)_{it}$ is the natural logarithm of the total cost; $FIRT_{it}$ is the financial intermediation result indicator; OII_{it} is the operating income indicator; PEI_{it} is the personnel expenses indicator; OEI_{it} is the operating expenses indicator; $FICT_{it}$ is the financial intermediation cost indicator and the υ_{it} and ν_{it} are the error terms. Total cost (TC) used in the estimation of the cost function is the sum of the costs of financial intermediation, personnel expenses, administrative expenses, tax expenses and other operating expenses divided by total assets.

The DEA analyzes the efficiency of the relationship between inputs and outputs, without requiring an explicit specification of the form of this relationship; thus, there is no need to estimate a cost function as in parametric models. In order to capture the essence of the banking business from minimizing costs, the model should use indicators such as "the lower the better" as inputs, and the "the higher the better" for outputs. In this respect, the input and output variables were used in the DEA according to the demonstrated in Table 1.

Regression Model with Panel Data

In the first stage of the research, we calculated the efficiency scores using the DEA nonparametric and the SFA parametric methodology. In the second phase, we investigated whether the found scores were determining factors for the profitability of financial institutions. For this purpose, a regression model with panel data was used.

The dependent variables used in this study to represent the profitability are the ROA and the ROE variables. The ROA was calculated by dividing the net profit by total assets. This indicator reflects the bank capacity to generate profit by using the total resources invested (D'Oliveira, 2014). The ROE is the measurement of the return that the company has on the resources invested in the business by its owners or stockholders (Assaf Neto, 2012).

The research variables were the efficiency scores measured by the DEA method (EFID) and the SFA method (EFIS), which were tested separately in the regression models. Using two research variables and two dependent variables (ROA and ROE), four regression models with panel data were elaborated.

Additionally, we included control variables in the models. The control variables are those that could affect dependent variables, as indicated by the literature and previous empirical evidence, and are used in order to isolate their effect on the dependent variables.

These variables have been used in the literature on the theme and are described in Table 2.

Table 2
Variables used in the regression model with panel data and expected signals

NAME/ACRONYM	DEFINITION AND CALCULATION	EXPECTED SIGNAL
DEA efficiency (EFID) or SFA efficiency (EFIS)	Measured by the DEA (EFID) or the SFA (EFIS), this indicator measures intermediation and operating incomes with the expenses incurred in these operations in order to reflect the dynamics of banking activity.	+
Size of banks (SIZ)	Calculated by the logarithm of total assets. It is used to measure gain of scale by maximizing the use of its inputs.	+
Capitalization (CAP)	It is calculated by the logarithm of the ratio between net equity and total assets. It measures the degree of capitalization, i.e., it is the capacity of an institution to capture demand deposits.	+
Loan intensity degree (LID)	It is calculated by the logarithm of the ratio between loans and total assets. It refers indirectly to the liquidity level. Thus, higher loan volume implies low liquidity.	+
Indicator of operating expenses in relation to assets (OEA)	It is calculated by the logarithm of the ratio between operating expenses and total assets. It refers to operating expenses in relation to the size of bank.	-
Diversification degree (DDG)	It is calculated by the logarithm of the ratio between operating incomes and total assets. It refers to alternative sources of income, such as incomes from services and fees.	+

In Table 2 is also presented the expected signs for the research and the used control variables, containing the expected effect on the dependent variable. Thus, a positive relationship between efficiency and profitability is expected, regardless of the method used to measure efficiency. Such theoretical hypothesis guides the development of the statistical analyses applied in the study. In this respect, we used four regression models to identify the relationship between efficiency and profitability: two models with the efficiency scores measured by the DEA with the dependent variables ROA and ROE, and two models with the efficiency scores measured by the SFA with the two dependent variables. The structure used in the four models operationalized in the present research is represented by Equation 2.

$$PROF_{it} = \beta_0 + \beta_1 EFI_{it} + \beta_2 SIZ_{it} + \beta_3 CAP_{it} + \beta_4 LID_{it} + \beta_5 OEAit + \beta_6 DDGit + \epsilon \quad (2)$$

Where: $PROF_{it}$ represents the profitability indicator of the bank i in the period t, which in each of the four used models corresponds to the ROA or the ROE variable; β_0 is the straight-line intercept; β_1 to β_6 are the slopes of line; $EFI_{it}, SIZ_{it}, CAP_{it}, LID_{it}$, and OEA_{it} are the independent variables for the bank i in the period t; and ϵ is the error term

of the regression. It should be emphasized that EFI represents the research variables corresponding to the efficiency, which in each of the models can be the efficiency measured either by the DEA (EFID) or the SFA (EFIS).

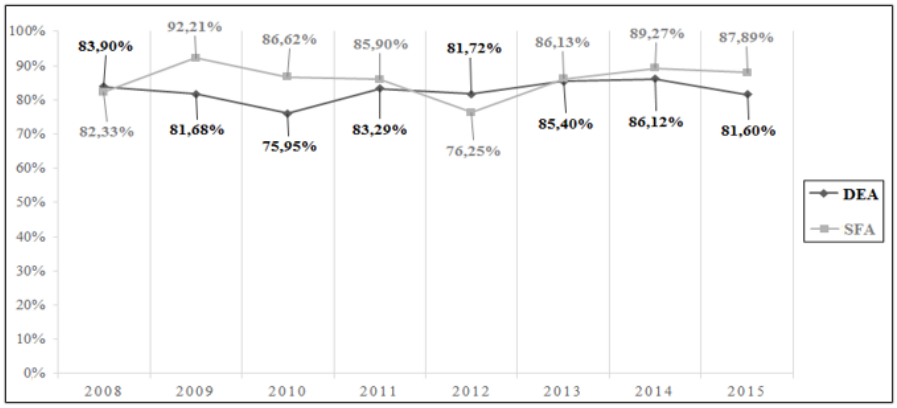
Results and Discussion

The first part of this section discusses results of the efficiency measured by the SFA and DEA methods. In the second part, the relationship between efficiency and profitability is addressed based on the application of the proposed econometric model.

Analysis of the Efficiency means Estimated by DEA and SFA

The mean efficiency scores estimated by the SFA and those estimated by the DEA in each of the years are represented in Figure 2.

Figure 2
Input and output indicators used to measure cost efficiency



According to Figure 2, the mean efficiency measured by the SFA method generally obtained higher scores in relation to the DEA method. In some years, such as 2008 and 2013, the means are very close (with a difference lower than 2%). In all the years, the mean scores remained within the range from 75% to 93% for both methods. The lowest mean efficiency scores were 75.95% for the DEA in 2010, and 76.25% for the SFA in 2012. The highest mean scores were 86.12% for the DEA in 2014, and 92.21% for the SFA in 2009. It is also possible to verify that, for the eight analyzed years, the mean efficiency scores estimated by the DEA were higher than the SFA only in 2008 and 2012. These findings are in agreement with the study by Nguyen et al. (2016), which found lower mean efficiency scores for the DEA in relation to the SFA.

Relationship of the Efficiency measured by SFA and DEA Methods with Profitability

In order to use the regression analysis with panel data, we initially verified the correlations among the study variables. The VIF (variance inflation factors) statistics confirmed the absence of multicollinearity, since the indicators varied between 1,105 and 2,200 for all the four models. According to Gujarati (2006), in the regression model the FIV should be lower than five. Therefore, there were no problems in relation to the multicollinearity of variables.

Regarding the normality of residues, this study considered the proposed by the central limit theorem, affirming that for samples with a number greater than 30 observations, it is assumed that the distribution of means is approximately normal. Thus, considering that 376 observations were used, the normal distribution can be assumed.

After applying the model using the ordinary least squares (OLS) method, the Breusch-Pagan and Hausman tests were performed for each of the proposed regression models. The tests indicated that the random effects are the panel approach that best fits the data for all analyzed models.

To verify the homoscedasticity of residues, we used the White test. The heteroskedasticity was detected and corrected through the White covariance matrix (robust standard errors). The final results obtained for Models 1 and 2, seeking to investigate the relationship between efficiency and profitability represented by ROA, are presented in Table 3.

Table 3
Results of regression by the random effects model with robust standard errors for the ROA dependent variable

DEA research variable				SFA research variable			
Variable	**Coefficient**	**Robust standard error**	**T statistics**	**Variable**	**Coefficient**	**Robust standard error**	**T statistics**
EFID	0.0301	0.0096	3.124***	EFIS	0.0122	0.0059	2.070**
SIZ	0.0012	0.0005	2.254**	SIZ	0.0011	0.0006	1.812*
CAP	0.0068	0.0019	3.503***	CAP	0.0086	0.0019	4.468***
LID	0.0009	0.0009	1.046	LID	0.0001	0.0009	0.1216
OEA	-0.0022	0.0012	-1.769*	OEA	-0.0035	0.0014	-2.513**
DDG	0.0015	0.001	1.478	DDG	0.0017	0.0011	1.58
const	-0.0245	0.0128	-1.919*	const	-0.0104	0.0123	-0.8422
Wald chi2(5) = 35.78		No. of observations: 376		Wald chi2(5) = 36.58		No. of observations: 376	
Prob >chi2 = 0.0000		R2 total = 0.2440		Prob >chi2 = 0.0099		R2 total = 0.1359	

Note: The asterisks indicate the significance level of the coefficients: ***(1%), **(5%) and *(10%)

It is observed that random effects estimation is consistent and that both models are significant at 1%, since the p-value of the chi-squared test is lower than 0.01. As presented in Table 3, the overall explanatory power (represented by the total R2) of Model 1 is 24.40%, and the Model 2 is 13.59%. Four statistically significant variables are observed in both models as explanatory factors of the ROA dependent variable of banks.

Statistically significant results were obtained for the control variables SIZ, CAP and OEA. The SIZ variable was significant at 5% in Model 1 and at 10% in Model 2. The CAP variable was significant at 1% in both models. The OEA variable was significant at 10% in Model 1 and at 5% in Model 2. Thus, the evidences indicate that these variables aid to explain the profitability of banks.

As the most relevant result, the efficiency research variable measured by the DEA (EFID) was significant at 1% (99% confidence), showing a positive relationship according to the coefficient presented for Model 1. In the Model 2, the efficiency research variable measured by SFA (EFIS) was significant at 5% (95% confidence), also showing a positive relationship. In this respect, the positive coefficient of the variables EFID and EFIS indicates that the greater the efficiency of the banking institution, the higher its ROA.

Subsequently, the Models 3 and 4 seek to investigate the relationship between the efficiency and profitability represented by the ROE, consisting of the return on invested capital (equity) in the company. The values of the coefficients and the t statistics for both the research variables and the control variables are presented in Table 4.

Table 4
Results of regression by the random effects model with robust standard errors for the ROE dependent variable

DEA research variable				SFA research variable			
Variable	**Coefficient**	**Robust standard error**	**T statistics**	**Variable**	**Coefficient**	**Robust standard error**	**T statistics**
EFID	0.1855	0.0583	3.181***	EFIS	0.0859	0.0373	2.303**
SIZ	0.0117	0.004	2.899***	SIZ	0.0115	0.0047	2.424**
CAP	0.0184	0.0133	1.389	CAP	0.0294	0.0144	2.043**
LID	-0.0011	0.0053	-0.2086	LID	-0.0071	0.0065	-1.083
OEA	-0.0156	0.0082	-1.904	OEA	-0.0234	0.009	-2.582***
DDG	0.0088	0.0044	2.001	DDG	0.0101	0.0054	1.847*
const	-0.2732	0.0742	-3.679***	const	-0.1968	0.083	-2.371**
Wald chi2(5) = 28.71		No. of observations: 376		Wald chi2(5) = 16.85		No. of observations: 376	
Prob >chi2 = 0.0001		R2 total = 0.2630		Prob >chi2 = 0.0099		R2 total = 0.1551	

Note: The asterisks indicate the significance level of the coefficients: ***(1%), **(5%) and *(10%)

As presented in Table 4, the overall explanatory power of Model 3 (represented by the total R2) is 26.30%, and the Model 4 is 15.51%. Model 3 presented two statistically significant variables as explanatory factors of the ROE dependent variable of banks, while Model 4 presented five statistically significant variables.

In Model 3, a statistically significant result was obtained only for the SIZ control variable, which was significant at 1%. In Model 4, the variables SIZ, CAP, OEA and DDG were statistically significant. The variables SIZ and CAP were significant at 5%, the OEA variable was significant at 1% and the DDG variable was significant at 10%.

The efficiency research variable measured by DEA (EFID) was significant at 1% (99% confidence) in Model 3, with a positive coefficient. Thus, the greater the efficiency measured by the DEA, the higher the ROE. Similarly, the efficiency measured by SFA (EFIS) was significant at 5% (95% confidence) in Model 4, also with a positive coefficient. This indicates that the greater the efficiency measured by the SFA, the higher will be the ROE.

The results obtained by the four models show that there is a positive relationship between the efficiency, both measured by the DEA and the SFA, and the profitability of institutions from the Brazilian banking sector. The research variables EFID (efficiency measured by DEA) and EFIS (efficiency measured by SFA) were statistically significant in the analyzed models.

Researches by Kirkwood and Nahm (2006); Martin et al. (2011); D'Oliveira (2014) also showed a statistically significant relationship between efficiency and profitability. The results of the present study corroborate with the obtained by the study of Martin

et al. (2011), which identified a positive relationship between the efficiency measured by the DEA method and the profitability measured by the ROA variable, and the study of D'Oliveira (2014), which identified a positive relationship between the efficiency measured by the SFA method and the profitability estimated by the variables ROA and ROE. When analyzing the coefficient for the EFID variable in Model 1, which investigated the relationship between efficiency and ROA, it is observed that its value is 0.0301, indicating that the increase of one unit in efficiency, measured by the DEA method, generates an increase of 0.0301 unit in profitability. Moreover, the coefficient for the EFIS variable in Model 2 (also in relation to ROA) was 0.0122, indicating that the increase of one unit in efficiency, measured by the SFA method, generates an increase of 0.0122 unit in ROA. Therefore, we concluded that the fact that the financial institution obtains maximum efficiency (and efficiency score equal to 1) by the DEA method is associated with an ROA around 3.01% higher than the very inefficient institution (and efficiency score equal to 0). Similarly, the fact that the institution obtains maximum efficiency (and efficiency score equal to 1) by the SFA method is associated with an ROA around 1.22% higher than the very inefficient institution (and efficiency score equal to 0).

On the other hand, wen analyzing the coefficient for the EFID variable in Model 3, which investigated the relationship between efficiency and ROE, its value equal to 0.1855 indicates that the increase of one unit in efficiency, measured by the DEA method, generates an increase of 0.1855 unit in profitability. Moreover, the coefficient for the EFIS variable in Model 4 (also in relation to ROE) is 0.0859 and indicates that the increase of one unit in efficiency, measured by the SFA method, generates an increase of 0.0859 unit in ROE.

Based on the scores found in Models 3 and 4, the results showed that the fact that the financial institution obtains maximum efficiency by the DEA method is associated with a return on invested capital (shareholder return) about 18.55% higher than the very inefficient institution. The fact that the institution obtains maximum efficiency by the SFA method is associated with a return on invested capital about 8.59% higher than the very inefficient institution. Therefore, the findings of the present study indicate that efficiency is an important factor to improve the profitability of the Brazilian banking system.

Conclusion

Based on the analysis of the four applied models, we identified the existence of a statistically significant relationship between efficiency and profitability of banks. The profitability measures used in this study (ROA and ROE) are directly and significantly related to the efficiency measured by the DEA and the SFA methods. The findings indicate that efficiency is a determining factor to improve the profitability of the Brazilian banking system, confirming the hypothesis of the literature on the positive relationship between efficiency and profitability.

The obtained results have some managerial implications and evidence that efficiency is associated with profitability but with a greater influence on the ROE than on the ROA indicator. Therefore, efficiency becomes even more relevant when the managerial objec-

tive is to maximize the value for shareholders. In the capital market context, this indicates that investors tend to obtain higher returns by buying shares of institutions with greater efficiency scores.

Evidences found and discussed in the present research should be considered taking into consideration the sample selection criteria (47 financial institutions from 2008 to 2015) and the limitations of the adopted methodology. There are limitations in the input and output indicators used to measure efficiency, since they capture only the aspects that are related to the groups of accounts that were used to formulate them. Other variables could influence profitability and were not considered in this study. Thus, the results are also limited to the adopted methodology and the variables that were used in the econometric models.

For future studies, we suggest to investigate which variables are determinants of bank efficiency, besides identifying other factors that may influence the profitability of these institutions. Furthermore, other methodologies could be studied to investigate the efficiency of banking institutions. Finally, we expect that the evidences of this study contribute to increase the knowledge on the importance of efficiency in cost management for the profitability of Brazilian banks and encourage the discussion on this theme.

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