EVOLUTION OF BANK EFFICIENCY IN BRAZIL: A DEA APPROACH

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Abstract

This paper investigates cost, technical and allocative efficiencies for Brazilian banks in the recent period (2000-2007). We use Data Envelopment Analysis (DEA) to compute efficiency scores. Brazilian banks were found to have low levels of economic (cost) efficiency compared to banks in Europe and in the US. For the period with high macroeconomic volatility (2000-2002) the economic inefficiency in Brazilian banks can be attributed mainly to technical inefficiency rather than allocative inefficiency. There is no evidence of differences in economic efficiency due to type of activity and bank size.

Resumo

Este trabalho investiga as eficiências custo, técnica e alocativa para bancos brasileiros, para o recente período de 2000 a 2007. Utiliza-se a Análise de Envelopamento de Dados (DEA) para calcular as medidas de eficiência. Encontrou-se que os bancos brasileiros possuem baixo nível de eficiência econômica (custo) comparativamente a bancos europeus e dos Estados Unidos. Para o período com alta volatilidade macroeconômica (2000-2002), a ineficiência econômica nos bancos brasileiros pode ser atribuída, de forma predominante, à eficiência técnica do que à alocativa. Não existe evidência de diferenças na eficiência econômica devido ao tipo de atividade ou tamanho do banco.

Keywords: DEA, Bank Efficiency, Emerging Markets.
JEL Classification: G21; G34.

1. Introduction

In the past decade the Brazilian banking industry underwent major transformations, with the entry of foreign banks, substantial mergers and acquisitions (M&A) activity and the privatization of state-owned banks. Mainly in the recent period, large banks have been buying small specialized banks, that operate on a more local basis and niche markets. This article studies bank efficiencies for the Brazilian banking system for the recent period and seeks to address, among other aspects, whether or not there are significant differences in efficiency due to ownership structure.

The debate on the role of public and foreign banks in Brazil has been intensified in recent years, as the share of public banks is still high (more than one third of banking assets), while the participation of foreign banks have been increasing. Financial markets in Brazil were opened in the early 1990´s to foreign participation in order to enhance competition and efficiency. Nonetheless, very little is known on the impact of the entry of these foreign banks on efficiency.

The Brazilian experience is interesting due to its importance in Latin America (largest banking system) and due to the weights of state-owned and foreign banks. Besides, the corporate bond market is not well developed, which reinforces the relevance of the banking system.

We contribute to the banking literature by examining cost, allocative and technical efficiencies of Brazilian banks in the period (2000-2007). The research questions addressed are: Are foreign banks more efficient than domestic banks? Has bank efficiency increased over the years? What are the main sources of inefficiency? Do banks that engage in different activities perform differently in terms of cost efficiency? Are large banks more efficient? Are private banks more efficient than public banks? Answers to these questions provide important insights to both policy makers and bank managers.

The remainder of the article is structured as follows. Section 2 reviews the literature on banking efficiency studies. Section 3 describes the data and sample used in the analysis. Section 4 is on methodology. Section 5 presents empirical results. Finally, Section 6 presents conclusions and final remarks.

2. Literature Review

There is a vast literature on bank efficiency discussing different aspects such as the role of M&A, of ownership, of bank size and differences in the regulatory framework and its impacts on banking efficiency.

Kwan (2006) uses the stochastic frontier approach to study cost efficiencies of banks in Hong Kong. The results show a quite large, but declining, inefficiency and a positive correlation between bank size and inefficiency, probably due to different portfolio compositions. Ariff and Can (2008) estimate cost and profit efficiencies for Chinese banks using DEA and second-stage Tobit regression. They find that private and medium-sized banks are the most efficient. Drake et al. (2006) use similar methodology for the Hong Kong banking system and find a strong positive size-efficiency relationship. Park and Weber (2006) study bank inefficiency and productivity change for the Korean banking sector with the financial liberalization and the Asian financial crisis. Using the directional technology distance function, they find that technical progress has offset the decline in industry efficiency and that banking systems reforms generated productivity growth. In the Brazilian case the recent wave of M&A has shown a number of large banks buying small and very small banks that are highly specialized, which suggests that these large banks may be trying to increase their efficiency in these niche markets (niche markets hypothesis). Unfortunately, we do not have a list of all M&A activities in the Brazilian banking system and, therefore, to test whether the niche markets hypothesis is plausible or not we have to evaluate the relative efficiencies of banks of different sizes.

Regarding the test of the effect of foreign ownership on bank efficiency, Lensink et al. (2008) use stochastic frontier analysis in 105 countries. They find a negative effect that becomes less pronounced with better home and host countries regulatory environment and smaller institutional differences between them. With similar approach, Sensarma (2006) also finds lower efficiency levels for foreign banks in India during the deregulation period. With different results,

Havrylchyk (2006). Mamatzakis et al. (2008) find lower levels of inefficiency for foreign banks among the ten new European Union member states. In their previous work (Staikouras et al. (2008)), similar findings were achieved when analyzing six South Eastern European countries, but significant inefficiency differences were observed among them. Sengupta (2007) investigates how information asymmetries affect foreign entry and lending behavior in credit markets by modeling competition between entrant and incumbent banks. He supports that a better legal environment may help overcome informational disadvantages.

To evaluate the impact of banking system reforms in Brazil, Beck et al. (2005) evaluate how the choice among privatization, federalization and restructuring was made and assessing the impact of it on bank performance. They find positive effects of privatization, but not for the restructuring process. Baer and Nazmi (2000) examine the crises resulting from the end of inflation in Brazil and the implications of the newly emerging bank structure. They conclude that the Brazilian banking system still remains inefficient and that competition and private sector involvement could increase efficiency. Fries and Taci (2005) examine cost efficiency in East European transition economies. Their findings point to the potential benefits of bank privatization to a strategic foreign investor and entry of newly established banks. Iannotta et al. (2007) and Williams and Nguyen (2005) also find larger profitability for private banks in the West European and South East Asian countries, respectively. On the contrary, Bonin et al. (2005), when analyzing 11 transition countries, conclude that privatization by itself is not sufficient to increase bank efficiency.

Berger et al. (2000) develop two main hypotheses to explain differences in the performance between foreign and domestic banks, the home field advantage hypothesis and the global advantage hypothesis. According to the first, domestic institutions are generally more efficient than institutions from foreign nations due to organizational diseconomies to operating or monitoring an institution from a distance and also to differences in regulatory and supervisory environment. Under the global advantage hypothesis some foreign institutions are able to overcome these disadvantages and operate more efficiently. They spread their superior managerial skills or best-practice policies and are able to lower their costs.

We analyze how ownership structure and size influences our efficiency estimates. In 1996 the Brazilian government launched the PROES (Program of Incentives to the Reduction of the State-level Public Sector in the Bank Activity) to reduce the participation of state-owned banks in the banking activity. An important consideration is that these banks had severe debt problems and therefore the federal government offered financial packages to bail them out and either liquidate or privatize them. In 2001 the PROEF (Program for the Strengthening of the Federal Financial Institutions) was launched and troubled assets from state-owned banks were transferred and some of these banks received capital injections, according to Baer and Nazmi (2000) and Nakane and Weintraub (2005).

Public banks are expected to be less efficient than private banks due to agency problems. However, in Brazil there are two important considerations regarding state-owned banks. First, these banks hold very large public servants payroll accounts and therefore have an important advantage. Second, most of the bad debts from state-owned banks were written off under the PROES and PROEF. Therefore, it's not clear on whether state-owned banks would be more or less efficient than their private counterparts. Nonetheless, this is a testable hypothesis, which we denominate the agency theory hypothesis.

3. Definitions of Inputs, Outputs and Covariates

The definition of outputs and inputs in banking studies is controversial. Colwell and Davis (1992) and Berger and Humphrey (2000) for an in-depth discussion on the matter. We follow the intermediation approach. Each output is measured in value and not in number of transactions or accounts. Therefore, banks are seen as primarily intermediating funds between savers and investors. There is not a unique recommendation on what should be considered the proper set of inputs and outputs. Some studies use off-balance sheet as an output. Unfortunately, due to data constraints we are not able to consider them in the analysis. Following the intermediation

approach we employ three outputs, which are investments, total loans net of provision loans, and deposits. For inputs we take purchased funds (funds and interest expenses they generate), capital (operational expenses net of personnel expenses), and labor (personnel expenses).

In the analysis only banks that have deposits and perform credit operations and therefore perform traditional universal banking operations were included. This sampling approach should help avoid spurious DEA measurements resulting from unique bank specializations.

We notice that interest expenses may depend on the economic cycle and therefore are not totally controlled by banks. Nonetheless, banks compete in the funds market and decide to some extent how much they will pay for its use. Besides, in the DEA approach we compare the relative use of funds across banks.

We include deposits as outputs since it is assumed that they are proportionate to the output of depositors services provided, following Berger and Humphrey (1991). Furthermore, loans and investments are important outputs to be considered in the Brazilian case. Loans and investments account for about two thirds of banking assets and are important services provided by banks.

In efficiency analysis one compares the generation of outputs of each individual bank relative to its peers. Higher interest expenses imply in a relative larger utilization of purchased funds. Therefore, an efficient bank is able to use fewer inputs such as interest expenses and capital and labor expenses and produce more outputs such as deposits, loans and investments.

Technical efficiency is associated to the efficient use of inputs within the bank's technology. Therefore, if technical efficiency explains a larger part of the overall (economic) efficiency we can infer that this may be due to under utilization or waste of inputs. In the case of utilization of funds it suggests that more efficient banks are able to produce more output with lower interest expenses. On the other hand, allocative efficiency is related to how the mix of inputs affects the production process. If a bank has a small allocative efficiency then one can argue that by changing the mix of its inputs usage (funds, capital and labor) it could increase its output.

The banking literature has provided evidence that bank size may be important in explaining bank efficiency. To include size as an explanatory variable we employ the classification provided by the Central Bank of Brazil. All banks that add up to 75% of total banking assets are classified as large. Medium sized banks are the banks that add up from 75%-90% of total assets. Banks that add from 90-99% of bank assets are classified as small. The other banks are classified as micro.

Size is an important variable as it may reflect important advantages that specific banks have in the banking sector. Small or micro banks, for example, may have cost advantages to operate in niche markets.

We consider non-performing loans, market share and equity over assets ratio as covariates. Non-performing loans is an important covariate to control for credit risk. The equity over assets ratio can help testing the moral hazard hypothesis that suggests that banks with higher capital should be more cautious and therefore would have higher efficiency rankings. The other covariate of interest is ownership. Ownership is important due to cultural differences that reflect in the management and to spillovers that foreign banks may receive from their headquarters abroad. Furthermore, foreign banks may have borrowing facilities in international markets, which may imply in lower borrowing costs. The levels of ownership considered here are Foreign, Private Domestic, Foreign Participation and State-owned banks. Domestic banks with foreign participation include banks in which foreign investors hold a participation equal to or greater than 10% and lower than 50% in total equity, whereas foreign banks include banks in which investors hold more than 50% of total equity. State-owned banks are defined as those in which the Brazilian government holds more than 50% of total equity.

Banks are also classified according to the nature of their operations. The levels are Complex, Credit, Treasury and Business, Retail and Others. The Central Bank of Brazil classifies banks as complex when they enter in different activities such as credit operations, business and treasury. Banks are classified as credit and treasury and business when they perform predominantly these operations, respectively. Banks are classified as retail when they have a large network of branches and a large number of customers. Dummy variables were defined for all categorical variables.

4. Methodology

Basically two approaches are available in the literature to assess bank efficiency. The stochastic efficiency frontier analysis and the deterministic frontier analysis. In the context of deterministic frontiers Data Envelopment Analysis (DEA) is by far the most used technique.

Data Envelopment Analysis is a technique easy to deal with multiple outputs and allows the assessment of cost, technical and scale efficiencies without direct knowledge of factor input prices. This is the main reason for its use here. Banker and Natarajan (2004) show how these measurements can be computed only using total expenditures data. Data Envelopment Analysis, in the context of the study of the influence of contextual variables, has the drawback of relying on two stage statistical procedures, where efficiencies computed in the first stage are modeled via a regression model in the second stage. The procedure poses technical problems since efficiency measurements will be correlated. If the contextual variables are exogenous to the production process, Simar and Wilson (2007), Souza and Staub (2007) and Banker and Natarajan (2008) show that the two stage analysis is viable and, under certain error conditions, may even capture nonparametric stochastic efficiency results. See Banker and Natarajan (2008). Motivated by these recent results in DEA we consider here an extension to panel data.

In this article we deal with three panel data models. Estimation for all three is available in Stata. The first is dynamic in the DEA response and follows Arellano and Bond (1991) and Blundel and Bond (1998). The second is autoregressive in the error structure and follows Baltagi and Wu (1999). The third is non dynamic and assumes a Tobit response to deal with truncation in the DEA response.

The general form of non dynamic panel data models used here models a response y as a function of covariates x_k as

$$y_{it} = \sum_{k=1}^{K} \beta_k x_{itk} + u_{it}$$

where β_k are parameters to be estimated and u_{it} include random errors and stochastic or fixed specific panel effects. For example an autoregressive first order specification without random effects assumes $u_{it} = \rho u_{it-1} + \varepsilon_{it}$ where ε_{it} is the white noise in t and uncorrelated in i.

The formulation of Baltagi and Wu (1999) allows for bank and random effects, i.e, $u_{it} = \nu_i + \eta_t + \zeta_{it}$ where the ν_i and η_t are random panel and time effects and $\zeta_{it} = \rho\zeta_{it-1} + \varepsilon_{it}$ is the first order autoregressive process. Estimation is carried out via generalized least squares.

The Tobit representation assumes a similar structure as the Baltagi and Wu model with $\rho = 0$ and stochastic panel effects. The response is $y^0_{i,t}$ and $u_{it} = \nu_i + \varepsilon_{i,t}$. The random effects, ν_i are assumed iid $N(0, \sigma^2)$ and $\varepsilon_{i,t}$ are iid $N(0, \sigma_\varepsilon^2)$ independent of the ν_i.

The responses $y^0_{i,t}$ represent the censored values of $y_{i,t}$. For an efficiency measurement in (0,1), $y_{i,t} = y^0_{i,t}$. If $y_{i,t} = 1$ then $y_{i,t} \leq y^0_{i,t}$. Estimation is via maximum likelihood.

The dynamic panel of Arellano and Bond (1991) and Blundel and Bond (1998) assumes

$$y_{it} = \sum_{j=1}^{p} \alpha_j y_{i,t-j} + \sum_{k=1}^{K} \beta_k x_{itk} + u_{it}$$

where β_k are parameters to be estimated and $u_{it} = \nu_i + \varepsilon_{it}$ the ν_i being stochastic panel specific effects uncorrelated with ε_{it}. The statistical analysis for this model uses GMM and is robust to the presence of second order autocorrelation and heteroskedasticity in the random components ε_{it}.

Consider a production process with n production units (banks). Each unit uses variable quantities of p inputs to produce varying quantities of s different outputs y. Denote by $Y = (y_1, \cdots, y_n)$ the $s \times n$ production matrix of the n banks and by $X = (x_1, \cdots, x_n)$ the $p \times n$ input matrix. Notice that the element $y_r \geq 0$ is the $s \times 1$ output vector of bank r and x_r

is the $p \times 1$ vector of inputs used by bank r to produce y_r (the condition $l \geq 0$ means that at least one component of l is strictly positive). The matrices $Y = (y_{ir})$ and $X = (x_{ir})$ must satisfy: $\sum_i l_{ir} > 0$ and $\sum_r l_{ir} > 0$ where l is x or y. In our application $p = 3$ and $s = 3$ and it will be required $x_r, y_r > 0$ (which means that all components of the input and output vectors are strictly positive).

Following Banker and Natarajan (2004) we deal with the notions of economic, technical and allocative cost efficiencies using aggregate cost variables. In this context let $C = (c_1, \ldots, c_n)$ denote the vector of total costs, where c_r denotes the total cost of production of bank r and let $V = (v_1, \cdots, v_n)$ denotes the input cost matrix. Here v_{ir}, is the expenditure of bank r in input i (the ith component of vector v_r). If a vector of input prices $g = (g_1, \cdots, g_p)$ is known one must have $v_{ir} = g_i x_{ir}$ and $c_r = \sum_{i=1}^{p} v_{ir}$.

We compute the economic (cost) efficiency of bank r as

$$\theta_r^e = argmin\{\theta; Y\lambda \geq y_r, C\lambda \leq \theta c_r, \lambda 1 = 1, \lambda \geq 0\}.$$

Technical efficiency is computed as

$$\theta_r^{tec} = argmin\{\theta; Y\lambda \geq y_r, V\lambda \leq \theta v_r, \lambda 1 = 1, \lambda \geq 0\}.$$

Finally, allocative efficiency is computed as the ratio

$$\theta_r^a = \frac{\theta_r^e}{\theta_r^{tec}}.$$

The efficiency measurements are computed for each bank, for each of T years generating a panel of observations $(\theta_{it}^e, \theta_{it}^{tec}, \theta_{it}^a)$ with $t = 1, \cdots, T$ and $i = 1, \cdots, n$. We use statistical models to assess the significance of covariates (factors) on these measurements assuming independence between factors and errors. The models we use, except for the Tobit, fall in the category of dynamic panel data analysis and take into account serial correlation in the bank population. Cross-correlations between banks within times induced by DEA calculations or otherwise seem to be negligible and following Souza and Staub (2007) and Banker and Natarajan (2008) they were not modeled.

It is worth mentioning that banks that are more efficient in a specific year tend to continue efficient in the next year. This persistence effect can be modeled more properly with dynamic models.

5. Statistical Results

5.1 Descriptive Statistics

Table 1 presents the participation of banks by ownership in main aggregates for the banking system. It is worth noticing that state-owned banks still have a large share in the banking market and therefore studies that assess relative inefficiencies of these banks are important. Furthermore, foreign banks also have a large share of the market in the period under analysis.

The number of banks has been decreased over the years. A large number of small and micro banks may be an obstacle to reaching a more adequate cost structure within the banking system. Many M&A have taken place in recent years, specially with large banks acquiring small and micro banks.

Our data comprise Brazilian banks for the period 2000-2007. The balance sheet and income statement data are taken from the COSIF, the plan of accounts that all Brazilian financial institutions have to report to the Central Bank on a monthly basis. The sample data includes an unbalanced panel data of 127 banks, which accounts for more than 95% of banking assets in the time period under consideration.

The evolution of cost, technical and allocative efficiencies for the entire sample is presented in Table 2. The average allocative and technical efficiencies are about 66.9% and 63.3%, respectively, which are quite low compared to other countries (Berger and Humphrey (2000)).

Allocative efficiency is always greater than technical efficiency for the period from June

2000 to December 2002. However, in the latter period, beginning in June 2003, allocative efficiency falls and is below technical efficiency in the end of 2006 and 2007. In the period from 2000 to 2002 the main source of cost inefficiency seems to be due to technical inefficiency rather than allocative inefficiency.

On the first semester of 2002 a reserves transfer system was put in operation as part of the new Brazilian payment system, which was set to reduce interbank settlement risk and therefore, mitigate systemic risk. This implementation required investments on technology by Brazilian banks, which may be one of the reasons why technical inefficiency is higher than allocative inefficiency within the 2000-2002 period. The Central Bank of Brazil classifies banks as complex when they enter in different activities such as credit operations, business and treasury. Banks are classified as credit and treasury and business when they perform predominantly these operations, respectively. Banks are classified as retail when they have a large network of branches and a large number of customers.

The lowest average cost efficiency is located in December 2002, a year in which the leftist party won the elections, which generated strong depreciations of domestic currency (Real vis-a-vis the US dollar) and turbulence in financial markets. Although such fears were dissipated in the early 2003, with a formal commitment of the new elected president to the previous economic policy, cost efficiency fluctuated in the 40%-50% range in the time period.

In the period 2002-2007 allocative inefficiency increases, which may be due to fluctuations and instability in factor prices. The Central Bank of Brazil classifies banks as complex when they enter in different activities such as credit operations, business and treasury. Banks are classified as credit and treasury and business when they perform predominantly these operations, respectively. Banks are classified as retail when they have a large network of branches and a large number of customers.

Table 3 presents average cost, technical and allocative efficiencies for banks according to size, activity and ownership. In regard to size the higher average efficiencies of small and micro banks suggest that the niche markets hypothesis is a plausible assumption, which may help explain the recent M&A wave. There seems to be very little differences among activity types except for banks specialized in treasury and business operations, which were relatively inefficient over the period.

When we turn the analysis to banks with different ownership structure it is striking the relative inefficiency of foreign banks. Furthermore, public banks are the most efficient. This supports the agency hypothesis.

5.2 Model Based Statistical Inference

The dynamic panel model specification is

$$y_{i,t} = \alpha_0 + \alpha_1 y_{i,t-1} + \alpha_2 NPL_{i,t-1} + \alpha_3 MS_{i,t} + \alpha_4 MS_{i,t-1} + \alpha_5 Equity_{i,t-1} + \alpha_6 Activity_{i,t} + \alpha_7 Size_{i,t} + \alpha_8 Ownership_{i,t} + \alpha_9 t + u_{i,t}$$

for $i = 1, \ldots, n$ and $t = 1, \ldots, T$. As before i represents a bank and t is time. The variable y is an efficiency measurement. $NPL_{i,t-1}$ is the ratio of non-performing loans over total loans of bank i at period $t-1$, $MS_{i,t}$ is the market share of bank i in the loans market, $Equity_{i,t-1}$ is the log of bank's i equity, $Activity$ is a vector of dummy variables to capture the effects of specialization, $Size$ is a vector of dummy variables to capture size effects, $Ownership$ is a vector of dummy variables that capture ownership effects, α_k are unknown parameters and the u_{it} are the error componets. Except for the presence of the lagged component of the response variable the dependence on the exogenous variables is the same for the other two non dynamic models specified in Section 4. For the Baltagi and Wu model time is random.

Table 4 shows the overall fits of the three panel data models considered in the analysis. For cost and technical efficiencies the dynamic specification is best. For the allocative efficiency the Baltagi and Wu non dynamic model is superior. The statistical fits of the best models are shown

in Table 5. The dynamic models pass the Sargan and autocorrelation specifications tests. The Hausman specification test cannot be computed for the Baltagi Wu model since the difference of covariance matrices between the estimators of the random and fixed models is not positive definite. For economic efficiency the only categorical effect detected is ownership. The significance is due to the superiority of state banks. For allocative efficiency, activity and ownership are significant effects. Again the ownership effect is due to the superiority of state banks and the activity effect is due to complex and credit institutions. These results fairly agree with the unadjusted descriptive statistics. For technical efficiency none of the categorical variables are statistically significant. These results are shown in Tables 6 and 7.

We see evidence in favor of the home field advantage hypothesis as foreign banks are less cost efficient than their domestic counterparts. The agency theory hypothesis is not accepted since state-owned banks are more efficient than private banks.

Non performing loans (NPL) show a negative effect for all efficiency models. It is marginally significant for cost efficiency and highly significant for allocative efficiency. Market share is significant in all instances and equities only for allocative efficiency. The persistence effect is highly significant and positive for all models.

6. Conclusions

This study estimates cost, technical and allocative efficiencies for the Brazilian banking system in the recent period (2000-2007) using cost data and Data Envelopment Analysis. Empirical results suggest that Brazilian banking inefficiency is high if compared to other countries.

We employ three different panel data specifications to analyze the determinants of bank efficiency scores. From these models we can infer that non-performing loans is an important indicator of efficiency level, as well as market share. Evidence is in favor of the *home field advantage hypothesis* since foreign banks are less cost efficient than their domestic counterparts. Furthermore, the *agency theory hypothesis* is not accepted as state-owned banks are more efficient than private banks.

Banks with foreign participation and the foreign banks are the least economic efficient compared to other ownership types, which suggests that *global advantage hypothesis* is not prevailing in Brazil. It is worth mentioning that most of the banks with foreign participation were bought by large banks (both private domestic and foreign) in the period under analysis, which suggests that higher efficiency may be the target within M&A activity.

There doesn't seem to be substantial differences in banks pursuing different activities. Size is not an important factor for economic efficiency although descriptive statistics suggests that small banks are more efficient within the time period under analysis. This would imply the *niche markets hypothesis*. However the statistical findings are not significant.

The results presented in this paper are important for the development of financial regulation and for bank managers. Further research could focus on the direct effects of the M&A on bank efficiency.

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		Equity	Total Assets	Deposits	Credit Operations
2000	State-Owned	16.68	41.03	49.58	42.53
	Private	83.32	58.97	50.42	57.47
	Foreign	36.44	24.41	16.53	20.76
	Private Domestic	33.64	27.11	28.18	28.89
	Foreign Participation	13.23	7.44	5. 71	7.82
	Total	100	100	100	100
2006	State-Owned	24.82	36.1	45.55	31.07
	Private	75.18	63.9	54.45	68.93
	Foreign	23.81	21.68	20.5	22.04
	Private Domestic	44.88	36.48	28.95	40.01
	Foreign Participation	6.49	5.74	5	6.87
	Total	100	100	100	100

Table 1. Bank participation in the main aggregates as of December, 2000 and 2006.

		CE		TE		AE	
Variable	N	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Jun-00	115	0.482	0.250	0.681	0.253	0.684	0.215
Dec-00	116	0.444	0.249	0.559	0.260	0.767	0.171
Jun-01	111	0.452	0.278	0.591	0.274	0.709	0.216
Dec-01	108	0.445	0.276	0.573	0.284	0.722	0.225
Jun-02	104	0.438	0.288	0.576	0.293	0.697	0.228
Dec-02	101	0.401	0.297	0.580	0.308	0.618	0.286
Jun-03	101	0.427	0.295	0.656	0.269	0.588	0.304
Dec-03	98	0.462	0.275	0.652	0.262	0.666	0.251
Jun-04	94	0.433	0.260	0.674	0.280	0.626	0.241
Dec-04	94	0.430	0.247	0.621	0.244	0.676	0.260
Jun-05	93	0.486	0.284	0.701	0.255	0.676	0.336
Dec-05	97	0.445	0.270	0.632	0.256	0.667	0.261
Jun-06	95	0.466	0.282	0.681	0.251	0.643	0.256
Dec-06	97	0.495	0.267	0.696	0.252	0.681	0.225
Jun-07	94	0.402	0.256	0.658	0.253	0.574	0.248
Total	1518	0.447	0.272	0.633	0.270	0.669	0.253

Table 2. Evolution of cost, technical and allocative efficiencies for the Brazilian banking sector for the period 2000-2007.

Level	CE	TE	AE
Large	0.38	0.65	0.58
Medium	0.29	0.47	0.52
Small	0.42	0.65	0.62
Micro	0.42	0.72	0.54
Complex	0.41	0.66	0.61
Credit	0.44	0.69	0.62
Treasury and Business	0.25	0.51	0.43
Retail	0.44	0.71	0.60
Foreign	0.28	0.55	0.45
Private Domestic	0.41	0.70	0.58
Foreign Participation	0.38	0.56	0.66
Public	0.66	0.77	0.85

Table 3. Average cost, technical and allocative efficiencies for the Brazilian banking sector for the period 2000-2007. Banks are classified according to size, activity and ownership.

Measure	Model	Cost	Technical	Allocative
MSS	Baltagi and Wu	0.043	0.050	0.035
	Tobit	0.043	0.049	0.036
	Dynamic	0.028	0.044	0.052
MAE	Baltagi and Wu	0.163	0.186	0.149
	Tobit	0.164	0.181	0.151
	Dynamic	0.130	0.175	0.181

Table 4. Mean residual sum of squares (MSS) and mean absolute residuals (MAE) for Baltagi and Wu, Tobit and Dynamic models.

Parameter	Cost	Technical	Allocative
Constant	0.817	1.666	2.222**
	(0.661)	(0.893)	(0.247)
DEA_{t-1}	0.410**	0.250**	-
	(0.079)	(0.057)	-
NPL_{t-1}	-0.209	-0.251	-0.328**
	(0.112)	(0.170)	(0.127)
MS_t	0.064**	0.069**	0.047**
	(0.020)	(0.020)	(0.009)
MS_{t-1}	-0.044**	-0.040	-0.008
	(0.014)	(0.026)	(0.010)

$Equity_{t-1}$	-0.025	-0.064	-0.079**
	(0.028)	(0.038)	(0.010)
Time	0.000	0.008**	-
	(0.003)	(0.003)	-
Complex	-0.008	0.281	0.194*
	(0.148)	(0.157)	(0.078)
Credit	0.044	0.100	0.114
	(0.099)	(0.114)	(0.065)
Treasury and Business	0.023	0.074	0.078
	(0.087)	(0.103)	(0.064)
Retail	0.013	0.148	0.076
	(0.097)	(0.113)	(0.065)
Large	-0.065	0.026	0.036
	(0.043)	(0.062)	(0.037)
Micro	0.016	0.054	0.026
	(0.050)	(0.039)	(0.022)
Medium	-0.028	0.003	0.041*
	(0.030)	(0.040)	(0.020)
Foreign	-0.087	-0.007	-0.034
	(0.095)	(0.113)	(0.054)
Domestic Private	0.054	-0.032	0.142*
	(0.119)	(0.174)	(0.056)
State-owned	0.297*	0.217	0.354**
	(0.135)	(0.170)	(0.062)

Table 5. Best Models for Cost, Technical and Allocative efficiencies. Values in parenthesis are standard errors. Levels Others, Foreign Participation and Small were omitted from the analysis. **,* stand for statistical significance at 1% and 5%, respectively.

Type	Cost	Technical	Allocative
χ^2-test Activity	2.12	5.12	9.91*
χ^2-test Ownership	15.27**	5.77	119.71**
χ^2-test Size	2.36	2.33	6.27
Q1	-6.62**	-7.75**	-
Q2	1.47	1.50	-
Sargan	111.45	110.52	-

Table 6. Chi-square tests for categorical effects, first and second order autocorrelation tests (Q1 and Q2, respectively), and Sargan's specification test.,* stand for statistical significance at 1% and 5%,respectively.**

Effect			Chi-square		
	A	B	Cost	Technical	Allocative
Activity	Complex	Credit	0.21	2.85	2.81
		Treasury and Business	0.06	3.27	5.31*
		Retail	0.03	1.67	6.85**
	Credit	Treasury and Business	0.35	0.34	3.28
		Retail	1.93	1.8	4.26*
	Treasury and Business	Retail	0.07	2.43	0.01
Control	Foreign	Domestic Private	2.42	0.03	49.45**
		State owned	14.48**	3.59	105.77**

	Domestic Private	State owned	6.18*	4.02**	33.7**
Size	Large	Micro	1.38	0.15	0.05
		Medium	1.51	0.24	0.02
	Micro	Medium	0.54	0.93	0.25

Table 7. Chi-square tests for the hypothesis A=B. **,* stand for statistical significance at 1% and 5%, respectively.