THE IMPACT OF DE-REGULAMENTATION ON THE BRAZILIAN BANKING INDUSTRY: A PRODUCTION METAFRONTIER APPROACH

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ABSTRACT

This paper analyzes the impact after the entry and the increase in the capital participation of foreign banks in the Brazilian financial institutions. In this sense, taking into account three sub-sets of banks by controlling capital origin - domestic privates, foreigner and public-, an analysis was carried out to find out whether there were technical efficiency and productivity gains in Brazil' banking industry. Therefore, a production frontier was built using the Data Envelopment Analysis (DEA) which allows for the calculation of technical efficiency. Next, performing one of these measures, Malmquist's total productivity index is calculated. The results showed that the technical efficiency of the Brazilian banking industry has not evolved as must as it has been expected, although a total productivity increase has actually occurred, arising only from the technological progress. The foreign banks earned the most productivity gains followed by the domestic private banks. The technological leadership (test), proposed by Marinho and Benegas (2002), showed that the domestic private banks determined the industry's technological pattern.

RESUMO

Este artigo analiza o impacto da entrada e do aumento da participação do capital estrangeiro nas instituições financeiras brasileiras. Neste sentido, considerando-se uma amostra de três subgrupos de bancos por origem do capital controlador – privados nacionais, estrangeiros e públicos-, uma análise é conduzida para avaliar se houve ganhos de eficiência e de produtividade na indústria bancária do Brasil. Assim sendo, constrói-se uma fronteira de produção utilizando-se a metodologia *Data Envelopment Analysis* (DEA) que permite o cálculo das eficiências técnicas. Em seguida, fazendo uso destas medidas calcula-se o índice de produtividade total dos fatores de Malmquist. Os resultados mostraram que a eficiência técnica nos subgrupos de bancos não evoluiu como se esperava, contudo houve aumento da produtividade total dos fatores, advindo unicamente do progresso tecnológico. Os bancos estrangeiros obtiveram os maiores ganhos de produtividade, seguidos dos privados nacionais e dos públicos. O teste de liderança tecnológica proposto por Marinho e Benegas (2002) mostrou que os bancos privados nacionais determinam o padrão tecnológico da indústria.

Key words: Brazilian banks, technological leadership, metafrontier, technical efficiency, DEA.

Palavras-chave: Bancos brasileiros, liderança tecnológica, metafronteira, eficiência técnica, DEA.

JEL Classification: G21, G28, O33.

ÁREA 7 - MICROECONOMIA, MÉTODOS QUANTITATIVOS E FINANÇAS

1 INTRODUCTION

Since 1995, the National Financial System (SNF) has been going through wide range changes, some of which of a legal and institutional character, others determined by the market forces. The government's direct intervention since that year was undertaken basically with the purpose of improving, consolidating and making the system more efficient, something which places this type of change within those of a legal and institutional order.

Within the measures undertaken by the government, the permission in connection with the participation of the foreign capital in the National Financial System was taken with a view to promote the increase of both productivity and efficiency of the Brazilian banks, further more it had been hoped for that it would have direct effects on the technological standard of the industry. Levine (1996) points out that the foreign banks entry may foster an increase in the quality and availability of financial service in the home banking market due to an increase of the competition, something which on its turn would motivate the use of more advanced technologies and banking practices. Once again, the governmental policies intent was aligned with the results which have been expected by the economic theory.

Bevilaqua and Loyo (1998) maintain that the arguments favorable to liberalization are: classical gains originating from the commercialization of some financial services, increment of competition with a reduction in the market power, gains of economic welfare, a fall in the financial intermediation costs, a better credit allocation, an increase in the modernization and estability of the payment system.

Claessens, Dermigüç-Kunt and Huizinga (2001) gathered together notes from approximately 7.900 banks in 80 countries in the years ranging from 1988 and 1995 and they arrived at results that corroborated the expectations in connection with the entry of foreign banks. The authors found evidences that, indeed for most of the countries under the study, it occurred an increase in the competition and consequently an increment of the efficiency in all bank institutions of the respective domestic markets.

In the beginning, the development of a financial system of a country is closely linked to the efficiency and productivity of its components, the banks especially on account of its role in the intermediation between savers and borrowers. In this sense, to understand and evaluate the behavior of these institutions becomes of interest not only of the academic research but as well as of the financial system regulating agencies. As Berger and Humphrey (1997) stated, in the last years, researchers have granted an increasing importance in the quantification of the financial productivity process, owing to its paramount role for the economic welfare.

On account of what has been expounded above, the purpose of this paper will be to evaluate the impact caused by the measures taken by the federal government as from 1995, mainly in what regards the liberalization of the foreign capital participation in the National Financial System (SFN) and its repercussion on productivity and technical efficiency of the banking institutions which have business concerns in the country. Besides that, eight years having being elapsed since changes in legislation have been in force, the present article will strive to analyze whether actually the foreign banks hold the leadership of the technological standard within the Brazilian banking industry, as was the initial government expectations.

For that purpose, the study will employ the methodology of the efficient frontier of production that provides a numerical measurement to determine the value of technical efficiency. This latter aspect is essential in the assessment of the impact of government measures whose objectives are exactly the system's efficiency improvement.

There are basically two methods to evaluate the efficient frontier of production. The first one was initially put forward by Aigner, Lovell and Schimidt (1977) and, independently, by Meeusen and Van Den Broeck (1977) and it became known as Stochastic Production Frontier (SPF). These method presumes the econometric estimative under a parametric manner for the production function or cost function. The DEA model, adopted in this paper has been developed by Charnes, Cooper and Rhodes (1978) and encompasses the use of a linear programming methods for the construction of non-parametric production efficient frontier.

Some factor have influenced the choice of the DEA methodology. One of them, for instance, was the fact that the DEA does not require that the business firm would assume behavioral assumptions such as minimization of cost or maximization of profits, opposite to what occurs with SPF. Indeed, this is extremely convenient when the banking industry is under analysis, whose characteristics are closer to a competitioning oligopoly (see Nakane, 2002; Belaisch, 2003; and Petterini L., 2003).

As long as estimates of productivity variations are carried out through the total factor productivity index of the Malmquist (1953), the DEA methodology allows for the decomposition of this total productivity index in the technical efficiency variation (catching up effect), technological variation (frontier displacement) and in the scale efficiency variation.

Notwithstanding Berger and Humphrey research (1997) pointing out that there is an equilibrium in the use of the two methodologies - DEA and FPE - in empirical studies undertaken on developed countries banking industry, the application of the DEA methodology, here in Brazil, is extremely incipient. Nakane (1999) and Silva and Jorge-Neto (2002) used stochastic frontier analysis to study the efficiency of Brazilian banks. On the other hand, one of the first studies was the one performed by Campos (2002), who employed DEA with Malmquist total productivity index to analyze the productivity and efficiency of the Brazilian private banking sector in the years ranging from 1994 to 1999. The difference between Campos' study and the current paper lies in the scope of the sample (inclusion of public banks) and the extention of the period under analysis (1995 to 2003).

Another aspect which differentiates this work is the utilization of the meta-frontier of production concept, initially proposed by Hayami (1969) and Hayami and Ruttan (1970, 1971), which is defined as the production efficient frontiers envelopment of the subgroups of banks which are intended to undergo analysis -- domestic private, foreign and public. The use of this concept will serve as a theoretical base for the performing of a technological leadership test, developed by Marinho and Benegas (2002), which shall point out which one or which of the three subgroups of banks will define the national production frontier.

Next, this article is divided according to the following: the next section (section 2) approaches the methodological concepts employed in the paper. Section 3 provides a description of data which are used to estimate the efficient production frontier; section 4 displays the technical efficiencies results collected through the DEA methodology and the total productivity indexes of Malmquist. Section 5 presents the main results of the technological leadership test proposed by Marinho and Benegas (2002). Finally, the last section concludes the study and presents a brief summary.

2 METHODOLOGY

2.1 SHEPHARD'S DISTANCE FUNCTION AND FARRELL'S TECHNICAL EFFICIENCY

Before defining Shephard distance function , the technology of production, in a certain period may be defined as follows:

$$T^t = \{(\mathbf{x}^t \mathbf{y}^t); \mathbf{x}^t \text{ can produce } \mathbf{y}^t\} \tag{1}$$

where, $\mathbf{x}^t \in R_+^N$, is an input vector and $\mathbf{y}^t \in R_+^M$ is a vector of products

Shephard (1970), formally defines the function distance oriented by the product with reference to technology in the period of t as[1]:

$$D_o^t(\mathbf{x}^t, \mathbf{y}^t) = \inf\{\phi : (\mathbf{x}^t, \mathbf{y}^t / \phi) \in T^t\} \tag{2}$$

Intuitively, the product oriented distance function calculates the maximal proportional expansion of the product vector, given a determined inputs vector, so that the production is still feasible. For example, in the case of a single product and a single input, φ, represents the lowest value through which the product requires to be deflationed so that production is placed on the production frontier. In this sense, the distance function will assume values lower than or equal to 1, that is, $D_o^t(\mathbf{x}^t, \mathbf{y}^t) \leq 1$. In the case in which $D_o^t(\mathbf{x}^t, \mathbf{y}^t) = 1$, $(\mathbf{x}^t, \mathbf{y}^t)$ will be on the technological frontier, and in this sense, production will be technically efficient. When $D_o^t(\mathbf{x}^t, \mathbf{y}^t) < 1$, it is said that $(\mathbf{x}^t, \mathbf{y}^t)$ is technically inefficient as in this case the activity is in the production set interior. Combining the facts above, it is shown in Färe and Primont (1995), that if the technology will satisfy the property of weakly disposal of products, then the distance function completely

[1] The distance function input oriented by the input is defined as $D_i^t(\mathbf{x}^t, \mathbf{y}^t) = \sup\{\theta : \mathbf{y}^t \in P_t(\mathbf{x}^t / \theta)\}$.

characterizes technology, in the sense in which $D_o^t(\mathbf{x}^t, \mathbf{y}^t) \leq 1$ if and only if $(\mathbf{x}^t, \mathbf{y}^t)$. Thus, the production correspondence may be alternatively expressed as:

$$T^t = \{(\mathbf{x}^t, \mathbf{y}^t); D_o^t(\mathbf{x}^t, \mathbf{y}^t) \leq 1\} \subset R_+^M \tag{3}$$

According to Farrell (1957), technical efficiency (TE) of production is defined as the capacity of a firm to obtain a maximal level of production in function of a given set of production factors. Once this is defined, it may be shown that Farrell's production- technical efficiency will be equal to the reciprocal of the output distance function. This observation is relevant when the DEA is used, in subsection 2.3, to calculate Malmquist total productivity index.

2.2 The Malmquist Total Productivity Index

Based on Malmquist's original ideas (1953), Caves, Christensen and Diewert (1982) have defined Malmquist total productivity index in connection with the *t* technology, output oriented and denoted by $M_{CCD}(t)$, as:

$$M_{CCD}(t) = D_0^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) / D_0^t(\mathbf{x}^t, \mathbf{y}^t) \tag{4}$$

where, right side components of (4) are output oriented distance functions defined in the sub-section 2.1.

The formulation in (4) is based on the technology in the t period. It is also possible to define the same index in connection with the existing technology in the t+1 period as:

$$M_{CCD}(t+1) = D_0^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}) / D_0^{t+1}(\mathbf{x}^t, \mathbf{y}^t) \tag{5}$$

Later on, Färe et al. (1994) redefined Malmquist total productivity index so as to avoid arbitrariety in the choice of the reference technology. For that purpose, the authors proposed that the geometric average of expressions (4) and (5) should be calculated, that is:

$$M(t,t+1) = \frac{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^t(\mathbf{x}^t, \mathbf{y}^t)} \left[\frac{D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^t(\mathbf{x}^t, \mathbf{y}^t)} \frac{D_o^t(\mathbf{x}^t, \mathbf{y}^t)}{D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)} \right]^{1/2} \tag{7}$$

where the expression outside the brackets measures the technical efficiency change (TEFFCH) between periods *t* and *t+1*. The terms inside the brackets in (7) measure the technological change (TECHCH) between the periods *t* and *t+1*. It is a common practice in the literature to define TEFFCH as the catching-up effect, that is, the approximation of productive units in the direction of the efficient frontier and TECHCH as the displacement effect of the frontier between two periods (technical or technological progress).

Malmquist index may present values greater, equal or lower than unity depending whether the productive unity presents, respectively, growth, stagnation or decline on the productivity between *t* and *t+1*. The same line of thinking may be extended to the index that defines the decomposition in (7). TEFFCH and TECHCH will have values greater than one when there occurs a gain in technical efficiency and technical progress, respectively; and, values equal to one, in the inexistence of technical and technological changes respectively; and, values lower than one, when there occurs a decrease in the technical efficiency and technological changes, respectively.

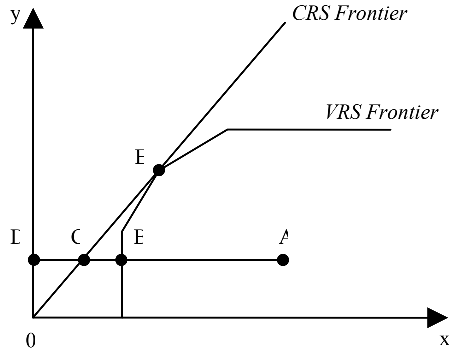
The decomposition of Malmquist total productivity index in (7) assumes that the firms are operating in an optimum scale of production. However, factors such as market imperfections may cause scale inefficiencies. Thus, generally speaking, the firms operate either on point or with increasing or decreasing returns in the scale. Taking that into account, Färe et. al. (1994) proposed decompose TEFFCH in two components: pure technical efficiency change (PTEFFCH) and scale efficiency change (SEFFCH).

In order to calculate these components it is required the construction of two production frontiers, one assuming constant returns to scale (CRS) and another with variable returns to scale (VRS). In case a firm presents different technical efficiency values under CRS and VRS, this evidences that it presents a scale inefficiency, which may be measured by the difference between technical efficiencies in relation to both frontiers.

These facts may be better viewed through a simple example, which involves the case of an output and an input, as presented in Figure 1. Under CRS the technical efficiency input oriented by firm A is given by the distance between points C and A. Under VRS the pure technical inefficiency is determined through the distance between points B and A. The difference between these two measurements is due to scale inefficiency. In terms of the definition of technical efficiency measurements, we have that:

- Technical Efficiency (CRS): TE = DC/DA
- Pure Technical Efficiency (VRS): PTE = DB/DA
- Scale Efficiency: SE = DC/DB

Figure 1: Returns to Scale



Therefore, it follows that:

$$TE = PTE \times SE \tag{8}$$

In short, technical efficiency under constant returns to scale may be decomposed in two components: pure technical efficiency change and scale efficiency change. Notice that this latter may be interpreted as the ratio of the firm mean product operating in point B and of the firm average product operating in the optimum scale point (point E).

2.3 DATA ENVELOPMENT ANALYSIS MODEL - DEA

DEA model involves the use of linear programming methods to construct a frontier (convex cone) on data for, next, to undertake the construction of efficiency measurements related to this frontier. The model used, was originally proposed by Charnes, Cooper and Rhodes (1978), that being the reason why it became known as DEA-CCR.

It is supposed the existence of K pairs, $(\mathbf{x}_k^t, \mathbf{y}_k^t)$, $k = 1,...,K$, where each pair corresponds to a feasible activity of a firm, so that $\mathbf{x}_k^t = (x_{k1}^t, x_{k2}^t, ..., x_{kN}^t)'$ is the inputs vector employed by the k activity in the t period and $\mathbf{y}_k^t = (y_{k1}^t, y_{k2}^t, ..., y_{kM}^t)'$ the vector of products produced by this very same firm within the same period. To be used later on, the matrices of inputs and products, are defined respectively as $\mathbf{X}^t = (\mathbf{x}_1^{t'}, \mathbf{x}_2^{t'}, ..., \mathbf{x}_K^{t'})'$ of $K\times N$ dimension and, $\mathbf{Y}^t = (\mathbf{y}_1^{t'}, \mathbf{y}_2^{t'}, ..., \mathbf{y}_K^{t'})'$ of $K\times M$ dimension. The production technology in the t period, constructed as from available observations, is defined as the lower convex cone which contains the vectors pairs $(\mathbf{x}_k^t, \mathbf{y}_k^t), k = 1,...,K$. Therefore, the production set is defined as:

$$T = \{(\mathbf{x}^t, \mathbf{y}^t); \mathbf{x}^t \geq \lambda' \mathbf{X}^t, \mathbf{y}^t \geq \lambda' \mathbf{Y}^t, \lambda \geq 0\} \tag{9}$$

The vector $\lambda \in \Re_+^K$ corresponds to the intensity levels in which each activity operates. Taking into account the technology given in (9) and the definition given in (2), the output distance function of the activity *k* in *t* can be calculated solving the following problem of linear programming:

$$D_o^t(\mathbf{x}^t,\mathbf{y}^t) = \begin{Bmatrix} \min\limits_{\lambda,\phi} \phi \\ s.a.\ \mathbf{x}_k^t \geq \lambda'\mathbf{X}^t \\ \mathbf{y}_k^t/\phi \leq \lambda'\mathbf{Y}^t \\ \lambda \geq 0 \end{Bmatrix} \tag{10}$$

As it was observed before, Farrell's technical efficiency (of the output) is the reciprocal of the output distance function. Thus, denoting by TE_k^t Farrell's technical efficiency corresponding to the *k-th* firm, this implies that, $TE_k^t = \left[D_o^t(\mathbf{x}_k^t,\mathbf{y}_k^t)\right]^{-1} = \sup\{\theta : \theta\mathbf{y}^t \in P(\mathbf{x}^t)\}$. So, using (10), the technical efficiency of the *k-th* firm is estimated by solving:

$$\left[D_o^t(\mathbf{x}^t,\mathbf{y}^t)\right]^{-1} = \begin{Bmatrix} \max\limits_{\lambda,\theta} \theta \\ s.a.\ \mathbf{x}_k^t \geq \lambda'\mathbf{X}^t \\ \theta\mathbf{y}_k^t \leq \lambda'\mathbf{Y}^t \\ \lambda \geq 0 \end{Bmatrix} \tag{11}$$

For the calculation of the distance functions which makes up Malmquist productivity index, defined by the expression (7), the distances $D_o^s(\mathbf{x}^w,\mathbf{y}^w)$ to s = *t, t+1* and w = *t, t+1*, are estimated as from the observations by solving:

$$D_o^s(\mathbf{x}^w,\mathbf{y}^w) = \begin{Bmatrix} \min\limits_{\lambda,\phi} \phi \\ s.a.\ \mathbf{x}_k^w \geq \lambda'\mathbf{X}^s \\ \mathbf{y}_k^w/\phi \leq \lambda'\mathbf{Y}^s \\ \lambda \geq 0 \end{Bmatrix} \tag{12}$$

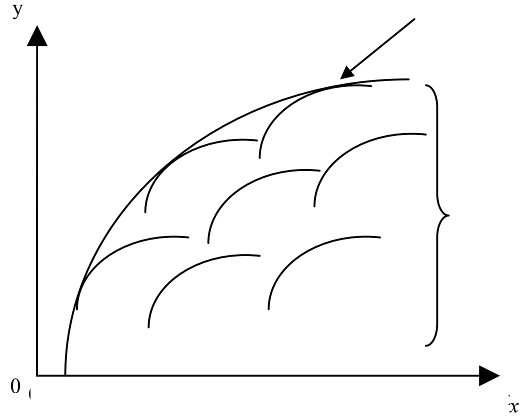
where $\mathbf{X}^s$ and $\mathbf{Y}^s$ are, respectively, the matrices of input and product of the observations concerning the *s* period. Finally, the estimates of pure technical efficiencies (PTE) and of scale efficiency (SE) are obtained by the solution of (11) adding the restriction $e'\lambda$ where $e = (1,...,1) \in \Re^K$. With the imposition of this condition, it can be calculated the distance functions under the technology with variable returns to scale and, employing expression (8), scales efficiencies can be obtained residually.

2.4 Production Metafrontier and the Technological Leadership Test

The concept of production metafrontier was first proposed by Hayami (1969) and Hayami and Ruttan (1970, 1971). At a later stage, Ruttan et al. (1978) undertaking the reformulation of these authors initial concept, redefined the production metafrontier as the envelopment of production points of the most efficient productive units.

Figure 2 represents graphically, in the output (Y)/input (X) space, production metafrontier concept of industry which is characterized for being the efficient product frontier(s) envelopment of subset of firms within this industry.

Figure 2: Production Metafrontier



Once the efficient product metafrontier is defined, it becomes possible to measure each firm's efficiency in relation to this frontier and also to perform comparisons between the firms in each subset. Moreover, it also allows for comparing the relative efficiency of firms operating under different technologies, as it may be well the case of comparisons between subgroups of a same industry.

Through DEA methodology, it can be calculated, separately, for each one of the firm subgroups their production frontiers by employing data concerning the firms in the several subgroups. Employing DEA again, the industry production metafrontier is calculated using data of all firms in the industry.

Since the interest in this paper is to perform comparisons between technical efficiencies relating to several industry sectors, there comes up a hurdle in order to aggregate these measures. However, in a recent work, Färe and Zelenyuk (2003), based on Aczél (1990) aggregate indication axiom, propose a manner to aggregate technical efficiency values of a determined group of firms, each one of them employing N inputs for the production of a single product. This may be synthesized in the proposition that follows below:

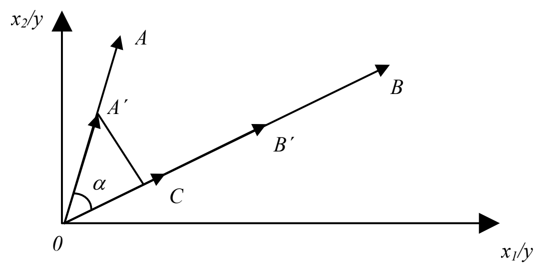
Proposition 1 *Consider an industry with I firms, each one of them using a vector* $\mathbf{x}_i \in R_+^N$ *of inputs for the production of a single output* $y_i \in \Re_+$. *Let* ,$D_o^i(\mathbf{x}_i, y_i)$ *,the output distance function of the i-th firm* (*i* = 1,2,....,I). *Then, the aggregate output distance function of I firms of these industry, denoted by* $\mathbf{D}_o^i(\mathbf{x}_1, \mathbf{x}_2, ..., \mathbf{x}_I, \sum_{i=1}^{I} y_i)$, *is given by*:

$$\mathbf{D}_o^i(\mathbf{x}_1, \mathbf{x}_2, ..., \mathbf{x}_I, \sum_{i=1}^{I} y_i) = \left[\sum_{i=1}^{I} \left[D_o^i(\mathbf{x}_i, y_i) \right]^{-1} S_i \right]^{-1} \tag{13}$$

where $S_i = y_i / \sum_{i=1}^{I} y_i$.

This result allows the direct comparison of the subgroups and the industries metafrontier. To achieve that, first of all, making use of (13), technical efficiency values of the industry subgroups are aggregated, for next, turning them fully efficient (through the radial projection of the observed point).

Figure 3 – Technological Leadership Test



For a determined subgroup of the industry, this procedure consists on the multiplication of the points under observation -- for example, point B in Figure 3 - by the aggregate technical efficiency value of the subgroup. This generates the fully efficient activity point of the subgroup represented by B on the frontier of this subgroup[2].

The same procedure is adopted now taking into account all the firms within the industry. Thus, the point A in Figure 3 represents the observed activity point in the industry and A' the industry's fully efficient point. On turning the subgroup and the industry fully efficient, now it is possible to test the existence of the technological gap between the subgroup frontiers and the industry frontier.

For that purpose, the technological leadership test proposed by Marinho and Benegas (2002) is applied, whose description in detail is provided next. So that Farrel's technical efficiencies obtained by the aggregation procedure of subgroups and of industry may be made possible to compare, it is required that these are on a same radial expansion, something which generally does not occur.

Therefore, this procedure is equivalent to project orthogonally the point of efficient activity on the industry, *A′* in Figura 3, on the vector of the fully efficient activity of the subgroup (vector *OC*) in respect of which the comparison shall be made. Now, points B′ and *C* are on the same radial expansion thus allowing the comparison of frontiers. Ratio *OC/0B′* represents a measure of the technological potential of the firms subgroup in relation to that of the industry.

The underlying intuition to such procedure is appealing from the theoretical point of view, as the orthogonal projection is away of turning x_2/x_1, measured by angle α in the Figure 3, the same for the subgroup of firms as well as for the industry.

This procedure isolates the technical efficiency differentials in the use of the production factors between the subgroup and the industry, it remaining only the differential or technological gap between them, which is exactly what is sought to be analyzed.

In what follows, it will be considered an industry comprising I firms, each one of them producing a single product employing two inputs and operating with technology under constant returns to scale. It is presumed that the industry is divided in G subgroups each one with a determined number I_g of firms. Let $\mathbf{x}_I = \sum_{i=1}^{I} \mathbf{x}_i \in \Re_+^2$ and $y_I = \sum_{i=1}^{I} y_i \in \Re_+$, respectively, the vector of inputs employed and the product of the industry, and, $\phi_I = \mathbf{D}_o^I(\mathbf{x}_I, y_I)$ its aggregate output distance function, obtained by the equation (13). Similarly, $\mathbf{x}_g = \sum_{i=1}^{I_g} \mathbf{x}_i \in \Re_+^2$, $y_g = \sum_{i=1}^{I_g} y_i \in \Re_+$ and $\phi_g = \mathbf{D}_o^g(\mathbf{x}_g, y_g)$ is defined as being, respectively, the input vector, the output and the aggregate output distance function of the g-th industry's subgroup, $g = 1,...,G$.

Therefore, Definition 2 that follows next describes how to formally undertake the technological leadership test, originally proposed by Marinho and Benegas (2002). In the definition below, it is shown that $\mathbf{x}_I^* = \mathbf{x}_I/(y_I/\phi_I) = \phi_I \mathbf{x}_I / y_I$ and $\mathbf{x}_g^* = \mathbf{x}_g/(y_g/\phi_g) = \phi_g \mathbf{x}_g / y_g$ are, respectively, the normalized input vectors of the industry and of the *g-th* subgroup which are on theirs respective frontiers. Notice that vectors $\mathbf{x}_I^* = (x_{I1}^*, x_{I2}^*)$ and $\mathbf{x}_g^* = (x_{g1}^*, x_{g2}^*)$ efine the inputs normalized by the efficient product, respectively employed by the industry and by the g-th subgroup. Indeed, due the homogeneity of degree +1 on the product[3], of the output distance function, it follows that:

$$\mathbf{D}_o^I(\mathbf{x}_I, y_I/\phi_I) = 1 \qquad (14)$$

Using once again the degree +1 homogeneity on the output and degree -1 homogeneity on inputs under constant returns to scale, it arises out of (14) that:

$$\mathbf{D}_o^I(\phi_I \mathbf{x}_I / y_I, 1) = 1 \qquad (15)$$

[2] In paper the choice was made to illustrate the procedure of comparison of technology through isoquant, although the radial projections are carried out on the output. However, on the hypothesis of constant returns to scale the radial projections on the output is equivalent to a radial projection of inputs normalized by the output.

[3] The proprieties of distance functions oriented by the output and by the input are demonstrated in Shephard (1970) or Färe and Primont (1995).

Finally, using the reciprocity property between the distance functions oriented by output and by input it follows that:

$$\mathbf{D}_i^I = \left[[\mathbf{x}_I / \mathbf{D}_i^I(\mathbf{x}_I, y_I)] / y_I, 1 \right] = 1 \tag{16}$$

where $\mathbf{D}_i^I(\mathbf{x}_I, y_I)$ is the industry input distance function as defined in the footnote 1. Therefore, vector $\mathbf{x}_I^* = [\mathbf{x}_I / \mathbf{D}_i^I(\mathbf{x}_I, y_I)] / y_I$ is on the unity isoquant. The same argument is valid for the vector of inputs $\mathbf{x}_g^* = (x_{g1}^*, x_{g2}^*)$.

Definition 2 *To an industry subgroup g, let* $p(\mathbf{x}_I^*) \in \Re_+^2$ *so that* $\alpha \mathbf{x}_g^{*'}(\mathbf{x}_g^* - p(\mathbf{x}_I^*)) = 0$, *for some* $\alpha > 0$, *that is* $p(\mathbf{x}_I^*)$ *is the orthogonal projection of vector* $\mathbf{x}_I^*$ *on the radial expansion passing through the vector* $\mathbf{x}_g^*$. *Then the technological leadership test result, concerning subgroup g, is given by* $\mu_g = \|p(\mathbf{x}_I)\| / \|\mathbf{x}_g\|$, *so that if* $\mu_g \geq 1$ *then subgroup g will be the leader in technology on industry. On the other hand,* $\mu_g < 1$, *then subgroup g shall be stated as non-leader on industry.*

Based upon the definition above, the following proposition 3 provides a simple manner to undertaken the technological leadership test.

Proposition 3 *If* μ_g *is the technological leadership test value of subgroup g then, since that θ is the angle formed by vector* $\mathbf{x}_I^*$, *there is* $\tau(\theta) \in [0,1]$ *such that*:

$$\mu_g = \tau(\theta)(x_{g1}^* / x_{I1}^*) + (1 - \tau(\theta))(x_{g2}^* / x_{I2}^*) \tag{17}$$

Proof. Since that by Definition 2, $p(\mathbf{x}_I^*)$ is the orthogonal projection of vector $\mathbf{x}_I^*$ on the radial expansion passing through the vector $\mathbf{x}_g^*$, it follows that $p(\mathbf{x}_I^*) = \beta \mathbf{x}_g^*$ where $\beta = \left((\mathbf{x}_I^{*'} \mathbf{x}_g^*) / \|\mathbf{x}_I^*\|^2 \right)$. Substituting $p(\mathbf{x}_I^*)$ in μ_g it follows that:

$$\mu_g = (\mathbf{x}_I^{*'} \mathbf{x}_g^*) / \|\mathbf{x}_I^*\|^2 \tag{18}$$

According to the definitions of inner product between vactors and norm of a vector, the expression (15) can be writte as:

$$\mu_g = \frac{x_{I1}^* x_{g1}^* + x_{I2}^* x_{g2}^*}{(x_{I1}^*)^2 + (x_{I2}^*)^2} = \frac{x_{I1}^* x_{g1}^*}{\left[1 + (x_{I2}^* / x_{I1}^*)^2\right](x_{I1}^*)^2} + \frac{x_{I2}^* x_{g2}^*}{\left[1 + (x_{I1}^* / x_{I2}^*)^2\right](x_{I2}^*)^2} \tag{19}$$

Given that $\cos^2 \theta = \left[1 + (x_{I2}^* / x_{I1}^*)^2\right]^{-1}$ and $1 - \cos^2 \theta = \left[1 + (x_{I1}^* / x_{I2}^*)^2\right]^{-1}$, from expression (19), it can be finally shown that $\mu_g = \tau(\theta)(x_{g1}^* / x_{I1}^*) + (1 - \tau(\theta))(x_{g2}^* / x_{I2}^*)$, where $\tau(\theta) = \cos^2 \theta \in [0,1]$.■

The proposition 3 above shows that the value of technological leadership test is equal to the weighted average of inputs employed in subgroups relatively to its utilization in industry. Aiming at a more intuitive interpretation of the leadership test, it can be noticed in Figure 3 that if $\mu_g \geq 1$ then, the *g-th* subgroup isoquant will be closer to the origin in relation to the industry isoquant, which implies that subgroup *g* uses proportionally less inputs (normalized) than industry does, and, therefore, it establishes the industry technological standard.

3 SAMPLE DATA

The inputs and outputs considered according to the intermediation approach, were obtained from trial balance sheet 4010 of the Financial System Institutions Accounting Plan (COSIF) and monetarily updated for June 2003 by Getulio Vargas Foundation's General Price Index - Internal Availability (IGP-DI)[4].

The outputs which were considered as being of importance within the Brazilian financial industry context were: credit operations (excluded those of mercantile lease), investments in bonds and securities and incomes from rendering of services. The first two outputs are basically present on most of studies on financial industry which adopt the intermediation approach for output definition. As not all the banks in the sample displayed a mercantile lease portfolio, this kind of operation had to be left out[5].

Drake and Hall (2003) stress out that the choice of incomes from service rendering reflects the fact that, in general, banks have marginally diversified their transactions beyond the traditional products of financial intermediation, such as, for example, in the fees collection and in activities outside the range of balance sheet (consulting, collections, negotiation of securities, brokerage, etc).

The inclusion of fixed assets[6], on the side of productions factors, works as proxy for capital stock, a variable which is greatly employed in other studies concerning the efficient frontier analysis. It is expected for that the more is invested in machines, equipment and buildings, the greater it will also be the number of business generated by these, and therefore, the banking institution may become more efficient.

Unlike the studies performed by Sousa, Staub and Tabak (2003) and Campos (2002), the number of employees was not used in the current paper as a variable for two reasons. Some of the financial conglomerates which purchased banking institutions in the last decade and at the start of the current one adopted as policy either the dismissal of employees or their transference to the staff of the leading bank of the group. The studies which were quoted were not hindered by such limitation because they used different periods of analysis and sampling. Secondly, as Lozano-Vivas, Pastor and Pastor (2002) underlined, on including all management expenditures, it allows for the description of technical efficiency as operational efficiency.

In this paper the totality of financial resources collected through bank deposits was considered as a production factor. Campos (2002), Sousa, Staub and Tabak (2003) and Canhoto and Dermine (2003) consider cash deposits captured as a banking product, in the sense of a service rendered through the bank to its clients. Brazilian banking practice points out that a percentage of the average of the daily cash deposit balances is actually set towards loans, operating in the case more like an input than as a output.

The choice of financial institutions submitted to analysis was based on the 50 Major Banks report by asset as published Brazil Central Bank. In June 2003, the Bank Consolidated I displayed 112 banking conglomerates and/or independent banking institutions. In what regards this potential banks sample it is required to make a relevant note. Should the current study interest lie in the Brazilian banks technical efficiency analysis, it would be quite possible to employ a non-balanced panel data. However, as this study will use the total product index of Malmquist, the adoption of a balanced panel data will become necessary.

This demand submits the current study to two kinds of criticism. The first is connected with the bias for the sampling selection, as the banks which stopped operating within the period under analysis probably were less efficient than those which kept operating as far as June 2003. Secondly, to undertake the separation of the banks within the three subgroups by major stockholders origin, it was taken into account the bank status in June 2003, leaving aside the changes in stockholding control occurred between the first semester of 1995 and that date[7]. Finally, the sample comprises 87 commercial and multiple banks which are described in Annex 1, whose control was of domestic private (43 banks), foreign (30 banks) or public (14 banks) origin.

[4] The data above was supplied by the Financial System Management department of Brazil Central Bank.

[5] Some banks in the sampling undertaken mercantile lease carried out through companies under their control whose accounting is posted in the consolidated balance sheet and not in trial balance sheet 4010.

[6] Within the accounting fixed asset is to be found among others: real state property for use, machine and equipment, buildings, etc.

[7] On account of the requirement to posses a balanced panel 26 banks which were not operating at the start of 1995 were eliminated. Moreover, 28 banks were left out of the analysis as they presented a value equal to zero in relation to either one of the products or one of the production factors chosen for the DEA calculation. Finally, four institutions in the sampling were excluded due to the fact that they presented a balance sheet structure completely different from the remaining institutions.

These banks participation in the total of assets of the National Financial System corresponded at the time to approximately 80%.

4 Results and Analysis

4.1 Technical Efficiency

This section is started with the analysis of Technical Efficiency (TE) and its decompositions on pure technical efficiency (PTE) and scale efficiency (SE) calculated through DEA methodology.

Table 1 displays TE, PTE and SE arithmetical average for all the banks in the sample to each period. TE, PTE and SE means from the whole of the period, were, respectively, equal to 0,703, 0,823 and 0,854. One value for TE of 0,703 (or 70,3%) signifies on average that the Brazilian banking industry could have expanded its product in 29,7% employing for that purpose the same quantity of inputs. This same reasoning applies to PTE and SE.

A priori, it would have been expected that, in a more competitive environment with the entry of new foreign banks it would have occurred gains in TE terms, according to the hypothesis put forward at the beginning of this work. However, between the first semester of 1995 and 2003, data shows that Brazil's banking industry presented a TE drop (from 0,695 to 0,670) of approximately 3,6%. Berger and Humphrey (1997) stated that the prevailing conditions in the banking industry prior to the deregulation period, may account for these non-expected results, which likewise were verified in banking efficiency studies in other countries.

However, when the scale effect is discarded, PTE, a measure employed to calculate efficiency in the production factors' use, presents a 3,13% gain within the same period. Therefore, this point out that the TE drop was caused by the SE worsening, thus making the Brazilian banking industry to be kept away from the production optimum scale level.

Therefore, these results are in opposition to the initially held hypothesis that forecast an improvement on the technical efficiency components. Actually, only PTE displayed a positive variation.

Table 1: Values of TE, PTE and SE of Brazilian banking industry

Period	TE	PTE	SE
1º/1995	0,695	0,798	0,871
2º/1995	0,752	0,812	0,927
1º/1996	0,704	0,829	0,850
2º/1996	0,708	0,842	0,841
1º/1997	0,731	0,821	0,890
2º/1997	0,754	0,838	0,900
1º/1998	0,757	0,843	0,897
2º/1998	0,669	0,785	0,852
1º/1999	0,693	0,786	0,882
2º/1999	0,731	0,843	0,867
1º/2000	0,653	0,833	0,784
2º/2000	0,780	0,879	0,887
1º/2001	0,680	0,821	0,828
2º/2001	0,657	0,812	0,810
1º/2002	0,631	0,810	0,779
2º/2002	0,685	0,815	0,841
2º/2003	0,670	0,823	0,814
Average Values			
Period	TE	PTE	SE
1º/1995 - 1º/2003	0,703	0,823	0,854
Period	ET	PTE	SE
1º/1995 - 2º/1998	0,721	0,821	0,879
1º/1999 - 1º/2003	0,687	0,825	0,832

Source: authors estimates

Campos (2002) obtained similar results for the Brazilian private banks in the years ranging from 1994 and 1999. In this period, there occurred a 1% reduction on the TE index, although PTE presented a 0,6% improvement. Therefore, the reduction on the SE was the overwhelming factor on the TE's global worsening.

On its turn, Nakane (1999), in terms of average, observed that Brazilian banks were more efficient in scale terms (73,8%) than in PTE terms (61,9%). Although our results corroborate this same order on technical efficiencies, there occurs, here, a greater equilibrium between SE and PTE, whose means were 0,854 and 0,823, respectively

According to Bos and Schmiedel (2003), scale inefficiencies and scope in the European and North American banking industry are equivalent, on average, to approximately 5% and are considered less important than the pure technical inefficiencies which are located on the average between 20% and 25%. If we consider that this international standard should be applicable to Brazil, the conclusion is that there are still adjustments to be undertaken on the SE of Brazilian banking industry.

Since that from the first semester of 1999, there occurred a change in the Brazilian exchange rate to the adoption of a floating exchange rate and with that a relative prices shift, analysis were carried out to see if this fact had any implication on the banking industry efficiency. For that purpose, the sample period was divided in two subperiods: from the first semester of 1995 up to the second semester of 1998 and from the following semester up to the second semester of 2005. The results for TE, SE and PTE are also displayed in Table 1.

This division disclosed a slight improvement on the PTE average, which increased from 0,821 to 0,824, and a worsening of SE, which dropped from 0,878 to 0,833. The effect of these on TE is that this presented a fall on the average from 0,721 to 0,687. In short, these results seem to evidence that the change in the Brazilian exchange rate caused a TE loss in the order of 4,7% and a loss of SE of 5,12%.

Table 2 displays as TEs, TPEs and SEs per subgroup of banks (domestic private and public, and foreign private) of Brazilian industry. The source of the data in Table 2 stems from Table 1 through the grouping of the individual means of TEs, of PTEs and SEs of each bank in its respective subgroup.

Tabela 2: Values of TE, PTE and SE of Brazilian banking industry by subgroup

	Banks								
	Publics			Domestic Privates			Foreings		
Period	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
1º/1995	0,748	0,880	0,850	0,720	0,813	0,885	0,621	0,724	0,858
2º/1995	0,747	0,859	0,873	0,760	0,807	0,942	0,742	0,795	0,934
1º/1996	0,702	0,864	0,813	0,743	0,861	0,863	0,637	0,752	0,847
2º/1996	0,680	0,858	0,793	0,755	0,884	0,854	0,641	0,758	0,846
1º/1997	0,676	0,803	0,842	0,776	0,857	0,905	0,681	0,766	0,889
2º/1997	0,622	0,712	0,874	0,806	0,900	0,896	0,738	0,801	0,922
1º/1998	0,678	0,774	0,876	0,815	0,892	0,914	0,698	0,798	0,875
2º/1998	0,677	0,748	0,905	0,692	0,836	0,828	0,623	0,717	0,868
1º/1999	0,712	0,804	0,886	0,712	0,805	0,884	0,649	0,742	0,874
2º/1999	0,761	0,861	0,884	0,758	0,868	0,873	0,665	0,787	0,845
1º/2000	0,600	0,771	0,777	0,696	0,866	0,804	0,607	0,811	0,748
2º/2000	0,749	0,842	0,889	0,815	0,912	0,894	0,735	0,841	0,873
1º/2001	0,630	0,773	0,815	0,706	0,846	0,835	0,661	0,803	0,824
2º/2001	0,470	0,668	0,706	0,701	0,841	0,833	0,689	0,844	0,816
1º/2002	0,450	0,690	0,651	0,686	0,837	0,820	0,639	0,832	0,768
2º/2002	0,564	0,716	0,788	0,733	0,843	0,869	0,671	0,821	0,817
2º/2003	0,566	0,713	0,793	0,719	0,871	0,825	0,643	0,799	0,805
Average Values									
Period	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
1º/1995 – 1º/2003	0,649	0,784	0,824	0,741	0,855	0,866	0,667	0,788	0,848
Period	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
1º/1995 – 2º/1998	0,691	0,812	0,853	0,758	0,856	0,886	0,673	0,764	0,880
1º/1999 – 1º/2003	0,611	0,760	0,799	0,725	0,854	0,849	0,662	0,809	0,819

Source: authors estimate

Data displayed on Table 2 show that the domestic private banks are, on average, the most efficient, followed by foreign banks and public banks, as they present, for the whole period, values for TE of 0,741, 0,667 and 0,649, respectively.

As to TE variation between the initial (1st /1995) and final (2nd /2003) period the foreign banks were the only subgroup that presented a positive TE variation (0,621 to 0,643) of 3,54%. Contrary to that, public banks presented the worst performance on TE terms, as this decreased from 0,748 to 0,566, with a negative variation of 24,3%. As for the TE of domestic private banks, it showed a slight fall of 0,14%.

In relation to the two sub-periods, TEs of the three subgroups of banks presented drops. Within the three subgroups, the public banks presented, remarkably, the greatest drop.

The foreign banks were the only ones to present an improvement in the PTE (5,9%), on the average comparison between the two sub-periods. On the other hand, the public banks as well as the domestic private banks presented a worsening in the PTE, it being that the former displayed a greater negative variation (6,5%). In relation to SE, none of the three subgroups presented gains.

In this sense, the change in the exchange rate as from 1999 seems to have negatively affected the operation of the foreign banks, domestic private and public banks in what concerns TE and SE. On the other hand, the foreign banks subgroup was the only subgroup to obtain PTE gains.

4.2 Malmquist Total Productivity Index

According to subsection 2.2, TFP index of Malmquist may be decomposed on the TEFFCH and TECHCH. This procedure allows to distinguish the contribution of each one of these components in the total productivity gains of the productive units. On addition, from the expression (8), the TEFFCH index may also be decomposed in PTEFFCH and SEFFCH.

Table 3 displays the accumulated geometric average for all indexes calculated from expression (7) and (8).

The factors total productivity presented a positive variation of 50% in the period, confirming the hypothesis presented at the beginning of the current study that the changes implemented by the federal government from 1995 assisted on creating an adequate environment for the Brazilian banking industry. These productivity gains were only explained by TECHCH as, while this latter presented a growth of 58,4%, TECHCH decreased 5,3%.

Table 3: Acumulate average changes of TEFFCH, PTEFFCH, TECHCH and TFPCH for Brazilian banking industry

Period	TEFFCH	PTEFFCH	SEFFCH	TECHCH	TFPCH
1°/1995 - 1°/1995	1,000	1,000	1,000	1,000	1,000
1°/1995 - 2°/1995	1,092	1,021	1,069	0,941	1,028
1°/1995 - 1°/1996	1,014	1,042	0,973	1,103	1,118
1°/1995 - 2°/1996	1,029	1,072	0,960	1,181	1,215
1°/1995 - 1°/1997	1,064	1,038	1,025	1,120	1,192
1°/1995 - 2°/1997	1,094	1,053	1,040	1,055	1,155
1°/1995 - 1°/1998	1,100	1,065	1,033	1,058	1,164
1°/1995 - 2°/1998	0,960	0,986	0,974	1,285	1,233
1°/1995 - 1°/1999	1,004	0,987	1,017	1,255	1,161
1°/1995 - 2°/1999	1,036	1,065	0,973	1,208	1,252
1°/1995 - 1°/2000	0,928	1,049	0,884	1,455	1,350
1°/1995 - 2°/2000	1,139	1,118	1,019	1,223	1,393
1°/1995 - 1°/2001	0,956	1,027	0,931	1,482	1,416
1°/1995 - 2°/2001	0,928	1,014	0,915	1,644	1,526
1°/1995 - 1°/2002	0,880	1,004	0,876	1,722	1,515
1°/1995 - 2°/2002	0,975	1,020	0,956	1,500	1,462
1°/1995 - 1°/2003	0,947	1,027	0,922	1,584	1,500

Source: authors estimate

A result alike this one was obtained by Campos (2002) in his analysis on Brazilian private banks. Between the years of 1995 and 1999, this group obtained a technological progess growth of 30,5%. These results were expected up to a point, taking into consideration that the past decade was highlighted by great investment on technology, both on the side of the private and foreign banks, as well as on the public banks.

The decrease of 5,3% of TEFFCH was explained by the SEFFCH drop of 7,8% that more than made up for the PTEFFCH growth of 2,7%. Notice that these results ratify the conclusions from the previous section, and in this sense it may be stated that Malmquist productivity index stands for the "dynamics" of the process.

Therefore, in PTEFFCH, Brazilian banking industry was efficient in its use of production factors; however the scale inefficiency more than decompensated these results, what caused an increase in the general inefficiency of the Brazilian banking system.

The international experience in other emerging economies shows that, in fact, the impacts of financial deregulation on banking efficiency are distinctive. The paper of Canhoto and Dermine (2003), which analyzed the impact caused by the entry of new banks in the banking system of Portugal, obtained qualitative results similar to those of this current study. As for the paper of Isik and Hassan (2003), on the financial deregulation of the banking industry of Turkey, displayed results opposite to those presented by Brazilian industry.

Tables 4, 5 and 6 presents the same indexes per banks subgroups. According to tables (4) and (5), the factors of total productivity of foreign and doemstic private banks increased significantly in the period. The former presented gains of total productivity of 85,7% that were explained much more by the TECHCH (78,8%) than by the TEFFCH (3,8%). As for the latter, they obtained productivity gains of 49,2% that were explained solely by the increase of 50,7% of TECHCH since the TEFFCH dropped 1%.

The worst performance, according to table (6), was those of public banks as, although they have obtained productivity gains of 5,9%, explained only by the increase of 50,2% of TC, this result is significantly lower when compared to those of the other subgroups.

Table 4: Accumulate average changes of TEFFCH, PTEFFCH, SEFFCH, TECHCH and TFPCH: Foreing banks

Period	TEFFCH	PTEFFCH	SEFFCH	TECHCH	TFPCH
1°/1995 - 1°/1995	1,000	1,000	1,000	1,000	1,000
1°/1995 - 2°/1995	1,205	0,839	1,117	1,079	1,100
1°/1995 - 1°/1996	1,014	1,146	1,035	0,980	1,162
1°/1995 - 2°/1996	1,033	1,255	1,066	0,969	1,297
1°/1995 - 1°/1997	1,096	1,180	1,072	1,023	1,294
1°/1995 - 2°/1997	1,202	1,109	1,124	1,069	1,334
1°/1995 - 1°/1998	1,150	1,135	1,142	1,007	1,306
1°/1995 - 2°/1998	1,015	1,369	1,026	0,990	1,390
1°/1995 - 1°/1999	1,058	1,399	1,043	1,014	1,480
1°/1995 - 2°/1999	1,089	1,347	1,112	0,979	1,467
1°/1995 - 1°/2000	0,985	1,641	1,143	0,862	1,617
1°/1995 - 2°/2000	1,188	1,391	1,181	1,006	1,653
1°/1995 - 1°/2001	1,035	1,669	1,102	0,939	1,727
1°/1995 - 2°/2001	1,111	1,835	1,204	0,923	2,039
1°/1995 - 1°/2002	0,990	1,995	1,155	0,857	1,976
1°/1995 - 2°/2002	1,083	1,720	1,162	0,932	1,863
1°/1995 - 1°/2003	1,038	1,788	1,134	0,916	1,857

Source: authors estimate

The foreign banks were the only group to obtain accumulated gain on TEFFCH of 3,8% (Table 4), while the domestic private and public banks presented losses of 1% (Table 5) and 2,9% (Table 6), respectively. The foreign banks TEFFCH decomposition in PTEFFCH and SEFFCH, shows that the PTEFFCH, with an increase of 13,4%, was the only one to contribute to this result as SEFFCH dropped 8,4%.

Table 5: Accumulate average changes of TEFFCH, PTEFFCH, SEFFCH, TECHCH and TFPCH: Domestic private banks

Period	TEFFCH	PTEFFCH	SEFFCH	TECHCH	TFPCH
1°/1995 - 1°/1995	1,000	1,000	1,000	1,000	1,000
1°/1995 - 2°/1995	1,066	0,983	0,989	1,078	1,048
1°/1995 - 1°/1996	1,042	1,079	1,067	0,977	1,125
1°/1995 - 2°/1996	1,073	1,157	1,107	0,969	1,241
1°/1995 - 1°/1997	1,112	1,100	1,071	1,038	1,224
1°/1995 - 2°/1997	1,157	1,051	1,129	1,024	1,216
1°/1995 - 1°/1998	1,160	1,071	1,112	1,044	1,243
1°/1995 - 2°/1998	0,965	1,312	1,027	0,940	1,266
1°/1995 - 1°/1999	0,997	1,253	0,987	1,011	1,250
1°/1995 - 2°/1999	1,010	1,209	1,066	0,948	1,220
1°/1995 - 1°/2000	0,950	1,443	1,069	0,888	1,371
1°/1995 - 2°/2000	1,157	1,230	1,140	1,015	1,423
1°/1995 - 1°/2001	0,961	1,504	1,049	0,916	1,445
1°/1995 - 2°/2001	0,971	1,572	1,043	0,930	1,526
1°/1995 - 1°/2002	0,948	1,601	1,036	0,915	1,517
1°/1995 - 2°/2002	1,011	1,458	1,035	0,978	1,475
1°/1995 - 1°/2003	0,990	1,507	1,072	0,924	1,492

Source: authors estimate

In terms of TECHCH, all groups presented technological gains. The foreign banks obtained technological gains of 78,8% (Table 4), followed by the domestic private banks (50,7%) (Table 5) and public banks (50,2) (Table 5), respectively. This results reflects the high investments on technology undertaken by the foreign banks during the past decade and the beginning of the current decade.

Table 6: Accumulate average changes of TEFFCH, PTEFFCH, SEFFCH, TECHCH and TFPCH: Public banks

Period	TEFFCH	PTEFFCH	SEFFCH	TECHCH	TFPCH
1°/1995 - 1°/1995	1,000	1,000	1,000	1,000	1,000
1°/1995 - 2°/1995	0,991	1,004	0,964	1,029	0,996
1°/1995 - 1°/1996	0,929	1,107	0,979	0,949	1,028
1°/1995 - 2°/1996	0,900	1,132	0,979	0,919	1,019
1°/1995 - 1°/1997	0,881	1,083	0,893	0,987	0,954
1°/1995 - 2°/1997	0,786	0,978	0,757	1,039	0,769
1°/1995 - 1°/1998	0,865	0,901	0,829	1,043	0,780
1°/1995 - 2°/1998	0,858	1,078	0,811	1,058	0,926
1°/1995 - 1°/1999	0,938	1,049	0,899	1,043	0,984
1°/1995 - 2°/1999	1,029	1,002	0,986	1,043	1,030
1°/1995 - 1°/2000	0,780	1,214	0,856	0,910	0,947
1°/1995 - 2°/2000	1,010	0,962	0,957	1,055	0,972
1°/1995 - 1°/2001	0,820	1,157	0,851	0,963	0,948
1°/1995 - 2°/2001	0,594	1,561	0,691	0,860	0,927
1°/1995 - 1°/2002	0,571	1,675	0,717	0,796	0,957
1°/1995 - 2°/2002	0,728	1,293	0,780	0,932	0,941
1°/1995 - 1°/2003	0,705	1,502	0,762	0,925	1,059

Source: authors estimate

5 THE TECHNOLOGICAL LEADERSHIP TEST

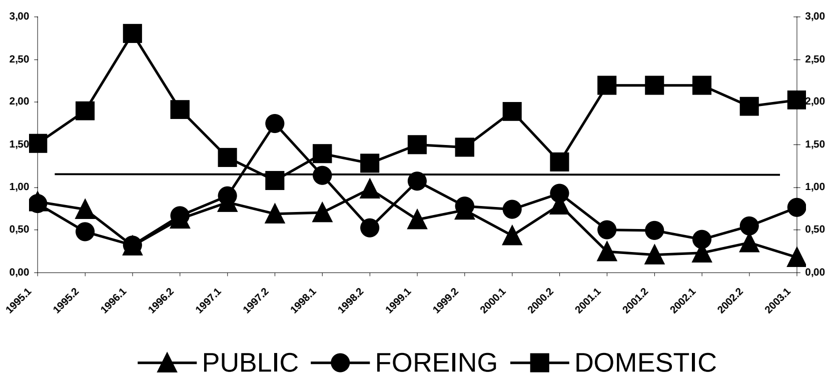
This section uses propositions 1 and 2, presented in subsection 2.4, to verify which of the banks subgroups determined the technological frontier of the banking industry in Brazil.

For the calculation of the aggregate technical efficiency, Färe and Zelenyuk´s (2003) theorem is valid only for an environment with several factors of production and a single product. For such purpose, was calculated, the arithmetic mean of the investments in bounds and securities , credit operations and service's incomes, weighted by its respective participations. Through this procedure a single product is obtained, thus allowing the application of the said theorem. The application of propositions 1 and 2, considering the seventeen periods that comprise the sample, produces the results of the technological leadership test which are: Public Banks = 0,901, Foreing Banks = 0,923 and Domestic Private Banks = 0,726.

In these terms, as $\mu_g \geq 1$ is for subgroup of domestic private banks, this subgroup defines the technological frontier of the Brazilian banking industry. On the other hand, the subgroups of foreign banks and public banks display technological gaps as the results of their tests were lower than one. However, as the foreign banks test value ($\mu_g = 0.923$) was greater than that of public banks ($\mu_g = 0.901$), the former presented themselves as technologically more advanced than these latter ones

Next, this same test is undertaken for each period of time of the sample. Figure 4, shows the trajectories of the technological leadership test for the several subgroups of banks. It can be seen in this figure that along the whole period, the domestic private banks defined the technological standard of Brazil's banking industry except for the second semester of 1997 when the foreign banks technologically overcame the domestic private banks. The worst performance belongs to the public banks as their trajectories are always lower than the other subgroups of banks.

Figure 4: Trajetories of Technological Leadership Test



6 Summary and Conclusion

The hypothesis formulated initially stated that the measures implemented by the federal government, along the past decade, especially the financial liberalization with a greater participation of foreign capital in the National Financial System, would imply in advantages in relation to productivity and efficiency of the Brazilian banking industry.

However, evidences have shown that the TE decreased along the period on observation. On its turn, when the effects to scale are not considered, there occurs a PTE growth, which shows that the TE drop was caused by the worsening of SE.

The analysis undertaken by subgroups of banks has shown that in TE terms, the domestic private banks were, on average, the most efficient followed by the foreign and public banks. However, when the variation between the first and last period of the sample is compared, the foreign banks were the only ones to present a positive variation. The public banks displayed the worst performance.

The change on the exchange rate policy from the first semester of 1999, from fixed to flexible exchange rate, seems to have caused a TE drop of all banks operating in Brazil. This result occurred due to the SE drop having more than offset the PTE growth. When the subgroups of banks are considered, only the foreign banks presented PTE gains.

In relation to total productivity, the Brazilian banking industry presented significant gains. This productivity growth was explained exclusively by TECHCH. In fact, the TECHCH increase more than compensated the TEFFCH drop, thus, causing the occurrence of total productivity growth. This evidence reflects the intense investments in technology undertaken by the banking industry from the second half of the 90s. The TEFFCH decrease occurred owing to the diminishing of SEFFCH that more than compensated for the increase in PTEFFCH. The banking industry was efficient in the use of production factors; however, the inefficiency to scale, more than overcame the positive variation of PTEFFCH what implied in the growth of the general inefficiency.

Actually regarding banks subgroups, the foreign banks were by far the ones that most presented total productivity earnings. Although far from the foreign banks subgroup, the domestic private banks also presented an outstanding performance, while the public banks, even though with positive productivity earnings displayed a performance much lower then expected in relation to the other subgroups.

The technological leadership test showed that the domestic private banks determined the industry technological standard for most of the sampling period. On the other hand, the foreign and public banks presented a technological gap. However, the foreign banks' performance was on average higher than that of public banks. Although apparent, there is no antagonism between the TECHCH results and the technological leadership test in what concerns the foreign banks. As a matter of fact, the good performance in relation to TECHCH and the technological gap in relation to the domestic private banks, suggested by the technological leadership test, indicates that foreign banks, when starting their activities, were faced with the need to invest proportionally more in technology than the domestic private banks did, since they presented inadequate technological standards in relation to the banking industry currently installed.

Summarizing, the government policy in the financial liberalization with a greater participation of foreign capital on the National Financial System has failed to reach its objectives in terms of technical efficiency. However, this policy has influenced positively the industry's total productivity. In this sense, the opening for the installation of new foreign banks in Brazil has contributed to a significant growth of productivity on the Brazilian banking industry.

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