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Bank Privatization and Productivity: Evidence for Brazil*

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Abstract

Over the last decade, the Brazilian banking industry has undergone major and deep transformations with several privatizations of state-owned banks, mergers and acquisitions, closing down of troubled banks, entry by foreign banks, etc. The purpose of this paper is to evaluate the impacts of these changes in banking total factor productivity. We first obtain measures of bank level productivity by employing the techniques due to Levinsohn and Petrin (2003). We then relate such measures to a set of bank characteristics. Our main results indicate that state-owned banks are less productive than their private peers, and that privatization has increased productivity.

Keywords: bank privatization, total factor productivity, Brazilian banking
JEL Classification: G21, L33, O54

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1. Introduction

The banking system in Brazil is the largest and the most complex one in Latin America. Like in many parts of the world, the banking industry in Brazil is undergoing a process of rapid and radical transformations. The common features of this process, in Brazil and elsewhere, include: an increase in competition from within the industry as well as from the outside; a wave of merger and acquisition (M&A) activities, including several cross-border deals; more globalized capital markets with highly volatile capital flows, which are capable of causing havoc in some national financial sectors; new financial products, with increasing reliance on off-balance sheet activities; new banking practices brought out by the information technology revolution.

The banking sector in Brazil has been strongly influenced by the changing domestic macroeconomic scene of the recent period, especially by the transition from a high to a low inflation environment. After many years of making a living out of inflationary rents, this transition was far from smooth for many banks.

Amongst those most affected by the many changes in the industry were the state-owned banks. Due to their poor performance, many of the state-owned banks in Brazil were either closed down or privatized. Less than half (14) of the 32 state-owned banks operating in the country by 1994 were still active by 2002.

The Brazilian experience represents an interesting case study on bank privatization not only because of its quantitative relevance but also due to the varied options given to the state-owned banks following their restructuring. Thus, some state-owned banks were straight privatized by their controllers (namely, the Brazilian states) whereas some others had their control first transferred from the states to the federal government and then privatized. Some other states also kept the control of their banks after restructuring. There are also some other state-owned banks that were just liquidated.

The purpose of this paper is to study the impact of the privatization of state-owned banks on productivity. Measures of bank-level total factor productivity are first obtained as the residuals from a production function estimate. The production function is estimated following the methodology suggested by Levinsohn and Petrin (2003) to

try to control for endogeneity problems arising from the simultaneous choice of inputs and productivity by the bank firm.

In a second stage, bank total factor productivity is related to a set of control variables. In an environment where many different types of corporate control changes are occurring simultaneously, it is important to try to control for as many of them as possible even though the primary interest of the paper lies on the effects of bank privatization. This is certainly the case for Brazil whereby privatization of state-owned banks were taking place alongside other corporate changes in the industry like domestic mergers and acquisitions, foreign acquisition of domestic banks, liquidation of banks, and pure exit from the market. We therefore follow the methodology proposed by Berger *et al*. (2003) and include variables controlling for static, selection, and dynamic effects. Static variables are dummies for groups of banks that have not had any corporate change over the sample period. Selection variables are dummies for groups of banks that have had some corporate change over the sample period. Such dummy variables are equal to one over the *whole* sample period for the corresponding banks. Dynamic variables are of two forms. A first set of dynamic variables are dummies for those banks that have had some corporate change over the sample period taking the value one only for the time periods following the change. A second set of dynamic variables track the number of time periods following the change. In addition to the static, selection, and dynamic variables we also included a set of dummy variables for those banks that have exited the market. Exit can occur either because the bank has been liquidated or because the bank has changed the nature of its activities.

Our main results show that state-owned banks are less productive than private-owned ones. Another main result of the paper is that privatization has had a positive impact on productivity. Moreover, the positive effects of privatization seem to take some time to materialize. Privatization proved also to be a superior strategy than restructuring and keeping the bank under state control. On the other hand, we could not find any strong performance differences related to the way a state-owned bank was privatized (i.e., straight privatization or federalization followed by privatization). We find no strong differences in the performances of the state-owned banks sold to foreign ones *vis a vis* state-owned banks sold to domestic ones either.

This paper contributes to the literature on bank productivity. The study of bank productivity is relevant because productivity is a summary performance measure. Thus, productivity analysis may be relevant to those involved in bank M&A issues, like bank practitioners or bank competition authorities. Also, to the extent that low productivity can work as an early warning, bank supervision authorities may use productivity measures as an additional monitoring instrument. Bank productivity studies are also useful due to the well-documented evidence that a bank system that efficiently channels available resources to productive uses is a powerful mechanism for economic growth [Levine (1997)].

This paper is also related to the literature on bank privatization. The empirical literature in this area takes the form of either cross-country studies or analyses of individual countries.[1] This literature provides broad support to the conclusions reached in this paper on the poorer performance of state-owned banks and on the beneficial impacts of bank privatization.

This paper is structured as follows. Section 2 gives a brief overview of the banking industry in Brazil, with a special emphasis on the state-owned sector. Section 3 describes the methodology to be applied in the empirical sections. Section 4 discusses data-related issues. Section 5 estimates the coefficients of a production function, from which the bank-level productivity measures are calculated. Section 6 studies the determinants of bank productivity, highlighting the role played by bank privatization. Section 7 concludes the paper.

2. Overview of the banking sector in Brazil

The launching of the stabilization plan, called the *Real Plan*, in July 1994 with the subsequent transition to an environment of more stable prices proved to be very costly to the Brazilian banks. During the high-inflation period, banks could profit from inflation transfers. Inflation imposes a tax over the holders of money and non-interest

[1] Boehmer *et al*. (2003), Bonin *et al*. (2003), Otchere (2003), and Nguyen and Williams (2003) are examples of cross-country studies. Some studies focusing on individual countries are, among others, Berger *et al*. (2003) for Argentina, Beck, Crivelli, and Summerhill (2003) for Brazil, Beck, Cull, and Jerome (2003) for Nigeria, Haber and Kantor (2003) for Mexico, Omran (2003) for Egypt, and

bearing deposits. As issuers of demand deposits, commercial banks receive part of the inflation tax. According to ANDIMA-IBGE (1997), the inflationary transfers to the banking system fell from an average of 3.4% of GDP in the 1990-93 period to 1.8% in 1994, and to 0.03% in 1995.

In the immediate aftermath of the stabilization plan, Brazilian banks tried to make up for the inflationary losses by increasing credit. Total loans of the financial system went up 43.7% after the first eight months of the stabilization plan. The rapid increase in the concession of loans was not followed by a careful consideration of the risk characteristics of those seeking credit. When the Central Bank dramatically increased the reserve requirements on deposits in the second half of 1994, coupled with the continuation of a policy of high interest rates, a credit retrenchment followed. Non-performing loans started to accumulate fast.

With the imminent insolvency of some big private banks[2] a bailout mechanism was put in place in November 1995[3]. Under this program, the Central Bank was given the mandate to compel a fragile bank to: a) increase its capital, or b) to transfer its shareholder control, or c) to be merged or acquired by another bank. PROER made easier for stronger financial institutions to acquire weaker ones by allowing the acquiring financial institutions to record as a premium the difference between the acquisition value and the market value of the acquired institution. Non-performing loans were recognized as losses and, under certain conditions, the premium could be used as a tax credit. It also allowed forbearance in the form of a temporary waive of the Basle minimum capital requirement for the ailing participants. In order to reduce the moral hazard problems associated to bailout schemes, PROER set out that banks could only qualify for official help when the ownership control was agreed to be transferred to some other institution. Seven banking institutions were restructured under the PROER resources.

Bonaccorsi di Patti and Hardy (2003) for Pakistan. Megginson (2003) and Clarke *et al.* (2003) provide comprehensive surveys about bank privatization studies.

[2] In August 1995, Banco Economico, the eight largest in the country by net worth, fell under Central Bank intervention. In November 1995, the same fate hit Banco Nacional, the sixth largest in the country by net worth.

[3] Program of Incentives to the Restructuring and Strengthening of the National Financial System, PROER.

The PROER program only reached private banks. A similar program aiming at the state-owned banks was launched in August 1996, the PROES[4]. The aim of this program was not only to reduce the participation of the Brazilian states (provinces) in the banking activity but also to address their chronic public debt problems[5]. Debt restructuring packages were offered for those states who agreed to give one of the following destinations to their banks: a) to liquidate it; b) to privatize it; c) to transfer its control to the federal government for future privatization, or, d) to transform it in a development agency. Less favorable financial packages were also offered to those states that still wanted to keep their banks after bailing them out.

When PROES was launched, there were 35 financial institutions under the control of the Brazilian states, including 23 commercial banks. With the exception of the states of Mato Grosso do Sul, Tocantins (which had no financial institutions under their control), Paraíba, and Distrito Federal, all the other state units joined PROES. Under PROES, ten financial institutions were/are being liquidated, six banks were privatized by the states, six banks were/are being privatized by the federal government, sixteen financial institutions were transformed into development agencies, and five banks were restructured and kept under the state control[6].

PROES only reached the banks owned by the states. For the banks owned by the federal government, an official restructuring program was launched in June 2001, the PROEF[7]. Under this program, many troubled assets were transferred to a newly created institution under the Finance Ministry control. Three federal government-owned banks (CEF, BNB, and Basa) also received capital injection[8].

The whole set of measures put in place drastically changed the ownership composition of the banking sector in the country. Tables 1 to 5 document such changes along several dimensions.

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[4] Program of Incentives to the Reduction of the State-Level Public Sector in the Bank Activity. See also Baer and Nazmi (2000), and Ness Jr. (2000) for more details.

[5] The two problems were not unrelated: state-level banks were the main purchasers of the public bonds issued by their main shareholders, the states themselves. Werlang and Fraga Neto (1995) study the role of state-owned banks in the creation of public debt. Bevilaqua (2000) describes state debt developments from the mid-1980s onwards, with special emphasis on the 1997 state debt bailout.

[6] See Appendix 1 for a list of the liquidated and privatized banks.

[7] Program for the Strengthening of the Federal Financial Institutions.

[8] Banco do Brasil (BB), another federal government-owned bank, was capitalized by the Treasury back in 1995.

TABLE 1 Number of Commercial Banks by Ownership

Year	Private Domestic	Foreign Minority	Foreign Control	State Owned	TOTAL
1994	146	31	37	32	246
1995	142	32	36	32	242
1996	130	29	40	32	231
1997	119	26	45	27	217
1998	105	17	58	23	203
1999	96	12	67	19	194
2000	93	13	69	17	192
2001	82	14	70	16	182
2002	75	10	56	14	155

The number of commercial banks operating in Brazil has been reducing since 1994. There were 91 fewer banks working in the country in 2002 than in 1994. Apart from foreign controlled banks, all the other bank segments showed considerable reductions in their numbers. Even for foreign controlled banks, the year 2002 represented a reversal of the trend when, after many years of continuing expansion, their number showed a reduction.

TABLE 2: Share of bank system net worth by ownership

Year	Private Domestic	Control Foreign	State Owned
1993	48.47	7.32	44.21
1994	56.03	9.64	34.33
1995	49.93	13.27	36.80
1996	56.03	10.42	33.55
1997	52.64	14.51	32.85
1998	50.55	22.21	27.23
1999	47.55	25.93	26.53
2000	51.35	28.88	19.76
2001	52.19	31.35	16.45
2002	49.74	33.62	16.64

TABLE 3: Share of bank system assets by ownership

Year	Private Domestic	Foreign Control	State Owned
1993	40.72	8.36	50.92
1994	41.29	7.17	51.53
1995	39.25	8.41	52.34
1996	39.12	9.82	51.06
1997	36.90	12.87	50.24
1998	35.47	18.47	46.06
1999	33.33	23.34	43.33
2000	35.50	27.62	36.88
2001	37.55	30.13	32.32
2002	37.32	27.67	35.01

TABLE 4: Share of bank system deposits by ownership

Year	Private Domestic	Foreign Control	State Owned
1993	38.85	4.84	56.32
1994	39.41	4.59	56.00
1995	36.48	5.41	58.11
1996	34.18	4.37	61.45
1997	33.01	7.58	59.42
1998	33.28	15.23	51.49
1999	32.07	16.93	50.99
2000	34.28	21.36	44.36
2001	35.80	20.41	43.79
2002	37.16	20.13	42.71

TABLE 5: Share of bank system loans by ownership

Year	Private Domestic	Foreign Control	State Owned
1993	31.55	6.57	61.88
1994	35.47	5.20	59.34
1995	31.93	5.75	62.32
1996	32.91	8.70	58.39
1997	35.61	11.80	52.59
1998	31.26	15.02	53.72
1999	32.03	19.98	48.00
2000	34.96	25.48	39.56
2001	42.82	32.03	25.15
2002	40.45	30.48	29.07

Tables 2 to 5[9] show that private domestic banks managed to keep their share of the bank system net worth, assets, and deposits. This group of banks even increased their share of the bank system loans.

Foreign controlled banks increased significantly their market penetration in the country. In 2002, they accounted for 33.6% of the bank system net worth, 27.7% of the bank system assets, 20.1% of the bank system deposits, and 30.5% of the bank system loans.

Despite the great reduction in the importance of the state-owned banks, they still account for significant shares of the bank system net worth (16.6%), assets (35%), deposits (42.7%), and loans (29.1%).

3. Methodology

Productivity is defined as any variation in output that cannot be explained by variations in inputs. On this account, productivity changes can be due either to variations in efficiency or to changes in technology.

The methodology to be applied in this paper follows the approach developed by Olley and Pakes (1996). A panel data for Brazilian banks will be used with the aim of estimating the parameters of a production function. In usual fashion, productivity is measured as the residual from this relation.

Olley and Pakes' approach allows one to consistently estimate the production function coefficients taking into consideration two possible sources of bias, namely a sample selection and a simultaneity bias.

The sample selection bias refers to the fact that many banks left the market during the sample period. It is reasonable to imagine that the unobservable productivity variable and the decision to leave the market are correlated, causing a potential sample selection problem. The simultaneity problem is related to the correlation between the unobservable productivity variable and the amount of inputs chosen by the bank.

[9] In tables 2 to 5, the foreign minority group is incorporated into the private domestic group.

The authors deal with both problems by first modeling the optimal firm decision regarding both the use of inputs as well as the market exit/no exit. The solution to the firm control problem takes the form of an exit rule and an investment demand function, respectively given by:

$$\chi_t = \begin{cases} 1 & if\ \omega_t \geq \underline{\omega}_t(k_t) \\ 0 & otherwise \end{cases} \tag{1}$$

$$i_t = i_t(\omega_t, k_t) \tag{2}$$

where χ_t is an indicator function equal to zero when the firm exits the market, ω_t is the firm productivity index, k_t is the firm capital stock, i_t is the firm investment level, and $\underline{\omega}_t(.)$ and $i_t(.)$ are functions that are determined as part of the Nash Markov perfect equilibrium of the firm optimization problem.

The procedure to be adopted in the estimation can be illustrated taking the example of a Cobb-Douglas production function:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \eta_{it} \tag{3}$$

where y_{it} is the log of the output of firm i in period t, k_{it} is the log of its capital stock, l_{it} is the log of its labor input, ω_{it} is its productivity, and η_{it} is an error stochastic term. Notice that both ω and η are not observed by the econometrician. The difference between them is that ω is a state variable in the firm decision problem and therefore it affects both the exit decision as well as the demand for inputs, while η has no such implications.

Olley and Pakes propose a three-step procedure to estimate the coefficients of (3) taking into consideration the sample selection and the simultaneity problems. In order to implement the first step, the inversion of (2), which is strictly increasing in ω, allows one to write:

$$\omega_t = h_t(i_t, k_t) \tag{4}$$

Equation (4) expresses the unobserved productivity variable as a function of observable variables. By replacing (4) in (3) it is possible therefore to control for ω in the estimation:

$$y_{it} = \beta_l l_{it} + \phi_t(i_{it}, k_{it}) + \eta_{it} \tag{5}$$

where:

$$\phi_t(i_{it}, k_{it}) \equiv \beta_0 + \beta_k k_{it} + h_t(i_{it}, k_{it}) \tag{6}$$

The "partially linear" model (5)-(6) is a semiparametric regression model. The first step in the estimation allows the identification of the variable input coefficient β_l, but it does not allow the identification of the fixed input coefficient β_k. That is, the estimation of (5)-(6) does not allow one to separate the effect of capital on output from the effect on the investment decision.

The second step involves the determination of the survival probability. After replacing (4) in (1), it is possible to express the survival probability as a function of observable variables only:

$$\text{Prob}\left[\chi_{t+1} = 1 \middle| \underline{\omega}_{t+1}(k_{t+1}), J_t\right] = P_t(i_t, k_t) \equiv P_t \tag{7}$$

where J_t is the information set available at *t*. Equation (7) can be alternatively estimated by probit/logit, where polynomial terms of i_t and k_t are used as regressors, or by non parametric methods.

The third step in the estimation begins with the assumption that productivity follows a first-order Markov process:

$$\omega_{t+1} = E\left[\omega_{t+1} \middle| \omega_t, \chi_{t+1} = 1\right] + \xi_{t+1} = g(\underline{\omega}_{t+1}, \omega_t) + \xi_{t+1} = g(P_t, \phi_t - \beta_k k_t) + \xi_{t+1} \tag{8}$$

where ξ_{t+1} is the innovation in ω_{t+1}.

By making use of the previous results, it is possible to show that $y_{t+1} - \beta_l l_{t+1}$ can be written in regression form as:

$$y_{t+1} - \beta_l l_{t+1} = \beta_k k_{t+1} + g(P_t, \phi_t - \beta_k k_t) + \xi_{t+1} + \eta_{t+1} \tag{9}$$

Since it is assumed that the capital stock in a given period is known at the beginning of the period, it then follows that ξ_{t+1} and k_{t+1} are independent variables, which makes possible the consistent estimation of β_k in (9). However, since ξ_{t+1} and l_{t+1} are not independent variables, one can see the need for the first step estimation.

Levinsohn and Petrin (2003) introduced an important improvement in the Olley and Pakes' methodology by making use of an intermediate input instead of investment as a proxy variable for the productivity. Investment can only work as a valid proxy if it does not take zero values, which can be a very restrictive condition for the data sets typically found in developing countries.

Levinsohn and Petrin also argue that the monotonicity condition required for the inversion of (2) may not be valid due to capital adjustment costs. The monotonicity condition for investment is then replaced by an equivalent requirement for the intermediate input function $\tau_t = \tau_t(\omega_t, k_t)$. Another requirement for the use of the intermediate input as a proxy for productivity is an assumption of competitive market. The indexation of the $\tau(.)$ function by *t* allows for temporal changes in prices although variation across firms is not allowed.

The methodology advanced by Levinsohn and Petrin does not require separability of all intermediate inputs in the production function. It is required that only one intermediate input be separable such that its isolated contribution to output can be computed. The authors choose electricity as the productivity proxy on the account that all firms need such input. Moreover, in their sample, there was no firm producing or selling electricity, which can be interpreted as an impossibility for storing such input, making it highly correlated with contemporaneous productivity levels.

The previous equations can then be adapted to the Levinsohn and Petrin extension:

$$\omega_t = h_t(e_t, k_t) \tag{10}$$

$$y_{it} = \beta_l l_{it} + \varphi_t(e_{it}, k_{it}) + \eta_{it} \tag{11}$$

where e_{it} is electricity, and

$$\varphi_t(e_{it}, k_{it}) \equiv \beta_0 + \beta_e e_{it} + \beta_k k_{it} + h_t(e_{it}, k_{it}) \tag{12}$$

Under the assumption that productivity follows a first-order Markov process, one obtains:

$$\omega_{it} = E[\omega_{it} | \omega_{it-1}] = g(\omega_{it-1}) = g[h_{t-1}(e_{it-1}, k_{it-1})] \tag{13}$$

Lagging (12) one period, replacing in (13), and replacing the result in (11), one obtains:

$$\begin{aligned} y_{it} - \beta_l l_{it} &= \beta_0 + \beta_e e_{it} + \beta_k k_{it} + h_t(e_{it}, k_{it}) + \eta_{it} = \beta_0 + \beta_e e_{it} + \\ &+ \beta_k k_{it} + g[\varphi_{t-1}(e_{it-1}, k_{it-1}) - \beta_0 - \beta_e e_{it-1} - \beta_k k_{it-1}] + \xi_{it} + \eta_{it} \end{aligned} \tag{14}$$

Expression (14) requires the knowledge of φ_{t-1}, which can be estimated in the first-step. Equation (14) is then used to estimate β_e and β_k by non-linear least squares.

In addition to the replacement of investment by an intermediate input as a proxy for productivity, Levinsohn and Petrin do not consider the estimation of the second step in the Olley and Pakes algorithm. In other terms, they do not account for the sample selection bias. Levinsohn and Petrin argue that the use of an unbalanced panel controls, to some extent, for such bias. Moreover, both Olley and Pakes (1996) and Levinsohn and Petrin (1999) found that controlling for selection has little effect on the final parameter estimates.

4. Data and sample

The empirical section of the paper aims at estimating a Cobb-Douglas production function having a measure of bank output as the dependent variable and three productive inputs as explanatory variables. Appendix 2 gives more detailed information on data sources and variable definitions.

The inputs are labor, capital, and intermediate inputs. Following Levinsohn and Petrin (2003), a separate intermediate input is used as a proxy variable for productivity. Unlike the manufacturing sector, however, the use of electricity as a proxy variable in the banking industry does not seem to be warranted. We therefore take communications as our proxy for the unobserved productivity. Capital stock is treated as a fixed input since adjustment costs may prevent instantaneous reallocations of such input. As for labor, we treat it alternatively as a variable and as a fixed factor.[10]

Measurement of bank output is more controversial, with many approaches being proposed in the literature[11]. Here, output is measured as the value of total bank working assets, making our model consistent with the intermediation approach. Haynes and Thompson (1999) use a similar procedure. Some empirical studies use bank deposits either as output or as input of the bank activity. However, because of the relevance of bank deposits in the liability side of a bank balance sheet, the inclusion of them would cause a serious problem in the estimation of the production function, due to the accounting identity equating total assets and total liabilities. In the present study therefore bank deposits are not included in the bank production process.

The source of the accounting data is COSIF (Accounting Plan of the National Financial System Institutions), elaborated by the Brazilian Central Bank, and by which all the financial institutions operating in the country have to report balance sheet and income statements on a monthly basis. The accounts for (end of) June and (end of) December of each year during the period from December 1990 to December 2002 were used.

The sample is unbalanced with 242 commercial banks. All the observations with zero values for the output or for one of the inputs were excluded from the analysis. In addition, banks with less than three observations, and outliers were also excluded. The final sample contains 4,444 observations[12].

[10] Labor economists in Brazil argue that, due to rigid labor market legislation, dismissal of labor force is very costly. Such friction can prevent instantaneous reallocations of the labor input making it behave as a fixed factor.

[11] See, among others, Berger and Humphrey (1992), and Fixler and Zieschang (1992).

[12] The criterion employed to eliminate the outliers was the following: initially, the ratios of output to labor, of output to capital, and of output to intermediate inputs were computed for all the valid observations. The observations in the lower 0.5% and in the upper 0.5% for each of the three ratios were excluded from the sample.

Table 6 shows some descriptive statistics for the sample variables for both the whole sample period, 1990-2002, and also for two sub-periods, 1990-1995, and 1996-2002. The privatizations of the public-owned banks are concentrated in the second sub-period.

TABLE 6 - Sample summary

Variable	Average	Standard Deviation
Output*		
1990 to 2002 (4444 obs.)	5,001	18,511
1990 to 1995 (1998 obs.)	3,629	15,135
1996 to 2002 (2446 obs.)	6,116	20,791
Employees		
1990 to 2002	3,261	12,381
1990 to 1995	3,596	13,248
1996 to 2002	2,988	11,625
Capital*		
1990 to 2002	123.9	648.2
1990 to 1995	141.0	789.6
1996 to 2002	110.0	504.7
Other intermediate inputs*		
1990 to 2002	28.0	101.8
1990 to 1995	26.2	92.9
1996 to 2002	28.4	108.4

* in million of Reais (December 2002 values)

The dispersion of the variables across banks is very large, with the standard errors being nearly four times larger than the mean values. There is no discernible difference between the two sub-periods in this regard. Firm bank heterogeneity is therefore very significant in the sample and for both sub-periods.

Mean production increases between the two sub-periods, alongside concomitant reductions in the use of labor and capital. Intermediate inputs, by contrast, have increased between the two sub-periods.

Figures 1 and 2 show the evolution of the mean values of the variables across time.

Figure 1: Evolution of average output, and number of employees

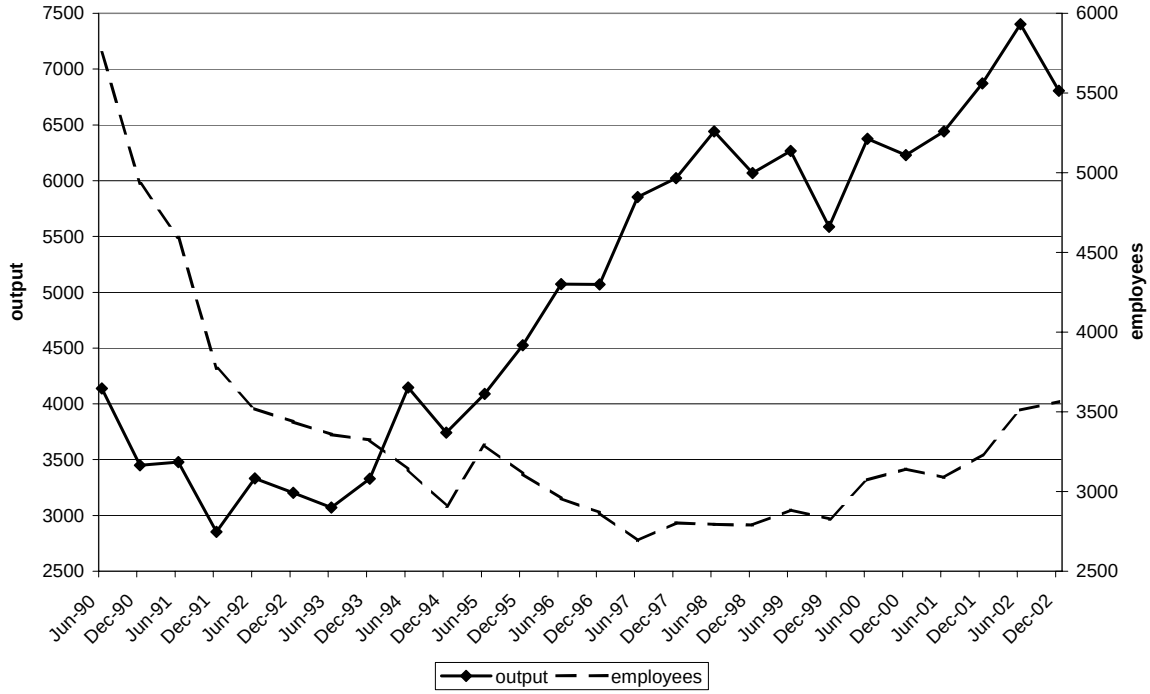
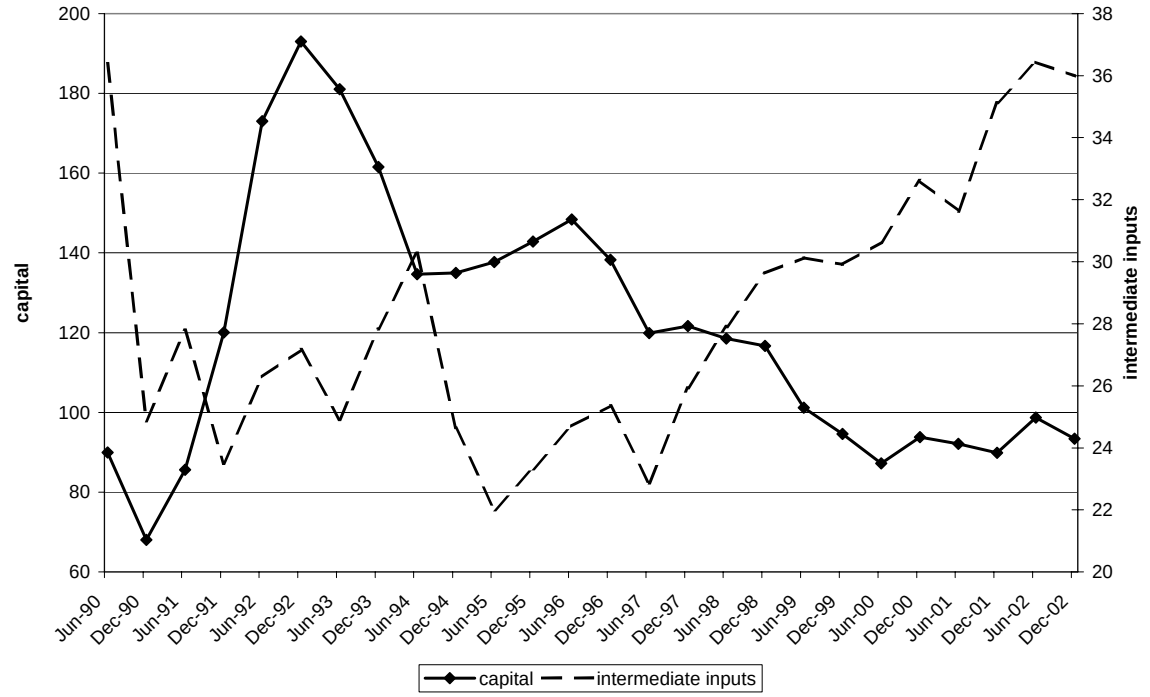


Figure 2: Evolution of average capital stock, and intermediate inputs



One can then observe that bank output starts to continuously increase since 1993, registering an accumulated growth of 122% between Jun 1993 and December 2002. Employment reduces over the sample period with the largest fall occurring between 1990 and mid-1997. After 2000, employment has recovered a little. Capital stock shows a decreasing trend starting in 1993. Average capital stock halved its value between the peak of December 1992 and December 2002. Intermediate inputs are the only inputs that followed the increasing pattern for the output in the most recent years.

5. Estimation of bank productivity

This section implements Levinsohn and Petrin (2003) methodology to obtain measures of productivity for a sample of Brazilian banks. In the next section, the bank-level productivity measures so obtained are regressed on a number of control variables, including, among them, dummy variables representing privatization of state-owned banks.

Levinsohn and Petrin (2003) modify Olley e Pakes (1996) approach in two ways. First, they replace investment by electricity as a proxy variable for productivity. Second, they do not model the exit decision by the bank. For the sample of Brazilian banks, troubled banks stop reporting employment levels to the Central Bank, which preclude us to implement the second step in Olley and Pakes algorithm. As Levinshohn and Petrin argue, we hope that the use of unbalanced panel data helps to reduce the sample selection bias.

The first step of the algorithm involves the estimation of the following "partially linear" equation:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_i i_{it} + \beta_c c_{it} + \beta_k k_{it} + h_t(c_{it}, k_{it}) + time_t + \varepsilon_{it} \qquad (15)$$

where y_{it} is the log of bank output, l_{it} is the log of labor, i_{it} is the log of other intermediate inputs, c_{it} is the log of communications, k_{it} is the log of capital, $time_t$ is a trend variable, and ε_{it} is the random error term.

The $h_t(c_{it}, k_{it})$ function is estimated by means of a polynomial series expansion where terms of up to the fourth degree of c_{it} and k_{it} are used. This series expansion is separately estimated for three different sub-periods: from 1990 to June 1994, from December 1994 to 1997, and from 1998 to 2002. In equation (15) labor is considered as a variable factor. We also estimated models where labor is treated as a fixed factor. When this is the case, labor is also incorporated in the polynomial series expansion.

The first step of the estimation allows one to obtain consistent estimates of the variable factor coefficients, β_l and β_i. Once these coefficients are obtained, we compute the term:

$$y_{it}^{p} = y_{it} - \hat{\beta}_l \, l_{it} - \hat{\beta}_i \, i_{it} \tag{16}$$

This term is then regressed on a polynomial series in (c_{it}, k_{it}). The fitted value from this regression is denoted $\hat{\varphi}_t(c_{it}, k_{it})$.

In the second step, consistent estimates for β_c and β_k are obtained through non-linear least squares applied to:

$$y_{it}^{p} = \beta_0 + \beta_c c_{it} + \beta_k k_{it} + g[\hat{\varphi}_{t-1}(c_{it-1}, k_{it-1}) - \beta_0 - \beta_c c_{it-1} - \beta_k k_{it-1}] + \xi_{it} + \varepsilon_{it} \tag{17}$$

where ξ_{it} is the innovation term in productivity.

Table 7 presents the production function coefficients estimated through the Levinsohn and Petrin (L-P) algorithm, alongside the coefficients obtained through least squares estimation.[13]

[13] The standard errors of the coefficients for the fixed inputs and for communications in the L-P models were obtained by bootstrap resampling 100 times. There are fewer observations in the L-P models due to the use of lagged terms in the estimation of (17).

TABLE 7 - Estimates of production function parameters

Input	Least Squares	L-P (variable labor)	L-P (fixed labor)
ln (labor)	-0.0479*	-0.1485***	0.4409***
	(-1.90)	(-3.30)	(4.17)
ln (other intermediate)	0.2599***	0.2137***	0.4391***
	(9.03)	(8.21)	(19.74)
ln (communications)	0.6162***	0.6119***	0.2047***
	(22.94)	(8.68)	(4.80)
ln (capital)	0.0236	0.0515*	0.064
	(1.50)	(1.89)	(1.07)
time	0.0482***	0.0379***	0.0546***
	(20.96)	(6.06)	(8.24)
Observations	4444	4202	4202

t-statistic in parentheses

*,**,*** indicate significant at 10, 5, and 1 percent, respectively

The labor coefficient in the least squares estimation is negative, and marginally significant. When labor is treated as a variable factor in the L-P approach, its coefficient becomes even more negative and highly significant this time. The last column of Table 7 shows the estimates of the L-P approach when labor is treated as a fixed factor. This model shows more reasonable values for the estimated coefficients, although the statistical significance of the capital stock coefficient is still low[14]. Thus, for the remaining of the analysis, the coefficients shown in the third column are used as the estimates for the bank production function.

As discussed in section 3, it is important that monotonicity with respect to productivity holds for the communications input. If this assumption is violated, we cannot invert this function to express productivity as a function of observable variables. In order to check the validity of this assumption, communications was regressed on productivity and on the fixed inputs (capital and labor). All the estimated coefficients are positive and significant.

[14] The results are robust to different cutoff values for the outliers (0.5%, 1%, 2%), and also to different degrees for the polynomial expansion series (fourth and fifth degrees).

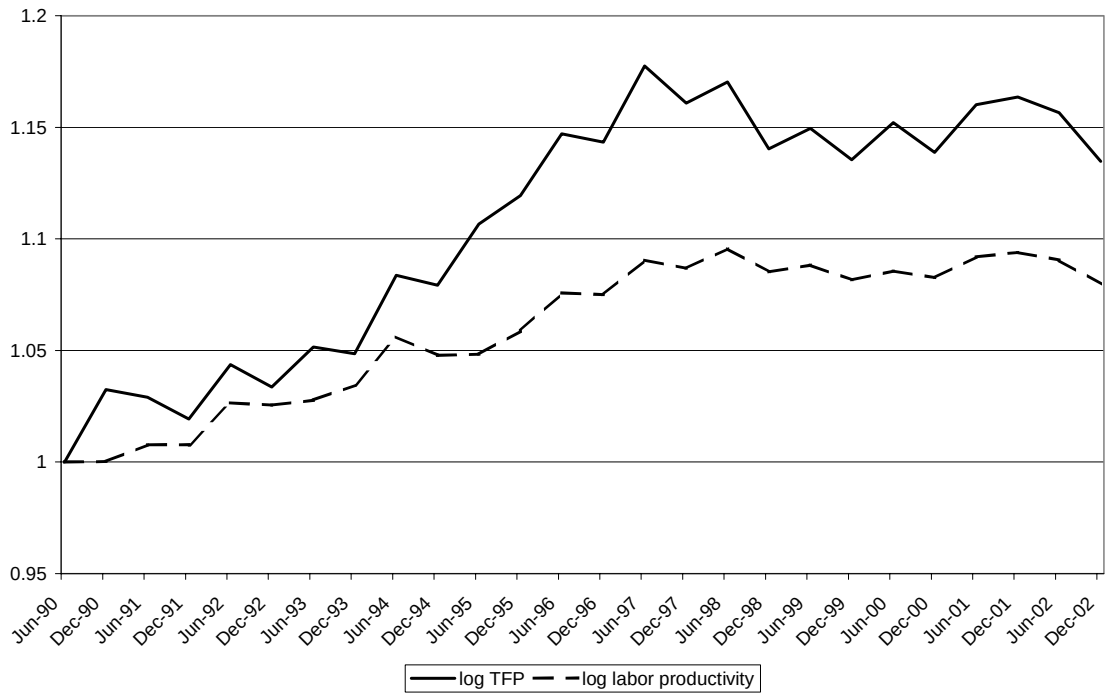
Bank-level (log of) total factor productivity is computed as the difference between actual and fitted output, given by:

$$\omega_{it} = y_{it} - \hat{\beta}_l \, l_{it} - \hat{\beta}_i \, i_t - \hat{\beta}_c \, c_{it} - \hat{\beta}_k \, k_{it}$$

Aggregate bank productivity is calculated as the weighted bank-level productivity for each period, where the weight is given by the market share of each bank product in each time period. Figure 3 shows the evolution of the aggregate productivity alongside a more standard measure of productivity, namely labor productivity (calculated as the weighted average of $y_{it} - l_{it}$), both normalized to one in June 1990.

Figure 3: Brazilian banking system: total factor, and labor productivity

(June 1990 = 1)



The two aggregate productivity measures display similar temporal patterns although their numerical scales differ. It is interesting to notice that labor productivity underestimates total factor productivity in banking, which is the opposite of what is found for the manufacturing sector in Brazil [Muendler (2002), Schor (2003)]. One possible reason for these differences is the large fall in the capital stock in banking

shown in Figure 3, whereas capital stock has increased in the manufacturing sectors over the 1990's.

Aggregate total factor productivity increases up to June 1997, remaining fairly flat after it. The accumulated productivity growth over the entire period is 13.48%, or an average annual growth rate of 1.02%. There is great heterogeneity across sub-periods though. In the period from June 1990 to June 1997, the average annual growth rate reached 3.70%. From June 1997 to December 2002, there is actually a small fall in the aggregate productivity: there is an accumulated fall of 3.63% or an average annual fall of 0.67%.

Nakane (1999) found similar results through the estimation of cost functions for Brazilian banks accounting for efficiency according to the stochastic frontier methodology[15]. According to his estimation, the average cost efficiency index for Brazilian banks reached 0.4151 in the June 1990 to June 1994 period, and increased to 0.5098 in the June 1994 to June 1997 period. Bevilaqua and Loyo (1998) also document cost efficiency gains for a panel of 38 Brazilian banks during the last quarter of 1994 and the second quarter of 1998.

6. Determinants of bank productivity

This section attempts to study the determinants of bank productivity. Special attention is paid to the role of the ownership structure. In face of an environment whereby different corporate changes are affecting the industry, Berger *et al*. (2003) argue that it is important to control for as many of the changes as possible. In other terms, even if the primary interest of the paper relies on the effects of bank privatization, the introduction of controls for corporate changes that do not involve state-owned banks (e.g. domestic M&As or foreign acquisition of domestic banks) are overdue.

[15] See Berger and Humphrey (1997) for a survey of efficiency studies applied to banking.

Moreover, Berger *et al*. (2003) develop a framework where static, selection, and dynamic effects are contemplated. Static effects refer to the differences in performance for groups of banks that have not been involved in any corporate change. Selection effects are those related to the performance differentials for the groups of banks that were involved in some ownership change. Finally, dynamic effects capture the changes in performance for the last group of banks that are *due to* the change in ownership. This framework has been applied to study the Argentinean case by Berger *et al*. (2003), the Brazilian case by Beck, Crivelli, and Summerhill (2003), and the Nigerian case by Beck, Cull, and Jerome (2003).

The Brazilian case seems to be well suited for an application of this methodology. First, many corporate changes affected the banking industry in the 1990's, involving bank privatization, domestic M&As, foreign acquisition of domestic banks, and bank closures. Second, as documented in section 2, the process of bank privatization was very rich in Brazil. Public banks owned by states were offered different solutions to their banks, including, liquidation, outright privatization, federalization followed by privatization, and restructuring.

Static dummy variables were created for those banks that did not face any ownership change over the sample period and were still active by the end of the sample period. Three static dummy variables were created for state-owned banks (*dstatic_state*), for foreign-controlled banks (*dstatic_foreign*), and for branches of foreign banks (*dstatic_branchforeign*). These dummy variables take the value one for the corresponding bank for all the time periods. Domestic private banks are the excluded reference group.

Out of the 242 banks with observations in the sample, 112 (46.28%) of them were active by December 2002 without experiencing any corporate change. Five (2.07% of the total) of them were state-owned banks, 64 (26.45%) of them were domestic private banks, 32 (13.22%) of them were foreign controlled banks, and 11 (4.55%) of them were branches of foreign banks.

The relevance of each group of banks cannot be entirely gauged by their respective numbers due to the presence of many small banks. We therefore computed the market share of each group in December 2002. On this account, the group of

commercial banks that have not experienced any corporate change responded for 79.94% of the market share. The market shares accounted by state-owned banks, domestic private banks, foreign controlled banks, and branches of foreign banks are, respectively, 32.52%, 28.25%, 15.91%, and 3.26%.

Selection dummy variables were created for those banks that have faced some corporate change over the sample period. Eight selection dummy variables were created for state-owned banks that were privatized and acquired by domestic banks (*dselection_privatized_domestic*), for state-owned banks that were privatized and acquired by foreign banks (*dselection_privatized_foreign*), for state-owned banks that were first federalized, later privatized and acquired by domestic banks (*dselection_federalized_privatized_domestic*), for state-owned banks that were first federalized, later privatized and acquired by foreign banks (*dselection_federalized_privatized_foreign*), for state-owned banks that were federalized and not privatized yet (*dselection_federalized_notprivatized*), for state-owned banks that were restructured and kept under state ownership (*dselection_restructured*), for domestic banks acquired by other domestic banks (*dselection_domestic*), and for domestic banks acquired by foreign banks (*dselection_foreign*). The selection dummy variables take the value one for the corresponding banks during all the time periods. Notice that the selection variables control not only for different solutions given to the state-owned banks but also to the ownership of the acquiring bank.[16]

Out of the 242 commercial banks in the sample, 55 (22.73%) of them have had some form of control change. State-owned banks account for 19 (7.85% of the total) of the cases with 5 privatized banks bought by domestic banks, 2 privatized banks bought by foreign banks, 2 federalized and privatized banks bought by domestic banks, 1 federalized and privatized bank bought by a foreign bank, 4 federalized and not yet privatized banks, and 5 reestructured state-owned banks. Of the remaining 36 cases (14.88% of the total) involving private banks, half of them are cases of domestic banks merging with other domestic banks whereas the other half are situations where domestic banks are being acquired by foreign ones. In terms of market share, the group of banks that were involved in any form of corporate change accounted for 20.06% of the market

in December 2002. The market shares of the state-owned banks, of the domestic banks acquired by other domestic banks, and of the domestic banks acquired by foreign banks are, respectively, of 9.51%, 5.17%, and 5.37%.

Dynamic dummy variables were created for those banks for which the selection dummies were equal to one to date the precise moment when the ownership change occurred. Ten dynamic dummy variables were created for state-owned banks that were privatized and acquired by domestic banks (*ddynamic_privatized_domestic*), for state-owned banks that were privatized and acquired by foreign banks (*ddynamic_privatized_foreign*), for state-owned banks that were first federalized, later privatized and acquired by domestic banks dating the time of federalization (*ddynamic_federalized_privatized_domestic_datefederalization*), for state-owned banks that were first federalized, later privatized and acquired by domestic banks dating the time of privatization (*ddynamic_federalized_privatized_domestic_dateprivatization*), for state-owned banks that were first federalized, later privatized and acquired by foreign banks dating the time of federalization (*ddynamic_federalized_privatized_foreign_datefederalization*), for state-owned banks that were first federalized, later privatized and acquired by foreign banks dating the time of privatization (*ddynamic_federalized_privatized_foreign_dateprivatization*), for state-owned banks that were federalized and not privatized yet dating the time of federalization (*ddynamic_federalized_notprivatized*), for state-owned banks that were restructured and kept under state ownership dating the time of restructuring (*ddynamic_restructured*), for domestic banks acquired by other domestic banks (*ddynamic_domestic*), and for domestic banks acquired by foreign banks (*ddynamic_foreign*). The dynamic dummy variables take the value one for the corresponding banks for all the time periods following a certain intervention.

The dynamic dummy variables capture the once-and-for-all changes associated to the interventions. However, in addition to this level effect, the interventions can have differentiated impacts over time. We therefore also created variables measuring the time lapsed since the intervention. Since we use 6-month observations in our sample, such variables are measured in semesters. Ten time variables were created, one for each dynamic dummy variable. The labels for such variables follow the same pattern as the

[16] For some few banks, there was more than one change of control. In such cases, we followed Berger *et*

ones defined for the dynamic dummy variables with *time* replacing *ddynamic*. For example, *time_federalized_privatized_foreign_datefederalization* measures the time since a state-owned bank that was federalized, privatized and acquired by a foreign bank was federalized. Typically, the *time* variables take the value one in the semester when the intervention occurred, the value two in the following semester, and so on.

We follow Berger *et al*. (2003) and actually exclude from the sample all observations for which the *time* variables equal one. In other terms, the semester during which the intervention occurred is not considered in the sample. The reason for this treatment is to try to control for noise introduced during the event of intervention, which usually produces some discontinuities in previous policies, involves legal costs associated to the intervention, etc.

In addition to the static, selection, and dynamic variables we created another group of variables to deal with the banks that exited the market.[17] Typically, banks have left the market either because they were liquidated or because they changed their activities from commercial banking into something else. Accordingly, we defined five exit dummy variables for liquidated state-owned banks (*dexit_liquidated_state*), for liquidated private banks (*dexit_liquidated_private*), for commercial banks that became other banking institutions, e.g. investment bank (*dexit_other_bank*), for commercial banks that became other non-banking financial institutions, e.g. broker house (*dexit_other_finance*), and for commercial banks that became other non-financial institutions (*dexit_nonfinance*). The exit dummy variables take the value one for the corresponding banks during all the periods for which they are present in the sample.

Out of the 242 commercial banks present in our unbalanced sample, 75 (30.99%) of them have exited the market. Six (2.48% of the total) state-owned banks were liquidated, 23 (9.50%) private banks were liquidated, 12 (4.96%) commercial banks became investment banks, 8 (3.31%) commercial banks became non-banking financial institutions, and 26 (10.74%) commercial banks became non-financial institutions. Obviously, the market share of the exited banks is zero by December 2002.

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al. (2003)'s procedure and only consider the last change.

[17] Beck, Crivelli, and Summerhill (2003) work with a balanced sample, excluding such banks from their analysis. We believe that keeping these banks in the sample is important to better deal with the sample selection problems discussed in section 3.

In addition to the above mentioned variables we also included two additional control variables given by the lagged market share (*market_share*), as measured by the share of each bank output in the sector output in each period, and lagged bank size given by the number of bank branches (*branches*). Time dummies were also included in the estimated regressions, with the aim of capturing macroeconomic effects not accounted for in the estimation.

Table 8 presents the results when the "time" variables capturing the effects of corporate change over time are not included in the regression. Robust standard errors are computed throughout. The coefficients of the time dummies are not reported to spare space.

TABLE 8 - Determinants of Log(TFP)

Variable	Coefficient	T statistics
dstatic_state	-1.0158***	-10.80
dstatic_foreign	0.2594***	4.72
dstatic_branchforeign	0.4413***	5.85
dexit_liquidated_state	-1.9681***	-18.89
dexit_liquidated_private	-0.5585***	-7.04
dexit_other_bank	-0.2243**	-2.08
dexit_other_finance	-0.3516***	-3.42
dexit_nonfinance	0.5255***	6.81
dselection_privatized_domestic	-1.1891***	-14.08
dselection_privatized_foreign	-1.8522***	-27.26
dselection_federalized_privatized_domestic	-1.7767***	-21.94
dselection_federalized_privatized_foreign	-1.1449***	-7.45
dselection_federalized_notprivatized	-1.7532***	-22.83
dselection_restructured	-1.3633***	-16.16
dselection_domestic	-0.1040	-1.22
dselection_foreign	0.0210	0.26
ddynamic_privatized_domestic	0.3158**	2.50
ddynamic_privatized_foreign	0.8214***	3.94
ddynamic_federalized_privatized_domestic_datefederalization	-0.0724	-0.57
ddynamic_federalized_privatized_domestic_dateprivatization	-0.1127	-0.59
ddynamic_federalized_privatized_foreign_datefederalization	-0.1079	-0.71
ddynamic_federalized_privatized_foreign_dateprivatization	0.1777**	2.02
ddynamic_federalized_notprivatized	-0.0940	-1.04
ddynamic_restructured	-0.2575**	-2.35
ddynamic_domestic	0.4764**	2.18
ddynamic_foreign	0.1531	1.14
market_share	18.5562***	6.99
branches	-0.0018***	-11.86
constant	7.1245***	70.19
Observations	4147	
R-squared	0.3829	

*,**,*** indicate significant at 10, 5, and 1 percent, respectively

The three static dummy variables are highly significant. The results show that state-owned banks are less productive than the private domestic ones (the reference group). On the other hand, both the foreign-controlled banks and the branches of foreign banks are more productive than the private domestic group.

The five exit dummy variables are significant and one of them is positive. Liquidated banks have lower productivity than those commercial banks that left the market due to a transformation in their activities. State-owned liquidated banks have the

poorest performance within this group, followed by the private liquidated banks. Commercial banks that left the market and became non-financial institutions were actually more productive than the private domestic banks (reference group). One possible reason for some banks to leave the market is related to the increasing costs of staying in the bank business related to more stringent prudent regulations as well as to the introduction of the new payment system in the country during 2002.

Five of the selection dummy variables are highly significant and negative. The remaining two selection variables are not significant with one of them having a positive sign. Overall, state-owned banks that underwent some corporate change are less productive than private banks that also faced some corporate change. The selection coefficients are non-significant for the latter group, indicating that their productivity is no different than the productivity of the reference group (domestic private banks).

As for the state-owned banks, there is no clear discernible pattern for the selection variables regarding the type of solution given to them. In other terms, one cannot clearly state that state-owned banks that were privatized, or that were first federalized and later privatized, or that were federalized and not privatized, or that were restructured and kept under state control have better or worse performance compared to each other. It is also not possible to state any firm conclusion related to the ownership of the acquiring bank (i.e. private domestic or foreign control) in terms of the selection of state-owned banks.

The static, exit and selection dummies plus the reference excluded group form a sample partition. One can therefore rank the groups according to the estimated coefficient for each dummy. Table 9 reports the ranking in increasing order (i.e. from the less to the more productive groups). The ordering is a weak one because some of the coefficients are not statistically different from each other. Equality coefficient tests are reported for pairs of adjacent variables and we indicate when the null is rejected.

TABLE 9 - Ranking of groups of banks according to static, exit, and selection variables

Group	F Statistics	P-Value
1. Liquidated state-owned bank	1.03	0.3101
2. Privatized and acquired by foreign	0.64	0.4229
3. Federalized, privatized and acquired by domestic	0.06	0.8134
4. Federalized and not privatized	14.41***	0.0001
5. Reestructured and kept under state control	2.68	0.1017
6. Privatized and acquired by domestic	0.06	0.8067
7. Federalized, privatized and acquired by foreign	0.87	0.3510
8. Active state-owned bank	15.70***	0.0001
9. Liquidated private bank	2.91*	0.0883
10. Transformed into financial non-banking institution	0.81	0.3680
11. Transformed into other banking institution	0.88	0.3482
12. Domestic bank acquired by domestic	1.50	0.2210
13. Active domestic bank	0.07	0.7983
14. Domestic bank acquired by foreign	7.27***	0.0071
15. Active foreign controlled bank	4.96**	0.0260
16. Active branch of foreign bank	0.76	0.3833
17. Transformed into non-financial institution		

*,**,*** indicate significant at 10, 5, and 1 percent, respectively
F Statistics report a test of equality for the coefficient of the corresponding group and the coefficient for the group in the row immediately below. All the tests have a F(1,4094) distribution.

One striking result from Table 9 is that all the groups involving state-owned banks occupy the lowest positions in the rankings. Even the still active state-owned banks have significantly lower productivity than liquidated private banks[18]. Returning to the results of Table 8, only five out of the ten dynamic dummy variables are statistically significant. One of them has a negative coefficient, though, which is contrary to expectations. As a matter of fact, only five of the dynamic variables have the expected positive sign. Overall, the dynamic effects are not large in magnitude.

As in Table 9, we can compute a weak ordering of the groups according to the estimated coefficients of the dynamic variables. Table 10 shows the results. We

[18] Possible reasons for these results could be that such banks may be used as government agents, playing a "social" role. For example, Banco do Brasil and CEF are major players in the concession of loans to the rural and to the low-income housing sector, respectively, usually at subsidized rates. Nonetheless, such conjecture needs a careful analysis, examining and comparing lending policies from such banks with their counterparts.

consider the state-owned banks that were first federalized and later privatized during two moments: the period they remained under federal control, and the period following privatization. The variables we name …*datefederalization* and …*dateprivatization* in Table 8 aim at capturing the dynamic impacts of federalization and of privatization, respectively. Thus, Table 10 reports the rankings of ten distinct groups in increasing order.

TABLE 10 - Ranking of groups of banks according to dynamic variables

Group	F Statistics	P-Value
1. Reestructured and kept under state control	0.44	0.5073
2. Federalized, privatized and acquired by domestic, after privatization	0.00	0.9841
3. Federalized, privatized and acquired by foreign, during federalization	0.01	0.9372
4. Federalized and not privatized	0.02	0.8799
5. Federalized, privatized and acquired by domestic, during federalization	1.66	0.1983
6. Domestic bank acquired by foreign	0.02	0.8763
7. Federalized, privatized and acquired by foreign, after privatization	0.87	0.3512
8. Privatized and acquired by domestic	0.42	0.5182
9. Domestic bank acquired by domestic	1.33	0.2491
10. Privatized and acquired by foreign		

*,**,*** indicate significant at 10, 5, and 1 percent, respectively
F Statistics report a test of equality for the coefficient of the corresponding group and the coefficient for the group in the row immediately below. All the tests have a F(1,4094) distribution.

The first five groups in Table 10 present negative impacts for the dynamic dummy variables. All of them involve state-owned banks. Three of such negative impacts are related to state-owned banks *during* periods of restructuring (either under federal or under state control). This result is not surprising because restructuring usually involves the transfer of troubled assets to the federal government. Since total assets are our measure of output, such banks may be facing a reduction in output while keeping unchanged their level of inputs and therefore reducing their productivity.

When the performance of the state-owned banks is measured after the privatization, the dynamic impacts show a more positive outcome. Three of the four possible groups improved their performance after privatization. Moreover, the way a state-owned bank was privatized seems to matter with better performance related to straight privatization (as opposed to first federalize and then privatize).[19]

[19] The tests that the dynamic effects for state-owned banks that were privatized and for state-owned banks that were first federalized and then privatized are equal give F statistics of 8.38 (p-value equal to 0.0038)

Moreover, the ownership of the acquiring bank also seems to matter with better dynamic performance related to the privatized banks acquired by foreigners.[20] Interestingly, when the corporate change involved only private banks, domestic banks seem to be associated with better dynamic performance than foreign ones, although the statistical significance for testing the difference between them is very low (F statistics equal to 1.64 with a p-value of 0.2010).

The ordering shown in Table 10 can be misleading because any given value for a dynamic variable may have different quantitative implications for different bank groups. For example, a coefficient of, say, 0.2 for a dynamic variable may represent a tremendous improvement for a privatized state-owned bank and not such a great performance for a private bank. We therefore re-computed the rankings of the bank groups displayed in Table 9 by considering the dynamic effects of Table 10. In other terms we add the coefficients for each selection variable and the corresponding dynamic one, comparing the result with the static and exit variables. Table 11 shows the resulting weak ranking in increasing order. For the state-owned banks that were first federalized and later privatized we show their combined performance after the privatization, i.e. we take into account the impacts of the federalization period.

when the acquiring bank is a foreign one and 3.52 (p-value equal to 0.0607) when the acquiring bank is a domestic one.

[20] The statistical significance for such tests are not very high though. The tests that the dynamic effects for privatized state-owned banks acquired by foreigners and for privatized state-owned banks acquired by domestic banks are equal give F statistics of 4.52 (p-value equal to 0.0336) when the state-owned bank was privatized by the state, and 2.09 (p-value equal to 0.1486) when the state-owned bank was first federalized and then privatized.

TABLE 11 - Ranking of groups of banks according to static, exit, and selection plus dynamic variables

Group	Previous Ranking	F Statistics
1. Liquidated state-owned bank	1	0.00
2. Federalized, privatized and acquired by domestic	3	0.51
3. Federalized and not privatized	4	8.48***
4. Reestructured and kept under state control	5	42.08***
5. Federalized, privatized and acquired by foreign	7	0.05
6. Privatized and acquired by foreign	2	0.00
7. Active state-owned bank	8	1.03
8. Privatized and acquired by domestic	6	6.29**
9. Liquidated private bank	9	2.91*
10. Transformed into financial non-banking institution	10	0.81
11. Transformed into other banking institution	11	4.34**
12. Active domestic bank	13	2.33
13. Domestic bank acquired by foreign	14	0.52
14. Active foreign controlled bank	15	0.29
15. Domestic bank acquired by domestic	12	0.10
16. Active branch of foreign bank	16	0.76
17. Transformed into non-financial institution	17	

*,**,*** indicate significant at 10, 5, and 1 percent, respectively
F Statistics report a test of equality for the coefficient of the corresponding group and the coefficient for the group in the row immediately below. All the tests have a F(1,4094) distribution.

It remains true that all the lowest positions are still occupied by former or active state-owned banks. Even the best performing in this group, the ones privatized and acquired by domestic banks, are still (significantly) lagging behind the worst performers in the group of private banks, namely the liquidated private banks.

However, some noticeable improvements have been detected for the state-owned banks that were directly privatized. Privatized state-owned banks that were acquired by foreign banks jumped four positions in the ranking while the ones acquired by domestic banks improved two positions. The former group caught up with the active state-owned banks while the latter leapfrogged this group.

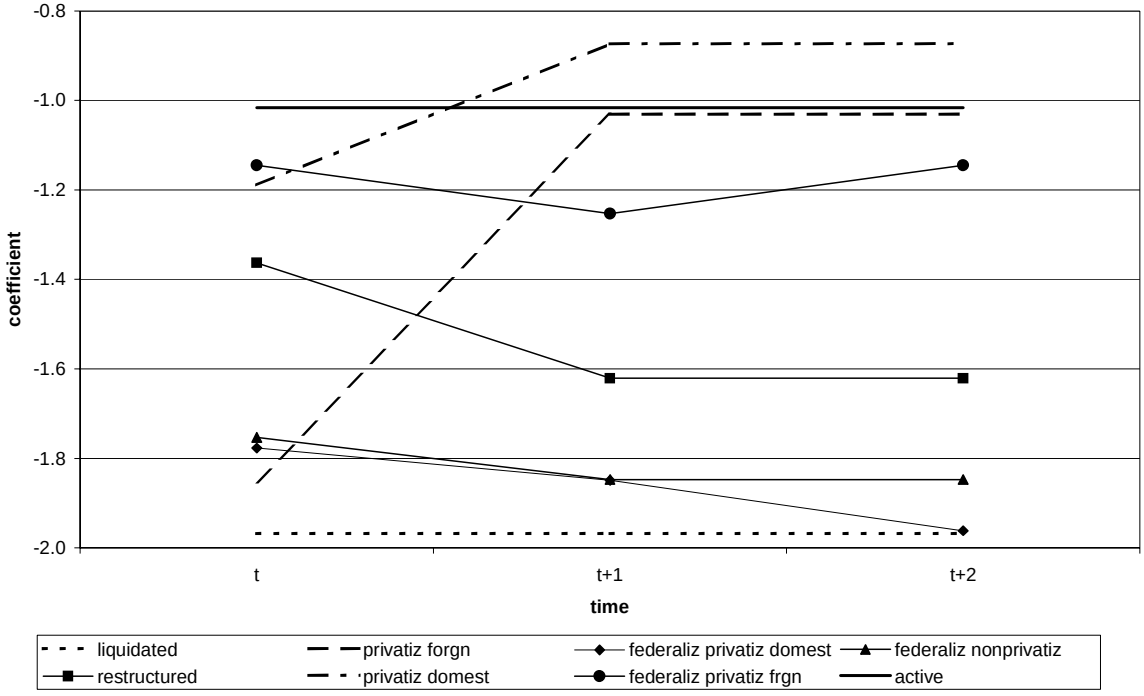
The same good performance is not verified for those privatized state-owned banks that were first federalized. The two bank groups belonging to this category lost positions in the ranking. As already mentioned, such banks faced the negative costs of

restructuring, which impaired their productivity. In special, those federalized banks that were privatized and bought by domestic banks had such a poor performance that, even after the privatization, they perform no better than the liquidated state-owned banks.

It is also worth mentioning that the alternative of restructuring the state-owned bank and keeping it under state control does not seem to yield good results. After taking into account the dynamic impacts, this group of banks lost one position in the ranking. On the plus side, restructured state-owned banks have significant greater productivity than those federalized state-owned banks that have not been privatized.

Figure 4 gives a graphical representation of the changes affecting the state-owned banks. It shows the eight groups representing these banks during three hypothetical time periods. Time *t* shows the distribution previous to the corporate change, as represented by Table 9. Time *t+1* shows the impact of the first corporate change, e.g. federalization for those banks that were federalized or privatization for those banks that were privatized straight away. Time *t+2* shows the final configuration, as represented by Table 10.

Figure 4: State-owned banks: static, exit, selection, and dynamic effects



Domestic banks that were sold to foreign banks leapfrogged the group of active domestic banks while domestic banks that were sold to other domestic banks significantly improved their performance increasing three positions in the ranking.

Overall, the results suggest that dynamic effects associated both to straight privatization and to corporate control change in the private sector worked towards improving productivity of the involved banks.

With regard to the other control variables included in the regression reported in Table 8, the results indicate a positive effect of lagged market share, and a negative effect of the lagged number of branches on bank productivity. Notice that the use of *lagged* market share helps to control for a possible reverse causality channel whereby more productive banks have an edge to increase their market shares. On the other hand, the negative effect for the number of bank branches may be pointing out to scale diseconomies. The operation of extensive branch networks can impart on productivity if the branches are small and geographically dispersed.

The results reported so far assumed that the dynamic impacts of any corporate change have a “once-and-for-all” nature. A more realistic picture may be represented by a setting whereby the dynamic impacts materialize over time. Table 12 reports the results when the “time” variables capturing the effects over time of the corporate changes are also included in the regression.

TABLE 12 - Determinants of Log(TFP) with effects over time

Variable	Coefficient	T statistics
dstatic_state	-1.0160***	-10.79
dstatic_foreign	0.2595***	4.71
dstatic_branchforeign	0.4413***	5.85
dexit_liquidated_state	-1.9680***	-18.86
dexit_liquidated_private	-0.5570***	-6.98
dexit_other_bank	-0.2252**	-2.09
dexit_other_finance	-0.3539***	-3.48
dexit_nonfinance	0.5276***	6.78
dselection_privatized_domestic	-1.1895***	-14.06
dselection_privatized_foreign	-1.8525***	-27.22
dselection_federalized_privatized_domestic	-1.7770***	-21.91
dselection_federalized_privatized_foreign	-1.1446***	-7.44
dselection_federalized_notprivatized	-1.7537***	-22.79
dselection_restructured	-1.3636***	-16.14
dselection_domestic	-0.1045	-1.23
dselection_foreign	0.0213	0.26
ddynamic_privatized_domestic	0.0221	0.13
ddynamic_privatized_foreign	-0.35545	-1.47
ddynamic_federalized_privatized_domestic_datefederalization	0.2071	0.50
ddynamic_federalized_privatized_domestic_dateprivatization	-1.1072***	-3.30
ddynamic_federalized_privatized_foreign_datefederalization	0.0909	0.44
ddynamic_federalized_privatized_foreign_dateprivatization	0.1112	0.62
ddynamic_federalized_notprivatized	-0.0447	-0.29
ddynamic_restructured	-0.2367	-1.19
ddynamic_domestic	0.3786	0.70
ddynamic_foreign	0.2387	1.22
time_privatized_domestic	0.0557*	1.89
time_privatized_foreign	0.2140***	6.91
time_federalized_privatized_domestic_datefederalization	-0.8510	-0.85
time_federalized_privatized_domestic_dateprivatization	0.5091***	3.11
time_federalized_privatized_foreign_datefederalization	-0.0575	-1.31
time_federalized_privatized_foreign_dateprivatization	0.1021*	1.66
time_federalized_notprivatized	-0.0120	-0.40
time_restructured	-0.0041	-0.12
time_domestic	0.0209	0.20
time_foreign	-0.0162	-0.61
market_share	18.5432***	6.98
branches	-0.0018***	-11.84
constant	7.1243***	70.08
Observations	4147	
R-squared	0.3833	

*,**,*** indicate significant at 10, 5, and 1 percent, respectively

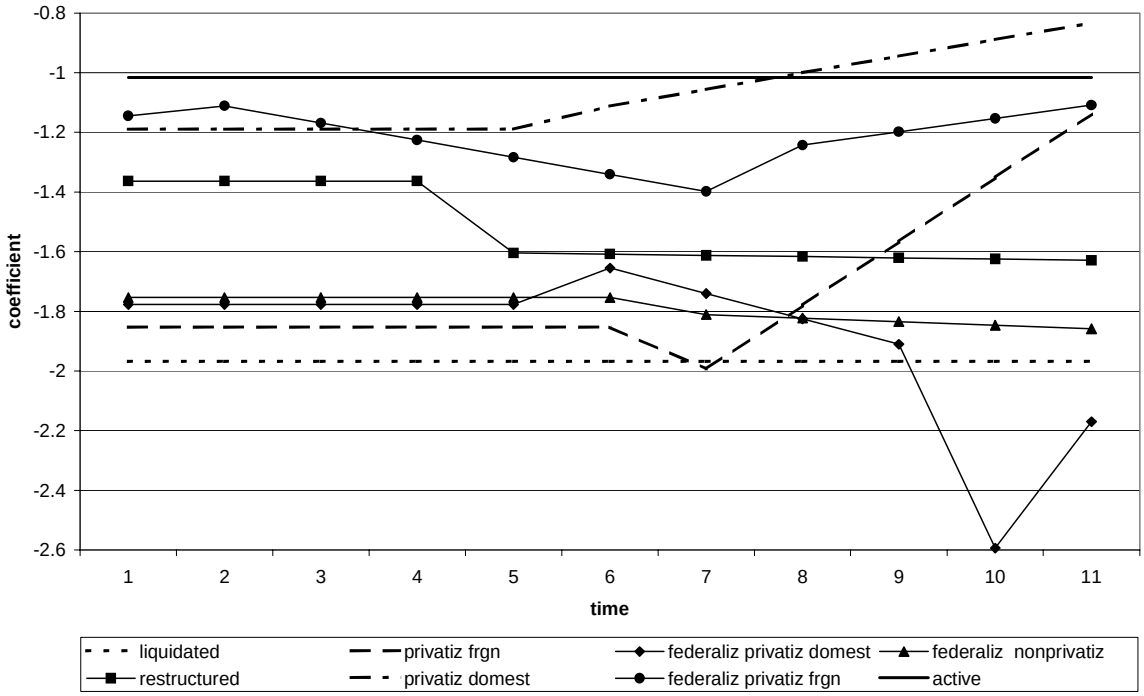
As expected, there is little change in the coefficients for the static, exit, and selection dummy variables. There is also no change in the coefficients for market share

and number of branches. With respect to the dynamic dummy variables, only one of them remains significant but with a negative sign. Five (out of ten) “time” variables are positive with four of them being statistically significant. None of the negative “time” variables are statistically significant.

More interestingly, all the four significant “time” variables are related to privatized banks. This finding gives support to the idea that productivity improvements after privatization may take some time to materialize. It is also worth mentioning that, unlike the previous findings, there is no clear dominance of one type of privatization over the other when the “over time” impacts are taken into account. There is also no clear dominance with regard to the ownership of the acquiring bank on the dynamic impacts of privatization.

Figure 5 shows the results of a counterfactual experiment where the dynamic effects are allowed to vary over time. In time period one, the state-owned banks are ranked according to their static, exit, and selection coefficients displayed in Table 12. The ordering is exactly the same as shown in Table 9 and in Figure 4. We then computed the number of periods during which a typical bank for each group underwent some corporate change. The number of periods is just an average for the banks within each group. It turns out that the longest time span for which an intervention involving state-owned banks was observed in the sample was 10 semesters for those banks that were first federalized and later privatized and bought by foreign banks. Thus, period two in Figure 5 computes the impact effects of federalization for these banks. Such effects are given by the sum of the coefficients for selection, dynamic (date of federalization), and time (date of federalization) variables for this group of banks. In period three, the coefficient for this group of banks is given by the sum of the coefficients for selection, dynamic (date of federalization), and two times the time (date of federalization) variables. And so on. The procedure to compute the coefficients for the other groups of state-owned banks was the same. Hence, Figure 5 preserves the time lengths typically observed in our sample during which the corporate changes were put in effect.

Figure 6: State-owned banks: static, exit, selection, and dynamic effects over time



The results are similar to those depicted in Figure 4 but with richer dynamic responses. The positive "over time" dynamic impacts of privatization are visible for all four involved groups. This effect is particularly impressive for the directly privatized banks bought by foreigners. Those banks that were directly privatized and bought by domestic banks aimed at leapfrogging the active state-owned banks three periods (one and a half years) after being privatized.

Figure 4 suggested a rather disappointing performance for the banks that were first federalized and later privatized to domestic banks. Even after privatization, their productivity was no better than the productivity of the liquidated state-owned banks. Figure 5 helps to explain what happened to such banks. The "over time" effects of federalization were negative to them and the "on impact" effect of privatization was strongly negative. The "over time" effects of privatization, however, are positive. Actually, this group of banks has the greatest coefficient on the "over time" effects, according to the estimates displayed in Table 12. It turns out that the privatization of these banks is of a more recent vintage. So, their apparent dismal performance is explained by the fact that the positive impacts of privatization have not taken their full

effect yet. Giving time to time, our estimates suggest that these banks are catching-up with the other groups.

Summing up, our results suggest that state-owned banks are less productive than their private peers. Privatization of state-owned banks improves productivity. In special, the beneficial effects of privatization are spread out over many periods. In addition, restructuring the state-owned banks and keeping it under state control seems to be a choice that is dominated by privatization when the dynamic effects are considered.

7. Conclusions

In the 1990s, the Brazilian banking sector underwent huge transformations. Following the control of the inflationary process, there was an intense wave of mergers and acquisitions, involving not only domestic agents but also foreign banks. Many state-owned banks were privatized; some of them were closed down. Many troubled private banks also went bust. Improved bank regulation and supervision were also put into action. The purpose of this study was to evaluate how bank productivity was affected by these changes. Particular attention was paid to the effects of the privatization of state-owned banks.

The empirical sections of the paper made use of an unbalanced panel data for 242 commercial banks, observed twice a year, from December 1990 to December 2002. Bank-level productivity measures were obtained as the difference between actual and expected output, where the latter is the fitted value from the estimation of a production function. The estimated production function follows the strategy suggested by Levinsohn and Petrin (2003) to account for endogeneity problems.

In the second stage of the investigation, we tried to evaluate the role of some control variables on the level of the bank productivity. Given the varied nature of corporate changes during the sample period, we follow Berger *et al*. (2003) and try to control for static, selection, and dynamic effects. We also include dummy variables controlling for exited banks. The results show a positive association between productivity and bank market share. It also shows negative effects from the number of

bank branches on productivity. Moreover, state-owned banks seem to be less productive than their private competitors. Bank privatization had positive “over time” impact on productivity. The way a state-owned bank is privatized seems to matter when the “over time” impacts of privatization are not computed. In this setting, straight privatization seems to be a superior strategy than federalization followed by privatization. However, when the impacts of privatization over time are taken into consideration, there is no clear dominance of one form of privatization over the other. There is also no clear dominance in the dynamic performance of privatized banks acquired by foreigners over those acquired by domestic banks and vice versa.

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Appendix 1: State-owned banks in Brazil

State-owned banks in Brazil operate under two government level structures: at the federal, and at the state (province) level. There were 32 state-owned commercial banks operating in Brazil in December 1994, which were reduced to 16 by December 2002. Eleven banks were privatized, four banks are currently under Central Bank intervention for future privatization, and ten commercial banks were/are being closed down.

Table 13 shows the list of the privatized banks, which includes banks for the following Brazilian states: Amazonas (AM), Bahia (BA), Goiás (GO), Minas Gerais (MG), Paraíba (PB), Paraná (PR), Pernambuco (PE), Rio de Janeiro (RJ), and São Paulo (SP). In addition, a bank previously owned by the federal government (Banco Meridional) was also privatized.[21]

Banespa, BEA, and BEG are cases of state-owned banks that were federalized previous to privatization. The other banks displayed in Table 13 were directly privatized.

The four commercial banks that are being prepared for the Central Bank for future privatization include the banks that were previously owned by the following states: Ceará (CE, BEC), Maranhão (MA, BEM), Piauí (PI, BEP), and Santa Catarina (SC, BESC).[22]

[21] Meridional was later sold to Santander in 2000. For reasons explained in section 6, this bank is therefore not included as a privatized state-owned bank.
[22] BEM was privatized and bought by Bradesco on February 10, 2004.

TABLE 13 - Privatized Banks

Bank	Privatization Year	Buyer
Banerj (RJ)	1997	Itaú
Meridional (federal)	1997	Bozano Simonsen
Bandepe (PE)	1998	ABN Amro
Bemge (MG)	1998	Itaú
Credireal (MG)	1998	Bradesco
Baneb (BA)	1999	Bradesco
Banespa (SP)	2000	Santander
Banestado (PR)	2000	Itaú
Paraiban (PB)	2001	ABN Amro
BEA (AM)	2002	Bradesco
BEG (GO)	2002	Itaú

Banks that were previously owned by the following states were closed down: Acre (AC, Banacre), Alagoas (AL, Produban), Amapá (AP, Banap), Goiás (GO, Caixego), Mato Grosso (MT, Bemat), Minas Gerais (MG, Minascaixa), Rio de Janeiro (RJ, Bancoerj), Rio Grande do Norte (RN, Bandern), Roraima (RR, Baner), and Rondônia (RO, Beron).

Appendix 2: Data Related Issues

A. Variables in the production function

The dependent variable in the production function is the value of the bank working assets. Working assets is total assets less fixed assets.

Capital stock includes premises, equipment, other fixed assets, and rented/leased premises and equipment. Capital stock is net of depreciation. Since capital stock is taken as a fixed factor in the production function, we lagged it one period in the estimation.

Intermediate inputs are the sum of communications costs, water, electricity, and gas bill costs, maintenance costs, non-durable goods acquisition costs, data processing costs, and transport costs. The proxy variable for productivity is communications costs.

The source for all the previous variables is COSIF, a monthly report on balance sheet and income statements accounts that all commercial banks in Brazil have to send to the Brazilian Central Bank.

The number of employees is the only variable that does not come from COSIF. The source of this variable is still the Brazilian Central Bank (DEFIN/DINFO unit).

Nominal values from December 1990 to June 1994 were first transformed into *Reais*, the new currency in effect from July 1994 onwards (1 *Real* = 2750 *Cruzeiros*). Constant values were obtained deflating the nominal values through the evolution of the IGP-DI, the general price index calculated by Fundação Getúlio Vargas (FGV). All constant values were converted to December 2002 values.

B. Explanatory variables in the productivity equation

Market share is the ratio of a bank output to the total output in each time period.

The Brazilian Central Bank (DEFIN/DINFO unit) provided the information on the number of bank branches.

The dummy variables for ownership control and transfer were formed from tables elaborated by the Brazilian Central Bank (DEORF unit) and available online. The only information not readily available was the restructuring date for the banks that kept their state ownership. Thorsten Beck kindly sent us this information, which was collected from different sources, including newspapers.

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