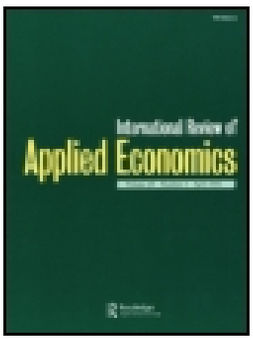

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From scratch to efficiency gains after a financial crisis? A tale of a restructured banking system

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ABSTRACT

We study the efficiency of the Argentine banking system after the 2001–2002 crisis. The financial system had to be restructured from scratch and recovered jointly with the economy, but its productivity and average cost levels have been stagnant since 2007. The analysis includes efficiency frontier estimations for retail banks and a comparison of subsamples for different categories of banks for the period 2005–15. We try to determine whether public banks are more efficient than private ones, whether privatized are more efficient than always private, as well as national versus foreign entities. Our findings show a modest average efficiency of the system and quite similar efficiency rankings for the different groups of banks. On average, public tend to be slightly more cost efficient than private, and national are slightly more efficient than foreign.

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1. Introduction

The paper seeks (i) to estimate the relative efficiency of the banking system using Stochastic Frontier Analysis (SFA) and (ii) to compare the system's efficiency indicators with a focus on different types of banks (national vs. foreign, private vs. public, and privatized vs. always private).

The intellectual production of banks' frontiers analysis can be classified in contributions to assess comparative efficiency, productivity evolution, returns to scale determination, effects on efficiency of mergers and branches' efficient analysis.

The Argentine banking system was forced to reset in the last decade in the aftermath of a severe crisis. It operated with half as many fixed assets as it had before the crisis (comparing 2015 vs. 2001), 10 fewer entities, 20 percent more branches, a greater technological level (measured by the number of ATMs in use) and, above all, a totally different model of business after 2002, based on very short-term deposits and loans, investment in treasury and Central Bank assets and different services to its clients related to the payment system, which constitutes an important source of revenue, while in the nineties mortgages were an important component of business.

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At the beginning of 2002, Argentina abandoned a currency board known as 'Convertibility'[1] and dismantled the bi-monetary financial system based on the dollar and the peso. Prices had stabilized the decade before, and a market of dollar-denominated loans was developed – mainly mortgages – funded from dollar deposits owned by residents. However, the real exchange rate appreciation, a high level of external debt, a long recession, an unemployment rate nearing a quarter of the active population, and a sustained fiscal deficit led to a significant currency devaluation, the end of the currency board and the near extinction of deposits and loans denominated in dollars. An attempt to recreate the long-term loan market through an indexed currency failed after the public opinion reluctance to allow generalized indexation.

The deposits of the post-2002 banking system, whose efficiency we examine in this paper, is now mainly denominated in the local currency. Although it is possible to hold deposits denominated in dollars, the destiny of loans generated from them is generally restricted to internationally tradable sectors. Note that the maturities of half of the deposits are no longer than 60 days and the rest do not exceed one year (Damill et al., 2012). New businesses conducted in subsequent years were mainly short-term loans (mostly personal loans), investment in treasury and Central Bank securities and services.

In this context, we try to answer the following questions:

(1) Which is the general level of banking efficiency for retail banks? How has it evolved?
(2) Are there efficiency differences between public and private banks, national vs. foreign capital, and privatized and always private?

Following this introduction, Section 2 presents a synthesis of the sector's evolution and a brief literature review. Section 3 discusses the estimation methods. Section 4 presents estimates and the database. Section 5 refers to estimation results and Section 6 concludes.

2. Banking sector evolution and previous studies on local banking efficiency

2.1. The last four decades

During the decades of import substitution industrialization that followed the crisis of the 1930s, local practice to regulate the banking system differed little to those pursued by most emerging countries: financial repression, controlled rates and credit, subsidizing 'critical' or 'strategic' sectors, as determined by the political power in office. Argentina experienced high inflation from the late 1940s (annually 20–30 percent), very high inflation for 15 years from the mid-1970s (80 to 600 percent) and hyperinflation in 1989 and 1990 (4000 percent in the former and 1500 percent in the latter). From the late-1970s, the banking sector was liberalized but successive banking and macroeconomic crises occurred. The most severe crisis was registered in 2001–02, leaving an over-expanded sector in the number of entities and branches but with low levels of deposits and loans relative to GDP. Although the economy recovered in the post-crisis period and has begun to grow significantly, after a decade, loan levels are low measured by either historical or international parameters.

To contextualize the Argentine banking system performance in the last decade, we summarize its recent history beginning (perhaps arbitrarily) 40 years ago. Six periods can be identified:

(1) 1973–77. Banks deposits were subject to 100 percent reserve requirements in the Central Bank, which oriented credit, rationing it according to economic policy

priorities (i.e. import substitution industrialization). One hundred percent reserve requirements, regulated rates and an increasing inflation context characterized this period.

(2) 1977–82. Banking activity was liberalized. Competition opened with free rates, many new banks were created and deposits were unconditionally guaranteed by the government. A sector crisis occurred in 1980 due to weak regulation and another severe macroeconomic crisis took place in 1982 (the Debt Crisis). Fractional and remunerated reserve requirements, free interest rates and high inflation were common during this period.

(3) 1982–85. Rates were initially regulated and then liberalized. Inflation continued to grow. From 1985 (to control quasi-fiscal money creation) the remuneration of reserve requirements was not more canceled by new issued money; instead it was periodically capitalized as non-disposable deposits of banks in the Central Bank, yielding interests that formed new non-disposable deposits. The system was converging to seven-day deposits, and reserve and non-disposable requirements close to 100 percent of the former.

(4) 1985–90. Although inflation was initially controlled, it accelerated at the end of 1988 and ultimately developed into hyperinflation months later. At the end of 1989, remunerated reserve requirements and non-disposable deposits – almost all of the bank assets – were converted into a ten-year dollar denominated public debt security (Bonex 89), which banks transferred to the depositors in exchange for their deposits. The system began from scratch, without any remuneration for reserve requirements. In 1990 banks were allowed to constitute dollar-denominated deposits for the account and to the order of the Central Bank.

(5) 1990–2002. After the second hyperinflationary episode in 1990, a bi-monetary banking system started, by which banks' assets and liabilities co-existed in pesos and dollars. From April 1991 to January 2002 ('Convertibility period') a fixed exchange rate was established and inflation stabilized. At the mid-point of the period a severe financial crisis occurred owing to the Mexican devaluation in 1995. Locally, nearly thirty banks were forced to close. During the period, the core business was mortgages (denominated in dollars). At the end of the period, a recession of increasing severity began causing banks' balance sheets to deteriorate and giving rise to capital flight and a fall in deposits. The anticipation of a devaluation eroded two-thirds of the country's international reserves between March and November 2001. At the end of 2001, restrictions were established on ATM withdrawals ('the playpen') and at the beginning of 2002, after a major institutional crisis, banks' dollar-denominated assets were 'pesified (transformed into pesos)' at a dollar parity of 1 to 1. The same occurred with liabilities at a parity of 1.4 to 1 (the new exchange rate). At the same time, long-term deposits and savings accounts were reprogrammed establishing initial amounts ('the large playpen'). Both 'pesified' components were indexed and deposits trapped in the 'playpen' were voluntarily exchanged for public securities. In December 2001, a public debt moratorium was declared, lasting until 2005. Negotiations ended with claims and denomination changes (mainly from dollars to indexed pesos).

(6) 2002-to date. Dollar denominated deposits almost disappeared after the crisis, and most of the deposits were denominated in pesos. The volume of dollar loans was strongly reduced after the crisis, and was concentrated in import-export activities. As a sterilization instrument in the monetization process following the crisis, Central Bank bills and notes were created. Interest rates were free but negative in real terms. Banks focused on very short-term deposits and loans. The economy grew at high rates with little credit in the subsequent years. Bank investments are concentrated in public securities from the Treasury and Central Bank. Loans are mainly personal, bank overdrafts and discounted documents, all of which are short term and denominated in pesos.

2.2. The 2000s

The entire fixed assets of the financial system, beginning in 2002 and expressed in constant pesos of December 2001, reached a maximum value in that year, exceeding 17 billion pesos. By 2015 that figure has halved. Between 2002 and 2011, the number of banks diminished from 61 to 52 (Table 1).

There have been 11 public banks throughout the period. In short, in 2015 the sector registered 52 active banks employing 84,000 persons, in almost 4260 branches, 14,500 ATMs in use and joint fixed assets of 8.3 billion constant pesos (from now on, all monetary variables are valued in December 2001 prices). The banks held deposits totaling 72 billion pesos, extended loans totaling 38 billion, invested 49.8 billion (almost all in Treasury and Central Bank bills) and obtained positive profits for 5 billion. As regards total costs, they reached at 2015 almost 20 percent higher levels than those in 2002, even though they fell significantly after the crisis.

We see large productivity growth and falls in average costs between 2002 and 2015: a 30 percent growth in loans/employees, 208 percent in investments/employees, 16 percent fall in total costs/loans and -60 percent in total costs/investments. However, from 2007 on, all indicators appear to be stagnant or show slight variations, until 2015 when modest improvements are seen (Table 2).

2.3. Previous studies on local banking efficiency

Bikker and Bos (2008) present a complete study that compiles and tabulates results of different banks efficiency studies to that date. Van Hoose (2010) is a good text on the industrial organization of banking with respect to regulatory issues.

Specifically, the Argentine banking system is studied by Chortareas, Girardone, and Garza-Garcia (2010) –among other Latin American countries – Guala (2002a) and (2002b), Moya (2012), Streb and D'Amato (1996), Berger et al. (2005), Clarke and Cull (1999 and 2005), Clarke et al. (2005).

Guala (2002a) evaluates Argentine banking efficiency in the 1990s using cost frontiers and the 'Quantile Regression Analysis'. His work covers the best years of the 'Convertibility's' period performance (see below). When all banks are considered together, empirical results reveal X-inefficiencies representing around 20% of banking costs. Public banks consistently show (on average) higher costs than private banks. There is little difference between

Table 1. Bank system characterization (monetary values in million constant pesos of 2001).

Year	Banks	Employees	Branches	Deposits	Loans	Investment	Earned interests	Net revenues by services	Total costs	Results	Fixed assets
2002	61	82,159	3606	48,514	25,490	15,789	10,036	3020	14,300	−13,769	17,590
2003	57	78,357	3556	47,130	16,616	23,664	3444	2128	8508	−3,852	16,717
2004	56	79,335	3515	47,303	15,439	32,724	2605	2113	5694	−353	14,861
2005	57	83,562	3686	50,011	17,378	44,923	3286	2292	6279	919	12,019
2006	55	87,413	3728	50,266	20,042	41,396	4048	2396	6968	1792	10,517
2007	54	93,215	3790	51,249	22,935	41,367	4975	2626	7800	1371	8763
2008	54	93,654	3812	52,119	26,499	36,152	6680	2883	9258	1671	8337
2009	51	92,028	3833	51,101	25,784	34,555	7354	3082	9856	2339	6929
2010	48	94,358	3862	53,906	26,218	40,011	6894	3223	9845	2981	6840
2011	48	93,678	3862	57,973	30,728	40,936	8268	3438	10,681	3033	6724
2012	49	98,598	4077	60,036	34,575	36,360	10,548	3609	12,113	3213	6796
2013	50	99,846	4137	64,876	39,319	34,627	12,596	3831	14,023	4007	7160
2014	52	101,049	4193	64,337	36,739	40,960	13,646	3648	15,431	4641	7219
2015	52	84,083	4258	71,961	37,950	49,799	14,920	3949	17,780	5098	8300

Note: The selection of 2001 as base year has the purpose to facilitate comparisons with precedent works, developed along 1990s (during the parity 1 to 1 between peso and dollar). The deflator applied here is the ICC index, prepared by Instituto Nacional de Estadísticas y Censos.
Source: Authors' elaboration from Central Bank of Argentina data.

Table 2. Partial productivity indicators and average costs (in million constant pesos of 2001).

Year	Loans/ Employees	Investment/ Employees	Output/ Employees	Loans/ Branches	Investment/ Branches	Output/ Branches	Total cost/ Loans	Total cost/ Investment	Total cost/ Output
2002	310	192	502	7069	4379	11,447	0.56	0.91	0.35
2003	212	302	514	4673	6655	11,327	0.51	0.36	0.21
2004	195	412	607	4392	9310	13,702	0.37	0.17	0.12
2005	208	538	746	4715	12,187	16,902	0.36	0.14	0.10
2006	229	474	703	5376	11,104	16,480	0.35	0.17	0.11
2007	246	444	690	6051	10,915	16,966	0.34	0.19	0.12
2008	283	386	669	6951	9484	16,435	0.35	0.26	0.15
2009	280	375	656	6727	9015	15,742	0.38	0.29	0.16
2010	278	424	702	6789	10,360	17,149	0.38	0.25	0.15
2011	328	437	765	7957	10,600	18,556	0.35	0.26	0.15
2012	351	369	719	8481	8918	17,399	0.35	0.33	0.17
2013	394	347	741	9504	8370	17,874	0.36	0.40	0.19
2014	364	405	769	8762	9769	18,531	0.42	0.38	0.20
2015	451	592	1044	8913	11,695	20,608	0.47	0.36	0.20

Source: Authors' elaboration from Central Bank of Argentina data.

foreign and domestic banks' costs. Guala (2002b) examines economies of scale and scope of the Argentine banking system after the financial reforms in the early 1990s. Estimation results reveal significant levels of scale economies, although increasing returns turned out to be consistently lower in year 1999, indicating a shift over time towards higher efficiency. Clarke and Cull (1999) study provincial bank privatizations of the 1990s in Argentina,[2] decisions due to fiscal problems, bad bank performance and political incentives. At the beginning of the 1990s all Argentine provinces and some municipalities owned at least one bank. They were a cheap mean of financing deficits and provide political patronage. But an anti-inflationary program plus political and financial incentives drove some provinces to privatize their banks: the rewards of public ownership were not attractive anymore and bad assets could be isolated from the privatizing entities. At the same time, to limit lay-offs and branch closures, banks were sold at low prices. Buyers were attracted, on the other hand, to continue providing monopolistic banking services to subnational governments (including paying salaries to public servants). As equity and asset base of the new privatized banks increased, their ROA and ROE figures tend to decline. Clarke et al. (2005) compare the corporate governance of different kind of banks (private versus public, domestic versus foreign owned) in Latin America and point out that foreign banks have a different pattern of business than national ones, the former concentrated in big firms and the latter in medium and small size firms and individuals. Their empirical results suggest that large foreign banks are more inclined to lend to small business in Argentina and Chile than in Colombia and Peru. In most countries, medium and large domestic banks also lend relatively less to small business than local small banks. Clarke et al. (2005) jointly analyze the static, selection and dynamic effects of domestic, foreign, and state ownership on bank performance. State-owned showed in the 1990s poor long-term performance (static effect) and improvements following privatization (dynamic effects, in part due to relocation of bad assets into residual entities in order to improve the attractive of the institution on sale). Cost efficiency do not show improvements in spite of the removal of nonperforming assets, when those were empirically evaluated. They find that state-owned banks have relatively bad performance when compare to private, both domestic and foreign owned. Chortareas, Girardone, and Garza-Garcia (2010) analyze the banking system's performance in several Latin American countries, simultaneously testing efficiency and market power. For efficiency, they use non-parametric methods and the period of analysis is 1997–2005. Moya (2012) examines banking productivity after the 2002 crisis, distinguishing between private and public banks, and finds stagnant levels of productivity after 2007.

3. Estimation method

There are two general methodologies to construct efficiency frontiers: the econometric approach and the mathematical programming method. Their differences lie in two characteristics. The econometric approach, which we follow, is: (1) stochastic, and as such, it tries to distinguish pure randomness ('stochastic noise') from inefficiency effects (management decisions), and (2) parametric, so that it assumes a specific functional form for the relations it studies. In contrast, the mathematical programming method is generally (1) deterministic (not distinguishing between pure randomness and efficiency) and (2) non-parametric (not assuming a functional form).

The general form to estimate a cost frontier (Battese and Coelli 1992 formulation) is:

$$C_{it} = C\left(y_{it}, w_{it}, z_{it}; \beta\right) + v_{it} + u_{it} \tag{1}$$

where C_{it} is the observed cost for each bank i, in period t; y_{it} is the output vector; w_{it} is the input price vector; z_{it} is the environmental variable vector; β is the unknown parameter vector to estimate; $v_{it} \sim N(0, \sigma_v^2)$ is a random error which is independently and identically distributed, $u_{it} \sim N^{+}\left(\mu, \sigma_u^2\right)$ is an inefficiency parameter with truncated normal distribution. In addition, u_{it} and v_{it} are independently distributed from each other and from the model's covariates.

The stochastic frontier model and the inefficiency term are simultaneously estimated through maximum likelihood. The likelihood function is expressed in terms of: (1) the variance parameters for the compound error term σ^2, that is the sum of the variances σ_v^2 and σ_u^2 and (2) gamma, the ratio between the variances $\gamma = \frac{\sigma_u^2}{\sigma^2}$, where$\gamma \in (0;1)$. If $\gamma = 0$ then the remaining of the volatility is totally explained by the random component v.

4. Data

The data-set cover a ten-year period beginning in 2005 and ending in 2015. Given the information volatility between 2002 and 2004 (because of the above described events), estimations are limited to the mentioned period. At the same time, some observations from the database have not been considered due to inconsistencies. As well, we decided to focus the efficiency analysis in retail banks. Taking the above into consideration, a definitive but rather more reduced sample results with 437 observations (49 banks were included in the estimates) for the period 2005–15. However, the sample represents 95 percent of the system for the variables being used, which are detailed in Table 3.

Table 3. Variables included in estimations.

Variables	Notation	Construction	Variables in estimation
Costs	C	Wages + Fees + Administrative Expenses + Interests Paid	ln c = ln C/W3
Outputs	Yi	Y1: Loans (Personals + Pledge loans + Mortgages + Discounted documents + Bank overdrafts)	ln Y1
		Y2: Investments (Treasury bonds + Private securities + Central Bank securities)	ln Y2
		Y3: Net revenues for services	ln Y3
Inputs	Xj	X1: Employees X2: Loanable funds (Deposits) X3: Fixed assets	
Inputs prices	Wk	W1: Wage (Spending on Wages/Employees)	ln w1 = ln (W1/W3)
		W2: Cost of capital (Fees + Administrative Expenses/ Fixed Assets)	ln w2 = ln (W2/W3)
		W3: Unit Cost of loanable funds (Interest paid/ Deposits) W3 is the numeraire	
Time Tendency	*T*	*T* (*T* = 1, 2, …, N, for period 2005–2011, respectively)	*T*
		T^2: square of time	T^2
Environmental and dummy variables	Z1 Dm	Z1: Branches	Z1
		D_ext: Foreign Capital Dummy	D_ext

Note: C and Wk variables have been divided by the numeraire, W3, so that to accomplish homogeneity.
Source: Prepared by the authors.

The variables for costs, outputs and input prices used in regressions were expressed in logarithms. Estimated cost functions are not decreasing, are linearly homogenous and concave in inputs if estimated β related to outputs and inputs prices (first order coefficients) are not negative and satisfy the restriction that the sum of β is equal to 1 for all the considered inputs. The way to achieve homogeneity is by dividing all input prices by any of them. This implies using a price as a numeraire to impose homogeneity. The numeraire we use is the price of loanable funds. The dependent variable is also divided by the same numeraire.

Total Costs have been regressed on three outputs: 'loans', 'investments in public and private bonds' ('investments' hereafter), and 'net revenues for services'; three input prices (unit cost of labor, of capital, and of loanable funds – numeraire – each of which is calculated as a ratio between the cost component and an input indicator, respectively, employees, fixed assets and deposits), and a time trend. This model includes the 'core' variables. The time trend variable is included to capture the technological progress effect on costs or frontier shift occurring in time. We assume that technological progress directly affects the cost function; that is, banks are subject to the same technological shocks overtime. These shocks include a quadratic polynomial of time in the Trans logarithmic equation because this functional form is a second order approximation (including the T term as well as the T^2 term). The rate of technological change is given by: $T^* = \partial y/\partial t$. Time can affect costs due to technical change. If $T^* < 0$, technical change is positive, indicating a decrease in costs, and viceversa. We also developed variables to capture commonalities between categories of banks (a dummy for Foreign capital banks to distinguish them from National ones) and number of branches to proxy geographic coverage.

Table 4 shows descriptive statistics of the sample used in regressions. The variables are expressed in levels. It includes costs disaggregated in its four components, the outputs, the unit costs of inputs, fixed assets and equity, and physical variables that help constructing prices, partial productivity indicators and unit costs.

The Table 5 shows a characterization of the activities that different kinds of banks perform, according to the variable classification (defined at Table 3), and compares average

Table 4. Descriptive statistics for retail banks in period 2005–2015.

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Costs	437	258,117	373,059	3,122	2,479,822
Spending on Wages	437	66,211	102,432	966	637,307
Fees	437	5067	5911	140	34,831
Administrative Expenses	437	90,500	105,433	1456	499,753
Interest paid	437	96,339	184,343	207	1,459,213
Outputs	437	1,616,249	3,107,865	8204	24,537,804
Loans	437	693,829	966,987	1308	6,000,986
Deposits	437	1,371,889	1,992,744	7682	12,000,000
Investments	437	922,420	2,371,518	169	18,536,818
Net revenues for services	437	77,183	101,691	37	434,882
Average Labor Cost	437	27	8	6	60
Cost of loanable funds	437	0.07	0.06	0.01	0.63
Cost of capital	437	0.93	0.60	0.04	4.54
Fixed assets	437	195,327	331,192	1874	3,162,702
Equity	437	289,601	468,384	4331	3,590,924
Employees	437	2274	3162	50	17,436
Branches	437	95	127	1	632
ATMs	437	310	434	0	2318

Note: Variables in levels, thousand pesos of 2001 for every variable except for employees, branches and ATMs, measured in unities; some decimals have been simplified to facilitate figures display.
Source: Authors' elaboration from Central Bank of Argentina data.

Table 5. Lines of business by type of bank (average 2005–2015).

Classification	Loans/ Outputs* (%)	Investments/ Outputs (%)	Net revenues for services/Outputs (%)	Outputs/ Employees	Outputs/ Loanable funds	Outputs/ Fixed assets
Whole System	42.9	57.1	4.8	710.7	1.2	8.3
Private + Local	50.4	49.6	5.9	604.7	1.1	6.2
Private + Foreign	56.6	43.3	6.9	681.3	0.8	8.1
Public + Local	30.5	69.5	2.8	817.1	1.6	10.5

Note: *Outputs = loans, investments and net revenues for services.
Source: Prepared by the authors.

productivity indexes (productivity of labor, productivity per unit of loanable funds and productivity per unit of fixed assets) between types of banks.

The information displayed in the Table shows that Private + Local banks have a business pattern quite similar to Private + Foreign banks: almost half of their business are investments, and the other half are loans. Output per employee and per fixed assets is higher in Private + Foreign than in Private + Local banks. The destination of the loans is different (big business in the first case, medium and small in the second) but the investments are mainly public and Central Bank securities in both cases. In turn, Public + Local banks have 70 percent of their business in investments and their output per employee and per fixed assets is considerably higher than both groups of Private.

We compute three partial productivity indicators of total products/staff, total products/loanable funds and total products/fixed assets. Public are over above average while Private are below the average of the system in relation to the three inputs. The latter results are a direct consequence of the great weight of public securities in the portfolios of the Public banks. In contrast, net revenues for services are much higher in Private than in Public banks.

5. Results

5.1. Econometric estimations: searching for the relevant model

The models' estimated parameters are shown in Table 6: they are Translogarithmic frontiers (TL), either Time Invariant (TI) or Time Varying Decay (TVD) (two, Models 1 and 3 including only core variables, and two, Models 2 and 4 including both, core and environmental ones).

Note that first order parameters are significant in every model. Additionally, they have the expected signs. On the other hand, parameters related to quadratic terms and cost of capital, are significantly different from zero at different levels of significance. Something similar occurs with the time trend variable in every model. Almost half of the interactions evidence significance.

We could separate the compound error variance in one part for inefficiency and another part for random effects in every model. In fact, high values of γ in each case showed that the greater part of the compound error is explained by inefficiency (always over 97 percent).

From the TVD models we see that the parameter η were not significant, indicating that inefficiency remained constant in time.

We compared the models to determine which one best represents the phenomena under study according to the sample data. We conducted a Likelihood Ratio Test comparing the log-likelihood of TL version with the log-likelihood of the TVD model.[3] In addition, Akaike

Table 6. Estimations results for each model.

	Translogarithmic Estimates (TL)			
Dependent variable	Time Invariant (TI)		Time Variant Decay (TVD)	
	Model 1	Model 2	Model 3	Model 4
lnC	Without Environmental (WE)	Including Environmental (IE)	Without Environmental (WE)	Including Environmental (IE)
Variables	1 TL TI WE	2 TL TI IE	3 TL TVD WE	4 TL TVD IE
lnY1	0.193***	0.178***	0.193***	0.175***
lnY2	0.0497***	0.0442***	0.0497***	0.0444***
lnY3	0.225***	0.187***	0.226***	0.186***
Lnw1	0.587***	0.597***	0.586***	0.600***
Lnw2	0.108***	0.0960***	0.108***	0.0947***
$LnY1^2$	0.105***	0.0742***	0.105***	0.0723***
$lniY2^2$	0.0255***	0.0246***	0.0255***	0.0245***
$lnY3^2$	0.111***	0.0963***	0.111***	0.0959***
$Lnw1^2$	0.000109	0.00737	5.12e-05	0.00805
$Lnw2^2$	0.0804***	0.0926***	0.0805***	0.0913***
lnY1Y2	−0.0457***	−0.0436***	−0.0457***	−0.0425***
lnY1Y3	−0.0726***	−0.0646***	−0.0727***	−0.0640***
lnY2Y3	0.0136	0.00597	0.0137	0.00536
Lnw1w2	0.00986	−0.000568	0.00992	−0.000637
lnY1w1	0.0689***	0.0585***	0.0691***	0.0571***
lnY2w1	0.0550***	0.0521***	0.0551***	0.0512***
lnY1w2	−0.0154	−0.0171	−0.0154	−0.0179
lnY2w2	−0.00540	−0.00544	−0.00537	−0.00543
lnY3w1	−0.128***	−0.116***	−0.128***	−0.116***
lnY3w2	0.00809	0.0112	0.00782	0.0129
T	0.0156**	0.0176***	0.0159*	0.0160**
T^2	0.0121***	0.0114***	0.0121***	0.0114***
D_ext		0.756***		0.769***
Branches		0.0021***		0.0021***
Constant	−1.441***	−1.481***	−1.442***	−1.485***
$ln\sigma^2$	−0.548*	−0.970***	−0.554	−0.931***
llgt*γ*	4.037***	3.705***	4.030***	3.750***
μ	1.297***	1.176***	1.296***	1.196***
η			0.000255	−0.00173
σ^2	0.5780	0.3790	0.5744	0.3943
γ	0.9826	0.9760	0.9825	0.9770
$\sigma^2 u$	0.5680	0.3699	0.5643	0.3852
$\sigma^2 v$	0.0100	0.0090	0.0100	0.0091
Banks	49	49	49	49
Observations	437	437	437	437

Source: Prepared by the authors.
*significant at 10%; ** significant at 5%; ***significant at 1%.

Table 7. Likelihood ratio tests and Akaike and Bayesian information criterions results.

Likelihood ratio	Model	Log likelihood	Degrees of freedom	Akaike criterion	Bayesian criterion	Best model
LR $\chi^2(1) = 0{,}000$	1 TL TI WE	242.1862	26	−432.3725	−326.2942	✓
Prob > $\chi^2 = 0{,}956$	3 TL TVD WE	242.1878	27	−430.3756	−320.2174	
LR $\chi^2(1) = 0{,}15$	2 TL TI IE	269.7219	28	−483.4438	−369.2056	✓
Prob > $\chi^2 = 0{,}695$	4 TL TVD IE	269.799	29	−481.5979	−363.2799	
LR $\chi^2(1) = 55{,}07$	1 TL TI WE	242.1862	26	−432.3725	−326.2942	
Prob > $\chi^2 = 0{,}000$	**2 TL TI IE**	**269.7219**	**28**	**−483.4438**	**−369.2056**	✓
LR $\chi^2(1) = 55{,}22$	3 TL TVD WE	242.1878	27	−430.3756	−320.2174	
Prob > $\chi^2 = 0{,}000$	4 TL TVD IE	269.799	29	−481.5979	−363.2799	✓

The bold values indicates the best of all models.
Source: Prepared by the authors.

and Bayesian[4] information criteria are calculated as another analysis to determine the best model (Table 7).

In sum, TL TI including environmental variables (Model 2) would appear to be the best fit, according to the estimated parameter significance, likelihood ratio tests and information criteria.

Analyzing the best model, TL in its TI version, and, given that the data are centered in their means, first order estimated parameters show cost elasticity to output and input price variations. At the same time, we find a significant cross effect between loans Y1 and investments Y2, as well as between loans Y1 and net revenues for services Y3. In turn, a significant term for the time trend T suggests that a positive) technological change is present across this period. The γ value shows that 97.6 percent of total error variance can be explained by inefficiency variance.

5.2. Efficiency estimations

We show in Table 8 the cost efficiency of retail banks. Its average is a modest 0.34–0.36 range, with a 20–21 percent standard deviation.

To compare efficiency indicators between different types of banks, Central Bank of Argentina (BCRA) categories have been used to identify groups of banks with homogeneous characteristics. Then, we run means' differences test for each pair of categories at 5 percent confidence levels. In doing so, we consider three classifications: (1) type of property: public or private (including cooperative) in Table 9; (2) capital origin: national or foreign in Table 10; and (3) privatized or ever private in Table 11. In all cases we do not reject the null hypothesis that compared average efficiencies are equal. That is, we do not find differences

Table 8. Cost Efficiency for TL TI with environmental variables model Argentine Banking System as a whole.

Whole Sample	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mean	0.34	0.34	0.36	0.36	0.35	0.34	0.35	0.34	0.34	0.34	0.34
Standard deviation	0.21	0.21	0.22	0.22	0.22	0.20	0.21	0.21	0.21	0.20	0.20
N	437	437	437	437	437	437	437	437	437	437	437

Source: Prepared by the authors.

Table 9. Cost efficiency for TL TI with environmental variables model, Argentine Banking System Public versus Private.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Public											
Mean	0.36	0.36	0.38	0.38	0.37	0.36	0.37	0.36	0.36	0.36	0.36
Standard deviation	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04
Private											
Mean	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Standard deviation	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05
Public versus Private											
Private	33	33	32	31	27	27	26	27	27	29	29
Public	10	10	10	11	11	11	11	11	11	11	9
P-value (H°: Difference in mean = 0)	0.36	0.36	0.25	0.24	0.32	0.36	0.30	0.36	0.33	0.32	0.37

Source: Prepared by the authors.

Table 10. Cost efficiency for TL TI with environmental variables model, Argentine Banking System Foreign versus Local.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foreign											
Mean	0.33	0.33	0.33	0.33	0.33	0.25	0.25	0.25	0.25	0.25	0.25
Standard deviation	0.08	0.08	0.09	0.09	0.09	0.03	0.03	0.03	0.03	0.03	0.03
Local											
Mean	0.34	0.35	0.36	0.37	0.35	0.36	0.37	0.37	0.37	0.37	0.37
Standard deviation	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Foreign versus Private											
Foreign	9	9	8	8	8	7	6	7	7	7	7
Local	34	34	34	34	30	31	31	31	31	33	31
P-value (H°: Difference in mean = 0)	0.79	0.79	0.69	0.69	0.80	0.17	0.23	0.17	0.17	0.17	0.16

Source: Prepared by the authors.

Table 11. Cost efficiency for TL TI with environmental variables model, Argentine Banking System Privatized versus Always Private.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Privatized											
Mean	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Standard deviation	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Always Private											
Mean	0.34	0.34	0.36	0.36	0.35	0.34	0.35	0.34	0.34	0.35	0.35
Standard deviation	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04
Privatized versus Always Private											
Privatized	3	3	3	3	3	3	3	3	3	3	3
Always Private	40	40	39	39	35	35	34	35	35	37	35
P-value (H°: Difference in mean = 0)	0.95	0.95	0.86	0.85	0.92	0.98	0.92	0.95	0.95	0.94	0.93

Source: Prepared by the authors.

between average efficiencies of each group in each comparison. All *p*-values are greater than 0.10 (10 percent).

6. Conclusions

The objective of this paper was to apply frontier estimation methods to estimate retail banking system's efficiency and to compare the efficiency means of different subsamples of banks. A series of related questions have been answered through this empirical work:

(1) Which is the general efficiency level for retail banks? How did its efficiency evolve?
(2) Are there efficiency differences between public and private banks, national and foreign capital ones, and privatized and always private?

The system was reset in the last decade in the aftermath of a severe crisis. It counts with half as many of its fixed assets as before the crisis (2015 vs. 2001), lost 10 entities, increased 20 percent the number of branches, has a greater technological level (measured by the number of ATMs in use) and, above all, a totally different model of business based on very short-term deposits and loans, investment in treasury and Central Bank assets, and different services to its clients related to the payment system, which constitute an important source of revenue.

We used Stochastic Frontier Analysis, and constructed a sample of the retail banking system for the period 2005–15 to estimate a Trans logarithmic cost frontier.

In the selected model (Trans logarithmic Time Invariant, including environmental variables), the greater part of the compound error of estimations resulted from inefficiency.

When classifying banks according to their capital origin, and type of property, the results shows that Foreign banks prove to be less efficient than national ones in the same years. Public banks have a slight advantage over Private ones. There are not differences in efficiency means between privatized and always private banks. These results are congruent with partial productivity indexes computed earlier as a mean of the whole period.

Notes

1. The currency board system was named after the 1991 Convertibility Law, by the norm which established a pegged exchange regime and a 1/1 local currency backed with US dollar reserves in the Central Bank. The name 'Convertibility' recalled a quite similar crisis the country suffered a century ago and the instrument –pegging to Gold Standard and full convertibility of local currency- which in 1890 permitted the recovery and a quarter of century of prosperity.
2. 18 banks were privatized, but after privatization, some were merged into others or closed. Currently, remains 5 privatized banks.
3. The test is based on the calculus of $-2\left[L_R - L_U\right]$–where L_R is the log-likelihood of the restricted model and L_U is one of the unrestricted models– which is distributed as a chi-square with degrees of freedom equal to the number of restrictions. The null hypothesis specifies the restricted model.
4. The Akaike and Bayesian indexes are information criteria to measure the model fit to data and are used to select from alternative models. Both criteria penalize the loss of degrees of freedom (or the increase in the number of parameters to estimate). The best model is the one with the lowest value for each criterion.

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No potential conflict of interest was reported by the authors.

References

Battese, G., and T. Coelli. 1992. "Frontier Production Functions, Technical Efficiency and Panel Data: With Applications to Paddy Farmers in India." *Journal of Productivity Analysis* 3: 153–169.

Berger, A., G. Clarke, R. Cull, L. Klapper, and G. Udell. 2005, August. "Corporate Governance and Bank Performance: A Joint Analysis of the Static, Selection, and Dynamic Effects of Domestic, Foreign, and State Ownership." *Journal of Banking & Finance* 29 (8-9): 2179–2221. Elsevier.

Bikker, J., and J. Bos. 2008. *Bank Performance. A Theoretical and Empirical Framework for the Analysis of Profitability, Competition and Efficiency*. Routledge International Studies in Money and Banking.

Chortareas, G., C. Girardone, and J. Garza-Garcia. 2010. "Banking Sector Performance in Some Latin American Countries: Market Power versus Efficiency." Working Papers 2010–20, Banco de México.

Clarke, G., and R. Cull. 1999, May. "Why Privatize? The Case of Argentina's Public Provincial Banks." *World Development* 27 (5): 865–886. Elsevier.

Clarke, G., and R. Cull. 2005, October. "Bank Privatization in Argentina: A Model of Political Constraints and Differential Outcomes." *Journal of Development Economics* 78 (1): 133–155. Elsevier

Clarke, G., R. Cull, M. Martinez-Peria, and S. Sanchez. 2005, February. "Bank Lending to Small Businesses in Latin America: Does Bank Origin Matter?" *Journal of Money, Credit, and Banking* 37 (1): 83–118.

Damill, M., R. Frenkel, and L. Simpson. 2012. "Regulaciones financieras y macroeconomía en la post crisis: la reconstrucción del sistema bancario argentino en los años 2000." *Boletín Informativo Techint 337*. Enero-abril, Buenos Aires.

Guala, F. 2002a. "Evaluating Bank Efficiency Using Cost Frontier and Quantile Regression Analysis: The Case of Argentina in the Late 1990s." Working Paper, University of Illinois at Urbana Champaign Department of Economics.

Guala, F. 2002b. "Measuring Economies of Scale and Scope for the Argentine Bank Industry: A Comparative Analysis, 1996–1999." Working Paper, University of Illinois at Urbana Champaign Department of Economics.

Moya, R. 2012. "Productividad Del Sistema Financiero Argentino: ¿Son Los Bancos Públicos Eficientes?." Documento de Trabajo N° 117. FIEL. Buenos Aires, octubre.

Streb, J, L. D'Amato. 1996. "Economies of Scale and Degree of Capacity Utilization. Evidence from Retail Banks in Argentina." Documento de Trabajo 108. CEMA.

Van Hoose, D. 2010. *The Industrial Organization of Banking. Bank Behavior, Market Structure and Regulation*. Springer.