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Efficiency Determinants and Dynamic Efficiency Changes in Latin American Banking Industries

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Abstract: This paper investigates the dynamic and the determinants of banking industry efficiency in Latin America. Allocative, technical, pure technical and scale efficiencies are calculated and analyzed in each country. We find that Latin American bank managers have been using resources efficiently, but they are not choosing an optimal input/output. Additionally, we find that traditional banking performance measures are positively correlated with efficiencies while variables that measure banking and financial structure development and macroeconomics present mixed results.

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1. Introduction

Financial liberalization took place in many Latin American countries in the late 1980s. This liberalization had the objective of stabilizing prices and exchange rates and reducing fiscal deficits. Specifically for the banking sector, the liberalization eliminated government interest rate control; bank obligation to give subsidized loans, among others; and gave central banks more autonomy. This series of reforms in the Latin American banking industries has the primary objective of improving banking efficiencies. Unfortunately, financial liberalization in the region was accompanied by neither an effective regulatory and normative framework nor an effective monitoring of Latin American banking systems. After the financial liberalization in many Latin American countries, there was a more competitive banking environment and a reduced demand for credit arising from more instability. As a consequence, banks looked for new sources of profitability. For example, many important Latin American banks bought unrelated companies that required some banking managers to be transferred to business areas that they did not know; they also acquired very risky long-term investment (such as junk bonds) that promised high yield.

However, due to increasing economic disturbances, some of those Latin American banks became insolvent and could not pay depositors. This situation generated banking crises in four Latin American countries (Venezuela, Mexico, Argentina and Brazil) between 1993 and 1995. Those crises were consequences of external and internal economical factors, financial difficulties, lack of mandatory capitalization and/or bad managerial practices. Moreover, similar events led to banking crises in Colombia and Ecuador between 1998 and 2000.

One exception in the region is Chile, which did not have a banking crisis during the 1990s. This country implemented structural reforms in the 1980s and its banking industry

operated in a strong macroeconomic environment, accompanied by a fairly good regulatory system, allowing the banking system to develop without financial distress (Wong, 2006).

The different banking crises forced governments in the region to adopt a series of additional reforms to escape the crises and to foster the growth of the banking system. These reforms mainly resulted in opening the market to foreign investment in the banking system, thereby allowing the creation of universal banks and either closing or privatizing public banks, among others. In general, governments passed stricter laws and regulations that require banks to adhere to the standards of the Basle accord, such as to work only in the financial business and to meet increased capital requirement, among others.

The reforms brought consolidation of the banking system, reductions in the number of banks (through merger and acquisitions), and increased bank concentration. This led practitioners, as well as the Latin American press, to claim that, in the new environment, an improvement of banking efficiencies should be observed. Nevertheless, Berger and Humphrey (1997) note that there are mixed results in the literature regarding this outcome and there is no conclusive evidence that financial deregulation and disruption have improved the efficiencies in banking systems.

A related question is whether financial structure and macroeconomic health affect efficiencies. For instance, Bossone and Lee (2002) argue that a well-developed financial system should support banking activities, making the banking industry more efficient; this means that a developed financial structure should enhance banking efficiencies because of greater competition. Additionally, the general health of a country's economy can be expected to improve banking efficiencies. For example, high inflation reduces the amount of financing to the private sector (Boyd, Levine, and Smith, 2000) and, consequently, banks have to reallocate their assets, affecting their economic efficiencies.

This paper comprehensively examines revenue, profit, cost allocative, technical, pure technical and scale efficiencies and their determinants in seven Latin American countries (Argentina, Brazil, Chile, Colombia, Ecuador, Mexico and Venezuela) during the period 1996-2003. A study of the dynamic changes of efficiencies after financial liberalization in those countries is missing in the literature. Furthermore, the determinants of banking efficiencies in Latin American via bank-specific financial structure and macroeconomic variables remain unanswered. Specifically, this paper investigates the major sources of economic inefficiencies, the causal relationships between economic efficiencies and bank-specific performance, financial structure and economical conditions, and change in efficiencies and productivity after deregulation in a more stringent regulatory framework in Latin America.

The paper first analyzes absolute efficiencies and traces the sources of inefficiencies in each country. Afterward, it investigates the determinants of the different efficiency measures by performing a fixed effect regression of the efficiencies on bank-level performance ratios, country-level financial and banking infrastructure measures, and country-level macroeconomic performance. In addition, the paper analyses the relative changes in efficiencies and total factor productivity index during the period 1996-2003. Data Envelopment Analysis is used to compute absolute efficiencies as well as Malmquist indices, which can be used to characterize productivity change in each country.

We find that most of the sources of inefficiencies are allocative (regulatory) rather than technical (managerial) in the selected counties. This means that bank managers are not choosing the correct (optimal) input and output mix because they are forced not to do so, given the environmental conditions (either government regulations or market conditions) faced in their respective countries. Moreover, the decomposition of technical efficiency into pure technical efficiency and scale efficiency shows that scale inefficiency has impacted most of the technical

inefficiencies of Latin America's banking industries. Thus, the results suggest that bank managers in Latin America countries are using bank resources efficiently but they are choosing a wrong mix of input and output, for reasons beyond their control.

Further study of the determinants of banking efficiencies shows that net interest margin is negative associated with all efficiencies (but cost efficiency), which is consistent with the assertion that high NIM should be negatively related with efficiency, because wider margins suggest lower competition (Dermiguc-Kunt and Levine, 1999). Moreover, traditional measures of bank performance such as assets quality ratios (loan loss reserves over gross loan), capital ratios (equity over total asset and capital funds over liabilities), and operation ratios (return on equity and return on assets) are consistent with the estimated efficiencies (for example, high ROE is positively related with high efficiency). Finally, praxis for measuring financial structure development shows mixed results. For example, concentration, measured as total assets of the three biggest banks over the country's total assets, is negatively related with scale technical efficiencies, but positively related with cost, profit and revenues efficiencies. These mixed results can be interpreted in two ways. On one hand, a negative relationship between concentration and scale efficiency suggests a degree of oligopoly in Latin American countries. On the other hand, a positive relationship between cost, profit and revenues efficiencies and concentration suggests high bank profitability because of their superior managers or production technologies.

Analyses of the efficiency dynamic demonstrate that most of the countries have had technological progress in their banking industries. However, in a few countries, the banking industry had technological progress but also showed decreased technical efficiency, which implies that banks are not using technology efficiently and resources are wasted. More important, countries that had their banking crisis between 1993 and 1995 (Argentina, Brazil,

Mexico and Venezuela), and that made further reforms to improve the banking system after the crises, experienced a decline in technical efficiencies.[1] Thus, after financial liberalization in these countries, combined with stricter regulation after the crisis, there was a decline in technical efficiency.

The remainder of this paper is divided as follow. Section 2 shows how efficiencies are estimated. Additionally, the estimates of sample statistics for inputs, outputs and prices are discussed in this section. Furthermore, section 2 analyzes and traces the sources of inefficiencies in each country. Section 3 explains the determinants of Latin American banking industry efficiency while section 4 studies productivity changes. Section 5 concludes.

2. Estimation of efficiencies

We calculate efficiencies using Data Envelopment Analysis (DEA) and then use the estimated efficiencies as dependent variables in regressions, where the explanatory variables are comprised by both bank-level characteristics and country-level characteristics (macroeconomic and financial structure). This section explains how efficiencies are calculated and analyzes the estimated efficiencies, whereas the next section explains the regression set-up and justifies the explanatory variables.

A firm's productivity is the ratio of outputs to inputs and it depends on production, process technology, and differences in environments in which production occurs, among other variables. The firm's efficiency is a comparison between observed and optimal values of outputs and inputs. The set of the optimal outputs, given the inputs (or the optimal inputs, given the outputs) is the efficient frontier. Farrell (1957) defines a simple measure of firm efficiency that could account for multiples inputs. He proposes that efficiency of any firm consists of two

[1] The only exception is Venezuela, which experienced an increase of 11 percent technical efficiency in between 1996-2003.

components: *technical efficiency*, or the ability of the firm to maximize outputs from the given set of inputs, and *allocative efficiency*, or the ability of the firm to use theses inputs in optimal proportion given their respective prices. Combining these two measures provides a measure of economic efficiency.[2] One measure of this economic efficiency is *cost efficiency*, which measures how far a bank's cost is apart from the best practice bank's cost that produces the same output level and under the same environmental conditions. *Cost efficiency* can be decomposed into *technical efficiency* and *allocative efficiency*. The level of *technical efficiency* is related to managerial decisions while *allocative efficiency* is related to the regulatory environment or macroeconomic conditions (Lovell, 1993).

Technical efficiency can be decomposed in two parts, one due to *scale efficiency*, and one due to *pure technical efficiency*. *Pure technical efficiency* refers to the firm's ability to avoid waste by producing as much output as input usage allows, or by using as little input as output production allows. Scale efficiency refers to the firm's ability to work at its optimal scale. Other measures of economic efficiencies are *revenue efficiency* and *profit efficiency*. While *revenue efficiency* measures the ratio between current revenues to optimal revenues given prices and outputs, profit *efficiency* measures the ratio of current profits to optimal profits, given inputs, outputs and their respective prices. In summary, we calculate cost, revenues and profit efficiencies and further decompose cost efficiency into technical efficiency and allocative efficiency. We also decompose technical efficiency into pure technical efficiency and scale efficiency.

In order to get these efficiency measures, a production function of a benchmark efficient firm has to be estimated from a sample data. There are two approaches to approximate the efficient production function: the parametric approach and the non-parametric approach. These

[2] Economic efficiency is also known as productive or overall efficiency.

approaches use different techniques to envelop the observed data and make different accommodations for random noise and for the flexibility in the structure of the production technology (Lovell, 1992).

The parametric (or econometric) approach specifies a production function and recognizes that deviation away from this given technology is given by two components; one represents statistical noise and the other represents inefficiency. The random term is due to events outside the control of the firm, e.g. uncontrollable factors directly related with the production function, or econometric error such as misspecification of the production function or measure errors. This has led to the development of the "Stochastic Frontier Approach" (SFA), which seeks to take into account external factors when estimating the efficiency of the firms.

The non-parametric approach does not require a production function in order to calculate the efficiency. It attempts to determinate the efficiency of the firm against some imposed benchmark through mathematical programming. The most common version of this approach is Data Envelopment Analysis (DEA). This paper uses the non-parametric approach, DEA, to estimate the production technology for the set of Latin American banking industries. We use Data Envelopment Analysis (DEA) because it allows us to perform analysis with small samples, which is the case for Latin American countries, and also allows us to calculate Malmquist indexes to characterize productivity changes.[3] DEA is a linear programming technique that allows calculating the relative efficiency of a business unit. It was developed by Charnes, Cooper and Rhodes (1978) in order to measure relative efficiency without knowing (*a priori)* what variables are more important, or what the relationship among them is.

[3] The estimation of economic efficiencies has become standard in the literature; therefore, we do not explain the technical details of how to get efficiencies and Malmquist indexes using DEA. Interested readers are referred to Coelli (1996) or Zhu (2003).

DEA can be used to calculate the Malmquist index, which measures productivity change that is decomposed into *technological change* and *efficiency change*. The index may be interpreted as an index of *total factor productivity*. It takes into account whether firms are improving in the use of resources to produce goods and services, and whether the existing technology has shifted. Values greater than one mean increases in productivity, while values less than one indicate decreases in productivity over time. The *technical efficiency* change can be further decomposed into *pure technical change* - whether managers have improved using resources - or *scale efficiency change* - whether the bank has moved to an optimal scale relative to the frontier. However, a change in *scale efficiency* may be caused either by (i) changes in the shape of the technology, (ii) change in the location of the bank in the input/output space from one year to another, or a combination of (i) and (ii); a change in the *pure technical efficiency* is caused by a movement of the bank relative to the existing technology (under managerial control).

2.1. Empirical Design

In any performance analysis, production units are expected to be relatively homogenous, providing similar services and using similar resources. This study concentrates only on commercial banks because they are relatively homogenous in each Latin American country.[4] Thus, the sample is all commercial banks with available information during the period 1996 – 2003 from the Bankscope database. Table 1 summarizes the commercial banks' characteristics in the selected countries. Panel A shows the number of banks per country and per year. In the sample, Brazil is the country with the most banks, followed by Argentina; others countries have a similar number of banks. The number of banks has declined because of mergers, acquisitions and closure of bankrupted banks.

[4] We exclude savings institutions because of their small market share in the sector as well as significantly different technology, structure and purpose.

Table 1: Number of banks per year

Country Name	1996	1997	1998	1999	2000	2001	2002	2003
Panel A. Number of Banks								
Argentina	84	85	90	83	77	77	70	51
Brazil	135	133	132	129	132	139	124	82
Chile	29	29	28	27	28	27	26	26
Colombia	29	30	28	25	26	25	26	26
Ecuador		34	34	29	34	34	34	31
Mexico	35	35	36	36	36	33	36	33
Venezuela	18	17	20	40	45	42	36	33
Panel B. Concentration (%)								
Argentina	41.9	32.8	28.8	29.8	30.1	34.4	40.3	50.5
Brazil	32.6	35.2	39.4	38.3	40.4	40.2	43.9	49.3
Chile	39.1	43.6	43.2	43.0	40.5	41.1	57.0	56.5
Colombia	36.5	32.7	36.3	33.5	32.1	31.8	32.5	32.7
Ecuador		46.3	44.2	49.1	44.3	45.0	47.1	51.0
Mexico	55.0	62.5	60.7	50.2	55.7	60.3	60.5	58.8
Venezuela	51.8	50.6	47.7	42.5	44.7	43.0	43.6	46.0
Panel C. Median Size (Millions nominal U.S. $)								
Argentina	270	366	405	382	308	257	89	148
Brazil	301	346	289	317	368	295	384	653
Chile	413	492	564	611	1,195	1,524	744	698
Colombia	496	634	516	760	858	1,112	923	941
Ecuador	102	114	109	47	39	58	72	71
Mexico	352	289	277	462	452	599	531	692
Venezuela	380	792	610	192	115	195	142	250
Panel D. Average Size (Millions nominal U.S. $)								
Argentina	889	1416	1682	1880	2121	1711	785	700
Brazil	1386	1615	1565	1739	1897	2137	2833	4411
Chile	1368	1452	1703	1887	2115	2392	2605	2717
Colombia	1010	1099	1042	1051	1001	1065	938	1068
Ecuador	354	236	231	132	115	166	187	221
Mexico	3804	3686	3304	4376	4399	5052	4482	5043
Venezuela	728	1096	1017	566	621	667	505	685

Concentration is defined as the total assets of 3 biggest banks over total assets in the country. Size is the bank's total asset in U.S. $ million.

As in many developing countries, Latin America has a very high level of concentration in the banking industry. Panel B shows the level of concentration, which is defined as the three biggest banks' assets over total assets of all commercial banks, in each country. Mexico has the highest level of concentration - the three biggest banks account for more than 50 percent of the

total country assets - while Colombia presents the lowest level of concentration. The level of concentration in Brazil is very high relative to the number of banks that it has, which indicates that many Brazilian banks are relatively small. We also note that concentration has increased over the period in all countries except Venezuela. We discuss concentration as a characteristic of the country's financial structure later in this paper.

Because of the high level of concentration, it is important to compare each country's industry by its median asset level, instead of the average asset level. Panel C shows the median size, measured as total assets in U.S. $ millions. Despite the number of banks and level of concentration, our sample is similar in banks' size across countries as measured by the median.[5]

2.2 Definition of data

DEA requires a set of inputs and outputs in order to measure efficiency, and therefore, relative productivity. There are two main approaches to measure efficiency: the *production approach* and the *intermediation approach*. In the first approach, outputs are measured as number of bills or processed transactions, and inputs are measured as capital or labor force, but not interest expenses. In contrast, the second approach assumes that banks are considered brokers, who transform financial resources in profits. This approach is more commonly used in the study of banking efficiency and so we adopt the intermediation approach in this study. Accordingly, we model commercial banks as multi-product firms, producing three outputs and employing three inputs. All variables are measured in 2000 real US $ millions, excepting the prices which are measured as ratios.

The output vector includes (1) net loans [LOANS]; (2) off-balance sheet items [OFF_BS], which includes guaranties and warranties (letter of guarantee, bank acceptance,

[5] We also check the first and third quartile and – with the exception of Ecuador – all countries have similar bank size distribution.

letters of credit, guaranteed pre-financing, endorsements and others), commitments, foreign exchange and interest rate transactions as well as other off-balance sheet activities; and (3) other earning assets [OTHER_EA], which consist of loans to special sectors, inter-bank funds, and investment securities (treasury bills, government bonds and other securities). All output prices are estimated by proxies, which are calculated as flows over the years divided by these stocks: (1) price of the loans [P(LOANS)] is the total interest income over net loans: 2) price of other operating income [P(OTHER_EA)] is defined as other operating income over other earning assets; (3) price of balance sheet items [P(OFF_BS)] is other operating income over off-balance sheet items.

The input vector includes: (1) Overhead [LABOR];[6] (2) book value of premises and fixed assets [CAPITAL]; (3) loanable funds [FUNDS], the sum of deposit (demand and time) and non-deposit funds as of the end of respective year. Also inputs prices are estimated by proxies: (1) price of labor [P(LABOR)] is calculated as overhead over total assets; (2) price of capital [P(CAPITAL)] is calculated as non-interest expense over total assets; and (3) price of funds [P(FUNDS)] is calculated as total interest expenses over loanable funds.

2.3 Sample Statistics

Table 2 shows summary statistics for output, inputs and their respective prices by country (average 1996-2000, real U.S. $ millions). Panel A shows outputs and their prices, whereas panel B shows inputs and their prices. Isik and Hassan (2002) argue that the off-balance sheet items are important in estimating efficiency because they represent a significant resource that a bank uses in its operations. Off-balance sheet items [OFF_BS] represent the most important output in value for Chile, Colombia, Ecuador and Venezuela and are an important proportion in

[6] Since many banks in each country do no report personnel expenses in the balance sheet, we were unable to proxy labor using this item; instead, we use overhead that includes personnel expenses and other administrative expenses.

Argentina. Also, off-balance sheet items have the highest price in all the countries except for Mexico and Venezuela. In Mexico, this price is comparable to that of other earning assets. The significantly larger size and price of this item emphasizes the importance of considering off-balance sheet in efficiency studies.

Table 2: Average outputs/inputs and their prices

Panel A. Output (2000 real U.S. $ millions) and their prices

	Argentina	Brazil	Chile	Colombia	Ecuador	Mexico	Venezuela
Outputs							
LOANS	681.6 (-)	661.2 (+)	1,306.0 (+)	641.7 (-)	104.4 (-)	2,532.6 (+)	325.8 (-)
OTHER_EA	543.2 (-)	1,188.7 (+)	436.2 (+)	240.2 (+)	62.4 (+)	928.9 (+)	213.6 (-)
OFF_BS	634.2 (-)	162.8 (+)	1,848.0 (-)	854.1 (-)	206.7 (-)	186.3 (+)	1,217.0 (-)
Output Price							
P(LOANS)	0.277 (+)	0.658 (-)	0.178 (-)	0.236 (-)	0.337 (-)	0.407 (-)	0.527 (+)
P(OTHER_EA)	0.130 (+)	0.195 (+)	0.113 (+)	0.274 (-)	0.268 (-)	1.128 (+)	0.325 (+)
P(OFF_BS)	2.064 (+)	2.069 (+)	1.700 (-)	1.121 (-)	0.977 (+)	1.078 (+)	0.035 (+)

Panel B. Input (2000 real U.S. $ millions) and their prices

Inputs							
CAPITAL	87.0 (+)	51.4 (+)	46.8 (+)	46.4 (-)	19.3 (-)	122.9 (+)	27.9 (-)
FUNDS	1,212.8 (-)	1,484.5 (+)	1,466.3 (+)	804.2 (+)	168.0 (-)	3,606.4 (+)	613.4 (-)
LABOR	86.6 (+)	140.8 (+)	59.9 (+)	89.5 (-)	14.7 (-)	200.9 (+)	66.7 (-)
Input prices							
P(CAPITAL)	0.050 (+)	0.136 (-)	0.051 (-)	0.093 (-)	0.310 (+)	0.195 (-)	0.063 (-)
P(FUNDS)	0.096 (+)	0.400 (+)	0.073 (-)	0.211 (+)	0.139 (-)	0.980 (+)	0.635 (+)
P(LABOR)	0.089 (+)	0.072 (-)	0.034 (+)	0.097 (+)	0.161 (+)	0.063 (+)	0.105 (+)

The output vector includes (1) net loans [LOANS]; (2) off-balance sheet items [OFF_BS], which includes guaranties and warranties (letter of guarantee, bank acceptance, letters of credit, guaranteed pre-financing, endorsements and others), commitments, foreign exchange and interest rate transactions as well as other off-balance sheet activities; and (3) other earning assets [OTHER_EA], which consist of loans to special sectors, inter-bank funds, and investment securities (treasury bills, government bonds and other securities). All output prices are estimated as proxies, which are calculated as flows over the years divided by these stocks: (1) price of the loans [P(LOANS)] is the total interest income over net loans: 2) price of other operating income [P(OTHER_EA)] is defined as other operating income over other earning assets; and (3) price of balance sheet items [P(OFF_BS)] is other operating income over off balance sheet items. Inputs vector include: (1) Overhead [LABOR]; (2) book value of premises and fixed assets [CAPITAL]; and (3) loanable funds [FUNDS], the sum of deposit (demand and time) and non-deposit funds as of the end of respective year. Also inputs prices are estimated as proxies: (1) price of labor [P(LABOR)] is calculated as overhead over total assets; (2) price of capital [P(CAPITAL)] is calculated as non-interest expense over total assets; and (3) price of funds [P(FUNDS)] is calculated as total interest expenses over loanable funds.

Off-balance sheet items are revenue generators in Latin American banking industries and the exclusion of this variable in efficiency analysis may cause bias in the results against banks that are actively involved in such activities (Isik and Hassan, 2002).

In many developed countries, loans [LOANS] represent an important output for estimating bank efficiency because the larger this figure, the larger revenues. In contrast, other earning assets [OTHER_EA] represent in Latin American a significant proportion of output and is an important generator of revenues. Some banks are more involved in inter-bank activities or direct lending, which is reflected in other earning assets. In Brazil, for example, the level of other earning assets is higher than the level of loans and it also has the highest price. In summary, at least in Latin America, "other earning asset" is a significant variable to be included in studies of banking efficiencies.

Panel B of Table 2 shows inputs and their prices. The most important input in value is loanable funds [FUNDS] for all countries, while fixed assets and overhead shows mixed results for different countries. Loanable funds are the most expensive among inputs for all countries but Ecuador, where capital is the most expensive. Regarding LABOR and CAPITAL, their order in importance differs across countries. In some countries, one is more important than the other, which reflects the different environments in which each banking industry is competing.

2.4 Analysis of Efficiencies Estimate

We analyze the sources of inefficiencies for each country based on the efficiency measures calculated relative to its own country production frontier, which is useful for both regulators and managers to improve the competitiveness of their industries. Knowing the sources of inefficiencies would allow them to trace a plan to make their respective industries more competitive. This section summarizes the main sources of inefficiencies for each country.

Table 3 presents efficiencies per year and country. Panel A shows the results for Argentina. Revenue, profit and cost efficiencies in this country decreased during the period, which is the result of economic crisis that led to the currency depreciation in 2002. Moreover,

technical efficiencies have been relatively low, averaging 70.6 percent during the period.[7] This implies that managers have been wasting resources in this country. The decomposition of technical efficiency into pure technical efficiency and scale efficiency shows that the problem is in the inefficient use of resources rather than in banks working at less than at an optimal scale.

Table 3: Revenue, profit and cost efficiencies

	1996	1997	1998	1999	2000	2001	2002	2003	Average
Panel A. Argentina									
1– Revenue efficiency	0.621	0.521	0.571	0.503	0.360	0.409	0.272	0.422	0.460 (–)
2– Profit efficiency	0.533	0.486	0.513	0.471	0.316	0.354	0.289	0.352	0.414 (–)
3– Cost efficiency	0.653	0.677	0.630	0.510	0.429	0.271	0.312	0.401	0.486 (–)
a– Allocative efficiency	0.854	0.856	0.814	0.680	0.650	0.411	0.525	0.612	0.675 (–)
b– Technical efficiency	0.765	0.791	0.774	0.750	0.660	0.660	0.594	0.656	0.706 (–)
b1– Pure technical efficiency	0.843	0.871	0.856	0.841	0.830	0.790	0.758	0.826	0.827 (–)
b2– Scale efficiency	0.907	0.907	0.903	0.886	0.798	0.820	0.771	0.789	0.848 (–)
Panel B. Brazil									
1.– Revenue efficiency	0.075	0.151	0.329	0.226	0.067	0.057	0.184	0.219	0.164 (+)
2.– Profit efficiency	0.043	0.094	0.242	0.150	0.037	0.027	0.118	0.181	0.111 (+)
3.– Cost efficiency	0.029	0.160	0.223	0.187	0.101	0.168	0.124	0.143	0.142 (+)
a.– Allocative efficiency	0.101	0.420	0.397	0.471	0.400	0.625	0.326	0.328	0.384 (+)
b.– Technical efficiency	0.288	0.382	0.562	0.398	0.252	0.268	0.381	0.435	0.371 (–)
b1 .– Pure technical efficiency	0.698	0.723	0.723	0.662	0.521	0.508	0.580	0.625	0.630 (–)
b2 .– Scale efficiency	0.406	0.529	0.780	0.621	0.555	0.611	0.700	0.726	0.616 (+)
Panel C. Chile									
1– Revenue efficiency	0.743	0.713	0.760	0.147	0.119	0.127	0.430	0.527	0.446 (–)
2– Profit efficiency	0.666	0.723	0.728	0.215	0.298	0.268	0.478	0.558	0.492 (–)
3– Cost efficiency	0.524	0.523	0.520	0.382	0.334	0.499	0.496	0.600	0.485 (+)
a– Allocative efficiency	0.598	0.580	0.579	0.438	0.375	0.568	0.555	0.742	0.554 (+)
b– Technical efficiency	0.877	0.902	0.898	0.873	0.891	0.879	0.893	0.808	0.878 (–)
b1– Pure technical efficiency	0.936	0.922	0.927	0.931	0.942	0.920	0.937	0.903	0.927 (–)
b2– Scale efficiency	0.937	0.978	0.968	0.934	0.942	0.954	0.951	0.892	0.945 (–)
Panel D. Colombia									
1– Revenue efficiency	0.083	0.070	0.284	0.001	0.132	0.447	0.416	0.454	0.236 (+)
2– Profit efficiency	0.040	0.054	0.256	0.374	0.087	0.485	0.373	0.406	0.259 (+)
3– Cost efficiency	0.421	0.402	0.530	0.667	0.391	0.587	0.508	0.340	0.481 (–)
a– Allocative efficiency	0.773	0.606	0.896	0.892	0.664	0.769	0.664	0.504	0.721 (–)
b– Technical efficiency	0.545	0.663	0.592	0.748	0.589	0.763	0.765	0.674	0.667 (+)
b1– Pure technical efficiency	0.685	0.725	0.858	0.748	0.744	0.870	0.825	0.823	0.785 (+)
b2– Scale efficiency	0.792	0.908	0.714	1.000	0.835	0.882	0.924	0.821	0.860 (+)

[7] The 70.6 percent means that the average bank could have produced the same level of output using 70.6 % of the resources actually employed.

Panel E. Ecuador								
1– Revenue efficiency	0.848	0.750	0.641	0.474	0.353	0.048	0.281	0.485 (–)
2– Profit efficiency	0.681	0.624	0.734	0.509	0.609	0.101	0.431	0.527 (–)
3– Cost efficiency	0.824	0.732	0.825	0.607	0.669	0.475	0.487	0.660 (–)
a– Allocative efficiency	0.910	0.828	0.925	0.741	0.818	0.696	0.642	0.794 (–)
b– Technical efficiency	0.906	0.884	0.892	0.819	0.818	0.682	0.758	0.823 (–)
b1– Pure technical efficiency	0.960	0.923	0.898	0.859	0.828	0.774	0.927	0.881 (–)
b2– Scale efficiency	0.943	0.953	0.992	0.957	0.978	0.788	0.788	0.914 (–)

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Average**
Panel F. Mexico									
1– Revenue efficiency	0.312	0.469	0.345	0.438	0.308	0.346	0.300	0.334	0.356 (–)
2– Profit efficiency	0.379	0.308	0.455	0.402	0.288	0.333	0.256	0.271	0.337 (–)
3– Cost efficiency	0.712	0.335	0.273	0.656	0.630	0.521	0.535	0.417	0.510 (–)
a– Allocative efficiency	0.848	0.397	0.600	0.830	0.860	0.733	0.746	0.587	0.700 (+)
b– Technical efficiency	0.840	0.845	0.455	0.790	0.733	0.711	0.717	0.710	0.725 (–)
b1– Pure technical efficiency	0.933	0.916	0.935	0.915	0.845	0.854	0.856	0.889	0.893 (–)
b2– Scale efficiency	0.899	0.923	0.473	0.863	0.881	0.849	0.839	0.792	0.815 (–)
Panel G. Venezuela									
1– Revenue efficiency	0.624	0.667	0.728	0.338	0.282	0.338	0.227	0.251	0.432 (–)
2– Profit efficiency	0.588	0.810	0.724	0.338	0.232	0.276	0.216	0.333	0.440 (–)
3– Cost efficiency	0.749	0.853	0.809	0.322	0.138	0.173	0.104	0.178	0.416 (–)
a– Allocative efficiency	0.924	0.962	0.948	0.549	0.318	0.296	0.195	0.285	0.560 (–)
b– Technical efficiency	0.811	0.887	0.853	0.587	0.434	0.584	0.535	0.623	0.664 (–)
b1– Pure technical efficiency	0.831	0.914	0.893	0.826	0.752	0.851	0.763	0.754	0.823 (–)
b2– Scale efficiency	0.971	0.968	0.950	0.719	0.624	0.683	0.694	0.820	0.804 (–)

Efficiencies are estimated using Data Envelopment Analysis (DEA). *Technical efficiency* refers to banks' ability to minimize inputs from the given set of output. A*llocative efficiency* is banks' ability to use theses inputs in optimal proportion, given their respective costs. The multiplication between *allocative efficiency* and *technical efficiency* provides cost efficiency (also called economics efficiency). The *technical efficiency* can be decomposed in two parts, one due to *scale efficiency*, and one due to *pure technical efficiency*. *Pure technical efficiency* refers to the firm's ability to avoid waste by producing as much output as input usage allows. *Scale efficiency* refers to the firm's ability to work at its optimal scale.

Allocative efficiencies were relatively high in 1997, but they decreased during the period as a result of Argentina's economic problems that ended in a currency crisis in 2002. The low allocative efficiency implies that managers are forced to choose an incorrect input and output mix because of the economic or regulatory conditions. The source of economic inefficiency is

due primarily to the economic environment (low and decreasing allocative efficiency), which results in low overall cost, revenues and profit efficiencies.[8]

Panel B shows Brazil's efficiencies. The average technical efficiency is 37 percent and it is because of both pure technical inefficiency and scale inefficiency. This means that managers are wasting resources and their banks are not working at optimal scale. Moreover, the low allocative efficiencies imply that the regulatory framework and/or economic conditions play an important role in economic efficiencies in the country. In summary, the level of efficiencies suggests that there is room for improvement at the bank level (managers) and regulatory level (policy makers) in this country.

Panel C shows Chile's efficiencies. The banking industry in Chile has been consistently efficient, averaging 87.8 percent technical efficiency. The major source of inefficiency is allocative (regulatory). This low allocative efficiency suggests that there are opportunities for improvement in the regulation of the system.

Panel D presents Colombia's efficiencies. The largest inefficiencies are revenue inefficiency, followed by profit inefficiency. The major source of inefficiency is allocative (regulatory) rather then technical (managerial). Managers are choosing (or are forced to choose by the regulatory conditions) a wrong input and output mix, given the regulatory framework and demand in the system. This problem is even severe on revenue, in which the efficiency is only 23 percent. This inefficiency is related to regulatory rather than managerial problems when using the resources, which is implied by the relative high technical efficiency that improved in the last three years.

Panel E shows Ecuador's efficiencies. Technical efficiencies are larger than revenue allocative efficiency in Ecuador, which implies – similar to the Chilean case – that the regulatory

[8] Overall (or economic) efficiency is the product of technical efficiencies and allocative efficiencies.

framework has affected the overall efficiency more rather than the managerial use of resources. The higher allocative revenue inefficiency implies that managers are choosing an incorrect mix of outputs, given the regulatory environment and/or market conditions. However, they do not waste significant resources, since technical efficiency is relatively high. The drop in the technical efficiency in 2002 and 2003 was due to a drop in scale efficiency, whereas the huge drop in revenue efficiency in 2002 was most likely due to the banking crisis at that time.[9]

The cases of Mexico and Venezuela are similar to the Chilean and Ecuadorian cases (panels F and G). The source of economic inefficiencies is allocative rather than technical. Banks choose a non–optimal mix of inputs and outputs because of either the regulatory framework or macroeconomic conditions. In summary, most sources of inefficiencies are allocative. Thus, most Latin American banks confront either a stringent regulatory framework that reduces efficiency, or an unhealthy economic environment that forces managers to choose a wrong mix of output and inputs.

3. Explaining Banking Efficiencies

The efficiency of a banking system depends on bank-level performance, the level of development in the financial system, and the macroeconomic health of the country. We investigate the determinant of Latin American banking efficiencies by running the following fixed effect regression for each efficiency estimate:

$$Eff = \mathbf{b}'\mathbf{BANK} + \mathbf{f}'\mathbf{FIN} + \mathbf{m}'\mathbf{MACRO} + \mathbf{t}'\mathbf{YEAR} + \mathbf{a}'\mathbf{COUNTRY} + \varepsilon$$

where *Eff* is the efficiency estimate. **BANK** is a vector comprised of the following ratios: loan loss reserve to gross loan [LLR_GR], equity to total assets [EQ_TA], capital funds to total liabilities [CF_L], net interest margin [NIM], return on average asset [ROAA], and return on average equity [ROAE]. **FIN** is a vector of variables containing proxies for financial

[9] Ecuador implemented a series of reform to leave the crisis, including the *dollarization* of the economy. The US dollar became the legal currency in Ecuador in 2002.

development: domestic credit to private sector (%of GDP) [CREDIT], stocks traded, total value (% of GDP), [STOCK], the total assets of the three biggest banks over total assets in the country [CONCEN], interest rate spread (lending rate minus deposit rate) [SPREAD], and number of banks in the country [NUMBER]. **MACRO** is a vector of macroeconomic variables: GDP per capita (constant thousand US$) [GDPPC], GDP growth (annual %) [GROWTH], inflation from the GDP deflator [INFLATION], real interest rate [REALINT], gross domestic savings (% of GDP) [SAVING], interaction between real interest rate and GDP per capita [RIGDPPC], and interaction between growth and GDP per capita [GRWGDPPC]. **COUNTRY** and **YEAR** are vectors of dummy variables for countries and years under study, while **b**, **f**, **m**, **t** and **a** are the coefficient vectors.

It is inherently interesting to study whether traditional banking performance (**BANK** vector) has a significant relationship with efficiencies. The first ratio, Loan Loss Reserve over Gross Loan, indicates how much of the total portfolio has been provided for, but not charged off. Given a similar charge-off policy, the higher the ratio, the poorer the quality of the loan portfolio would be, and the lower the expected efficiency. Equity to total assets ratio and Capital Funds over Liabilities are good proxies for capital adequacy. The higher these ratios are, the higher efficiency ratios are. Net interest margin measures the profitability of assets. High NIM is not associated with high efficiency because wider margins suggest lower competition that results in lower economic efficiencies (Dermiguc-Kunt and Levine, 1999). Thus, we expect negative relationship between NIM and efficiencies. Finally, return on average assets and return on average equity are measures of profitability and related to a good use of resources. We expect a positive relationship between those ratios and efficiencies.

A well-developed financial system (**FIN** vector) should support banking activities making it more efficient (Bossone and Lee, 2002). Domestic credit to the private sector is a measure of financial depth (Levine and Zervos, 1998). The higher this ratio, the higher the financial depth and therefore higher efficiencies are expected. Capital markets efficiency should

positively impact banking efficiencies. Capital efficiency depends on the profundity, size and resilience of the markets, which are related to liquidity. Total value of stocks traded as percentage of GDP is frequently used as a measure of liquidity (Levine and Zervos, 1998).[10] We expect a positive relationship between this measure and efficiencies. High spread is a measure of bank inefficiency in intermediation (Dermiguc-Kunt and Huizinga, 1999) and therefore a positive relationship is expected between inefficiency scores and the interest rate spread. Finally, we do not expect, *a priori,* a given sign for the number of banks. If the relationship is negative, it would mean that there are too many banks for the banking system during the period, while a positive relationship would suggest that adding more banks to the system would improve efficiencies.

High profitability may be explained either by market power (oligopoly) or by efficiency. Concentration is a measure of the degree of oligopoly in the banking system. Oligopoly is not socially desirable, and the government should intervene. If the relationship between concentration and efficiencies is negative, it would suggest the first case. However, if high efficiency is the explanation for high profitability, concentration would be favorable to consumers and a positive relationship is expected (Berger, 2000).

Macroeconomic conditions (**MACRO** vector) affect banking performance. For instance, GDP per capita should have positive association with banking efficiencies. There is no clear evidence in the direction of efficiencies when there is growth in a country. Efficiencies could react later to current year growth; therefore, we use both current growth and lagged growth to investigate whether efficiencies are related to growth. We expect a positive relationship between lagged growth and efficiencies. Boyd, Levine and Smith (2000) find that high inflation reduces

[10] Dermiguc-Kunt and Levine (1996) also use turnover (value of stock transaction and total market size). The correlation between turnover and total value of stocks traded as percentage of GDP is 92% in our sample, which means that we could use either one as a measure of capital market efficiency.

the amount of financing to private sector, while Khan, Abdelhak and Smith (2001) find that low inflation is harmful for the banking system as well. We expect a negative relationship between inflation and efficiencies because of the relative high inflation in Latin America during the 1990s. Related to inflation is the real interest rate. High real interest rates would limit demand for private credit, negatively affecting efficiencies. Jaffe and Levonian (2000) find that the level of saving in the economy is highly related to financial development, so we include this variable as a macroeconomic factor affecting efficiencies.[11]

3.1 Sample statistics

Table 4 shows averages of each explanatory variable by country and, in parentheses, the sign of the slope during the period to proxy for trends. The source for bank-level variables is BankScope, while country-level variables are from the World Development Indicators 2006 database (World Bank) and our own calculations. Panel A shows bank characteristics. We highlight differences among the countries first, and then summarize trends in each country.

Loan Loss Reserve over Gross Loan [LLR_GL] ratio is significantly higher in Ecuador as a consequence of the government taking over defaulting banks (three largest banks) in 2001. The capital ratios have improved in Argentina, Brazil, Venezuela and Mexico. This is primarily because of the introduction of new regulation following the Basle agreement standards that called for an increase in the required capital relative to total assets. Net interest margin decreased in Brazil, Chile, Colombia, and increased in Argentina, Ecuador and Mexico. Those values are high compared to developed markets. Finally, profitability ratios (ROAA and ROAE) are not only different among countries, but also negative in some cases.

[11] There is a gray zone in deciding whether to use this variable as a macroeconomic variables or a financial structure variable.

Table 4: Averages and trends for both bank-level and country-level variables

	Argentina	Brazil	Chile	Colombia	Ecuador	Mexico	Venezuela
Panel A. Bank Characteristic							
LLR_GR	11.13 (+)	9.87 (–)	6.44 (–)	5.97 (+)	27.39 (+)	5.61 (+)	5.73 (+)
CF_L	47.10 (+)	37.97 (+)	44.31 (+)	10.77 (–)	3.77 (–)	33.74 (+)	42.57 (+)
EQ_TA	21.40 (+)	20.76 (+)	19.20 (–)	9.22 (–)	–53.82 (–)	18.62 (+)	23.26 (+)
NIM	8.50 (+)	11.67 (–)	5.67 (–)	3.90 (–)	11.27 (+)	5.56 (+)	20.06 (–)
ROAA	–2.53 (–)	2.07 (+)	0.99 (–)	–2.42 (+)	–10.29 (–)	0.16 (+)	5.73 (–)
ROAE	–9.58 (–)	11.79 (+)	8.02 (+)	–20.47 (+)	10.56 (+)	1.40 (+)	31.02 (–)
Panel B. Banking and Financial Structure							
CONCEN	36.08 (+)	39.91 (+)	45.50 (+)	33.51 (–)	46.71 (+)	57.96 (+)	46.24 (–)
CREDIT	20.25 (–)	34.59 (+)	61.21 (+)	30.51 (–)	27.27 (–)	19.94 (–)	11.95 (–)
NUMBER	77.13 (–)	125.75 (–)	27.50 (–)	26.88 (–)	32.86 (–)	35.00 (–)	31.38 (+)
SPREAD	5.90 (+)	47.84 (–)	4.45 (+)	8.09 (–)	9.81 (–)	7.79 (–)	9.32 (–)
STOCK	3.40 (–)	15.81 (–)	7.85 (–)	0.91 (–)	0.29 (–)	7.97 (–)	1.25 (–)
Panel C. Macroeconomic Conditions							
GDPPC	7.49 (–)	3.43 (+)	4.90 (+)	2.03 (–)	1.35 (+)	5.63 (+)	4.77 (–)
GROWTH	0.86 (–)	1.88 (–)	3.81 (–)	1.50 (+)	2.29 (+)	3.67 (–)	–1.12 (–)
INFLATION	4.62 (+)	9.64 (+)	3.71 (+)	11.68 (–)	3.21 (+)	14.04 (–)	38.05 (–)
REALINT	13.63 (+)	56.81 (–)	9.31 (–)	13.49 (–)	26.50 (–)	4.46 (–)	–1.57 (+)
SAVINGS	19.00 (+)	20.14 (+)	24.45 (–)	14.88 (–)	22.47 (+)	21.70 (–)	32.29 (+)

This table shows loan loss reserve to gross loan [LLR_GR], equity to total assets [EQ_TA], capital funds to total liabilities [CF_L], net interest margin [NIM], return on average asset [ROAA], and return on average equity [ROAE], domestic credit to private sector (%of GDP) [CREDIT], total stocks traded relative to GDP [STOCK], concentration, the total assets of the three biggest banks over total assets in the country [CONCEN], interest rate spread (lending rate minus deposit rate) [SPREAD], number of banks in the country [NUMBER], GDP per capita (constant thousands U.S. $) [GDPPC], GDP growth (annual %) [GROWTH], inflation from the GDP deflator [INFLATION], real interest rate [REALINT], and gross domestic savings (% of GDP) [SAVING]. The sign in parentheses indicates whether the variable has increased or not – on average – during the period. The source for bank-level variables is BankScope, while country-level variables are from both the IWD database (Word Bank) and our own calculations.

Panel B shows the measures for banking and financial structure. Concentration [CONCEN] has increased in Argentina, Brazil, Chile, Ecuador and Mexico, with the latter having the highest level of concentration. As emphasized by Wong (2006), this level of concentration is not high relative to an international standard. Germany and Spain, for example, have higher levels of concentration than any other country in the set. The total credit provided to the private sector (CREDIT) is high in Chile, which is correlated with its relatively healthy banking system. Chile and Brazil have increased this figure, while in the rest of the countries this ratio has declined, which denotes weakening financial depth. As mentioned in the previous

section, the number of banks in the countries has declined because of closing, mergers and acquisitions in the last few years. The lowest value of the spread is in Chile, while the highest is in Brazil. The spread has been declining in Colombia, Ecuador Mexico and Venezuela but has increased in Argentina, Brazil, and Chile. In all countries, the size of the stock market relative to GDP has declined.

Macroeconomic measures are shown in panel C. Argentina has the highest GDP per capita, while Ecuador has the lowest. GDP per capita has increased in Brazil, Chile, Ecuador, and Mexico. Chile and Mexico present the highest average growth during the period. All countries except Colombia and Ecuador have had a slowing in growth during the period. Venezuela presents the highest average inflation, which, together with regulation and administrative controls on interest rates, has resulted in the lowest (negative) real interest rate. The real interest rate is extremely high in Brazil. Venezuela has the highest gross domestic saving relative to GDP and this figure has increased on average during the period.

We now summarize trends on bank specific, financial structure and macroeconomic measures in each country during 1996-2003.[12] Before the currency crisis of 2002, Argentina had a loan loss reserve over gross loan (LR_GL) average ratio of 8 percent that jumped to 20 percent in 2002, and decreased to 15 percent in 2003. Moreover, capital funds to total liabilities (CF_L) increased to 75 percent in 2002, while the average before that year was below 35 percent. Equity to total assets (EQ_TA) also increased from 15 percent in 1996 to 33 percent in 2003 because of the strict capital requirement imposed by the government to confront the economic crisis. Interestingly, net interest margin (NIM) jumped to 19 percent in 2001 (a few months before the crisis), but the return on assets (ROA) and return on equity (ROE) decreased -39 and -14 percent respectively.

[12] To save space, we do not report yearly estimation of the variables. However, the tables are available upon request.

As a consequence of the 2002 crisis, some banks closed and therefore concentration increased. Furthermore, domestic credit to private as percentage of GDP (CREDIT) decreased from an average of 20 percent to 15 and 10 percent in 2002 and 2003. Inflation bounded from 1 percent (and even deflation), previous to 2002, to 30 percent and 10 percent in 2002 and 2003 respectively. There was a 10 percent reduction in the real GDP in 2002. However, in 2003, there was a resumption in growth in GDP, a reduction in inflation and a recovery of its capital market (STOCK), which is also a sign of economic recovery.

Brazil presents stable banking ratios. The only exception is ROE, which increased to 29 percent on average in 1999 and then returned to its historical level in 2000. Regarding macroeconomic variables, real interest rate (REALINT) has been constantly decreasing since 1999. In 1996, the real interest rate was 65 percent and increased to 70 percent in 1999, which may explain the high ROE. However, by 2003, real interest rate (REALINT) decreased to 45 percent. Regarding inflation, the country has had single digit inflation, but it rose to 15 percent in 2003. Finally, the measures of financial structure have remained approximately constant during 1996-2003.

In Chile, loan loss reserve over gross loan (LLR_GR) has remained at the same level (with a small trend to decrease). Net interest margin (NIM) also has not changed during the period. However, return on equity (ROE) increased to 12 percent in 2001-2002 but in 2003 decreased to its previous level. Both macroeconomic and financial structure measures present stable values during the period. The only exception is GDP growth (GROWTH), which shows volatility for the period. For example, in 1996 GDP growth (GROWTH) was 7.4 percent and decreased to -0.8 percent in 1999.

Concerning Colombia, macroeconomic and financial structure figures have remained steady with the exception of real interest rate (REALINT), which decreased during the period. In

1996 the real interest rate was 21.5 percent, while in 2003 it had dropped to 6.5 percent. Colombia had a banking crisis in 1999 and banking performance measures reflect this fact. For example, average loan loss reserve over gross loan (LLR_GR) was 17.6 percent in 1999 while its level in other years is around 5 percent. Also, the average return on assets (ROA) and return on equity (ROE) are -11.7 and -80.4 percent respectively in 1999, a consequence of the banking crisis. All bank performance ratios and macroeconomic and financial structure measures show improvements during 2003.

In Ecuador, economic and banking crises in 2001-2002 are reflected in all measures. For example, loan loss reserve over gross loan (LLR_GR) sprang from 5 percent in 1997 to 40 percent in 2000. Moreover, return on assets (ROA) is negative (-25% and -10% for 2000 and 2001). Regarding macroeconomic variables, inflation (INFLATION) shows high volatility and real interest rate (REALINT) has decreased from 50 percent in 1996 to 1.7 in 2003.

In Mexico, capital funds to total liabilities (CF_L, ROA) and return on equity (ROE) shows high volatility, whereas the rest of bank performance ratios are stable during the period. The average return on assets (ROA) and return on equity (ROE) were negatives during 1997-1999, showing a subsequent recovery. All macroeconomic and financial structure measures except INFLATION show steady values. Inflation (INFLATION) has been decreasing since 1996, from 30 percent in 1996 to 8.5 percent in 2003.

Finally, in Venezuela, equity to total assets (EQ_TA) has been rising, while other measures have been highly volatile (up and downs). For example, the average ROA in 1996 is 44 percent; it declines to 5 percent in 2001 and increases to 36 percent in 2003. Also, Venezuela is the only country in the sample that shows a negative real interest rate (REALINT) as well as the highest inflation (INFLATION) level during the period. Furthermore, GDP growth (GROWTH) has been on average negative and so the GDP per capita has been declining.

3.2. Analysis of the Regressions' Results

We performed regressions of the estimated efficiencies on the set of bank characteristic variables, financial structure variable and macroeconomic variables. Table 5 shows the regressions. Regarding bank characteristics, loan loss reserves over loan gross (LLR_GR) is negatively related with cost efficiency as expected. Capital ratios (EQ_TA and CF_L) show positive relations to efficiencies. This means that a higher level of capital adequacy will positively affect the level of efficiencies.

Net interest margin (NIM) is negatively related with technical efficiency (TE), pure technical efficiency (PTE), revenue efficiency (RE) and profit efficiency (PE). These results confirm previous findings for Brazil and Venezuela (Herrero, Santillan, Gallego, Cuadro and Egea, 2002, p. 13) and agree with the view that wider margins suggest lower competition that results in lower economic efficiencies (Dermiguc-Kunt and Levine, 1999). However, NIM has a significantly positive relationship with cost and allocative efficiencies. This finding suggests that managers allocate resources more efficiently to cut cost, but to the detriment of technical efficiency.

Profitability ratios, return on assets (ROA) and return on equity (ROE), are positively related to higher efficiencies. The results confirm previous finding for the Turkish banking industry (Isik and Hassan, 2002), as well as findings for developed banking industries (Berger and Humphrey, 1997).

Table 5: Determinant of banking efficiencies in Latin America

The regression (White heteroskedasticity consistent) is based on fixed effect estimation with dummies for years, and covers the period 1996-2003. The independent variables are cost efficiency (CE), its decomposition, allocative efficiency (ACE) and technical efficiency (TE), pure technical efficiency (PTE), scale efficiency (SE), revenue efficiency (RE) and profit efficiency (PE). The number of observations is 2,089 year-banks from seven Latin American countries. Variables definitions can be found at Table 4's footnote. The *, **, and *** denote significance at 10, 5 and 1 percent.

	CE	ACE	TE	PTE	SE	RE	PE
Bank Characteristics							
LLR_GR	-0.060*	-0.092	-0.063	-0.070	-0.025	-0.080	-0.029
	(0.036)	(0.082)	(0.086)	(0.088)	(0.038)	(0.076)	(0.107)
EQ_TA	0.131***	0.298**	0.017	-0.046	0.074***	0.038	0.067**
	(0.017)	(0.134)	(0.030)	(0.028)	(0.026)	(0.024)	(0.034)
CF_L	0.041***	-0.068	0.052***	0.035***	0.021*	0.022*	0.063***
	(0.013)	(0.050)	(0.013)	(0.010)	(0.011)	(0.013)	(0.017)
NIM	0.114**	1.699*	-0.472***	-0.596***	0.030	-0.175***	-0.213***
	(0.045)	(0.954)	(0.061)	(0.069)	(0.073)	(0.048)	(0.067)
ROA	-0.167**	-0.266	0.112	-0.021	0.172	-0.010	0.103
	(0.079)	(0.281)	(0.100)	(0.144)	(0.105)	(0.092)	(0.118)
ROAE	0.020**	0.012	0.034***	0.049***	0.001	0.025*	0.032*
	(0.009)	(0.039)	(0.013)	(0.015)	(0.017)	(0.015)	(0.018)
Banking and Financial Structure							
CREDIT	-0.428**	-1.879	0.763***	0.216	0.739***	-0.674***	-0.145
	(0.173)	(2.006)	(0.174)	(0.154)	(0.170)	(0.238)	(0.304)
STOCK	-1.408**	-7.345***	0.698	0.276	0.157	-4.550***	-2.303**
	(0.551)	(2.331)	(0.493)	(0.487)	(0.488)	(0.731)	(0.917)
CONCEN	0.496**	7.949*	-0.702***	-0.260	-0.494**	1.371***	0.892*
	(0.229)	(4.163)	(0.245)	(0.189)	(0.233)	(0.352)	(0.459)
SPREAD	1.115**	7.251**	2.586***	1.824***	1.635***	0.417	1.391*
	(0.469)	(2.981)	(0.491)	(0.428)	(0.465)	(0.569)	(0.742)
NUMBER	0.004	0.011	-0.016	-0.006	-0.013	0.015	-0.006
	(0.009)	(0.144)	(0.010)	(0.009)	(0.010)	(0.011)	(0.015)
Macroeconomic Conditions							
GDPPC	0.266***	-1.287**	0.082	-0.051	0.162**	0.019	-0.027
	(0.058)	(0.598)	(0.066)	(0.054)	(0.064)	(0.073)	(0.094)
GROWTH	-2.326***	3.898	-1.026	0.956	-2.655***	1.646*	0.353
	(0.735)	(6.098)	(0.831)	(0.704)	(0.774)	(0.954)	(1.358)
GROWTH(-1)	0.978**	9.355**	0.578	0.733*	-0.096	1.857***	1.644**
	(0.437)	(3.965)	(0.463)	(0.424)	(0.448)	(0.586)	(0.751)
INFLATION	0.671**	-0.841	-1.224***	-0.764***	-0.856***	-0.083	-0.600
	(0.297)	(1.586)	(0.323)	(0.282)	(0.311)	(0.363)	(0.476)
REALINT	0.355	-1.136	-0.845***	-0.234	-0.926***	0.575	-0.304
	(0.251)	(2.249)	(0.271)	(0.218)	(0.251)	(0.358)	(0.466)
SAVING	0.316	-14.511**	-0.292	-0.453	0.283	1.582*	-0.135
	(0.544)	(6.416)	(0.662)	(0.604)	(0.667)	(0.849)	(1.033)
RIGDPPC	-0.185***	-1.420**	-0.030	-0.124**	0.075	-0.015	-0.031
	(0.048)	(0.632)	(0.055)	(0.049)	(0.046)	(0.069)	(0.092)
GRWGDPPC	0.464***	-0.488	0.003	-0.211**	0.260**	-0.159	-0.063
	(0.111)	(0.744)	(0.124)	(0.106)	(0.113)	(0.146)	(0.203)
Adj-R2	0.60	0.05	0.45	0.29	0.23	0.37	0.26

* RIGDPPC: interaction variable, real interest rate and GDP per capita. GRWGDPPC: interaction variable, growth and GDP per capita.

Regarding banking and financial structure, domestic credit provided to the private sector has mixed results depending on efficiency measures. Remember that the higher the value of those variables, the higher the development of financial system. Domestic credit to private sector (CREDIT) is significantly positively related with scale efficiency and technical efficiency. However, this variable is significantly negatively related with overall (cost, revenues and profit) efficiencies. Bossone and Lee (2002), using a sample of 975 bank in 75 countries, also find that financial depth is positively related to scale efficiencies.

Contrary to our hypothesis, the total value of stocks traded as percentage of GDP is negatively related to economic efficiencies in Latin America. Our explanation is that because the size of the capital market is so small relative to developed market, the marginal effect on efficiencies is negative. La Porta, Lopez-de-Silanes, Shleifer and Vishny (1997) and Beck and Levine (200) present evidence that the choice between a bank-based and a capital-market-based model is not as important as the degree of efficiency in the financial structure, once one model is chosen. It appears that underdeveloped capital markets in Latin American are mirrored in low economic efficiencies.

High concentration diminishes scale and technical efficiencies. These results support the view that greater concentration may result in lower competition that would affect the customer. However, high concentration augments overall efficiencies (cost, revenues, and profit) and allocative efficiency, supporting the view that high concentration leads to better managerial techniques and higher efficiency. Finally, the interest spread is positively associated with all efficiencies, except for revenue and profit efficiencies.

Regarding macroeconomic variables, high GDP per capita is related with high cost and scale efficiencies but is negatively related with allocative efficiency. In general, both high inflation and high real interest rate are associated with low banking efficiencies. Lagged growth

is positively related with pure technical efficiency, allocative efficiency and all overall efficiencies, which shows that economic growth is positively related with future efficiencies.

4. Malmquist Productivity Change in the Latin American Banking Industry

Table 6 shows the Malmquist indexes per year as well as the compounded growth for the period 1996–2003 in each country, while Table 7 summarizes whether there has been an improvement on the index (+) or not (-). Banking industries in Argentina, Brazil, Chile, Colombia and Mexico had technological progress during the period 1996–2003, while Ecuador and Venezuela had technological regress during the period. Brazil shows the highest improvement in technology (141 percent), followed by Colombia (74.1 percent) and Argentina (70 percent).

Argentina's total productivity change is 8.8 percent. This modest change is due to the huge drop in technical efficiency, which fell 36.3 percent during the period. Clearly, the 2002 currency crisis affected the banking efficiency in Argentina, since efficiency dropped by 43 percent and the change was due to both wasting resources (pure technical efficiency) and not working at optimal scale (scale efficiency). The good news is that the technical efficiency increased 19 percent in 2003, which is correlated with Argentina's economic growth in those years.

Brazil's total productivity change 41 percent during the period 1996–2003. The change is primarily due to the technological progress during the period that more than offset the drop in technical efficiency (–41.5 percent). The drop in technical efficiency suggests that Brazilian banks have not been using their resources efficiently (the pure technical efficiency fell 29.2 percent).

Table 6: Malmquist indexes

Year	Technological Change	Technical Efficiency Change	Pure Technical Efficiency Chance	Scale Efficiency Change	Total Factor Productivity Change
Argentina					
1997	0.993	1.002	1.005	0.997	0.995
1998	1.019	0.983	0.988	0.995	1.001
1999	0.986	0.955	0.978	0.976	0.942
2000	0.941	0.973	1.003	0.970	0.916
2001	1.067	1.025	0.996	1.029	1.094
2002	1.761	0.571	0.740	0.771	1.005
2003	0.967	1.190	1.120	1.062	1.151
1996 –2003	**1.706**	**0.637**	**0.804**	**0.791**	**1.088**
Brazil					
1997	1.342	0.816	0.974	0.838	1.095
1998	0.958	1.044	1.039	1.004	0.999
1999	1.040	0.909	0.913	0.996	0.946
2000	1.054	1.036	0.953	1.087	1.092
2001	1.415	0.855	0.880	0.972	1.210
2002	0.967	1.032	1.023	1.009	0.998
2003	1.250	0.826	0.893	0.926	1.033
1996 –2003	**2.410**	**0.585**	**0.708**	**0.827**	**1.410**
Chile					
1997	1.061	1.025	1.008	1.017	1.088
1998	0.975	0.979	0.982	0.997	0.955
1999	0.984	0.982	1.020	0.963	0.966
2000	1.049	1.006	0.989	1.017	1.056
2001	0.975	0.999	0.982	1.017	0.974
2002	1.028	1.019	1.028	0.992	1.048
2003	1.169	0.887	0.961	0.923	1.036
1996 –2003	**1.251**	**0.895**	**0.969**	**0.925**	**1.121**
Colombia					
1997	0.970	0.986	0.892	1.105	0.956
1998	0.958	1.046	1.212	0.863	1.002
1999	1.037	1.117	1.040	1.074	1.158
2000	1.173	1.031	1.043	0.989	1.210
2001	1.075	1.122	0.977	1.148	1.206
2002	1.129	0.932	0.945	0.986	1.052
2003	1.269	0.883	0.966	0.915	1.121
1996 –2003	**1.741**	**1.097**	**1.046**	**1.049**	**1.909**

Table 6 (continued)

Year	Technological Change	Efficiency Change	Pure Technical Efficiency Chance	Scale Efficiency Change	Total Factor Productivity Change
Ecuador					
1998	1.001	1.002	1.020	0.983	1.003
1999	0.947	0.951	0.934	1.018	0.901
2000	0.931	0.782	0.835	0.937	0.728
2001	0.930	1.022	1.069	0.957	0.951
2002	0.942	1.062	1.053	1.008	1.000
2003	1.090	1.025	1.119	0.916	1.117
1997 –2003	**0.843**	**0.829**	**1.002**	**0.829**	**0.699**
Mexico					
1997	1.121	0.964	0.988	0.976	1.080
1998	0.776	1.040	1.022	1.017	0.807
1999	0.934	0.906	0.939	0.965	0.846
2000	1.371	0.830	0.863	0.961	1.138
2001	0.772	0.995	1.048	0.949	0.768
2002	1.216	1.066	1.062	1.004	1.296
2003	1.086	1.083	1.045	1.037	1.176
1996 –2003	**1.136**	**0.866**	**0.952**	**0.909**	**0.982**
Venezuela					
1997	0.893	1.082	1.025	1.056	0.966
1998	0.838	0.979	0.979	1.000	0.820
1999	0.825	0.977	0.991	0.987	0.806
2000	1.001	1.054	1.031	1.022	1.055
2001	1.020	1.016	1.011	1.005	1.036
2002	1.325	0.970	0.994	0.976	1.285
2003	1.096	1.037	0.994	1.043	1.137
1996 –2003	**0.915**	**1.115**	**1.024**	**1.090**	**1.020**

Malmquist index measures productivity growth (change). A bank's productivity change could be due to either by change in *technical efficiency* or by change in the *technology* – a technological progress in the industry – or both. The total factor productivity change is the product between *technical efficiency* change and *technological* change. *Technical efficiency* change is decomposed in *pure technical efficiency* and *scale efficiency* change. The table highlights in bold the compounded change for the period 1996–2003.

Table 7: Total factor productivity change directions and their components

Country	Technological Change	Technical Efficiency Change	Pure Technical Efficiency Chance	Scale Efficiency Change	Total Factor Productivity Change
Argentina	(+)	(–)	(–)	(–)	(+)
Brazil	(+)	(–)	(–)	(–)	(+)
Chile	(+)	(–)	(–)	(–)	(+)
Colombia	(+)	(+)	(+)	(+)	(+)
Ecuador	(–)	(–)	(+)	(–)	(–)
Mexico	(+)	(–)	(–)	(–)	(–)
Venezuela	(–)	(+)	(+)	(+)	(+)

Chile's total productivity change is 12.1 percent and this change is due to high technological progress (25.1 percent) that offsets the small drop in technical efficiency (–10.5 percent). Colombia shows the highest productivity change during the period (90.9 percent). This productivity change is due mainly to technological progress (74.1 percent). However, the technical efficiency increased as well (9.7 percent), which suggests that the Colombian banking industry has improved in the use of resources.

Ecuador's total productivity dropped 30.1 percent during the period 1997–2003.[13] This change is attributed to both technological regress (–15.3 percent) and a drop in efficiency (17.1 percent). Further decomposition of efficiency change shows that the source of this change in efficiency is due to change in scale efficiencies (–17.1 percent) and not because of pure technical efficiency, which virtually did not change. The results suggest that Ecuadorian managers have been consistent in using resources efficiently (since the absolute technical efficiencies showed in Table 3 are relatively high). The biggest drop in efficiency was in 2000, year in which Ecuador experienced a banking crisis.

Mexico's total productivity dropped less than 2 percent during the period 1996–2003. The technological progress (13.6 percent) was not enough to offset the drop in technical efficiency (-13.4 percent). This drop in technical efficiency is primarily due to the drop in scale efficiency (-9.1 percent).

Venezuela has a modest increase in total productivity (2 percent) besides the technological regress (–8.5 percent). The increase in productivity is due to better use of resources as shown by the increase in technical efficiency (11.5 percent). The decomposition of the efficiency results in an increase of scale efficiencies (9 percent) with small increase in pure technical efficiency (2.4 percent).

[13] Note that Ecuador's base year is 1997 (not 1996 as in the other countries).

In summary, most of the countries have had technological progress in their banking industries. However, many banking industries that had technological progress also had decreased technical efficiency, which implies that banks are not using the technology efficiently and resources have been wasted. Countries experiencing banking crises between 1993 and 1995 and undertaking reforms with the objectives of improving efficiencies have seen declines in their technical efficiencies. In others word, in a period of financial liberalization without financial distress in Argentina, Brazil, and Mexico, we find a decline in technical efficiencies, whereas in Venezuela we find a rise in its technical efficiency. These results give more evidence that financial liberalization does not necessarily lead to an increase in efficiency.

5. Concluding Remarks

Employing Data Envelopment Analysis (DEA), we estimate and compare the efficiencies and productivity of seven Latin American countries (Argentina, Brazil, Chile, Colombia, Ecuador, Mexico and Venezuela). We find that most of the sources of inefficiencies are allocative (regulatory) rather than technical (managerial) in the majority of these countries. This means that bank managers are not choosing the correct (optimal) input and output mix and this is likely because they are forced not to do so by the environmental conditions (either government regulations or market conditions). The decomposition of technical efficiency into pure technical efficiency and scale efficiency shows that, while small, scale inefficiency is driving most of the technical inefficiencies in Latin American countries' banking industries.

Total factor productivity increased in all countries except Ecuador and Mexico. The increase in the productivity came primarily from technological progress. However, total technical efficiency decreased in all countries but Venezuela and Colombia, which means that banks are either wasting more resources or working at suboptimal scale relative to 1996. Further

study of the determinants of banking efficiencies shows that net interest margin (NIM) is negatively associated with all efficiencies (but cost efficiency), which is consistent with the assertion that high NIM is associated with lower efficiency because wider margins suggest lower competition. Traditional measures of bank performance such as asset quality ratios (loan loss reserves over gross loans), capital ratios (equity over total assets and capital funds over liabilities), and operation ratios (return on equity and return on assets) are consistent with the estimated efficiencies (for example, high ROE is positively related with high efficiency).

Regarding macroeconomic variables, lagged growth is associated with high efficiencies. Thus, economic growth would affect positively efficiencies after a year, while higher inflation or real interest rates harm banking efficiencies. In contrast, banking and financial structure have mixed results. For example, domestic credit to the private sector, a proxy for financial depth, is positively associated with scale and technical efficiencies, but negatively related with cost and profit efficiencies. Moreover, total value of stocks traded, a proxy for capital market efficiency, is negatively linked with efficiencies.

We also find a decline in technical efficiencies for Argentina, Brazil and Mexico, but a rise in technical efficiency for Venezuela. The 1996-2003 period is free of financial distress and banks have operated in a liberalized environment. Thus, as discussed in Berger and Humphrey (1997), there is no conclusive evidence that financial liberalization will result in improved efficiencies.

The results of this paper also suggest that there are opportunities to improve in both the regulatory framework in Latin American banking and in the macroeconomic environment where those banks operate. A good macroeconomic environment is necessary, but not sufficient, to improve efficiency in Latin American banking. A better regulatory framework that promotes efficiency is also needed.

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