

Ownership and Efficiency in the Banking Industry. Empirical Evidence for Argentina.*

María Eugenia Delfino[†]

December 2003

Abstract

The Argentine banking industry experienced major restructuring during the last decade. As a result privatisation, demutualisation and foreign entry, the ownership structure of the sector changed to a substantial degree. This paper uses different approaches to measure cost and profit efficiency as well as scale economies and technical change for different ownership types in the Argentine sector over the period 1993-2000. The results indicate that within the domestic-owned banking sector, stock banks seem to be more cost efficient than mutual and public-owned banks, that all banks operate under increasing returns to scale but that only stock banks benefited from technical progress. The findings also reveal that domestic-owned stock banks appear to be as efficient as foreign-owned banks in terms of both costs and profits. The results also indicate an increase in efficiency for all ownership types over the sample period, however, the most significant improvement appear to be that of mutual and public-owned banks.

Keywords: efficiency, stochastic frontiers, ownership, banking industry.

JEL classification: L20, G21, C20, D20.

* I am grateful to Keith Cowling and Jeremy Smith for encouragement and helpful suggestions. All errors are mine.

[†] Assistant professor, IAE – Universidad Austral, Casilla de Correo nro. 49, Mariano Acosta s/n y Ruta Nac. 8, 1629 Pilar, Argentina. Tel.: +54 2322 481000, Fax: +54 2322 481050, E-mail: MDelfino@iae.edu.ar.

1 Introduction

Post-deregulation developments in the Argentine banking industry led to changes in its ownership structure. During the 1990s several provincial banks were privatised, the number of mutual banks significantly decreased as a result of mergers and conversions to stock banks, and foreign financial institutions entered the domestic market primarily through acquisitions of domestic banks. A consequence of these developments was a switch from a sector dominated by domestic-owned banks, with similar participation of public and private financial institutions, to a liberalised system where foreign banks play a major role. At the end of the decade, public banks controlled just one third of the assets in the banking sector, having lost almost 20 percent to private banks, while foreign-owned banks controlled more than half of the assets, against less than one fifth by the early 1990s.

These developments were the result of banking sector reforms implemented under the assumption that a more competitive framework, with a major participation of private domestic- and foreign-owned banks, is more suitable to increase the efficiency of the banking system. On the one hand, the entry of foreign banks could improve the competitive environment and also have positive spillover effects on domestic banks derived from a (potential) better technology and expertise in offering specialised banking products. This could place domestic banks under peer pressure to improve operational efficiency. On the other hand, the privatisation of banks could also contribute to enhance the efficiency of the banking system by improving staff productivity or rationalising the branch network. These efficiency improvements could bring about benefits to consumers through reductions in prices and expansions in the amount and quality of services.

The literature has offered a diversity of theoretical arguments and mixed empirical evidence on the relationship between ownership and efficiency, though empirical studies have mainly concentrated on non-financial firms. Only few works have analysed ownership-efficiency in the banking industry, and the results have been diverse. This study contributes to this literature in different ways. Firstly, this study analyses efficiency characteristics of stock, mutual and public-owned banks. As such, it differs from previous works that mainly concentrate on efficiency differences between mutual and stock financial institutions and from the few studies that analyse private and public banks. Secondly, it also differs from past works in that it explores the relative efficiency of foreign- and domestic-owned banks in a developing country.¹ Consequently, this is

¹ It has been documented that the increasing presence of foreign banks in developing economies increases efficiency and reduces profitability of domestic-owned banks though the opposite occurs in developed countries (Claessens et al, 1999).

the first work to consider efficiency differences among four ownership types. Thirdly, it is also distinct from past studies because it examines efficiency differences in a developing country while most of the empirical evidence explores the banking industry in developed economies, especially in the U.S..

This study uses data from the Argentine banking industry to estimate economic efficiency, scale economies and technical change using parametric techniques. It estimates cost and profit frontiers using the stochastic frontier approach - with different assumptions about the distribution of inefficiencies - and the distribution free approach on a panel data set over the 1993-2000 period. The evidence indicates that within the domestic-owned banking sector, stock banks seem to be more cost efficient than mutual and public-owned banks, that all banks operate under increasing returns to scale but that only stock banks benefited from technical progress. The findings also imply that domestic-owned stock banks appear to be as efficient as foreign-owned banks. The results also indicate an increase in efficiency for all ownership types over the period, however, the largest improvement in performance appear to be that of mutual and public-owned banks.

The rest of the paper is organised as follows. Section 2 describes the changes in the ownership structure of the industry during the post-deregulation period. Section 3 consists of two subsections. The first reviews theoretical studies on the relationship between ownership and efficiency while the second examines empirical studies related to efficiency differences in the banking industry. Section 4 outlines the methodology employed, while Section 5 describes the data sources and the definition of variables and provides a brief overview of the data set. Section 6 discusses the results. Finally, the last section summarises and presents the conclusions.

2 Ownership Structure

The Argentine banking industry is characterised by a diversity of bank ownership types. Argentine banks can be classified as public- and private-owned banks. The former can be national- or provincial-owned, whereas the latter can have a mutual or stock ownership structure. Mutual banks are formally owned by their depositors and possibly their borrowers while stock banks are owned by their shareholders.² Stock banks can be further classified as domestic- or foreign-owned. The ownership structure of the industry changed during the 1990s as a result of the privatisation of public provincial banks, the consolidation of mutual banks and

the entry of foreign financial institutions through the acquisition of domestic banks. Table 2.5 shows the evolution of the ownership structure in the Argentine banking industry over the 1993-2000 period.

The privatisation of banks started in 1991, but the funds provided by the Fondo Fiduciario - set up during 1995 with funds from multilateral institutions - and the deposit insurance agency (SEDESA) contributed to accelerate the process (Calomiris and Powell, 2001). As a consequence, 12 banks were privatised during the period 1994-1996, followed by an additional 4 during the period 1997-2000. The privatised institutions were primarily acquired by other existing domestic banks or domestic groups of investors. Two of the ten largest banks in Argentina, the Banco de la Nacion Argentina and the Banco de la Provincia de Buenos Aires, still remain under the control of the national government and the provincial government of Buenos Aires, respectively.

Table 1
Ownership structure
Argentine retail banking industry, 1993-2000.

Year	Total	Public		Mutual	Private	
		Provincial ^a	National		Stock	Foreign ^b
1993	134	28	1	39	56	10
1994	135	28	1	38	58	10
1995	106	25	1	16	53	11
1996	95	18	1	8	55	13
1997	89	14	1	7	46	21
1998	75	10	1	4	40	20
1999	71	10	1	2	36	22
2000	65	10	1	1	33	20

Source: Own calculations based on Información de Entidades Financieras, Banco Central de la República Argentina.

Notes: ^a Includes municipal banks. ^b Includes local banks under foreign control (50% or more of shares foreign-owned) and local offices of foreign banks.

Table 1 shows that privatisation reduced the number of public provincial banks from 28 in 1993 to 10 in 2000.³ In addition, the number of private institutions decreased from 105 to 54. The number of private banks halved as a result of mergers, acquisitions and failures, especially after the Mexican crisis of 1994. Table 2 presents the market share of public- and private-owned

² These two types of banks also differ in that the stock bank can increase its capital by issuing new stock while the mutual increases capital via retained earnings.

³ Two provincial banks were absorbed i.e. the Banco Social de Córdoba was absorbed by the Banco de la Provincia de Córdoba and the Banco Municipal de Paraná was absorbed by Banco de Entre Ríos S.A.

banks over 1993-2000. The figures reveal that public banks lost almost 20% of the market for loans, nearly 10% of the market for deposits and about 15% of total assets. In contrast, the two largest public banks - Banco Nacion and Banco de la Provincia de Buenos Aires - slightly increased their market share of loans (deposits) from 20.6% (23.7%) in 1993 to 24.6% (25.6%) in 2000. Finally, private banks gained more than 15% of the market for loans, nearly 8% of the market for deposits and almost 10% of total assets.⁴

Table 2
Market share of public- and private-owned banks

Argentine retail banking industry, 1993-2000.

Year	Loans			Deposits			Assets		
	Public	Largest public ^a	Private	Public	Largest public ^a	Private	Public	Largest public ^a	Private
1993	24.2	20.6	55.2	17.3	23.7	59.0	17.8	17.9	64.3
1994	19.8	20.2	60.0	14.9	21.0	64.1	15.3	17.0	67.7
1995	18.0	23.2	58.8	13.4	24.4	62.2	13.2	18.1	68.7
1996	14.1	22.2	63.7	10.5	25.0	64.5	9.4	15.2	75.4
1997	11.4	22.1	66.5	7.9	25.8	66.3	6.7	14.0	79.3
1998	10.6	22.7	66.7	8.3	26.9	64.8	7.1	14.1	78.8
1999	5.9	23.2	70.9	7.6	25.6	66.8	4.1	14.2	81.7
2000	4.6	24.6	70.8	7.5	25.6	66.9	3.9	12.9	83.2

Source: Own calculations based on Financial Statements.

Notes: ^a The two largest public banks are Banco Nacion and Banco de la Provincia de Buenos Aires.

Another distinguishing feature of the Argentine banking industry during the 1990s was the consolidation of mutual banks. Between 1994 and 1995, the number of mutual banks decreased from 38 to 16, mainly as a consequence of mergers and acquisitions. These banks basically merged due to the loss of deposits experienced during the Mexican crisis. For example, five banks merged into a new mutual bank - Banco Argencoop - while another eight originated a new stock bank - Banco BISEL. During the second half of the decade the number of mutual banks further declined as a consequence of failures and also the conversion of several mutual banks to stock financial institutions. As a result, the share of mutual banks in total loans (deposits) fell from 5.5% (6.6%) to 1.2% (1.4%) between 1993 and 2000.

Probably the most notorious change in the Argentine banking industry during the last decade was the entry of foreign banks. The removal of restrictions on foreign direct investment and the

⁴ During the Tequila crisis, the financial system lost deposits, however larger private and public banks gained deposits from other mutual and public provincial banks i.e. flight to 'quality' (Calomiris and Powell, 2001).

repatriation of profits facilitated by the Convertibility Law allowed more foreign institutions to enter the domestic market. After the Mexican crisis, British, Canadian, French and Spanish (to name a few) financial institutions entered the domestic market primarily through acquisitions of domestic banks that were in a good financial condition and have an extended network of branches, rather than through the acquisition of privatised provincial banks. This process began slowly in 1995-1996, but accelerated significantly during 1997-1999. As a result, the number of foreign banks increased from 10 in 1993 to 20 in 2000 the majority of which are European followed by American. Table 3 presents the evolution of market shares of foreign- and domestic-owned banks in Argentina over 1993-2000. The data shows that foreign-owned banks significantly increased their market share of loans (deposits) from 14.5% (14.0%) in 1993 to 49.6% (48.4%) in 2000. In contrast, domestic banks lost almost 35% of the market for loans and deposits.

Table 3
Market share of foreign- and domestic-owned banks
Argentine retail banking industry, 1993-2000.

Year	Loans		Deposits		Assets	
	Foreign ^a	Domestic	Foreign ^a	Domestic	Foreign ^a	Domestic
1993	14.5	85.5	14.0	86.0	14.2	85.8
1994	15.1	84.9	15.3	84.7	13.6	86.4
1995	17.6	82.4	18.8	81.2	18.9	81.1
1996	41.1	58.9	38.2	61.8	40.5	59.5
1997	44.4	55.6	41.4	58.6	46.1	53.9
1998	45.6	54.4	42.6	57.4	47.6	52.4
1999	47.9	52.1	46.8	53.2	50.4	49.6
2000	49.6	50.4	48.4	51.6	53.5	46.5

Source: Own calculations based on Financial Statements.

Notes: ^a Includes local banks under foreign control (50% or more of shares foreign-owned) and local offices of foreign banks.

Table 4 presents efficiency and profitability indicators by ownership type. Efficiency ratios at the beginning of the period show that mutual and public-owned banks appear to be the least efficient in terms of operating expenses to total assets, labour expenses to total assets and deposits per employee. These efficiency indicators also reveal an improvement for all ownership types over the decade. During the second half of the period, the differences between stock, mutual and public-owned banks in terms of operating expenses to total assets, labour expenses to total assets and deposits per employee are smaller than over the first half of the period.

Profitability measures at the beginning of the period show that within the domestic banking sector stock banks appear to be more profitable, in terms of both returns on equity and returns on assets, than mutual and public-owned banks. But the differences in profitability between stock domestic- and foreign-owned banks seem to be small. When analysed over time, profitability shows an improvement for all ownership types, but especially for mutual institutions. In fact, at the end of the period mutual banks exhibit the highest rate of return on assets (and rate of return on equity) when compared with the other ownership types. This result may be explained by the significant decline in the number of mutual banks leading to the presence of just one mutual institution at the end of the decade.

Table 4
Financial indicators
Stock, mutual, public- and foreign-owned retail banks, 1993-2000.

Indicator (%) ^a	1993-1996				1997-2000			
	Public	Mutual	Stock	Foreign	Public	Mutual	Stock	Foreign
Interest rates								
Deposits	9.9	12.6	10.6	5.8	6.3	6.7	7.1	6.2
Loans	18.3	25.9	22.4	13.3	15.1	19.6	18.9	14.6
Economic efficiency								
Operating exp / Assets	10.4	13.7	9.7	7.5	8.5	8.8	8.3	6.3
Labour exp / Assets	6.1	7.3	5.2	4.2	4.2	4.0	4.1	3.0
Deposits/Employee (thousand \$)	269.4	213.5	280.6	515.6	468.9	482.8	449.8	775.9
Profitability								
Profit / Equity (ROE)	-20.5	-0.8	7.4	4.2	7.2	16.4	16.6	14.9
Profit / Asset (ROA)	-5.4	0.0	0.9	0.5	1.0	2.7	2.5	2.1

Source: Own calculations based on Financial Statements.

Notes: ^a Annual indicators.

3 Literature Review

3.1 Theoretical Studies

The economic literature provides several arguments to explain efficiency differences between public and private ownership. The dominant model considering the effect of ownership on performance uses the agency and public choice theories to stress the importance of management being constrained by market discipline. According to these theories private firms should outperform public firms. The *agency theory* argues that managers (the agent) in both types of

firms are assumed to pursue their own interests rather than that of the firm or its owners (the principal). In private firms, however, this divergence is reduced through the following mechanisms: the existence of a market for ownership rights, which enables the owners to sell if they are not satisfied with managerial performance – this is the focus of the *property rights theory*; the threat of takeover and the labour market for managers, which may discourage managers from pursuing their personal agenda (Alchian, 1965; Manne, 1965; De Alessi, 1980; Fama, 1980). In the case of public firms all of these mechanisms are virtually absent.⁵

The *public choice theory* points to specific inefficiency factors that arise from government ownership irrespective of market conditions. According to this theory, government officials tend to pursue their own interests (or the interests of pressure groups), rather than the public interest. Government officials are inclined to impose goals on public firms that could lead them to gain votes, but achievement of such goals could be in conflict with efficiency. Moreover, government's attempts to accommodate diverse interest groups leads to multiple and frequently changing objectives in these firms, which intensify agency problems since managerial decisions' outcomes become more difficult to monitor (Estrin and Perotin, 1991).⁶

Several theoretical contributions raise doubts over the predictions of the property rights and public choice arguments. Grossman and Hart (1980) argue that the takeover threat in private firms may be empty due to the existence of free rider problems while Mueller (1989) and Wintrobe (1987) suggest that the voting market might operate as a substitute for the market for corporate control in disciplining public firms. Caves and Christensen (1980), Borcherting et al. (1982) and Millward (1988) argue that competition might have a greater impact on performance than ownership. More recently, Martin (1993) shows that in some cases more competition might increase managerial slack.⁷ In addition, Willner (1999) suggests that the nature of the managers' motivation may sometimes have a greater impact on efficiency than the ownership or objectives of an organisation.

The arguments presented above refer to efficiency differences between public and private firms. In the case of private firms, the literature offers alternative arguments to explain differences in

⁵ The managerial labour market may not be absent. Two separate markets can be observed for private- and public-owned firms' managers, respectively. However, the latter is generally dominated by political decisions, making it useless as a threat to managerial discretion. Cragg and Dyck (1997a,b,1998) provide empirical evidence about this fact.

⁶ Other approaches, based on the agency and public choice theories, focus on the differences between private and public firms in terms of organisational characteristics such as incentives and control mechanisms (Ricart et al., 1991) or culture (Bishop and Thompson, 1992), for example.

⁷ He shows that if demand is linear, an increase in the number of firms in an oligopoly will actually increase managerial slack.

efficiency between mutual and stock firms. The dominant model also uses *agency theory* to explain these differences.⁸ This theory does not provide, however, sufficient arguments in favour of an ownership type. Mayers and Smith (1981) argue that firms with alternative organisational forms are sorted into market segments where they have comparative advantages in dealing with various types of principal-agent conflicts. According to this view, stock firms are expected to be more efficient than mutual firms in controlling agency problems between owners and manager because stock ownership provides more effective mechanisms for controlling management, either through the market for corporate control or the managerial labour market (Nicols, 1967; O'Hara, 1981).⁹ However, mutual firms are expected to be more effective in controlling owner-customer conflicts because the ownership and customer functions are merged in the mutual firm (Mayers and Smith, 1988).

The literature also provides several arguments to explain the relative efficiency of domestic- and foreign-owned firms. Several authors argue that multinational enterprises (MNEs) operating abroad face higher costs relative to domestic firms. These costs may arise from several sources. Zaheer and Mosakowski (1997) group these costs as spatial, unfamiliarity and home and host country environment costs. Spatial costs refer to transportation costs and coordination over distance; unfamiliarity costs consider lack of knowledge of host environments or lack of information networks and political influence; host country environment costs refer to the differential government treatment of domestic versus foreign firms or nationalistic buyers' reluctance to buy from foreign firms; and home country environment costs relate to regulatory restrictions imposed by a firm's home government.

These arguments do not provide though support in favour of on ownership type. Counter arguments suggest that in order to overcome these additional costs and compete successfully against local firms, MNEs need to provide their overseas subunits with some firm-specific advantages, often in the form of organisational or managerial capabilities (Buckley and Casson, 1976; Caves, 1982; Hennart, 1982). These arguments suggest that multinationals' subunits try to overcome the higher costs of operating abroad by importing organisational or managerial capabilities from their parent firms, particularly if the subunits are competing in an undifferentiated product market in which other sources of imported competitive advantage, such

⁸ In a mutual organisation the customers are the owners with very limited control over management. In stock institutions on the other hand, there is a separation between owners and customers, and managers are periodically monitored by owners (stockholder)

⁹ Fama and Jensen (1983) argue that customers of mutuals have other form of controlling management i.e. by withdrawing their funds from the control of management, which is a form of partial takeover or liquidation.

as a brand name, a superior technology or factor-cost advantages, have little role to play (Zaheer, 1995).

The preceding analysis suggests that there is no simple relationship between ownership and efficiency. The theoretical arguments do not provide conclusive predictions: it is not obvious that stock firms are more efficient than mutual or public-owned organisations or that domestic firms outperform foreign-owned institutions. On the one hand, the property rights theory suggests that private firms should be more efficient than public firms, as private ownership provides more effective mechanisms for controlling management. This argument is also valid for stock as compared to mutual firms. On the other hand, other theoretical contributions suggest that there is no simple relationship between ownership and efficiency. These works challenge the effective functioning of the market for corporate control for private firms or the absence of this market for public firms and point to the effectiveness of mutual firms in controlling customer-owner problems. These conflicting arguments suggest empirical analyses could contribute to shed some light on the direction of this ownership-efficiency relationship.

3.2 Empirical Studies

Empirical evidence on efficiency differences between private- and public-owned firms largely concentrates on non-financial firms.¹⁰ The studies that examine the relative efficiency of public-owned and private financial institutions are more recent. Tulkens (1993) uses non-parametric techniques to analyse the relative performance of branches of two large banks in Belgium (one private and one public). He finds the public bank's branches to be relatively more efficient than those of the private bank. Zaim (1995) uses Data Envelopment Analysis to investigate the efficiency differences among banks in Turkey. He finds that public banks are more efficient than their private counterparts. Bhattacharyya et al. (1997) also use Data Envelopment Analysis to examine the relative performance of banks in India. They find public-owned banks appear to be more efficient than private-owned banks. Burdisso et al. (1998) use parametric techniques and report that private banks in Argentina seem to be more cost efficient than public financial institutions. Altunbas et al. (2001) using data for Germany find that public banks have slight cost and profit advantages over stock financial institutions.

¹⁰ The results of these studies are mixed. On the one hand, Millward (1982), Millward and Parker (1983) and Martin and Parker (1997) conclude that there is no evidence to suggest that public firms are less efficient than private firms. On the other hand, Borchering et al (1982) conclude that the evidence seems to indicate that private firms are more efficient than their public counterparts, but that these differences are related to differences in competition. In contrast, Vining & Boardman (1992) argue that private firms outperform public firms even after controlling for competition.

The results of studies analysing the relative performance of mutual and stock financial institutions are not conclusive. Verbrugge and Goldstein (1981) explore the cost structure of saving and loan associations (S&Ls) in the U.S. concluding that mutual organisations exhibit higher costs than stock institutions while Blair and Placone (1988) find no differences between stock and mutual S&Ls. More recent studies use cost frontier methodologies and also reach mixed conclusions. Mester (1993) finds mutual S&Ls in the U.S. to be more cost efficient than stock institutions while Cebenoyan et al. (1993) find no difference.¹¹ Altunbas et al. (2001) find that mutual banks in Germany have cost and profit advantages over stock financial institutions. Finally, Hasan and Lozano-Vivas (2002) report Spanish savings banks (mutual institutions) to be more inefficient than commercial banks.

Studies analysing efficiency differences associated with foreign and domestic ownership provide mixed conclusions. DeYoung and Nolle (1996), Mahajan et al. (1996) and Hasan and Hunter (1996) find that foreign-owned banks in the U.S. are significantly less efficient than domestic banks, while Elyasiani and Mehdiian (1997) find that, on average, foreign-owned banks are as efficient as U.S.-owned banks. Studies for other countries also provide mixed evidence. Bhattacharyya et al. (1997) find foreign-owned banks in India to be more efficient than private-owned domestic banks (but government-owned banks to be more efficient than both of them). Zaim (1995) finds similar results for banks in Turkey. Berger et al. (2001) report that foreign-owned banks in France, Germany, Spain and the U.K. are more cost and profit efficient than domestic-owned banks. In contrast, in the U.S. foreign banks are less cost and profit efficient than U.S.-owned banks. In line with this, they also find that in France, Germany, Spain and the U.K., foreign banks from the U.S. generally exceed the cost- and profit-efficiencies of domestic banks.

To sum up, theoretical contributions and empirical evidence both suggest that there is no simple relationship between ownership and efficiency. However, most studies focus on the experiences of developed economies characterised by well functioning capital markets. The particular characteristics of developing countries may make the analysis of the ownership-efficiency relationship even more complex. Developing economies are characterised by information poverty (which affects the effectiveness of shareholder monitoring), high transaction costs, stringent takeover regulations and also by the fact that the success or failure of a takeover may depend on the ability of firms or individuals to gather government support (Sarkar et al., 1998).

¹¹ Gardner and Grace (1993) and Berger et al. (1996a) analyse the U.S. life insurance industry and the U.S. property-liability insurance industry respectively finding no significant differences between stocks and mutuals in terms of cost efficiency, but stock firms providing property liability insurance present higher profit efficiency than mutuals.

Additionally, the few empirical studies that have analysed the ownership-efficiency relationship within a developing country have not offered conclusive evidence. This calls for further analysis of the banking industry in developing economies.

4 Methodology

Two approaches can be used to analyse efficiency differences across ownership types. It would be possible: (i) to estimate an industry frontier, including all ownership types, from which efficiencies can be calculated or alternatively, (ii) to estimate frontiers for each ownership type. The former would allow comparisons between ownership types relative to the industry best-practice cost or profit frontier, whereas the latter would only permit comparison between banks of the same ownership type. This study uses the first approach, for two reasons. Firstly, one objective of this work is to estimate efficiency differences across ownership types and this would not be possible by estimating separate frontiers. Secondly, there is no evidence to suggest that in Argentina banks of different ownership type have access to different technologies.

Economic efficiency can be estimated using cost, revenue or profit frontiers. The use of cost or profit frontiers to evaluate economic efficiency is related to owners' and managers' objectives in different organisations. In stock banks, for example, the owners are possibly requesting maximum profits and market forces may discipline managers to maximise profits. However, it is not clear whether managers of mutual and public banks have similar objectives. The owners' objectives in mutual banks may be related to the minimisation of the spread between the rates offered to depositors and those charged to borrowers while in public ownership may be the maximisation of social welfare. Since the objectives of each ownership type are not clear, the evaluation of each bank's capability to achieve its superior goals should be left aside. The solution to this problem could be to focus on subobjectives that are unambiguous for the different ownership types. Cost minimisation might be a good candidate in this respect to analyse the efficiency differences of stock, mutual and public-owned banks. In contrast, stock domestic- and foreign-owned banks should have similar objectives i.e. profit maximisation, then, profit frontiers could also be used to evaluate these banks' efficiency. A cost frontier is then estimated using pooled data on all banks, regardless of their ownership type, while a profit frontier is estimated from data of stock domestic- and foreign-owned banks.

To measure cost efficiency, the cost function for bank i , which takes exogenous output quantities y and input prices w , is specified as:

$$(1) \ln c = f(y, w, z) + \ln u^c + \ln v^c$$

where c is total cost, $f(y, w, z)$ is a cost function with outputs, variable input prices and other control and shift variables as arguments, $\ln u^c$ denotes an inefficiency factor that may increase costs above the best-practice level, and $\ln v^c$ denotes the random error that incorporates measurement error and any other statistical noise that may temporarily give firms high or low costs. The term $\ln u^c + \ln v^c$ is a composite error term. The efficiency measurement techniques used in this study separate the two components making different assumptions.

To measure profit efficiency, the alternative profit function that takes output quantities y and exogenous input prices w , is written as follows:

$$(2) \ln \pi^* = f(y, w, z) - \ln u^\pi + \ln v^\pi$$

where $\pi^* = \pi + \theta$ such that π is total profit of bank i and θ is a constant added to every bank's profit so that the natural logarithm is taken of a positive number; $\ln u^\pi$ represents inefficiency that reduces profits and $\ln v^\pi$ represents random error.

The functional form adopted for the cost and profit function is the translog. This is the functional form most frequently used in the literature. However, McAllister and McManus (1993) and Mitchell and Onvural (1996) show that the fitting of a translog over a wide range of firm sizes, could lead to specification bias. They suggest that the use of a more flexible functional form could alleviate this problem. One such function is the Fourier flexible form, which augments the translog by including Fourier trigonometric terms. Several studies show that the Fourier fits the data for U.S. financial institutions better than does the translog (see McAllister and McManus, 1993; Mitchell and Onvural, 1996; Berger and DeYoung, 1997). However, with regard to efficiency estimates, there appears to be little economic gain from the additional trigonometric terms. Berger and Mester (1997) and Vander Venet (2002) report that the translog and the Fourier flexible form yield similar average level and dispersion of measured efficiency and rank individual banks in almost the same order. In this study, the translog and the Fourier flexible specifications provide similar efficiency scores and ranking of firms, hence, results reported are those for the translog function.¹²

The translog cost function can be written as follows (omitting firm and time subscript):¹³

¹² Efficiency scores obtained with the Fourier flexible form are presented in the Appendix.

¹³ Input cost (output revenue) share equations embodying Shephard's Lemma (Hotelling's Lemma) restrictions are excluded because this would impose the assumption of no allocative inefficiencies.

$$\begin{aligned}
(3) \ln c(y, w, z) = & \alpha_0 + \sum_j \beta_j \ln w_j + \sum_m \beta_m \ln y_m + \beta_t t + \frac{1}{2} \sum_j \sum_k \delta_{jk} \ln w_j \ln w_k \\
& + \frac{1}{2} \sum_m \sum_n \delta_{mn} \ln y_m \cdot \ln y_n + \frac{1}{2} \delta_{tt} t \cdot t + \sum_j \sum_m \delta_{jm} \ln w_j \cdot \ln y_m \\
& + \sum_j \delta_{jt} \ln w_j \cdot t + \sum_m \delta_{mt} \ln y_m \cdot t + \ln u^c + \ln v^c
\end{aligned}$$

where c represents total cost (operating and interest costs), w_j denotes input prices, y_m represents the volume of output of firm i in period t and subscripts $j, k = d, l, k, m, f$ denote inputs deposits, labour, physical capital, materials and other funds and $m, n = L, S$ denote outputs loans and securities.¹⁴ A time trend t is added to serve as an indicator of technological progress, u is the inefficiency term and v the random error term.¹⁵

The alternative profit function has the same translog specification as the cost function. The use of the same functional form for the cost and profit functions assures that any observed differences in measured cost and profit efficiency are due to the efficiency concept (i.e. cost efficiency or profit efficiency) and not to the choice of functional form. The use of the same functional form therefore avoids confounding inefficiency differences with specification differences. The cost function and the alternative profit function not only have the same functional form but also have exactly the same right-hand side variables, the only difference being the dependent variable: total costs and total pre-tax profits, respectively. Following Berger and Mester (1997), the constant $\theta = |\pi^{\min}| + 1$ is added to every firm's profits so that the natural logarithm is taken of a positive number, since the minimum profits are typically negative.¹⁶

To ensure symmetry and linear homogeneity in input prices, the following parameter restrictions on the cost function are imposed *a priori*: $\sum_j \beta_j = 1$, $\sum_j \delta_{jk} = 0$, $\delta_{jk} = \delta_{kj}$ for all j, k , $\sum_j \delta_{jm} = 0$ and $\sum_j$

¹⁴ Berger and Mester (1997) include financial capital as a fixed input in the cost function to control for risk. Efficiency scores obtained with the translog cost function including financial capital as a fixed input are presented in the Appendix.

¹⁵ Berger and Mester (1997) include the ratio of non-performing to total loans to control for output quality. They report negligible differences in cost and profit efficiency measures obtained after adding this control variable. In addition, Berger and DeYoung (1997) point out that if loan quality is driven by bad management, controlling for non-performing loans in cost and profit functions will artificially increase measured efficiency. For these reasons, the ratio of non-performing loans is not included in the analysis.

¹⁶ The value of one plus the absolute value of the largest negative profit in the sample is included in π^* . The dependent variable for firm i at time t is then: $\ln \pi_{it}^* = \ln(\pi_{it} + |\pi^{\min}|)$, where π is measured profits and $\min$ indicates the sample minimum, which is negative. This modification is made for all observations and for the firm with the lowest value of π the dependent variable will be $\ln(1) = 0$.

$\delta_{jt}=0$.¹⁷ The homogeneity restriction does not have to be imposed on the alternative profit function, but following Berger and Mester (1997) it is imposed to keep the functional forms equivalent. In contrast, monotonicity with respect to output quantities and input prices are not general properties of the translog functional forms and unlike symmetry, they cannot be conveniently summarised by linear restrictions on parameters of equation (4.8). Consequently, the consistency of the estimated equations with respect to these properties must be evaluated.¹⁸

Cost and profit efficiencies are estimated using the parametric approaches SFA and DFA, allowing efficiency to vary across banks. The TFA is not applied since it does not provide estimates of efficiency at the firm level. Four different techniques are used within the SFA to estimate bank efficiency; all use the same translog cost (profit) specification. Two panel estimation techniques are based on Schmidt and Sickles (1984): a fixed-effects model (FEM) and a random-effects model (REM). The other two are Maximum Likelihood (MLE) techniques, which are based on Battese and Coelli (1988).

In the FEM the inefficiency term u_i is treated as a firm-specific constant and the error term v_{it} is assumed to be iid $(0, \sigma_v^2)$ and uncorrelated with the regressors. The model is estimated by Ordinary Least Squares with Dummy Variables using the within-groups (WITHIN) transformation (since the number of firms is too large to accommodate with simple OLS). If a cost function is estimated, the firm with the lowest fixed effect is assumed to be the most efficient in the sample, and efficiency is measured by the distance between the fixed effect of each firm and that of the most efficient one:

$$(4) \text{ CE}_i = \exp[-(\hat{\alpha}_{oi} - \hat{\alpha}_{oi}^{\min})]$$

where $\alpha_{oi} = \alpha_o + u_i$ are the fixed effects. The fixed-effects are intended to capture variation across firms in time-invariant efficiency. However, they also capture the effects of all firm time-invariant events (Kumbhakar and Lovell, 2000). The random-effects model that follows is intended to address this drawback.

In the REM the inefficiency term u_i is randomly distributed but is assumed to be uncorrelated with the regressors and with the v_{it} , which are assumed to have zero mean and constant variance.

¹⁷ In the empirical implementation, linear homogeneity in input prices is imposed by normalising the dependent variable and all input price variables by one input price before taking logarithms.

¹⁸ In the case of the alternative profit function, even when it is not possible to specify the properties satisfied by π , it is reasonable to assume that it is non-decreasing in output quantities and non-increasing in input prices (Kumbhakar and Lovell, 2000).

The model is estimated by the two-step Generalised Least Squares (GLS) method. In this model, the inefficiency term forms part of the random error, and efficiency is computed as follows:

$$(5) CE_i = \exp[-(\ln \hat{\varepsilon}_i^* - \ln \hat{\varepsilon}_i^{*\min})]$$

where $\ln \hat{\varepsilon}_i^* = (1/T_i) \cdot \sum \ln \hat{\varepsilon}_{it}$, $\ln \hat{\varepsilon}_{it}$ are the residuals and T_i is the number of observations for firm i .

The MLE techniques assume the random error v_{it} is two-sided while the inefficiency term u_i is one-sided. The model is estimated by MLE and the inefficiency component is inferred from the composite error $\varepsilon_{it} = u_i + v_{it}$, where $v_{it} \sim \text{iid } N(0, \sigma_v^2)$ and u_i and v_{it} are distributed independently of each other, and of the regressors. If the inefficiency term is assumed to follow a truncated normal distribution, $u_i \sim \text{iid } N^+(\mu, \sigma_u^2)$, the efficiency estimate for firm i is given by (Battese and Coelli, 1988):

$$(6) CE_i = E[\exp(-u_i) | \varepsilon_{it}] = \frac{1 - \Phi[\sigma_i^* - (\mu_i^* / \sigma_i^*)]}{1 - \Phi(-\mu_i^* / \sigma_i^*)} \cdot \exp[\mu_i^* + \frac{1}{2} \sigma_i^{*2}]$$

where Φ is the cumulative density function of the standard normal distribution, $\mu_i^* = \{(\mu \cdot \sigma_v^2 + T_i \cdot \sigma_u^2 \cdot \hat{\varepsilon}_i^*) / [\sigma_v^2 + (\sigma_u^2 \cdot T_i)]\}$, $\sigma_i^* = \{(\sigma_u^2 \cdot \sigma_v^2) / [\sigma_v^2 + (\sigma_u^2 \cdot T_i)]\}^{1/2}$, $\hat{\varepsilon}_i^* = (1/T_i) \cdot \sum \ln \hat{\varepsilon}_{it}$ and T_i is the number of observations for firm i .¹⁹ If the inefficiency component is assumed to follow a half normal distribution, $u_i \sim \text{iid } N^+(0, \sigma_u^2)$, the firm-specific time-invariant efficiency estimates can be produced simply by restricting μ to equal 0 in (4.11).²⁰ Efficiency is measured relative to the estimated frontier rather than the best-practice bank (that with a zero value for $\ln u$), which may not be achieved by any bank in the sample. To make the efficiency measures comparable across techniques, the efficiency estimates are normalised to be deviations from the smallest observed expected value of $\ln u$, so the most efficient bank in the sample will have efficiency of one (Berger and Mester, 1997).

¹⁹ The parameter $\gamma = \sigma_u^2 / \sigma^2$ represents the share of inefficiency in the overall residual variance and ranges between 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in favour of a standard OLS estimation (no inefficiency effects).

²⁰ Berger and Humphrey (1997) point out that even when the half-normal assumption for the distribution of inefficiencies is relatively inflexible (and presupposes that most firms are clustered near full efficiency), the use of other distributions such as the gamma or truncated normal distributions, which are more flexible, may make it difficult to separate inefficiency from random error.

The other parametric technique used to analyse efficiency is the DFA. This approach makes no assumptions on the distribution of the inefficiency term u_i and disentangles inefficiency u_i from random error v_{it} by assuming that the former is constant and that the latter tend to average out to zero over time. The cost and profit functions are estimated separately for each year over the sample period and the average residual for each bank is an estimate of $\ln u_i$. Despite the assumption that random errors average out to zero over time, the extreme values of these inefficiency estimates may reflect substantial random components. Hence, truncation is used to give less extreme values to banks with the most extreme values in each of different bank size classes.²¹ The time-invariant efficiency estimate for firm i is calculated as follows:

$$(7) CE_i = \exp[-(\ln \hat{\varepsilon}_i^* - \ln \hat{\varepsilon}_i^{*min})]$$

where $\ln \hat{\varepsilon}_i^* = (1/T) \cdot \sum \ln \hat{\varepsilon}_{it}$ and $\ln \hat{\varepsilon}_{it}$ are the residuals of the estimation of the model for each year.²²

The preceding analysis is based on the assumption that efficiency is time-invariant. Several techniques can be used to model time-varying efficiency, however, these methods are subject to several limitations, especially when technical change is considered in the analysis. Two different approaches can be used to model time-varying efficiency using fixed- or random-effects. One of these techniques assumes $u_{it} = u_i \beta_t$, where the β_t are time-effects represented by time dummies and the u_i can be either firm-specific fixed- or random-effects (Lee and Schmidt, 1993). This model is only suitable in cases where the number of firms is large and the number of time-series observations is relatively small (Kumbhakar and Lovell, 2000). The main drawback of this method is that it assumes a common temporary pattern of variation on efficiency across firms. The other approach assumes u_{it} to be $u_{it} = \Omega_{1i} + \Omega_{2i}t + \Omega_{3i}t^2$, where the Ω s are firm-specific parameters (Cornwell, Schmidt and Sickles, 1990). Hence, this method allows temporal efficiency changes to differ across firms. However, if technical change is proxied by a time trend, it is impossible to separate the effects of technical change and of time-varying technical efficiency using this approach (Kumbhakar, Heshmati and Hjalmarsson, 1997).

²¹ Each bank at the top and bottom 5% of the distribution of the average residuals in a size category is assigned the value for the bank that is just at 5th or 95th percentile, respectively. Truncation is performed within size class quartiles (by total assets) (DeYoung and Nolle, 1996).

²² Profit efficiency can be measured using (4), (5) and (7) with some sign changes and with respect to the firm with the highest fixed-effect or average residual and using (6) with some sign changes. However, since θ is subtracted from π , these expressions can no longer be used. Instead profit efficiency needs to be computed as the ratio of predicted actual profits to predicted maximum profits for a best-practice bank as follows: $\{\{\exp[\ln(\hat{\pi} + \theta)] \cdot \exp[\ln(\hat{u}^*)]\} - \theta\} / \{\{\exp[\ln(\hat{\pi} + \theta)] \cdot \exp[\ln(\hat{u}^{max})]\} - \theta\}$.

A maximum likelihood approach can be used to solve this problem by positing a non-linear specification on the time trend in the function identifying the temporal pattern of inefficiency. This method assumes that $u_{it} = u_i \cdot \beta(t)$, where $\beta(t)$ is a parametric function of time and u_i is a nonnegative random variable (Kumbhakar, 1990; Battese and Coelli, 1992). In this case the time effects can be separated by using a non-linear specification for $\beta(t)$. However, the main drawback of this approach is the assumption that efficiency change is the same for all banks and that the ranking of banks according to efficiency is the same at all time periods. This model does not account for situations in which some firms are relatively inefficient initially but become more efficient in later periods.

Another maximum likelihood approach allows for the temporary pattern of variation on efficiency to differ across firms (Battese and Coelli, 1995). The inefficiency term is assumed to follow a truncated distribution with different means for each individual. The distribution of the inefficiency effects is assumed to be a function of observable variables. The u_{it} are non-negative random variables independently distributed, and obtained by truncation of the $N^+(\mu_{it}, \sigma_u^2)$ distribution:

$$(8) \mu_{it} = m_{it} \cdot \xi$$

where m_{it} is a vector of observable explanatory variables and ξ is a vector of unknown parameters. Consequently the inefficiency effects are defined as:

$$(9) u_{it} = m_{it} \cdot \xi + w_{it}$$

where w_{it} is defined by truncation of a normal distribution being $m_{it} \cdot \xi$ the truncation point. These assumptions are consistent with u_{it} being the non-negative truncation of the $N^+(m_{it} \cdot \xi, \sigma_u^2)$ distribution.

The efficiency estimate for firm i at time t is given by (Battese and Coelli, 1995):

$$(10) \quad CE_{it} = E[\exp(-u_{it}) | \varepsilon_{it}] = \frac{\Phi[(\mu_{it}^* / \sigma^*) - \sigma^*]}{\Phi(\mu_{it}^* / \sigma^*)} \cdot \exp[\mu_{it}^* + \frac{1}{2} \sigma^{*2}]$$

where $\mu_i^* = (\sigma_v^2 \cdot m_{it} \cdot \xi + \sigma_u^2 \cdot \varepsilon_{it}) / (\sigma_u^2 + \sigma_v^2)$ and $\sigma^* = [(\sigma_u^2 \cdot \sigma_v^2) / (\sigma_v^2 + \sigma_u^2)]^{1/2}$. The goal of this technique is to analyse the determinants of inefficiencies among firms, however, it can also be used to

measure time-varying efficiency. Even though the inclusion of a time trend among the explanatory variables in the inefficiency function leads to the same identification problems mentioned above, the use of time-varying variables allows estimation of inefficiencies that vary across firms and time. This approach is used to analyse efficiency changes over time.²³

The preceding analysis refers to the measurement of economic efficiency from the estimation of a cost or profit function. Several cost elasticities can be also computed from the parameters of the cost function (3). The elasticity of cost with respect to output, which represents the cost changes associated with scale y may be expressed as $\varepsilon_{cy} = \sum_m (\partial c / \partial y_m) \cdot (y_m / c) = \sum_m (\partial \ln c / \partial \ln y)$. In terms of the coefficients of (3), the elasticity of cost with respect to output can be written as:

$$(11) \quad \varepsilon_{cy} = \sum_m \left(\beta_m + \delta_{mm} \ln y_m + \delta_{mn} \ln y_n + \sum_j \delta_{jm} \ln w_j + \delta_{mt} t \right)$$

Since scale economies can be measured as $SCE = 1/\varepsilon_{cy}$ values of ε_{cy} lower (higher) than one indicate the presence of scale economies (diseconomies). The elasticity of cost with respect to time often interpreted as technological change, which measures the rate of downward shift of the cost function over time, can be estimated from the cost function as $\varepsilon_{ct} = (\partial c / \partial t) \cdot (1/c) = (\partial \ln c / \partial t)$, which from (3) can be written as follows:

$$(12) \quad \varepsilon_{ct} = \beta_t + \delta_{tt} t + \sum_j \delta_{jt} \ln w_j + \sum_m \delta_{mt} \ln y_m$$

where negative values indicate the contribution of technical change in reducing firm costs.

5 Data and Variables

The data used to estimate the cost and profit frontiers consist of annual information from the Report of Condition and Income Statement of each retail bank over the period 1993-2000. Data for the 1993-1997 period were provided by the Banco Central de la República Argentina, while data for the 1998-2000 period were obtained from *Información de Entidades Financieras*, Banco Central de la República Argentina. Banks are classified as stock, mutual, public- and foreign-owned. The data set is an unbalanced panel of 715 observations: 124 refer to public banks, 346 to stock banks, 115 to mutual banks and 130 to foreign banks. The unbalanced

²³ Only few studies in the banking literature analyse time-varying efficiency or the determinants of inefficiencies using parametric approaches (Lang and Welzel, 1999; Esho, 2001; Frame and Coelli, 2001;

nature of the panel is due to: (i) privatisation of public banks; (ii) mergers among mutual financial institutions; (iii) mergers in the stock (domestic) sector and (iv) entry of foreign banks, which mainly occurred through acquisition of domestic banks. The following dummy variables D_{stock} , D_{mut} , D_{pub} and D_{for} equal 1 for stock, mutual, public- and foreign-owned banks, respectively, and 0 otherwise.

The definition of outputs and inputs follows the intermediation approach. Thus, y_L is measured as the volume of loans and y_S as total assets minus loans, property and equipment and other fixed assets. Since loans are denominated in domestic (pesos) and foreign (dollars) currency, a quantity index is constructed by Divisia aggregation of loans in pesos and dollars as follows: $\ln y_t - \ln y_{t-1} = (1/2) \sum_i (s_{it} + s_{i,t-1}) \cdot (\ln y_{i,t} - \ln y_{i,t-1})$ where y_i represents the i th type of loan, p_i the interest rate, $s_i = p_i \cdot y_i / \sum_i p_i \cdot y_i$ its share in total revenues and t represents the time period.²⁴

The input prices (labour, capital, materials and other funds) are computed as follows. The wage rate for each bank (w_l) is proxied by the ratio of personnel expenses (wages and insurance payments) to the number of employees. The price of capital for each bank (w_k) is constructed as sum of the depreciation rate and the opportunity cost of capital. The latter is approximated by the interest rate for loans less the expected rise in the value of the investment goods employed, which is proxied by the growth rate of the wholesale price index (Lang and Welzel, 1996). The price of materials (w_m) is constructed as administrative expenses minus personnel and capital costs divided by the value of total assets. The price of other funds (w_f) is given by the ratio of interest expenses on other purchased funds to other borrowed funds (including interbank funds purchased, commercial papers and other purchased funds). Total cost in each bank (c) includes all operating expenses and interest payments on deposits and other purchased funds while total profit (π) is given by net income before tax adjusted to exclude negative values. All nominal data were converted into 2000 prices using the wholesale price index.

Table 5 displays descriptive statistics by ownership type. The data indicate that banks differ in terms of assets. On average, stock banks held \$610 million of assets, mutual banks had \$258 million of assets and public-owned banks held assets for \$2.2 billion. The average foreign-owned bank also had \$2.2 billion of assets. On the output side, foreign-owned banks held fewer loans as proportion of total assets and charged lower interest rates than did domestic-owned banks. In the domestic-owned sector, stock banks held fewer loans than their mutual and public sector counterparts and mutual banks paid the highest interest rates on loans of the market.

Cavallo and Rossi, 2002).

²⁴ 11 institutions were excluded due to negative or implausibly large prices.

Table 5

Descriptive statistics

Stock, mutual, public- and foreign-owned retail banks, 1993-2000

Variable ^a		All banks	Domestic banks			Foreign banks
			Stock	Mutual	Public	
Output quantities (% of assets)						
Loans	y_L	57.6 (16.3)	55.0 (16.8)	65.2 (9.0)	60.8 (18.5)	54.8 (15.5)
Securities	y_S	31.2 (16.2)	33.1 (17.1)	20.4 (9.2)	31.6 (14.8)	35.4 (16.2)
Output prices (%)						
Loans	p_L	19.8 (9.9)	20.7 (11.0)	26.1 (6.7)	17.3 (8.9)	14.2 (5.7)
Securities	p_S	6.5 (11.7)	6.7 (11.2)	6.7 (7.6)	6.2 (19.4)	6.1 (4.4)
Input quantities (% of assets)						
Employees (per million \$ of assets)	x_l	1.8 (1.3)	1.8 (1.2)	3.2 (1.3)	1.8 (0.9)	0.9 (0.5)
Capital	x_k	6.9 (3.7)	6.6 (3.9)	8.8 (3.4)	6.4 (3.1)	6.6 (3.6)
Materials	x_m	3.2 (1.9)	3.2 (1.6)	4.9 (2.4)	2.3 (1.3)	2.3 (1.6)
Deposits	x_d	50.1 (20.1)	49.5 (24.5)	58.8 (11.9)	48.3 (15.2)	45.7 (14.1)
Other funds	x_f	24.6 (14.9)	24.5 (14.4)	13.3 (9.4)	27.5 (14.4)	32.0 (14.7)
Input prices (%)						
Labour (thousand \$ per employee)	w_l	31.8 (11.5)	30.2 (10.4)	24.5 (5.8)	31.2 (8.9)	43.2 (12.4)
Capital	w_k	23.5 (10.0)	24.7 (10.7)	28.8 (6.8)	19.7 (9.6)	19.1 (7.4)
Materials	w_m	3.2 (1.9)	3.2 (1.6)	4.9 (2.4)	2.3 (1.3)	2.3 (1.6)
Deposits	w_d	8.8 (7.5)	9.0 (8.8)	11.5 (6.9)	9.7 (7.0)	6.0 (1.8)
Other funds	w_f	12.1 (17.6)	10.4 (10.4)	22.2 (30.1)	12.0 (13.1)	8.0 (18.9)
Other characteristics % of assets						
Costs ^b	c	16.2 (7.8)	15.7 (6.7)	23.2 (7.3)	16.2 (7.8)	11.7 (4.8)
Profits	π	0.45 (7.3)	1.53 (5.5)	0.92 (2.6)	0.46 (7.3)	1.14 (3.2)
Assets (million \$)		1,132.1 (2,615.4)	610.4 (1,548.4)	258.1 (407.4)	2,237.4 (4,297.1)	2,239.5 (3,142.2)
Number of banks ^c		123 (62)	49 (31)	39 (1)	22 (10)	13 (20)

^a Mean values and standard deviation in parenthesis. Constant pesos December 2000. ^b Includes operating and financial costs. ^c Number of banks in 1993 (2000) respectively.

On the inputs side, foreign-owned banks used fewer employees per million of assets than did domestic-owned banks, but paid them higher wages and benefits. This result suggests that foreign-owned banks used labour inputs rather efficiently and/or pursued a less labour-intensive strategy. In the domestic-owned sector, mutual banks relied more heavily on labour than public-owned and stock banks. Mutual banks, however, paid lower salaries. In terms of funds, foreign-owned banks had fewer deposits than domestic-owned banks financing a larger proportion of their assets with purchased funds. This result may indicate that foreign-owned banks had difficulty competing for deposits from domestic customers and/or that they have access to foreign sources of funds. However, foreign-owned banks paid the lowest interest rate on deposits but similar rates on purchased funds. In the domestic-owned sector, mutual banks had more deposits than non-mutual banks and paid the highest rates for deposits and purchased funds.

6 Results

Results are analysed in several sections. Cost frontiers are estimated using SFA and DFA techniques on pooled data for retail banks over the 1993-2000 period. Profit frontiers are estimated for the pooled data of stock domestic- and foreign-owned banks. The first sections analyse time-invariant efficiency measures. Section 6.1 presents the average cost efficiency scores obtained for the pooled data. This section also examines the consistency across measurement techniques. Section 6.2 reports and discusses the differences in cost efficiency, economies of scale and the effects of technical progress across ownership types. Section 6.3 presents profit efficiency differences across stock domestic- and foreign-owned banks. The last section analyses time-varying efficiency indicators. Section 6.4 reports the changes in efficiency across ownership types over the subperiods 1993-1996 and 1997-2000.

6.1 Cost Efficiency Scores and Rankings across Techniques

Cost frontiers based on the pooled data are estimated within the SFA using MLE and panel estimation techniques (GLS and WITHIN) and also using the DFA (see Table A1 in the Appendix). MLE assumes the inefficiency error term follows a half normal and a truncated normal distribution. The cost function estimates are used to compute efficiency scores for each bank using (4), (5), (6) and (7). Table 6 reports a number of distributional characteristics of the cost efficiency scores that allow comparison across the different techniques. The results based on the estimations performed using MLE techniques show that average cost efficiencies are lower (and dispersion higher) with the truncated normal model than with the half normal model,

as average efficiencies are 0.696 and 0.820, respectively. These results also reveal that the panel estimation techniques and DFA method provide lower efficiency estimates than the MLE, as average efficiency scores are 0.563 and 0.309 for GLS and WITHIN techniques, respectively, and 0.661 for the DFA model.²⁵ These figures are within the range found in the literature.²⁶ Overall, these results suggest that the choice of methodology has an important impact on the estimated average efficiency scores.

Table 6
Descriptive statistics of cost efficiency scores by technique

Method ^a	Mean	Median	Standard Deviation	Maximum	Minimum
Stochastic frontier approach- SFA					
MLE Half Normal	0.820	0.829	0.096	1.000	0.409
MLE Truncated Normal	0.696	0.685	0.103	1.000	0.374
GLS Random-effects	0.563	0.556	0.105	1.000	0.362
WITHIN Fixed-effects	0.309	0.285	0.150	1.000	0.141
Distribution free approach – DFA	0.661	0.662	0.076	1.000	0.390

^a MLE Half Normal (Truncated Normal): maximum likelihood estimates under the assumption of half-normal (truncated normal) distribution for the inefficiency error term; GLS Random effects: generalised least square estimates of random effects model; WITHIN Fixed effects: LS estimates of fixed effects model using within transformation.

Table 7 displays pairwise Spearman rank correlation coefficients of the efficiency scores obtained with the different methods. These correlation coefficients are useful to analyse the consistency of methods in ranking banks, as they show how close the rankings of banks (given by the different frontier techniques) are among each other. The MLE methods appear to be highly consistent in ranking banks according to cost efficiency, with a pairwise correlation coefficient of 97.8 (also see figures A3 to A6 in the Appendix). The rank correlation among the panel estimation techniques is lower – at 62.3 percent. The DFA method is highly correlated with MLE and GLS techniques, however, the correlation with the WITHIN estimators is low – 41.1 percent. In addition, the MLE methods and GLS model appear to be consistent in ranking banks according to cost efficiency with pairwise correlation coefficients of 94.5 and 95.1 percent. However, the rank correlations are lower when comparing the MLE and WITHIN

²⁵ Burdisso et al. (1998) find average efficiency scores for a sample of (stock and public) Argentine banks over the 1991-1996 period of 0.486 and 0.717 using the WITHIN and DFA methods respectively.

²⁶ Berger and Humphrey (1997) survey 122 frontier studies that apply efficiency analysis to depository institutions. They find that the distribution of average cost efficiency from parametric studies of U.S. (non U.S.) financial institutions has a mean of 0.84 (0.76) with standard deviation of 0.06 (0.12) and range of 0.61-0.95 (0.20-0.90).

estimators, ranging from 49.5 to 58.7 percent. Despite the WITHIN-fixed effects, the GLS-random effects and the DFA methods produce lower efficiency scores than the MLE techniques, these results suggest that the measurement techniques produce comparable efficiency rankings. These results are consistent with previous studies.²⁷

Table 7
Spearman rank-order correlations among efficiency scores

Method	Stochastic Frontier Approach				Distribution Free Approach
	MLE Half Normal	MLE Truncated Normal	GLS Random effects	WITHIN Fixed effects	
Stochastic frontier approach- SFA					
MLE Half Normal	1.000	0.978 ***	0.945 ***	0.495 ***	0.827 ***
MLE Truncated Normal		1.000	0.951 ***	0.587 ***	0.806 ***
GLS Random-effects			1.000	0.623 ***	0.795 ***
WITHIN Fixed-effects				1.000	0.411 ***
Distribution free approach – DFA					1.000

***, **, * indicates significance at the 1%, 5% and 10% level, respectively.

Table 8 reports the proportions of banks that are identified by one technique as having efficiency scores in the top 10% that are also identified in the top decile by other technique. This information is useful to determine the degree to which different techniques identify the same banks as being in the highest and lowest efficiency groups. The results show that MLE methods are reasonably consistent in identifying the most and least efficient firms, as 86.7 percent of banks identified as in the best and worst 10% practice by the MLE Half normal technique are also identified in the highest and lowest decile by the MLE Truncated normal technique. The results also reveal that the correspondence of the best and worst practice 10% of banks between the WITHIN and GLS techniques are lower at 53.3 and 46.7 percent, respectively. In addition, the MLE methods and GLS technique are highly consistent in identifying the most and least efficient banks, though the correspondence with WITHIN and DFA techniques are lower. These

²⁷ Bauer et al. (1993) compare results obtained from MLE and panel data techniques (WITHIN and GLS) using U.S. banking data over 1977-1988. They report correlation of 89 percent between WITHIN and GLS efficiency estimates, but correlation between these two estimates and MLE estimates in the range 38.0-50.0 percent. For the same sample of U.S. banks Bauer et al. (1998) compare MLE, WITHIN, GLS, DFA, TFA and DEA estimates. They find that correlation between MLE and WITHIN and GLS estimates are 49.5 and 56.6 percent respectively, while the correlation between the later two is 93.6 percent. They also report correlation of 96.4 between MLE and DFA estimates but correlation between the later and WITHIN and GLS estimates of 48.4 and 56.7 percent respectively. Furthermore, Berger and Mester (1997) compare results obtained from MLE and DFA approaches (assuming a half normal distribution for the inefficiency error term) using U.S. banking data. They report a rank-order correlation coefficient of 98.8 percent.

results suggest that the different methods generate similar efficiency rankings, particularly at the top and bottom of the distribution.

Table 8
Correspondence of best practice and worst practice banks across techniques

Method	Stochastic Frontier Approach				Distribution
	MLE Half Normal	MLE Truncated Normal	GLS Random effects	WITHIN Fixed effects	Free Approach
Stochastic frontier approach- SFA					
MLE Half Normal		0.867	0.800	0.533	0.467
MLE Truncated Normal	0.867		0.867	0.600	0.467
GLS Random-effects	0.800	0.733		0.533	0.533
WITHIN Fixed-effects	0.333	0.333	0.467		0.400
Distribution free approach – DFA	0.600	0.533	0.600	0.333	

Each number above (below) the diagonal represents the proportion of banks that are identified by one technique as having efficiency scores in the most (least) efficient decile of banks that are also identified in the most (least) efficient decile by the other technique.

6.2 Cost Efficiency, Scale Economies and Technical Change Differences across Ownership Types

Despite producing different efficiency scores, the analysis of the previous section indicates that the measurement techniques produce comparable efficiency rankings, particularly at the top and bottom of the distribution.²⁸ The cost functions estimated above are used to analyse the differences across stock, mutual, public- and foreign-owned banks in terms of efficiency, scale economies and technical change over the 1993-2000 period. The efficiency scores for each bank computed above are averaged out to obtain the average cost efficiency of each ownership type. Cost elasticities are computed for each bank using the cost function estimates and (11) and (12), and they are then averaged out for each ownership group. Table 9 presents the average cost efficiency, scale elasticities and technical change for each ownership type.²⁹ The data show that all models generate similar results, except the fixed-effects model, which provides lower efficiency and scale economies measures.

²⁸ However, the WITHIN method appears to be the least consistent with respect to the others.

²⁹ Table A2 in the Appendix reports the average efficiency scores obtained using the Translog including financial capital as a fixed input. Table A3 also reports the average efficiency measures obtained from the Fourier flexible form. The efficiency differences and ranking of banks across specifications are very small.

The results for the domestic private-owned banks are presented in Panels A and B. The cost efficiency measures for stock banks reported in Panel A indicate that cost efficiency is 62.3 percent on average (range from 31.1 to 84.6 percent). This finding suggests that if all stock banks operate on the efficient frontier they could produce the same level of output with 62.3 percent of current inputs. Altunbas et al. (2001) and Bhattacharyya et al. (1997) report higher average cost efficiencies for stock banks in Germany and India (of about 80 and 76 percent, respectively).³⁰ Burdisso et al. (1998) find that the average efficiency for stock banks in Argentina over the 1991-1996 period is 61.8 percent.³¹ The results also show that the average scale elasticity for stock banks is 0.873, which indicates that a 10% increase in output would raise costs by 8.73% holding other variables constant. This result suggests that stock banks operate under increasing returns to scale, and that an increase in the size of stock banks would lead to costs reductions. Finally, the findings indicate that technical change has reduced costs by less than 0.5 percent per year.

The results for the mutual banking sector shown in Panel B reveal that these banks exhibit lower cost efficiencies and higher scale economies than stock banks. The average cost efficiency is 58.5 percent across the different techniques, however, it varies from 30.5 to 80.4 percent depending on the method. This result suggests that if all mutual banks operate on the efficient frontier they could produce the same level of output with 58.5 percent of current inputs. The findings reveal that mutual banks also operate under increasing returns to scale with an average scale elasticity of 0.862 percent. Altunbas et al. (2002) report similar scale economies estimates but higher average cost efficiencies (about 85 percent) for mutual banks in Germany. In addition, technical change has not made a positive contribution to reducing costs, with costs having increased around 2 percent per year. This result may be due to cost increasing effects that have cancelled out technical innovations effects since technological change, defined as a trend, may capture not only production innovations but also the impact of other factors such as changes in organisational structure and processes on bank costs.

The cost efficiency measures for the public-owned banking sector shown in Panel C appear to be lower when compared with the private-owned – stock and mutual - banks. Cost efficiency for public banks ranges from 22.2 to 72.3 percent, with an average of 51.1 percent. These figures suggest that, on average, about 50 percent of costs are wasted relative to a best-practice bank. Altunbas et al (2002) and Bhattacharyya et al (1997) report higher average cost efficiencies for public-owned banks of around 84 and 87 percent, respectively. Burdisso et al. (1998) find that

³⁰ The former uses SFA and DFA and the latter uses DEA.

³¹ They use WITHIN fixed-effects.

the average cost efficiency for public-owned banks in Argentina is 28.3 percent. The results also show that the average scale elasticity for stock banks is 0.906, which indicates that a 10% increase in output would raise costs by 9.06% holding other variables constant. This finding suggests that public-owned banks also operate under increasing returns to scale. As for mutual banks, technical progress does not appear to have reduced costs in the public banking sector.

Table 9
Cost efficiency, scale economies and technical change
Stock, mutual, public- and foreign-owned banks, 1993-2000

Type of bank	MLE Half normal	MLE Truncated normal	GLS Random effects	WITHIN Fixed effects	DFA	Average
Panel A. Private (stock) banks						
Cost efficiency	0.846 (0.09)	0.726 (0.10)	0.587 (0.10)	0.331 (0.14)	0.686 (0.08)	0.623
Scale elasticity	0.953 (0.07)	0.917 (0.07)	0.938 (0.07)	0.685 (0.09)	0.963 (0.05)	0.873
Technical change	-0.010 (0.02)	-0.010 (0.02)	-0.008 (0.02)	0.020 (0.01)		-0.002
Panel B. Private (mutual) banks						
Cost efficiency	0.804 (0.06)	0.676 (0.08)	0.554 (0.09)	0.305 (0.15)	0.643 (0.06)	0.585
Scale elasticity	0.944 (0.06)	0.904 (0.07)	0.932 (0.07)	0.669 (0.09)	0.966 (0.03)	0.862
Technical change	0.011 (0.01)	0.020 (0.01)	0.013 (0.01)	0.037 (0.01)		0.020
Panel C. Public banks						
Cost efficiency	0.723 (0.12)	0.610 (0.10)	0.491 (0.08)	0.222 (0.08)	0.609 (0.08)	0.511
Scale elasticity	0.977 (0.07)	0.956 (0.09)	0.967 (0.08)	0.722 (0.10)	0.986 (0.07)	0.906
Technical change	0.005 (0.02)	0.008 (0.02)	0.005 (0.01)	0.027 (0.01)		0.011
Panel D. Foreign banks						
Cost efficiency	0.844 (0.09)	0.720 (0.11)	0.567 (0.13)	0.324 (0.21)	0.668 (0.05)	0.614
Scale elasticity	0.961 (0.07)	0.946 (0.09)	0.935 (0.08)	0.709 (0.09)	0.969 (0.05)	0.888
Technical change	-0.015 (0.02)	-0.016 (0.01)	-0.015 (0.02)	0.016 (0.01)		-0.008
Panel E. Overall average						
Cost efficiency	0.820 (0.09)	0.696 (0.10)	0.563 (0.11)	0.309 (0.15)	0.661 (0.08)	0.597
Scale elasticity	0.955 (0.07)	0.923 (0.08)	0.940 (0.07)	0.688 (0.09)	0.968 (0.05)	0.876
Technical change	-0.001 (0.02)	-0.001 (0.02)	-0.001 (0.02)	0.027 (0.01)		0.006

Mean and standard deviation in parenthesis.

The results for foreign-owned banks presented in Panel D reveal similar cost efficiency and scale economies, but higher technical progress than domestic-owned stock banks. The average cost efficiency is 61.4 percent, which ranges between 32.4 and 84.4 percent depending on the technique used. Bhattacharyya et al. (1997) find similar cost efficiency for domestic private- and

foreign-owned banks in India of around 75 percent. Berger et al. (2001) report that domestic-owned banks in France, Germany, Spain and the U.K. are more cost efficient than foreign-owned competitors while the opposite is true for banks in the U.S. The findings also show that foreign banks also operate under increasing returns to scale with scale elasticities averaging about 0.888. Finally, the results indicate that technical change has reduced costs by about 1 percent per year.

These results suggest that within the domestic-owned banking sector, stock banks seem to be more cost efficient than mutual and public-owned banks. The findings also imply that domestic-owned stock banks appear to be as efficient as foreign-owned banks. To further test whether these differences are statistically significant, the non-parametric Mann-Whitney rank test is used to infer whether different ownership types have identical or different populations.³² Table 10 presents the results of the tests undertaken. These results suggest that the efficiency differences between stock, mutual and public-owned banks are statistically significant at levels of 10% or less in most cases. The findings also imply that cost efficiency differences between stock domestic- and foreign-owned banks are not statistically significant but that differences between the latter and mutual and public-owned banks are statistically significant in most cases.

Table 10
Mann-Whitney tests of cost efficiency differences across ownership types

Stock, mutual, public- and foreign-owned banks, 1993-2000

Differences between ownership types:	MLE Half normal	MLE Truncated normal	GLS Random effects	WITHIN Fixed effects	DFA
Difference within domestic-owned banks					
Stock - Mutual banks	-2.660 ***	-3.010 ***	-2.491 **	-0.912	-3.016 ***
Stock - Public banks	-4.073 ***	-3.901 ***	-3.666 ***	-3.834 ***	-3.316 ***
Mutual - Public banks	-2.948 ***	-2.258 **	-2.450 **	-3.270 ***	-0.988
Differences between domestic- and foreign-owned banks					
Stock - Foreign banks	-0.100	-0.259	-0.909	-0.717	-1.422
Mutual - Foreign banks	-1.640 *	-1.884 *	-1.012	-2.590 ***	-1.169
Public - Foreign banks	-3.109 ***	-2.895 ***	-2.088 **	-2.595 ***	-1.768 *

***, **, * indicates significance at the 1%, 5% and 10% level, respectively.

³² The Mann-Whitney statistic is obtained by pooling the groups that are to be compared, ranking in increasing order of magnitude according to efficiency and calculating the rank sum S of the first group. Then, the distribution of the rank sum statistic S is approximately normal with mean $m \cdot (m + n + 1)/2$ and variance $m \cdot n \cdot (m + n + 1)/12$ where m is the number of observations in the first group and n is the number of observations in the second group. By normalising S, the test statistic obtained is: $Z = \{[S - (n+m+1)/2] / [m \cdot n \cdot (m+n+1)/12]^{1/2}\}$, which has an approximated normal distribution if n and m are large.

6.3 Profit Efficiency of Stock Domestic- and Foreign-owned Banks

The analysis of the previous section suggests that cost efficiency differences between stock domestic- and foreign-owned banks are not statistically significant. However, since stock banks may seek to maximise profits, this section examines profit efficiency differences between stock domestic- and foreign-owned banks using SFA and DFA. Profit frontiers are estimated from the pooled data of stock domestic- and foreign-owned banks using the different techniques (see Table A4 in the Appendix). From these frontier estimates, the profit efficiency for each domestic- and foreign-owned bank is calculated as the ratio of predicted actual profits to predicted maximum profits. The average alternative profit efficiency for each ownership type is then obtained by averaging out the efficiency of individual banks belonging to each ownership group. Table 11 presents the average profit efficiency scores for domestic- and foreign-owned banks. These results show that all models generate similar results except for the fixed-effects model, which provides lower efficiency measures.

Table 11

Profit efficiency

Stock domestic- and foreign-owned banks, 1993-2000

Type of bank ^a	MLE Half normal	MLE Truncated normal	GLS Random effects	WITHIN Fixed effects	DFA	Average
Overall average	0.300 (0.09)	0.261 (0.09)	0.272 (0.11)	0.161 (0.15)	0.326 (0.09)	0.264
Domestic banks	0.301 (0.10)	0.263 (0.10)	0.281 (0.12)	0.173 (0.14)	0.330 (0.11)	0.270
Foreign banks	0.295 (0.05)	0.255 (0.04)	0.236 (0.06)	0.105 (0.18)	0.322 (0.06)	0.243
Mann-Whitney ^b	-0.445 (0.66)	-0.455 (0.65)	-1.183 (0.24)	-0.848 (0.37)	-0.446 (0.66)	

^a Standard deviation in parenthesis. ^b p values in parenthesis.

The results show that the average estimated alternative profit efficiency for stock domestic- and foreign-owned banks is 26.4 percent (range from 16.1 to 32.6 percent). These values indicate that the average domestic/foreign-owned stock bank earns 26.4 percent of the profits of a best-practice bank producing the same output bundle. This overall profit efficiency estimate is consistent with the findings of previous studies. Berger and Mester (1997) find average profit efficiencies of U.S. banks of 46.3 and 35.1 percent using DFA and MLE respectively. Berger et al. (2001) also use DFA to examine profit efficiency in various countries and report average

alternative profit efficiency of 44.2 percent for banks in France, 52.2 percent in Germany and 67.1 and 66.1 percent in Spain and the U.K., respectively.

The findings for Argentina show that the average profit efficiency of domestic-owned stock banks ranges from 17.3 to 33.0 percent, depending on the technique used to compute the estimates. The results further reveal that the average alternative profit efficiency of foreign-owned banks varies from 10.5 to 31.1 percent. The Mann-Whitney statistics suggest that the efficiency differences between domestic- and foreign-owned banks are not statistically significant. This result differs from the findings of Berger et al. (2001), who report that domestic banks in France, Germany, Spain and the U.K. are more profit efficient than foreign-owned competitors, although these profit efficiency differences are not statistically significant. However, they also find that foreign banks in the U.S. are less profit efficient than domestic-owned banks.

A further decomposition of foreign banks by country of origin provides mixed results. The MLE estimates suggest that Latin American banks are slightly more profit efficient than U.S. and European banks but the WITHIN, GLS and DFA estimates suggest that U.S. banks are slightly more efficient than other foreign-owned banks (Latin American and European). However, these profit efficiency differences across banks classified by country of origin are small. Berger et al. (2001) find that U.S. banks operating in France, Germany, Spain and the U.K., generally exceed the cost- and profit-efficiencies of domestic banks.

6.4 Cost Efficiency Differences Over Time

The preceding analysis is based on time-invariant efficiency measures. This section estimates time-varying efficiency scores using the MLE technique proposed by Battese and Coelli (1995) to analyse the changes in efficiency of each ownership type over the sample period. The cost function (3), based on the pooled data, is estimated along with the inefficiency function (9), which includes ownership dummy variables and size as explanatory variables. Table A5 in the Appendix presents the parameters estimates for the cost frontier and the inefficiency function. The results show that most of the parameter estimates of the inefficiency function are significant at the 1% level. The coefficient on D_{pub} is positive and highly significant, which confirms the previous results that public-owned banks are more inefficient than stock banks. The coefficient on D_{for} is insignificant implying that the efficiency differences between stock foreign- and domestic-owned banks are insignificant. The estimate for D_{mut} is positive and statistically significant, which also confirms the previous findings that mutual banks are less efficient than stock banks. Finally, the coefficient on $Size$ (measured as the logarithm of total assets) is

negative and highly significant suggesting that cost inefficiencies decline as bank total assets grow.

The cost and inefficiency function estimates are used to compute efficiency scores for each bank in each year using (10). These efficiency indicators are then averaged out to obtain the average cost efficiency of each ownership type in each year over the sample period. Table 12 presents the average cost efficiency for each ownership group and for different subperiods. The results show that the efficiency of the banking system increased from 0.837 to 0.863 between the first and the second half of the sample period as a result of an increase in the average efficiency of all ownership types. The developments that occurred during this post-deregulation period might explain this finding. The privatisation of highly inefficient public banks, the failures and acquisitions of stock and mutual banks characterised by poor performance and the higher pressure from foreign banks may explain this improvement in efficiency over the post-deregulation period.

The findings show that the efficiency of stock banks increased from 0.851 during 1993-1996 to 0.864 over 1997-2000 (and dispersion declined from 0.12 to 0.09). Mutual banks also show an improvement over the sample period from 0.833 to 0.858. The efficiency of public-owned banks increased (and dispersion declined) from 0.777 to 0.810 over the subperiods analysed. Finally, foreign-owned banks became more efficient over the sample period since average efficiency increased from 0.884 to 0.891 between 1993-1996 and 1997-2000.

The results also show that the ranking of ownership types is the same across time. Public-owned banks are the least efficient banks and stock and foreign-owned banks are the most efficient banks over the sample period, however, during 1999-2000 mutuals appear to be more efficient than stock banks.³³ The findings also show that the performance of mutuals and public-owned banks improved significantly over the sample period. The efficiency of public-owned banks increased notably over time, a result that could be explained by the effects of the privatisation of (potentially) high inefficient provincial banks and of the higher pressure resulting from the entry of foreign banks, as mentioned above. Additionally, the performance of mutual banks also improved notably over the sample period, a result that could be explained by the acquisition or failure of (highly) inefficient mutuals.

³³ This result could be explained by the structural changes observed in the mutual banking sector. As a result of several M&A, failures and conversions to stock banks, only one mutual bank is left operating in the system at the end of the sample period.

Zaim (1995) reports that public-owned banks in Turkey are the most efficient while private domestic-owned banks the least efficient in both pre- and post liberalisation periods. They also find that all ownership types (private, public- and foreign-owned) became more efficient after the liberalisation of the banking sector. In line with these findings, Bhattacharyya et al. (1997) report that public-owned banks in India are the most efficient over the early stages of the liberalisation period. They also find that foreign-owned banks are the least efficient at the beginning of the period, but that they are as efficient as public-owned banks by the end of the sample period (the efficiency of the latter decreased while the former became more efficient after the liberalisation of the sector).

Table 12
Efficiency differences across ownership types and over time
Stock, mutual, public- and foreign-owned banks, 1993-2000

Period	Overall	Stock	Mutual	Public	Foreign
1993-1996	0.837 (0.12)	0.851 (0.12)	0.833 (0.07)	0.777 (0.15)	0.884 (0.07)
1997-2000	0.863 (0.10)	0.864 (0.09)	0.858 (0.05)	0.810 (0.11)	0.891 (0.07)
1993-1994	0.852 (0.09)	0.880 (0.08)	0.840 (0.06)	0.795 (0.11)	0.874 (0.10)
1995-1996	0.823 (0.15)	0.821 (0.16)	0.818 (0.07)	0.759 (0.19)	0.893 (0.04)
1997-1998	0.874 (0.08)	0.888 (0.07)	0.821 (0.10)	0.803 (0.12)	0.904 (0.04)
1999-2000	0.851 (0.11)	0.841 (0.11)	0.906 (0.00)	0.817 (0.10)	0.879 (0.10)

Mean and standard deviation in parenthesis.

To sum up, the cost efficiency measures presented in Section 4.6.2 suggest that stock banks are more cost efficient than mutual banks. This result may be explained by the higher proportion of employees and deposits used and also by the higher interest costs faced by mutuals. The findings also reveal that stock banks appear to out-perform public-owned banks in terms of cost efficiency. Overall, this evidence indicates agency problems for both mutual and public-owned banks in Argentina. The cost and profit efficiency measures presented in Section 4.6.2 and 4.6.3 indicate that efficiency differences between foreign- and domestic-owned banks are not significant. This result may be explained in part by the fact that foreign-owned banks use more purchased funds and pay significantly higher salaries than domestic-owned banks. These findings may be related to organisational diseconomies to operate and monitor an institution from a distance, which increases costs relative to domestic institutions. However, foreign-owned banks use fewer employees than domestic institutions, which may probably be indicative of the access by foreign-banks to best-practice procedures and policies. Finally, the findings from Section 4.6.4 suggest that the post-deregulation developments appear to have induced

significant efficiency improvements since all ownership types, but especially public-owned and mutual banks, increased their cost efficiency over the post-deregulation period.

7 Conclusions

This study adds new evidence on the conflictive link between ownership and efficiency in the banking industry by examining efficiency differences between stock, mutual, public- and foreign-owned banks in Argentina over the 1993-2000 period. The cost and profit characteristics of these bank ownership types are compared by using a variety of techniques to evaluate differences in cost and profit efficiency, scale economies and the impact of technical progress across these ownership groups. Cost frontiers from pooled data of all banks are estimated using different parametric techniques to analyse the consistency across the different methods. From these cost frontiers, the differences between stock, mutual, public- and foreign-owned banks are examined by computing cost efficiency scores and cost elasticities measures. Profit frontiers from data of stock domestic- and foreign-owned banks are also estimated to explore profit efficiency differences between these profit maximising ownership types. Finally, the changes in cost efficiency over the post-deregulation period are analysed across ownership groups.

The results suggest that the choice of methodology has an important impact on the estimated efficiency scores. However, the different methods generate similar efficiency rankings, particularly at the top and bottom of the distribution, where managerial interest is concentrated. Cost efficiency measures suggest that within the domestic-owned banking sector stock banks seem to be more cost efficient than mutual and public-owned banks, but that the differences between stock domestic- and foreign-owned banks do not appear to be significant. The findings also show that all banks appear to benefit from widespread economies of scale, though, only stock and foreign-banks seem to have benefited from the cost reduction effects of technical progress. Profit efficiency measures show that stock domestic- and foreign-owned banks do not differ in terms of profit efficiency. Finally, the results further reveal that the efficiency of the banking system increased over the sample period as a result of an improved performance of all ownership types, but especially that of mutual and public-owned banks.

A conclusion that arises from the empirical investigation seems to be that banks can gain by increasing their scale of operations and, especially, by identifying and tackling the sources of inefficiencies. The evidence also shows that differences in efficiency between public and private-owned banks are much more relevant than differences within private banks. These findings are coherent with theoretical predictions that point towards agency problems in public-owned banks as responsible for lower efficiency levels. The empirical evidence also suggests

that differences between domestic- and foreign-owned financial institutions are not significant. A conclusion which can be drawn from these findings seems to be that foreign-banks appear to offset the costs of operating abroad by importing capabilities from their parent organisations. Finally, the finding that efficiency increased for all ownership types over the sample period suggests that post-deregulation developments: privatisation of (inefficient) public banks, mergers and acquisitions among stock and mutual banks and the (higher pressure from) the entry of foreign banks played a significant role in the banking industry.

The previous results have important policy implications. First, the results suggest that the use of multiple techniques could prove useful for regulatory analyses. If the methods provide similar efficiency scores and ranking of firms, especially at the top and bottom of the distributions, regulators could be more confident about the conclusions drawn. Second, the findings indicate that public-owned banks are more inefficient than private banks, however, the efficiency of the former notably increased over the post-deregulation period. This evidence suggests that privatisation policies may contribute to improve the performance of the banking sector. This finding could help policy makers by providing additional information on the beneficial effects of privatisation policies, given that the negative effects, such as credit availability to small and medium-sized customers, are not too high. Third, the results also suggest that the efficiency of the banking sector increased over a period characterised by strong foreign bank entry. This finding implies that foreign bank entry may contribute to improve the functioning of domestic banking markets. These results could provide policy makers in developing countries with information regarding the benefits of liberalising entry into their banking sectors, provided any adverse effects of foreign bank entry are not too severe.

Appendix

Table A1

Parameter estimates for cost function using MLE, GLS and WITHIN methods

Parameter	MLE		MLE		GLS		WITHIN	
	Half normal ^a		Truncated normal ^a		Random effects		Fixed effects	
	Coef.	t ratio	Coef.	t ratio	Coef	t ratio	Coef.	t ratio
α	0.991	0.906	0.809	0.844	-1.034	-0.829		
β_L	0.123	0.756	0.037	0.191	0.894 ***	5.608	0.635 ***	3.460
β_S	0.794 ***	5.619	0.659 ***	3.289	0.153	1.118	-0.096	-0.649
β_d	0.231	1.009	0.351	0.775	0.067	0.265	-0.165	-0.656
β_l	0.455	1.320	0.909 **	2.562	0.788 **	2.026	0.866 **	1.994
β_k	-0.029	-0.092	-0.550	-1.085	0.276	0.815	0.546	1.636
β_m	0.603 **	2.256	0.455	0.659	0.474 *	1.655	-0.090	-0.293
β_t	0.067	1.155	0.131 **	2.219	0.124 *	1.942	0.110 *	1.731
δ_{LL}	0.222 ***	12.449	0.214 ***	11.410	0.096 ***	13.886	0.074 ***	10.630
δ_{SS}	0.243 ***	14.413	0.224 ***	12.397	0.183 ***	12.118	0.121 ***	7.225
δ_{dd}	0.156 ***	3.469	0.176 ***	3.573	0.175 ***	3.608	0.127 ***	2.907
δ_{ll}	0.047	0.763	-0.043	-0.698	0.036	0.535	0.031	0.432
δ_{kk}	0.179 **	2.521	0.128	1.613	0.316 ***	4.067	0.346 ***	4.777
δ_{mm}	0.185 ***	3.312	0.187 **	2.355	0.230 ***	3.803	0.204 ***	3.397
δ_{tt}	-0.003	-0.814	-0.001	-0.135	-0.003	-0.673	0.001	0.389
δ_{Ld}	-0.021	-0.942	-0.035	-1.165	-0.027	-1.149	-0.012	-0.537
δ_{Ll}	0.036	1.464	0.031	1.165	0.001	0.029	-0.033	-1.202
δ_{Lk}	-0.024	-1.063	-0.024	-1.033	-0.059 **	-2.491	-0.033	-1.523
δ_{Lm}	0.005	0.185	0.021	0.548	0.050 *	1.854	0.077 ***	2.901
δ_{Sd}	0.085 ***	3.805	0.092 ***	3.938	0.107 ***	4.388	0.085 ***	3.751
δ_{Sl}	-0.108 ***	-4.301	-0.094 ***	-2.761	-0.090 ***	-3.158	-0.040	-1.520
δ_{Sk}	-0.025	-1.040	-0.018	-0.704	-0.011	-0.418	-0.032	-1.289
δ_{Sm}	0.056 **	2.134	0.032	1.061	0.016	0.574	-0.001	-0.044
δ_{dl}	-0.109 ***	-2.888	-0.117 **	-1.976	-0.091 **	-2.188	-0.056	-1.458
δ_{dk}	-0.109 **	-2.211	-0.125 **	-2.353	-0.156 ***	-2.976	-0.093 *	-1.926
δ_{dm}	0.043	1.072	0.029	0.681	0.055	1.273	0.015	0.348
δ_{lk}	0.077	1.507	0.159 **	2.284	0.042	0.751	-0.019	-0.365
δ_{lm}	-0.089 *	-1.888	-0.054	-0.652	-0.074	-1.478	-0.020	-0.390
δ_{km}	-0.110 **	-2.366	-0.119 **	-2.460	-0.154 ***	-3.050	-0.168 ***	-3.462
δ_{Lt}	0.003	0.542	0.003	0.458	-0.012 *	-1.895	-0.002	-0.292
δ_{St}	0.002	0.348	0.000	-0.065	0.014 **	1.967	0.001	0.125
δ_{dt}	0.030 **	2.446	0.031 **	2.500	0.015	1.108	0.001	0.098
δ_{lt}	-0.016	-1.576	-0.021 **	-2.087	-0.014	-1.207	-0.009	-0.878
δ_{kt}	-0.030 **	-2.271	-0.030 **	-2.248	-0.035 **	-2.375	-0.017	-1.267
δ_{mt}	0.002	0.223	0.003	0.290	0.009	0.830	0.007	0.802
δ_{LS}	-0.207 ***	-13.395	-0.188 ***	-11.338	-0.114 ***	-12.293	-0.064 ***	-5.578
γ	0.655 ***	11.980	0.515 ***	9.802				
μ			0.370 ***	7.577				
σ^2	0.104 ***	7.333	0.066 ***	7.600				
Log likelihood	85.15		97.65					
LR test								
$\gamma = 0$	114.94 ***		139.94 ***					
$\mu = 0$			24.99 ***					
Adj R ²					0.981		0.990	
LM test					158.43 ***			
Hausman test					225.06 ***			

***, **, * indicates significance at the 1%, 5% and 10% level, respectively.^a The cost residuals have the correct (rightward) skew in all cases. Number of observations: 715.

Table A2

Cost efficiency using Translog cost function (including financial capital)

Stock, mutual, public- and foreign-owned banks, 1993-2000

Type of bank	MLE Half normal	MLE Trunc normal	GLS Random effects	WITHIN Fixed effects	DFA
A. Excluding financial capital					
Private (stock) banks	0.846 (0.090)	0.726 (0.102)	0.587 (0.104)	0.331 (0.138)	0.686 (0.079)
Private (mutual) banks	0.804 (0.060)	0.676 (0.075)	0.554 (0.092)	0.305 (0.153)	0.643 (0.059)
Public banks	0.723 (0.120)	0.610 (0.098)	0.491 (0.080)	0.222 (0.079)	0.609 (0.084)
Foreign banks	0.844 (0.086)	0.720 (0.108)	0.567 (0.130)	0.324 (0.211)	0.658 (0.049)
Overall average	0.820 (0.096)	0.696 (0.103)	0.563 (0.105)	0.309 (0.150)	0.661 (0.076)
B. Including financial capital					
Private (stock) banks	0.825 (0.103)	0.682 (0.115)	0.673 (0.113)	0.429 (0.158)	0.698 (0.075)
Private (mutual) banks	0.782 (0.066)	0.630 (0.082)	0.620 (0.083)	0.393 (0.127)	0.657 (0.056)
Public banks	0.701 (0.107)	0.567 (0.083)	0.559 (0.076)	0.295 (0.077)	0.641 (0.049)
Foreign banks	0.817 (0.102)	0.675 (0.126)	0.667 (0.136)	0.415 (0.226)	0.670 (0.047)
Overall average	0.799 (0.102)	0.651 (0.111)	0.643 (0.111)	0.397 (0.157)	0.676 (0.068)

Mean and standard deviation in parenthesis.

Financial capital is added to the translog cost specification to capture default risk and the risk preferences of bank management. The translog cost function, including financial capital as a fixed input, is specified as follows:

$$\ln c(y, w, z) = \text{translog} + \beta_r \ln r + \frac{1}{2} \cdot \delta_{rr} \ln r \cdot \ln r + \sum_m \delta_{rm} \ln r \cdot \ln y_m \\ + \sum_j \delta_{rj} \ln r \cdot \ln w_j + \delta_{rt} \ln r \cdot t + \ln u^c + \ln v^c$$

where r is financial capital measured as total equity. Berger and Mester (1997) report similar efficiency scores from including and excluding financial capital.

Table A3
Cost efficiency using Fourier flexible cost function
 Stock, mutual, public- and foreign-owned banks, 1993-2000

Type of bank	MLE Half normal	MLE Trunc normal	GLS Random effects	WITHIN Fixed effects	DFA
A. Translog					
Private (stock) banks	0.846 (0.090)	0.726 (0.102)	0.587 (0.104)	0.331 (0.138)	0.686 (0.079)
Private (mutual) banks	0.804 (0.060)	0.676 (0.075)	0.554 (0.092)	0.305 (0.153)	0.643 (0.059)
Public banks	0.723 (0.120)	0.610 (0.098)	0.491 (0.080)	0.222 (0.079)	0.609 (0.084)
Foreign banks	0.844 (0.086)	0.720 (0.108)	0.567 (0.130)	0.324 (0.211)	0.658 (0.049)
Overall average	0.820 (0.096)	0.696 (0.103)	0.563 (0.105)	0.309 (0.150)	0.661 (0.076)
B. Fourier Flexible					
Private (stock) banks	0.848 (0.091)	0.737 (0.099)	0.624 (0.100)	0.387 (0.151)	0.765 (0.077)
Private (mutual) banks	0.802 (0.061)	0.685 (0.070)	0.580 (0.062)	0.366 (0.131)	0.720 (0.059)
Public banks	0.725 (0.117)	0.626 (0.096)	0.524 (0.082)	0.268 (0.085)	0.698 (0.083)
Foreign banks	0.847 (0.086)	0.726 (0.105)	0.620 (0.127)	0.375 (0.232)	0.736 (0.055)
Overall average	0.821 (0.096)	0.707 (0.100)	0.598 (0.099)	0.361 (0.155)	0.740 (0.075)

Mean and standard deviation in parenthesis.

The Fourier flexible form is a global approximation that augments that translog by adding Fourier trigonometric terms. For the cost function is written as follows:

$$\ln c(y, w, z) = \text{translog} + \sum_n [\varphi_n \cos(x_n) + \omega_n \sin(x_n)] + \sum_n \sum_q [\varphi_{nq} \cos(x_n + x_q) + \omega_{nq} \sin(x_n + x_q)] + \ln u^c + \ln v^c$$

where x_n are re-scaled values of the $\ln y_m$, such that each of the x_n is in the interval $[0, 2\pi]$, and π refers to the number of radians. However, each end of the $[0, 2\pi]$ is cut 10% to reduce approximation problems near the endpoints. The formula for x_n is $0.2\pi \cdot \mu \cdot a + \mu \cdot \ln y$, where (a, b) is the range of variation of $\ln y$ and $\mu = (0.9 \cdot 2\pi - 0.1 \cdot 2\pi) / (b - a)$. Following Berger, Leusner and Mingo (1997), the Fourier terms are applied to the outputs leaving the input price effects to be

defined by the translog terms. In addition, the linear homogeneity and symmetry restrictions are also applied to the translog portion of the function.

Table A4

Parameter estimates for profit function using MLE, GLS and WITHIN methods

Parameter	MLE Half normal ^a		MLE Truncated normal ^a		GLS Random effects		WITHIN Fixed effects	
	Coef.	t ratio	Coef.	t ratio	Coef	t ratio	Coef.	t ratio
α	27.077 ***	4.044	26.354 ***	21.239	16.269 ***	3.547		
β_L	-1.667 *	-1.845	-1.630 **	-2.445	-1.012	-1.595	-3.970 ***	-4.667
β_S	0.981	1.276	1.036	1.414	0.441	0.811	1.310 *	1.754
β_d	-2.883 **	-2.194	-2.888 ***	-2.824	-1.993 **	-2.137	-0.293	-0.263
β_l	-3.239	-1.583	-3.221 ***	-3.713	-0.221	-0.157	-3.139	-1.570
β_k	2.775	1.542	2.747 ***	2.909	1.542	1.214	2.214	1.439
β_m	0.674	0.455	0.619	0.612	0.326	0.315	0.967	0.711
β_t	0.080	0.235	0.086	0.260	0.012	0.051	-0.058	-0.196
δ_{LL}	0.292 ***	2.793	0.291 ***	2.809	0.260 ***	3.553	0.398 ***	4.366
δ_{SS}	-0.158	-1.616	-0.147	-1.528	-0.126 *	-1.799	-0.543 ***	-4.994
δ_{dd}	-0.052	-0.191	-0.033	-0.127	-0.069	-0.357	0.006	0.030
δ_{ll}	0.472	1.368	0.486 **	2.159	0.096	0.402	0.437	1.327
δ_{kk}	0.268	0.737	0.269	0.756	0.471 *	1.826	0.269	0.901
δ_{mm}	0.105	0.318	0.138	0.473	0.076	0.326	0.017	0.062
δ_{tt}	-0.010	-0.433	-0.010	-0.411	-0.009	-0.516	0.005	0.272
δ_{Ld}	0.339 ***	2.735	0.339 ***	2.905	0.261 ***	2.991	-0.006	-0.058
δ_{Ll}	-0.265 *	-1.802	-0.258 *	-1.894	-0.268 **	-2.572	-0.283 **	-2.297
δ_{Lk}	0.254 *	1.901	0.249 *	1.835	0.191 **	2.013	0.105	0.976
δ_{Lm}	-0.299 **	-2.096	-0.299 **	-2.143	-0.225 **	-2.220	0.134	1.102
δ_{Sd}	-0.063	-0.462	-0.060	-0.439	-0.079	-0.817	0.170	1.520
δ_{Sl}	0.386 **	2.471	0.367 **	2.388	0.365 ***	3.302	0.453 ***	3.518
δ_{Sk}	-0.119	-0.748	-0.113	-0.726	-0.073	-0.648	0.031	0.238
δ_{Sm}	0.204	1.336	0.211	1.382	0.080	0.735	-0.257 **	-1.968
δ_{dl}	-0.281	-1.283	-0.286	-1.484	-0.191	-1.230	-0.360 **	-2.062
δ_{dk}	0.548 **	1.981	0.546 **	2.044	0.427 **	2.200	0.268	1.195
δ_{dm}	-0.319	-1.277	-0.337	-1.451	-0.247	-1.391	-0.069	-0.344
δ_{lk}	-0.662 **	-2.291	-0.656 ***	-2.938	-0.492 **	-2.418	-0.563 **	-2.330
δ_{lm}	0.118	0.440	0.125	0.548	0.308	1.637	0.092	0.409
δ_{km}	0.092	0.385	0.075	0.315	-0.183	-1.079	0.145	0.713
δ_{Lt}	0.085 **	2.282	0.083 **	2.226	0.085 ***	3.213	0.067 **	2.297
δ_{St}	-0.107 ***	-2.599	-0.106 **	-2.575	-0.093 ***	-3.173	-0.098 ***	-3.017
δ_{dt}	0.131 *	1.712	0.128 *	1.694	0.149 ***	2.731	0.152 **	2.515
δ_{lt}	0.043	0.744	0.044	0.788	0.020	0.476	0.046	0.928
δ_{kt}	-0.087	-1.119	-0.090	-1.192	-0.080	-1.448	-0.048	-0.790
δ_{mt}	-0.048	-0.827	-0.048	-0.835	-0.032	-0.779	-0.082 *	-1.884
δ_{LS}	-0.083	-0.930	-0.088	-0.987	-0.085	-1.339	0.140	1.587
γ	0.285 ***	3.354	0.536 ***	3.150				
μ			-1.937	-1.278				
σ^2	1.139 ***	9.030	1.751 ***	3.183				
Log likelihood	-630.5		-629.7					
LR test								
$\gamma = 0$	16.65 ***		18.10 ***					
$\mu = 0$			1.46					
Adj R ²					0.638		0.690	
LM test					12.79 ***			
Hausman test					93.53 ***			

***, **, * indicates significance at the 1%, 5% and 10% level, respectively. ^a The profit residuals have the correct (leftward) skew in all cases. Number of observations: 476.

Table A5

Parameter estimates for cost function using time-varying MLE

Parameter	Cost function		Parameter	Inefficiency function	
	Coef.	t ratio		Coef.	t ratio
α	1.928 **	2.158	ξ_0	5.362 ***	12.139
β_L	0.185	1.221	ξ_{Dpub}	1.780 ***	7.749
β_S	0.889 ***	6.532	ξ_{Dfor}	-0.053	-0.273
β_d	0.138	0.707	ξ_{Dmut}	0.826 ***	2.254
β_l	-0.098	-0.358	ξ_{Size}	-0.674 ***	-15.468
β_k	0.106	0.356			
β_m	1.071 ***	4.667			
β_t	0.026	0.495			
δ_{LL}	0.226 ***	13.517			
δ_{SS}	0.257 ***	15.718			
δ_{dd}	-0.012	-0.271			
δ_{ll}	0.022	0.428			
δ_{kk}	0.136 **	2.083			
δ_{mm}	0.103 **	2.151			
δ_{tt}	-0.004	-0.853			
δ_{Ld}	0.034	1.586			
δ_{Ll}	0.074 ***	3.143			
δ_{Lk}	-0.027	-1.148			
δ_{Lm}	-0.089 ***	-3.818			
δ_{Sd}	-0.003	-0.113			
δ_{Sl}	-0.080 ***	-3.292			
δ_{Sk}	-0.023	-0.910			
δ_{Sm}	0.078 ***	3.370			
δ_{dl}	-0.025	-0.675			
δ_{dk}	-0.086	-1.637			
δ_{dm}	0.078 **	2.008			
δ_{lk}	0.047	0.942			
δ_{lm}	-0.037	-0.888			
δ_{km}	-0.124 ***	-2.866			
δ_{Lt}	0.000	0.053			
δ_{St}	0.009	1.390			
δ_{dt}	0.026 **	2.051			
δ_{lt}	-0.018 *	-1.907			
δ_{kt}	-0.014	-1.144			
δ_{mt}	0.004	0.442			
δ_{LS}	-0.242 ***	-16.179			
γ	0.965 ***	17.624			
σ^2	0.510 ***	8.566			
Log likelihood	138.95				
LR test					
$\gamma = 0$	222.54 ***				

***, **, * indicates significance at the 1%, 5% and 10% level, respectively.^a The cost residuals have the correct (rightward) skew. Number of observations: 715.

References

- Aigner, D., Lovell, C.A.K. and Schmidt, P. (1977). Formulation and Estimation of Stochastic Frontier Production Models. *Journal of Econometrics* 6, p. 21-37.
- Altunbas, Y., Evans, L. and Molyneux, P. (2001). Bank Ownership and Efficiency. *Journal of Money, Credit and Banking* 33, p. 926-954.
- Banco Central de la República Argentina (2001). *Boletín Estadístico*. Buenos Aires.
- Banco Central de la República Argentina (various years). *Información de Entidades Financieras*. Buenos Aires.
- Banco Central de la República Argentina (various years). *Informe al Congreso de la Nación*. Buenos Aires.
- Banco Central de la República Argentina. *Boletín Monetario y Financiero*. Buenos Aires.
- Battese, G. E., and Coelli, T.J. (1988). Prediction of Firm-Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data. *Journal of Econometrics* 38, p. 387–399.
- Battese, G. E., and Coelli, T.J. (1992). Frontier Production Functions, Technical Efficiency, and Panel Data: With Application to Paddy Farmers in India. *The Journal of Productivity Analysis* 3, p. 153–169.
- Battese, G. E., and Coelli, T.J. (1995). A Model for Technical Efficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics* 20, p. 325–332.
- Bauer, P. W., Berger, A.N., Ferrier, G.D. and Humphrey, D.B. (1998). Consistency Conditions for Regulatory Analysis of Financial Institutions: A Comparison of Frontier Efficiency Methods. *Journal of Economics and Business* 50, p. 85-114.
- Bauer, P.W., Berger, A.N. and Humphrey, D.B. (1993). Efficiency and Productivity Growth in US Banking. In H.O. Fried, C.A.K. Lovell, and S.S. Schmidt (eds.) *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press, Oxford, p. 386-413.
- Berger, A.N. (1993). Distribution-free Estimates of Efficiency in the U.S. Banking Industry and Tests of the Standard Distributional Assumptions. *Journal of Productivity Analysis* 4, p. 261-292.
- Berger, A. N. (1995). The Profit-Structure Relationship in Banking - Tests of Market-Power and Efficient-Structure Hypotheses. *Journal of Money, Credit and Banking* 27, pp. 404-431.
- Berger, A.N., Hancock, D. and Humphrey, D.B. (1993). Bank Efficiency derived from the Profit Function. *Journal of Banking and Finance* 17, p. 317-347.
- Berger, A. N. and Humphrey, D. B. (1991). The Dominance of Inefficiencies over Scale and Product Mix Economies in Banking. *Journal of Monetary Economics* 28, p. 117-148.
- Berger, A. N., Hunter, W.C. and Timme, S.G. (1993). The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present and Future. *Journal of Banking and Finance* 17, pp. 221-249.

- Berger, A.N. and Mester, L. (1997). Inside the Black Box: What explains Differences in the Efficiencies of Financial Institutions. *Journal of Banking and Finance* 21, p. 895-947.
- Bishop, M. and Thompson, D. (1992). Regulatory Reform and Productivity Growth in the U.K.'s Public Utilities. *Applied Economics* 24, p. 1181-1190.
- Blair, D.W. and Placone D.L. (1988). Expense Preference Behavior, Agency Costs and Firm Organization: The Savings and Loan Industry. *Journal of Economics and Business* 40, p. 1-15.
- Borcherding, T.E., Pommerehne, W.W., and Schneider, F (1982). Comparing the Efficiency of Private and Public Production: The Evidence from Five Countries. *Journal of Economics* 0, Supplement 2, p. 127-156.
- Boycko, M., Shleifer, A. and Vishny, R. W. (1996). A Theory of Privatization. *The Economic Journal* 106, p. 309-319.
- Burdisso, T., D'Amato, L. and Molinari, A. (1998). Privatización de Bancos en Argentina: ¿El Camino hacia una Banca más Eficiente? Banco Central de la República Argentina Documento de Trabajo nro. 4.
- Caves, D.W. and Christensen, L.R. (1980). The Relative Efficiency of Public and Private Firms in a Competitive Environment: The Case of Canadian Railroads. *Journal of Political Economy* 88, p. 958-976.
- Cebenoyan, A.S., Cooperman, E.S., Register, C.A. and Hudgins, S.C. (1993). The Relative Efficiency of Stock vs. Mutual S&Ls: A Stochastic Frontier Approach. *Journal of Financial Services Research* 7, p. 151-170.
- Claessens, S., Demirgüç-Kunt, A. and Huizinga, H. (1999). How Does Foreign Entry Affect the Domestic Banking Market? *Journal of Banking and Finance* 25, p. 891-911.
- Coelli T., Prasada Rao D.S. and Battese, G.E. (1998). *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers.
- Cornwell, C., Schmidt, P. and Sickles, R. (1990). Production Frontiers with Cross-Sectional and Time-Series Variation in Efficiency Levels. *Journal of Econometrics* 46, p. 185-200.
- Cragg, M.I. and Dyck, I.J.A. (1997a). Management Control and Privatization in the UK: A Quiet Life Disturbed. Harvard Business School Working Paper 97-045.
- Cragg, M.I. and Dyck, I.J.A. (1997b). Fat Cats or Corporate Agents? U.K. Privatization and Corporate Control. Mimeo, Harvard Business School.
- Cragg, M.I. and Dyck, I.J.A. (1998). Executive Pay and U.K. Privatization, the Demise of 'one Country, Two systems. Mimeo, Harvard Business School.
- Cummins, J.D. and Zi, H. (1998). Comparison of Frontier Efficiency Methods: An Application to the U.S. Life Insurance Industry. *Journal of Productivity Analysis* 10, p. 131-152.
- DeBorger, B., Ferrier, G. D. and Kerstens, K. (1995). The Choice of a Technical Efficiency Measure on the Free Disposal Hull Reference Technology: A Comparison Using U.S. Banking Data. Working paper, University of Arkansas, U.S.A.
- DeYoung, R. and Nolle, D. (1996). Foreign-owned Banks in the U.S.: Earning Market Share or Buying it? *Journal of Money, Credit and Banking* 28, p. 622-636.

- Eisenbeis, R. A., Ferrier, G. D. and Kwan, S. (1997). The Informativeness of Linear Programming and Econometric Efficiency Scores: An Analysis Using U.S. Banking Data. Working paper, Bureau of Business and Economic Research, University of Arkansas.
- Elyasiani, E. and Mehdiian, S. (1990). Efficiency in the Commercial Banking Industry: A Production Frontier Approach. *Applied Economics* 22, p. 539-551.
- Esho, N. and Sharpe, I. G. (1996). X-efficiency of Australian Permanent Building Societies, 1974-1990. *The Economic Record* 72, p. 246-259.
- Estrin, S. and Perotin, V. (1991). Does Ownership Always Matter? *International Journal of Industrial Organization* 9, p. 55-72.
- Fama, E. (1980). Agency Problems and the Theory of the Firm. *Journal of Political Economy* 88, p. 288-307.
- Fama, E. F. and Jensen, M. C. (1983). Separation of Ownership and Control. *Journal of Law and Economics* 26, p. 301-325.
- Farrell M. J. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistical Society* 120, Sec. A, p. 253-281.
- Ferrier, G. D. and Lovell, C. A. K. (1990). Measuring Cost Efficiency in Banking: Econometric and Linear Programming in Evidence. *Journal of Econometrics* 46, p. 229-245.
- Gardner, L., and Grace, M. F. (1993). X-Efficiency in the U.S. Life Insurance Industry. *Journal of Banking and Finance* 17, p. 497-510.
- Giokas, D. (1991). Bank Branch Operating Efficiency: A Comparative Application of DEA and the Loglinear Model. *OMEGA International Journal of Management Science* 19, p. 549-557.
- Grossman, S. and Hart, O. (1980) Takeover Bids, the Free-Rider Problem and the Theory of the Corporation. *Bell Journal of Economics* 11, p. 42-64.
- Hasan, I., and W. C. Hunter. (1996). Efficiency of Japanese Multinational Banks in the U.S. In A. H. Chen (ed.), *Research in Finance* 14. JAI Press, Greenwich, p. 157-173
- Hasan, I. and Lozano-Vivas, A. (2002). Organisational Form and Expense preference: Spanish Experience. *Bulletin of Economic Research* 54, p. 135-150.
- Hill, H. (1982). State Enterprises in a Competitive Industry: An Indonesian Case Study. *World Development* 10, p. 1015-1023.
- Humphrey, D.B. and Pulley, L.B. (1997). Banks Responses to Deregulation: Profits, Technology, and Efficiency. *Journal of Money Credit and Banking* 29, p. 73-93.
- Jensen, M. C. and Meckling, W. H. (1979). Rights and Production Functions: An Application to Labour Managed Firms and Co-determination. *Journal of Business* 52, p. 469-506.
- Jondrow, J., Lovell, C. A. K., Materov, I. S. and Schmidt, P. (1982). On the Estimation of Technical Efficiency in the Stochastic Frontier Production Model. *Journal of Econometrics* 19, p. 233-238.
- Kim, K.S. (1981). Enterprise Performances in the Public and Private Sectors: Tanzanian Experience 1970-75. *Journal of Developing Areas* 15, p. 471-484.

- Kumbhakar, S. C. (1990). Production Frontiers, Panel Data and Time-Varying Technical Inefficiency. *Journal of Econometrics* 46, p. 201–211.
- Kumbhakar, S. C. and Lovell, C.A.K. (2000). *Stochastic Frontier Analysis*. Cambridge University Press, Cambridge.
- Kumbhakar, S. C., Lozano-Vivas, A., Lovell, C.A.K. and Hasan, I. (2000). The Effects of Deregulation on the Performance of Financial Institutions: The Case of Spanish Savings Banks. *Journal of Money, Credit and Banking* 33, p. 101-121.
- Lang, G. and Welzel, P. (1996). Efficiency and Technical Progress in Banking: Empirical Results for a Panel of German Cooperative Banks. *Journal of Banking and Finance* 20, p. 1003-1023.
- Lozano, A. (1997). Profit Efficiency for Spanish Savings Banks. *European Journal of Operational Research* 98, 381–394.
- Manne, H.G. (1965). Mergers and the Market for Corporate Control. *Journal of Political Economy* 73, p. 110–120.
- Martin, S. (1993). *Advanced Industrial Economics*. Blackwell publishers, Oxford.
- Martin, S. and Parker, D. (1997). *The Impact of Privatisation. Ownership and Corporate Performance in the U.K.* Routledge, London.
- Maudos, J., Pastor, J.M., Perez, F. and Quesada, J. (2002). Cost and profit Efficiency in European Banks. *Journal of International Financial Markets, Institutions and Money* 12, p. 33-58.
- Mayers, D. and Smith, C. (1981). Contractual Provisions, Organizational Structure, and Conflict Control in Insurance Markets. *Journal of Business* 54, p. 407-434.
- Mayers, D. and Smith, C. (1988). Ownership Structure Across Lines of Property-Casualty Insurance. *Journal of Law and Economics* 31, p. 351-378.
- McAllister, P.H. and McManus, D. (1993). Resolving the Scale Efficiency Puzzle in Banking. *Journal of Banking and Finance* 17, pp. 389-405.
- Meeusen, W. and van den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error Term. *International Economic Review* 18, p. 435-444.
- Mester, L. J. (1989). Testing for Expense Preference Behavior: Mutual versus Stock Savings and Loans. *The Rand Journal of Economics* 20, p. 483–498.
- Mester, L. (1993). Efficiency in the Savings and Loan Industry. *Journal of Banking and Finance* 17, p.267-286.
- Miller, S. M. and Noulas, A. G. (1996). The Technical Efficiency of Large Bank Production. *Journal of Banking and Finance* 20, p. 495-509.
- Millward, R. (1982). The Comparative Performance of Public and Private Ownership. In E. Roll (ed.), *The Mixed Economy*. McMillan, London, p. 58–93.
- Millward, R. (1988). Measured Sources of Inefficiency in the Performance of Public and Private Enterprises in LDCs. In P. Cook and C. Kirkpatrick (eds.), *Privatisation in Less Developed*

Countries, St. Martin's Press, New York, p. 143–161.

Millward, R. and Parker, D.M. (1983). Public and Private Enterprise: Comparative Behavior and Relative Efficiency. In R. Millward, D. Parker, L. Rosenthal, M.T. Summer and N. Topham (eds.), *Public Sector Economics*, Longman, London, p. 199–280.

Mitchell, K. and Onvural, N.M. (1996). Economies of Scale and Scope at Large Commercial Banks: Evidence from the Fourier Flexible Functional Form. *Journal of Money, Credit and Banking* 28, p. 178–199.

Mohamed, R. (1992). Performance of Public and Private Enterprises in Malaysia: An Empirical Analysis. *Singapore Economic Review* 37, p. 35–47.

Mueller, D.C. (1989). *Public Choice II*. Cambridge University Press, Cambridge.

Nicols, A. (1967). Property Rights and Behavior: Stock versus Mutual Savings and Loan Associations: Some evidence of Differences in Behavior. *American Economic Review* 57, p. 337–346.

O'Hara, M. (1981). Property Rights and the Financial Firm. *Journal of Law and Economics* 24, p. 313–333.

Parker, D. (1993). Ownership, Organizational Changes and Performance. In T. Clarke and C. Pitelis (eds.), *The Political Economy of Privatization*. Routledge, London, p. 31–53.

Parker, D. (1995). Privatization and Agency Status, Identifying the Critical Factors for Performance Improvement. *British Journal of Management* 6, p. 29–43.

Pitt, M. M., and Lee, L.F. (1981). Measurement and Sources of Technical Inefficiency in the Indonesian Weaving Industry. *Journal of Development Economics* 9, p. 43–64.

Rasmusen, E. (1988). Mutual and Stock Banks. *Journal of Law and Economics* 31, p. 395–421.

Resti, A. (1997). Evaluating the Cost-Efficiency of the Italian Banking System: What Can Be Learned from the Joint Application of Parametric and Non-Parametric Techniques. *Journal of Banking and Finance* 20, p. 221–250.

Ricart, J.E., Gual, J., López, G., Rosanas, J.M. and Valor, J. (1991). *Incentivos y Control en la Empresa Pública*. Ariel Economía, Barcelona.

Sarkar, J., Sarkar, S. and Bhaumik, S.K. (1998). Does Ownership Always Matter?-Evidence from the Indian Banking Industry. *Journal of Comparative Economics* 26, p. 262–281.

Schmidt, P., and Sickles, R. (1984). Production Frontiers and Panel Data. *Journal of Business and Economic Statistics* 2, p. 367–74.

Shleifer, A. and Vishny, R. W. (1986). Large Shareholder and Corporate Control. *Journal of Political Economy* 94, p. 461–88.

Tulkens, H. (1993). On FDH Efficiency Analysis: Some Methodological Issues and Applications to Retail Banking, Courts and Urban Transit. *Journal of Productivity Analysis* 4, p.183–210.

Vander Venet, R. (2002). Cost and Profit Efficiency of Financial Conglomerates and Universal Banks in Europe. *Journal of Money, Credit and Banking* 34, p. 254–282.

Verbrugge, J.A. and Goldstein, S.J. (1981). Risk, Return, and Managerial Objectives: Some Evidence from the Savings and Loan Industry. *Journal of Financial Research* 4, p. 45-58.

Vickers, J. and Yarrow, G. (1988). *Privatization: An Economic Analysis*. MIT Press, Cambridge.

Vining, A.R. and Boardman, A.E. (1992). Ownership versus Competition: Efficiency in Public Enterprise. *Public Choice* 73, p. 205–239.

Wintrobe, R. (1987). The Market for Corporate Control and the Market for Political Control. *Journal of Law and Economic Organization* 3, p. 435-448.

Worthington, A.C. (1996). Technical and Scale Efficiency in Australian Thrifts: A Nonparametric Approach. Discussion Papers in Economics, Finance and International Competitiveness, 41, School of Economics and Finance, Queensland University of Technology.