DOKUZ EYLÜL UNIVERSITY

FACULTY OF BUSINESS

DEPARTMENT OF ECONOMICS

EFFICIENCY AND FOREIGN OWNERSHIP IN BANKING: AN INTERNATIONAL COMPARISON

Adnan Kasman

Saadet Kırbaş-Kasman

Oscar Carvallo

DISCUSSION PAPER SERIES

NO. 05/03

OCTOBER 2005

Efficiency and Foreign Ownership in Banking: An International Comparison

By

Adnan Kasman[a]*, Saadet Kirbas-Kasman[b], Oscar Carvallo[c]

[a]Department of Economics, Faculty of Business, Dokuz Eylul University, 35160, Buca, Izmir, Turkey, Tel: +90 (0) 232 453 5042/3109, Fax:+90 (0)232 453 5062, E-mail: adnan.kasman@deu.edu.tr
[b] Department of Economics, Faculty of Business, Dokuz Eylul University, 35160, Buca, Izmir, Turkey, Tel: +90 (0) 232 453 5042/3113, Fax:+90 (0)232 453 5062, E-mail: saadet.kasman@deu.edu.tr
[c]Chief Economist, Venezuelan Banking Association, Caracas, Venezuela, Tel: (058212) 9514711, Fax: 9514927, Email: oscarcarvallo@abv.com.ve
*Corresponding Author

Abstract: This paper estimates cost and profit efficiency for Latin American and the Caribbean banking sectors. This study also conducts a comparative analysis of the performance of foreign and domestic banks operating in these counties. Using a model proposed by Battese and Coelli (1995), a common cost and profit frontiers with country-specific environmental variables have been estimated for a panel of 427 banking firms from sixteen countries. The empirical analysis reveals the importance of the environmental variables in explaining the efficiency differences among countries. The results show that profit efficiency levels are well below those corresponding to cost efficiency, implying that the most important inefficiency is on the revenue side. The results further indicate that on average foreign banks are more efficient than domestic banks.

JEL classification: G21; G28

Keywords: Banking; Efficiency; Foreign ownership

1. Introduction

Banking sectors in Latin America and the Caribbean countries have undergone major changes in the last two decades due to the deregulation, financial innovation and automation. Resulting from the liberalization efforts, the change in foreign participation in banking in these countries in recent years is dramatic. The market share of foreign banks in Mexico, for example, increased from 6.2% in 1995 to 75.5% in 2001 (see Carvallo and Kasman, 2004)[1]. To understand the consequences of this growing market share of foreign banks in these countries it is helpful to examine whether foreign banks are more efficient than their domestic counterparts. Despite the importance of this question, as far as we are aware no detailed study of it has yet been done for Latin American banking systems. Hence one of the objectives of this paper is to investigate the differences in efficiency (profit and cost) between domestic and foreign banks in order to provide information on comparative managerial performance. Since they transfer know-how, technology and expertise, the existence of foreign banks in the sectors may produce positive externalities to the sector as a whole by disseminating good practice.

Several studies have compared the performance of foreign and domestic banks. Claessens, Demirguc-Kunt and Huizinga (2001) investigate performance differences between domestic and foreign banks in eighty countries, both developed and developing, over an eight-year period from 1988-1995. They find that foreign bank entry was followed by a reduction in both the profitability and the overhead expenses of domestic banks. They suggest that foreign participation improves the efficiency of domestic banking. Weill (2003) analyses the performance of foreign-owned and domestic-owned banks operating in the Czech Republic and Poland. He finds that on average, foreign banks are more efficient than domestic banks and suggests that the degree of openness of the banking sector to foreign capital has a positive impact

on performance in two transition countries. Kasman (2004) also finds similar results for the banking sectors of the Czech Republic and Poland. However, the banking sectors in Latin America and the Caribbean are different from their counterparts in the developed and transition countries due to the legal and economic environment. Thus it is worthwhile to compare the performance of foreign and domestic banks in these countries for policy purposes.

A small number of studies have compared banking performance differences across countries[2]. More recent studies have tried to analyze the profit as well as cost efficiency of banking across countries[3]. The main problem of the previous cross-country studies is the specification of the common frontiers. When the regulatory and economic environments of financial firms are very different across countries, it is difficult to interpret the cross-country comparisons of the previous papers. In these studies, the specification of common frontier ignores the influence of the country-specific environmental factors (structural and institutional), which justify the use of a common frontier to compare banking performance differences across countries.

Hence the other objective of this paper is to analyze profit efficiency and cost efficiency in a sample of 16 countries in Latin America and the Caribbean over the period 1996-2001 using Battese and Coelli (1995) approach. An expanded model is proposed which incorporates country-specific environmental factors within the definition of a common stochastic frontier. Carvallo and Kasman (2004) recently examined the cost efficiency, scale and scope economies of banks operating in the Latin American and Caribbean banking industries for the period 1995–1999 using a stochastic frontier model with country-specific environmental variables. Their results suggest that there is a wide range of inefficiency levels across countries. Our study, however, expands the work of Carvallo and Kasman (2004) in two respects. First, since

empirical evidence shows that profit inefficiency is quantitatively more important than cost inefficiency, it aims to analyze profit efficiency as well as cost efficiency using Battese and Coelli (1995) approach. Second, it also analyzes the differences in profit and cost efficiency between domestic and foreign banks in order to provide information on comparative managerial performance.

The rest of the paper is organized as follows: Section 2 describes the methodology and econometric specification used to estimate the common cost and profit functions. The data and empirical results of the estimation are reported in section 3. Section 4 provides the summary and conclusions of the paper including the implications of the findings.

2. Methodology

The majority of the studies reviewed in the baking literature focused on the analysis of cost efficiency[4]. Berger et al. (1995) argue in favor of using a profit function to examine efficiency of banking firms. They identify two important advantages of estimating a profit function over a cost function. First, the profit function allows an examination of output inefficiencies by incorporating the revenue effects of producing incorrect levels or mixes of outputs. Second, when there is unmeasured variance in the quality of an output, higher quality may be erroneously identified as lower efficiency under cost function estimation since more inputs are needed usually to produce the higher quality. The profit function is much less affected by this problem since higher quality brings additional revenues that tend to offset the additional costs. Since estimating profit function constitutes a more important source of information for bank management than the partial vision offered by analyzing cost efficiency, this paper analyses both profit and cost efficiency in the Latin American and Caribbean banking systems.

The combination of technical and allocative efficiencies is commonly referred to as X-efficiency and is regarded as a measure of the quality of management (see Leibenstein, 1966). Technical efficiency is defined using minimal level of inputs given output and the input mix whereas allocative efficiency implies that a firm uses its inputs in the optimal proportions. Cost efficiency, which refers to both technical and allocative efficiency, provides a measure of how close a bank's actual cost is to what a best-practice firm's cost would be for producing an identical output bundle under comparable conditions. Profit efficiency is, however, a wider concept than cost efficiency since it combines both costs and revenues in the measurement of efficiency. Profit efficiency measures the extent to which a firm's profits fall below the profit of the best practice firm[5].

This study employs the stochastic frontier approach (SFA), introduced by Aigner et al. (1977), Meeusen and van den Broeck (1977) and Battese and Corra (1977), to generate cost and profit efficiencies for each bank in the sample over the period 1996-2001. These models' error term have two components. The first component is a two-sided classical statistical error term that incorporates the effects of measurement errors and things like bad luck, natural or economic disasters. The second component is a one-sided variable that captures inefficiency relative to the frontier.

We estimate bank efficiency using the stochastic frontier model of Battese and Coelli (1995) in which inefficiency term is drawn from a truncated normal distribution. The model is a one-step procedure in which the stochastic frontier is specified using the Fourier flexible functional form while the level of firm inefficiency is determined by a vector of country-specific environmental factors that a priori are postulated to affect inefficiency[6]. The importance of specifying environmental variables in order to avoid bias in efficiency models has been

recognized in the banking literature (see for example Dietsch and Lozano-Vivas, 2000; Lozano-Vivas et al., 2001; Lozano-Vivas et al., 2002).

The model proposed by Battese and Coelli (1995) offers several interesting methodological challenges. First, it controls for environmental differences across countries and analyzes the effects of these variables on estimated efficiency scores. Second, it alleviates several of the anomalies present in the two-step approach (see Berger and Mester, 1997, for a discussion of the limitations of two-step approach). This methodology essentially allows for a firm-specific and time-varying intercept shift in the distribution of the inefficiency term, and this intercept shift is itself a function of the exogenous environmental variables that vary across countries.

The model can be expressed as follows

$$y_{it} = \exp(x_{it}\beta + v_{it} \pm u_{it}) \tag{1}$$

where y_{it} denotes total costs if $u_{it} \geq 0$ and it denotes profit if $u_{it} \leq 0$; x_{it} is a vector of known inputs and outputs; β is a vector of unknown parameters to be estimated; v_{it} are independently and identically distributed $N(0, \sigma_v^2)$ random errors that are independently distributed of the u_{it}; u_{it} are independently distributed, such that u_{it} is obtained by truncation (at zero) of the normal distribution with mean, $z_{it}\delta$, and variance σ^2, that is $N(m_{it}, \sigma_u^2)$; z_{it} is a $(1 \times m)$ vector of country-specific environmental variables that are allowed to vary over time; and δ is an $(m \times 1)$ vector of unknown coefficients of the environmental variables.

The inefficiency effects, u_{it}, in Eq (1) can be specified as

$$u_{it} = z_{it}\delta + w_{it} \tag{2}$$

where w_{it} is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $z_{it}\delta$. Battese and Coelli (1995) show that when Eq (1) is assumed, the alternative profit efficiency (or the cost efficiency) for an individual banking firm can be defined as

$$TE_{it} = \exp(-u_{it}) = \exp(-z_{it}\delta - w_{it}) \tag{3}$$

For the functional form we tried both the standard translog and the Fourier-flexible specification (see McAllister and McManus 1993; Mitchell and Onvural 1996; Berger and Mester 1997). The Fourier functional form is a global approximation because the sin and cos terms are mutually orthogonal, so that each term aids in fitting the function closer to the true path of the data. Since formal tests indicate that the Fourier terms are jointly significant, the results reported here are those for the following Fourier flexible cost (or profit) function specification:

$$\begin{aligned}
\ln tc_{st}(\Pi+\theta) = {} & \alpha_0 + \sum_{i=1}^{3}\alpha_i \ln y_{ist} + \frac{1}{2}\sum_{i=1}^{3}\sum_{k=1}^{3}\alpha_{ik}\ln y_{ist}\ln y_{kst} + \sum_{j=1}^{3}\beta_j \ln w_{jst} \\
& + \frac{1}{2}\sum_{j=1}^{3}\sum_{m=1}^{3}\beta_{jm}\ln w_{jst}\ln w_{mst} + \sum_{i=1}^{3}\sum_{j=1}^{3}\delta_{ij}\ln y_{ist}\ln w_{jst} \\
& + \gamma_1 \ln E + \frac{1}{2}\gamma_2 \ln E \ln E + \sum_{i=1}^{3}\psi_{i1}\ln y_{ist}\ln E + \sum_{i=1}^{2}\phi_{i1}\ln w_{jst}\ln E \\
& + \sum_{l=1}^{10}\zeta_l x_{lt} + \sum_{i=1}^{3}[\eta_i \cos(z_{ist}) + \omega_i \sin(z_{ist})] \\
& + \sum_{i=1}^{3}\sum_{j=1}^{3}[\eta_{ij}\cos(z_{sti}+z_{jst}) + \omega_{ij}\sin(z_{ist}+z_{jst})] + v_{st} + u_{st}
\end{aligned} \tag{4}$$

where *tc* (Π) is total costs (total profits) of the banking firm in a given year. y_i = outputs (total loans, total off-balance sheet items and other earning assets); w_j = input prices (borrowed funds, labor and capital); E = financial capital[7]; x_l = country-specific environmental variables; z_i = the adjusted values of the log output, $\ln Y_i$, such that they span the interval $[0, 2\pi]$[8,9]. Following

Berger et al. (1997) we restrict the z_i to span $[0.1 \cdot 2\pi, 0.9 \cdot 2\pi]$, cutting 10% off of each end of the $[0, 2\pi]$ interval to reduce approximation problems near the end points. To ensure that the estimated cost frontier is well-behaved, standard restrictions of linear homogeneity in input prices and symmetry of the second order parameters are imposed.

The alternative profit function uses essentially the same specification as the cost function (Equation 4). In the case of the profit function, the variable to be explained is the net income before tax. Since a number of banks in the sample exhibit negative profits, a constant, of a size sufficient to eliminate the negative value is added to the profits of all firms in the sample (θ is equal to the absolute value of minimum profit plus one so that the natural log is taken of a positive number)[10].

3. Data and Empirical Results

In this section, we discuss the data set and present estimates of cost and profit values obtained by the translog multiproduct cost and profit functions using a panel of banks and financial institutions in 16 Latin American and Caribbean countries over the period 1996-2001. The countries included with the number of banks in parentheses are Argentina (64), Bolivia (12), Brazil (81), Chile (19), Colombia (29), Costa Rica(23), Dominican Republic (22), Ecuador (22), Honduras (17), Jamaica (11), Mexico (21), Panama (14), Paraguay (16), Peru (15), Uruguay (20) and Venezuela (41). Accordingly we have an unbalanced panel data of 427 banking firms over the period consisting of 1853 observations. Although we select banks belonging to seven different organizational types (commercial banks, cooperative banks, saving and loans banks, investment banks, real estate and mortgage banks, medium and long-term credit banks, and

specialized governmental credit institutions) 89% of the firms in the sample are commercial banks.

3.1. Data

International comparisons of efficiency must be very careful in the selection of data. Not only the possible accounting heterogeneity of the variables used has to be considered, but also the different specializations and the different environments. In this study, the data is taken from Bankscope, a financial database distributed by BVD-IBCA, an international information agency, which homogenizes the financial information into a global format and classifies firms in terms of specialization, so that the accounting uniformity is guaranteed.

Although the debate about the definition of outputs used in cost and profit efficiency continues, the traditional intermediation approach suggested by Sealey and Lindley (1977) is followed, where the inputs, labor, physical capital and deposits are used to produce earning assets. As some authors recognize, this approach is more relevant for financial institutions, as it is inclusive of interest expenses, which often account for one-half to two-thirds of total costs (Berger & Humphrey, 1997). Three outputs are used: loans, other earning assets, and total off-balance sheet items (measured in nominal terms). Technically, off balance sheet items are not earning assets, but we recognize that this type of business constitutes an increasing source of income for banks and, therefore, should be included when modeling banks' cost (or profit) characteristics. Excluding off balance sheet items would tend to understate total output (Jagtiani and Khanthavit, 1996)[11].

The second type of variables that appear in the cost and alternative profit functions are the prices of factors of production. Three prices are used: the price of labor, the price of

borrowed funds, and the price of physical capital. The price of labor is calculated as the ratio between personnel expenses and total assets. The price of loanable funds is calculated by dividing total interest expenses by their corresponding liabilities (deposits, money market funding and other funding). Finally, the price of capital is given by operating costs net of personnel expenses over fixed assets. Table 1 presents summary statistics.

(Insert Table 1)

Table 1 also reports average costs per unit of assets and the average return on asset (ROA) of banking systems in the sample. The coefficients of variation show greater dispersion for ROA than average costs per unit of assets.

3.2. Environmental Variables

To identify the common frontier, we chose several geographic, market structure as well as financial depth variables, which explain the peculiar features of each country's banking sector. Averages of these variables are reported in Table 2. As in Dietsch and Lozano-Vivas (2000), these variables are categorized in three groups. The first group includes measures of density of population, income per capita, and density of demand for each country. Second group includes a concentration ratio, average capital ratio, and intermediation ratio. Final group includes a proxy for an accessibility of banking services variable and other environmental variables that are relevant to determine bank efficiency[12]. The list and averages of these variables are reported in Table 2.

(Insert Table 2)

3.3. Cost Inefficiency

The common cost frontier with country-specific environmental variables was estimated as specified in Section 2. Parameter estimates are presented in Table A1 in Appendix[13]. The average estimated cost inefficiency scores across country, time and different size groups are reported in Table 3. The results indicate an average cost efficiency of 77.3% for sixteen countries considered. According to this estimate it would be possible to reduce costs by about 22.7% simply by eliminating X-inefficiencies[14]. The banking systems in Latin America and the Caribbean countries are operating more inefficiently than the banking systems in the U.S. and in Europe. As a matter of comparison, Cavallo and Rossi (2001) examine cost inefficiency and scale and scope economies of six European banks, namely France, Germany, Italy, the Netherlands, Spain and UK, found an average inefficiency level of 15.64%. Maudos et al. (2002), however, investigate cost inefficiency of 10 European Union banking systems and found an average inefficiency level of 17.3%. Berger et al. (1993) discusses that the X-inefficiency for the U.S. depository institutions is around 20 percent of the costs.

The results presented in Table 3 also indicate a wide range of cost inefficiency scores across countries. All banking systems display significant level of cost-inefficiency ranging from 11.6% to 38.9%. Mexico, Venezuela, Paraguay and Colombia emerge as the least efficient countries. Panama and Honduras are, however, the most efficient countries during the sample period.

We also examine the cost inefficiency in the banking sectors of Latin American and the Caribbean countries by dividing banks into five asset classes. Results in Table 3 suggest that cost efficiency and bank size were very strongly related. The results suggest that the large banks (those with assets greater than $5 billion and less than $10 billion) are on average more efficient

than other groups of banks in the sample. The less cost efficient banks are the small banks (those with assets less than $500 million).

The average estimated cost inefficiency fluctuates along the six years of our sample. Although there does not seem to be a clear trend, banking sector become more cost inefficient in recent years.

As for the organizational types, the results indicate that cooperative banks are the most cost efficient among the banks that engaged in traditional banking activities. The results also suggest that Real Estate/Mortgage Banks achieved the highest efficiency level. It should be noted that about 89% of banks in our sample are commercial banks.

(Insert Table 3)

3.4. Profit Efficiency

Parameter estimates are presented in Table A2 in Appendix[15]. The results for alternative profit inefficiency are reported in Table 4. As in the cost inefficiency, the inefficiency measures vary greatly across countries. The results indicate that banks in the Latin American and Caribbean banking systems have serious profit inefficiency problem. Overall average of profit inefficiency is 0.309. This result suggests that, on average, profits are approximately 30.9% below those realized by the best-practice banks.

As seen in Tables 3 and 4, the profit efficiency levels are lower than those of cost efficiency[16]. This result is consistent with the previous studies that examined the US, European, and Spanish banking systems (see for example Berger and Mester, 1997; Rogers, 1998; Lozano, 1997; and Maudos et al., 2002). The results suggest that banking system in Panama (12.1%),

Dominican Rep. (13.1%), Bolivia (14.0%) and Honduras (15.1%) were the most profit efficient during the sample period. Brazil (49.9%), Mexico (42.7%) and Uruguay (40.4%), however, had the most profit inefficient banking systems. The range of variation among countries is greater than that of cost efficiency. The difference between the least efficient system and the most efficient is around 37.8%. In every country (except for Bolivia, Dominican Rep. and Paraguay) profit efficiency is lower than cost efficiency.

Observing the profit inefficiency trend over the six years of our sample, no improvement in profit efficiency during the sample period. The results suggest that there is a very strong relationship between profit efficiency and bank size. Very large banks were the most profit inefficient in the sample. The results also suggest that cooperative banks were the most profit efficient among the banks that engaged in traditional banking activities.

Table 5 presents the evolution of inefficiency (cost and profit) in each country. Although there does not seem to be a clear trend in general, inefficiency scores have been increasing in later years in most countries in the sample.

(Insert Table 4)

(Insert Table 5)

We also compare the efficiency of domestic and foreign banks[17]. The results for the cost and profit inefficiency appear in Table 6 and 7, respectively. Although Claessens, Demirguc-Kunt and Huizinga (2001) find that foreign bank entry was followed by a reduction in both the probability and the overhead expenses of domestic banks, the banking literature on the comparative performance of domestic and foreign banks generally concludes that domestic

banks have an advantage in developed countries (see Berger et al., 2000). The cause seems to be the weaknesses of foreign banks, such as cultural barriers or organizational diseconomies involved in the operation and monitoring of a bank from a distance. These cultural barriers might be expected to play a significant role in Latin American and the Caribbean countries where managers of foreign banks often come from developed countries.

The shareholders of foreign banks in Latin America and the Caribbean are mainly from the US and Spain. This gives foreign banks two important advantages over domestic banks. Firstly, since the most shareholders of foreign banks in these countries are banks, they can provide their know-how, expertise and technology to their subsidiaries, which gives foreign banks a clear advantage over domestic banks. Secondly, Western shareholders are more used to monitoring bank managers.

We observe that foreign banks are more cost-efficient on average than domestic banks in twelve out of fifteen countries. The mean cost inefficiency score is 21.4% for foreign banks, while it is 23.4% for domestic banks. The analysis of the dispersion of efficiency scores shows significant difference between two types of banks. Foreign banks operating in the banking sectors of Argentina, Colombia, Ecuador, Panama, Paraguay, Peru and Venezuela are significantly more efficient than domestic banks. Domestic banks in Bolivia and Chile are however, significantly more efficient than foreign banks.

(Insert Table 6)

As seen in Table 7, foreign banks are more profit efficient than domestic banks in eleven countries. The results also indicate that the profit efficiency levels are lower than those of cost

efficiency. Foreign banks in Argentina, Brazil, Chile, Paraguay, Peru and Uruguay are significantly more profit efficient than domestic banks. In contrast to cost efficiency, foreign banks operating in Chile are significantly more profit efficient than domestic banks.

(Insert Table 7)

4. Conclusion

One of the objectives of this paper is to investigate the profit and cost efficiency of banks in sixteen Latin American and the Caribbean countries over the period 1996-2001. This paper also analyzes the impact of the nature of ownership on the banking efficiency of banks in these countries. This is an issue of considerable interest, due to the increasing involvement of foreign capital in the banking sectors in the region.

We used a model proposed by Battese and Coelli (1995) and then specified a common stochastic frontier with country-specific environmental variables for a panel of 427 banking firms. In cross-country comparison of efficiency, controlling for environmental factors is important due to the significant differences in regulatory and economic environment. The estimation results show that banking systems in these countries are characterized by an efficiency differentiation, which can be ascribed to heterogeneity in the environment as a whole and in the structure of firms. Hence, environmental variables appear to play an important role in explaining the efficiency differences among countries.

We then compared the cost and profit efficiency in each country in the sample. All banking systems display significant level of cost-inefficiency and profit-inefficiency ranging from 11.6% to 38.9% and 12.1% to 49.9%, respectively. The results indicate that the average

level of cost efficiency is higher than that of profit efficiency, verifying the importance of inefficiencies on the revenue side of banking activity. The Spearman rank correlation coefficient between the two definitions of efficiency was also calculated. The rank correlation coefficient is low but positive and significant, suggesting that the most cost efficient banks are also the most profit efficient. The results further suggest that the large and very large banks are on average more cost efficient than other groups of banks. As for the profit efficiency, the results, however, suggest that larger banks are the more profit inefficient.

The levels of cost and profit inefficiency vary greatly from country to country in the region. Among the five big economies (Argentina, Brazil, Chile, Mexico, and Venezuela), only Argentinean and Chilean bank managers have been successful, on average, keeping costs close to the efficient frontier over the period 1996-2001. Brazil has performed around the average, while Venezuela and Mexico has performed poorly. The range of variation in profit inefficiency among countries is, however, greater than that of cost inefficiency. Again Argentinean and Chilean bank managers have been successful, on average, keeping profits close to the efficient frontier during the sample period.

We finally analyzed the impact of foreign ownership on the banking efficiency. We found evidence in favor of the positive influence of foreign ownership on both cost and profit efficiency in around twelve countries. We observed that foreign banks operating in seven (six) Latin American countries were significantly more cost (profit) efficient than their domestic counterparts. This clear advantage in favor of foreign banks can be explained by the fact that they benefit from a transfer of banking know-how, technology and expertise, since many mother companies are banks, and by better corporate governance exercised by foreign shareholders.

The findings of the paper have a clear set of policy implications for Latin American and the Caribbean countries. The main conclusion of this paper on the impact of foreign ownership is that the degree of openness of the banking sector to foreign capital has a positive impact on performance. Hence, entry of foreign banks should be promoted since it, as also shown in the previous studies (see for example Claessens, Demirguc-Kunt and Huizinga, 2001; Weill, 2002; and Kasman, 2004), increases the efficiency of the system. Since foreign banks transfer know-how, technology and expertise, the existence of foreign banks in the sectors produces positive externalities to the sector as a whole by disseminating good practice. The findings of this paper also suggest that banking systems in the region have serious inefficiency problem. Hence, competition from foreign banks would increase efficiency of banking system. It may also have a positive influence on the macroeconomic performance of these countries, because of the important role of the banking sector in the financing of these economies.

Notes

1. The market share of foreign banks has increased dramatically in most Latin American countries. Particularly, large international banks like Banco Bilbao Vizcaya Argentaria, Santander Central Hispano, Citibank, HSBC Bank, Fleet Boston, ABN AMRO Bank, Scotiabank and JP Morgan are very active players across all markets.
2. See Fecher and Pestiau (1993), Allen and Rai (1996), Pastor et al. (1997) and Maudos et al.(2002), Weill (2003).
3. The studies on banking efficiency have mostly concentrated on the analysis of cost efficiency, disregarding possible inefficiencies on the revenue side. The objective of profit maximization requires both cost minimization and revenue maximization. Estimating profit efficiency therefore constitutes a more important source of information for bank management than the partial vision offered by analyzing cost efficiency. Empirical evidence from a few studies analyzing the profit efficiency of banking industries shows that profit inefficiency is quantitatively more important than cost inefficiency (see for example Rogers, 1998 and Maudos et al, 2002).
4. See Berger and Humphery (1997).
5. Following Berger and Mester (1997), two profit functions can be distinguished depending on whether or not the existence of market power in the setting of output price is considered. The standard profit function assumes perfect competition in the markets for outputs and inputs. In contrast to the cost frontier, the standard profit frontier relates bank profit to input prices and output prices. The exogenous nature of the price of the output vector in the standard profit function has the disadvantage that it assumes the non-existence of market power in pricing. As indicated by Berger and Mester (1997),

alternative profit efficiency is a closer representation of reality whenever the assumption of perfect competition in the setting of prices is questionable or when there are differences of quality/specialization among the individuals of the sample or when output prices are not accurately measured, as is generally the case in banking research. Since our sample includes a diverse group of countries with different levels of competition, it seems more appropriate to estimate alternative profit function than standard profit function for international comparisons. Hence, we estimate only the alternative profit frontier. The alternative or "nonstandard" approach to estimating profit frontiers has been applied to banks by Rogers (1998), Berger and Mester (1997), Humphrey and Pulley (1997), and Maudos et al. (2002).

6. See Wang and Schmidt (2002) for a discussion of one-step and two-step methods.
7. Following Mester (1996), equity is included in the cost function specification to control for differences in risk preferences. If managers from one bank are more risk-averse than the managers from other banks, they can hold a higher level of equity than the cost-minimizing level. Hence, by omitting the level of equity, we may consider a bank as inefficient even if it behaves optimally, given the risk preferences of its managers. This variable is fully interactive with the output and input price variables.
8. The formula for z_i is $0.2\pi - \mu \cdot a \ln Y_i$, where $\mu \equiv (0.9 \cdot 2\pi - 0.1 \cdot 2\pi)/(b-a)$ and [a, b] is the range of $\ln Y_i$.
9. Since the input prices show little variation across banks we exclude Fourier terms for the input prices in order to have limited number of Fourier terms.
10. It should also be noted that in the empirical analysis most of the estimation is carried out using the FRONTIER 4.1 and LIMDEP 7.0.

11. A small number of banking firms did not produce off balance sheet items during the sample period. Hence, the values like $1000 is added to the off-balance sheet items of all firms in the sample.
12. See Dietsch and Lozano-Vivas (2000) for details on country-specific environmental variables.
13. All of the estimated coefficients on the environmental variables (except for the inflation) in the estimation of the cost function are significant at 5% level. Hence the environmental variables are important determinants of bank costs. The results suggest that banks operating in countries with a higher population density are significantly more efficient because they face relatively lower costs than banks in less dense areas. The sign of the income per capita is also negative, indicating that banks operating in richer countries (measured by GDP per capita) are significantly more efficient. A priori the coefficient on the deposit density is expected to be negative because greater density implies easier access to banking products and services. Our results suggest that increase in deposits per square kilometer decreases the banking costs. The average capital ratio (measured by average equity level/total assets) is an indicator of the state of regulation in each country. The capital ratio has a negative sign, suggesting that a strengthening of regulations would lead to lower bank costs. The concentration (Herfindahl) index is positive, which implies that banks have higher costs in highly concentrated markets. The intermediation ratio measures the cost of producing loans in terms of the amount of required deposits. The sign of the coefficient of the intermediation ratio is negative, indicating that higher amounts of loans per unit of deposits decrease banking costs. The regression results also

indicate that financial deepening variable money/GDP and GDP growth rate have negative signs. The sign of the coefficient of urban population is, however, positive.

14. Our average inefficiency score is a little higher than the result of Carvallo and Kasman (2004) because we use different technique, outputs and time span in estimating cost efficiency.
15. All of the estimated coefficients on the environmental variables (except for the average capital ratio) in the estimation of the alternative profit function are significant at 5% significance level. Hence macro economic factors play an important role in determining profit efficiency. The results suggest that banks operating in countries with a higher population density are more profit efficient. Banks operating in richer countries are significantly less profit efficient. This is an unexpected finding, one possible implication is that since bank customers in richer countries are more sophisticated the competition between banks may be relatively more aggressive. The concentration index has a positive sign indicating that banks are more profit efficient in highly concentrated markets. The sign of coefficient of intermediation ratio is positive, indicating that higher amounts of loans per unit of deposits increases banking profits.
16. The Spearman rank correlation coefficient between the two definitions of efficiency is low (0.112) but positive and statistically significant. Hence, the most cost efficient banks are also the most profit efficient, although the correlation is very small.
17. BankScope definition of foreign ownership is adopted in classifying banks into foreign or not. One important limitation of the data is that BankScope classifies banks into foreign or not at the time of the last update of the database.

References

Allen, L. and A. Rai. (1996). "Operational Efficiency in Banking: An International Comparison." Journal of Banking Finance 20, 655–672.

Battese, G.E. and G.S. Corra. (1977). "Estimation of a production frontier model: with application to the pastoral zone of Eastern Australia." Australian Journal of Agricultural Economics, 21, 169-179.

Battese,G.E. and T. J. Coelli. (1995). "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data." Empirical Economics 20, 325 –332.

Berger, A.N., W.C. Hunter and D.B. Humphrey. (1993). "The Efficiency of Financial Institutions: A Review and Preview of Research, Past, Present and Future." Journal of Banking and Finance17, 221-250.

Berger, A., A. Kashyip and J. Scalise. (1995). "The Transformation of the U.S. Banking Industry: What a Long Strange Trip It's Been." Brookings Papers on Economic Activity 0, 55-201.

Berger, A.N. and D.B. Humphrey. (1997). "Efficiency of Financial Institutions: International Survey and Directions for Future Research." European Journal of Operational Research 98, 175–212.

Berger, A.N. and L.J. Mester. (1997). "Inside the Black Box: What Explains Differences in the Efficiencies of Financial Institutions." Journal of Banking and Finance, 21, 895–947.

Berger, A.N. R. DeYoung, H. Genay, and G. Udell.(2000). "Globalization of financial institutions: Evidence from cross-border banking performance.", Brookings-Wharton Papers on Financial Services, 23 –125.

Carvallo, O. and A. Kasman. (2004). "Cost Efficiency in the Latin American and Caribbean Banking Systems." Journal of International Financial Markets, Institutions and Money, Forthcoming.

Claessens, S., A. Demirgüc-Kunt, and H. Huizinga. (2001). "How Does Foreign Entry Affect the Domestic Banking Market?" Journal of Banking and Finance 25: 891-911.

Dietsch, M. and L. Lozano-Vivas. (2000). "How the Environment Determines Banking Efficiency: A comparison Between French and Spanish Industries." Journal of Banking and Finance 24, 985-1004.

Fecher, F. and P. Pestieau. (1993). Efficiency and Competition in O.E.C.D. Financial Services, in: H.O. Fried, C.A.K. Lovell, and S.S. Schmidt, eds., The Measurement of Productive Efficiency: Techniques and Applications, (Oxford University Press, U. K.) 374-85.

Humphrey, D. B. and L.B. Pulley. (1997). “Bank’s Responses to Deregulation: Profits, Technology, and Efficiency.” Journal of Money, Credit and Banking 29, 73-93.

Jagtiani, J. and A. Khanthavit. (1996). “Scale and Scope Economies at Large Banks: Including Off-balance Sheet Products and Regulatory Effects (1984-1991).” Journal of Banking and Finance 20, 1271-87.

Kasman, A. (2004). “Efficiency and Scale Economies in Transition Economies: Evidence from Poland and the Czech Republic.” Emerging Markets Finance and Trade, Forthcoming.

Lozano, A. (1997). “Profit Efficiency for Spanish Saving Banks.” European Journal of Operational Research, 98, 381-394.

Lozano-Vivas, A., J.T. Pastor and I. Hasan. (2001). “European Bank Performance Beyond Country Borders: What Really Matters?” European Finance Review 5, 141-165.

Lozano-Vivas, A., J.T. Pastor and J.M. Pastor. (2002). “An Efficiency Comparison of European Banking Systems Operating Under Different Environmental Conditions.” Journal of Productivity Analysis 18, 59-77.

Maudos J., J. Pastor, F. Perez and J. Quesada. (2002). “Cost and Profit Efficiency in European Banks.” Journal of International Financial Markets, Institutions and Money 12, 33-58.

Meeusen, W. and J. van den Broeck. (1977). “Efficiency estimation from Cobb-Douglas production functions with composed error.” International Economic Review, 18, 435-444.

McAllister, P. H. and D. McManus. (1993). “Resolving the Scale Efficiency Puzzle in Banking.” Journal of Banking and Finance 17: 389-405.

Mester, L. J., (1996). “A Study of Bank Efficiency Taking into Account Risk-Preferences.” Journal of Banking and Finance 20, 1025-1045.

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

Pastor, J.M., F. Perez and J. Quesada. (1997). “Efficiency Analysis in Banking Firms: An International Comparison.” European Journal of Operational Research 98, 395–407.

Rogers, K. E. (1998). “Nontraditional Activities and the Efficiency of US Commercial Banks. Journal of Banking and Finance 22, 467-482.

Sealey, C. and J.T. Lindley. (1977). “Inputs, Outputs and a Theory of Production and Cost at Depository Financial Institution.” Journal of Finance 32, 1251-1266.

Wang, H-J. and P. Schmidt. (2002). “One-step and Two-step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels.” Journal of Productivity Analysis 18, 129-144.

Weill, L. (2003). “Banking Efficiency in Transition Economies: The Role of Foreign Ownership.” Economics of Transition 11, 569-592.

Table 1. Summary statistics of the variables: 1996-2001

	Average	Standard Deviation	Coefficient of Variation
Total costs (*tc*)	478226.90	1724427.80	3.61
Pre-tax profits (Π)	30813.53	152107.44	4.94
Total assets (*ta*)	2664892.87	8672117.08	3.25
Total loans (y_1)	1311057.65	4498389.00	3.43
Other earning assets (y_2)	1021799.16	3656498.91	3.58
Off-balance sheet items (y_3)	358392.02	1318237.25	3.68
Price of funds (w_1)	0.126	0.093	0.737
Price of labor (w_2)	0.032	0.026	0.816
Price of Capital (w_3)	1.830	1.899	1.038
tc/ta	0.201	0.244	1.216
Π */ta*	0.010	0.049	4.916

Note: *tc*, Π, *ta*, y_1, y_2, and y_3 in thousands of US$

Table 2. Average Values of Environmental Variables (1996-2001).

	POP	INC ($)	DEMAND ($)	HHI (%)	AEQ	INT	URBAN	GDPG (%)	MONEY (%)	INF (%)
Argentina	13.335	7608.086	30754.479	7.235	0.185	1.310	88.111	0.324	30.208	-0.691
Bolivia	7.341	1007.028	6144.887	1.328	0.121	0.774	61.504	2.265	49.048	5.504
Brazil	19.584	3932.583	30833.325	7.469	0.162	4.481	80.348	0.959	28.401	8.200
Chile	19.753	4829.281	60592.991	3.498	0.229	1.232	85.417	2.327	44.277	4.589
Colombia	36.092	2276.646	20832.384	1.050	0.172	1.489	74.157	1.322	22.846	13.127
Costa Rica	73.083	3978.897	98777.776	4.232	0.191	2.176	58.616	3.535	31.944	11.188
Dominican Republic	169.253	2153.455	116413.211	1.997	0.150	24.946	64.665	4.472	29.447	7.280
Ecuador	43.712	1442.919	19702.892	1.993	0.116	0.643	62.415	-0.333	24.272	-2.300
Honduras	56.352	895.458	21625.194	1.227	0.124	0.784	51.990	1.229	41.306	11.584
Jamaica	232.832	2819.671	309355.189	2.411	0.158	1.152	55.613	-0.455	45.053	10.101
Mexico	49.133	5106.720	84053.044	16.308	0.155	9.443	74.124	3.583	23.328	14.455
Panama	37.062	3641.717	35213.727	1.505	0.099	0.833	55.954	2.384	65.954	1.460
Paraguay	12.928	1543.120	5631.940	1.345	0.157	0.811	55.212	0.194	32.304	6.879
Peru	19.801	2180.435	13940.370	2.419	0.118	0.803	72.338	1.334	29.558	4.814
Uruguay	18.760	6095.662	91385.358	2.424	0.117	0.869	91.692	0.712	46.624	8.190
Venezuela	26.312	4701.270	21263.353	2.028	0.193	3.904	86.812	-0.627	16.526	24.065

Sources: Bankscope IBCA, World Development Indicators; International Financial Statistics, own calculations.
Note: INC=Income per capita; POP= Density of population; DEMAND = Density of demand; INF = Inflation; HHI = Concentration (Herfindahl Index); INT=intermediation ratio; AEQ= Average capital ratios; GDPG= GDP Growth; URBAN = Urban population (% of total); MONEY= Money / GDP (%).

Table 3. Average cost inefficiency scores (1996-2001).

	Mean	Standard Deviation	Coefficient of Variation
Countries in the Sample			
Argentina	0.161	0.125	0.774
Bolivia	0.172	0.124	0.722
Brazil	0.212	0.209	0.988
Chile	0.144	0.154	1.071
Colombia	0.339	0.232	0.686
Costa Rica	0.151	0.148	0.977
Dominican Republic	0.182	0.120	0.661
Ecuador	0.269	0.194	0.722
Honduras	0.126	0.051	0.408
Jamaica	0.175	0.113	0.649
Mexico	0.389	0.290	0.747
Panama	0.116	0.095	0.823
Paraguay	0.344	0.228	0.662
Peru	0.213	0.105	0.494
Uruguay	0.141	0.147	1.038
Venezuela	0.379	0.241	0.636
Overall	0.227	0.204	0.897
Trend			
1996	0.197	0.173	0.875
1997	0.168	0.123	0.730
1988	0.198	0.175	0.886
1999	0.251	0.225	0.898
2000	0.239	0.204	0.854
2001	0.259	0.237	0.914
Size (Million US Dollars)			
0-500 N = 1021	0.240	0.223	0.930
500-1000 N = 233	0.222	0.202	0.910
1000-5000 N = 406	0.221	0.185	0.838
5000-10000 N = 81	0.153	0.074	0.483
10000+ N = 112	0.198	0.120	0.606
Organizational Type			
Commercial Banks	0.226	0.201	0.892
Cooperative Banks	0.192	0.154	0.804
Savings&Loans Banks	0.282	0.239	0.848
Investment Banks	0.286	0.247	0.865
Real Estate/Mortgage Banks	0.117	0.047	0.398
Medium- and Long-term Banks	0.266	0.300	1.126
Specialized Governmental Credit Institutions	0.193	0.170	0.877

Note: Estimations are based on a common cost frontier with country-specific environmental variables. Our pooled sample data includes 427 banking firms over the period between 1996-2001 consisting of 1853 observations. Yearly estimates are simply average from the year from the pooled estimate.

Table 4. Average profit inefficiency scores (1996-2001).

	Mean	Standard Deviation	Coefficient of Variation
Countries in the Sample			
Argentina	0.206	0.107	0.520
Bolivia	0.140	0.044	0.313
Brazil	0.499	0.149	0.299
Chile	0.194	0.071	0.364
Colombia	0.340	0.118	0.365
Costa Rica	0.223	0.118	0.528
Dominican Republic	0.131	0.046	0.349
Ecuador	0.273	0.128	0.468
Honduras	0.151	0.036	0.238
Jamaica	0.321	0.095	0.297
Mexico	0.427	0.141	0.331
Panama	0.121	0.038	0.373
Paraguay	0.299	0.103	0.344
Peru	0.232	0.111	0.479
Uruguay	0.404	0.156	0.386
Venezuela	0.385	0.191	0.583
Overall	0.309	0.178	0.578
Trend			
1996	0.303	0.181	0.598
1997	0.306	0.179	0.584
1988	0.311	0.184	0.592
1999	0.325	0.191	0.589
2000	0.289	0.161	0.557
2001	0.315	0.176	0.559
Size (Million US Dollars)			
0-500 N = 1021	0.283	0.168	0.596
500-1000 N = 233	0.317	0.182	0.575
1000-5000 N = 406	0.339	0.190	0.560
5000-10000 N = 81	0.367	0.167	0.455
10000+ N = 112	0.369	0.178	0.483
Organizational Type			
Commercial Banks	0.306	0.177	0.578
Cooperative Banks	0.263	0.157	0.599
Savings&Loans Banks	0.297	0.174	0.588
Investment Banks	0.420	0.199	0.473
Real Estate/Mortgage Banks	0.175	0.096	0.548
Medium- and Long-term Banks	0.280	0.114	0.408
Specialized Governmental Credit Institutions	0.317	0.183	0.576

Note: Estimations are based on a common profit frontier with country-specific environmental variables. Our pooled sample data includes 427 banking firms over the period between 1996-2001 consisting of 1853 observations. Yearly estimates are simply average from the year from the pooled estimate.

Table 5. Evolution of cost and alternative profit inefficiency

	1996	1997	1998	1999	2000	2001
Cost Inefficiency						
Argentina	0.150	0.109	0.160	0.177	0.181	0.137
Bolivia	0.093	0.099	0.116	0.150	0.241	0.314
Brazil	0.198	0.177	0.174	0.259	0.206	0.246
Chile	0.096	0.105	0.115	0.188	0.132	0.203
Colombia	0.280	0.247	0.315	0.329	0.415	0.384
Costa Rica	0.094	0.136	0.118	0.126	0.191	0.172
Dominican Republic	0.185	0.145	0.146	0.175	0.214	0.190
Ecuador	-	0.161	0.168	0.327	0.371	0.303
Honduras	0.126	0.122	0.117	0.121	0.111	0.148
Jamaica	0.097	0.141	0.170	0.236	0.191	0.160
Mexico	0.495	0.241	0.356	0.385	0.371	0.519
Panama	0.082	0.076	0.089	0.086	0.168	0.162
Paraguay	0.221	0.172	0.347	0.309	0.332	0.534
Peru	0.269	0.194	0.228	0.252	0.183	0.181
Uruguay	0.087	0.087	0.089	0.116	0.149	0.208
Venezuela	0.294	0.332	0.435	0.435	0.340	0.364
Profit Inefficiency						
Argentina	0.158	0.148	0.159	0.190	0.204	0.275
Bolivia	0.155	0.131	0.132	0.143	0.157	0.120
Brazil	0.469	0.479	0.531	0.557	0.463	0.491
Chile	0.191	0.201	0.227	0.197	0.186	0.165
Colombia	0.374	0.277	0.367	0.361	0.292	0.281
Costa Rica	0.215	0.258	0.146	0.155	0.271	0.288
Dominican Republic	0.100	0.098	0.103	0.106	0.155	0.170
Ecuador	-	0.288	0.307	0.355	0.205	0.205
Honduras	0.174	0.175	0.177	0.160	0.144	0.130
Jamaica	0.236	0.343	0.289	0.298	0.317	0.370
Mexico	0.328	0.430	0.435	0.473	0.465	0.360
Panama	0.109	0.093	0.083	0.083	0.120	0.123
Paraguay	0.206	0.192	0.311	0.296	0.307	0.377
Peru	0.234	0.222	0.242	0.240	0.242	0.212
Uruguay	0.517	0.349	0.367	0.434	0.352	0.483
Venezuela	0.199	0.360	0.323	0.359	0.284	0.365

Note: We do not have observations for 1995 for Ecuador.

Table 6. Average cost inefficiency scores by groups (1996-2001)

	Mean	Standard Deviation	Coefficient of Variation
Foreign Banks			
Argentina	0.139*	0.118	0.853
Bolivia	0.220*	0.151	0.685
Brazil	0.194	0.194	1.000
Chile	0.184*	0.223	1.215
Colombia	0.286*	0.212	0.741
Costa Rica	0.146	0.057	0.392
Dominican Republic	0.195	0.061	0.312
Ecuador	0.259**	0.218	0.844
Honduras	0.098	0.013	0.137
Mexico	0.386	0.309	0.801
Panama	0.087*	0.022	0.255
Paraguay	0.295*	0.182	0.615
Peru	0.189*	0.080	0.423
Uruguay	0.145	0.179	1.235
Venezuela	0.288*	0.144	0.500
Overall	**0.214***	**0.200**	**0.934**
Domestic Banks			
Argentina	0.178	0.127	0.715
Bolivia	0.151	0.105	0.699
Brazil	0.223	0.218	0.977
Chile	0.113	0.042	0.370
Colombia	0.360	0.238	0.661
Costa Rica	0.152	0.154	1.012
Dominican Republic	0.181	0.126	0.695
Ecuador	0.270	0.191	0.707
Honduras	0.128	0.053	0.411
Mexico	0.393	0.265	0.676
Panama	0.127	0.110	0.863
Paraguay	0.396	0.261	0.659
Peru	0.242	0.124	0.513
Uruguay	0.136	0.080	0.590
Venezuela	0.405	0.257	0.634
Overall	**0.234**	**0.205**	**0.879**

Note: We did not have information on foreign banks in Jamaica.
* Significantly different from domestic mean scores at 5% significance level.
** Significantly different from domestic mean scores at 10% significance level
The tests were conducted under the assumption of unequal variances.

Table 7. Average profit inefficiency scores by groups (1996-2001)

	Mean	Standard Deviation	Coefficient of Variation
Foreign Banks			
Argentina	0.201**	0.134	0.667
Bolivia	0.131	0.026	0.197
Brazil	0.473*	0.153	0.324
Chile	0.178*	0.081	0.455
Colombia	0.334	0.075	0.218
Costa Rica	0.205	0.087	0.425
Dominican Republic	0.111	0.019	0.173
Ecuador	0.293	0.109	0.372
Honduras	0.111	0.017	0.157
Mexico	0.439	0.157	0.359
Panama	0.097	0.024	0.244
Paraguay	0.270*	0.104	0.386
Peru	0.193*	0.050	0.259
Uruguay	0.368*	0.152	0.414
Venezuela	0.305	0.186	0.611
Overall	**0.316**	**0.179**	**0.567**
Domestic Banks			
Argentina	0.221	0.083	0.393
Bolivia	0.143	0.049	0.344
Brazil	0.517	0.144	0.279
Chile	0.206	0.059	0.288
Colombia	0.315	0.131	0.415
Costa Rica	0.225	0.120	0.536
Dominican Republic	0.133	0.047	0.356
Ecuador	0.269	0.131	0.487
Honduras	0.154	0.035	0.229
Mexico	0.410	0.116	0.282
Panama	0.105	0.043	0.407
Paraguay	0.330	0.093	0.283
Peru	0.277	0.142	0.513
Uruguay	0.459	0.149	0.323
Venezuela	0.335	0.193	0.576
Overall	**0.305**	**0.178**	**0.583**

Note: We did not have information on foreign banks in Jamaica.
* Significantly different from domestic mean scores at 5% significance level.
** Significantly different from domestic mean scores at 10% significance level
The tests were conducted under the assumption of unequal variances.

Appendix

Table A1. Maximum likelihood parameter estimates of the common cost frontier with country specific - environmental variables

Variable	Parameter	Coefficients	p-value	
Constant	α_0	-11.644	0.998	-11.669
$\ln Q_1$	α_1	1.411	0.296	4.768
$\ln Q_2$	α_2	2.565	0.382	6.709
$\ln Q_3$	α_3	0.214	0.281	0.760
$\ln P_1$	β_1	0.510	0.058	8.776
$\ln P_2$	β_2	0.461	0.063	7.331
$\ln EQ$	γ_1	-0.084	0.084	-1.009
$\ln Q_1 \ln Q_1$	α_{11}	0.073	0.031	2.367
$\ln Q_2 \ln Q_2$	α_{22}	-0.044	0.039	-1.136
$\ln Q_3 \ln Q_3$	α_{33}	-0.019	0.034	-0.553
$\ln P_1 \ln P_1$	β_{11}	0.161	0.009	17.258
$\ln P_2 \ln P_2$	β_{22}	0.179	0.013	14.051
$\ln EQ \ln EQ$	γ_2	-0.069	0.019	-3.558
$\ln Q_1 \ln Q_2$	α_{12}	-0.169	0.008	-21.716
$\ln Q_1 \ln Q_3$	α_{13}	-0.009	0.002	-3.967
$\ln Q_2 \ln Q_3$	α_{23}	0.002	0.002	1.067
$\ln P_1 \ln P_2$	β_{12}	-0.172	0.009	-18.725
$\ln Q_1 \ln P_1$	δ_{11}	0.004	0.007	0.570
$\ln Q_1 \ln P_2$	δ_{12}	0.005	0.008	0.657
$\ln Q_2 \ln P_1$	δ_{21}	-0.033	0.005	-6.163
$\ln Q_2 \ln P_2$	δ_{22}	0.020	0.007	2.915
$\ln Q_3 \ln P_1$	δ_{31}	0.003	0.001	2.032
$\ln Q_3 \ln P_2$	δ_{32}	0.000	0.002	0.062
$\ln Q_1 \ln EQ$	ψ_1	0.028	0.011	2.676
$\ln Q_2 \ln EQ$	ψ_2	0.039	0.009	4.361
$\ln Q_3 \ln EQ$	ψ_3	0.002	0.002	1.040
$\ln P_1 \ln EQ$	ϕ_1	0.036	0.010	3.648
$\ln P_2 \ln EQ$	ϕ_2	-0.036	0.012	-3.020
$\cos(z_1)$	η_1	0.597	0.236	2.531
$\sin(z_1)$	ω_1	0.897	0.285	3.144
$\cos(z_2)$	η_2	-2.241	0.274	-8.172
$\sin(z_2)$	ω_2	2.924	0.779	3.752
$\cos(z_3)$	η_3	0.142	0.254	0.560
$\sin(z_3)$	ω_3	0.428	0.848	0.504
$\cos(z_1 + z_1)$	η_{11}	-0.047	0.043	-1.077
$\sin(z_1 + z_1)$	ω_{11}	0.146	0.050	2.944
$\cos(z_2 + z_2)$	η_{22}	-0.168	0.100	-1.675
$\sin(z_2 + z_2)$	ω_{22}	-0.327	0.066	-4.948
$\cos(z_3 + z_3)$	η_{33}	-0.076	0.096	-0.789
$\sin(z_3 + z_3)$	ω_{33}	0.015	0.065	0.229
$\cos(z_1 + z_2)$	η_{12}	-0.094	0.085	-1.113

$\sin(z_1 + z_2)$	ω_{12}	-0.152	0.063	-2.409
$\cos(z_1 + z_3)$	η_{13}	0.123	0.038	3.219
$\sin(z_1 + z_3)$	ω_{13}	-0.031	0.033	-0.928
$\cos(z_2 + z_3)$	η_{23}	-0.035	0.050	-0.690
$\sin(z_2 + z_3)$	ω_{23}	0.026	0.032	0.788
Constant	ζ_0	1.193	0.478	2.497
Population density	ζ_1	-0.012	0.003	-4.086
GDP per capita	ζ_2	0.000	0.000	-5.611
Deposit density	ζ_3	-0.000	0.000	-4.493
Herfindahl	ζ_4	0.073	0.013	5.517
Average capital	ζ_5	-1.707	0.810	-2.108
Intermediation	ζ_6	-0.440	0.073	-6.002
GDP growth	ζ_7	-0.105	0.017	-6.158
Inflation	ζ_8	0.001	0.002	0.543
Money	ζ_9	-0.090	0.015	-6.092
Urban	ζ_{10}	0.012	0.006	2.108
$\sigma^2 = \sigma_u^2 + \sigma_v^2$		0.564	0.070	8.012
$\lambda = \sigma_u / \sigma_v$		0.947	0.007	132.141
Log likelihood function				-53.553

Table A2. Maximum likelihood parameter estimates of the common profit frontier with country specific - environmental variables

Variable	Parameter	Coefficients	p-value	
Constant	α_0	-18.311	0.986	-18.573
$\ln Q_1$	α_1	8.012	0.475	16.865
$\ln Q_2$	α_2	-3.424	0.436	-7.847
$\ln Q_3$	α_3	0.136	0.312	0.435
$\ln P_1$	β_1	1.142	0.122	9.339
$\ln P_2$	β_2	0.025	0.124	0.199
$\ln EQ$	γ_1	0.026	0.181	0.146
$\ln Q_1 \ln Q_1$	α_{11}	-0.607	0.058	-10.452
$\ln Q_2 \ln Q_2$	α_{22}	0.446	0.045	9.878
$\ln Q_3 \ln Q_3$	α_{33}	-0.007	0.037	-0.190
$\ln P_1 \ln P_1$	β_{11}	0.084	0.020	4.193
$\ln P_2 \ln P_2$	β_{22}	0.037	0.024	1.542
$\ln EQ \ln EQ$	γ_2	0.121	0.039	3.088
$\ln Q_1 \ln Q_2$	α_{12}	-0.018	0.018	-0.982
$\ln Q_1 \ln Q_3$	α_{13}	-0.006	0.005	-1.126
$\ln Q_2 \ln Q_3$	α_{23}	0.007	0.004	1.658
$\ln P_1 \ln P_2$	β_{12}	-0.013	0.019	-0.688
$\ln Q_1 \ln P_1$	δ_{11}	-0.093	0.014	-6.837
$\ln Q_1 \ln P_2$	δ_{12}	0.067	0.014	4.743
$\ln Q_2 \ln P_1$	δ_{21}	0.031	0.011	2.758
$\ln Q_2 \ln P_2$	δ_{22}	-0.053	0.013	-3.916
$\ln Q_3 \ln P_1$	δ_{31}	0.007	0.003	2.236
$\ln Q_3 \ln P_2$	δ_{32}	-0.013	0.003	-4.009
$\ln Q_1 \ln EQ$	ψ_1	-0.039	0.021	-1.870
$\ln Q_2 \ln EQ$	ψ_2	-0.062	0.018	-3.401
$\ln Q_3 \ln EQ$	ψ_3	-0.003	0.005	-0.644
$\ln P_1 \ln EQ$	ϕ_1	0.023	0.019	1.183
$\ln P_2 \ln EQ$	ϕ_2	0.031	0.022	1.409
$\cos(z_1)$	η_1	-0.078	0.541	-0.145
$\sin(z_1)$	ω_1	7.063	0.490	14.421
$\cos(z_2)$	η_2	-0.926	0.687	-1.347
$\sin(z_2)$	ω_2	-8.260	0.877	-9.414
$\cos(z_3)$	η_3	-0.394	0.408	-0.964
$\sin(z_3)$	ω_3	0.285	0.935	0.305
$\cos(z_1 + z_1)$	η_{11}	-0.762	0.079	-9.590
$\sin(z_1 + z_1)$	ω_{11}	0.211	0.107	1.968
$\cos(z_2 + z_2)$	η_{22}	0.876	0.134	6.540
$\sin(z_2 + z_2)$	ω_{22}	-0.209	0.151	-1.391
$\cos(z_3 + z_3)$	η_{33}	-0.043	0.118	-0.360
$\sin(z_3 + z_3)$	ω_{33}	-0.075	0.107	-0.701
$\cos(z_1 + z_2)$	η_{12}	0.201	0.211	0.954

$\sin(z_1 + z_2)$	ω_{12}	-0.083	0.135	-0.614
$\cos(z_1 + z_3)$	η_{13}	0.085	0.081	1.047
$\sin(z_1 + z_3)$	ω_{13}	-0.316	0.069	-4.585
$\cos(z_2 + z_3)$	η_{23}	-0.198	0.094	-2.100
$\sin(z_2 + z_3)$	ω_{23}	0.225	0.070	3.198
Constant	ζ_0	1.057	0.882	1.197
Population density	ζ_1	0.060	0.008	7.720
GDP per capita	ζ_2	-0.001	0.000	-9.389
Deposit density	ζ_3	0.000	0.000	8.337
Herfindahl	ζ_4	0.038	0.013	2.927
Average capital	ζ_5	0.036	1.013	0.036
Intermediation	ζ_6	0.650	0.070	9.275
GDP growth	ζ_7	-0.086	0.019	-4.493
Inflation	ζ_8	-0.022	0.006	-3.881
Money	ζ_9	-0.129	0.016	-8.036
Urban	ζ_{10}	0.041	0.010	3.898
$\sigma^2 = \sigma_u^2 + \sigma_v^2$		0.917	0.070	13.105
$\lambda = \sigma_u / \sigma_v$		0.884	0.014	62.894
Log likelihood function				-1244.032