Effects of Financial Capital on Colombian Banking Efficiency *

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Abstract

In this paper we discuss cost and profit efficiency for a sample of financial institutions on the Colombian financial market in the period 1989-2003, using stochastic frontier efficiency analysis. During the period, the cost efficient frontier deteriorates, but profit efficient frontier is relatively stable. We found significant difference when we compare the efficiency scores between types of financial intermediaries. Additionally, our analysis show that the scores for profit and cost efficiency have different distribution. We found big differences between profit and cost efficiency among the different type banks. This is evidence in favor of some banks behaving collusively and capturing oligopoly rents.

JEL code C23; D24; G21; L11.

key words: Frontier; Efficiency; Cost; Profit; Financial Capital

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1 Introduction

In the last years, there have been a series of changes related to global trends in the supply of financial services. These trends include economic integration, technological change, increased competition, disintermediation, deregulation and financial crises [1]. Colombia has not been apart from this phenomenon and its financial market is assumed to have led to increase in competition during the last years. In this way, both from banks and non-bank financial institutions, cost efficiency becomes a prerequisite for survival. The efficiency analysis is a leading indicator of how the financial firms adopt some strategies to face the consolidation process.

With efficiency analysis we can study the effects of the liberalization, distinguishing between cost and profit analysis. We use the stochastic frontier analysis (SFA) to identify the different level of inefficiency for each financial firm. It yields a best practice frontier as well as individual firm performance measures benchmarked against this frontier. We apply the analysis to a sample of financial firms of the Colombian financial system in the period 1989-2003. During this period changes occurred in the Colombian financial system originated by a financial crises, deregulation and consolidation processes.

We analyze the efficiency with cost and profit functions using variables such as financial capital and linear and quadratic trend term to determine whether shifts in the efficient cost and profit frontiers occur. In addition, we check for trend changes in average cost efficiency and average profit efficiency between 1989-2003. We conclude that the cost and profit efficiency are different with respect to the levels for each type of financial firm and with respect to the evolution during the period. Profit efficiency was approximately constant while the cost efficiency showed a significant change during the period. To find differences amongst financial institutions, we test equality between cost and profit efficiency for the different types of financial institutions, according to the traditional division of the Colombian financial system. The results show different levels in the cost and profit efficiency, suggesting that some banks benefit from sheer size and market power in the financial system. This is an evidence in favor of some banks behaving collusively and capturing oligopoly rents.

Additionally, in this paper we find that the incorporation of the financial capital as a control variable is relevant to measure the cost and profit

[1] For an overview see Berger (1998).

efficiency.

The remainder of this paper is organized as follows. In section 2, a general review of the literature to model inputs and outputs for the financial firm and the role of the financial capital. Next, in section 3 we present the *translog* function to estimate the efficiency measures. The section 4 show the empirical evidence for the Colombian case. The section 5 presents the estimation results. We conclude in section 6.

2 Production Function

2.1 Inputs and outputs for the financial institution

Actually, there is a wide debate on the accurate specification of the production function. We can distinguish two alternative approaches, on the one hand, the *production* approach distinguishes labor and physical capital as inputs to be combined to obtain outputs measured as credit and deposit transactions [2]. On the other hand, the *intermediation* approach starts from the traditional core function of financial institutions and takes deposits as inputs and defines loans and investments as outputs. This approach has been widely used in the literature: Benston, Hanweck and Humphrey (1982), Murray and White (1983) and Mester (1987) [3]. Some authors such as Hancock (1991) and Hughes, Mester, and Moon (2000), do not establish a priori if the deposits transactions are inputs or outputs in the production function. They use a regression for the profit function, using different variables that must be checked as input and output. In their empirical exploration for US financial institutions, they found that credit and deposit transactions are outputs in the estimated profit function.

2.2 The role of the financial capital

In this paper, we incorporate the financial capital to measure the effects related with risk and information management on the efficiency of the financial

[2]See Ferrier and Lovell (1990). This approach had been used recently analyzing branch bank behavior, in which there is no total dependency between the intermediation strategies.

[3]There are another approaches, that pretend to compute specifically another roles of financial institutions, such as risk administration, information management and/or agency problems.

institutions. Note that the approaches mentioned previously fail to incorporate all the aspects of risk, information processing and the solution of agency problems arising from the differences between loans and deposits and from the separation between management and ownership. Potential solutions to the shortcomings could be a different formulation of the constraints under which banks solve their minimization and maximization problems respectively. Berger and Mester (1997) argue that a bank's insolvency risk depends on its financial capital available to absorb portfolio losses, as well as on the portfolio risks themselves. Insolvency risk affects the cost and profit structure via the risk premium on uninsured debt, and through the intensity of risk management activities the bank undertakes.

Apart from risk, a bank's capital level directly affects cost by providing an alternative funding resource for assets. Interest paid on deposits represents a cost, but dividends paid do not. On the other hand, raising equity typically involves higher costs than raising deposits. In this way, banks with different relation equity/deposits can see modified their cost and profit structure. In some cases, large banks depend more on deposits funding to finance their portfolios than small banks do, so a failure to control for equity could yield a scale bias [4].

Additionally, if we consider the size of the assets, banks with lower risk positions can choose to set higher capitalization levels to send good signals. While banks with low capital level and higher risk position cannot imitate those actions given the opportunity cost incurred by having additional capital position. These kind of banks need to have riskier assets that are compensated with higher interest rate to alleviate higher variance and risk level. The specification of the capital in the cost and profit function also goes part of the different risk preferences of banks. If the banks are more risk averse than others, they may hold a higher level of financial capital to maximize profits or minimize cost. If financial capital is ignored, the efficiency of these banks would be mismeasured, even though they behave optimally given their risk preferences.

The financial firms combine inputs such as labor, physical capital and financial capital (equity and/or debt) to offer certain outputs: loans, investments and off-balance-sheet operations. The production process for these assets and products involves collecting relevant information, taking credit

[4]For a brief summary describing the role of financial capital within the financial technology see Lucas and McDonald (1992) and Hughes and Mester (1998).

risk positions, monitoring activities, and relationships between managers, owners and borrowers. Banks that are more efficient at accomplishing these tasks expect a higher return and a lower variance of return on individual loans. Hence, banks that are more efficient producers can reduce both the systematic and idiosyncratic components of an individual risk's total variance through better credit assessment, contract writing, and monitoring. Unlike individual investors, banks can influence the magnitude of an individual asset's systematic risk. When loans are combined in banks' portfolios, more efficient banks can expect a lower variance for any given return on their portfolios. Thus, capital markets price this efficiency.

Most of the literature about financial efficiency has ignored the role of financial capital to estimate bank efficiency. The financial capital is a source of resources to finance loans and other assets and it serves as instrument to protect banks against financial crises and as we mentioned before, it serves as a signal to the agents about bank's credit and management risk position. Banks that finance their assets with a lower proportion capital-deposits, need more liabilities and then a higher insolvency risk, *ceteris paribus*.

Hughes, Mester and Moon (2000) try to solve the following question: how is the cost of equity capital taken into account in computing efficiency? They formulate the answer by conditioning the minimum cost on the level of equity capital and computing equity capital's shadow price from this conditional optimum. In the same way, we compute the optimization problem of the banks taking in account the cost and profit functions both conditioned by the financial capital.

Now, we will do a brief description of the two optimization problems, considering a financial technology that is represented according with the function $F(y, x, z) \leq 0$ where y denotes different assets such as information-intensive loans, financial interbank services, and other investments; $x = x_d + x_p$, denotes the level of inputs; x_d representing deposits, x_p denoting labor and physical capital and z, denotes equity capital. The prices for each inputs are denoted by w_i. The economic cost of producing the output vector y is given by $w_d x_d + w_p x_p + w_z z$, omitting the cost of equity capital, the function cost is denominated *cash-flow* cost and is represented as $w_d x_d + w_p x_p$.

2.3 Bank Production, Cost and Profit

Here, we summarize the main aspects related with the intermediation approach, widely used in the literature. Based on the minimization cost and profit maximization methods, we evaluate efficiency with respect to certain objective function. In the first case, the inefficiency is caused by suboptimal choices of used inputs, given input prices, output quantities and available financial capital. In the second case, the profit-inefficiency measures foregone profits due to a suboptimal choice of output quantities given output prices (or suboptimal output prices given quantities). In perfectly competitive markets, the two approaches could yield identical results fixing the output quantity. However, in the case of imperfect competition, market power might lead to a profit efficient bank that is inefficient in terms of cost or viceversa. The combined use of cost minimization problem and profit maximization problem will therefore shed light on the character of inefficiencies. Using the same notation of the previous subsection, we present the two mentioned approaches.

2.4 Cost Minimization

The minimization problem is set up as follows. Based in Hughes et. al. (2000), we consider a function $C(.)$ consisting of the cost incurred due to buying input quantities x at price w. We distinguish three alternative cost functions: operating cost function, cash flow cost function and economic cost function.

Given a deposits level x_d and a financial capital level z, the *operating cost function* $C_p(y, w_p, x_p, x_d^0, z^0)$ is defined by:

$$\mathrm{Min}_{x_p} = w_p' x_p \quad s.t. \quad F(x, y, z) \leq 0; \quad x_d = x_d^0; z = z^0 \tag{2.1}$$

The operating cost function considers capital structure by conditioning cost on the levels of financial capital while excludes their expense from the cost function. Deposits and financial capital are taken as given.

A cash-flow measure of cost $C_{cf}(y, w_p, w_d, z^0)$ includes the cost of deposits but excludes the cost of equity capital. The minimum cash-flow cost function is defined by

$$\mathrm{Min}_{x_p, x_d} = w_p' x_p + w_d' x_d \quad s.t. \quad F(x, y, z) \leq 0; \quad z = z^0 \tag{2.2}$$

The level of deposits minimizes cost while cost is conditioned on the level of financial capital. Hence, the level of equity capital does not have to minimize cost. This formulation accounts for capitalization but does not require a price for financial capital.

In contrast, the minimum economic cost function $C_e(y, w_i)$ is conditioned on the price of financial capital rather than on the quantity and, hence, the level of equity capital minimizes cost:

$$\mathrm{Min}_{x_p,x_d,z} = w_p' x_p + w_d' x_d + w_z z \quad s.t. \quad F(x,y,z) \leq 0 \tag{2.3}$$

While these three formulations of cost incorporate financial capital's influence on production, many bank cost studies omit any role of financial capital in defining cash-flow cost in the following way:

$$\mathrm{Min}_{x_p,x_d} = w_p' x_p + w_d' x_d \quad s.t. \quad F(x,y,z) \leq 0 \tag{2.4}$$

The differences among these four formulations of cost are important. The last expression is very similar to (2.3) but does not consider z. The differences between (2.2)-(2.4) are important, given that in the last equation we don't consider financial capital, when this variable changes, the equation (2.4) does not capture those variations in the cost functions.

If there are two banks with different capital-deposits ratio. Given (2.4), the bank with lowest capital appears with a higher cash flow cost compared with the other bank. As we mentioned before, the level of financial capital effects the risk position of banks and the incurred costs managing risk. A specification likes (2.4) does not take in account these kind of decisions of the banks and then, it can generate wrong conclusions when we evaluate efficiency in the cost function for the banks with different capitalization level.

The corresponding Lagrangian function can be formulated as:

$$Ł = \sum_i (w_i' x_i) - \lambda F(.)$$

Taking fist derivatives and solving yields the conditional factor demand equations, or, in terms of Hughes and Mester (1994), the restricted input requirement set:

$$x_i^* = x_i^*(y, w, z)$$

The minimum cost level is obtained by substituting into the cost function:

$$\mathrm{TC}^* = w' x_i^*(y, w, z) = \widetilde{c}(y, w, z) \tag{2.5}$$

The conditional demand for inputs depends on the amount of output sold prevailing prices, the given factor prices in input markets and the level of capital in the production period.

2.5 Profit Maximization

Like the minimization cost problem, we can deduce the maximization problem. When we assume that the market is perfectly competitive in inputs and outputs, in which banks choose optimal quantities of inputs and outputs, given prices, we are using the standard approach, expressed in the following form:

$$\mathrm{Max}_{y,x} = p'y - w'x \quad \text{s.t.} \quad F(y,x) = 0 \tag{2.6}$$

With $F(y,x)$ is the transformation function of the factors vector x to outputs vector y. The Lagrangian system can be written as:

$$Ł = p'y - w'x - \lambda F(.)$$

The simultaneous solution for x and y, produces the optimal output and input vectors:

$$y^* = y^*(p,w)$$

$$x^* = x^*(p,w)$$

Substituting in the profit function, we obtain a optimal profit level:

$$\pi = py^*(p,w) - w'x^*(p,w) = \pi^*(p,w) \tag{2.7}$$

The problem related with this approach is associated with the assumption of perfect competition among banks. It could be a unrealistic assumption. Following Humphrey and Pulley (1997) and Bos and Kool (2001), we modify the profit function and permit banks to exercise a form of market power in choosing output prices. This market power is limited to output markets; banks remain competitive purchasers of inputs [5].

WE assume that banks maximize profits for a given output quantities, y, and input prices w, by choosing output prices p, along with input quantities, x. The associated indirect profit function is derived as the solution to the problem:

[5] In practice, banks exploit local market power for certain deposit and loan services and have the ability to differentiate output prices among customer groups, across geographic areas, and over time.

$$\text{Max}_{p,x} = p'y - w'x \quad \text{s.t.} \quad F(y,x) = 0 \quad \text{and} \quad G(y,p,w,z) = 0 \tag{2.8}$$

Where $G(y, p, w, z)$ represents a bank's pricing opportunity set for transforming given values of y, w and z into output prices. This reflects the bank's assessment of the willingness of customers to pay the prices the bank wishes to charge. The function $G(.)$ also reflects any conjetural variations incorporated in pricing rules the bank may follow, such as differentiability marking up the cost of funds; hence the inclusion of input prices.

The Lagrangian system can be written as:

$$Ł = p'y - w'x - \lambda F(.) - \theta G(.)$$

And the solution give us the optimal choice for output prices $p^* = p^*(y, w, z)$ and input quantities $x^* = x^*(y, w)$:

$$p^* = p^*(y, w, z)$$

$$x^* = x^*(y, w, z)$$

Substituting in the *alternative* profit function (2.8), el optimal profit level will be:

$$\pi = p^*(y, w, z)'y - w'x^*(y, w, z) = \widetilde{\pi}(y, w, z) \tag{2.9}$$

The appealing feature if this profit function is that it allows for market imperfections on the output side. Additionally, output prices, which are required to the traditional profit function estimation are not required for the empirical analysis of the alternative profit function [6].

The next section, presents the functional form to estimate the different cost and profit systems within the financial system.

[6]Berger and Mester (1997) argue that alternative profit function may provide useful information when one or more of the following conditions affect the bank behavior: i. there are a substantial unmeasured differences in the quality of banking services; ii. output are not completely variable, so that a bank cannot achieve every output scale and product mix; iii. output market are not completely competitive, then, there are market power; iv. output prices are not accurately measured, a very common problem for the empirical analysis.

3 Specification

For the estimation of cost and alternative profit frontier functions a *translog* functional form is chosen with three inputs and three outputs. This form has been employed widely and has proven to allow for the necessary flexibility when estimating the frontier function [7].

Berger and Mester (1997) have compared the *translog* to the Alternative Fourier Flexible Form. Despite the latter's added flexibility, the difference in results between both methods appears to be negligible. Additionally, given the larger number of parameters in the second functional form, we avoid its implementation, since we don't have enough data set. For this reason we adopt the *translog* functional form in our analysis. The frontier cost function for a k bank in the period t is represented by:

$$\begin{aligned}\widetilde{c}_{kt}(y,w,z) = \beta_0 &+ \sum_{i=1}^{3}\beta_i \text{ln}y_{ikt} + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\beta_{ij}\text{ln}y_{ikt}\text{ln}y_{jkt} \\ &+ \sum_{i=1}^{3} b_i \text{ln}w_{ikt} + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} b_{ij}\text{ln}w_{ikt}\text{ln}w_{jkt} \\ &+ \sum_{i=1}^{3}\sum_{j=1}^{3} d_{ij}\text{ln}w_{ikt}\text{ln}y_{jkt} + U_{kt} + V_{kt}\end{aligned} \tag{3.1}$$

We denoted this 3-input/3-output model as model 1 (**M1**). Here, U_{kt} and V_{kt} are the inefficiency and random error terms, respectively. For the profit function, the left-hand side is replaced with net profits and the inefficiency term is $-U_{kt}$.

In the model 2 (**M2**), we incorporate variables related to financial capital and its interactions with the explanatory variables to analyze the effect of financial capital on cost and profit functions of the financial intermediaries. The new cost function will be:

[7] Fuss, Mcfadden and Mundlak (1978) describe the different characteristics that must be considered to choose a functional form and summarize the main functional forms used in the literature, such as Cobb-Douglas, CES, Leontief/Lineal, Translog, Generalized Cobb-Douglas, Quadratic, Concave generalized.

$$
\begin{aligned}
\widetilde{c}_{kt}(y,w,z) = \mathbf{M1} &+ d_0 \ln z_{kt} + \frac{1}{2} d_1 (\ln z_{kt})^2 \\
&+ \sum_{i=1}^{3} e_i \ln w_{ikt} \ln z_{kt} + \sum_{i=1}^{3} f_i \ln y_{ikt} \ln z_{kt}
\end{aligned}
\tag{3.2}
$$

To allow for the impact of consolidation and deregulation on the efficient frontier, we alternatively include a linear and quadratic trend term as well as trend. These will be referred to as model 3 (**M3**) [8]:

$$
\widetilde{c}_{kt}(y,w,z) = (\mathbf{M2}) + g_0 t + \frac{1}{2} g_1 t^2 \tag{3.3}
$$

The alternative profit function for each model is similar except for the before-mentioned modifications:

$$
\begin{aligned}
\widetilde{\pi}_{kt}(y,w,z) = \beta_0 &+ \sum_{i=1}^{3} \beta_i \ln y_{ikt} + \frac{1}{2} \sum_{i=1}^{3} \sum_{j=1}^{3} \beta_{ij} \ln y_{ikt} \ln y_{jkt} \\
&+ \sum_{i=1}^{3} b_i \ln w_{ikt} + \frac{1}{2} \sum_{i=1}^{3} \sum_{j=1}^{3} b_{ij} \ln w_{ikt} \ln w_{jkt} \\
&+ \sum_{i=1}^{3} \sum_{j=1}^{3} d_{ij} \ln w_{ikt} \ln y_{jkt} + U_{kt} + V_{kt}
\end{aligned}
\tag{3.4}
$$

Following Lang and Welzel (1999), to ensure symmetry and linear homogeneity in input prices, we impose the usual restrictions:

$$
\begin{aligned}
&\beta_{ij} = \beta_{ji} \ \forall_{ij}, \ \ b_{ij} = b_{ji} \ \forall_{ij}, \\
&\sum_{i=1}^{3} b_i = 1, \ \ \sum_{i=1}^{3} b_{ij} = 0 \ \forall_i, \sum_{i=1}^{3} b_{ij} = 0 \ \forall_j, \\
&\sum_{i=1}^{3} e_i = 0, \ \ \sum_{i=1}^{3} f_i = 0
\end{aligned}
\tag{3.5}
$$

[8] A negative number and significant statistically of the parameter t , indicate us a multi-factor productivity growth. Obviously, these trend terms may capture pure technological change as well as effects of consolidation and deregulation jointly. We are not able to determine the relative contribution of each factor separately.

In the empirical estimation, linear homogeneity in input prices is imposed by normalizing the dependent variable (total cost or profit) and all factor price variables (w_i) before taking logarithms [9]. Each one of the variables is included as a ratio relative to one of the factor price variables. Note that this imposes homogeneity of degree one in factor prices only [10]. Therefore, this implies that only two coefficients (b_i) for the input factor price variables are obtained, while the third can be inferred from the imposed restriction. The random error term V_{kt} is assumed i.i.d. with $V_{kt} \sim N(0, \sigma_V^2)$ and represents those shocks that are not directly controlled by the financial intermediaries and it is assumed to be independently of the explanatory variables [11].

The inefficiency term U_{kt} is i.i.d. with $U_k \sim N(\mu, \sigma_U^2)$ and is independent of V_{kt}. It is drawn from a non-negative distribution truncated in μ instead than in zero [12].

For the cost model, let $E_{kt} = V_{kt} + U_{kt}$. The specific cost efficiency estimation of a bank k at time t is given by the mean of the conditional distribution of U_{kt} given E_{kt}, defined as:

$$\text{EFF}_{kt}(\widetilde{c}) = \text{E}[\exp(U_{kt})|E_{kt}]$$

This measure takes values in the interval $(1, \infty)$. Values equal to one mean fully efficient. Values close to one, indicate that efficiency on bank's cost, conditional on its outputs, input prices and capital level, is above of the cost that fully efficient bank could incur under the same conditions. For the profit function, $E_{kt} = V_{kt} - U_{kt}$. Firm specific profit efficiency is again the mean of the conditional distribution of U_{kt} given E_{kt}, and is defined as:

$$\text{EFF}_{kt}(\widetilde{\pi}) = \text{E}[\exp(-U_{kt})|E_{kt}]$$

[9] See Coelli et al. (1998)

[10] To impose constant returns to scale, normalization of the output variables would be required too.

[11] See Aigner et al. (1977) and Coelli (1996).

[12] Coelli et al. (1998) argue that the truncated distribution is a generalization of the half-normal distribution. It is obtained by the truncation at zero of the normal distribution with mean, μ, and variance σ^2. If μ is pre-assigned to be zero, then the distribution is the half-normal. The distribution may take a variety of shapes, depending on the size and sign of μ. The estimation of the truncated-normal stochastic frontier involves the estimation of the parameter, μ, together with the other parameters of the model. The log-likelihood function required for the Maximum-Likelihood (ML) estimation of the parameters of the model was first given by Stevenson (1980). Expressions for appropriate predictors of the technical efficiencies of firms were given in Battese and Coelli (1988).

which takes values on the interval $(0, 1)$, where 1 indicates a fully efficient financial intermediary.

The frontier functions are estimated through ML methods. For this purpose we used the computer program FRONTIER 4.1 by **?** [13]. Following Coelli (1996), the terms σ_U^2 and σ_V^2 are replaced by $\sigma^2 = \sigma_U^2 + \sigma_V^2$ and $\gamma = \sigma_U^2/(\sigma_U^2 + \sigma_V^2)$ [14]. The parameter γ represents the share of inefficiency in the overall residual variance with values in the interval $[0, 1]$. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in favor of a standard OLS estimation. In the latter case, no structural inefficiency exists.

4 Empirical Evidence

4.1 Colombian Banking Sector

Table (1) illustrates the different papers related with the Colombian banking sector efficiency. We can say that the empirical evidence is not enough given the lag in the considered period and the methodology used in the estimations. Another limitation is that the results just apply for one type of financial intermediary. In this paper, we consider a period of time between 1989 and 2003 and the majority of financial institutions of the Colombian banking sector.

4.2 The data

We extend the data set of the previous papers considering a wider period. Our analysis period runs from the first quarter of 1989 to the third quarter of 2003. Additionally, we incorporate the different types of Colombian financial institutions jointly: comercial banks, specialized mortgage loan banks [15], financial corporations (investment banks) and specialized commercial loan

[13]The computer program FRONTIER 4.1 has been written to provide ML estimates of a wide variety of stochastic frontier production and cost functions.

[14]The log-likelihood function for this stochastic frontier and inefficiency model is presented in the appendix in Battese and Coelli (1993), together with the first partial derivatives of the log-likelihood function with respect to the different parameters of the model.

[15]Since 1997, these institutions are transformed from saving and loan banks to specialized mortgage loan banks.

Table 1: **Colombian Bank Efficiency Literature**

Date	Author	Period	Method [a]	Institution Type[b]
1996	Misas y Suescún	1989-1995	TFA	CB
2000	Mendoza	1996-1999	DEA	CB
2001	Castro	1994-1999	DFA	CB
2002	Badel	1998-2000	DFA	CB
2003	Janna	1992-2002	SFA	CB

[a] DEA:Data Envelopment Analysis, DFA: Distribution Free Approach, SFA: Stochastic Frontier Analysis, TFA: Thick Frontier Analysis. [b] CB: Comercial Bank.

Table 2: **Colombian Financial Institutions: 2003** [a]

	Public Banks	**Private Banks**	**Foreign Banks**	**Total**
Commercial Banks	3	10	9	22
Mortgage Loan Banks	1	5	0	6
Financial Corporations	1	4	0	5
Commercial Loan Banks	0	10	4	14
Leasing Banks	1	8	2	11
Financial Cooperative Institutions	0	7	0	6
Public Specialized Banks	9	0	0	9
Total	15	44	15	74

[a] Source: Superintendency of Banks.

banks. This gives us a general perspective of the bank efficiency of the sector.

During the period, the Colombian banking system has been affected by process of deregulation and consolidation. For this reason, the Colombian financial institutions have reacted to the new market situation. They were forced to reconsider their strategic options and to restructure [16]. Between 1989 and 2003, the financial sector had 46 mergers, take overs and transformations. Additionally, at the beginning of the 90's, the Colombian financial system was affected by an internationalization process with the incorporation of foreign banks, principally Spanish like BBVA and Santander. In 1998, 14 foreign banks existed, but now, there are only 9 foreign banks .

After the consolidation process of the 90's decade, the financial sector had 74 financial intermediaries divided in 22 commercial banks, 6 specialized mortgage loan banks, 5 financial corporation (investment banks), 14 specialized commercial loan banks, 7 financial cooperative institutions, 11 leasing financial firms and 9 public specialized financial institutions. Table (2) shows the composition by sectors of the financial institutions for 2003.

We use data set provided by the Colombian superintendency of banks. For each year, we include only those banks for which all variables are available. This leaves us with a non-balanced panel, of 57 periods and 5326 observations[17].

4.3 Selection Variables

We identify three outputs: loans (y_1) is the total stock of all loans supplied, investments (y_2) is the sum of total securities, equity investments, bond (private and public) investments and other investments. The third output is deposits held with other banks (y_3). As explained before and in line with Hughes and Mester (1993), we include (z) as a control variable [18].

Finally, we identify three input prices. The price of financial capital (w_1), expressed in percentage and computed as: (interest expense/customer

[16] The data set includes in 1989 84 financial institutions (33 commercial banks and specialized mortgage loan banks, 22 financial corporations and 30 specialized commercial loan banks).

[17] The included financial intermediaries in the sample represent more than 96% of the total assets of the Colombian financial sector during the period 1989-I to 2003-I.

[18] This variable includes social capital, earnings, reserves and banks's funds with specific destination.

and short-term funding+other funding)*100. Next, we compute the price of labor (w_2). Unfortunately, the information about the number of employees of banks is not complete. Therefore, we approximate the number of employees as follows: we assume a constant relationship between number of employees and fixed assets. For all banks in the Colombian sector, for which we have information about the number of employees, we regress the logarithm of the number of employees on the logarithm of fixed assets [19].

This result is used to estimate the number of employees for all banks. Our proxy for the price of labor is then composed as follows: Personnel Expenses / Estimated number of Employees.

The price of physical capital (w_3) [20] is: Administrative fees / Fixed assets. Before the estimations, we divide profit before tax PBT, total cost TC, w_1 and w_2 by w_3, the physical-capital price, to impose input-price lineal homogeneity.

In table (3), we present a few summary statistics for the variables involved. All quantity variables are expressed in millions of Pesos and corrected for inflation [21]. The explanatory variables are (PBT) and (TC). Both are taken from the banks's profit and loss account, where the latter is the sum of interest expenses, personnel expenses and other operating expenses.

In the period 1989-2003, the commercial banks present a higher level of dispersion in the analyzed variables [22]. Based on table (3), the banks have, in real terms, the higher levels of cost and profits, but with higher dispersion, too. It can be verified when we consider the mean and median value for each variable.

The analysis of the outputs data, shows us significant differences between the different types of financial intermediaries. The commercial banks (CB)

[19] The rest of employees data were estimated using a regression between the number of employees and fixed assets:

$$\underset{(0.23)}{\ln(\text{employees}) = -1.983} + \underset{(0.024)}{0.945} * \ln(\text{fixed assets}) \underset{(0.002)}{-0.0478} * t$$

with $R^2 = 0.787$. Standard Error in parenthesis.

[20] Administrative fees includes those fees different from personnel fees: operating indirect cost, depreciation and amortizations. Fixed assets include own used goods and another assets.

[21] We used the CPI, 100=dec/98.

[22] From now on, we denote banks as the sum of commercial banks and mortgage loan banks.

Table 3: **Summary Statistics: Millions of Pesos** [a,b]

Variable	Max.	Min.	Mean.	Median	SD.	Asymmetry.	Kurtosis.
TOTAL SYSTEM (161)							
TC	13208.6	0.3820	344.1	98.6	582.4	4.4	52.3
PBT	10530.2	1.0000	8217.2	8209.5	219.9	-14.3	437.7
$y1$	40169.4	0.0407	4054.1	1055.4	6579.3	2.3	5.4
$y2$	22270.7	0.0001	950.4	187.7	2098.4	4.7	29.0
$y3$	5187.8	0.0031	135.1	25.0	320.5	5.6	47.9
z	12207.5	3.4102	859.4	256.4	1501.6	3.1	11.7
$w1$	1634.1	0.0087	5.6	5.3	22.7	69.2	4943.7
$w2$	51940.0	0.9580	535.0	277.3	1161.3	21.0	781.6
$w3$	10202.2	0.2093	27.5	17.0	156.5	55.1	3433.2
Commercial Banks (49)							
TC	5063.8	10.82	755.1	498.2	716.8	1.6	3.3
PBT	9866.2	1.00	8232.5	8235.2	333.1	-11.1	217.6
$y1$	40169.4	1.32	8882.6	5740.7	8263.3	1.2	0.8
$y2$	22270.7	1.27	2018.7	1033.4	2909.2	3.4	13.9
$y3$	5187.8	0.04	302.0	132.7	462.7	3.8	21.8
z	12207.5	68.58	1669.7	870.7	1944.2	2.2	5.3
$w1$	1634.1	0.59	4.6	3.6	36.4	44.6	1996.1
$w2$	14060.4	0.96	523.5	348.7	679.4	7.4	110.2
$w3$	10202.2	0.61	29.5	19.4	229.1	43.8	1942.8
Investment Banks (29)							
TC	1986.3	1.57	162.9	83.8	209.4	2.5	8.9
PBT	10530.2	5906.34	8208.5	8207.9	168.8	-2.0	102.5
$y1$	16258.8	0.14	2551.0	1074.6	3679.9	2.2	3.8
$y2$	9158.2	0.93	830.0	230.7	1523.4	2.8	8.0
$y3$	1182.9	0.02	68.6	19.2	146.9	4.1	18.9
z	5430.2	16.62	881.6	289.2	1336.8	2.0	2.7
$w1$	81.4	0.34	5.6	5.6	3.2	14.9	319.6
$w2$	7790.3	2.02	327.4	185.1	503.3	5.8	57.6
$w3$	387.6	0.21	18.4	11.6	24.8	5.6	56.4
Specialized Commercial Loan Banks (83)							
TC	13208.6	0.3820	66.4	39.5	281.7	44.3	2063.5
PBT	10343.7	7989.62	8207.8	8206.3	48.0	38.3	1712.1
$y1$	29925.8	0.0407	511.5	213.7	925.2	15.0	446.1
$y2$	4371.9	0.0001	71.7	38.5	125.6	18.3	599.9
$y3$	1721.6	0.0031	19.1	8.2	45.6	23.6	846.3
z	8217.4	3.4102	142.2	92.2	212.0	24.5	917.5
$w1$	197.2	0.0087	6.4	6.3	5.8	24.8	738.7
$w2$	51940.0	8.3497	637.7	300.3	1607.0	17.7	486.0
$w3$	3941.1	0.4348	29.7	16.4	103.5	28.0	962.9

[a] Source: Bank's Profit and Loss Account and Balance Sheet of Banks. Superintendency of Banks. Period 1989-2003.

[b] CT: Total Cost, PBT: Profits Before Taxes, y_1: Credit, y_2: Investmets, y_3: Deposit in other banks, z: Capital, w_1: Financial-Capital Price, w_2: Labor-Price, w_3: Physical-Capital Price.

terms, for all type of intermediaries. The investment banks incremented this variable in 332%, while commercial banks and specialized commercial banks incremented its financial capital 164% and 28% respectively. See table (4).

During the period, the pertinent variables have varied differently among the type on financial institutions [23]. With respect to the cost variable, the commercial banks presented higher cost levels compared with the another type of institutions, this behavior is accentuated in crisis period. For the profit variable, the commercial banks had profit level below the levels of IB and SCB. However, it is important to emphasize the significant difference between the mean and median values for the analyzed variables for each type of intermediaries. It explains the high dispersion among the different banks, for the CB the dispersion is more accentuated than (IB) and (SCB) in which the difference in dispersion is lower.

5 Estimation Results

We now turn to the empirical analysis. In the next subsection, we show the estimation of the different models for both, cost and profit translog functions. We test the three models and select one as preferred model and interpret it. We investigate how the consolidation process may change the estimation results in both the efficient frontier and estimated mean cost and profit efficiency relative to the frontier. In sub-section 5.2 we use the preferred models to compute individual efficiency scores. We use the efficiency scores for individual financial institutions to analyze differences in efficiency between different type of banks.

5.1 Estimated Cost and Profit Frontiers

The detailed estimation results for the different versions of cost and profit models respectively are presented in tables 5 and 6. We also present both LR test and LR test (one side) of the standard response function (OLS) versus full frontier model [24]. The LR test results show that we can reject the

[23]To evaluate the evolution of variables, we have divided the period into three subperiods: 1989-I to 1998-III; 1998-IV to 2000-IV (crises period); and 2001-I to 2003-III.

[24]Kodde and Palm (1986). The null hypothesis in this test is $\gamma = 0$ versus the alternative $\gamma > 0$.

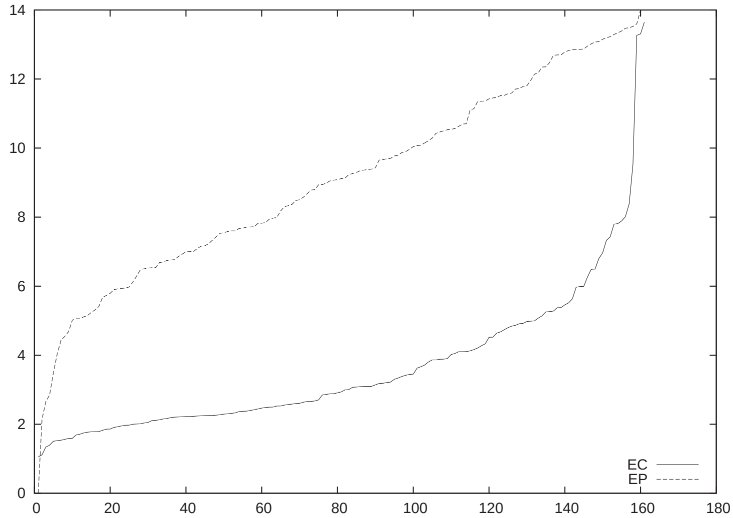
Table 4: **Summary Statistics: Millions of Pesos** [a,b]

	CB		**IB**		**SCB**	
	Mean	SD.	Mean	SD.	Mean	SD.
1989-1998						
TC	742.3	712.2	140.4	171.6	70.6	320.6
PBT	8270.8	154.6	8222.5	139.6	8209.0	53.6
$y1$	8073.8	7401.6	2132.6	3059.1	538.2	1010.9
$y2$	1357.7	1473.1	534.9	1008.0	73.0	137.2
$y3$	256.6	372.2	52.4	112.1	17.8	49.0
z	1396.1	1633.7	718.1	1235.2	131.6	230.1
$w1$	4.1	1.4	5.7	2.2	6.8	5.3
$w2$	311.6	313.8	263.9	313.6	423.9	1035.6
$w3$	24.3	30.5	18.5	24.9	27.4	105.7
1998-2000						
TC	929.2	856.1	294.7	365.1	59.5	65.8
PBT	7997.2	755.7	8114.2	272.3	8198.5	22.0
$y1$	11444.8	10506.4	4468.3	5717.2	434.7	598.6
$y2$	2777.8	3391.0	1840.0	2058.9	66.9	81.7
$y3$	439.7	632.7	148.7	267.3	25.2	35.2
z	2572.5	2697.7	1623.6	1598.8	178.8	139.2
$w1$	3.8	2.2	4.9	1.8	5.9	4.1
$w2$	952.0	631.1	598.1	1032.7	996.8	3068.7
$w3$	23.2	23.6	18.9	29.0	34.6	117.7
2001-2003						
TC	626.6	495.2	318.7	241.5	42.0	37.9
PBT	8276.4	164.0	8157.1	280.8	8212.5	13.9
$y1$	10847.0	9334.1	6389.5	5024.0	416.3	475.0
$y2$	5222.7	5523.0	3948.4	2759.1	70.8	67.0
$y3$	420.0	644.7	198.7	222.6	19.5	24.8
z	2290.7	2176.9	2385.2	1157.6	168.7	117.7
$w1$	8.8	105.8	2.8	0.6	3.8	10.7
$w2$	1328.9	1287.5	932.1	875.8	1724.2	1567.7
$w3$	69.2	659.9	19.3	17.2	39.4	41.3

[a] Source: Bank's Profit and Loss Account and Balance Sheet of Banks. Superintendency of Banks. Period 1989-2003.

[b] CB: Commercial Banks, IB: Investment Banks, SCB: Specialized Comercial Banks.

Figure 1: **Distribution Efficiency**



restrictions imposed by OLS. Consequently, we use the specification including a stochastic inefficiency term for all models.

With respect to the estimated cost function in table (5), we have that γ, the proportion of inefficiency in the global residual variance, is significantly different from 1, which indicates a stochastic frontier. Also, for our cost model μ is significantly positive with a value of 1.10 in model 3. This means that the top of the half normal distribution of our inefficiency term U lies close to 3, as we can verify in figure (1). Hence, most of our financial institutions are relatively cost inefficient and the average cost inefficiency is high.

The profit efficiency results in table (6) show again that γ is significantly different from 1 so that efficient frontier is stochastic. The estimated value of μ changes significantly between the different models. The impact of a different value of μ can be easily seen from the comparison between the distribution of cost and profit efficiency scores in figure (1). In the case of cost efficiency, the relatively large value of μ indicates that the peak of the density function of inefficiency term U is not close to zero. As a result, most individual efficiency scores are not close to the full efficiency value of 1. This is reflected in the very flat path of the efficiency scores. The large negative μ for profit function in model 3 implies that the peak of the density function on inefficiency terms is far away from zero. Consequently, most individual banks

Table 5: **Estimation Results under Cost Minization** [a]

	Model 1		**Model 2**		**Model 3**	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	-2.3375	-20.70	-3.362	-24.14	-3.405	-23.89
$\ln y_1$	-0.0348	-1.90	-0.037	-1.54	-0.046	-1.91
$\ln y_2$	0.2104	11.96	0.261	8.90	0.269	9.23
$\ln y_3$	0.1525	9.69	0.100	5.25	0.092	4.89
$\ln w_{13}$	0.7755	34.38	0.866	32.98	0.828	30.24
$\ln w_{23}$	0.2568	8.09	0.128	3.73	0.176	4.95
$0.5\ln y_1 \ln y_1$	0.1444	40.25	0.128	32.22	0.128	32.11
$0.5\ln y_1 \ln y_2$	-0.0648	-11.38	-0.021	-3.21	-0.019	-2.95
$0.5\ln y_1 \ln y_3$	-0.0502	-9.89	-0.041	-8.20	-0.039	-7.78
$0.5\ln y_2 \ln y_2$	0.0373	15.36	0.035	12.76	0.035	12.77
$0.5\ln y_2 \ln y_3$	0.0265	5.41	0.057	10.02	0.056	9.71
$0.5\ln y_3 \ln y_3$	0.0009	0.27	-0.004	-1.30	-0.004	-1.37
$0.5\ln w_{13} \ln w_{13}$	0.0138	2.48	0.014	2.57	0.008	1.36
$0.5\ln w_{23} \ln w_{23}$	0.0114	1.64	0.031	4.15	0.016	2.00
$0.5\ln w_{13} \ln w_{23}$	0.0152	1.64	0.011	1.08	0.034	3.07
$\ln w_{13} \ln y_1$	0.0067	1.92	0.008	2.29	0.009	2.66
$\ln w_{13} \ln y_2$	0.0120	3.34	0.017	4.17	0.018	4.54
$\ln w_{13} \ln y_3$	-0.0114	-3.72	-0.009	-2.92	-0.010	-3.09
$\ln w_{23} \ln y_1$	-0.0127	-2.51	-0.003	-0.63	-0.004	-0.71
$\ln w_{23} \ln y_2$	-0.0195	-4.04	0.004	0.67	0.003	0.61
$\ln w_{23} \ln y_3$	-0.0123	-3.53	0.001	0.28	0.002	0.54
$\ln z$			0.461	10.78	0.477	10.70
$\ln z \ln z$			0.018	2.57	0.017	2.37
$\ln w_{13} \ln z$			-0.021	-3.14	-0.022	-3.37
$\ln w_{23} \ln z$			-0.033	-4.15	-0.033	-4.13
$\ln y_1 \ln z$			-0.018	-3.08	-0.016	-2.78
$\ln y_2 \ln z$			-0.054	-8.15	-0.055	-8.41
$\ln y_3 \ln z$			-0.016	-3.26	-0.015	-3.18
t					-0.005	-3.39
$0.5t^2$					0.000	4.49
$\sigma^2 = \sigma_V^2 + \sigma_U^2$	0.479	11.26	0.396	11.92	0.388	11.25
$\gamma = \sigma_U^2/\sigma^2$	0.816	64.45	0.796	55.17	0.792	50.29
μ	1.251	10.52	1.124	10.96	1.109	10.47
LR Test	-1495.1		-1244.4		-1232.5	
LR Test (1 side)	5097.9		4398.3		4380.8	
Iterations	31		38		41	

[a] FRONTIER4.1 program was used for the estimations.

Table 6: **Estimation Results under Profit Maximization** [a]

	Model 1		**Model 2**		**Model 3**	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Constant	7.848	55.82	7.928	53.03	6.601	54.64
lny_1	0.044	2.20	-0.105	-3.87	-0.138	-5.23
lny_2	-0.029	-1.51	-0.045	-1.34	-0.039	-1.20
lny_3	0.027	1.64	0.017	0.76	-0.026	-1.25
lnw_{13}	1.000	37.99	1.019	34.84	0.858	29.04
lnw_{23}	-0.032	-0.94	-0.047	-1.25	0.164	4.30
0.5ln$y_1$lny_1	-0.010	-2.68	-0.013	-2.99	-0.009	-2.02
0.5ln$y_1$lny_2	0.005	0.78	-0.013	-1.86	-0.002	-0.29
0.5ln$y_1$lny_3	-0.007	-1.33	-0.010	-1.72	-0.006	-1.17
0.5ln$y_2$lny_2	-0.002	-0.94	0.003	1.05	0.005	1.60
0.5ln$y_2$lny_3	0.032	6.03	0.030	4.63	0.028	4.46
0.5ln$y_3$lny_3	-0.013	-3.97	-0.013	-3.69	-0.011	-3.26
0.5lnw_{13}lnw_{13}	0.047	7.89	0.047	7.92	0.020	3.36
0.5lnw_{23}lnw_{23}	0.047	6.38	0.047	5.60	0.011	1.27
0.5lnw_{13}lnw_{23}	-0.132	-12.56	-0.124	-11.31	-0.034	-2.89
lnw_{13}lny_1	0.005	1.30	0.004	1.05	0.005	1.22
lnw_{13}lny_2	0.000	-0.13	0.000	0.03	0.007	1.53
lnw_{13}lny_3	0.000	-0.04	-0.001	-0.20	-0.006	-1.86
lnw_{23}lny_1	-0.003	-0.54	-0.003	-0.52	0.010	1.72
lnw_{23}lny_2	0.002	0.47	0.007	1.18	0.005	0.91
lnw_{23}lny_3	-0.015	-4.14	-0.016	-3.89	-0.012	-3.13
ln$z$			0.238	4.94	0.410	8.51
ln$z$ln$z$			-0.060	-7.60	-0.054	-7.08
lnw_{13}ln$z$			-0.005	-0.73	-0.009	-1.29
lnw_{23}ln$z$			0.002	0.20	-0.019	-2.18
ln$y_1$ln$z$			0.042	6.19	0.033	5.08
ln$y_2$ln$z$			0.010	1.35	0.006	0.79
ln$y_3$ln$z$			0.004	0.82	0.007	1.35
t					-0.031	-19.30
$0.5t^2$					0.001	18.26
$\sigma^2 = \sigma_V^2 + \sigma_U^2$	0.255	20.60	0.256	14.33	0.523	6.43
$\gamma = \sigma_U^2/\sigma^2$	0.577	24.20	0.598	22.84	0.806	26.45
μ	0.767	6.78	0.783	8.57	-1.298	-4.57
LR Test	-1869.8		-1806.9		-1656.0	
LR Test (1 side)	1022.1		1084.6		1030.0	
Iterations	34		36		50	

[a] FRONTIER4.1 program was used for the estimations.

Table 7: **Likelihood Ratio Test**

Cost Function				
	Restrictions	Test Statistic	$\chi^2_{0.95}$-value	Decision
$\text{Model}_{1,3}$	9	525.20	16.92	Reject H0
$\text{Model}_{2,3}$	2	23.81	5.99	Reject H0
$\text{Model}_{1,2}$	7	501.39	14.07	Reject H0
Profit Function				
	Restricciones	Estadístico	$\chi^2_{0.95}$-value	Decisión
$\text{Model}_{1,3}$	9	427.61	16.92	Reject H0
$\text{Model}_{2,3}$	2	301.87	5.99	Reject H0
$\text{Model}_{1,2}$	7	125.74	14.07	Reject H0

are in the tail of the density, leading to wider dispersion in profit efficiency than in cost efficiency.

Table (7) reports likelihood tests for all considered models. For both, cost and profit frontiers, all restrictions are rejected. Therefore, model 3 is the preferred for cost and profit functions [25].

Interpretation of the regression coefficients requires more attention, given that there are many interrelations between the different explanatory variables in the *translog* function. The marginal effect of an increase in the loan variable $\ln(y_1)$ on the respective dependent variables total cost (TC) and before tax profits (BTP) must include not only the magnitude of the coefficient on $\ln(y_1)$, but also the combination of all coefficients on explanatory variables that include $\ln(y_1)$. With these caveats in mind, the following holds for the direct effects, excluding the no less important interaction terms.

For cost function, model 3 coefficients on the output variables have significant t-value and the coefficient of $\ln(y_1)$ has a negative value, representing scale diseconomies with respect to this output. High financial capital are significantly positively correlated with total cost. The direct effect of input prices is diverse; it is high and significantly positive (0.828) for the price of financial capital (w_1); low and significantly positive (0.176) for the price of labor (w_2); and negative (1-0.828-0.176=-0.004) for the price of physical cap-

[25] Remember that the model 1 corresponds to the estimations of the functions without taking into account the role of financial capital and technological change, while model 2 introduce financial capital, but does not includes trend variables

ital (w_2). The negative coefficient on (w_3) suggests that total cost decrease with higher physical capital price.

The negative coefficient on the linear trend term (t) suggest a shifting cost curve with lower cost (on the frontier through) time. The positive square trend coefficient offsets the linear trend effect when time goes on. From the point estimates on the linear and quadratic trend term we derive a improvement of the cost function between 1989 and 2003.

For the profit frontier, the model M3 has been chosen. The coefficients on the outputs are negative and significant. Overall, increasing the size of production leads a lower or profits, implying diseconomies of scale (again excluding the interaction effects). The coefficient on financial capital is positive and significant. The coefficient on the price of financial resource (w_1) is significantly positive (0.858). The coefficient on the prices of personnel (w_2) was (0.164) and physical capital (w_3) are (1-0.858-0.164=-0.022).

5.2 Efficiency Scores

Now, we turn to the mean efficiency scores that result from the M3 to the cost and profit frontiers. remember that profit efficiency scores are in a range from 0 t 1, where 1 indicates a banks is efficient and operates on the frontier. For cost efficiency, scores lie range from 1 to ∞, where an efficient bank again has a score of 1. In table (8), we report a few summary statistics on cost and profit efficiency scores.

Table (8) shows that individual cost efficiencies vary from 1.05 to 13.64. Moreover, the mean of cost efficiency of 3.62 suggest that most of financial institutions have an efficiency score not close to 1. While to the profit function, the individual scores vary from 0.41 to 1, suggesting that the most of banks have scores close to 1. This is consistent with the graphical evidence in figure (1). The distribution of individual profit efficiency score is more uniform and less concentrated than in the case of cost function. In addition, figure (2) provides graphical evidence on the relation between cost and profit efficiency scores for individual bank firms. The scatter plot suggests a weak correlation between both scores. This is confirmed by the bilateral correlation coefficient between two scores [26]. It provides evidence in support of our claim that both cost and profit efficiency need to be investigated.

[26]Both, The Spearman rank correlation test and Pearson correlation coefficient were 0.44 and 0.36 respectively.

Table 8: **Summary Efficiency Statistics** [a]

	N	Max.	Mean	Min.	SD.
Cost Function					
Total System	161	13.64	3.62	1.05	2.15
Commercial Banks	49	6.48	3.62	1.59	1.07
Investment Banks	29	3.33	2.10	1.11	0.44
Specialized Commercial Banks	83	13.64	4.15	1.05	2.69
Profit Function					
Total System	161	1.00	0.79	0.41	0.11
Commercial Banks	49	0.98	0.81	0.41	0.13
Investment Banks	29	1.00	0.79	0.55	0.11
Specialized Commercial Banks	83	1.00	0.77	0.50	0.11

[a] Profit efficiency scores are in a range from 0 to 1, where 1 indicates a bank is efficient and operates on the frontier. For cost efficiency, score lie range from 1 to ∞, where an efficient bank again has a score of 1. The selected model to compute efficiency scores was the model 3.

Figure 2: **Cost v.s. Profit Efficiency Scores**

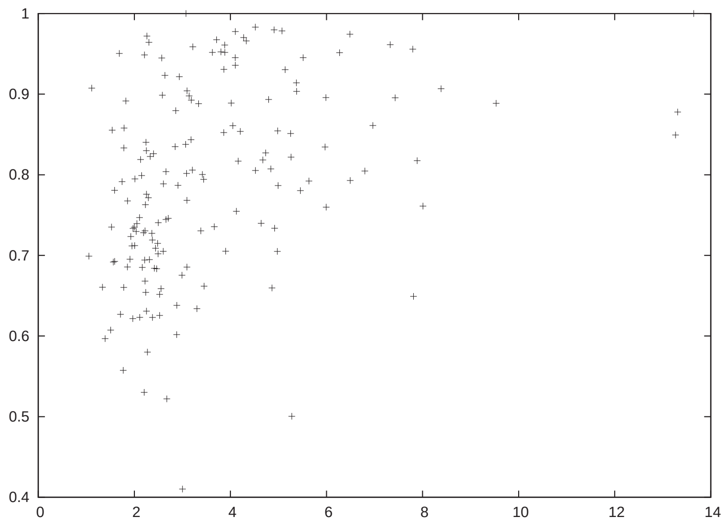


Table 9: **Independent Samples Type of Banks** [a]

	Cost Eff.			**Profit Eff.**		
	CB	IB	SCB	CB	IB	SCB
N	49	29	83	49	29	83
Min.	1.59	1.11	1.05	0.41	0.55	0.50
Max.	6.48	3.33	13.64	0.98	1.00	10.00
Mean	3.62	2.10	4.15	0.81	0.79	0.77
S.D.	1.07	0.44	2.69	0.13	0.11	0.11
t-Statistic		7.28	-1.05		0.69	1.89
t-Value [b]		2.29	-2.27		2.29	2.27

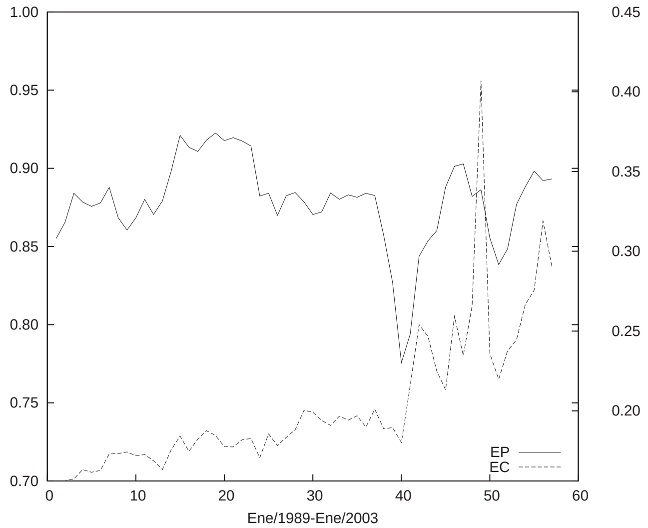
[a] Profit efficiency scores are in a range from 0 to 1, where 1 indicates a bank is efficient and operates on the frontier. For cost efficiency, score lie range from 1 to ∞, where an efficient bank again has a score of 1. The selected model to compute efficiency scores was the M3.
[b] 5% level of significance.

5.3 Specialization Effects on Efficiency Scores

In this section we analyze differences in cost and profit efficiency across individual banks in more detail. To this purpose, we first distinguish between different type of financial institutions. In table (9) we report independently the efficiency scores for each type of financial institutions. In the case of cost efficiency scores, the specialized commercial banks presented a higher mean levels of inefficiency scores (4.15), while that commercial banks and investments banks had mean inefficiency scores levels of 3.62 and 2.10 respectively.

The results in table (9) show that cost efficiency is marginally higher for both (IB) and (SCB) with respect to (CB). The t-test show that his difference is statistically significant. In the case of profit efficiency, the conclusions are quite different. The difference in mean profit efficiency was no significant comparing comercial banks with the another type of intermediaries. Overall, out results suggest that differentiation between type of bank firms are unable to exploit their specialization on the profit side. A possible explanation is the presence of more opportunities of scale economies on the input size than on output size.

Figure 3: **Cost-Profit Efficiency Trends**



5.4 Temporal Analysis

During the period, the trend variables were significant into the estimations frontiers for cost and profit functions. Consequently, it is important to analyze if the mean efficiency scores has changed, specially, when have identified three different subperiods in our sample [27].

Figure (3) reports the time path of mean cost and profit efficiency for the years 1989-2003, both weighted by total assets. The figure shows that weighted mean cost efficiency is relatively more variable than profit efficiency over time. In the crisis period we found a impairment in the mean profit efficiency. The evolution after the crises period suggest us that the impact of the consolidation process are affected the financial intermediaries differently adjusting their cost and profit functions. The mean cost efficiency for the period was 20%, while that for alternative profit efficiency was 80%. Comparing the standard deviations, we found that the mean cost (4.6%) efficiency was more irregular than mean profit efficiency (2.8%).

[27] To save space, the coefficient estimates for the time varying frontier analysis have been left out. They are available from the authors upon request.

6 Conclusions

In this paper, we analyzed the cost and profit efficiency scores to the Colombian financial system during the period 1989-2003, in which the banking system has been affected by different consolidation, liberation and crises process. We used the parametric method of stochastic frontier to estimate cost and alternative profit functions, using a translog specification, that includes financial capital and trend time terms.

Our results show that there are significant difference between cost and profit estimations. Both Cost and profit functions, must be estimated using stochastic frontier method. The incorporation of financial capital was determinant to the frontier estimation in both cases. Furthermore, the inclusion of trend terms was important to determine the best frontier. The efficiency scores presented a higher variance in cost efficiency than profit efficiency, However, profit efficiency had a more uniform distribution among financial intermediaries.

We have offered evidence obtained by incorporating capital structure in the bank production is important to consider banks' risk-taking behavior. In this way, incorporating financial capital plays an important role in the determination on the production efficiency to the financial firms and if we ignore this variable, we can generate bias in the efficiency estimation.

Analyzing microeconomic duality between minimization cost and maximization profits, the results suggest that the empirical data in the period analyzed, there are not perfect competition in the Colombian banking system. The correlation between cost and profit efficiency scores wasn't high. For this reason, when we want to analyze efficiency, we need to use both cost and profit functions. To our knowledge, this is the first paper of the efficiencies considering a long period, the first to compare cost and profit efficiency of Colombian financial intermediaries and the first using important control variable such as financial capital.

Finally, distinguishing by type of financial intermediaries, we found a significant differences between commercial banks with the rest of bank firms in the case of cost function. We find that whereas all banks appear to perform rather similarly in terms of profit efficiency, in terms of cost efficiency there are differences when we consider efficiency mean.

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