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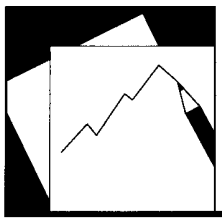

IMF Working Paper

Bank Efficiency amid Foreign Entry: Evidence from the Central American Region

Torsten Wezel

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Bank Efficiency amid Foreign Entry: Evidence from the Central American Region

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Abstract

This paper investigates the efficiency of domestic and foreign banks in the Central American region during 2002-07. Using two main empirical approaches, Data Envelopment Analysis and Stochastic Frontier Analysis, the paper finds that foreign banks are not necessarily more efficient than their domestic counterparts. If anything, the regional banks that were acquired by global banks in a wave of acquisitions during 2005-07 can keep up with the local institutions. The efficiency of these acquired banks, however, is shown to have dropped during the acquisition year, recovering only slightly thereafter. Finally, it is important to account for the environment in which banks operate, as country-, sector- and firm-specific characteristics are found to have a considerable influence on bank efficiency.

JEL Classification Numbers: D24, G21

Keywords: Bank efficiency, total factor productivity, data envelopment analysis, stochastic frontier analysis, Central America

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I. INTRODUCTION

The region comprised of the five Central American countries, the Dominican Republic, and Panama experienced a wave of foreign bank entry in recent years. Between 2005 and 2007, banks from the United States, the United Kingdom, Canada and neighboring countries such as Colombia acquired well-established local and regional institutions to get a foothold in this promising region that, until recently, was characterized by rapid financial deepening and attractive margins owing to previously low market penetration. The degree of foreign bank entry has been different from country to country, ranging from minor (Guatemala and the Dominican Republic) to very high (El Salvador, with close to 95 percent of bank assets now foreign-owned), see Figure 1. Naturally, this process has had implications for market structure and bank efficiency by virtue of increased competition affecting margins and the supposedly superior technology of foreign banks reducing operating costs.

This paper measures bank efficiency in the region, broken down by country and type of bank. In doing so, it attemps to shed light on the following questions: (i) are foreign banks, i.e. global banks and the banks they acquired, more efficient than local incumbents?; (ii) how did the takeovers affect efficiency of the acquired banks and the rest of the banking sector?; and (iii) how much are efficiency estimates affected by the environment in which banks operate?[2] The following analyses compute efficiency measures for each bank in the region and tracks productivity changes during the 2002-07 period. Panama was not directly included in the efficiency analysis for the region due to its status as a financial center with specific economies of scale inhibiting a direct comparision with the rest of the region, but a separate DEA calculation for Panama can be found in Appendix I.

Methodogically, the paper uses the two most widely applied approaches in efficiency studies, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA).[3] DEA represents a linear programming approach to efficiency analysis that constructs a non-parametric unit-wise frontier over the data space. It has the advantage of being computationally simple, as it does not require the stochastic estimation of a production function. DEA also allows to compute so-called Malmquist indices that track productivity developments over a longer time. In turn, SFA estimates a parametric frontier function based on the assumption of a certain production technology and avoids problems of a potentially biased deterministic frontier by decomposing the error term into a white noise component and a non-negative component yielding efficiency estimates. SFA has the advantage over DEA of not attributing measurement errors and other noise to the efficiency scores, but it

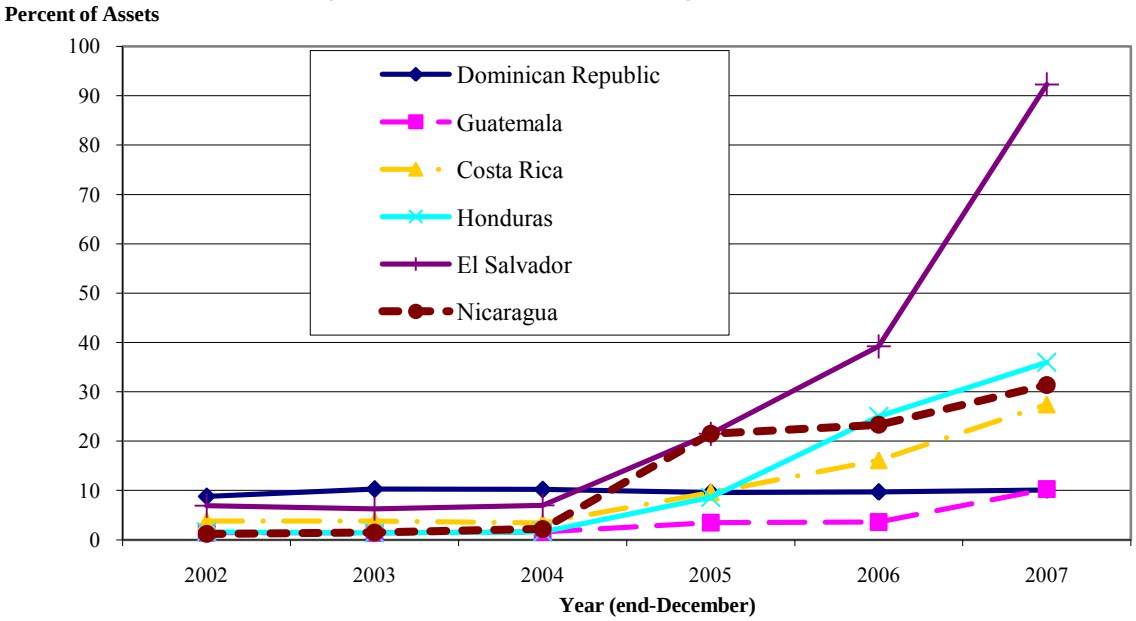
[2] The paper does not attempt to answer the question to what extent foreign bank entry affected the efficiency of domestic banking markets as was done by Claessens et al. (2001).

[3] A number of studies use traditional regression analysis to explain variations in banks' interest margins or spreads—see for example, Beck and Hesse (2006), Claeys and Vander Vennet (2007) or Dabla-Norris and Floerkemeier (2007).

requires the assumption of a particular functional form and of the distribution of the non-random error terms.[4] The two measures are conceptually different from traditional financial soundness indicators such as return on assets, which is not a direct productivity measure.[5]

The two methods point to the same principal finding that foreign banks are not necessarily superior in efficiency. While foreign banks outperform their domestic competitors in a few markets, on average local and regional banks are shown to have a higher efficiency than domestic banks both during and toward the end of the sample period. Among the group of foreign banks, it is the acquired banks that can keep up with local banks, whereas the globally operating banks, some of which have acquired regional groups, are clearly inferior. This said, even the acquired banks lost ground in efficiency during the year of the takeover, which is borne out by both DEA and SFA. As it turns out, it is important to include in the regressions variables that control for the environment in which banks operate (see Section IV.B), as efficiency estimate may change considerably when also accounting for country-, sector- and bank-specific factors.

Figure 1. Market Share of Foreign-Owned Banks



The paper is organized as follows. Section II reviews the bank efficiency literature, focusing on studies that assess the performance of foreign banks versus that of local

[4] Aiming to overcome this problem, the alternative Distribution-free Approach (DFA) does not impose a certain production function. However, it makes the strong assumption that efficiency stays constant over the sample period, which is unlikely in transition countries or those undergoing structural change, e.g. foreign bank entry.

[5] Appendix II (bottom) includes the correlations between return on assets and efficiency estimates produced by SFA. Note that correlations range from -0.68 to 0.76, thus pointing to the differences between the two concepts.

institutions. Section III applies a DEA framework to each of the region's banking markets for 2007 and studies the development of efficiency using Malmquist productivity indices for the period of 2003 to 2007. It also examines changes in average productivity—especially of the acquired banks—during the takeover period of 2006-07. Section IV uses an SFA approach based on a single frontier, estimating both for a cross section in 2007 and a panel for the entire sample period of 2002 to 2007. The econometric model measures "pure" efficiency as well as "controlled" efficiency, i.e. adjusted for certain idiosyncrasies. Section V concludes.

II. RELATED LITERATURE

Although empirical approaches differ—single vs. multi country studies, developed vs. developing countries, parametric vs. non-parametric approaches—foreign banks tend to be more efficient than domestic banks. This is less true for developed economies, since incumbent domestic banks already possess superior technology and processes, thereby aggravating foreign bank entry, see Berger et al. (2000) and Berger (2007). Nevertheless, a few studies of advanced banking markets find the efficiency of foreign banks to be superior, e.g. for Australia the DEA-based analyses by Sturm and Williams (2002) and Wu (2004). Among emerging market economies, the empirical evidence corroborates that foreign banks are more efficient than local institutions. Among single country studies of emerging markets reporting such evidence (mostly DEA-based) are analyses for Chile—Fuentes and Vergara (2003)[6]; China—Berger et al. (2007)[7]; Croatia— Kraft et al. (2002); the Czech Republic—Preteanu-Podpiera et al. (2008); Hungary—Hasan and Marton (2003); Pakistan—Qayyum and Khan (2007); Romania—Asaftei and Kumbhakar (2008); Russia—Karas et al. (2008); and Turkey—Öncel and Süer (2008) and Ege (2009). On the other hand, there is reverse evidence for selected Asian countries—Hadad et al. (2008) for Indonesia, and Chantapong (2005) for Thailand—and for Argentina—Berger et al. (2005). Quite obviously, idiosyncratic factors also exert an influence on whether foreign banks thrive in a given jurisdiction.

Among the regional studies most akin to this paper, many also find that foreign banks are more efficient. For example, Bonin et al. (2004), Fries and Taci (2004) and Grigorian and Manole (2006)—all studying banks in selected European transition countries—find evidence that foreign banks and the institutions they acquired are superior in efficiency. This finding is qualified by Poghosyan and Poghosyan (2009) for a sample of such transition countries and by Havrylchyk (2006) for Poland, who find evidence that newly established foreign banks outperform formerly domestic banks that were acquired by foreigners. For other regions, the superior performance of foreign banks is corroborated by Barry et al. (2008) for a sample of six East Asian countries, and by Chen (2009) for eight Sub-Saharan

[6] In Chile, foreign banks became more efficient than local banks in 2000.

[7] The authors show that minority foreign ownership in Chinese banks is associated with efficiency improvements.

African middle income countries. By contrast, Zajc (2006) and Košak and Zajc (2006) report a lower efficiency of foreign banks for samples of six and eight European transition countries, while Kablan (2007) does so for a sample of six West African countries. Methodologically, many studies use stochastic frontier analysis to avoid DEA's problem of cross-country comparability. Nevertheless, a few studies apply a multi-country DEA, e.g. Sathye (2005) for Asian and Pacific Rim countries, or Hasan et al. (2000) who for 10 European countries find that foreign banks thrive when entering banking markets with favorable characteristics. For a survey of the bank efficiency literature see Berger (2007).

There are only a few multi-country studies of bank efficiency in Latin America. Chortareas et al. (2009), Kasman et al. (2005), as well as Figueira et al. (2009) assess the efficiency of banks in 9, 15 and 20 Latin American countries, respectively. Of these, however, only 1, 4 and 5 countries, respectively, belong to the Central American region, thus not allowing to draw conclusions for this sub-region. Nonetheless, it is noteworthy that Figueira et al. (2009) similarly find that foreign banks did not perform as well as their domestic counterparts, whereas Kasman et al. (2005) report mixed evidence on the Central American countries in the sample.

Regarding bank performance during and after takeovers, there is some evidence that efficiency improvements are realized only after an initial dip in productivity. Some acquiring banks likely incurred costs of reorganizing the local banks and dealing with non-performing loans, as was the case in Central and Eastern Europe (Košak and Zajc, 2006), Argentina (Delfino, 2007), or post-crisis Thailand (Chantapong, 2005).

Lastly, there is evidence on the importance of including environmental variables in efficiency estimations. Of the 14 multi-country studies reviewed in this section, all but one employ environmental variables in the estimations, and of these, 11 studies report a significant impact of most of these variables (notably, all three studies of Latin American countries). Among the environmental variables bank-specific correlates consistently reported as significant, whereas there is less convincing evidence for country or sector-specific ones.

III. Bank Efficiency Based on Data Envelopment Analysis

A. Methodology

Data Envelopment Analysis is a widely used method in banking efficiency studies.[8] DEA is a linear non-parametric optimization procedure that uses information on each bank's input-output mix to construct an efficient production frontier for the banking system as a whole. The efficiency score of an individual bank is then computed as its "distance" from the efficient frontier.

[8] For more information on DEA see chapters 6 and 7 of Coelli et al. (1998).

DEA is able to measure a bank's relative position with respect to the bank(s) defining the efficient frontier, thereby yielding three central efficiency measures:[9]

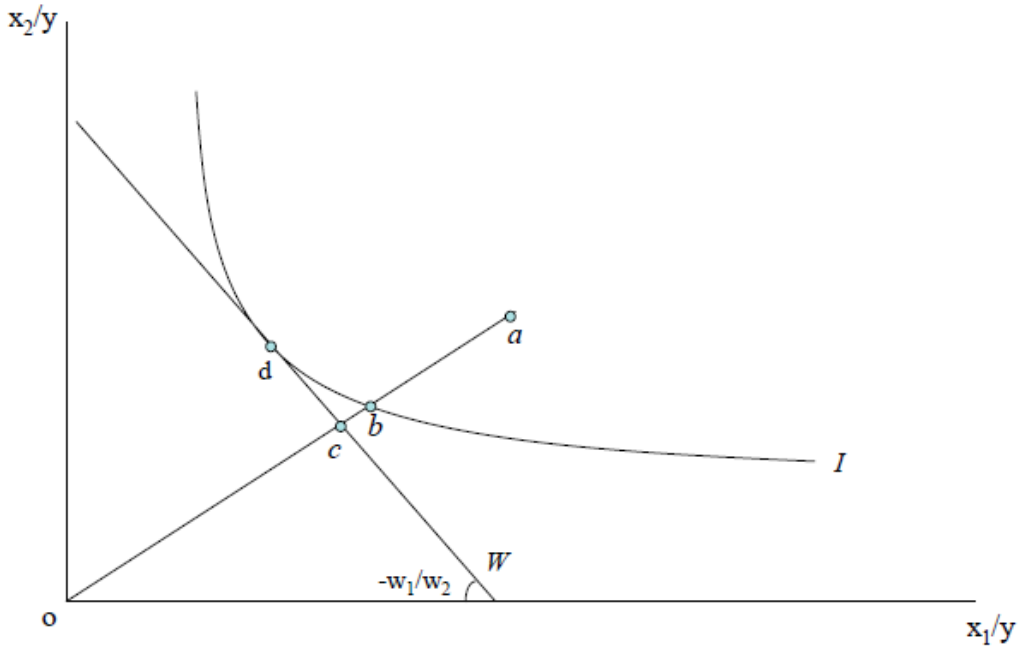
(i) *Technical Efficiency* (TE), referring to the ability of a bank to minimize input (or maximize output) use given a target output (or specific inputs);

(ii) *Allocative Efficiency* (AE), denoting the ability to use the inputs in optimal proportions, given their respective prices and the underlying production technology (this is sometimes also referred to as "cost efficiency");

(iii) *Scale Efficiency* (SE), which measures the part of the technical efficiency score that is associated with a bank's ability to operate at its optimal firm size.

Figure 2 illustrates the concept of technical and allocative efficiency. A fully-efficient bank that uses two inputs (x_1, x_2) to produce one output (y) has a certain production possibility frontier denoted by the unit isoquant *I*. A bank that produces at point *a*, which is inferior to the optimal production, has a technical inefficiency that is measured by the distance *ab* or in relative terms, the ratio *ab*/*ao* which gives the percentage by which both inputs would have to be reduced by the bank to attain full technical efficiency. Conversely, the technical efficiency score is denoted by TE = 1- *ab*/*ao* = *bo*/*ao*. Therefore, the efficiency scores are normalized to between 0 and 1, expressing in percentage terms the degree of efficiency with respect to the leading bank(s) or "best practices".

Figure 2. Technical and Allocative Efficiency



[9] The concept of technical and allocative efficiency was first proposed by Farrell (1957). DEA itself was first applied by Charnes, Cooper and Rhodes (1978).

Allocative efficiency (AE) is depicted by the distance between a point on the isoquant and the isocost line *W* whose slope is the ratio of the input prices, $-w_1/w_2$. The additional distance *bc* represents the reduction in production costs that would be obtained by changing the input mix in favor of using more of the relatively inexpensive factor x_2 and, thus, moving along the isoquant to attain the allocatively (and technically) efficient point *d*.

B. Data and Variables

In all of the following DEA specifications, one dedicated output is related to three inputs. Output is either the sum of loans and securities, or of total operational revenue earned from these assets. In producing these outputs, banks utilize labor, physical capital, and financing,[10] whose costs in all specifications correspond to total personnel expenses, all other administrative costs including depreciation, and total interest paid on deposits, respectively. In addition, DEA makes it possible to run a cost efficiency analysis by breaking down each expense category into a volume component (number of employees, number of bank offices, and volume of deposits) and a cost component (average compensation, administrative cost per office, and interest paid on deposits). This decomposition paves the way for measuring allocative efficiency by isolating the cost effect of inputs utilized in the intermediation process.[11]

In contrast to other studies, the analysis does not distinguish between two or more outputs. This is simply because the focus of most banks in the region is on the lending business, with securities being typically held for liquidity purposes and, thus, clearly subordinated to the main objective of generating loans.

Three different DEA models are specified. The first model relates total loans and securities holdings to labor, physical capital, and financing (in the third column of Table 1), whereas the second model uses the total revenue generated by banks' assets (fourth column). The third model splits expense inputs into volume and costs and relates them to total revenue as output in order to compute allocative (or cost) efficiency (fifth column).[12] The scale efficiency scores in the final column are obtained from the first model by dividing the

[10] These are common inputs in bank efficiency analyses, e.g. Barry et al. (2008), Fiorentino et al. (2006), Gjirja (2004), Grigorian and Manole (2006), Holló and Nagy (2006), or Hung (2007). By treating deposits as an input rather than an output, this study follows the "intermediation approach" to measuring bank efficiency that was first proposed by Sealey and Lindley (1977).

[11] It is possible to include variables accounting for environmental variables that could impact the efficiency results. As opposed to the stochastic frontier analysis applied in Section IV of this study, the DEA presented here forgoes such variables.

[12] The technical efficiency scores obtained from this cost efficiency DEA are not reported because they likely introduce a bias in favor of banks with a small number of offices—typically foreign banks with only one subsidiary in a given country or with a very small branch network.

technical efficiency score under constant returns to scale (assumed in all previous calculations) by that under the alternative assumption of variable returns to scale (not reported separately).[13]

The overall sample consists of 86 banks in the six countries in the region surveyed: Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras and Nicaragua. However, for each country a separate DEA system was computed, with the largest (smallest) individual sample equaling 20 (9) observations. All observations are as of end-December 2007, as supplied by the national regulatory authorities, including the aforementioned input data on bank employees and branches.

For the purpose of the exercise, "foreign" banks are those globally operating banks headquartered outside the region, whereas "acquired" banks are those that were recently taken over. "Regional" banks are those domiciled in the region and present in at least two countries thereof (i.e. in their home country and in one or more other countries)[14], while "d**omestic" banks are those confined to operating in their own jurisdiction.[15] "L**arge" and "s**mall" banks differ as to where they stand in the quartiles of banks' total assets.

Importantly, the DEA results should not be taken as absolute efficiency measures, and for this reason they do not lend themselves to cross-country comparisons. Banks' individual degree of efficiency is determined in relative terms, i.e. the efficiency scores merely indicate the distance of one or more entities to the most efficient bank(s) in a given country. Therefore, the efficiency scores are not directly comparable across countries. Conceivably, a less-than-efficient bank in one country may still be more efficient than the best performer in another country.

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[13] Coelli et al. (1998) note that the assumption of constant returns to scale is appropriate only if banks can be assumed to be operating at an optimal scale, i.e. in the absence of imperfect competition, financing constraints and other hindrances. The DEA in this study uses constant returns to scale because the average scale efficiency scores are sufficiently close to 100 percent in most cases, i.e. larger than 90 percent in 5 countries (and larger than 95 percent in three of them). Moreover, assuming variable returns to scale causes the curvature of the production possibility frontier to conform to the production points of the individual banks, which means that most of the banks are deemed to be fully efficient when in fact significant differences in technical efficiency are obtained under constant returns to scale.

[14] The group of regional banks does include a Mexican bank with subsidiaries in Guatemala and Honduras. Furthermore, one regional bank was assigned to the group of foreign (acquired) banks, since the largest shareholder acquired three fourths of capital after initially owning just fewer than 50 percent.

[15] This grouping includes a Peruvian-owned bank in Guatemala and a Panamanian-owned bank in Nicaragua, neither of which has another subsidiary in the region and, hence, do not qualify as a regional bank as defined here.

C. Results of the DEA Procedure

The results obtained from the DEA optimization procedure[16] (Table 1) do not clearly confirm that foreign banks, i.e. global banks and the regional banks they acquired, are on average more efficient than domestic banks. While global and acquired banks do show a higher allocative (cost) efficiency than local banks, their technical efficiency is not superior in at least half of the sample countries.

Regarding the two measures of technical efficiency, foreign banks are shown to be superior only in the Dominican Republic, El Salvador and, partly, in Guatemala. Even in the latter two countries, it is the performance of the acquired, formerly domestic banks that is driving the result. By contrast, in Costa Rica and Honduras domestic banks outperform their foreign and regional counterparts. Similarly, in Nicaragua two regional banking groups of local ownership dominate all other players in terms of technical efficiency.

In terms of allocative (cost) efficiency, in all but one country the foreign-owned banks are found to operate more efficiently than their local competitors. Yet once again, it is the efficiency of the acquired banks that makes a difference. In four out of the five countries with recent foreign bank entry, the acquired banks have a higher allocative efficiency than the global banks, particularly in El Salvador where the leading domestic banks changed ownership. This finding is somewhat surprising given that internationally active banks are commonly assumed to possess better technology, and, as mentioned in Section II, have empirically been shown to outperform incumbent banks in a number of empirical studies around the globe.

The scale efficiency of foreign banks is higher than that of local ones in all but one country, but not so in relation to the regional banks. Again, in almost all cases where foreign banks thrive this is due to the acquired banks' superior scale efficiency. Like in technical efficiency, foreign banks do not outperform regional banks on this count, and in fact dominate them only in Guatemala. This said, the differences in scale efficiency are not large across types of banks, with most scores between 90 and just under 100 percent of the scores that constitute best practices in the region.

[16] This section uses the publicly available computer program *DEAP* developed by Tim Coelli and described in chapter 6 of Coelli et al. (1998).

Table 1. DEA Estimation Results for 2007

Costa Rica

Type of Bank	No. of banks*	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Allocative Efficiency	Scale Efficiency
Overall	15	**80.1%**	**81.4%**	**64.1%**	**91.8%**
Foreign banks	6	**79.5%**	**73.2%**	**65.4%**	**93.6%**
o/w global banks	2	88.8%	81.4%	60.5%	91.8%
o/w acquired bks	4	74.9%	74.9%	67.3%	94.5%
Regional banks	2	**73.8%**	**81.6%**	**65.3%**	**97.1%**
Local banks	7	**82.4%**	**88.4%**	**62.3%**	**89.1%**
o/w public banks	4	81.3%	84.6%	66.4%	93.0%
Large banks	4 (1/0)	82.4%	80.8%	59.5%	89.7%
Small banks	4 (2/0)	73.0%	89.4%	73.6%	83.8%

* in parentheses: of which foreign/regional

Dominican Republic

Type of Bank	No. of banks*	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Allocative Efficiency	Scale Efficiency
Overall	11	**87.7%**	**88.2%**	**88.9%**	**91.8%**
Foreign banks	2	**97.1%**	**90.8%**	**91.0%**	**94.2%**
Local banks	9	**85.6%**	**87.7%**	**88.4%**	**90.6%**
Large banks	3 (0/0)	98.1%	96.0%	83.9%	96.0%
Small banks	3 (0/0)	69.6%	79.5%	85.8%	81.6%

* in parentheses: of which foreign/regional

El Salvador

Type of Bank	No. of banks*	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Allocative Efficiency	Scale Efficiency
Overall	13	**87.7%**	**82.8%**	**60.5%**	**96.3%**
Foreign banks	9	**88.9%**	**87.0%**	**63.0%**	**96.4%**
o/w global banks	4	81.8%	80.5%	47.4%	92.8%
o/w acquired bks	5	94.6%	92.3%	75.6%	99.2%
Regional banks	2	**85.3%**	**77.3%**	**56.6%**	**98.7%**
Local banks	2	**84.3%**	**69.6%**	**53.3%**	**94.0%**
Large banks	3 (3/0)	98.4%	92.9%	68.5%	96.5%
Small banks	3 (2/1)	95.0%	69.9%	37.2%	92.9%

* in parentheses: of which foreign/regional

Table 1 (continued).

Guatemala

Type of Bank	No. of banks*	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Allocative Efficiency	Scale Efficiency
Overall	20	**76.5%**	**78.7%**	**69.5%**	**96.9%**
Foreign banks	4	**84.9%**	**85.9%**	**83.2%**	**99.2%**
o/w global banks	1	83.8%	69.0%	100.0%	97.6%
o/w acquired bks	3	85.3%	91.6%	77.6%	99.7%
Regional banks	2	**97.1%**	**90.5%**	**47.2%**	**97.1%**
Domestic banks	14	**71.2%**	**68.6%**	**68.8%**	**96.2%**
Large banks	5 (0/0)	97.0%	80.5%	72.0%	97.0%
Small banks	5 (0/1)	70.1%	72.2%	62.3%	93.8%

* in parentheses: of which foreign/regional

Honduras

Type of Bank	No. of banks*	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Allocative Efficiency	Scale Efficiency
Overall	18	**85.2%**	**83.8%**	**62.1%**	**96.7%**
Foreign banks	7	**83.6%**	**78.2%**	**62.7%**	**96.7%**
o/w global banks	2	99.4%	78.5%	59.4%	99.7%
o/w acquired bks	5	77.3%	78.2%	64.1%	95.5%
Regional banks	3	**73.3%**	**80.7%**	**44.6%**	**98.4%**
Local banks	8	**90.9%**	**89.8%**	**68.0%**	**96.0%**
Large banks	4 (1/0)	90.6%	86.8%	64.8%	93.0%
Small banks	4 (1/1)	88.8%	87.0%	36.2%	99.0%

* in parentheses: of which foreign/regional

Nicaragua

Type of Bank	No. of banks*	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Allocative Efficiency	Scale Efficiency
Overall	9	**80.7%**	**93.4%**	**89.5%**	**85.6%**
Foreign banks	4	**69.9%**	**92.5%**	**91.5%**	**78.5%**
o/w global banks	1	49.2%	90.7%	85.2%	66.7%
o/w acquired bks	3	76.8%	93.1%	93.6%	82.4%
Regional banks	2	**98.9%**	**94.3%**	**86.7%**	**98.9%**
Local banks	3	**80.9%**	**94.1%**	**88.8%**	**86.3%**
Large banks	2 (0/2)	98.9%	94.3%	86.7%	98.9%
Small banks	2 (1/0)	100.0%	100.0%	90.8%	100.0%

* in parentheses: of which foreign/regional

Large banks are generally more efficient than small banks, albeit with some exceptions. In five out of six countries large banks have a superior technical efficiency in terms of assets. However, when considering costs this is no longer obvious. While the allocative efficiency of large banks is much higher particularly in El Salvador and Honduras, they are outperformed by small banks in this respect in Costa Rica, the Dominican Republic and Nicaragua. Finally, the scale efficiency of large banks is superior, except in Honduras and Nicaragua. This finding raises questions about obstacles to competition in a number of countries, particularly in the Dominican Republic where the difference is 15 percentage points.

The banking markets in the region are found to have some other noteworthy characteristics. In Costa Rica, public banks hold a uniquely significant share of the banking market and are able to keep up with all other groups of banks, with the allocative efficiency score being particularly competitive. In the Guatemalan banking sector no less than nine banks turn out to be 100 percent technically efficient in either category and, therefore, the relatively low efficiency averages indicate a wide dispersion of results for the remaining banks. Local Honduran banks define best practices in efficient input use, leading foreign and regional banks by about 10 percentage points when both categories of technical efficiency are jointly considered. Lastly, the striking characteristic of the Nicaraguan banking industry is the large difference between very high average cost efficiency and rather low scale efficiency, also evidenced by the gap between technical efficiency in output and revenue terms.

D. Multi-year Changes in Factor Productivity

In addition to the efficiency analysis per year-end 2007, it is instructive to track efficiency developments for the 2002-07 period, using the so-called Malmquist index. Essentially, this output-oriented chain index measures the evolution of total factor productivity (TFP) of each entity, i.e. the distance between two production points or input-output mixes irrespective of the distance to other banks. Still, this procedure also allows to compute the part of the absolute productivity change that represents the mere "catching-up" to the most efficient bank(s) in the system (labeled below "A Relative Efficiency").

As in the DEA analysis, productivity performance is computed regarding (i) the aggregated portfolio of earning loans and securities and (ii) total revenue generated by such assets. A third column in the tables below indicates the aforementioned "catching-up" change in relative efficiency with respect to total revenue as output, with an overall positive change signaling that below-average banks have caught up to best practices. With 2002 being the base year, the change in productivity is computed for the years 2003 to 2007. In addition, to isolate the effect foreign bank entry may have had on banks' productivity, the three right-hand columns display productivity changes during 2006-07, the period in which the bulk of cross-border acquisitions occurred. The productivity time series are deflated using the consumer price index for each country and year.

The productivity indices computed for 2003-07 (see Table 2) indicate that productivity in managing loans and securities increased in all countries (between 1.9 percent and 7.6 percent a year). However, the results for productivity with respect to revenue from such assets are less clear, with only three countries registering an annual productivity gain of 1 percent or more. Specifically, while banks in Costa Rica and Guatemala improved on both counts, their Honduran and Dominican counterparts experienced declining efficiency in generating revenue despite considerably increasing productivity with respect to managing assets.

Distinguishing between types of banks, the five-year productivity changes do not support the notion that foreign banks feature higher productivity gains than local institutions. In fact, global banks outperformed their competitors in productivity terms only in three countries, Costa Rica, Nicaragua and the Dominican Republic. Conversely, domestic and regional banks achieved the strongest productivity gains in El Salvador and Guatemala. The record is mixed for Honduras with local banks performing relatively well in generating assets and foreign banks in generating revenue. Remarkably, the regional banking groups that were eventually acquired by global banks registered below-average productivity advances in all countries except Nicaragua.

During 2006-07—the heyday of foreign bank entry—productivity performance in managing assets was weaker in four countries relative to the whole period, but in terms of revenues the reverse is true. This striking divergence can be interpreted as banks putting greater emphasis on profitability than mere asset growth and, hence, bank size. Interestingly, the change in relative efficiency, i.e. the change in the distance to the most efficient bank(s), is, on average, positive for the entire five-year period but negative for the recent takeover period, indicating that a number of banks have been losing ground to the market leaders in efficiency terms.

In the takeover phase, global banks saw their productivity in generating revenue deteriorate in all but one country (El Salvador). The decline relative to the pre-takeover period was especially pronounced in Costa Rica, Honduras and Nicaragua. In these countries, domestic banks were able to strengthen their relative positions against not only global banks but also the acquired banking groups, which improved markedly only in one country, Guatemala. The independent regional banks continued to perform relatively well in the takeover period, registering reasonably strong productivity growth in Costa Rica, El Salvador and Guatemala and catching up to best practices in a number of locations.

Table 2. Productivity Developments Computed Using Malmquist Indices

COSTA RICA	# of Bks	2003-07 Δ TFP Loans&Sec.	2003-07 Δ TFP Revenue	2003-07 Δ Relative Efficiency	2006-07 Δ TFP Loans&Sec.	2006-07 Δ TFP Revenue	2006-07 Δ Relative Efficiency
Overall	**15**	**+7.6%**	**+3.1%**	**-0.1%**	**+0.9%**	**-0.8%**	**-5.6%**
Global Banks	2	+17.3%	+12.3%	+1.0%	+15.6%	-3.1%	-7.7%
Acquired Banks	4	+1.3%	+2.0%	-1.5%	-9.9%	-4.3%	-10.6%
Regional Banks	2	+1.2%	+0.6%	+2.3%	+0.2%	+1.9%	+0.6%
Domestic Banks	7	+10.3%	+1.8%	-0.2%	+3.0%	+1.4%	-4.0%
o/w Public Banks	4	+12.8%	+2.0%	-0.9%	+10.5%	+0.3%	-6.2%

DOMINICAN REPUBLIC	# of Bks	2003-07 Δ TFP Loans&Sec.	2003-07 Δ TFP Revenue	2003-07 Δ Relative Efficiency	2006-07 Δ TFP Loans&Sec.	2006-07 Δ TFP Revenue	2006-07 Δ Relative Efficiency
Overall	**8/10**	**+3.2%**	**-3.3%**	**+2.9%**	**+13.6%**	**-0.1%**	**+3.5%**
Global Banks	2	+5.9%	-2.9%	0.0%	+15.3%	-2.0%	+0.6%
Domestic Banks	6/8	+2.3%	-3.4%	+3.9%	+13.1%	+0.3%	+4.2%

EL SALVADOR	# of Bks	2003-07 Δ TFP Loans&Sec.	2003-07 Δ TFP Revenue	2003-07 Δ Relative Efficiency	2006-07 Δ TFP Loans&Sec.	2006-07 Δ TFP Revenue	2006-07 Δ Relative Efficiency
Overall	**13**	**+1.9%**	**+1.0%**	**+2.4%**	**0.0%**	**+1.9%**	**-1.5%**
Global Banks	4	+1.2%	+0.1%	+1.9%	+1.7%	+6.2%	0.0%
Acquired Banks	5	-0.1%	+0.8%	+3.1%	-7.5%	-0.8%	-2.1%
Regional Banks	2	+6.7%	+1.4%	+4.6%	+20.3%	+4.8%	+5.1%
Domestic Banks	2	+3.8%	+2.9%	+2.1%	-4.7%	-2.6%	-9.9%

GUATEMALA	# of Bks	2003-07 Δ TFP Loans&Sec.	2003-07 Δ TFP Revenue	2003-07 Δ Relative Efficiency	2006-07 Δ TFP Loans&Sec.	2006-07 Δ TFP Revenue	2006-07 Δ Relative Efficiency
Overall	**18**	**+3.9%**	**+3.3%**	**+1.0%**	**-3.7%**	**+8.4%**	**-9.3%**
Global Banks	1	+3.0%	-3.8%	-5.2%	-20.1%	-2.8%	-12.4%
Acquired Banks	3	-2.2%	+1.7%	+0.2%	+4.5%	+20.4%	-0.4%
Regional Banks	1	+9.0%	+9.4%	+7.5%	+1.2%	+12.1%	-0.1%
Domestic Banks	13	+5.0%	+3.8%	+1.2%	-4.8%	+6.3%	-11.9%

HONDURAS	# of Bks	2003-07 Δ TFP Loans&Sec.	2003-07 Δ TFP Revenue	2003-07 Δ Relative Efficiency	2006-07 Δ TFP Loans&Sec.	2006-07 Δ TFP Revenue	2006-07 Δ Relative Efficiency
Overall	**15/16**	**+3.8%**	**-4.3%**	**+1.1%**	**+7.2%**	**-3.2%**	**-2.8%**
Global Banks	1	-0.2%	+0.5%	+4.3%	-4.8%	-5.6%	0.0%
Acquired Banks	4/5	+3.1%	-6.0%	+0.5%	+1.9%	-7.0%	-3.7%
Regional Banks	2	+2.3%	-11.9%	-2.2%	+9.3%	-7.0%	-4.6%
Domestic Banks	8	+5.0%	-2.2%	+1.8%	+11.5%	+0.5%	-2.2%

NICARAGUA	# of Bks	2003-07 Δ TFP Loans&Sec.	2003-07 Δ TFP Revenue	2003-07 Δ Relative Efficiency	2006-07 Δ TFP Loans&Sec.	2006-07 Δ TFP Revenue	2006-07 Δ Relative Efficiency
Overall	**7/9**	**+4.8%**	**+0.4%**	**-1.0%**	**-5.6%**	**-0.4%**	**+2.4%**
Global Banks	1	+18.1%	+7.8%	+1.1%	-3.4%	-5.2%	-4.8%
Acquired Banks	2/3	+6.6%	+1.8%	-1.1%	-11.4%	-4.9%	+1.6%
Regional Banks	2	+1.5%	-1.1%	-1.2%	-6.3%	-0.2%	+4.0%
Domestic Banks	2/3	-0.3%	-3.3%	-1.6%	0.0%	+5.5%	+4.5%

E. Pre-/Post-Acquisition Performance

This section tracks the productivity developments of the regional banks that were acquired by global banks, from the year preceding the takeover to the year following it. During 2005-06 five banking groups were bought by financial institutions headquartered in the United States, the United Kingdom and Colombia. In each case, the acquisition year (T) is set to be the year in which the takeover was announced and integration of the acquired bank begun.

i) Absolute Productivity Change

Using Malmquist productivity indices for each of the acquired banks, the average absolute change in total factor productivity regarding revenue is calculated for each year of the respective pre-/post-acquisition phase. As can be inferred from Table 3 below, there is a marked difference in the change in banks' average productivity from one year to the next.

Table 3. Absolute Productivity of Acquired Banks during Takeover Phase

Acquired Banks	T-1	T	T+1
Δ Productivity (mean)	+4.5%	-0.5%	+1.2%
(Standard deviation)	(12.1)	(13.6)	(20.1)
Δ Productivity (median)	+3.5%	-1.1%	+2.6%

While the productivity of the acquired banks rose by an average of 4.5 percent in the pre-acquisition year, this number turned slightly negative in the takeover year (minus 0.5 percent) and recovered somewhat to +1.2 percent thereafter. The rebound is stronger when taking the median rather than the mean, given that one negative outlier biases the latter downward. This deterioration-and-bounceback effect is also reported for foreign banks that have entered into Central and Eastern European countries (Poghosyan and Poghosyan, 2009). That said, it needs to be mentioned that the dispersion of individual outcomes, as measured by the standard deviation, is relatively high and growing over time, rendering the results less robust.

From this analysis emerges that the need to integrate and possibly restructure the acquired banks has tended to slow productivity growth. Some acquiring banks likely incurred costs of reorganizing the local banks and deal with non-performing loans (Košak and Zajc, 2006), as was the case in Central and Eastern Europe, Argentina (Delfino, 2007), or post-crisis Thailand (Chantapong, 2005).

ii) Relative Productivity Change

As these results may be biased by strong (poor) productivity growth in good (bad) years for the industry as a whole, the individual productivity gains are corrected for overall productivity growth. The following table depicts the aforementioned absolute productivity changes net of the average productivity growth recorded for the year in question.

Table 4. Relative Productivity of Acquired Banks during Takeover Phase

Acquired Banks	T-1	T	T+1
Δ Productivity (mean)	+4.5%	-0.6%	-0.2%
(Standard deviation)	(9.0)	(10.8)	(16.2)
Δ Productivity (median)	+4.7%	0.0%	-2.2%

Interestingly, up until the takeover period absolute and relative changes in productivity (regarding means) are virtually identical, indicating the lack of such a cyclical bias. However, in the post-acquisition year, there is a difference of 1.4 percentage points between the two measures (+1.2 percent pre-acquisition vs. -0.2 percent post-acquisition). Thus, average total factor productivity of the acquired banks improved in absolute terms, but this modest improvement vanishes when viewed in relation to the gains all other institutions achieved. The finding that the average post-merger performance of the acquired banks is not different from the industry average is in accordance with the evidence that domestic and independent regional banks have recently managed to achieve productivity gains to position themselves firmly in a more competitive environment.

IV. Bank Efficiency Based on Stochastic Frontier Analysis

A. Methodology

Stochastic Frontier Analysis—the other main efficiency estimation method—involves a specific production function and the decomposition of the error term (into a pure random error and an inefficiency term). This approach proposes a solution to the noise measurement problem faced by DEA and other deterministic applications, which is caused by attributing all measurement errors to the efficiency estimates. The following equation is estimated:

$$\ln(y_i) = x_i\beta + v_i - u_i ,$$

where x_i is a vector of logarithmized input variables and the error term consists of two distinct components, v_i and u_i. While v_i is a traditional random error that picks up the impact of measurement errors and other noise factors on output values, y_i, and is therefore iid $N(0,\sigma_v^2)$, the additional error term, u_i, is a non-negative random variable that accounts for technical inefficiency in banks' production and is iid truncated at zero of the $N(\mu,\sigma_u^2)$ distribution. As with DEA, the inefficiency term describes the distance to the firm(s) with

best practices on the efficient frontier. Depending on the model to be estimated, the sign of μ can vary, thus resulting in distinct models of estimating inefficiency effects.[17] The importance or impact of the inefficiency term, as measured by the contribution of its variance to overall variance, is denoted by $\gamma = \sigma_u^2/(\sigma_v^2+\sigma_u^2)$ and conveniently expressed in percentage terms.

Note that there is no prior for the functional form of the production function, nor the distributional form of the inefficiency term. While any such assumption may be justified, in the literature common threads have emerged. Most empiricial bank efficiency studies use either a Cobb-Douglas or a translog[18] functional form, while assuming either a half-normal or truncated-normal distribution of the inefficiency term. In any case, the validity of the assumed form or distribution will have to stand up to hypothesis testing.

The technical efficiency of a bank, TE = exp(-u_i), is not directly measurable, since at best only the difference in the error term $e_i = v_i - u_i$ could be observed. However, it is known that the best predictor for the u_i is the conditional expectation of u_i, given the value of $(v_i - u_i)$. With this in mind, Battese and Coelli (1988) posit that the best predictor of firm-level technical efficiency terms u_i is

$$E\left[\exp(-u_i)|e_i\right] = \frac{1-\phi(\sigma_A+\gamma e_i/\sigma_A)}{1-\phi(\gamma e_i/\sigma_A)}\exp\left(\gamma e_i + \frac{\sigma_A}{2}\right),$$

where $\sigma_A = \sqrt{\gamma(1-\gamma)\sigma_S^2}$; $e_i = \ln(y_i) - x_i ß$; and $\phi(.)$ is the density function of a standard normal random variable. In the empiricial application, the unknown values in the above equation for the best predictor are replaced by the maximum-likelihood estimates.

Two different stochastic frontier models using cross section and panel data are estimated. Model 1, in the version using panel data, estimates efficiency effects that may rise or decay over the sample period, while model 2 makes it possible to take into account environmental variables that are commonly viewed as affecting bank efficiency. Econometrically, the difference between the models lies in the properties of the inefficiency term. In model 1, the so-called error components model proposed by Battese and Coelli (1992), the inefficiency term is defined as

$$u_{it} = \{\exp[-\eta(t-T)]\}u_i \ ,$$

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[17] Assuming μ to be zero yields the original stochastic frontier model by Aigner, Lovell and Schmidt (1977), whereas a positive number results in the two models by Battese and Coelli (1992, 1995) used in this study; see Coelli (1996).

[18] The translog (short for transcendental logarithmic) functional form with its second order terms does not impose restrictions upon returns to scale like the Cobb-Douglas function, and it allows for substitution possibilities.

where η is an unknown factor between 0 and 1 to be estimated that measures the variation in technical efficiency over time (t and T being the current and the last period in the sample, respectively). For $\eta = 0$, the model reduces to the aforementioned time-invariant model. By contrast, model 2 that is based on the so-called technical efficiency effects specification of Battese and Coelli (1995) does not amend the inefficiency term but rather adjusts the truncation of its distribution $N(\mu_{it}, \sigma^2)$, where $\mu_{it} = z_{it}\,\delta$, with z_{it} being a vector of explanatory environmental variables and δ a vector of unobserved scalar parameters to be estimated. This approach to including exogeneous factors avoids known problems with inconsistencies in the error term properties associated with two-stage regressions by way of estimating these factors together with the technical efficiency terms in a single-stage maximum likelihood procedure.

B. Data and Variables

As with the DEA model, one output variable, in this case total revenue[19], is related to three inputs. These inputs are again: (i) personnel costs, (ii) other administrative costs, and (iii) total interest paid, and, in some cases, other exogeneous variables. In addition to a linear specification á la Cobb-Douglas, a translog production function uses squared input terms and cross terms, adding up to a total of nine variables.[20]

Six regressions are run.[21] Regressions (1) to (3) use a cross section for 2007. Specifically, **r**egression (1) uses model 1—the error components model. The next two regressions follow model 2—the technical efficiency effects model—with and without other explanatory variables. Regressions (4) to (6) replicate the first three regressions using panel data for 2002-07. For each regression, hypothesis tests are carried out to ascertain the appropriateness of the specification chosen (see Section IV.C).

In two specifications, model 2 employs "environmental variables" to control for country- and bank-specific characteristics that may influence bank efficiency. Following the seminal paper by Berger and Mester (1997) that shed light on the influence of external factors using a sample of U.S. banks, several studies—e.g. Dietsch and Lozano-Vivas (2000), Hasan et al. (2000), Lozano-Vivas et al. (2002) and Sathye (2005)—elaborated on the importance of capturing such characteristics in multi-contry efficiency studies (see Berger (2007) for a summary of the argument for using such factors). These variables are thought to

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[19] The technical efficiency measure related to total productive assets in the DEA is omitted, as the scaling of two of the firm-level environmental variables by total (productive) assets may have caused endogeneity issues.

[20] More precisely, the following standard translog function is estimated (see Table 6):

$$\ln(Y_i) = ß_0 + ß_1 \ln(L_i) + ß_2 \ln(K_i) + ß_3 \ln(F_i) + ß_4 \ln(L_i)^2 + ß_5 \ln(K_i)^2 + ß_6 \ln(F_i)^2 + ß_7 \ln(L_i K_i) + ß_8 \ln(L_i F_i) + ß_9 \ln(K_i F_i) + v_i - u_i$$

where L is personnel cost, K is administrative cost, and F is interest paid.

[21] This study uses the publicly available computer program FRONTIER 4.1 developed by T. Coelli. For more information, see Coelli (1996).

explain some of the differences in banks' efficiency scores, both within the banking sector and between countries. Six of such environmental variables are added to regressions (3) and (6) which employ model 2. The three country-specific correlates are frequently used in bank efficiency studies, e.g. Fries and Taci (2004), Grigorian and Manole (2006), Zajc (2006) and Kablan (2007), whereas the three bank-specific variables chosen in this paper are less common in the literature, e.g. Poghosyan and Poghosyan (2009). Note that correlates that are deemed to improve efficiency actually lower the efficiency score because a beneficial (detrimental) environment is deemed to bias the "pure" efficiency of a bank upward (downward) and, thus, needs to be corrected for.

Three country-level correlates account for the economic and regulatory environment. *GDP per capita* aims at proxying the level of development of a country's banking system, as higher income implies higher wealth and, thus, a supply of sophisticated bank products. A positive sign is expected. *Concentration* represents the share of the three largest banks in total assets of the banking sector (as in Zajc (2006)), thereby proxying market power of incumbent banks or barriers to entry. The sign of the concentration variable can be expected to be negative, if monopolistic structures prevent more cost-efficient bank to gain market share, or positive, if high concentration itself is the result of efficient production processes of the dominant banks.[22] *Freedom* signifies the Heritage Foundation's index of financial freedom that depicts the degree of government influence in banking, with scores ranging from 100 percent denoting negligible influence to 0 percent in cases of repressive influence.[23] A high score should coindice with a positive effect on bank efficiency.

In addition, three firm-specific correlates are included to account for banks' unique characteristics impacting on their efficiency. *NPL* denotes the share non-performing loans in the loan portfolio. A high share of bad loans indicates that a bank is poorly run and is indicative of low efficiency, hence a negative sign is expected.[24] *Liquidity* measures the share

[22] In the first instance, concentrated banking markets reduce competitive pressure as bank managers are less pressured to maximize a bank's efficiency (known as the *relative market power hypothesis*), whereas in the second instance efficiency actually explains profitability and subsequently leads to a larger market share (the *efficient structure hypothesis*; see Chortareas et al. (2009)).

[23] More specifically, this indicator measures the relative openness of a country's banking and financial system. It is determined by scoring (i) the extent of government regulation of financial services; (ii) the extent of state intervention in banks and other financial services; (iii) the difficulty of opening and operating financial services firms (for both domestic and foreign individuals); and (iv) government influence on the allocation of credit (see Heritage Foundation (2009)). The indicator was also used by Figueira et al. (2009) in their efficiency study of Latin American banks.

[24] A number of studies—e.g. Fuentes and Vergara (2007) and Kablan (2007)—corroborate the negative impact of non-performing loans on bank efficiency. Other studies instead use loan loss provisions as a measure of credit risk, e.g. Barry et al. (2008), Chen (2009) and Poghosyan and Poghosyan (2009). However, as Barry et al. (2008) note, the expected sign of the provisions variable is unclear since high provisions may be viewed to imply either solidity or rather high operating costs associated with extensive risk management operations.

of liquid assets in a bank's total assets, whereby the degree of bank liquidity is a function of regulatory requirements and/or of banks' own liquidity preferences. Evidently, the higher this share the lower the contribution of earnings assets to overall revenue, suggesting a negative sign for this variable. Finally, *Takeover* is a dummy variable that picks up the impact of the acquisition process on the efficiency of the target bank (set to one in the takeover year and zero otherwise). As the empirical evidence (see Section II) points to difficulties in the takeover process affecting performance, a negative sign is expected.

C. Tests of Hypotheses

Several hypothesis tests are carried out to find the appropriate specification for each model-sample combination. A typical likelihood ratio test[25] is employed to verify the validity of four different hypotheses (Table 5). First, the functional form of the frontier is tested for both models and sample sets (regressions (1), (2), (4) and (5)). In each case, the null hypothesis of a linear specification is rejected at the 1%-level of significance in favor of a translog functional form. Second, the existence of inefficiency effects is verified. In regressions (1) and (4), the null of no such effects $\gamma = \mu = 0$ is not rejected and the option to include μ is omitted (i.e. assumption of a half normal distribution instead of a truncated one). In regressions (2) and (5), however, this null hypothesis is rejected, confirming the existence of inefficiency effects. Third, the significance of the environmental variables is tested. In both specifications (3) and (6), the null of joint insignificance of the six correlates is rejected at least at the 5 percent level. Finally, the hypothesis of no time-invariant inefficiency effects in the panel model of regression (4) cannot be rejected and thus η is set to be zero.

Table 5. Generalized Likelihood Ratio Tests of Hypotheses

#	Regression	H_0 / Parameter	LL	LR	Critical value	Reject H_0?	Type of hypothesis tested
1	Regr. (1)	$ß_4 = \ldots = ß_9 = 0$	-27.42	20.71	12.59***	Yes	Test for functional form
2		$\gamma = \mu = 0$	-17.07	1.24	2.71	No	Test for inefficiency effects (IE)
3	Regr. (2)	$ß_4 = \ldots = ß_9 = 0$	-26.70	18.04	12.59***	Yes	Test for functional form
4		$\gamma = \delta_0 = 0$	-16.64	2.84	2.71**	Yes	Test for inefficiency effects (IE)
5	Regr. (3)	$\delta_0 = \ldots = \delta_6 = 0$	+2.39	40.15	14.07***	Yes	Test for significance of correlates
6	Regr. (4)	$ß_4 = \ldots = ß_9 = 0$	18.67	66.89	12.59***	Yes	Test for functional form
7		$\mu = 0$	52.58	0.92	2.71	No	Test for inefficiency effects (IE)
8		$\eta = 0$	52.12	0.01	2.71	No	Test for time-invariant IE
9	Regr. (5)	$ß_4 = \ldots = ß_9 = 0$	-108.71	86.13	12.59***	Yes	Test for functional form
10		$\gamma = \delta_0 = 0$	-53.72	41.15	2.71***	Yes	Test for significance of correlates
11	Regr. (6)	$\delta_0 = \ldots = \delta_6 = 0$	-46.34	14.77	14.07**	Yes	Test for significance of correlates

LL=Log-likelihood function; LR=Likelihood ratio;
***=significant at the 1%-level; **=significant at the 5%-level; *=significant at the 10%-level.

[25] The likelihood ratio test statistic is defined as: $LR = -2\{\ln[L(H_0)]-\ln[L(H_1)]\}$. Under the null hypothesis the statistic is asymptotically distributed as a Chi-square random variable with degrees of freedom equal to the number of restrictions imposed, with the exception of parameter γ which has a mixed Chi-square distribution with lower critical values, as reported in Kodde and Palm (1986).

D. Results of the SFA Procedure

Based on the specifications derived from the hypothesis tests, the six regressions using stochastic frontier analysis are specified (Table 6). Not all of the nine translog production function regressors are significant, first and foremost in the cross section for 2007 (regressions (1) through (3)), but even the ones lacking significance contribute to an overall higher likelihood relative to the alternative linear specification. In the panel model of regressions (4) through (6), most of the regressors are highly significant and carry the expected positive sign.

Most of the environmental variables in regressions (3) and (6) conform to their hypothesized impact. In particular, these regressions suggest the benign influence of high per-capita income, the importance of freedom from government interference (though only in the panel model), and conversely, the cost burden of high loan delinquencies as well as the negative effect of the takeovers. The banking concentration variable has a negative sign in both specifications, which is line with the barriers-to-entry hypothesis stipulating that market power of large banks impairs overall bank efficiency. Still, in regression (3) the financial freedom variable is insignificant (for lack of cross-country variability), and in regression (6) the liquidity variable has a counterintuitive positive sign. It also needs to be mentioned that in cross section regression (3) the significance of γ (measuring the contribution of the inefficiency effect to overall variance) disappears, indicating that the regression may be misspecified, but the result should not be overemphasized since the sample size is fairly small. To be sure, in the panel regressions—notably in (6)—γ turns out to be highly significant.

The six SFA regressions confirm several of the findings of the DEA approach. First, foreign banks are on average not more efficient than their local or regional competitors: With the exception of regressions (1) and (4) using time-invariant technical efficiency effects, foreign banks are actually inferior. This holds especially true for the global banks that consistently score lower than the banks they acquired. Second, the efficiency scores tended to improve in the latter years of the sample period, with the scores in four countries (Dominican Republic, El Salvador, Guatemala, Nicaragua) rising by about ½ to 2 percentage points (comparing the average 2002-07 scores listed in parentheses of regression (5) to the 2007 scores of regressions (2) or (5)). Third, the takeover process has evidently impaired technical efficiency, as indicated by the negative sign of the takeover dummy variable depicting the impact in the acquisition year. This confirms the finding of Section III.E showing a slump in efficiency precisely in the takeover year.

Table 6. SFA Estimation Results for 2007 and for 2002-2007

Regression No.	(1)	(2)	(3)	(4)	(5)	(6)
Model No.	Model 1	Model 2	Model 2	Model 1	Model 2	Model 2
Year(s)	2007	2007	2007	2002-2007	2002-2007	2002-2007
No. of Observations	86	86	86	485	485	485
Const.	3.505	3.991	2.403	1.937	5.097	4.654
	(3.841)	(2.604)	(3.431)	(1.749)	(1.225)***	(1.052)***
ß1=Personnel	0.811	0.108	0.026	1.238	0.803	0.893
	(0.947)	(0.830)	(0.825)	(0.339)***	(0.308)**	(0.326)***
ß2=Admin. cost	-1.323	-1.446	-0.564	-0.663	-1.071	1.014
	(0.814)	(0.734)**	(0.774)	(0.340)*	(0.288)***	(0.301)***
ß3=Interest paid	1.268	1.061	1.416	0.446	0.840	0.754
	(0.648)*	(0.614)*	(0.526)***	(0.171)***	(0.169)***	(0.173)***
ß4=ß1*ß1	0.044	0.055	0.141	0.043	0.060	0.080
	(0.117)	(0.116)	(0.105)	(0.020)**	(0.024)**	(0.024)***
ß5=ß2*ß2	0.183	0.185	0.132	0.131	0.142	0.138
	(0.060)***	(0.057)***	(0.057)***	(0.024)***	(0.022)***	(0.023)***
ß6=ß3*ß3	0.065	0.050	0.090	0.027	0.042	0.038
	(0.047)	(0.043)	(0.036)**	(0.005)***	(0.006)***	(0.006)***
ß7=ß1*ß2	-0.094	-0.133	-0.118	-0.137	-0.113	-0.140
	(0.128)	(0.116)	(0.107)	(0.034)***	(0.035)***	(0.036)***
ß8=ß1*ß3	-0.022	-0.022	-0.143	-0.006	-0.038	-0.03
	(0.149)	(0.149)	(0.133)	(0.020)	(0.026)	(0.027)**
ß9=ß2*ß3	-0.167	-0.125	-0.097	-0.059	-0.080	-0.051
	(0.152)	(0.141)	(0.126)	(0.025)**	(0.031)***	(0.031)*
GDP/Capita			0.287			2.067
			(0.086)***			(0.559)***
Concentration			-1.301			-3.779
			(0.354)***			(0.771)***
Freedom			-0.020			4.906
			(0.334)			(1.469)***
NPL			-0.904			-4.334
			(0.444)**			(1.167)***
Liquidity			-0.775			2.068
			(0.265)***			(0.740)***
Takeover			-0.181			-1.006
			(0.910)**			(0.353)***
μ or δ_0		-11.743	-0.834		-11.912	-18.919
		(25.791)	(0.756)		(4.613)**	(5.538)***
γ	0.573	0.972	0.000	0.859	0.979	0.903
	(0.298)*	(0.066)***	(0.000)	(0.026)***	(0.008)***	(0.022)***
Log. Likelihood	-17.686	-16.640	2.389	52.120	-53.719	-46.335
Efficiency estimates by country / type of bank for year-end 2007 (averages for 2002-2007 in parentheses)						
Costa Rica	77.5	82.9	56.3	66.7	83.1 (83.1)	79.6 (80.4)
Dominican Repub.	80.5	85.9	80.9	74.4	86.3 (84.7)	86.3 (86.2)
El Salvador	79.6	84.0	62.9	67.5	83.5 (81.8)	79.9 (79.7)
Guatemala	87.5	91.1	74.1	84.7	92.0 (90.1)	91.4 (89.0)
Honduras	75.6	80.3	64.3	62.5	78.7 (83.2)	78.5 (84.3)
Nicaragua	85.9	89.9	83.7	80.4	90.3 (89.7)	93.2 (92.2)
Foreign Banks	80.1	84.1	68.8	71.4	83.6 (n/a)	82.5 (n/a)
o/w global	76.5	79.6	66.7	61.7	77.7 (81.1)	74.9 (79.4)
o/w acquired	82.2	86.8	70.0	77.2	87.2 (87.3)	87.0 (87.2)
Regional Banks	79.6	84.9	70.4	67.5	84.1 (83.8)	83.2 (83.3)
Local Banks	82.1	86.8	69.1	74.7	87.2 (86.0)	86.2 (85.8)

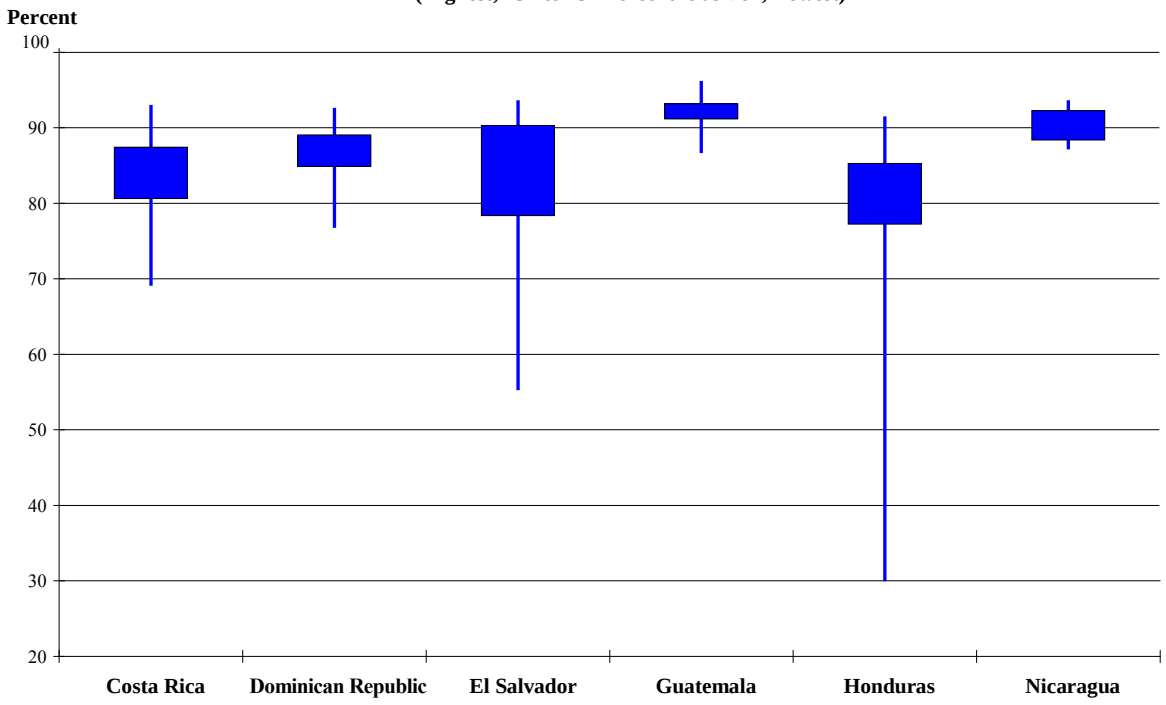
The environmental variables included in regressions (3) and (6) generally do not change the ordering of countries (except for Nicaragua gaining the high score in the panel regression). What the set of correlates does do, however, is to change the ―pure" efficiency scores by up to 3.6 percentage points. Comparing regression (6) using correlates to its pure efficiency companion (5), the average efficiency score of Nicaragua is found to rise by 2.5 and 2.9 points for 2007 and the average 2002-07 scores, respectively, while the scores of the more benign banking environments of Costa Rica and El Salvador drop by between 2.1 and 3.6 percentage points (with the other countries exhibiting changes of only up to 1½ percent). Disaggregating by type of bank, the changes in efficiency caused by country and bank specific variables are smaller (up to 1 percentage point), with the expection of the global banks whose efficiency scores are corrected downward by 2.8 and 1.7 percentage points for 2007 and the 2002-07 average, respectively. The larger correction for global banks is in line with the ―home court advantage" hypothesis (Berger et al., 2000).

Beyond the environmental variables, other exogenous, unaccounted-for factors have likely influenced the efficiency results. It needs to be borne in mind that the region's banking markets, while being fairly comparable, still differ in structure and business mix (e.g. the prominent role of state-owned banks in Costa Rica, the importance of corporate banking in Guatemala, and cross-border investment activities in Panama). Also, in a number of countries other structural changes have taken place during the sample period (e.g. legal changes in Guatemala in 2002 and widespread accounting changes in the region, as well as banking crises in the Dominican Republic and in Guatemala in 2004 and 2007, respectively, with ramifications for market structure).

Within countries, the variation of efficiency estimates differs. Figure 3 presents the distribution of efficiency scores for 2007 obtained from regression (5), listing the highest and lowest values as well as quartile values. While banks in the Dominican Republic, Guatemala and Nicaragua are quite homogeneous (low spread between the highest and lowest quartile), the variation in scores is larger in the remaining countries, notably in El Salvador and Honduras, where one bank each has a particularly low efficiency score. Arguably, in the case of Honduras this extreme value could be considered an outlier, as the bank in question entered the country in the same year, presumably having incurred significant set-up costs relative to recorded earnings.

Figure 3. Distribution of Efficiency Estimates

(Highest; 75th to 25th Percentile as Box; Lowest)



The efficiency scores vary considerably across countries and time. Both in the cross section and the panel estimations the difference in scores between the most and the least efficient banking markets is generally 11 to 13 percentage points (except in regressions (3) and (4)). At year-end 2007, Guatemala and Nicaragua featured the highest technical efficiency, and Honduras was the least efficient banking market—partly caused by the aforementioned inefficient international bank.[26] The Dominican Republic was in third place, closely followed by El Salvador and Costa Rica. The scores also fluctuate over time. Appendix II breaks regressions (5) and (6) down by year and by type of bank: Some countries experienced a dip in efficiency (Dominican Republic, El Salvador, Honduras), while one other trended upward (Guatemala) and two countries stayed largely unchanged (Costa Rica, Nicaragua). Disaggregating by type of bank shows that global banks registered a decline in efficiency over time (which is smaller when correcting for the aforementioned inefficency case) as did the banks they acquired,[27] whereas local banks saw their efficiency

[26] The efficiency score for Honduras as of end-2007 rises slightly (from 78.7 to 81.5 percent in regression (5)) when accounting for the particularly inefficient bank that entered in 2007. This, however, does not change the ordering of the efficiency of banking markets within the region.

[27] Correcting the efficiency score in 2007 for that relatively inefficient bank raises the score from 77.7 to 82.0 percent in regression (5) and from 74.9 to 79.1 percent in regression (6), scores that are still 1.5 and 3.6 percent lower, respectively, than in 2002.

scores increase slightly. The negative impact of the takeover process is less apparent in that table as the acquisitions were spread out over 2005-07.

V. CONCLUSIONS

This paper has studied the development of bank efficiency in Central America, the Dominican Republic and Panama during the recent phase of foreign bank entry. It is the first bank efficiency study for this region, and it applies the two principal methods in efficiency analysis, Data Envelopment Analysis and Stochastic Frontier Analysis, to a sample of 86 banks during the period of 2002-07 that in the latter part saw a wave of foreign bank entry.

The efficiency results obtained from both the DEA and the SFA do not support the notion that foreign-owned banks are generally more efficient than local banks. Using the DEA approach, it is found that, as of year-end 2007, technical efficiency of foreign banks was lower in three of the six countries surveyed. While foreign banks are shown to have a better cost efficiency, this result is largely driven by the efficiency scores of the banks they acquired. This is an indication that global banks chose to acquire relatively efficient banks. Interestingly, independent regional banks performed on average at least as well as foreign banks.

The somewhat surprising lack of a competitive edge of foreign banks is to some extent a product of the recent past. Using productivity indices for the main acquisition period of 2006-07, the study finds that domestic and regional banks generally achieved higher productivity gains than international banks, particularly with respect to generating revenue. On average, banks had a better revenue performance than in the three years prior (2003-05), indicating a widespread quest for higher cost efficiency. Finally, the productivity growth of the banks that were taken over since 2005 tended to dwindle upon acquisition—most likely due to reorganization costs—and, in fact, a separate takeover dummy used in the SFA part came in significantly negative.

Application of the SFA approach confirmed the DEA findings. Again, foreign banks did not outperform local and regional banks. If anything, the acquired banks could match up against the local institutions, but globally operating banks were found to be considerably inferior in efficiency. This finding goes against the evidence reported from transition countries and several other emerging markets.

Lastly, correcting for the environmental conditions in which banks operate is warranted. A set of environmental correlates—country-, sector- and bank-specific—that was added to the "pure" baseline specifications turned out to be significant in most regressions and did have a measurable, although not decisive effect on individual or aggregate efficiency scores.

Further research should examine in more detail the drivers of the efficiency performance and re-assess this regional case once substantially more post-acquisition data are available. In particular, it would be interesting to know which latent characteristics are causing the efficiency differences between types of banks and whether foreign-owned banks can eventually catch up with the local banks once the merger process has been left behind. In this context, it must be noted that the effects of the entry of foreign banks will not become fully evident in one or two years after the acquisition but rather unfold gradually. Therefore, the implications for the overall efficiency of the system remain to be seen. Still, it is to be expected that thanks to higher competition and externally-driven investment in information technology as well as human capital and better risk management, the regional banking system as a whole will become more efficient over time.

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APPENDIX I. BANKING EFFICIENCY IN PANAMA BASED ON DEA

With more than 70 licensed banks (not counting representative offices), the Panamanian banking sector is a regional financial center. Foreign banks account for more than three fourths of all institutions and can choose to operate under a general license like their domestic counterparts or under an international license, which requires lower equity capital but restricts business essentially to dealing with residents.

Notwithstanding the generally high productivity of Panamanian Banks, the relatively low DEA efficiency estimates for 2007 do not imply that Panamanian banks are less efficient than banks elsewhere, but rather indicate a large efficiency gap between the majority of banks and a few exceedingly efficient foreign-owned banks. Since those foreign banks could be considered statistical outliers, the efficiency scores reported below should be interpreted with caution. The efficiency gap is larger for local banks than it is for the other foreign banks operating under either type of licence. Hence, on average, foreign-owned banks are more efficient than their domestic competitors. It should be mentioned though that banks with general license tend to focus on traditional lending while those with international license have a wider product mix (also specializing in asset management) and often a smaller professional staff.

*Panama Efficiency Analysis for 2007**

Type of Bank	No. of banks	Technical Efficiency Output: Loans + Sec.	Technical Efficiency Output: Revenue	Scale Efficiency
Banks with general license	**40**	**34.3%**	**53.3%**	**59.0%**
o/w local public	2	26.8%	52.7%	40.4%
o/w local private	13	22.3%	45.5%	50.0%
o/w foreign-owned	25	41.4%	57.3%	65.1%
Banks with international license	**31**	**51.3%**	**79.7%**	**72.1%**

* Allocative efficiency not computed due to incomplete data on inputs.

The calculation of selected Malmquist indices shows that productivity growth of revenues for banks with general license was negative during both periods under consideration (2003-07 and 2006-07). By contrast, productivity in foreign banks with international license advanced by 1 percent a year, which is striking considering that those operating under general licence lost ground. Among the domestic institutions, public banks were able to turn their performance around in the recent past, while private banks saw a continued erosion of revenue productivity.

Panama Productivity Developments

Type of Bank	**2003-07**		**2006-07**	
	No. of banks	Δ TFP Revenue	No. of banks	Δ TFP Revenue
Banks with general license	**30**	**-2.1%**	**35**	**-3.5%**
o/w local public	2	-1.7%	2	+0.5%
o/w local private	11	-2.0%	12	-3.6%
o/w foreign-owned	17	-2.2%	21	-3.8%
Banks with international license	**20**	**+1.0%**	**25**	**+1.0%**

APPENDIX II: YEARLY EFFICIENCY ESTIMATES BY COUNTRY AND BY TYPE OF BANK

Efficiency Estimates By Country

Regr. (5)	2002	2003	2004	2005	2006	2007	**Country Avg.**
Costa Rica	84.3%	82.2%	83.2%	82.9%	83.1%	83.1%	83.1%
Dom. Rep.	85.2%	84.8%	90.2%	75.8%	85.8%	86.3%	84.7%
El Salvador	82.6%	83.4%	79.5%	80.8%	81.1%	83.5%	81.8%
Guatemala	88.2%	89.1%	88.6%	91.2%	91.6%	92.0%	90.1%
Honduras	86.3%	84.6%	81.8%	83.2%	84.6%	78.7%	83.2%
Nicaragua	91.1%	90.4%	91.0%	85.8%	90.0%	90.3%	89.7%
Yearly Avg.	86.3%	85.8%	85.7%	83.3%	86.0%	85.7%	**85.4%**

Regr. (6)	2002	2003	2004	2005	2006	2007	**Country Avg.**
Costa Rica	82.5%	79.2%	80.4%	79.7%	80.8%	79.6%	80.4%
Dom. Rep.	86.6%	89.5%	92.4%	75.4%	86.7%	86.3%	86.2%
El Salvador	81.6%	82.0%	77.5%	78.7%	78.6%	79.9%	79.7%
Guatemala	87.2%	87.9%	86.3%	90.9%	90.2%	91.4%	89.0%
Honduras	89.5%	88.2%	82.6%	83.4%	83.9%	78.5%	84.3%
Nicaragua	91.1%	92.8%	93.1%	90.2%	92.6%	93.2%	92.2%
Yearly Avg.	86.4%	86.6%	85.4%	83.1%	85.5%	84.8%	**84.9%**

Efficiency Estimates By Type of Bank

Regr. (5)	2002	2003	2004	2005	2006	2007	**Type Avg..**
Global	83.5%	83.2%	79.1%	80.7%	82.1%	77.7%	81.1%
Acquired	88.4%	87.5%	86.2%	86.0%	88.3%	87.2%	87.3%
Regional	85.3%	85.2%	84.2%	82.6%	81.4%	84.1%	83.8%
Local	85.5%	85.5%	86.5%	84.3%	87.1%	87.2%	86.0%
Yearly Avg.	86.3%	85.8%	85.7%	83.3%	86.0%	85.7%	**85.4%**

Regr. (6)	2002	2003	2004	2005	2006	2007	**Type Avg..**
Global	82.7%	82.5%	77.5%	78.8%	80.3%	74.9%	79.4%
Acquired	88.5%	87.4%	85.4%	86.9%	87.7%	87.0%	87.2%
Regional	85.7%	85.0%	83.6%	81.5%	80.8%	83.2%	83.3%
Local	86.1%	86.5%	86.1%	83.5%	86.3%	86.2%	85.8%
Yearly Avg.	86.4%	86.6%	85.4%	83.1%	85.5%	84.8%	**84.9%**

Return on Assets and its Correlation with Efficiency Estimates of Regression (5)

	2002	2003	2004	2005	2006	2007	**Correlation**
Costa Rica	1.6	1.9	1.7	2.1	2.0	2.6	-0.36
Dom. Rep.	2.8	2.0	2.6	2.0	2.2	2.3	0.57
El Salvador	1.1	1.1	1.0	1.2	1.5	1.3	0.13
Guatemala	0.8	1.1	1.3	1.6	1.2	1.8	0.76
Honduras	1.1	1.6	1.6	2.0	2.2	2.4	-0.68
Nicaragua	1.9	2.1	2.8	2.6	2.4	2.2	-0.38

Source of return on assets data: IMF Global Financial Stability Report April 2008 and authorities' websites