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EFFICIENCY OF BANKS IN CROATIA: A DEA APPROACH*

by

Igor Jemrić and Boris Vujčić

Abstract

An understanding of a bank's relative efficiency is important for analysts, practitioners and policymakers alike. In this paper, we analyze bank efficiency in Croatia between 1995 and 2000, using Data Envelopment Analysis. We find that foreign-owned banks are on average most efficient, that the new banks are more efficient than the old ones, and that smaller banks are globally efficient but large banks appear to be efficient when we allow for variable returns to scale. We also find that there has been strong equalization in terms of average efficiency in the Croatian banking market, both between and within the peer groups of banks.

JEL: G21, C4

Keywords: envelopment analysis; efficiency frontier; operating approach; intermediation approach; Croatia; banks

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Igor Jemrić and Boris Vujčić

EFFICIENCY OF BANKS IN CROATIA: A DEA APPROACH

1 Introduction

Bank efficiency has been an important issue in transition. All transition countries have been faced with at least one banking crisis, and many with more. In most of the transition countries, the relative comparison of banks by size, type of ownership or date of appearance has at some point been an issue. How good it is to let new banks enter the market? Should the domestic banking sector be sold to foreigners? Do small banks have a future in the era of globalization and banking market consolidation? These, and other questions, continue to dominate discussions in many transition countries. Therefore, an understanding of a bank's relative performance compared to the market, or over a period of time, is important for analysts, practitioners and policymakers alike.

In this paper we analyze bank efficiency in Croatia using Data Envelopment Analysis (DEA). Data Envelopment Analysis is a methodology for analyzing the relative efficiency and managerial performance of productive (or response) units, having the same multiple inputs and multiple outputs. It allows us to compare the relative efficiency of banks by determining the efficient banks which span the frontier. The most important advantage of DEA over traditional econometric frontier studies is that it is a non-parametric, deterministic method and therefore does not require a priori assumptions about the analytical form of the production function. Therefore, the probability of a misspecification of the production technology is zero. The disadvantage is that, being a non-parametric method, it is more sensitive to possible mismeasurement problems.

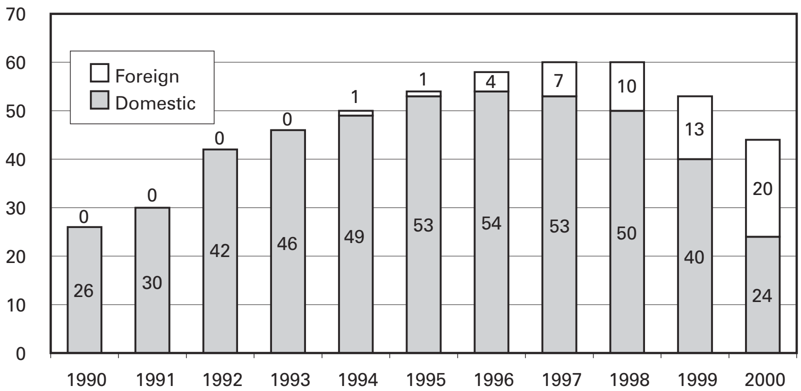
We measured the relative efficiency of banks in the Croatian market according to size, ownership structure, date of establishment and quality of assets in the period from 1995 until 2000. We found that foreign-owned banks are the most efficient on average, that the new banks are more efficient than the old ones, and that smaller banks are globally efficient but large banks appear to be locally efficient. We also found that there has been strong equalization in terms of average efficiency in the Croatian banking market, both between and within the peer groups of banks. Regarding particular inputs, the most significant cause of inefficiency among state-owned and old banks vs. foreign-owned and new ones is the number of employees and fixed assets. In terms of size, the most efficient in various specifications are either the smallest or largest banks, and the technically more efficient banks are those that have, on average, less non-performing loans, but this conclusion becomes more obvious only with the gradual consolidation in the banking sector.

2 Banking Industry Development

After gaining independence in 1990, Croatia already had a two-tier banking system from ex-Yugoslavia. However, it had to rebuild its banking system, establishing new standards of market-based banking practice. During the process, many new commercial banks were established. In Croatia, banks represent by far the most important segment of financial intermediation. Their share in the estimated total balance sheet of financial institutions is almost 90 percent. The number of banks in Croatia was on the rise until 1997 (Figure 1). Barriers to entry were low, as the minimum equity capital to found a bank was about HRK 55 million for a full international license (this was raised with the introduction of the new Banking Law at the end of 1998), which helped the entry of a substantial number of new small banks.

However, the main reason for the successful growth of smaller banks was the high interest rate spread, which allowed many small new banking institutions without the burden of old debts to do business with a large profit. It was only after the rehabilitation process of large state-owned banks had started that the spread came down from 20 percentage points to below 10 percentage points (Figure 2).

Figure 1 Number of banks



Source: Croatian National Bank

Figure 2 Interest rate spread

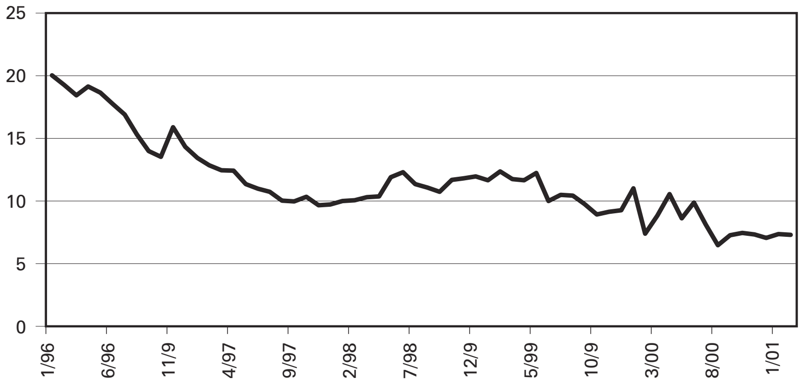


Figure 3 Share in total assets

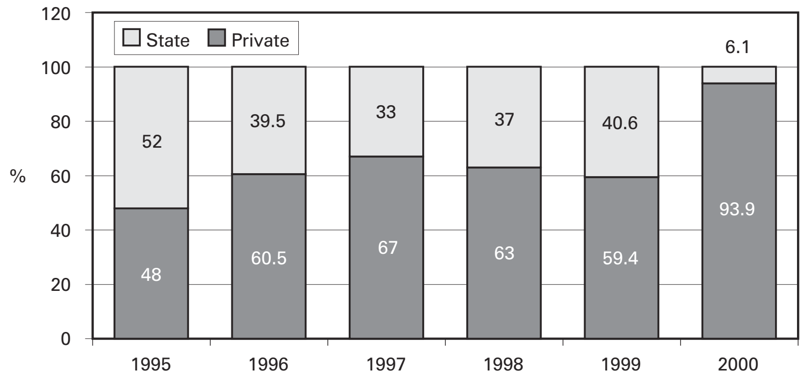
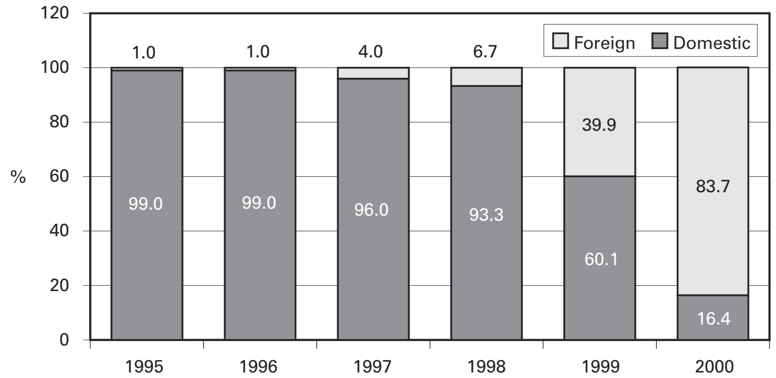


Figure 4 Share in total assets



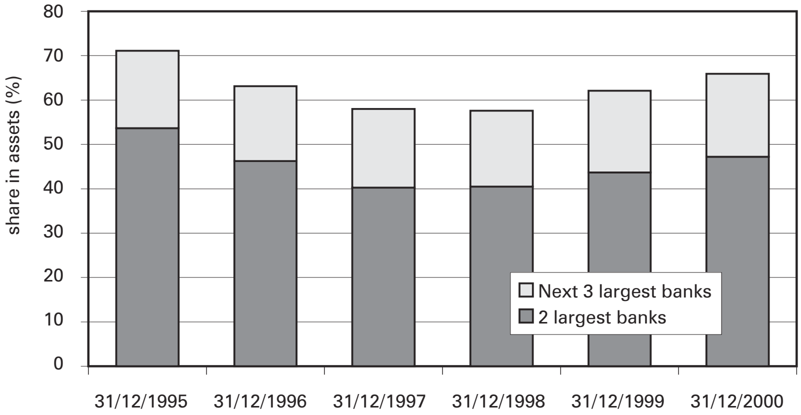
There were 26 banks in Croatia in 1990, but, by the end of 1997, the Croatian banking sector comprised 61 universal banks,[1] of which nine were foreign-owned. Foreign banks started entry relatively late, only after the Dayton peace agreement in 1995, which put an end to the hostilities in Croatia and Bosnia-Herzegovina. The entry of foreign banks, coupled with the exit from the market of some badly managed/undercapitalized banks (since 1998), gradually increased competition in the domestic market. As the high interest rate spreads started to come down, a number of banks experienced difficulties in adjusting to the new conditions and increased competition. During 1998-2000, 13 small and medium-sized banks failed: eleven exited from the market and two were rehabilitated. After these failures, and some mergers and acquisitions, the number of banks fell rapidly. This rapid process of consolidation will continue. Two small banks failed in 2001 and a number of M&As are currently under way.

Since 1995, the ownership structure of the banking industry has substantially changed (Figure 3).

The previously predominant state ownership, when measured by assets, was down to only 6.1 percent at the end of 2000, when only three banks remained majority state-owned. In 1999, however, before the sale of three large rehabilitated banks to foreign strategic owners, the share of state-owned banks was still high – 40.6 percent. An equally dramatic change occurred in the domestic/foreign structure of ownership.

1 There were also 33 saving banks, whose combined assets were less than 1 percent of the total assets of the banking system.

Figure 5 Share of the largest banks in total assets



By 2000, although only 20 banks out of 44 were foreign-owned, 84 percent of the banking system's assets were in the hands of foreign-owned banks (Figure 4), up from only 7 percent in 1998. This rapid change was a consequence of the sale of the largest state-owned banks to foreign owners.

The concentration in the banking sector is high, as is the case in other transition countries of Central and Eastern Europe. The market structure is oligopoly-like. Almost half of total banking deposits, and 47 percent of total assets, belong to the two largest banks. The five largest banks control 65 percent of total assets.

A number of new private banks, unburdened by dubious operations from socialist times, were established in the nineties. However, these banks were financially quite insignificant and did not influence much the main aggregate indicators, including the concentration ratio. Although the loan and deposits growth was faster among these banks, the concentration changed only slowly. The share of the two largest banks fell primarily due to the downsizing of one of them in the rehabilitation process. Since 1998, however, their market share has been on the rise again, in part due to the exit from the market of a number of small and medium-sized banks.

The only efficiency analysis of the Croatian banking system so far is Kraft, Tirtiroglu (1998), which uses the stochastic-cost frontier analysis on the data for 1994 and 1995 and estimates both operating and scale efficiency for old vs. new and state vs. private banks. The results show that the old state-owned banks were more (both operating and scale) efficient than the new ones, although the new banks were highly profitable. The authors ascribe that "abnormality" to free-riding opportunities created by distressed borrowers, limited competition, and start-up difficulties at the new banks.

3 Data Envelopment Analysis

DEA is a methodology for analyzing the relative efficiency and managerial performance of productive (or response) units, having the same multiple inputs and multiple outputs. It allows us to compare the relative efficiency of banks by determining the efficient banks as benchmarks and by measuring the inefficiencies in input combinations (slack variables) in other banks relative to the benchmark. Since the mid-eighties, DEA has become increasingly popular in measuring efficiency in different national banking industries, for example in Sherman and Gold (1985), Rangan et al. (1988), Ferrier and Lovell (1990), Aly et al. (1990), Elyasiani and Medhian (1990), Berg et al. (1993), Brockett et al. (1997), and in many other papers. Leibenstein and Maital (1992) argue that DEA is the superior method for measuring overall technical inefficiency.

Data Envelopment Analysis is a non-parametric, deterministic methodology for determining the relatively efficient production frontier, based on the empirical data on chosen inputs and outputs of a number of entities called Decision Making Units (DMUs). From the set of available data, DEA identifies reference points (relatively efficient DMUs) that define the efficient frontier (as the best practice production technology) and evaluate the inefficiency of other, interior points (relatively inefficient DMUs) that are below that frontier.

Data Envelopment Analysis provides an alternative approach to regression analysis. While regression analysis relies on central tendencies, DEA is based on extremal observations. While the regression approach assumes that a single estimated regression equation applies to each observation vector, DEA analyzes each vector (DMU) separately, producing individual efficiency measures relative to the entire set under evaluation.

The main advantage of DEA is that, unlike regression analysis, it does not require an a priori assumption about the analytical form of the production function. Instead, it constructs the best practice production function solely on the basis of observed data, and therefore the possibility of misspecification of the production technology is zero. On the other hand, the main disadvantage of DEA is that the frontier is sensitive to extreme observations and measurement errors (the basic assumption is that random errors do not exist and that all deviations from the frontier indicate inefficiency).

Among the number of DEA models, we used the two most frequently used: the CCR-model (after Charnes, Cooper, Rhodes, 1978) and the BCC-model (after Banker, Charnes and Cooper, 1984). The main difference between these two models is the treatment of returns to scale: while the latter allows for variable returns to scale, the former assumes that each DMU operates with constant returns to scale.

3.1 CCR-model

Charnes, Cooper and Rhodes introduced a measure of efficiency for each DMU that is obtained as a maximum of a ratio of weighted outputs to weighted inputs. The weights for the ratio are determined by the restriction that the similar ratios for every DMU have to be less than or equal to unity, thus reducing multiple inputs and outputs to a single "virtual" input and single "virtual" output without requiring preassigned weights. The efficiency measure is then a function of the weights of the "virtual" input-output combination. Formally, the efficiency measure for DMU_0 can be calculated by solving the following mathematical programming problem:

$$\max_{u,v} h_0(u,v) = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \tag{3.1}$$

subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad j = 1,2,\ldots, j_0,\ldots, n \tag{3.2}$$

$$u_r \geq 0, \quad r = 1,2,\ldots, s \tag{3.3}$$

$$v_i \geq 0, \quad i = 1,2,\ldots, m, \tag{3.4}$$

where x_{ij} = the observed amount of input of the i_{th} type of the j_{th} DMU ($x_{ij} > 0$, $i = 1,2,...,n$, $j = 1,2,...,n$) and y_{rj} = the observed amount of output of the r_{th} type for the j_{th} DMU ($y_{rj} > 0$, $r = 1,2,...,s$, $j = 1,2,...,n$).

The variables u_r and v_i are the weights to be determined by the above programming problem.[2] However, this problem has an infinite number of solutions since if (u^*, v^*) is optimal then $\alpha\ (\alpha u^*, \alpha v^*)$ is also optimal for each positive scalar. Following the Charnes-Cooper transformation (1962), one can select a representative solution (u, v) for which

$$\sum_{i=1}^{m} v_i x_{i0} = 1 \tag{3.5}$$

to obtain a linear programming problem that is equivalent to the linear fractional programming problem (3.1) – (3.4). Thus, the denominator in the above efficiency measure h_0 is set to equal one and the transformed linear problem for DMU_0 can be written:

$$\max_u z_0 = \sum_{r=1}^{s} u_r y_{r0} \tag{3.6}$$

subject to

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad j = 1,2,\ldots, n \tag{3.7}$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1 \tag{3.8}$$

$$u_r \geq 0, \quad r = 1,2,\ldots, s \tag{3.9}$$

$$v_i \geq 0, \quad i = 1,2,\ldots, m. \tag{3.10}$$

2 In the original model, these variables are restricted to being strictly positive. However, their strict positive sign can be guaranteed by using the infinitesimal to generate the Non-Archimedean ordered extension field, in which its usage guarantees that optimal solutions of the transformed linear program are at finite non-zero extremal points.

For the above linear programming problem,[3] the dual can be written (for the given DMU_0) as:

$$\min_{\lambda} z_0 = \Theta_0 \qquad (3.11)$$

subject to

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}, \quad r = 1,2,\ldots,s \qquad (3.12)$$

$$\Theta_0 x_{i0} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, \quad i = 1,2,\ldots,m \qquad (3.13)$$

$$\lambda_j \geq 0, \quad j = 1,2,\ldots,n \qquad (3.14)$$

Both above linear problems yield the optimal solution Θ^*, which is the efficiency score (so-called technical efficiency or CCR-efficiency) for the particular DMU_0, and efficiency scores for all of them are obtained by repeating them for each DMUj, j=1,2,....,n. The value of Θ is always less than or equal to unity (since when tested, each particular DMU_0 is constrained by its own virtual input-output combination). DMUs for which $\Theta^* < 1$ are relatively inefficient and those for which $\Theta^* = 1$ are relatively efficient, having their virtual input-output combination points on the frontier. The frontier itself consists of linear facets spanned by efficient units of the data, and the resulting frontier production function (obtained with the implicit constant returns-to-scale assumption) has no unknown parameters.

3.2 BCC-model

The absence of constraints for the weights λ_j, other than the positivity conditions in the problem (3.11) – (3.14), implies constant returns to scale. For allowing variable returns to scale, it is necessary to add the convexity condition for the weights λ_j, i.e. to include in the model (3.11) – (3.14) the constraint:

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad (3.15)$$

The resulting DEA model that exhibits variable returns to scale is called the BCC-model, after Banker, Charnes and Cooper (1984). The input-oriented BCC-model for the DMU_0 can be written formally as:

$$\min_{\lambda} z_0 = \Theta_0 \qquad (3.16)$$

3 The problem (3.6) – (3.10) is so-called "input-oriented CCR-model", in which the maximization is oriented toward the choice of "virtual multipliers" (i.e. weights) u and v which produces the greatest rate of "virtual output" per unit of "virtual input". The analogous "output-oriented CCR-model" can be obtained by output (instead of input) normalization used in the Charnes-Cooper linearization.

subject to

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}, \quad r = 1,2,\ldots,s \tag{3.17}$$

$$\Theta_0 x_{i0} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, \quad i = 1,2,\ldots,m \tag{3.18}$$

$$\sum_{j=1}^{n} \lambda_j = 1. \tag{3.19}$$

$$\lambda_j \geq 0, \quad j = 1,2,\ldots,n \tag{3.20}$$

The BCC-efficiency scores are obtained by running the above model for each DMU (with similar interpretation of its values as in the CCR-model). These scores are also called "pure technical efficiency scores", since they are obtained from the model that allows variable returns to scale and hence eliminates the "scale part" of the efficiency from the analysis. Generally, the CCR-efficiency score for each DMU will not exceed the BCC-efficiency score, which is intuitively clear since the BCC-model analyzes each DMU "locally" (i.e. compared to the subset of DMUs that operate in the same region of returns to scale) rather than "globally".

4 Relative Efficiency of the Croatian Commercial Banks

Using both the CCR and BCC models, the relative efficiency of the Croatian commercial banks was measured for the period 1995-2000 (separately for each year). Both DEA models were used under two different approaches in estimating the relative efficiency of the banks: 1) operating approach and 2) intermediation approach. These two approaches reflect two different ways of evaluating bank efficiency: one from the perspective of cost/revenues management, and the other, more mechanical, one which takes banks as entities which use labor and capital to transform deposits into loans and securities.

4.1 Specification of the Data

As a statistical basis for input and output data, the end-of-year balance sheets and financial statements of the Croatian commercial banks were used, as well as survey data on employee numbers. Different sets of input and output data were used for the two approaches in estimating efficiency. For the operating approach, all data were taken from banks' financial statements:

for each (j-th) Decision Making Unit (i.e. for each bank) the input data (x_{ij}) were:

- Input1 (x_{1j}) – interest and related costs,
- Input2 (x_{2j}) – commissions for services and related costs,

- Input3 (x_{3j}) – labor-related administrative costs (gross wages)
- Input4 (x_{4j}) – capital-related administrative costs (amortization, office maintenance, office supplies etc.),

while the output data (y_{ij}) were:

- Output1 (y_{1j}) – interest and related revenues, and
- Output2 (y_{2j}) – non-interest revenues (commissions for provisions of services and related revenues).

For the intermediation approach, three inputs were chosen for each (j-th) bank:

- Input1 (x_{1j}) – fixed assets and software (balance sheet item),
- Input2 (x_{2j}) – number of employees (survey data),
- Input3 (x_{3j}) – total deposits received (balance sheet item),

and two outputs (both being balance sheet items):

- Output1 (y_{1j}) – total loans extended, and
- Output2 (y_{2j}) – short-term securities issued by official sectors – CNB bills and MoF treasury bills.

We excluded from our sample banks that went bankrupt during the analyzed period. It was found that these banks had misreported data to the central bank. Given the fact that DEA is a non-stochastic method, it is particularly sensitive to the problems of mismeasurement. Therefore, the inclusion of these banks into the sample could have seriously undermined the quality of the results.

4.2 Relative Efficiency – Operating Approach

4.2.1 Summary Results

The summary results for the analysis via the operating approach (for both CCR and BCC models) are presented in Table 1. In the table, average efficiency (M) stands for the average of all optimal values Θ_0^* obtained by running separate programs (3.11) – (3.14) (for the CCR-model) or (3.16) – (3.20) (for the BCC-model) for each commercial bank.

Under the constant returns-to-scale assumption, the Croatian financial system in 1995 was characterized by large asymmetry between banks regarding their technical efficiency. Only four (out of 39) banks were efficient in that year, and the average efficiency of the banks was only 0.445. This means that the average bank, if producing its outputs on the efficiency frontier instead of at its current (virtual) location, would have needed only 44.5 percent of the inputs currently being used (or, in terms of average inefficiency, it would have needed 124.6 percent more inputs to produce the same outputs as an efficient bank). Such a figure can be, without doubt, treated as not relatively but absolutely low, since it is among the ten lowest average efficiencies out of 124 obtained from 36 DEA studies of bank efficiency conducted for 11 countries (see Berger and Humphrey, 1997). For comparison, the mean value of average efficiencies obtained from 78 separate measurements of US banks' efficiencies using non-parametric techniques (either Data Envelopment Analysis or Free Disposal Hull approach) was 0.72 (ibid.).

These two facts (the efficiency frontier being spanned by only four entities and relatively low average efficiency) indicate that being relatively efficient in the Croatian

Table 1: Summary results – operating approach

Summary results (CCR-model)						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Number of DMUs:	39	42	45	48	47	43
No. of efficient DMUs:	4	6	12	10	11	8
Average efficiency (M):	0.445	0.658	0.734	0.736	0.793	0.745
Average inefficiency ((1-M)/M):	1.246	0.520	0.362	0.358	0.261	0.343
Standard deviation (sigma)	0.261	0.218	0.195	0.182	0.174	0.180
Interval I = [M-sigma; M+sigma]	(0.18;0.71)	(0.44;0.88)	(0.54;0.93)	(0.55;0.9)	(0.65;0.92)	(0.57;0.93)
Percentage of DMUs in I	74.36%	54.76%	57.78%	60.42%	46.81%	53.49%

Summary results (BCC-model)						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Number of DMUs:	39	42	45	48	47	43
No. of efficient DMUs:	18	16	20	20	17	17
Average efficiency (M):	0.777	0.791	0.844	0.849	0.868	0.852
Average inefficiency ((1-M)/M):	0.287	0.264	0.184	0.178	0.153	0.173
Standard deviation (sigma)	0.252	0.217	0.168	0.166	0.166	0.152
Interval I = [M-sigma; M+sigma]	(0.53;1.03)	(0.57;1.08)	(0.68;1.01)	(0.68;1.02)	(0.70;1.03)	(0.70;1.00)
Percentage of DMUs in I	82.05%	76.19%	80.00%	81.25%	74.47%	86.05%

financial system in 1995 implied an unusual, extreme behavior. Indeed, the four efficient banks were relatively small, newly established private banks.

However, as Table 1 shows, the situation changed in subsequent years. The number of efficient banks rose rapidly, and there was a rapid catch-up towards "normal" levels of efficiency, resulting in a much higher average efficiency of 0.793, and 0.745 in 1999 and 2000 respectively. The only statistical indicator that moved in the opposite direction is the percentage of banks whose efficiency falls within the interval of one standard deviation around the mean. This is, however, mainly a simple mathematical consequence of the fact that efficient units never fall within that interval (and in later years there were more such units than in 1995) and that the interval itself narrowed to 68 percent of its initial size.

If we allow for variable returns to scale (BCC-model), we find much less of a change during the analyzed period. Allowing for variable returns to scale always results in a higher average efficiency because DMUs that were efficient under constant returns to scale are accompanied by new efficient DMUs that might operate under increasing or decreasing returns to scale. Allowing for variable returns to scale reveals the impact of only a few relatively small banks that were spanning the production possibilities frontier under the CCR-model.

However, under both assumptions (of either constant or variable returns to scale) one can conclude that in the six-year transition period the Croatian financial system moved towards the equalization of the banks regarding their technical efficiency. This convergence in the banking market was spurred by increasing competition and the exit of a number of bad banks from the market after 1998.

4.2.2 Structural Insight

Here we classify the Croatian commercial banks into peer groups and present the results separately for each group.

When interpreting the data, it is important to bear in mind that the composition of the peer groups changed over time. Banks moved from one group to the other, and the number of banks changed over the analyzed period. That, together with the nature of the DEA method, makes comparisons of changes in relative efficiency over time sensitive to the changing structure of the banking market.

Table 2: Average efficiency of the banks grouped by size (CCR-model)

Peer		1995	1996	1997	1998	1999	2000
1	Over HRK 5bn	0.24	0.65	0.72	0.66	0.70	0.77
2	HRK 1 – 5bn	0.30	0.63	0.69	0.67	0.78	0.71
3	HRK 0.5 – 1bn	0.29	0.64	0.69	0.76	0.73	0.82
4	Less than HRK 0.5bn	0.54	0.67	0.77	0.79	0.83	0.73

Table 3: Average efficiency of the banks grouped by size (BCC-model)

Peer		1995	1996	1997	1998	1999	2000
1	Over HRK 5bn	0.92	1.00	0.95	1.00	0.99	0.98
2	HRK 1 – 5bn	0.89	0.82	0.86	0.83	0.84	0.85
3	HRK 0.5 – 1bn	0.69	0.70	0.83	0.84	0.75	0.91
4	Less than HRK 0.5bn	0.74	0.77	0.82	0.84	0.89	0.79

The results show that, until 1999, smaller banks were technically the most efficient. The average efficiency of peer groups 1 and 3 reached their maximum at the end of the period, with the largest banks being more efficient than the smallest ones for the first time. At the beginning of the period, the largest banks were overstaffed and burdened with non-performing assets inherited from the previous system. On the other hand, as previously noted, the main reason for the successful growth of smaller banks was a high interest rate spread (as shown in Figure 2), a situation in which many small new banking institutions without the burden of old debts could do business with exceptional profit. There were two main reasons for the high spreads: 1) lending was risky owing to inadequate financial discipline and the lack of an institutional framework to protect the creditors, and 2) there were substantial structural problems in banks regarding operating efficiency and staff efficiency. Once spreads started to come down, after three of the four large banks were rehabilitated and then sold to foreign owners, the situation changed. Thus, the "catch up" of large banks from the position in which they were in 1995 is related to the successful rehabilitation of four banks and their subsequent privatization.

In terms of pure technical efficiency, i.e. allowing for variable returns to scale, the situation looks quite different. Throughout the period, the most efficient banks are the largest ones. Interestingly, the inverse results that we obtained by using the two different models (constant and variable returns to scale) is a common finding for many studies of the banking industry. In the constant returns-to-scale model, smaller banks dominate the frontier (see, for example, Berg et al. 1993), while in the variable returns-to-scale model, frontier banks are on average much larger. Although it appears that the variable returns-to-scale model is a more plausible model for an analysis of the banking industry, it has to be taken into account that peer group 1 consists of only the 3-5 largest banks, and they might appear efficient simply because there is no good reference bank (or group of banks) for them. Therefore, with a relatively small sample of large banks, the concept of local efficiency might be misleading.

Regarding the homogeneity of the peer groups, in general, the smaller the banks are, the less homogeneous they are in their efficiency. Table 4 provides further evidence of the equalization trend in the domestic banking market, as measured by coefficients of variation of average efficiency from within the peer group mean. For peer groups 2-4, a strong process of equalization is evidently present, while within peer group 1, the coefficient of variation remained low throughout the period.

Table 4: Coefficients of variations of the banks grouped by size (CCR)

	Peer	1995	1996	1997	1998	1999	2000
1	Over HRK 5bn	1.176	2.803	3.176	3.100	0.590	2.150
2	HRK 1 – 5bn	7.239	5.916	4.388	3.549	4.328	3.449
3	HRK 0.5 – 1bn	4.654	9.658	4.463	3.293	2.378	4.920
4	Less than HRK 0.5bn	13.753	7.746	8.629	4.723	3.780	4.864

The hypothesis that private banks are more technically efficient than state-owned banks was also tested. Here, the basis for grouping was the dominant type of ownership: banks with more than 50 percent of their capital in government hands were classified as state-owned, with the same principle being applied to classify banks as private domestic or foreign-owned.

Under the constant returns-to-scale model, state banks are constantly the least efficient, which is consistent with the previous finding since three out of four of them are peer group 1 large banks. Foreign-owned banks, on the other hand, are clearly the most efficient under both models, except in 1996 when a small number of them that had just entered the market had high start-up costs and little revenues. However, under both the constant and variable returns-to-scale models, the state-owned banks started to catch up in terms of average efficiency after the rehabilitation process in

Figure 6 Operating efficency by ownership status (CCR-model)

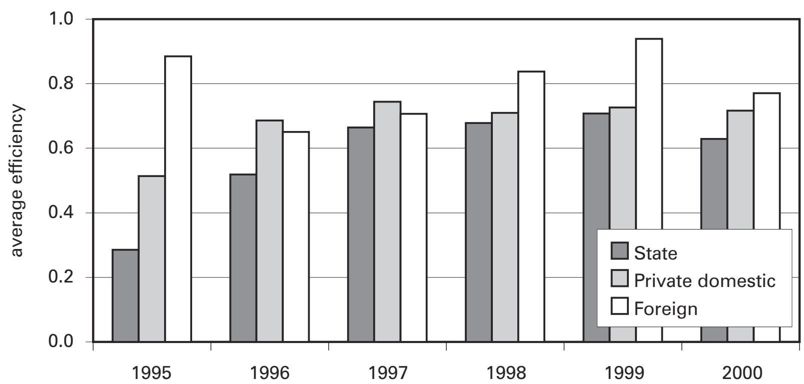
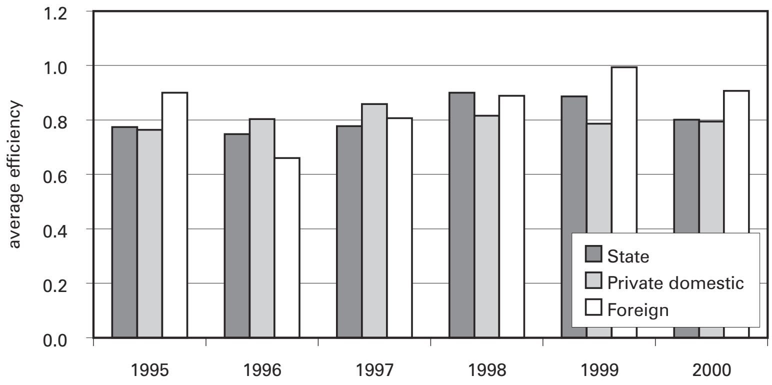


Figure 7 Operating efficency by ownership status (BCC-model)



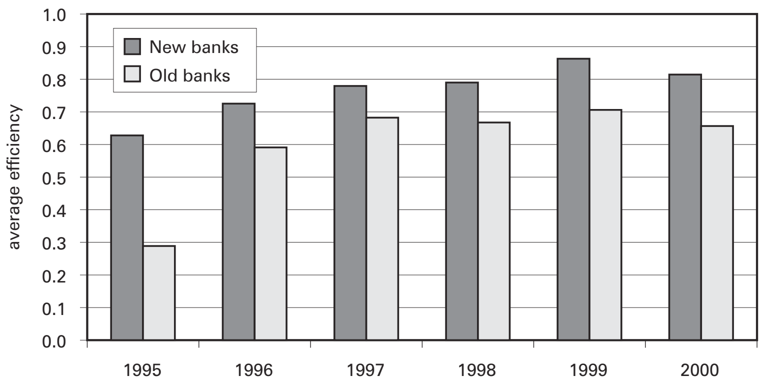
four of them, and, under the variable returns-to-scale model, even became more efficient than the private domestic banks.

We also compared the new and the old banks. Banks established in or after 1990 were treated as new, while those established in or before1989 were treated as old.

Clearly, the new banks were more efficient than the old ones over the whole period. Under the constant returns-to-scale model, again, most of the efficiency equalization took place until 1997. The new banks, however, kept a significantly higher average efficiency throughout the period. The same conclusion can be obtained under the variable returns-to-scale model, although the banks' efficiency is more equal (by the construction of the model) and the difference between the new and old banks' efficiency is less pronounced.

A particular problem for the old banks, as well as for the state-owned banks, were non-performing portfolios dating back to the previous system; however, the scale of this problem was reduced by the rehabilitation of four old state-owned banks. The rehabilitation process in the large state-owned regional banks, whose constant liquidity problems had created high low-risk demand in the money market, helped bring about a substantial decrease in interest rate spreads and thus a more competitive environment. The first rehabilitation process started in 1995 in a regional bank that had suffered the most from the war. In 1996, rehabilitation was initiated in two other regional banks; both of them received liquidity injections and had their bad assets carved out. Finally, at the beginning of 1997, rehabilitation was initiated in the country's second largest bank. However, the final restructuring of the rehabilitated banks

Figure 8 Operating efficency by age (CCR-model)



(business focus, staff reductions, and so on) is still under way after they were taken over by foreign owners.

4.3 Relative Efficiency – Intermediation Approach

An interesting finding appears from the above efficiency analysis of the Croatian banking system: it seems that the most efficient banks are either the smallest or the largest while, on average, the most slippery territory appears to belong to medium-sized banks. Another often used specification of the efficiency measurement in DEA models hints at this conclusion even more than the above results do. Here we present the results of what might be called the measurement of intermediation efficiency. The idea is to look more mechanically at what banks do. Under the "pure" intermediation approach, banks use labor, capital and deposits in order to produce loans and other investments. The actual production process is a black box whose efficiency is simply judged by the amount of output produced from a certain amount of input.

4.3.1 Summary Results

First we present the summary results of the analysis for both the CCR and BCC models in Table 4 (the meaning of average efficiency (M) is analogous to that in Table 1 for the operating approach).

As the previous approach, this one confirms the gradual equalization of efficiency in the Croatian banking market, although the trend is much less visible. For both models, the average efficiency is lower over the whole period than in the operating approach, and the number of efficient banks is half of that obtained in the operating ap-

Table 5: Summary results – intermediation approach

Summary results (CCR-model)						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Number of DMUs:	39	42	45	48	47	43
No. of efficient DMUs:	2	2	5	7	8	5
Average efficiency (M):	0.429	0.336	0.450	0.517	0.629	0.505
Average inefficiency ((1-M)/M):	1.332	1.973	1.222	0.933	0.589	0.979
Standard deviation (sigma)	0.249	0.216	0.229	0.261	0.228	0.269
Interval I = [M-sigma; M+sigma]	(0.18;0.68)	(0.12;0.55)	(0.22;0.68)	(0.26;0.78)	(0.40;0.86)	(0.24;0.77)
Percentage of DMUs in I	79.49%	80.95%	77.78%	66.67%	65.96%	67.44%

Summary results (BCC-model)						
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Number of DMUs:	39	42	45	48	47	43
No. of efficient DMUs:	10	11	12	12	16	15
Average efficiency (M):	0.614	0.602	0.656	0.686	0.748	0.659
Average inefficiency ((1-M)/M):	0.630	0.662	0.524	0.457	0.337	0.518
Standard deviation (sigma)	0.265	0.289	0.264	0.261	0.234	0.303
Interval I = [M-sigma; M+sigma]	(0.35;0.88)	(0.31;0.89)	(0.39;0.92)	(0.43;0.95)	(0.51;0.98)	(0.36;0.96)
Percentage of DMUs in I	53.85%	57.14%	53.33%	43.75%	48.94%	39.53%

proach in almost all years. Therefore, being efficient in the Croatian banking business was more unusual from the intermediation point of view.

4.3.2 Structural Insight

In both model specifications, the average efficiency among peer groups is U-shaped in many years, i.e. the largest, or smallest, banks were the most efficient in using their inputs to produce outputs, while the medium-sized banks were often less efficient.

However, the relative inefficiency of the medium-sized banks might be attributable more to many of them being regional banks than to their size, with their efficiency problems arising from the environment in which they operate. On the other hand, the smallest banks are often niche banks. Being a small bank, however, does not

Figure 9 Intermediation efficiency by size (CCR-model)

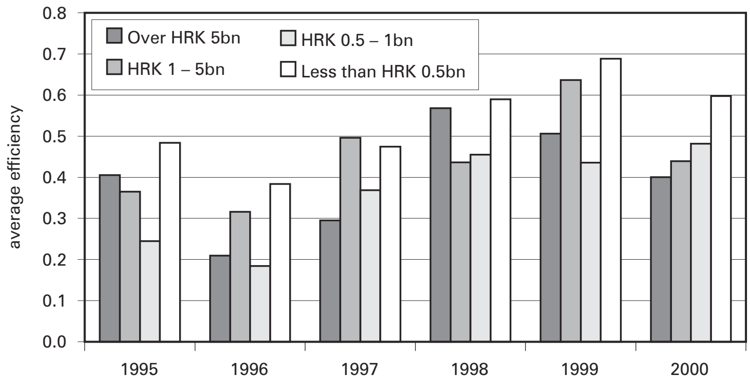
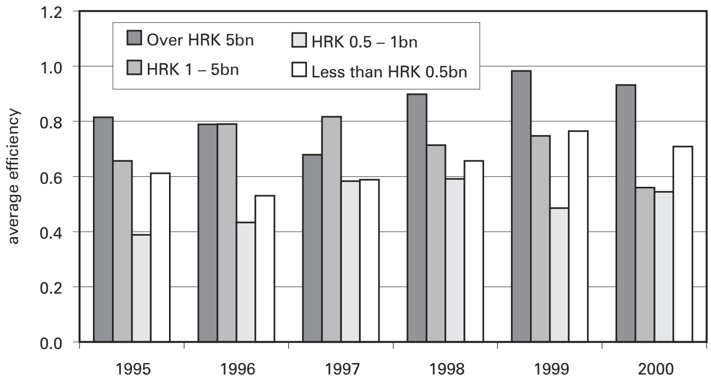


Figure 10 Intermediation efficiency by size (BCC-model)

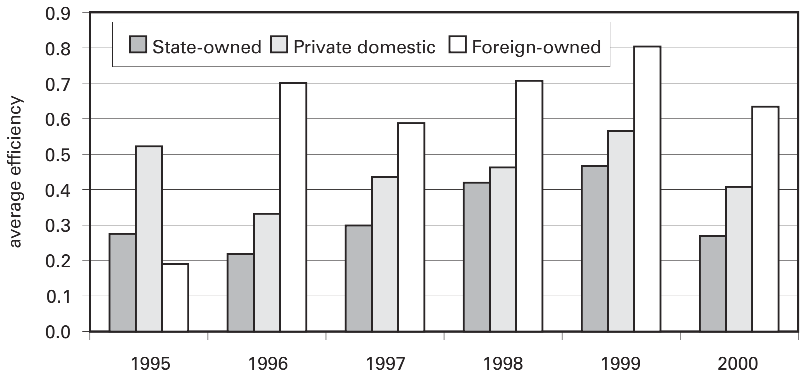


guarantee relative efficiency, as the coefficient of variation of efficiency scores in that group is relatively high.

The intermediation approach confirms the findings on the relative efficiency of new/old and state/private/foreign banks. Since both models support the same conclusions, in the rest of the paper we present figures only for the CCR-model.

Under the intermediation approach, the foreign-owned banks were even more efficient relative to the private domestic and state-owned banks than was the case when costs and revenues were taken as inputs and outputs. In other words, except in 1995 when there was only one foreign-owned bank, the foreign-owned banks were able to produce an equal amount of output (loans and securities) from much less input (fixed capital, labor and deposits) than the other banks. The intermediation approach thus

Figure 11 Intermediation efficiency by ownership status (CCR-model)



emphasizes the dominant position of the foreign-owned banks relative to the other banks in the market. Again, equalization is observable over time. Under the constant returns-to-scale model, the state-owned banks demonstrated a rapid improvement in average efficiency relative to the other banks after the rehabilitation process started in 1996. In 2000, after being privatized, the three largest state-owned banks joined the group of foreign-owned banks. This caused a modest decline in the average efficiency of that peer group and a much more pronounced decline in the average efficiency of the state-owned banks (of which only three remained in 2000).

In terms of bank age, the intermediation approach emphasizes the superior performance of the new banks relative to the old ones. Again, it demonstrates the catch-up of the old banks to the new ones before the privatization of three state-owned banks, with the same kind of post-privatization effect on the two peer groups as in the case of state-owned vs. foreign-owned banks.

Regarding particular inputs, the DEA analysis suggests that the most significant cause of inefficiency among state-owned and old banks vs. foreign-owned and new ones is the number of employees and fixed assets. Both at the beginning and at the end of the period, between one-half and two-thirds of the inefficient banks had excess labor and too high costs of fixed assets.

Finally, we look at the intermediation efficiency of banks grouped by percentage of zero-risk assets. We did the same for technical efficiency but do not present the results here, as the conclusions are the same as for intermediation efficiency. With the exception of the first two years, when the picture was somewhat mixed, the results

Figure 12 Intermediation efficiency by age (CCR-model)

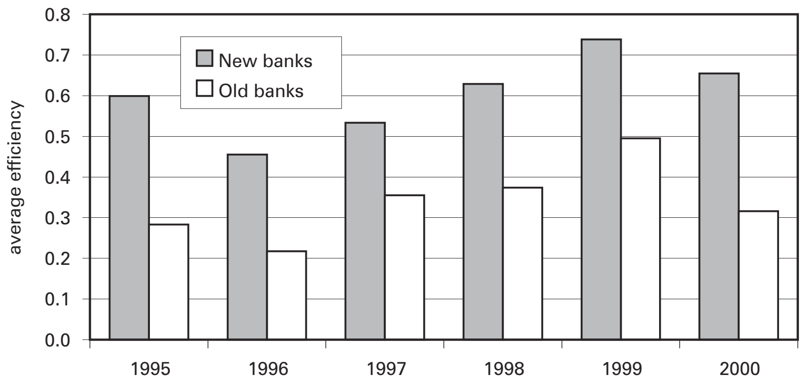
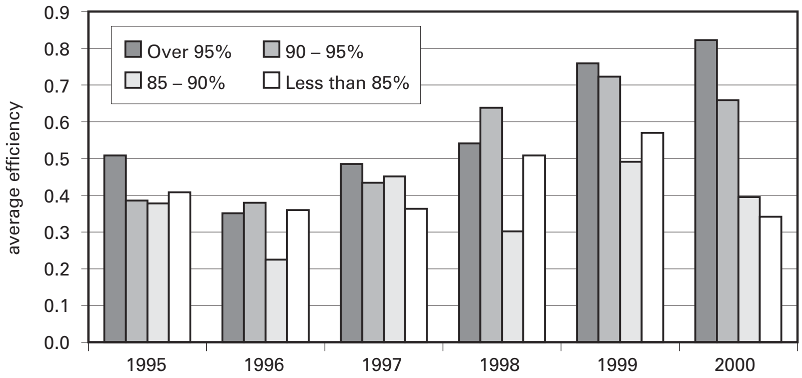


Figure 13 Intermediation efficiency by zero-risk assets (CCR-model)



show that the more efficient banks are also those that have, on average, more zero-risk assets. This conclusion becomes more evident as we move towards the end of the analyzed period.[4]

This finding may be interpreted as suggesting that, in spite of the process of equalization in the banking industry, there is still a group of banks with a relatively high proportion of non-performing loans and low level of efficiency. It might become difficult for these banks to withstand the challenges of an increasingly competitive environment. The fact that two banks that belonged to the rightmost peer group in 2000 in Figure 13 failed in 2001 confirms the validity of such a conclusion.

5 Conclusions

We used Data Envelopment Analysis to analyze the efficiency of the banks in the Croatian banking market in the period 1995-2000, years for which relatively reliable bank balance sheets are available and in which the macroeconomic environment was stable.

Overall, the analysis leads to the conclusion that the foreign-owned banks are on average the most efficient, and that the new banks are more efficient than the old ones. A particular problem for the old banks, as well as for the state-owned banks, were non-performing portfolios dating back to the previous system; this problem improved with the rehabilitation of the large old state-owned banks. The rehabilitation process in the large state-owned banks not only improved their efficiency but also contributed to a substantial decrease in interest rate spreads and thus a more competitive environment in the banking market.

In terms of size, the smaller banks are globally efficient, but the large banks appear to be locally efficient. The question remains whether the frontier is adequately spanned for the small number of largest banks. Another conclusion is that there has been strong equalization in terms of average efficiency in the Croatian banking market since 1995. This conclusion is supported by the fact that, under the constant returns-to-scale assumption, the large banks, which started with approximately 45 percent of the smallest banks' average efficiency in 1995, became somewhat more efficient than the smallest banks in 2000. In the case of state-owned and old banks, they

4 The last couple of years were also the years in which reporting of the asset quality to the CNB was best.

started with 32 percent and 46 percent of foreign-owned and new bank's efficiency, respectively, and ended up in 2000 with 81 percent and 82 percent of their efficiency, respectively. The process of equalization also took place within the peer groups, as measured by coefficients of variation of average efficiency from the peer group mean.

It appears that the most efficient in various specifications are either the smallest or largest banks. On average, the most slippery territory appears to be the one in which medium-sized banks operate. It might be that the middle-sized banks' relative inefficiency is actually attributable more to the fact that many of these banks are regional banks than to their size, with their efficiency problems arising from the environment in which they operate. On the other hand, the smallest banks are often niche banks. However, being a small bank does not guarantee relative efficiency, as the coefficient of variation of efficiency scores is highest in that group, and as a number of banks in that group failed in the recent past.

Regarding particular inputs, the DEA analysis suggests that the most significant cause of inefficiency among state-owned and old banks vs. foreign-owned and new ones is the number of employees and fixed assets. Under different specifications both at the beginning and at the end of the period, between one-half and two-thirds of the inefficient banks had excess labor and too high costs of fixed assets.

Finally, the results also show that the technically more efficient banks are also those that have, on average, less non-performing loans. This is true for both the operating and intermediation approaches. In the years prior to the banking crisis, this correlation was somewhat blurred, but as we move towards the end of the analyzed period, i.e. as the situation in the banking sector consolidates, that conclusion becomes increasingly evident. However, in spite of the consolidation and equalization in the banking market, there is still a group of banks with a high level of non-performing loans and low technical efficiency.

What we have empirically shown on the Croatian example is that some of the typical transition questions appear to have easy answers. Private banks are more efficient than state-owned banks, and foreign-owned banks are more efficient than domestic ones. Therefore, the decision to privatize and let foreign-owned banks enter the market was a right one. The new owners introduce new production methods and optimize the use of inputs. As a result, efficiency rises and the interest rate spread narrows. The weaker banks cannot withstand the increased competition and either exit from the market or become targets of other banks. Keeping state ownership of the banking sector, keeping foreigners out of the domestic market or keeping afloat weak banks prevents consolidation in the banking market. The consequence is lower efficiency in the banking sector. That, in turn, hurts the real sector of the economy and hampers growth through a higher interest rate spread and an inferior supply of banking products. We have shown how, free from interference, the market brings equalization in efficiency through competitive pressure. It eliminates weak banks and improves the operation of the remaining market participants. In a competitive banking market, low average (relative) efficiency is simply not a viable equilibrium.

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