Current Issues in

Emerging Market Economies

Organised by the Croatian National Bank

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Efficiency of Banks in Transition:

A DEA Approach

Hotel "Argentina", Dubrovnik
June 28 - 30, 2001

Draft version
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Efficiency of Banks in Transition: A DEA Approach

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- preliminary draft -

Dubrovnik, June 2001

Views expressed in this paper are those of the authors, and do not necessarily reflect views of the Croatian National Bank.

I. Introduction

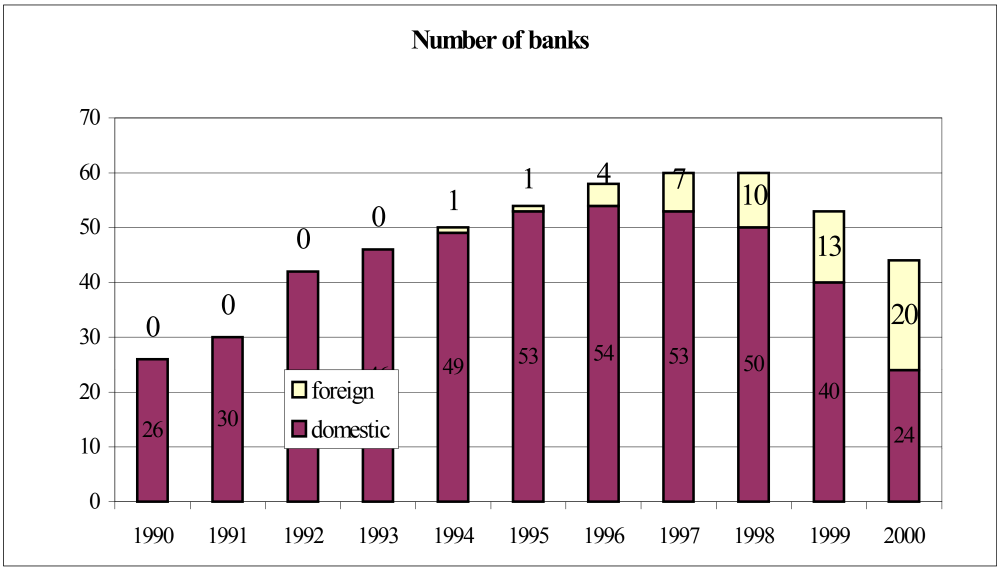
Bank efficiency has been an important issue in transition. All transition countries have been faced with at least one banking crisis, and many with more. In most of the transition countries the question of relative comparison of banks by size, type of ownership or date of appearance has at some point been an issue, or will become an issue in the near future. How good it is to let new banks into the market; should the domestic banking sector be sold to the foreigners; do small banks have a future in the era of globalization and banking market consolidation, etc. These, and others, are all questions which continue to dominate discussions in many transition countries. For most advanced transition countries, the question of how competitive their banks are compared to the EU banks has become an important issue as they get ready to enter the EU market. 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. Apart from the traditional analysis of financial statements of the banks, a most common way to tackle the issue was to use an econometric approach to measure various aspects of bank efficiency in a multi bank environment. Well known studies include. In Croatia, the first study, and so far the only one is by Kraft and Tirtiroglu (1998) which uses stohastic frontier function to estimate efficiency of Croatian banks in 1994-95.

We use a Data Envelopment Analysis (DEA) to analyze efficiency of the banks in Croatian banking market. 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. We use two major DEA models: (1) the CCR ratio model (constant returns to scale); and (2) the BCC model (which allows for variable returns to scale). DEA allows us to compare 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 mid-eighties, DEA has become increasingly popular in measuring efficiency in different national banking industries, as 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. In Leibenstein and Maital (1992) has even been argued that DEA is the superior method for measuring overall technical inefficiency.

We segment the banking market according to the following criteria: bank size, ownership structure, date of the establishment and quality of assets. We use data on Croatian banks in a period from 1995 until 2000, the years for which relatively reliable bank balance sheets are available, and a period in which macroeconomic environment has been stable. That relatively short period, however, as is often the case in transition countries, encompasses three distinct sub-periods:.a period of high economic growth, coupled by an increase in number of banks and their balance sheets (boom phase), a period of slowdown/stagnation in which economic growth stalled, and number of banks went bankrupt; and a period of economic recovery, and banking market consolidation/internationalization.

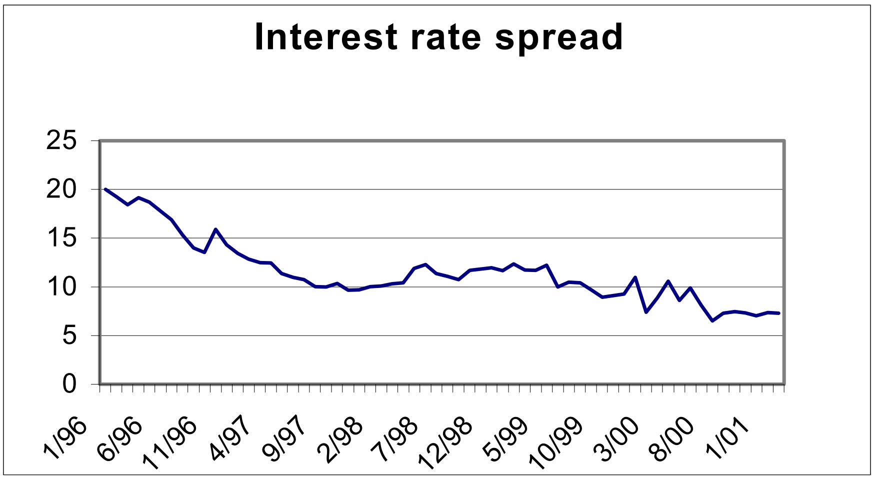
2. Banking industry development

After gaining independence in 1990, preceding and along the stabilization effort, Croatia 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 per cent. The number of banks in Croatia has been rising 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 has been raised with the introduction of the new Banking Law at the end of 1998). That has 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 spread of the interest rates, a situation in which many small new banking institutions without the burden of old debts could do business with large profit. In a period 1995-1997 spread was very high. It was only after the rehabilitation process of large state-owned banks had started that the spread came down from 20 percentage points level, to below 10 percentage points (Figure 2).

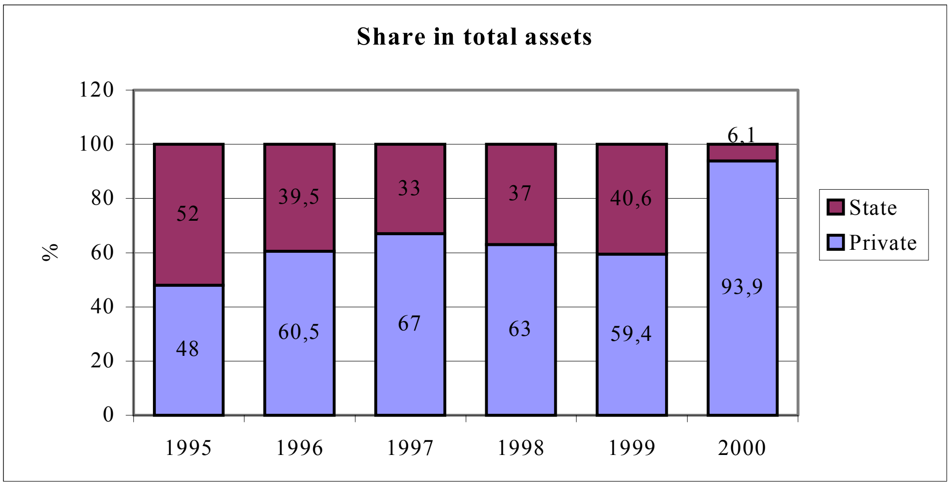
Another reason for the emergence of new small and private banks was the fact that larger state-owned banks did not service well the whole market, but were rather concentrated on the large old clients. Thus, new banks had some positive role to play in the market. Almost all new banks were private.

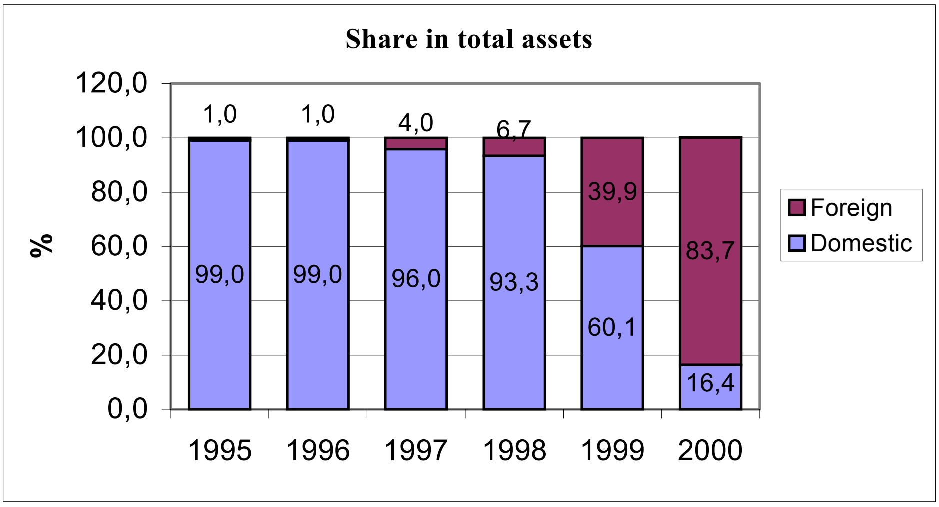


In 1990 there were 26 banks in Croatia, but by the end of 1997, Croatian banking sector already comprised of 61 universal banks[1], of which nine were foreign owned. As can be observed from the graph, as opposed to other transition countries of Central and Eastern Europe, foreign banks started entry only after the Dayton peace agreement in 1995, which has put an end to the hostilities in Croatia and Bosnia and Herzegovina. Entry of foreign banks, coupled with the exit from the market of some badly managed/undercapitalized banks (since 1998), has gradually increased competition in the domestic market. Banks had to start with serious restructuring in order to meet the challenges of changing market circumstances. Since the very high interest rate spreads have started to come down, some banks have experienced difficulties in adjusting to the new conditions and increased competition.

During 1998-2000 period 13 small and medium sized banks failed. Eleven of them exited from the market, and two were rehabilitated. After those failures, and some mergers and acquisitions that took place in late nineties, number of banks fell rapidly. This rapid process of consolidation will continue. Two small banks failed in 2001 and, after a number of M&As which are under way, will be completed, number of banks will fall further. That, however does not necessarily mean that small banks will be wiped out of the market; some will find their niche in the market, while others will merge among themselves or with larger banks.

[1] There were also 33 saving banks, whose combined assets were less than 1 per cent of total assets of the banking system.

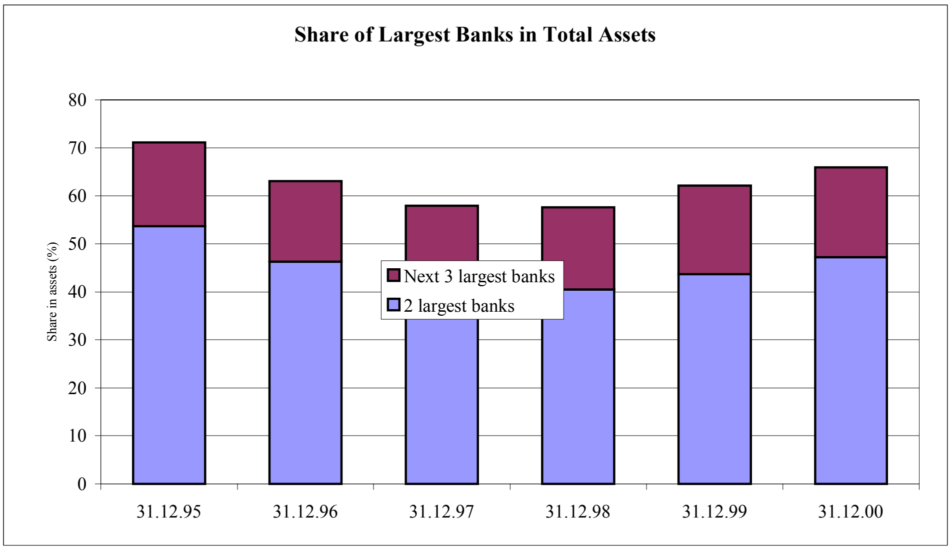




Since 1995, ownership structure of the banking industry has substantially changed (Figure 2). Previously predominant state ownership, when measured by assets is down to only 6.1 per cent at the end of 2000, when only three banks remained majority state-owned. In 1999, however, before a sale of three large rehabilitated banks to foreign strategic partners, the share of state owned banks was still high - 40.6 per cent. Equally dramatic change has happened when we look at the domestic/foreign structure of ownership. By 2000, although only 20 banks out of 44 were foreign owned, measured by assets 84 per cent of the banking system was already in hands of foreign owned banks (Figure 3). Speed of change is reflected in a fact that this was up from only 7 per cent in 1998. Such a speed of structural change in the banking market is, however, not surprising in transition countries. It comes with a sale of largest state owned banks to foreign owners, usually after the rehabilitation process has been completed.

2.1. Market concentration ratio

The concentration in the banking sector is high, as is the case in other transition countries of the central and east Europe. Market structure is oligopoly-like. Although the number of banks is still high for the size of the market, there is a high concentration in the banking industry and almost one-half of total banking deposits, and 47 per cent of assets belong to the two largest banks, Privredna and Zagrebačka bank. Zagrebačka bank has a majority private (and foreign) ownership and is listed on the London Stock Exchange, while Privredna bank was rehabilitated and sold to a foreign strategic partner (Italian BCI). Next three largest banks have approximately 18 per cent of assets, i.e., the five largest banks control 65 percent of total assets.



As shown earlier, a number of new private banks, unburdened by dubious operations from socialist times have been established in nineties. However, these banks were financially quite insignificant and did not influence much main aggregate indicators, including the concentration ratio. Although the loan and deposits growth was faster among those banks, the concentration was only slowly changing. The share of two largest banks fell primarily because one of them was downsized in the rehabilitation process. Since 1998, however, their market share is on the rise again, in part due to the exit from the market of a number of small and medium sized banks from the market. The largest bank alone controls somewhat less than a third of the market assetwise.

3. Model

In a view of banking activity as a transformation of particular set of inputs (e.g. capital, labor, deposits etc.) into a particular set of outputs (e.g. loans, securities etc.), the relative efficiency of banks can be analyzed by using Data Envelopment Analysis (DEA). DEA is a non-parametric, deterministic methodology for determining 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 identify 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.

Compared to the regression analysis, data envelopment analysis provides an alternative approach. While regression analysis relies on central tendencies, the DEA is based on extremal observations; while in the regression approach a single estimated regression equation is assumed to apply to each observation vector, DEA analyze each vector (DMU) separately, producing individual efficiency measures relative to the entire set under evaluation.

The main advantage of DEA is that, unlike the regression analysis, it does not require 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 minimized.

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 number of DEA models, we use two most frequently used ones: CCR-model (after Charnes, Cooper, Rhodes, 1978) and BCC-model (after Banker, Charnes and Cooper, 1984).

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 a restriction that the similar ratios for every DMU have to be less than or equal to unity, thus reducing multiple inputs and outputs to single "virtual" input and single "virtual" output without requiring preassigned weights. The efficiency measure is then a function of weights of the "virtual" input-output combination. Formally the efficiency measure for the 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

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

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

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

where x_{ij} = the observed amount of input of the ith type of the jth 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 infinite number of solutions since if (u*,v*) is optimal then for each positive scalar α (αu*,αv*) is also optimal. 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, 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

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

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

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

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

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

[2]In the original model, those variables are restricted to be 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.

[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

$$\min_{\lambda} z_0 = \Theta_0 \tag{3.11}$$

subject to

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}, \qquad r = 1,2,...,s \tag{3.12}$$

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

$$\lambda_j \geq 0, \qquad j = 1,2,...,n \tag{3.14}$$

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 repeating them for each DMU_j, j=1,2,....,n efficiency scores for all of them are obtained. The value of Θ is always less then or equal unity (since when tested, each particular DMU_0 is constrained by its own virtual input-output combination too). DMUs for which $\Theta^* < 1$ are relatively inefficient and those for which $\Theta^* = 1$ are relatively efficient, having their virtual input-output combination points laying 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

Since there are no constraints for the weights λ_j, other than the positivity conditions in the problem (3.11) - (3.14), it 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:

$$\sum_{j=1}^{n} \lambda_j = 1. \tag{3.15}$$

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

$$\min_{\lambda} z_0 = \Theta_0 \tag{3.16}$$

subject to

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rate of "virtual output" per unit of "virtual input" The analogous "output-oriented CCR model" can be

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

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

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

$$\lambda_j \geq 0, \qquad j = 1,2,...,n \tag{3.20}$$

Running the above model for each DMU, the BCC-efficiency scores are obtained (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 eliminate the "scale part" of the efficiency from the analysis. Generally, for each DMU the CCR-efficiency score will not exceed the BCC-efficiency score, what is intuitively clear since in the BCC-model each DMU is analyzed "locally" (i.e. compared to the subset of DMUs that operate in the same region of returns-to-scale) rather than "globally".

Following the scale properties of the above two models, [Cooper et al, 2000] give the definition of scale efficiency: for a particular DMU the scale efficiency is defined as a ratio of its overall technical efficiency score (measured by the CCR-model) and pure technical efficiency score (measured by the BCC model). This definition is also used in our empirical analysis of the scale efficiency of the Croatian banks.

4. Specifications and Data

Using both the CCR and BCC models, the efficiency of the Croatian commercial banks is measured for the period 1995-2000 (separately for each year). Both DEA models are used under two different approaches in estimating relative efficiency of the banks: 1) operating approach, and 2) intermediation approach.

Two approaches that we use reflect two different ways in which efficiency of banks can be evaluated. 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.

As a statistical basis for input and output data, both end-of-year balance sheets and financial statements of Croatian commercial banks are used, as well as survey data on number of employees.

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obtained by output (instead of input) normalization used in the Charnes-Cooper linearization.

Different sets of input and output data are used for the two approaches in estimating efficiency. For the operating approach all data are taken from banks' financial statements. The input data are:

Input1 - interest and related costs
Input2 - commissions for services and related costs,
Input3 - labor related administrative costs (gross wages)
Input4 - capital related administrative costs (amortization, office maintenance, office supplies etc.),
while the output data are:
Output1 - Interest and related revenues and
Output2 - non-interest revenues (commissions for provisions of services and related revenues).

For the intermediation approach three inputs are chosen:

Input1 - fixed assets and software (balance sheet item),
Input2 - number of employees (survey data),
Input3 - total deposits received (balance sheet item),
and two outputs (both being balance sheet items):
Output1 - total loans extended and
Output2 - short-term securities issued by official sectors - CNB bills and MoF treasury bills .

We exclude from our sample banks that went bankrupt during the analyzed period. It has been found that those banks have misreported data to the central bank. Given the fact that DEA is a non-stohastic method, it is particularly sensitive to the problems of mismeasurement. Therefore, inclusion of those banks into the sample could seriously undermine the quality of the results.

5.Results

5.1. Operating approach

The summary results for the analysis via operating approach are presented in Table 1.

Table 1. Summary results of the 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; 0,92)	(0,65; 0,97)	(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%

Under the constant returns to scale (CRS) assumption in 1995 the Croatian financial system was characterized with 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. That 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 % of the inputs currently being used (or, in terms of average inefficiency, it would have needed 124,6 % more inputs to produce the same outputs as an efficient bank). Such a figure can be, without doubts, treated as not relatively but absolutely low, since it is among ten lowest average efficiencies out of 124 obtained from 36 different DEA studies of banks' efficiency that were conducted for 11 different countries (see Berger and Humphrey, 1997). For the comparison, the mean value of average efficiencies obtained from 78 separate measurements of US banks' efficiencies by using nonparametric techniques (either Data Envelopment Analysis or Free Disposal Hull approach) was 0.72 (ibid.).

Those two facts (the efficiency frontier being spanned by only four entities and relatively low average efficiency) indicate that in 1995 being relatively efficient in the Croatian financial system implied an unusual, extreme behavior. Indeed, it appeared that those four efficient banks were relatively small, newly established private banks.

However, as Table 1 shows, in subsequent years the situation has changed. The number of efficient banks rose rapidly, resulting in more than a quarter of all banks being efficient in 1997, and much higher average efficiency, catching up to the "normal" level of 0.793, and 0.745 respectively in 1999 and 2000. The only statistical indicator that has 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 of such units then in 1995) and that the interval itself narrowed to 68 % 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 (VRS) always results in a higher average efficiency because DMUs that were efficient under the constant returns to scale (CRS) are accompanied by new efficient DMUs that might operate under the increasing, or decreasing returns to scale. Introducing VRS demonstrates the impact of the fact that only few relatively small banks were spanning the production posibilities frontier under the CCR model.

Both under the CRS and VRS assumption one can, however, conclude that in the six-year transition period the Croatian financial system has moved towards the equalization of the banks regarding their technical efficiency. This convergence in the banking market was spurred by increasing competition, and helped by exit of a number of bad banks from the market after 1998.

Following table compares results that we have obtained for Croatia with existing results from other country studies published until 1997. It must be noted that for some countries results exist for various years and both CCR and BCC models, while for other countries there are only one model, or couple of years results.

Country	**Average efficiency**	**Country**	**Average efficiency**
Croatia	0.45 - 0.87	Mexico	0.69 - 0.75
Denmark	0.80 - 0.85	Norway	0.47 - 0.89
Finland	0.80 - 0.86	Spain	0.81 - 0.85
India	0.75 - 0.86	Switzerland	0.56
Italy	0.73 - 0.98	Turkey	0.83 - 0.94
Japan	0.44 - 0.86	US	0.33 - 0.97

Source for other countries: Berger and Hmphrey (1997)

Structural Insight

Here, Croatian commercial banks are classified into peer groups (according to the size of their total assets, ownership status, date of establishment, and quality of assets) and the results are presented separately for each group.

Following the above classification, data on average technical efficiency for each peer group are presented.

Table 2. Average efficiency of the banks grouped by their size (CCR model)

Peer		1995	1996	1997	1998	1999	2000
1	over 5 bln HRK	0,24	0,65	0,72	0,66	0,70	0,77
2	1 - 5 bln HRK	0,30	0,63	0,69	0,67	0,78	0,71
3	0,5 - 1 bln HRK	0,29	0,64	0,69	0,76	0,73	0,82
4	less than 0,5 bln	0,54	0,67	0,77	0,79	0,83	0,73

Table 3. Average efficiency of the banks grouped by their size (BCC model)

Peer		1995	1996	1997	1998	1999	2000
1	over 5 bln HRK	0,92	1,00	0,95	1,00	0,99	0,98
2	1 - 5 bln HRK	0,89	0,82	0,86	0,83	0,84	0,85
3	0,5 - 1 bln HRK	0,69	0,70	0,83	0,84	0,75	0,91
4	less than 0,5 bln	0,74	0,77	0,82	0,84	0,89	0,79

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

Table: Number of banks in each peer group

	1995	1996	1997	1998	1999	2000
Peer Group 1	3	3	4	4	4	5
Peer Group 2	8	10	12	16	15	13
Peer Group 3	4	4	6	7	5	8
Peer Group 4	24	25	24	21	23	17

The results show that, until the last year, smaller banks were technically most efficient. Average efficiency of peer groups I and III, has reached its maximum at the end of the period, largest banks being more efficient than smallest ones for the first time. At the beginning of the period 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 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 high spreads: 1) lending was risky owing to inadequate financial discipline and the lack of an institutional framework to protect the creditors, and 2) substantial structural problems in banks regarding the operating efficiency and staff efficiency. Once spreads have start to come down, after three out of four large banks were rehabilitated and sold to foreign strategic partners, the situation changed. Thus, the "catch up" of large banks from the position in which they were in 1995, is related to the successfully conducted process of rehabilitation of four banks and their subsequent privatization.

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

Coefficients of variations of the banks grouped by their size (CCR model)							
Peer		**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1	over 5 bln HRK	1,176	2,803	3,176	3,100	0,590	2,150
2	1 - 5 bln HRK	7,239	5,916	4,388	3,549	4,328	3,449
3	0,5 - 1 bln HRK	4,654	9,658	4,463	3,293	2,378	4,920
4	less than 0,5 bln	13,753	7,746	8,629	4,723	3,780	4,864

Regarding the homogeneity of the peer groups, in general, the smaller the banks are, the less homogeneous they are in their efficiency. The above table provides further evidence of a trend of equalization 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 the peer group 1, coefficient of variation remained low throughout the period.

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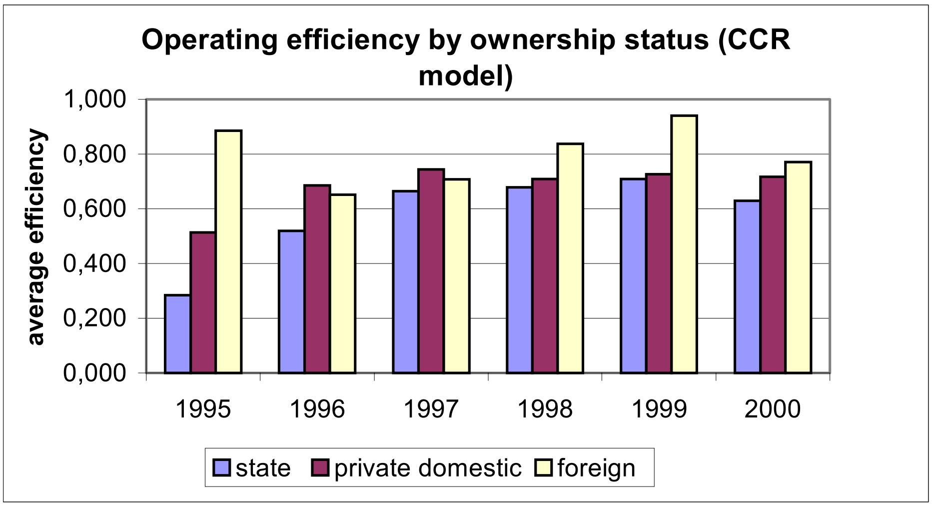
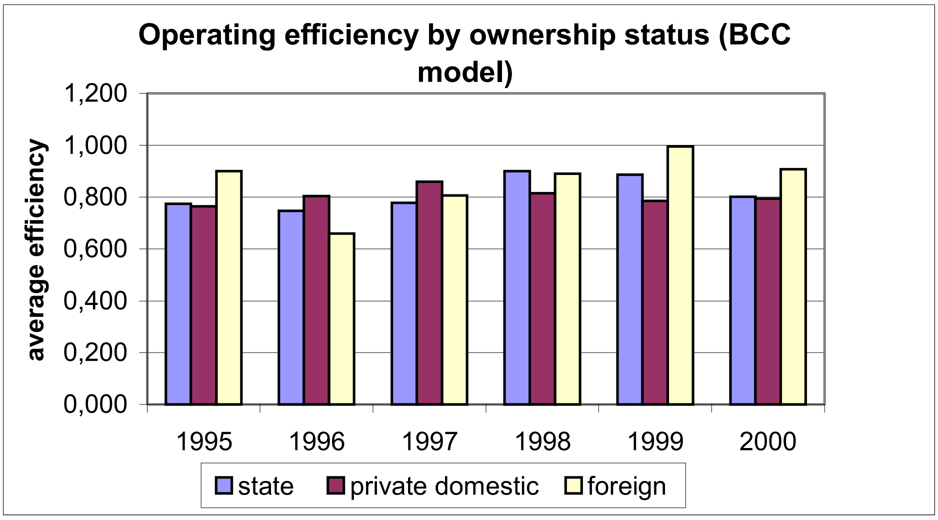
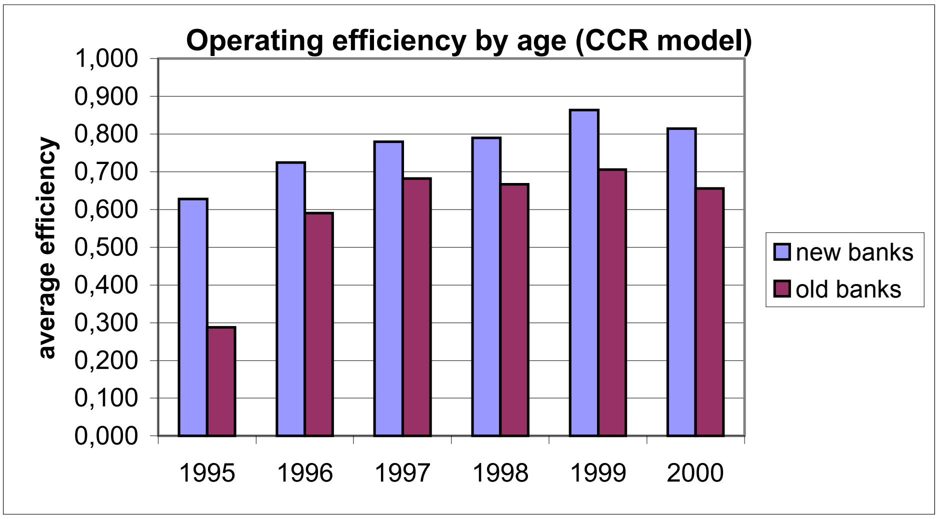


The hypothesis of private banks being more technically efficient than those that are state-owned has also been tested. Here, the basis for grouping was the dominant type of ownership, thus classifying all the banks with more than 50% of their capital in government hands as state, with the same principle being applied to private domestic and foreign-owned banks.

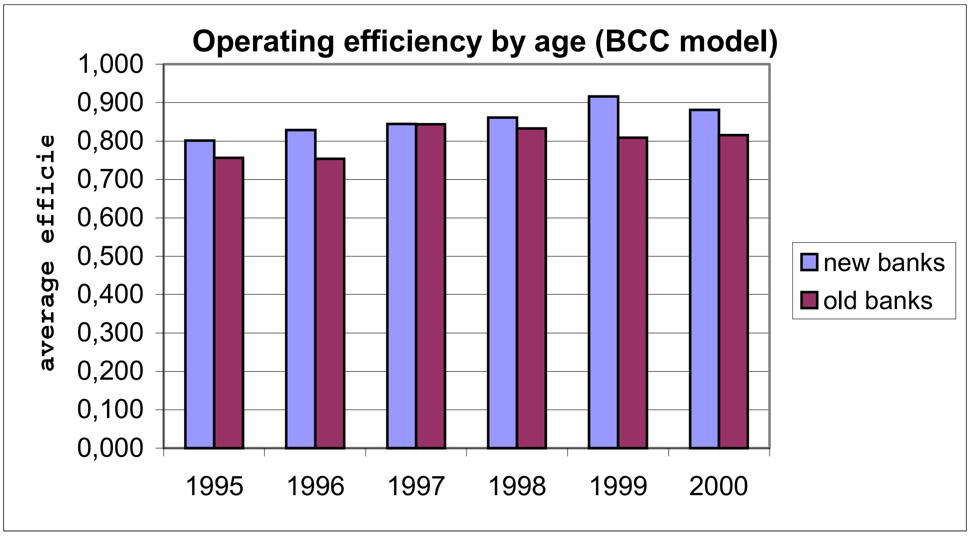


Under the CRS case state banks are constantly least efficient (which is consistent with previous finding since three out of four of them are Peer Group 1 large banks). Foreign owned banks, on the other hand, dominate under both models, being clearly most efficient, except in 1996 when a number of them had high start-up costs, and little revenues. Also, both under CRS and VRS, state owned banks catch-up in terms of average efficiency after the rehabilitation process in four of them, and under VRS even become more efficient than private domestically owned banks.

We also compare new with the old banks. Banks established in 1990 or later are treated as new, while those established in 1989, or earlier, as old.



Clearly, in the whole period, new banks were more efficient than the old ones. Under CRS, again, most of the efficiency equalization happened until 1997. New banks have, however, kept a significantly higher average efficiency until the end of the period. Under the VRS, banks efficiency is, by model, more equal, and the difference between new and old banks' efficiency less pronounced.



Particular problem for old, as well as for state-owned banks, were non-performing portfolios dating back to the previous system; this problem has been improved with rehabilitation of four old state-owned banks. Rehabilitation process in the large state-owned regional banks which were in constant liquidity problems and, therefore, created high and low-risk demand in money market before their rehabilitation process has started, has helped a substantial decrease in interest rate spreads and, therefore, created a more competitive environment. The first rehabilitation process started in 1995 in a regional bank that was most badly hurt by 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 process started in the country's second largest bank. The final restructuring of the rehabilitated banks (focus of business, staff reductions…), however, is still under way after the banks were taken over by foreign owners.

Overall, analysis supports conclusion that foreign owned banks were on average most efficient, and that new banks are more efficient than old ones, which were often burdened with old bad debts. In terms of size, smaller banks are globally efficient, but large banks are be locally efficient. The question remains whether the frontier is adequately spanned for small number of largest banks. Another conclusion is that, after 1995, equalization in terms of average efficiency has happened in Croatian banking market. That conclusion is supported by the fact that, under the CRS, large banks, which started with approximately 45% of smallest banks' average efficiency in 1995, became actually somewhat more efficient in 2000. In a case of state-owned and old banks, they started with 32 and 46% of foreign, and new banks efficiency, respectively, and ended up in 2000 with 81% and 82% of their efficiency.[4]

5.2. Intermediation approach

Although not that clearly supported by the above results, another interesting conclusion appears. It, seems that most efficient in various specifications are either smallest, or largest banks. On average, the most slippery territory appears to be being a medium-sized bank. Another often used specification of the efficiency measurement in DEA models hints at that conclusion even more. In the next few graphs we present, what might be called intermediation approach to measurement of efficiency. The idea is to look more mechanically at the intermediation efficiency of banks. Under the "pure" intermediation approach banks use labor, capital and deposits in order to produce loans and other investments. Actual production process is a black box whose efficiency is simply judged by the amount of output produced combining certain amount of inputs.

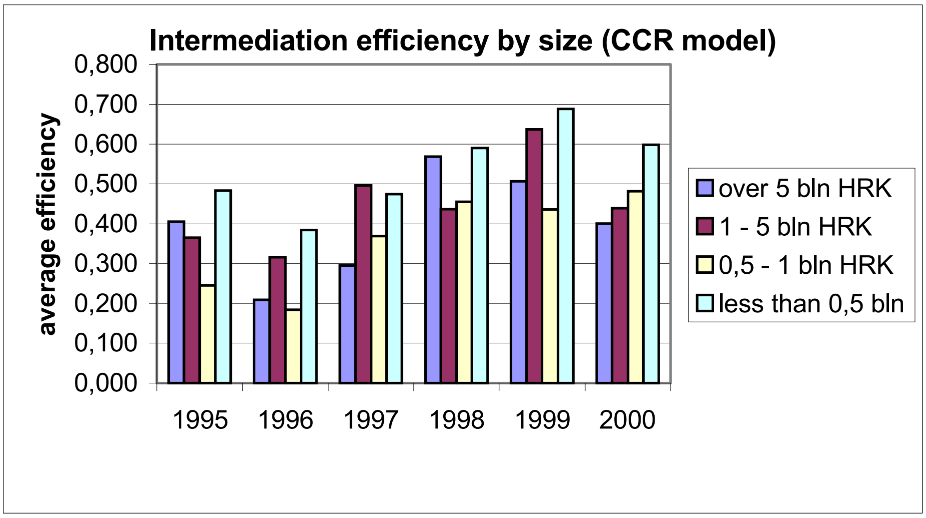
The summary results of the analysis via intermediation approach are presented in Table 4.

[4] These figures should be taken with the grain of salt because of the many structural changes that happened in the market during the analyzed period, and which were already mentioned. However, conclusion is clearly supported even by casual observation of above graphs.

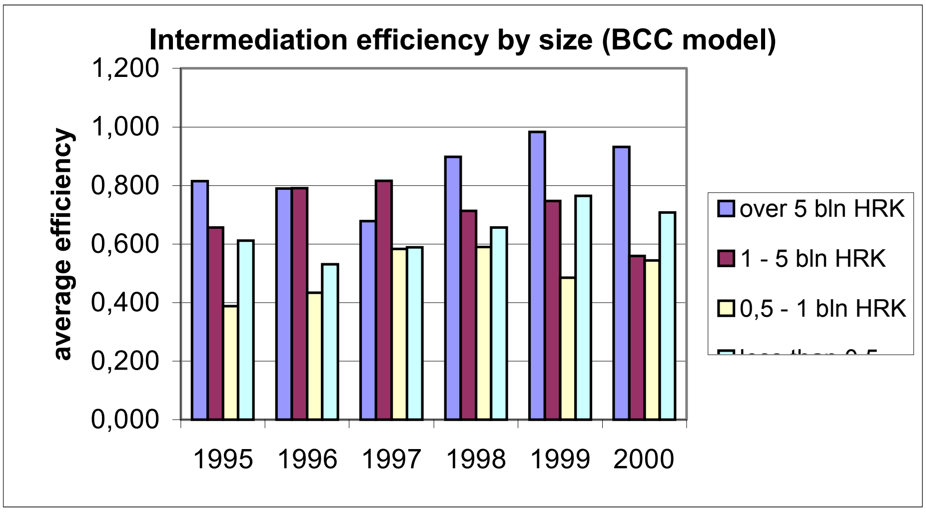
Table 4. Summary results of the intermediation approach

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%



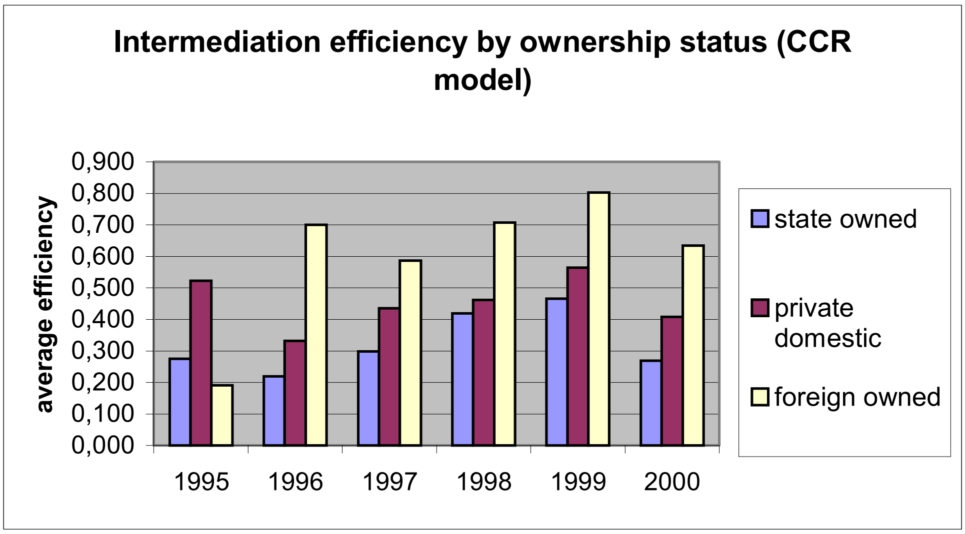
In both model specifications average efficiency among peer groups in many years is U-shaped, i.e. either largest, or smallest banks were using their inputs in a way to produce most of outputs, while medium sized banks were often less efficient.

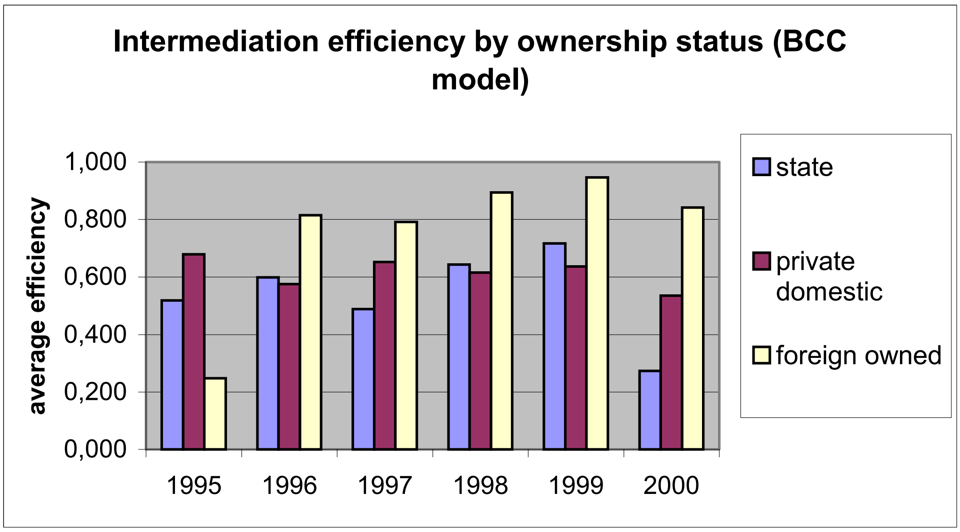


As in the previous approach, this one also confirms gradual equalization of efficiency in the Croatian banking market.

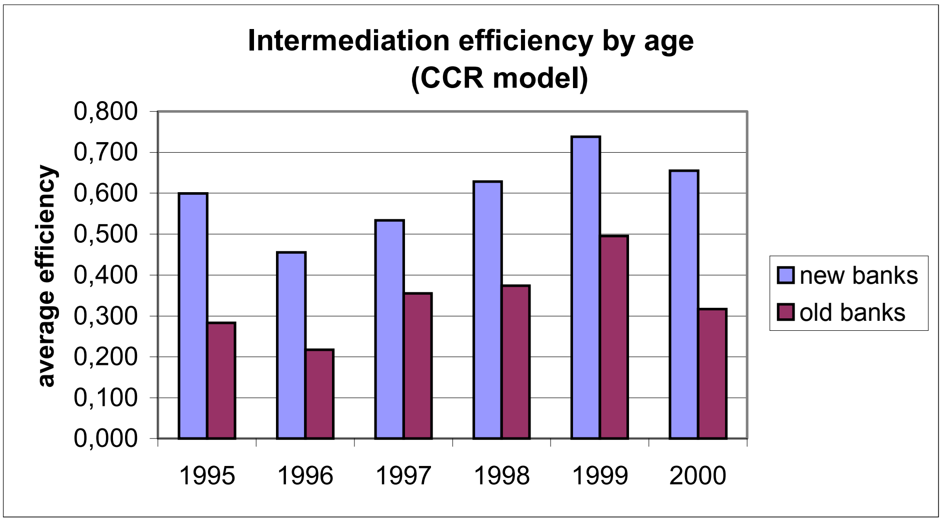
It might be the case that what looks as a middle sized banks relative inefficiency is actually attributable more to the fact that many of those banks are regional banks, and that efficiency problems arise more from the environment in which they operate, than their size. On the other hand, smallest banks are often niche banks. Being a small bank, however, also does not guarantee relative efficiency, as the coefficient of variation of efficiency scores in that group is relatively high.

Intermediation approach confirms above findings on the relative efficiency of new/old, and state/private/foreign banks.

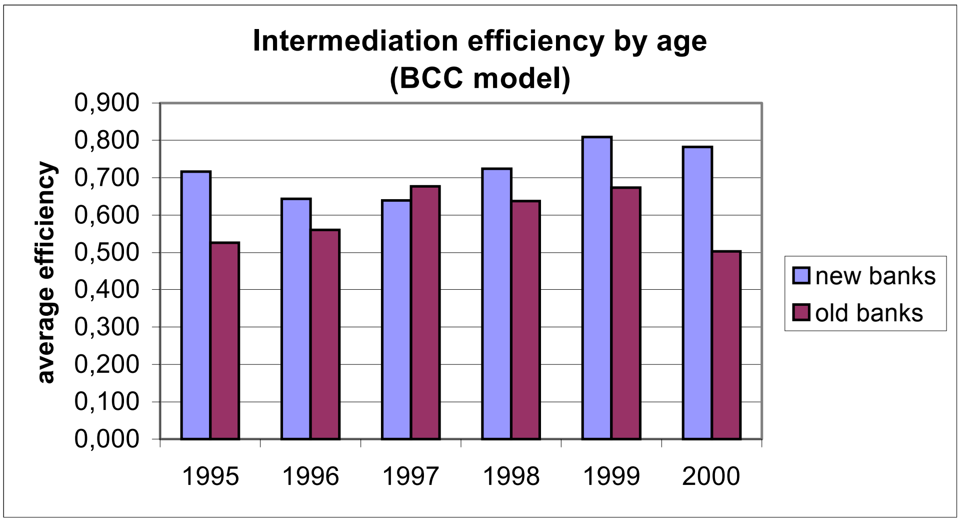




Under the intermediation approach, foreign banks are even more efficient relative to private domestic and state owned banks, than was the case when costs and revenues were taken as inputs and outputs. In other words, except in 1995 when there was only one foreign bank, foreign banks were capable of producing equal amount of output (loans and securities) using much less inputs (fixed capital, labor and deposits) than other banks. Therefore, intermediation approach emphasizes even more dominant position of foreign banks relative to other banks in the market. Again, equalization is observable over time. Under the constant returns to scale model, since 1996, when the rehabilitation process started, state owned banks demonstrated rapid improvement in average efficiency relative to other banks. In 2000, after being privatized, three largest state owned banks joined the group of foreign banks which has caused a modest decline in average efficiency of that Peer Group, but, on the other side, also a much more pronounced decline in the average efficiency of state owned banks (of which only three remained in 2000).



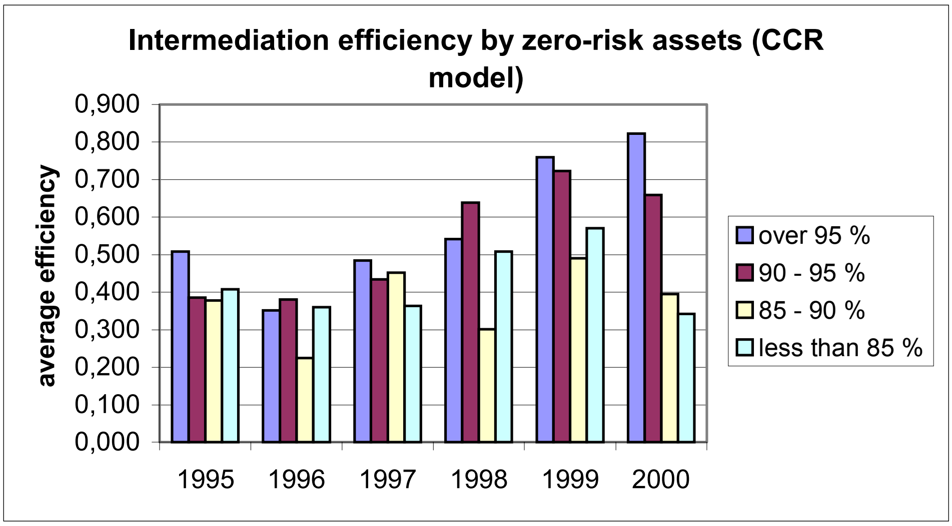
In the case of bank's vintage intermediation approach also emphasizes even more superior performance of new banks relative to the old ones. And again it demonstrates catch-up of old banks to the new ones before privatization of three state owned banks, with the same kind of post-privatization effect on two Peer Groups as in the case of state-owned vs. foreign banks.



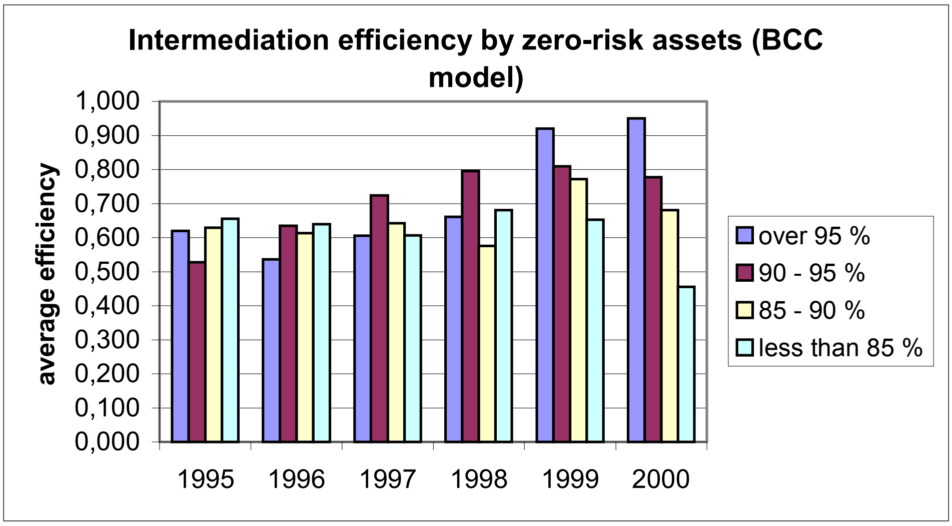
Regarding particular inputs, from the results of the DEA analysis it appears that the most significant cause of inneficiency among state owned and old banks vs. foreign and new ones is the number of employees and fixed assets. Under different specifications both at the beginning, and at the end of the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

Finally, 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 results here, as the conclusions are the same as for the intermediation efficiency. With the exception of the first two years, when picture was somewhat mixed, results show that more efficient banks are also banks that have, on average, more zero-risk assets. As we move towards the end of the analyzed period, this conclusion becomes more evident[5].

[5] Last couple of years were also years in which reporting of the quality of assets to the CNB was best.



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



7. Conclusion

We use the Data Envelopment Analysis to analyze efficiency of the banks in the Croatian banking market. DEA has become increasingly popular in measuring efficiency in different national banking industries. It allows us to compare 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.

Segmentation of the banking market was done along the following lines: bank size, ownership structure, date of the establishment and quality of assets. We use data on Croatian banks in a period from 1995 until 2000, the years for which relatively reliable bank balance sheets are available, and a period in which macroeconomic environment was stable.

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

In terms of size, smaller banks are globally efficient, but large banks appear to be locally efficient. The question remains weather the frontier is adequately spanned for a small number of largest banks. Another conclusion is that, since 1995, strong equalization in terms of average efficiency has happened in Croatian banking market. That conclusion is supported by the fact that, under the constant returns to scale assumption, large banks, which started with approximately 45% of smallest banks' average efficiency in 1995, became actually somewhat more efficient in 2000. In a case of state-owned and old banks, they started with 32, and 46% of foreign and new banks efficiency, respectively, and ended up in 2000 with 81% and 82% of their efficiency, respectively. We have also demostrated that the process of equalization happened within peer groups, as mesured by coefficients of variation of average efficiency from the peer group mean.

Although not as clearly supported by the results, another interesting conclusion appears. It seems that the most efficient in various specifications are either smallest or largest banks. On average, the most slippery territory appears to be the one in which a medium-sized banks operate. It might be a case that what looks as a middle sized banks' relative inefficiency, is actually attributable more to the fact that many of those banks are regional banks, and that efficiency problems arise more from the environment in which they operate, than their size. On the other hand, smallest banks are often niche banks. Being a small bank, however, does not guarantee relative efficiency, as the coefficient of variation of efficiency scores in that group is highest, and as a number of banks from that group failed in recent past.

Regarding particular inputs, from the results of the DEA analysis it appears that the most significant cause of inneficiency among state owned and old banks vs. foreign 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, results also show that technically more efficient banks are also banks that have, on average, less non-performing loans. This is true for both the operating and intermediation approach. In 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 a group of banks with high level of non-performing loans, and low technical efficiency still exists.

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