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PRIVATIZATION, FOREIGN BANK ENTRY AND BANK EFFICIENCY IN CROATIA: A FOURIER-FLEXIBLE FUNCTION STOCHASTIC COST FRONTIER ANALYSIS

by
Evan Kraft
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Abstract

Using bank balance sheet data for 1994-2000, this paper estimates a Fourier-flexible frontier cost function. Specification tests indicate that the stochastic frontier model with a Fourier-flexible form with a truncated normal distribution of the inefficiency term allowing for time varying technical efficiency is preferred. The results show that new private and privatized banks, contrary to some expectations, are not the most efficient banks through most of the period. Privatization also does not seem to have an immediate effect on improved efficiency. However, better cost efficiency is associated with a lower likelihood of failure, suggesting that better risk management and better cost management are signs of better management in general. Finally, foreign banks have substantially better efficiency scores than all categories of domestic banks.

JEL: G21, C4

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

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Evan Kraft, Richard Hofler and James Payne

PRIVATIZATION, FOREIGN BANK ENTRY AND BANK EFFICIENCY IN CROATIA: A FOURIER-FLEXIBLE FUNCTION STOCHASTIC COST FRONTIER ANALYSIS

1 Introduction

The privatization of banks in transition countries has been high on the policy agenda in recent years. Past practice strongly suggests that the political direction of lending is not only undesirable but it cannot be ended without removing banks from state ownership. In addition, there is the strong presumption that state-owned banks are overstaffed, poorly equipped technically and reluctant to adopt banking innovations (EBRD, 1998). During the process of privatization, several transition countries have decided to sell large portions of banking system assets to foreign banks. Among the first was Hungary in 1995-96, motivated by the failure of several attempts to use public funds to recapitalize its largest banks. Since then, Poland, Estonia, the Czech Republic, Croatia, Latvia and Albania, as well as Hungary, have all reached levels of foreign ownership above 50% (Group of Banking Supervisors from Central and Eastern Europe, 1999).

The purpose of this paper is to analyze the relative efficiency of state-owned, private and foreign banks in the case of Croatia. This paper uses a stochastic-frontier cost function to estimate cost efficiency scores for banks from 1994 to 2000. The period spans the privatization of almost all the state-owned banks, the entrance of the first foreign banks as "greenfield" firms, a systemic banking crisis and the privatization of three of the largest state-owned banks to foreign owners.

Our findings extend those in Kraft and Tirtiroglu (1998). Like them, we find that the efficiency levels of both new private banks and privatized banks initially tended to lag behind those of state banks. Furthermore, efficiency gains from privatization were not to be found at all in the first 2-3 years after privatization. However, foreign banks are consistently more efficient, and the whole population seems to converge at much higher levels of efficiency by 2000. Also, despite using estimation methods that decrease possible bias towards finding larger banks more efficient, we find that the very largest banks were the most efficient in all years except one. Finally, we find some evidence that failed banks had worse efficiency levels than those banks that survived or left the market voluntarily through mergers.

The rest of the paper is organized as follows. Section 2 provides some background on the Croatian banking system. Section 3 discusses the data and the specification of the cost function. Section 4 presents the empirical results, Section 5 presents analysis of the results, and Section 6 provides concluding remarks.

2 The Evolution of the Croatian Banking System

2.1 Macro Environment

Although the first years of Croatia's existence as an independent country were marked by war and high inflation, by 1994 the environment had settled down somewhat. A successful stabilization program, launched in October 1993, had brought inflation from monthly rates of 35% or more down to zero or below (Anušić et al., 1995). The military/political situation was also more stable by 1994, but it was not fully crystallized until the successful Croatian military operations of May and August 1995 and until the Dayton Accord brought settlement to the Bosnian conflict and the Erdut Accord brought settlement to the last major territorial issues in Croatia. The years 1995-98 were characterized by rapid GDP growth, stimulated by the government's war reconstruction spending and rapidly growing bank lending. The resulting consumption boom, coupled with weak export growth, led to an alarming current account deficit of 11.6% of GDP in 1997. Efforts to control the lending boom and several bank failures in 1998 led to a slowdown and ultimately a recession that lasted from the fourth quarter of 1998 to the fourth quarter of 1999. Finally, growth recovered in late 1999 and early 2000, and the current account deficit, which had fallen substantially during the recession, reached a more manageable 2.1% of GDP.

2.2 The Banking Market: Entry

At the start of its transition from socialism to capitalism in 1990, Croatia had 26 state-owned banks. In an effort to promote competition, bank licensing was liberalized. By 1994, the first year in our data set, the total number of banks had reached 49, and by 1997, the total had reached 60. However, during the banking crisis of 1998-99, some 14 banks failed. By end-2000, the number of banks was down to 43.

The increase in the number of banks did not necessarily translate into substantially increased competition. Most of the new banks operated in very limited geographical areas, most of all in Zagreb and Split. Only two banks had a truly national

Table 1: Number of Banks by Ownership Category

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1 Domestic	26	30	42	43	49	53	53	53	50	40	23
1.1 State	22	22	29	25	26	14	10	7	8	10	3
1.2 Private	4	8	13	18	23	39	43	46	42	30	20
2 Foreign					1	1	5	7	10	13	20
Total	26	30	42	43	50	54	58	60	60	53	43

Source: Croatian National Bank.

presence, and even they were not present in all parts of the country. Several of the old banks had been set up as regional banks under the former Yugoslavia and retained overwhelming market share in their home regions. The overall level of concentration remained quite high, as Table 2 shows. Concentration grew during and after the banking crisis, thanks in part to the exit of the failed banks and in part due to a "flight to quality".

Table 2: Asset Shares of the Largest Banks

	1995	1996	1997	1998	1999	2000
Two largest banks	54	46	40	41	44	48
Four largest banks	68	60	53	53	58	62

Source: Croatian National Bank.

Foreign entry to the banking market was cautious at first. One foreign bank started up in late 1994, even before the end of the war activities. Foreign entry picked up after the Dayton Accord, with 3 foreign banks established in 1996 and another 3 in 1997. The market share of the foreign banks remained small until 1999, when foreign banks purchased two large banks that had been rehabilitated by the government. When two more large banks were sold to foreigners in 2000, foreign ownership rose to some 83.7% of total banking assets.

2.3 Privatization

The Croatian method of bank privatization was unusual. Under the former Yugoslavia, banks had been "founded" by real sector enterprises. When the socialist system was overhauled in 1989-90, equity was allocated (for the most part) to these same enterprises, even though they were the banks' debtors. This decision institutionalized an unhealthy cross-ownership in the state-owned banks. After this, the state-owned banks were not the subjects of any direct privatization procedures. Instead, the banks' owners, real sector firms, were privatized. In this way, the banks were privatized "in passing". A few of the better functioning banks did issue new equity, thereby gaining shareholders that actually paid for the shares. However, for the most part, privatization was passive and indirect. By 1996, most of the old state banks had been privatized, with the exception of the four banks taken over by the government for rehabilitation. These last four banks were sold to foreign strategic investors in 1999 and 2000.

Table 3: Shares in Total Banking Assets of Ownership Categories, %

	1995	**1996**	**1997**	**1998**	**1999**	**2000**
State	52.0	39.5	33.0	37.0	40.6	6.1
Domestic private	47.0	59.5	63.0	56.3	19.5	10.2
Foreign	1.0	1.0	4.0	6.7	39.9	83.7

Source: Croatian National Bank.

2.4 The Banking Market: Rehabilitation, Bankruptcy, and Crisis

In the period immediately after stabilization in October 1993, it became clear that four large banks were insolvent, and three of these were also highly illiquid. The government did not act to deal with the problems until the smallest of the four was put under rehabilitation procedures in November 1995, and then the two next smallest were taken over in March 1996. In the interregnum from early 1994 to summer 1996, interbank interest rates rose precipitously, reaching real rates of over 25%. Given the expectation that these banks would not be allowed to fail, interbank lending became a very easy and profitable activity. Kraft and Tirtiroglu (1998) argue that this opportunity to "free-ride" on high interest rates allowed relatively inefficient but highly liquid new banks to be profitable during this time.

However, once the three banks (and eventually the last and biggest of the group) were given liquidity injections and had their balance sheets "cleaned" of bad assets, interbank rates came down below rates on retail or wholesale lending. At this point (roughly Fall 1996), banks had to turn their attention to making loans in order to make profits. This they did with a vengeance. Total bank lending grew by some 48% in 1997, with lending to households growing 93% (from a very small base). In this extraordinary credit expansion, risk management was often weak, and in some cases banks did not even have written lending policies (Kraft et al., 1998). In addition, insider lending was rife, as some of the new private banks lent to the corporate groups that had founded them (see Škreb and Šonje, 2000 and Jankov, 2000 for more details on the causes of bank failures).

The result was that bank failures began as soon as economic growth slowed. The first bank to fail was a privatized regional bank, in March 1998. Failures continued through that year, reaching a peak in February-March 1999. Overall, some 14 banks failed in the 1998-99 banking crisis.

Without attempting a detailed account of the crisis here (see Kraft, 1999), it is important to note that the crisis was resolved via a number of bankruptcies and the granting of lender of last resort-type liquidity loans to 6 banks. In what follows, we will test whether either the failed banks or the illiquid banks showed specific efficiency characteristics. Another outcome of the crisis was the decision to sell the rehabilitated banks to foreign strategic investors. This decision was taken mainly to prevent further banking instability and to facilitate knowledge transfer. Very likely, the country's growing foreign debt and deteriorating fiscal position also stimulated the government's acquiescence in such sales.

3 Data and Specification of the Cost Function

The ideal instrument to study the relative efficiency of the different kinds of banks mentioned in the account above would be a profit function. Unfortunately, a conventional profit function requires reliable price data for outputs, which are unavailable. In addition, the alternative profit function sketched by Berger and Mester (1997d) is difficult to define in Croatia because of inaccurate provisioning by banks, especially in the years through 1998. Instead, we examine bank efficiency by estimating a cost fun-

ction. Cost efficiency provides a measure of how close a bank's cost is to what a best practice bank's costs would be for producing the same output under the same conditions. A bank is considered inefficient if its costs are higher than the best-practice bank after removing random error. The cost function approach is given as follows:

$$\ln C = f(w, y, z, \nu) + u_c + \varepsilon_c \quad (1)$$

where ln denotes the natural logarithm; C measures variable costs; $f(\cdot)$ represents the functional form; w is the vector of prices of variable inputs; y is the vector of quantities of variable outputs; z is the quantities of any fixed netputs (inputs or outputs); ν is the vector of variables associated with environmental or market factors that may affect bank performance; u_c denotes an inefficiency factor that may increase costs beyond the best-practice level; and ε_c denotes random error.

Table 4 lists the variables associated with the cost function specified in equation (1).

The data is based on call reports provided by Croatian banks to the Croatian National Bank. All the variables are deflated to 1994, using the retail price index. Several comments on the data are necessary.

First, frozen foreign exchange deposits are excluded from the household deposit data. The reason for this is that, after 1995, banks had very little expenses related to such deposits. Twice a year, the banks would receive an installment payment on government bonds backing these deposits, which the banks were required to use to pay off part of their obligations to depositors. Many banks, in fact, completely paid off the

Table 4: Variable Definitions in Cost Function

Symbol	Definitions
Dependent variable	
C	Total costs
Variable input prices	
w_1	Capital cost ratio
w_2	Labor cost ratio
w_3	Funding cost ratio
Variable output quantities	
y_1	Loans to enterprises
y_2	Loans to households
y_3	Deposits of enterprises
y_4	Deposits of households
Fixed netput quantities	
z_1	Total assets
z_2	Total capital
Environmental variables	
PVTDUM	Dummy variable for private banks
NEWDUM	Dummy variable for new banks
FORDUM	Dummy variable for foreign banks

frozen deposits out of their own funds. Those banks that did not pay off the deposits, however, basically could ignore them (except for the twice-yearly installments). In 1994, there was active trading in such deposits, as those eager to gain access to their deposits were allowed to buy them at approximately a 30% discount, or to use them to purchase state-owned real estate or companies. Because of these active transactions, Kraft and Tirtiroglu (1998) included such deposits in their definition of total deposits. However, given the inactivity of such deposits after the first installment payment in 1995, it was deemed better to leave them out of the analysis here. Such an approach also provides consistent variable definitions for the whole period.

The second comment on the data is that a few items on the balance sheets of Croatian banks have not been included. Specifically, it was assumed that the expenses of handling government-supplied rehabilitation bonds (both "big" bonds given to enterprises in 1991 and then transferred to banks to cover debts and "rehabilitation" bonds issued to banks in rehabilitation to replace bad assets in 1995-99) would be negligible.

The third comment on the data is that no effort is made to correct for the quality of services, due to lack of data. In addition, we are unable to correct for differences in the labor skill profile of different banks. Thus, banks with extensive retail operations and considerable numbers of lower-paid staff such as tellers may appear more efficient for this reason.

Following Berger and Mester (1997d) we estimate the Fourier-flexible functional form, which augments the popular translog specification to include trigonometric terms. These terms, which use transformations of the variables to the 0, 2π (radians interval), allow the estimation to better fit a broader range of curves. Studies by McAllister and McManus (1993), Mitchell and Onvural (1996), Berger et al. (1997a), Berger et al. (1997b), Berger and DeYoung (1997c) and Berger and Mester (1997d) find the Fourier-flexible functional form provides a better fit of U.S. financial institutions data than the translog specification.

Equation (2) specifies the Fourier-flexible form for the cost function.

$$\ln\frac{C}{w_3 z_2} = \alpha + \sum_{i=1}^{2}\beta_i \ln\frac{w_i}{w_3} + \frac{1}{2}\sum_{i=1}^{2}\sum_{j=1}^{2}\beta_{ij}\ln\frac{w_i}{w_3}\ln\frac{w_j}{w_3} + \tag{2}$$

$$+\sum_{k=1}^{4}\gamma_k \ln\frac{y_k}{z_2} + \frac{1}{2}\sum_{k=1}^{4}\sum_{m=1}^{4}\gamma_{km}\ln\frac{y_k}{z_2}\ln\frac{y_m}{z_2} + \delta\ln\frac{z_1}{z_2} +$$

$$+\sum_{i=1}^{2}\sum_{k=1}^{4}\eta_{ik}\ln\frac{w_i}{w_3}\ln\frac{y_k}{z_2} + \sum_{i=1}^{2}\rho_i \ln\frac{w_i}{w_3}\ln\frac{z_1}{z_2} +$$

$$+\sum_{k=1}^{4}\tau_k \ln\frac{y_k}{z_2}\ln\frac{z_1}{z_2} + \sum_{n=1}^{7}\left[\phi_n \cos(x_n) + \omega_n \sin(x_n)\right] +$$

$$+\sum_{n=1}^{7}\sum_{q=n}^{7}\left[\phi_{nq}\cos(x_n + x_q) + \omega_{nq} sin(x_n + x_q)\right] +$$

$$+\sum_{n=1}^{7}\left[\phi_{nnn} cos(x_n + x_n + x_n) + \omega_{nnn}\sin(x_n + x_n + x_n)\right] +$$

$$+\nu_1 ln(DUM) + \frac{1}{2}\nu_{11}\left[ln(DUM)\right]^2 + \ln u_c + \ln\varepsilon_c$$

In equation (2) above, w_1 and w_1 have been normalized by w_3 (the funding cost ratio) to impose linear homogeneity with respect to input prices. Furthermore, the cost, variable output quantities and fixed netput quantities are defined as ratios to z_2 (total capital) to control of size-related heteroskedasticity and minimize scale biases in the estimation (Berger and Mester, 1997d, pp. 918). The trigonometric terms of the Fourier-flexible form, x_n, are the variable input prices and variable output quantities normalized to fall within the interval $[0.1 \times 2\pi, 0.9 \times 2\pi]$.

4 Estimation Results and Choice of Functional Form

The estimation of the Fourier-flexible form of the cost function will proceed using the panel model proposed by Battese and Coelli (1995). The Battese and Coelli panel model allows us to concurrently estimate the stochastic production frontier and the determinants of a bank's cost efficiency. This model is superior to the alternative two-stage method in which efficiency estimates from the frontier are regressed on selected influences on efficiency in a second-stage equation. In our study of Croatian bank efficiency, three indicator variables are used as determinants of a bank's cost efficiency: new banks, privately owned banks and foreign owned banks. In the estimation of the stochastic production frontier, the inefficiency and random error components of the error term must be isolated by explicitly making assumptions concerning their distributions. The random error term, ε_c, is assumed to be normally distributed whereas the inefficiency term, u_c, is assumed to be one-sided.

We compare two assumptions concerning the distribution of the inefficiency term: half-normal and truncated normal. In addition to comparing the assumptions regarding the distribution of the inefficiency term, we also investigate whether the Fourier-flexible form is preferred over the translog specification of the cost function as well as a comparison of time-invariant and time varying technical efficiency. Panel A of Table 5 reports the likelihood ratio results of testing the null hypothesis that there is no difference between the translog specification and the Fourier-flexible form allowing for the distribution of the inefficiency term to be half-normal or truncated normal as well as whether technical efficiency is time-invariant or time varying. Regardless of the distributional assumption of the inefficiency term and whether technical efficiency is time-invariant or time varying, the Fourier-flexible form is preferred over the translog specification. In the case of the truncated normal distribution for the inefficiency term and time varying technical efficiency, the Fourier-flexible form would be preferred over the translog specification at the 6 percent significance level.

Given the preference of the Fourier-flexible form over the translog specification, Panel B of Table 5 reports the results of testing the null hypothesis that there is no difference between time-invariant and time varying technical efficiency using the Fourier-flexible form allowing for the distribution of the inefficiency term to be half-normal or truncated normal. The results in Panel B favor allowing technical efficiency to be time varying rather than time-invariant.

We next test the null hypothesis that there is no difference between the half-normal and truncated normal distributional assumptions regarding the inefficiency term

within the Fourier-flexible form with time varying technical efficiency. Panel C reports that that we fail to reject the null hypothesis indicating that either the half-normal or the truncated normal distributional assumptions of the inefficiency term can be used. Panel D tests the null hypothesis that there is no difference between the Fourier-flexible form with a half-normal distribution of the inefficiency term and time-invariant technical efficiency and the Fourier-flexible form with a truncated normal distribution of the inefficiency term and time varying technical efficiency. The results indicate that the Fourier-flexible form with a truncated normal distribution of the inefficiency term with time varying technical efficiency is preferred. Finally, Panel E tests the null hypothesis that there is no difference between the Fourier-flexible form with

Table 5: Likelihood Ratio Tests of Specifications

Panel A: Translog vs. Fourier			
Half-Normal	Translog	Fourier	Likelihood ratio statistic
TE time-invariant	–11.768	173.836	371.207 (.000)
TE time varying	11.625	182.306	341.361 (.000)
Truncated normal	Translog	Fourier	Likelihood ratio statistic
TE time-invariant	–10.521	172.229	365.501 (.000)
TE time varying	130.437	183.118	105.361 (.057)
Panel B: Fourier: time-invariant vs. time varying technical efficiency			
Half-Normal	Fourier	Likelihood ratio statistic	
TE time-invariant	173.836		
TE time varying	182.306	16.940 (.000)	
Truncated normal	Fourier	Likelihood ratio statistic	
TE time-invariant	172.229		
TE time varying	183.118	21.778 (.000)	
Panel C: Fourier time varying: half-normal vs. truncated normal			
Half-Normal	Fourier	Likelihood ratio statistic	
TE time-invariant			
TE time varying	182.306		
Truncated normal	Fourier	Likelihood ratio statistic	
TE time-invariant			
TE time varying	183.118	1.624 (.202)	
Panel D: Fourier half-normal/time-invariant vs. Fourier truncated normal/time varying			
Half-Normal	Fourier	Likelihood ratio statistic	
TE time-invariant	173.836		
TE time varying			
Truncated normal	Fourier	Likelihood ratio statistic	
TE time-invariant			
TE time varying	183.118	18.564 (.000)	
Panel E: Fourier truncated normal/time varying vs. non-stochastic frontier model			
		Likelihood ratio statistic	
		140.898 (.016)	

Notes: Probability values associated with the likelihood ratio statistics are given in parentheses.

Table 6: Means of Cost Efficiency Estimates by Subsamples

Panel A: All 363 observations in sample					
BANK	MEAN	SD	MIN	MAX	N
All banks	1.370	.318	1.003	2.601	363
Domestic banks	1.404	.317	1.003	2.601	318
Foreign banks	1.128	.208	1.006	2.149	45
State banks	1.312	.246	1.023	2.119	79
Private banks	1.386	.334	1.003	2.601	284
Old banks	1.402	.307	1.003	2.392	135
New banks	1.351	.324	1.005	2.601	228
Failed banks	1.438	.356	1.003	2.566	110
Non-failed banks	1.340	.296	1.007	2.601	253
Panel B: All 253 Non-failed bank observations in sample					
BANK	MEAN	SD	MIN	MAX	N
Domestic banks	1.372	.294	1.007	2.601	217
Foreign banks	1.146	.227	1.009	2.149	36
State banks	1.310	.241	1.023	1.912	64
Private banks	1.350	.313	1.007	2.601	189
Old banks	1.385	.292	1.009	2.281	119
New banks	1.300	.295	1.007	2.601	134

Notes: BANK denotes the type of bank, the descriptive statistics associated with the cost efficiency estimates are denoted as follows: MEAN the mean, SD the standard deviation, MIN the minimum value, MAX the maximum value, and N the number of banks.

a truncated normal distribution of the inefficiency term and time varying technical efficiency and a non-stochastic frontier model. The results indicate that the stochastic frontier model with a Fourier-flexible form with a truncated normal distribution of the inefficiency term allowing for time varying technical efficiency is preferred

Table 6 provides the descriptive statistics for the cost efficiency estimates of the various categories of banks based on the Fourier-flexible form with a truncated normal distribution of the inefficiency term and time varying technical efficiency. With respect to interpreting the means, cost efficiency is bounded from below by 1.00. A perfectly cost efficient bank would exhibit a cost efficiency estimate equal to 1.00. For example, a bank whose cost efficiency estimate is 1.59 is 59 percent higher than the minimum possible efficiency.

5 Analysis of Efficiency Results

5.1 Efficiency and Ownership

Many theoretical arguments and much empirical evidence supports the notion that privately-owned firms are more efficient. Our cost efficiency estimates allow us to test this contention in the case of Croatia. As Kraft and Tirtiroglu (1998) argue, there are several mitigating factors in the Croatian case. First, privatization was “passive”: banks were privatized by the privatization of their owners. For many big banks, this

Table 7: Relative Efficiencies of Private, State and Foreign Banks by Year

	1994	1995	1996	1997	1998	1999	2000
Private	1.418	1.448	1.440	1.438	1.510	1.406	1.237
State	1.341	1.305	1.240	1.308	1.345	1.264	1.358
Foreign			1.138	1.152	1.100	1.151	1.056
Banks with 50% foreign ownership			1.394	1.177	1.119	1.046	1.041

Table 8: Relative Efficiencies by Age and Privatization Status

	1994	1995	1996	1997	1998	1999	2000
Old state	1.360	1.274	1.299	1.337	1.394	1.174	1.322
New state	1.290	1.341	1.200	1.280	1.285	1.354	1.376
Privatized	1.098	1.358	1.452	1.621	1.585	1.466	1.201
New private	1.434	1.519	1.403	1.342	1.388	1.285	1.120

simply meant that a majority of the shareholders were now private companies, but in fact the same companies as before. Management did not necessarily change, and changes in corporate governance or the behavior of shareholders was gradual. Second, during the period from 1994 through mid-1996, very high real interest rates on the interbank market offered almost risk free returns to liquid banks. Because of this, operating efficiency was not particularly important for profitability. Third, competition was relatively weak, particularly through 1998.

Table 7 shows that indeed private banks were less efficient than state banks until 2000 (but in that year there were only 3 state banks remaining). Also, the relative efficiency of the foreign banks is striking.

Table 8 provides a slightly different breakdown, distinguishing between new banks formed after the beginning of transition (1990) and old banks. One might have expected that new private banks, because they would not be overstaffed, would have been more efficient than other banks. But this is not borne out by the data: in fact, only in 1999 do new private banks outperform even new state banks. By 2000, they have the best efficiency scores, but this is largely due to the influence of the foreign banks (the greenfield foreign banks are classified as new private institutions).

Another interesting point is the relative deterioration of the privatized banks in 1996 and 1997. One factor that may be clouding our view is the fact that there were several new banks entering each year in the 1995-98 period, and then a number of fail-

Table 9: Efficiencies of 12 Privatized Banks

1994	1.361
1995	1.398
1996	1.479
1997	1.596
1998	1.525
1999	1.471
2000	1.229

ures in 1998 and 1999. To attempt to better isolate the effects of privatization per se, we show in Table 9 the time path of the efficiency scores of 12 banks that were privatized in 1995 and 1996 and remained in business throughout the whole sample period:

If one were to take these scores literally, one could say that privatization worsened efficiency in the short-run. However, there are other possible explanations. The privatized banks were generally medium to large banks with significant retail operations. It could be that the deterioration in efficiency actually reflects improved service quality and costs of introducing new products.

Another possible explanation is that the privatized banks in particular hired more skilled workers in this period. Hiring experts in more specialized areas such as mergers and acquisitions, foreign exchange trading or information systems could have added to labor costs. Since our measure of labor input does not correct for skill levels, it could wrongly impute a deterioration of efficiency when in fact what is happening is the construction of a more skilled employee base.

A final explanation is the arrival of the foreign banks in 1996 and 1997. These banks clearly "pushed out" the efficiency frontier. Since our efficiency scores are relative to the frontier and not absolute, the deterioration in 1996 and 1997 may more be more a reflection of the movement of the frontier than a reflection of growing inefficiency in the privatized banks. Table 10 reinforces this view, focusing on the 8 new private banks continuously in operation during the whole period.

A final point in this discussion relates to the distribution of scores by bank type. Table 11 shows the composition of six tiers of banks ranked by efficiency. The ranking is based on the banks' average efficiency scores for all the years they are present in the sample. What we see is that the distribution of foreign bank scores is bi-modal, but with a much stronger peak in the top 10 banks. The old state banks seem to have a single peaked distribution with a peak in the 21-30th most efficient range, while both new

Table 10: Efficiencies of 8 New Private Banks

1994	1.355
1995	1.473
1996	1.574
1997	1.414
1998	1.305
1999	1.333
2000	1.228

Table 11: Distribution of Average Efficiencies for All Years in the Sample

	New foreign	Old state	New state	Privatized	New private
Top 10	6	1	1	1	1
11 to 20	0	0	2	3	5
21 to 30	2	3	0	0	5
31 to 40	0	1	1	3	5
41 to 50	0	0	3	3	4
Bottom 11	0	0	0	5	6

state and new private banks seem to also have bi-modal distributions (one peak for both groups in the 11-20th group and a peak for the new state banks in the 41-50th and for the privatized banks in the bottom group). Finally, the new private banks are almost evenly spread from the second best to the worst group.

The distributions add some richness to our characterization of the bank groups. It seems that a minority of privatized banks achieved relatively high efficiency, for example, while a larger number were towards the bottom of the rankings. New private banks also did not have a single niche in the efficiency rankings.

In summary, our findings do not show clear positive short-run effects of privatization on efficiency. Given the weaknesses of the Croatian bank privatization method, the possibilities for free-riding and the lack of competition during the 1994-98 period, this is not entirely surprising. However, we cannot exclude the possibility that the deterioration in efficiency scores was due to improvements in output quality and new product introduction, increasing investment in human capital, and/or the movement of the frontier due to the entry of more efficient foreign banks.

5.2 Efficiency and Scale

The estimation method suggested by Berger and Mester (1997) and adopted in this paper is designed to avoid possible scale bias. Table 12 shows efficiency scores by asset size group.

Table 12: Efficiency by Asset Size

	1994	1995	1996	1997	1998	1999	2000
Below HRK 500 million	1.442	1.520	1.443	1.394	1.411	1.383	1.201
HRK 500 million – 1 billion	1.212	1.211	1.187	1.607	1.415	1.354	1.111
HRK 1 – 5 billion	1.317	1.293	1.375	1.398	1.500	1.264	1.176
Above HRK 5 billion	1.153	1.119	1.217	1.167	1.315	1.211	1.080
Min-Max Range	0.289	0.401	0.256	0.441	0.185	0.172	0.121

Several observations are in order. First, the largest banks consistently have the best efficiency scores with the single exception of 1996. The efficiency of this group of banks declines noticeably in 1996 and 1998. It should be noted that this group is very small (3 or 4 banks in all years). Second, efficiency is not monotonically associated with size. In the years 1994-96, the banks with HRK 1-5 billion assets were less efficient than the banks with HRK 500 million-1 billion, and this pattern was repeated in 1998 and 2000.

Third, there is a clear convergence of scores, especially after 1997. The overall range of scores decreases substantially. This accords with the observation that competition increased significantly and interest rate spreads fell, pushing banks to pay more attention to cost efficiency.

5.3 Efficiency, Profitability and Failure

Another interesting question is whether efficiency is directly related to profitability. The answer is not entirely obvious, for several reasons. First, a bank with greater measured efficiency by our method could suffer from lower output quality than other banks or lag in investment in human capital. Second, banks that are input efficient might make inefficient output allocations and thus lower profits. Unfortunately, since we are unable to estimate a profit function, we cannot test this second hypothesis. Third, Kraft and Tirtiroglu (1998) find that profitability and efficiency were not statistically related in the 1994-95 period, mainly due to free-riding effects.

Table 13: Regression Models of Return on Average Assets

Independent variables	Model 1	Model 2
Constant	0.92[b] (4.39)	0.75[b] (3.81)
Efficiency	–0.29[a] (2.01)	–0.27[a] (1.99)
Foreign	–0.08 (0.62)	
New domestic		0.22[b] (2.60)
Total assets	–0.00 (1.60)	–0.00 (0.70)
adj R^2	.01	.03
n	277	277

Notes: t-statistics in parentheses. [a] Significant at 5%. [b] Significant at 1%.

Table 13 shows two regression models of the efficiency profitability link.

The results suggest a statistically significant connection between contemporaneous efficiency and profitability. Note that a lower efficiency value indicates greater cost efficiency. Hence, a negative coefficient on "efficiency" means that lower efficiency values (greater efficiency) are correlated with higher profits. However, the economic size is not large: a one-standard deviation improvement of efficiency in the year 2000 of .187 would result in an increase in return on average assets of .05 percentage points, hardly a drastic change.

In addition, one can ask whether efficiency is related to bank survival. Berger and DeYoung (1997) show that banks with poorer x-efficiency also tend to have higher levels of non-performing loans in the US. They argue that this correlation suggests that such banks are badly managed in general and are not just the victims of bad luck. In the same spirit, we ask whether banks that did not fail during our sample period were characterized by better cost-efficiency. Banks that were solvent but exited due to merger are not considered as failed. Table 14 shows the results of simple logit regressions on this subject. We have distinguished between insolvency and illiquidity, since some 5 banks took advantage of lender of last resort facilities but did not fail in 1999. Also, we test the models on all banks and on domestic banks only, to see if the foreign

Table 14: Logit Regressions for Non-Failure (1 = not failed)

	Model 1	Model 2	Model 3	Model 4
	All banks	All banks	Domestic banks	Domestic banks
	Insolvency only	Insolvency and illiquidity	Insolvency only	Insolvency and illiquidity
Constant	4.44[b]	2.36	4.12[b]	0.92
	(5.29)	(3.72)[b]	(4.63)	(1.32)
Efficiency	–1.29[b]	–1.06[b]	–1.27[a]	–0.45
	(2.65)	(2.62)	(2.57)	(1.06)
New domestic	–1.56[b]	–0.04	–1.43[b]	0.11
	(3.73)	(0.14)	(3.19)	(0.42)
Total Assets	0.00	0.00[a]	0.00	0.00[a]
	(1.41)	(2.34)	(1.39)	(2.94)
McFadden R^2	0.15	0.05	0.12	0.05
n	300	300	263	263

Notes: Z-statistics in parentheses. [a] Significant at 5%. [b] Significant at 1%.

banks high efficiency scores affected the results. Finally, we control for asset size under the suspicion that there may be scale effects.

The regressions provide some support for the notion that the more efficient banks were less likely to fail. As the regressions on profitability suggest, this is most likely not because of increased profits deriving from better cost efficiency. Rather, it seems that more cost-efficient banks were also more prudent risk managers. In other words, the findings support the idea that good management could both control costs and manage risks well, so that survival was a result of good management in general. The results for the new domestic bank dummy simply confirm that these banks failed more frequently than other categories. However, most of the illiquid banks were old domestic banks, so that when illiquidity and insolvency are studied together, the coefficient on the new domestic dummy is insignificant. Finally, while there is no indication of a size bias among failures, liquidity problems did hit somewhat larger banks, so the coefficient of total assets on insolvency and illiquidity together is significant.

5.4 Comparison with DEA Analysis

Many of the questions discussed in the previous sections were also covered in Jemrić and Vujčić (2002) data envelopment analysis of Croatian bank performance. However, there are numerous differences between the two studies. First, Jemrić and Vujčić start their analysis in 1995. Second, Jemrić and Vujčić exclude failed banks since they assert that the failed banks misreported data and that DEA is very sensitive to data errors. Third, Jemrić and Vujčić's intermediation method estimates, which are closest to the ones reported here, use the same inputs as in the present study but employ different outputs. They aggregate all loans together and treat short-term securities issued by official sectors (central bank and ministry of finance) as outputs.

With these differences in mind, we can compare the findings here with Jemrić and Vujčić's DEA findings. Unlike the present study, Jemrić and Vujčić find new private banks to be the most efficient group. Also, they find that the smallest and largest

banks are the most efficient, a finding that our study does not reproduce. At the same time, both studies find a strong convergence of efficiency scores over ownership groups and asset size groups. In addition, both studies find foreign banks to be among the most efficient. Although other comparisons of DEA and stochastic-frontier estimates usually show broad similarity, the differences in approach between the present study and that of Jemrić and Vujčić may explain the differences in findings. In particular, the exclusion of failed banks may be crucial.

6 Conclusions

This paper has shown that the Fourier-flexible form cost function provides the best specification for modeling Croatian bank efficiency, just as it is the preferred form for modeling US bank efficiency. In addition, analysis of the efficiency results suggests several conclusions about banking reform in transition countries. First, efficiency gains are not immediate on privatization and may be just as dependent on increased competition and the removal of free-riding opportunities. Second, although improved efficiency contributes to profitability, the fundamental determinant of profitability is probably good management, which succeeds both in cutting costs and in managing risks prudently. It is probable that good management rather than cost efficiency explains the survival of more cost efficient banks in the turbulent waters of transition banking. Third, reputable foreign banks do seem to have strong efficiency advantages.

One policy conclusion from this analysis is that liberalization in the form of opening the banking market to all comers is not an especially productive exercise. The low efficiency and high rate of failure of new private banks certainly raises questions about the wisdom of initial liberalization policies. Certainly, some of the new private banks were good (apparently those that sought particular market niches rather than pretending to be universal banks competing for substantial market share with existing large banks). But these banks might well have entered even if licensing standards had been much tougher.

Our other policy conclusion is that reaping the benefits from privatization requires not only adequate privatization per se but also a strong macroeconomic framework that can minimize shocks and a regulatory framework that can remove free-riding opportunities. Privatization to strategic foreign investors (along with allowing foreign banks to open greenfield operations) does seem to be justified by the analysis of this paper, although deeper analysis of these questions will have to await another occasion.

Endnotes

1. For more detail on this period, see Franičević and Kraft (1997).

2. 3. Berger and Mester (1997d, footnote 29, pp. 917) rescale the x_n terms so that each x_n is in the interval [0, 2π]. In order to reduce approximation problems near the endpoints, Berger and Mester cut off the values of x_n to span the interval [$0.1 \times 2\pi$, $0.9 \times 2\pi$]. Berger and Mester's formula for rescaling x_n is as follows: $0.2 - \mu x a + \mu x$ (variable value) where [a, b] represents the range of the variable and $\mu = \frac{(0.9 \times 2\pi - 0.1 \times 2\pi)}{b - a}$.

4. The full results of estimating the Fourier-flexible form of the stochastic frontier are available upon request from the authors.

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