THE EFFICIENCY OF EMERGING EUROPE'S BANKING SECTOR BEFORE AND AFTER THE RECENT ECONOMIC CRISIS

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Abstract

This paper provides estimates for the relative efficiency of banks in emerging Europe before the recent boom, just before the crisis, and right after the crisis, using a Data Envelopment Analysis (DEA). The results suggest that DEA efficiency scores before the recent crisis were strongly linked to the host country's level of development; were higher for foreign-owned banks; but did not stand out for bank groups with a presence in more than one country. The results also suggest that bank efficiency increased during the pre-crisis boom, but fell during the crisis. Finally, foreign-owned banks in emerging Europe seem to be less efficient than their mother banks, suggesting that although they may bring some efficiency benefits to their host country, they are highly affected by the local business and operational environment.

Keywords: emerging Europe, macro-financial links, bank sector efficiency

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1 Introduction

Emerging Europe grew fast before the onset of the economic crisis in 2008. During this period, the region included some of the fastest growing emerging economies, even after controlling for differences in initial per capita GDP (figure A1).

The region's pre crisis boom was to a large extent driven by fast bank-led credit growth.[1] As part of the EU-driven reforms and widespread liberalization – in new EU members and countries with EU aspirations – capital controls and credit market regulations were dismantled in most countries (figures A2 and A3). Financial openness, measured by foreign assets plus foreign liabilities as a share of GDP, increased substantially (figure A4), and borrowing costs fell sharply throughout the region. As a result, private credit expanded in emerging Europe faster than in other emerging economies (figure A5).

The opening up of the emerging European economies combined with privatization in the financial sector led to a sharp increase in foreign bank ownership throughout the region. Before the crisis, the share of foreign banks in total bank assets reached a range from 29 percent in Slovenia to 99 percent in Estonia, with an average of 77 percent and a median of 84 percent (figure A6). The easy access of foreign owned banks to financing from their parent banks was to a large extent the engine of the pre-crisis credit boom.

The importance of bank lending in emerging Europe's recent boom-and-bust cycle raises questions about the efficiency of the banks in the region. It could be argued that bank efficiency could suffer during a credit boom, as temporarily high bank profitability relaxes incentives to save costs. On the other hand, intense competition during a boom may increase bank efficiency. With almost all major banks retaining their exposure in the region during the crisis – coordinated through the Vienna initiative[2] – questions related to bank efficiency are also relevant for the growth prospects of emerging Europe looking forward.

Previous literature has focused primarily on bank efficiency in emerging Europe during the liberalization years, before the recent boom-and bust-cycle. Poghosyan and Kumbhakar (2010), who review the early literature, also focus on the cost efficiency of banks in 20 emerging European economies during 1993-2004 and find it to depend on progress in economic reforms, economic stability, capital regulation, and market structure in the banking sector. They also find foreign ownership to increase bank efficiency, but only in less developed economies. Their results also suggest that the adoption of EU standards by the new EU members has improved bank performance. Poghosyan and Poghosyan (2010) address similar issues, but focus on foreign owned banks. Their sample includes banks in 11 countries, during 1992-2006. They find foreign owned banks to be more efficient than domestic banks, particularly foreign green-field banks. Similar evidence in support of foreign owned banks is provided by Havrylchyk and Jurzyk (2006; 2008).[3]

[1] For more details see Vamvakidis (2009) and Ranciere, Tornell and Vamvakidis (2010).

[2] The Vienna initiative avoided any sudden halt to new lending and the resulting fire-sale of assets that would have resulted if banks had pulled out of emerging European economies during the crisis. Foreign mother banks agreed to roll-over the exposure of their subsidiaries in countries of the region, as they would have been worse off if all of them were to exit at the same time.

[3] For a review of country studies see Poghosyan and Poghosyan (2010).

This paper uses Data Envelopment Analysis (DEA) to examine bank efficiency in emerging Europe before and after the recent crisis. It compares DEA scores before the recent boom, just before the crisis, and right after the crisis. Focusing on the period just before the crisis, it compares DEA scores in different countries and attempts to explain differences based on a number of determinants, including ownership, bank size and country characteristics. In addition, the paper compares estimates of bank efficiency in bank groups that are present in more than one country and compares DEA scores in foreign owned banks with the scores of their mother banks; as far as we know, the existing literature has not addressed these issues. The sample includes only large commercial banks, as defined by Bankscope, to reduce noise and to focus on banks that could be systemic for the countries in the sample and, potentially, the region.

The results suggest that DEA efficiency scores before the recent crisis were strongly linked to the host country's level of development. Furthermore, foreign-owned banks seem to be more efficient than domestic banks, although with a relatively small difference. Bank groups with a presence in more than one country do not have higher DEA scores than the other banks in the sample. The results also suggest that bank efficiency increased during the pre-crisis boom, but fell after the crisis. Finally, foreign-owned banks in emerging Europe seem to be less efficient than their mother banks, suggesting that although they may bring some efficiency benefits to their host country, they are also affected by the local business and operational environment.

The rest of the paper is organized as follows: section two discusses the methodology; section three discusses the data and the empirical approach; section four presents results for DEA efficiency scores in banks in emerging Europe just before the recent crisis and analyses their determinants; section five compares DEA efficiency scores in banks in emerging Europe before the pre-crisis boom, just before the recent crisis and after the crisis; section six compares DEA efficiency scores in foreign-owned banks in emerging Europe with that of their mother banks; and section seven concludes.

2 Methodology

In general, a financial institution (referred to as decision-making unit or DMU) can be said to be efficient if it cannot produce more output without a consequent relative increase in inputs, or if it cannot reduce its inputs without a consequent relative decrease in output. Traditional approaches to efficiency measurement are often focused on simple ratios, although such ratios have a number of deficiencies and may be misleading because they do not control for product mix or input prices (Berger, Hancock and Humphrey, 1993; DeYoung, 1998; Diacon, 2001). The traditional accounting approach provides opportunities for comparison of the trends, and measures the performance of banks in terms of profitability. More modern approaches to efficiency measurement try to avoid the problems associated with traditional methods by using frontier efficiency methodologies. These methods proceed by identifying "best practice" frontier (and the DMUs which lie nearest to that frontier). The frontier represents the best performance that can be achieved using the currently available production technology. The efficiency of each DMU can then be measured by comparing it to the "frontier" firms which are closest to it.

There are two major classes of efficiency frontier estimation methods: the parametric approach and the non-parametric approach. Berger and Humphrey (1997) identify five different approaches to determining the efficiency frontier. The three main parametric approaches to specification of the efficiency frontier are the stochastic frontier approach (SFA), the distribution-free approach (DFA) and the thick frontier approach (TFA), while the two non-parametric approaches are DEA and the free disposal hull (FDH) method.

A major challenge for both sets of approaches is in distinguishing random error arising from accounting practice or some other source from inefficiency. Each of the parametric approaches has different ways of dealing with random error, whereas the non-parametric approaches generally ignore it. Thus, the above approaches to efficiency measurement mainly differ in the distributional assumptions imposed on random error and inefficiency.

Charnes, Cooper and Rhodes (1978) were the first to use the term DEA. Their approach applied the efficiency concept outlined by Farrell (1957). DEA gets its name because the empirical frontier truly envelops the entire data set. Since then, there have been a large number of studies that have applied and extended the methodology.

To establish the frontiers, we use linear programming-based DEA, as it is more proficient than parametric approaches at describing frontiers. DEA constructs a piecewise linear surface that connects the set of the best-practice DMUs, yielding a convex production possibilities set. We choose the DEA approach for the following reasons:

- the DEA approach has been used extensively in estimating efficiency for banking and insurance research;
- the non-parametric approach avoids the potentially inappropriate assumption for the distribution of the error terms of the parametric approach; and
- the DEA approach separately evaluates the efficiency of every DMU relative to its reference set, thus providing a relative measurement of efficiency for every single DMU.

Due to the flexible feature and its various advantages (Sengupta, 1999; and Lewin and Minton, 1986), DEA has been widely used in a variety of research areas, including in banking (Charnes et al., 1994). The DEA approach enables the determination of multiple outputs and multiple inputs in efficiency score calculation. At the same time, unlike parametric approaches, it needs no long time series. As Evanoff and Israilevich (1991) note, DEA allows one to work with fewer data, fewer assumptions and a smaller sample. A rule of thumb commonly used with DEA suggests that the number of observations in the data set should be at least three times the sum of the number of input and output variables (Cooper, Seiford and Tone, 2000; 2006).

DEA estimates the frontiers by solving a series of linear programming problems. The efficiency of each DMU is then measured by computing its distance from the frontiers. Efficiency ranges from 0 to 1, with a DMU operating on the frontier (efficiency of 1) measured as fully efficient. As this approach focuses primarily on the technological aspects of production functions, it can be used to estimate productive efficiency without requiring estimates of input and output prices. Moreover, as Cooper, Seiford and Tone (2000) describe it, for DEA the measurement units of the different inputs and outputs do not need to be congruent: inputs and outputs can be expressed in different units.

A non-parametric technique originally developed by Charnes, Cooper and Rhodes (1978) was based on constant returns to scale (CRS), but was subsequently extended by Banker, Charnes and Cooper (1984) into a model providing for variable returns to scale (VRS). However, under VRS, most large banks might appear fully efficient, possibly because of the lack of truly comparable efficient banks (Berg, Førsund and Jansen, 1991; and Berg, Hjalmarsson and Suominen, 1993). In this case, the CRS assumption allows comparing large banks to be compared with much smaller banks, thus avoiding them appearing artificially efficient.

As DEA assesses efficiency by comparing a bank's efficiency with those of others, each inefficient bank will have a group of efficient banks against which its performance is identified as inefficient. This group of efficient banks is the reference set for that inefficient bank, and the methodology directly identifies ways in which inefficiency can be increased.

DEA models may have either an input or an output orientation. An input orientation aims at reducing the input amounts as much as possible while keeping at least the present output levels, while an output orientation aims at maximizing output levels without increasing use of inputs (Cooper, Seiford and Tone, 2000; 2006). To date, the theoretical literature is uncertain as to the best choice among the alternative orientations of measurement. Nevertheless, in many cases, the choice of orientation has only a minor influence on the obtained scores (Coelli, Prasada and Battese, 1998).

A distinction is also made between the production and intermediation models, with the intermediation model having a number of different forms. Under the production approach, banks are considered as using labor and capital to produce deposits and loans, with both inputs and outputs usually measured on a physical scale, rather than in money measures. However, this approach fails to capture the role of a bank as a financial intermediary and does not include interest expenses, which is usually the largest portion of total costs.

This paper uses the intermediation approach, originally developed by Sealey and Lindley (1977). The intermediation approach perceives deposits and other funds being transformed into loans, with its different versions: the asset approach, which uses funds as inputs and loans as outputs; the user cost approach, which looks at the various contributions to banks' net revenue; and the value added approach, where inputs and outputs are identified according to their share of value added (Berger and Humphrey, 1992).

A brief description of the underlying linear programming model follows. It is assumed that there are m inputs and s outputs for every DMU. Specifically DMU_j uses amount x_{ij} of input i and produces amount y_{rj} of output r. We further assume that $x_{ij} \geq 0$ and $y_{rj} \geq 0$ and that each DMU should at least have one positive input and one positive output. For each DMU we try to obtain a measure of the ratio of all outputs over all inputs. To select the optimal weights (u and v are vectors of weights), the following problem is proposed:

$$\begin{aligned} &\max h_o(u,v) = \textstyle\sum_r u_r y_{ro} / \sum_i v_i x_{io} \\ &\textstyle\sum_r u_r y_{rj} / \sum_i v_i x_{ij} \leq 1 \quad \text{j=1,…,n;} \quad \forall r,i \,;\; u_r, v_i \geq 0 \end{aligned} \tag{1}$$

The numerator in (1) represents a set of desired outputs and the denominator represents a collection of resources used to obtain these outputs. The value h_o^* obtained from this ratio satisfies $0 \leq h_o^* \leq 1$ and can be interpreted as an efficiency rating in which $h_o^*=1$ represents full efficiency and $h_o^* < 1$ means inefficiency is present.[4] The optimal values u_r^* and v_i^* may be interpreted as weights when solutions are available from (1). But, they are determined in the solution of the model and not a priori. So these multipliers are called *virtual multipliers* and they yield a *virtual output* and a *virtual input* which can allow the efficiency ratio to be computed.

This can easily be converted to a linear programming problem (Charnes, Cooper and Rhodes, 1978):

$$\begin{aligned} &\max h_o(u,v) = \sum_{r=1}^{s} u_r y_{ro} \\ &\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \\ &\sum_{i=1}^{m} v_i x_{io} = 1 \\ &u_r, v_i \geq 0 \\ &\text{j=1,…,n; } \forall r, i \end{aligned} \tag{2}$$

The objective is to maximize virtual output (as defined above) subject to unit virtual input, while maintaining the condition that virtual output cannot exceed virtual input for any DMU that is considered in the study.

This problem is solved *n* times (once for every single DMU) and the results include relative efficiency scores of all DMUs. Thereafter, every DMU selects the combination of inputs and outputs that maximizes its efficiency.

DEA has been used extensively in studies of the banking industry in developed and developing economies. The method was applied for cases in the U.S., Norway, Spain, U.K., Italy, Greece, New Zealand, Malaysia, Poland, Estonia, Canada and several other countries (Emrouznejad and Podinovski, 2004; and Berger and Humphrey, 1997). It has also recently been used for Central America (Wezel, 2010) and Sub-Saharan Africa (Anayiotos and Toroyan, 2009). In addition, there are a lot of inter-country comparisons based on DEA (Berg, Hjalmarsson and Suominen, 1993; Pastor, Perez and Quesada, 1997; and Bergendahl, 1998).

3 Data and empirical approach

The sample includes 125 large commercial banks from 14 emerging European economies. It includes all commercial banks defined by Banscope as large, with available data. From these banks, 41 are domestic banks and 84 are foreign owned. From the domestic banks, 6 are stated owned and 35 are private banks. The sample also includes 9 bank groups with a presence in more than one country. The estimates are for: 2004, which

[4] The star (*) indicates an optimal value obtained from solving the model.

is the year when growth accelerated and spread in emerging Europe; 2007, which is the year before the crisis in emerging Europe; and 2009, which is the crisis year – the crisis in emerging Europe started in late 2008, while 2009 was the first year with negative growth rates throughout the region.

The relative efficiency of banks was assessed using the DEA methodology described in the previous section. As emphasized above, the choice of inputs and outputs is essential in the DEA methodology. An intermediation approach was applied in this case. Within the intermediation approach, an asset approach was chosen. In this case, resources used by the DMU should serve as inputs, while assets and incomes are outputs.

The variables chosen as inputs and outputs were determined based on data availability and considerations from previous literature. Total capital, interest expense and operating expense were chosen to serve as inputs:

- Capital indicates investment in the firm by shareholders. It can be seen as an input in two ways. First, it is a fund that banks can use to allocate and earn profit on it. Second, capital determines how much risk a bank can take and hence it limits investment in risky assets, including loans.
- Interest expense measures the cost of bank funding.[5]
- Operating expenses proxy for the operational efficiency of a DMU and, to some extent, the size of a bank.

Total loans, pre-tax profit and securities portfolio were chosen as outputs:

- The loans and securities portfolio constitute almost 80 percent of bank assets in the sample. Assets are treated as outputs as they indicate future financial inflow.
- Profit is the final outcome of a business entity. The choice of pre-tax profit is caused by the existence of the different business (tax) environments in which the banks in the sample operate.
- Security portfolio has the second biggest stake in the income bearing assets.

4 Bank efficiency in emerging Europe before the crisis

This section discusses consolidated results for different bank groups in emerging Europe for 2007, which is the year before the crisis. First, it discusses results by country of operation. It then discusses some simple comparisons and correlations of DEA scores. Finally, a simple cross-section regression is estimated with the DEA scores as the dependent variable.[6] The next section re-estimates DEA scores pooling data for all the banks in the sample for the years 2004, 2007 and 2009, in order to compare bank efficiency before, during and after emerging Europe's recent boom-and-bust cycle.

Before discussing the DEA estimates, it is interesting to examine which factors affect the efficiency scores the most. The results suggest that interest expense from inputs

[5] One could include deposits instead. However, many foreign owned banks in emerging Europe have financed a large share of their lending through borrowing from their mother banks. Domestic banks also borrowed from abroad before the crisis. Therefore, including the overall cost of funds may be more appropriate.

[6] Detailed results by bank are available from the authors.

and pre-tax profit from outputs have the largest impact on relative efficiency scores (table A1).[7] In contrast, capital and securities portfolio affect the DEA score the least. However, in the case of inputs, this sequence does not hold for some countries (in the Czech Republic, Estonia, Hungary, and Poland, operating expense has the most effect on DEA scores), while it holds for almost all countries in the case of outputs-with the exception of Hungary.

Grouping by country of operation, the results in figure A7 suggest the highest efficiency in the Czech Republic, FYR Macedonia and Bulgaria, followed by Poland, Lithuania, Estonia, Latvia, and the Slovak Republic. The lowest efficiency estimates are in Albania, Ukraine, and Serbia. Croatia, Romania and Hungary seem to be intermediate cases. These results seem close to what one would expect, at least based on each country's income levels, with the exception of FYR Macedonia, where banks seem to be more efficient than one would expect.[8]

Table A2 presents some simple comparisons of the average DEA bank scores with country characteristics. The correlation between the DEA estimates and the per capita PPP GDP is equal to 0.5 – it increases to 0.7 if FYR Macedonia, which seems to be an outlier, is excluded. However, there is no correlation of DEA scores with recent real GDP growth. The correlation with bank credit/GDP and financial openness is close to zero. However, the correlation of DEA scores with the country interest rate spread between lending and deposit rates, which to a large extent is determined by competition in the banking sector, is negative, suggesting that more competition is linked to more efficiency. The correlation with the ratio of nonperforming to total loans is also negative, suggesting that higher efficiency and better loan quality are linked. An index of credit market regulation is positively correlated with the DEA estimates (the index increases as regulation declines), suggesting that less regulation is correlated with more efficiency. The ratio of stocks traded to GDP is also positively correlated with DEA scores, suggesting that more competition from nonbank financing sources could increase bank efficiency. Finally, EU country members seem to have slightly more efficient banks – again, the difference is higher if FYR Macedonia is excluded.

When banks are grouped into domestic- and foreign-owned, the results suggest that, on average, foreign-owned banks are more efficient, with a score of 0.7, compared with 0.5 for domestic banks.

Turning to banks with a presence in more than one country, the results suggest no difference with the rest of the sample. The sample includes 9 financial institutions with a presence in more than one country.[9] Even though one may expect some similarities in the relative efficiency scores of such banks, we find no evidence in support of this hypothesis. The average DEA score in banks that belong to a group is equal to 0.67, compared with 0.63 in the other banks in the sample, which is a negligible difference. Moreover, the average standard deviation within bank groups is equal to 0.14, compared with 0.21 in the

[7] This analysis has been done on individual bank level, although the paper discusses consolidated results.

[8] Note that only two banks were represented from FRY Macedonia hence the results could be somewhat misleading.

[9] Erste (Austria), Raiffeisen (Austria), BRE (Denmark), MKB (Denmark), Komercni (France), Alpha (Greece), UniCredit (Italy), Parex (Latvia), Swedbank (Sweden).

other banks in the sample, which again is very small. These results suggest that country specific factors dominate bank efficiency and that foreign owned banks with a presence in more than one country do not transfer their knowledge and experience across-borders, at least not as much as would have been expected.

A regression framework helps determine which of the above correlations are the most robust. Table A3 presents estimates from a cross-section of the 125 banks in the sample, with the DEA scores as the dependent variable. The independent variables include: the log of the initial PPP GDP per capita, a dummy variable if the bank is foreign owned, a dummy variable for EU membership, the log of total assets, a dummy variable if a bank belongs to a group, an index of credit market regulations, the ratio of domestic bank credit to GDP, the interest rate spread, a dummy for state-owned banks, the ratio of non-performing loans to total loans, and stock traded as a percent of GDP.

The results suggest a strong link between bank efficiency and per capita GDP, foreign ownership and the stock of domestic credit to GDP. The estimate of the per capita GDP is positive and statistically significant at the 5 percent level in all but one specification. Therefore, more developed economies in emerging Europe have more efficient banks. The estimate of the dummy variable for foreign bank ownership is always positive and statistically significant at the 5 percent level – however, the estimate is relatively small, which is consistent with results in the earlier literature. Therefore, foreign owned banks seem to be somewhat more efficient in emerging Europe, even after controlling for other possible bank and country characteristics. The estimate of the stock of domestic credit to GDP is negative and statistically significant, although at the 10 percent level. This suggests that as credit expands bank efficiency suffers. This result may be linked to the period of the estimates, which is just before the recent crisis and the bursting of bubbles in the region.

The other variables do not turn out to have statistically significant estimates, in contrast to what some of the simple correlations in table A2 would suggest. The last regression in table A3 is a stepwise OLS, and confirms that per capita GDP, foreign ownership and the stock of domestic credit to GDP have the most explanatory power from the variables considered. This specification also includes EU membership, bank size, and credit market regulation.

5 Bank efficiency in emerging Europe during the boom-and-bust cycle

This section reestimates DEA scores pooling data for all the banks in the sample for the years 2004, 2007 and 2009, in order to compare bank efficiency before, during and after emerging Europe's recent boom-and-bust cycle.[10] The comparisons with respect to 2004 should be treated with caution, as there are missing values. However, data are available for almost all banks in the sample for 2009.

The results suggest that bank efficiency increased during the boom, but fell during the crisis (figure A8). On average, bank efficiency was equal to 0.55 in 2004, increasing to 0.61 in 2007, just before the crisis, but falling to 0.52 just after the crisis. Bank effi-

[10] Therefore, the DEA scores for 2007 in this case may differ from the scores in the previous section.

ciency during the boom years increased the most in Romania, Poland, and Bulgaria. It fell only in Estonia and, somewhat less so, in Slovakia and in Lithuania. In contrast, the fall in bank efficiency following the crisis was almost universal in the region. It fell the most in Bulgaria, Romania, and Lithuania, and did not increase in any of the countries in the sample.

These results also confirm higher efficiency scores in foreign owned banks, although there seems to be no difference between foreign and domestic banks in efficiency trend during the recent boom-and-bust cycle in the region (figure A9). During all this period, foreign banks had on average higher DEA scores than domestic banks. Efficiency scores increased only slightly more in foreign banks during the boom years (from 2004 to 2007) than in domestic banks. However, they fell in both cases during the crisis.

6 Bank efficiency in emerging Europe's foreign banks compared with their mother banks

This section focuses on the foreign-owned banks in the sample and compares their efficiency with that of their mother banks abroad. The above results suggest that foreign-owned banks are somewhat more efficient than domestic banks in emerging Europe. However, bank groups, with presence in more than one country, do not stand out. By comparing the efficiency scores of foreign-owned banks with that of their mother banks, this section helps to determine whether and to what extent the former are affected primarily by the business environment in their host or their source country.

Data availability limits the sample to 43 foreign owned banks operating in emerging Europe. The total number of mother banks equals 18, as one mother bank could own more than one foreign owned bank in emerging Europe. The analysis focuses on the period just before the crisis – which is the year 2007 – as there are more missing values for the earlier or later periods. Moreover, the period after the crisis involved substantial shocks in the financial sectors of most advanced European economies, which could affect the results.

The results suggest that mother banks are more efficient than their subsidiaries in emerging Europe. The average DEA score of mother banks is 0.88 compared with an average of 0.74 for their subsidiaries in emerging Europe. The standard deviation of the difference of DEA scores by bank is equal to 0.23. Moreover, from the sample of 43 subsidiaries, only 13 of them have higher DEA scores than their mother banks. Figure A10 shows that the difference in DEA scores is relatively high in some cases.

These results suggest that although foreign-owned banks in emerging Europe are more efficient than domestic banks, they are not as efficient as their mother banks. Therefore, although they may bring some efficiency benefits to their host country, they are also affected by the local business and operational environment.

7 Conclusions and further research

This paper provides estimates for the relative efficiency of banks in emerging Europe before the pre-crisis boom, just before the recent crisis, and after the crisis, using a DEA. It assesses the relative importance of possible determinants of DEA bank efficiency sco-

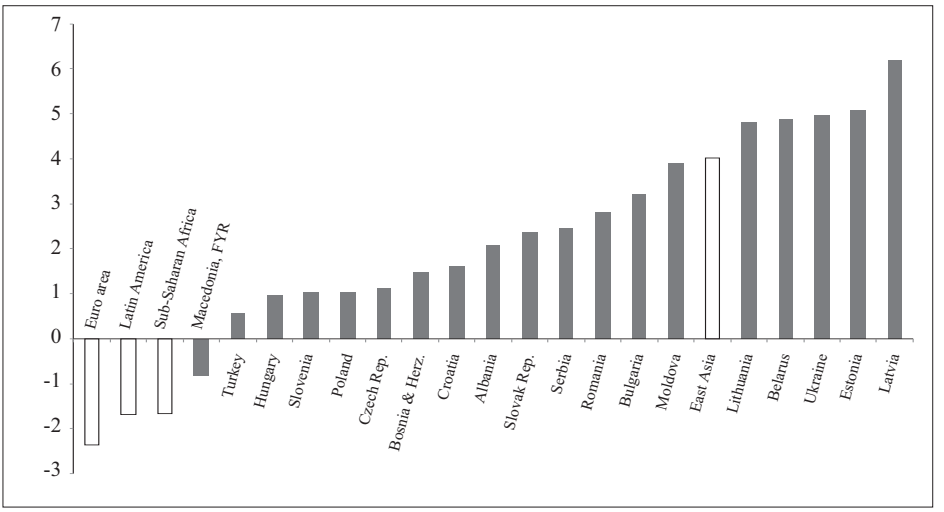
res in the region, estimates scores for bank groups with a presence in more than one country, and compares efficiency scores between foreign-owned and domestic banks, and between foreign-owned banks and their mother banks.

The results suggest that DEA efficiency scores before the recent crisis were strongly linked to the host country's level of development. Furthermore, foreign-owned banks seem to be more efficient than domestic banks, although with a relatively small difference. Bank groups with a presence in more than one country do not have higher DEA scores than the other banks in the sample. The estimates also suggest that as credit expanded before the crisis, bank efficiency suffered, which could be linked to the bubbles building in the region during this period. Other possible determinants of bank efficiency, including size, EU membership, being in a financial group with a presence in more than one country, credit market regulation, interest rate spreads, state ownership, asset quality, and stock market size do not turn out to have a statistically significant impact.

The results also suggest that bank efficiency increased during the pre-crisis boom, but fell during the crisis. Foreign owned-banks remained more efficient than domestic banks during this period. Finally, foreign-owned banks in emerging Europe have lower DEA efficiency scores than their mother banks, suggesting that although they may bring some efficiency benefits to their host country, they are highly affected by the local business and operational environment.

APPENDIX

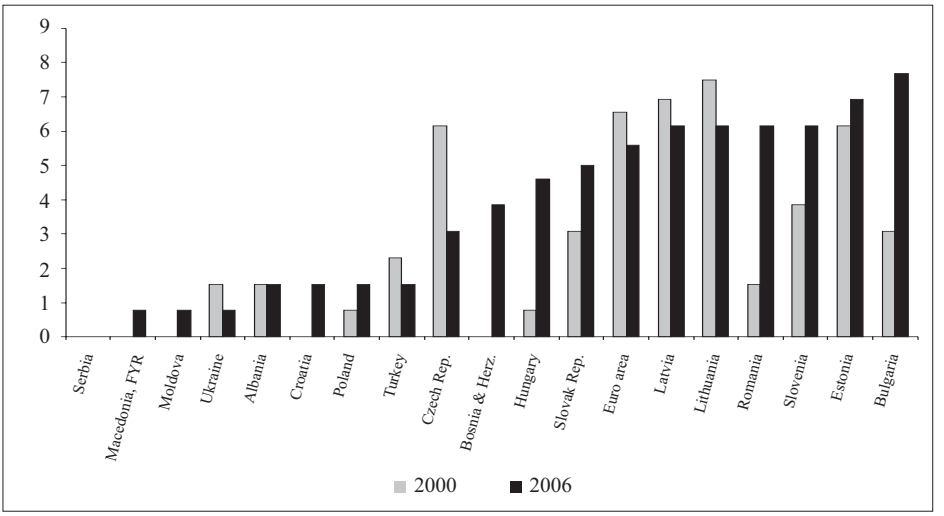
Figure A1: Real per capita GDP growth, emerging Europe and the rest of the world, 2000-2007



Note: Residuals from a growth regression that controls for initial GDP per capita.

Source: IM World Economic Outlook.

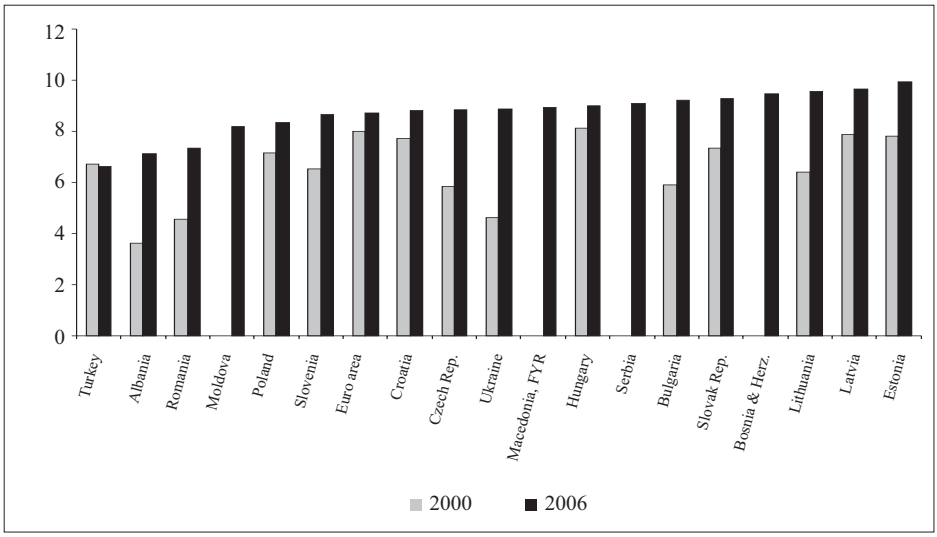
Figure A2: Capital controls, emerging Europe, 2002-2006 (an increase suggests less capital controls)



Note: Index from 1 to 10, increasing when capital controls are removed.

Source: Index of Economic Freedom, Frasere Institute.

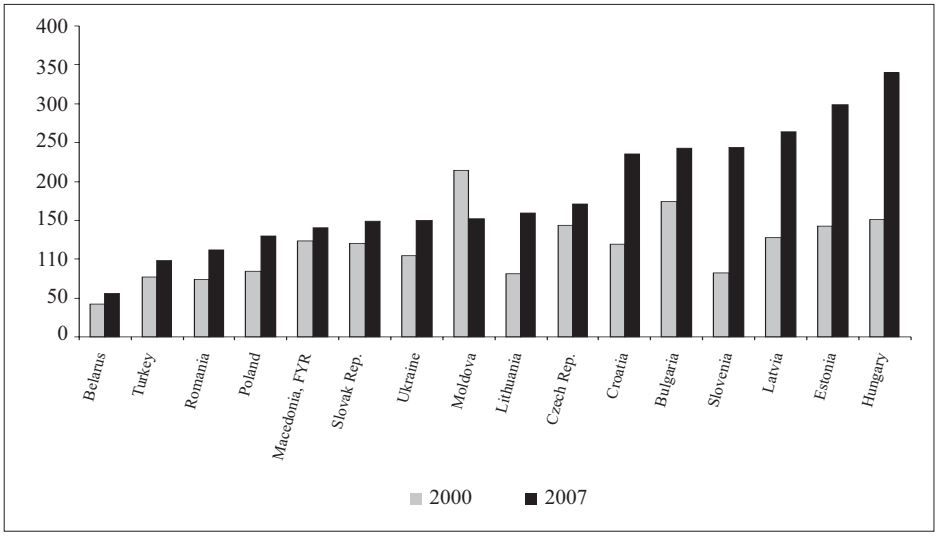
Figure A3: Credit market regulations, emerging Europe, 2000-2006 (an increase suggests less regulation)



Note: Index from 1 to 10, increasing as credit markets are liberalized.

Source: Index of Economic Freedom, Fraser Institute.

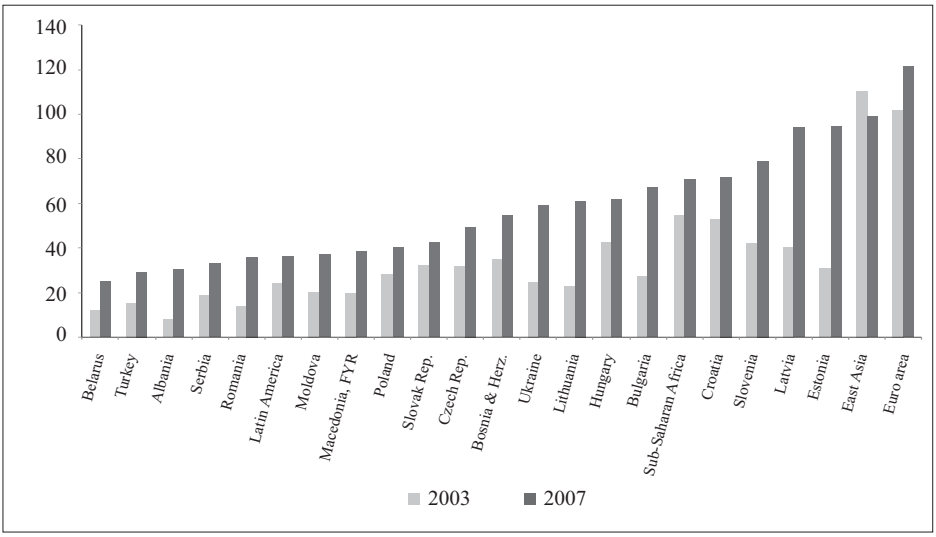
Figure A4: Financial openness (foreign assets plus foreign liabilities/GDP), emerging Europe, 2000-2007



Note: The sum of total foreign assets plus total foreign liabilities of a country's banking sector as a share of GDP proxies for financial openness.

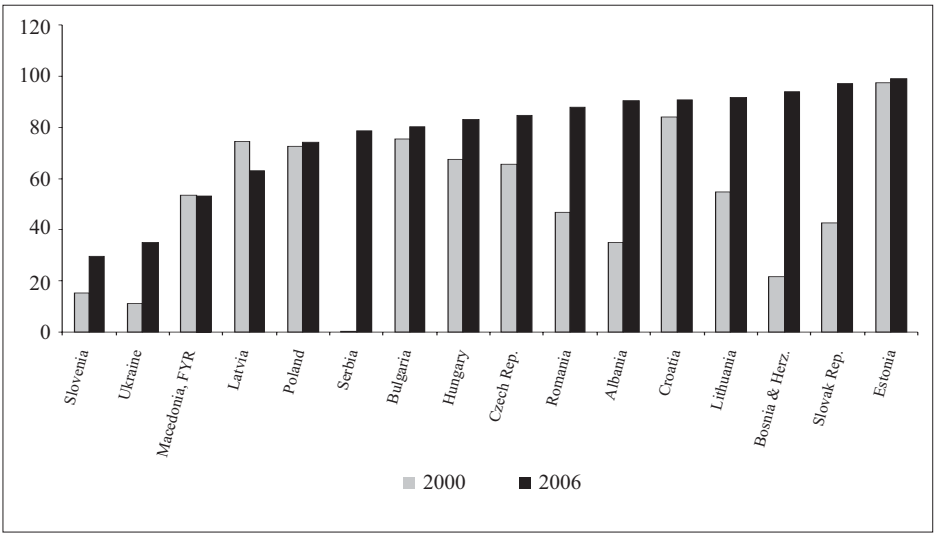
Source: IMF, International Financial Statistics.

Figure A5: Domestic private sector credit/GDP, emerging Europe and the rest of the world, 2003-2007



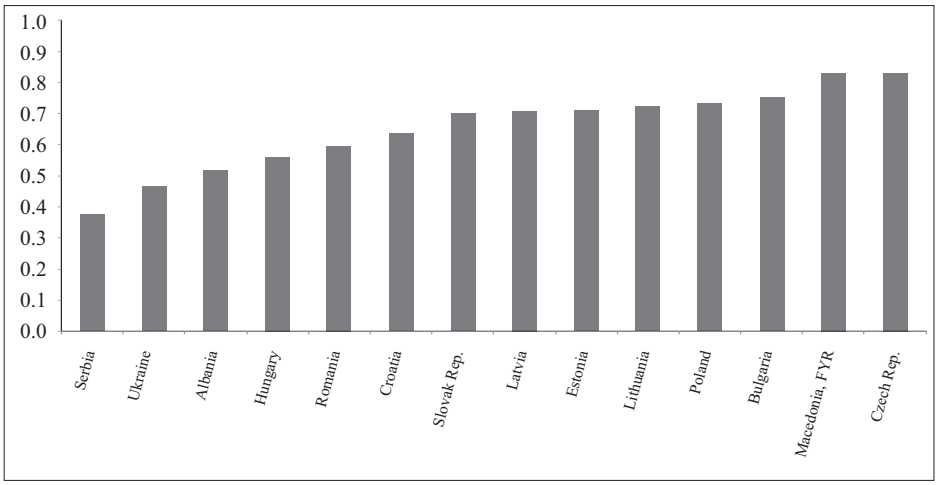
Source: IMF World Economic Outlook.

Figure A6: Asset share of foreign-owned banks, emerging Europe, 2000-2006



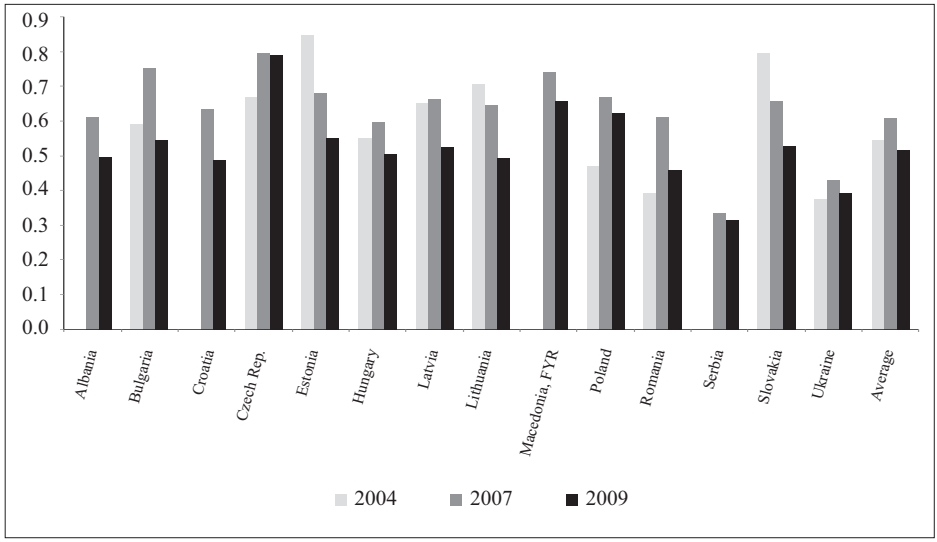
Source: Arvai, Driessen and Otker-Robe (2009).

Figure A7: Average bank sector DEA by country in emerging Europe before the crisis (2007)



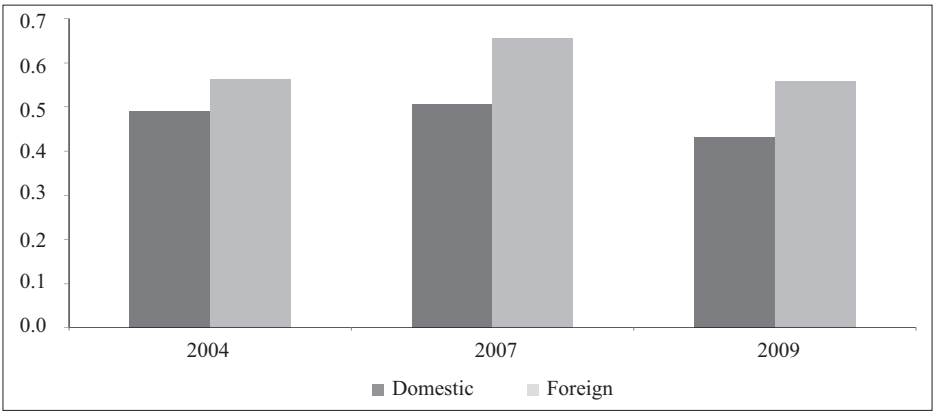
Source: Authors' calculations.

Figure A8: Average bank sector DEA by country in emerging Europe during the recent boom-and-bust cycle



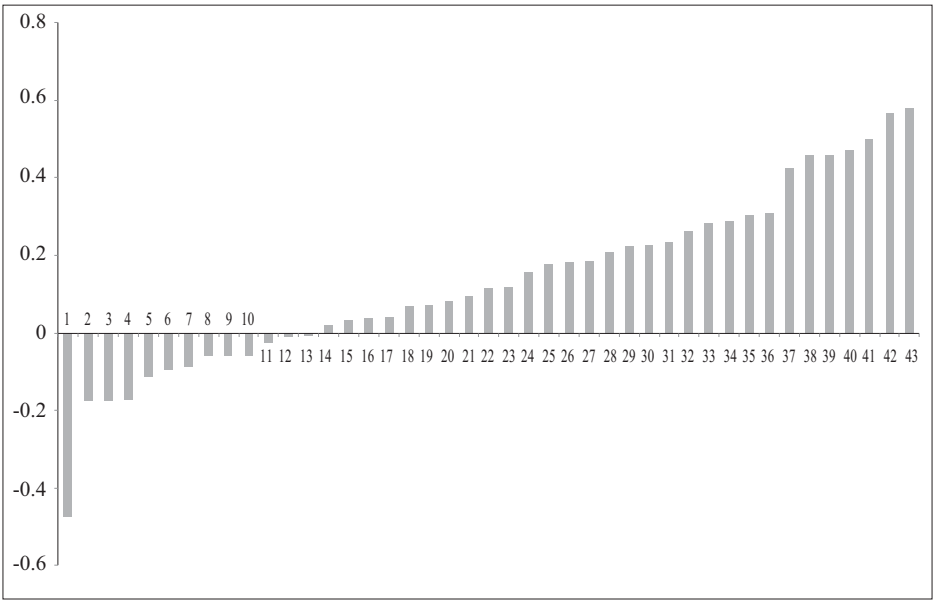
Source: Authors' calculations.

Figure A9: Average bank sector DEA by country in emerging Europe during the recent boom-and-bust cycle, foreign versus domestic banks



Source: Authors' calculations.

Figure A10: Difference in DEA scores, 2007: scores in mother banks – scores of their subsidiaries in emerging Europe



Note: Differences of DEA effeciency scores in 18 mother banks from the scores of their 43 subsidiaries operating in emerging Europe.

Source: Authors' calculations.

Table A1: Importance of factors for DEA efficiency scores (the higher the number, the more important the respective factor for the efficiency in each country)

Countries	Total capital	Interest expense	Total operating expense	Total loans - net	Pre-tax profit	Total securities
Albania	17.9	60.6	50.5	1.6	33.3	2.0
Bulgaria	20.5	617.0	150.2	17.4	40.8	11.5
Croatia	31.1	425.6	68.1	13.2	39.5	4.9
Czech Rep.	17.8	72.3	122.0	3.7	18.9	1.6
Estonia	7.4	148.6	236.1	1.9	95.0	0.9
Hungary	20.2	7.1	22.9	0.7	6.5	0.9
Latvia	30.9	278.0	48.0	9.7	31.5	2.8
Lithuania	17.5	192.3	25.6	6.3	14.6	2.2
Macedonia, FYR	79.5	3,089.6	813.5	76.2	321.9	71.0
Poland	9.2	56.7	58.4	2.4	17.9	0.4
Romania	6.4	63.7	7.8	2.2	4.0	0.3
Serbia	12.8	394.7	4.2	7.7	18.7	1.1
Slovakia	11.9	190.4	50.1	5.1	24.8	3.7
Ukraine	72.8	480.0	212.3	18.1	73.6	7.0

Source: Authors' calculations.

Table A2: Estimates of bank efficiency and other country economic indicators, 2007

	Average DEA	Log of PPP GDP per capita	Growth in last 5 years	Bank sector credit/ GDP	Financial openness	Interest rate spread	Non-performing loans	Credit market regulations	Stocks traded (% of GDP), 2003-07
Albania	0.5	8.8	5.8	61.3		8.4	3.4	7.1	
Bulgaria	0.8	9.3	6.1	59.2	243.2	6.3	2.1	9.2	5.4
Croatia	0.6	9.8	4.7	72.6	235.0	7.0	4.8	8.8	2.9
Czech Rep.	0.8	10.1	5.5	53.2	171.3	4.5	2.6	8.9	21.2
Estonia	0.7	9.9	8.3	95.1	298.9	2.1	0.5	10.0	9.2
Hungary	0.6	9.8	3.6	74.2	340.0	2.3	2.4	9.0	21.2
Latvia	0.7	9.8	9.7	89.5	264.1	4.8	0.4	9.7	0.7
Lithuania	0.7	9.8	8.4	60.2	159.1	1.5	1.0	9.6	3.1
Macedonia, FYR	0.8	9.1	4.2	34.4	140.9	5.4	9.1	8.9	2.4
Poland	0.7	9.7	5.2	46.3	130.6	n.a.	3.1	8.4	11.3
Romania	0.6	9.3	6.4	35.7	112.2	6.6	9.7	7.3	2.7
Serbia	0.4	9.2	5.7	30.8		7.1	3.8	9.1	3.5
Slovak Rep.	0.7	9.9	7.1	51.5	149.2	4.3	2.5	9.3	0.6
Ukraine	0.5	8.9	7.9	61.1	149.5	5.8	13.2	8.9	0.8
Correlation with DEA	1.0	0.5	0.0	0.1	-0.1	-0.4	-0.3	0.3	0.2
EU members	0.7								
Non EU countries	0.6								

Sources: IMF WEO; IMF IFS; World Bank World Development Indicators; and Index of Economic Freedom (Fraser Institute).

Table A3: DEA and bank and country characteristics in emerging Europe before the crisis (2007)

Initial PPP GDP per capita	0.20***	0.18***	0.13**	0.13**	0.13**	0.14**	0.15	0.13**
	(0.03)	(0.03)	(0.06)	(0.06)	(0.06)	(0.06)	(0.11)	(0.06)
Foreign owned		0.08**	0.08**	0.08**	0.07**	0.07**	0.08**	0.08**
		(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.035)
EU membership			0.08	0.08	0.08	0.09	0.11	0.08
			(0.06)	(0.06)	(0.06)	(0.06)	(0.09)	(0.055)
Assets			-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Belongs to a group			0.005	0.004	0.01	0.01	0.005	
			(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	
Credit market regulations				0.004	0.04	0.05	0.09*	0,04
				(0.02)	(0.03)	(0.04)	(0.05)	(0.035)
Bank credit/ GDP					-0.003*	-0.003*	-0.003**	-0.003**
					(0.001)	(0.001)	(0.002)	(0.001)
Interest rate spread						0.01	0.01	
						(0.01)	(0.01)	
State owned						0.003	0.003	
						(0.09)	(0.10)	
Non-performing loans/total loans							0.003	
							(0.01)	
Stocks traded (% of GDP)							0.001	
							(0.003)	
Observations	125	125	125	125	125	125	123	125
Adjusted R squared	0.20	0.23	0.23	0.23	0.25	0.24	0.23	0.26

Note: The dependent variable is the DEA score of 125 banks in 14 emerging European economies. Heteroscedasticity-adjusted standard errors in parentheses. The last column includes estimates from a stepwise regression.

Source: Authors' calculations.

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