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EFFICIENCY OF BANKS IN SOUTH-EAST EUROPE: WITH SPECIAL REFERENCE TO KOSOVO

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Abstract

Using a unique database consisting of almost all banks in four countries in South-East Europe and employing non-parametric methodologies, the efficiency of banks is investigated and the superior efficiency of foreign-owned banks in intermediation is confirmed. It is argued that the overall efficiency improvement has originated from the change in technology rather than scale and technical efficiency, and banks on average have not been able to catch-up with best performers, thus widening the efficiency gap. The largest sources of inefficiency are found to be lending shortfalls, cost and scale inefficiencies. In Kosovo, although there has been some improvement, the banking system remained less efficient than elsewhere. Based on these findings, a number of policy implications aiming at enhancing the intermediation efficiency of banks are derived.

JEL classification: C14, G21

Key words: Bank efficiency, Data Envelopment Analysis, Malmquist Index, South-East Europe

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1. INTRODUCTION

The relative performance of banks in terms of intermediation in a particular market and over time is an important question for analysis. This is particularly the case for the South-East Europe (SEE) region that has lagged behind the advanced transition economies (TEs) in banking sector intermediation, despite having undergone a fundamental transformation. Given that the banking sector is virtually the only source of external finance for the real sector in SEE, it is important for policymakers to ensure the efficiency of the banking industry in allocating financial resources, while maintaining stability and enhancing competition. Thus, the aim of this paper is to investigate intermediation efficiency of banks in four SEE countries, namely Bulgaria, Croatia, Kosovo and Montenegro in the period 2002-2005.

In the first decade of transition SEE countries faced serious difficulties in restructuring their banking sectors. Subsequently, governments decided to develop competitive, strong and stable banking systems by allowing foreign banks to enter the market, on the presumption that these were contributing to efficiency improvements. If foreign banks are more efficient, then an important question to be addressed in this paper is whether there is an overall efficiency improvement in the sector and whether there is any convergence in the efficiency of domestic and foreign banks, that is if there are any spillover effects from foreign banks in improving the efficiency of domestic banks. This paper puts special emphasis on the case of Kosovo by examining the extent to which the banking sector has been able to catch-up with other countries. Also an important question to be addressed is the intermediation efficiency of banks by the size of the operation, i.e. if inefficiencies are driven by the sub-optimal scale size, in the light of mergers and acquisitions (M&As) undergone by the banking sector in SEE. This is particularly important for competition authorities to assess whether M&As achieved their intended aims.

These research questions will be explored by employing Data Envelopment Analysis (DEA), a non-parametric linear programming technique, which measures the relative efficiency of banks in the SEE from the intermediation point of view using bank-level data. Intermediation efficiency is defined as the ability to transform deposits into loans while maintaining profitability, i.e. maximizing revenues given costs. DEA efficiency frontiers are estimated for individual countries as well as for the four SEE countries as a group. Several sensitivity tests such as the test of outliers, the test for the stability of the DEA efficiency scores over time and the use of the DEA scores in conjunction with accounting ratio analysis will be conducted to assess the plausibility of the DEA efficiency scores. In addition, the sources of inefficiency are estimated, given that an advantage of the DEA method is that it can identify these directly. Furthermore, the DEA is extended by employing the Malmquist Total Factor Productivity Change Index which enables the gauging of the contribution of technical efficiency change (a catching-up effect), technological change (a frontier shift effect) and scale efficiency change on the total factor productivity change.

The paper is structured as follows. In the next section the methodologies used in the empirical work on measuring efficiency in the banking studies are reviewed. In section 3 the literature on the efficiency of banks in TEs is surveyed, putting special emphasis on the impact of ownership on bank performance. Section 4 defines inputs and outputs in the banking business used in the study. In section 5 DEA is used to measure the intermediation efficiency of banks in four SEE countries, followed by some sensitivity tests in section 6. The DEA analysis is extended by employing the Malmquist Index in section 7. Finally, section 8 concludes.

2. THE METHODOLOGY

The notion of efficiency in economics, as developed by Farrell (1957), refers to the minimization of inputs used by a firm to produce a given level of outputs or the maximization of outputs produced by a given set of inputs under a given state of technology. This is also known as technical efficiency where the efficient units cannot reduce any of inputs without increasing another or reducing the output. However, for any given firm or industry the absolute level of efficiency is not known. What may be known is the efficiency of a firm relative to another firm or to some benchmark for the industry, which is the reference technology giving rise to the frontier analysis in efficiency measurement.

The empirical implications of Farrell's ideas have been tested by using both econometric and non-parametric linear programming techniques. Among the non-parametric techniques, formalized first by Charnes, *et al*. (1978), the Data Envelopment Analysis (DEA) is the most widely used for efficiency measurement in many industries, including banking.[1] Often a problem with the use of parametric methods is that they require data on input prices (the cost function) or both input and output prices (the revenue or profit function), which are usually not easy to obtain. Apart from data availability, there is an inherent problem in the analysis of banking because of the difficulties in defining and measuring the prices of bank inputs and outputs. Also prices derived from a bank's financial statements are endogenous to the bank's behaviour leading to the misspecification of the efficient frontier in the presence of market power making the use of price data inadvisable (Pastor *et al*., 1997; Bos and Kool, 2006).[2] Therefore, in this paper the DEA method is used to assess the efficiency of banks in SEE.

2.1. Data Envelopment Analysis

DEA is a non-parametric linear programming technique used in assessing the relative efficiency of functionally comparable entities such as banks. Banks use some inputs, e.g. labour and capital, in order to produce some outputs, e.g. loans. The DEA method, being an extreme point method,[3] enables the construction of a frontier or a 'virtual' efficiency benchmark as a linear combination of efficient entities with the best combination of inputs and outputs among the observed entities. Any deviation of a particular observation from the frontier is attributed to inefficiency. Those firms that are on the frontier are efficient since it is not possible to reduce any input without increasing another for producing the same level of output. Firms that are not on the frontier are inefficient. DEA assumes that all entities under investigation face the same (unspecified) technology that defines their production frontier. The differentials in input costs or product differentiation between the entities are not taken into account explicitly, thus, it accounts for technical efficiency only. It is important to note that technical inefficiency of financial institutions has generally been found to dominate scale and product mix inefficiencies (Aly *et al*., 1990; Isik and Hassan, 2002).

[1] The two approaches, parametric and non-parametric, differ in their assumptions, have their advantages and disadvantages, and there is no agreement in banking studies on which approach is better. Methodologies employed in measuring efficiency in banking studies can be divided into two broad groups, parametric (Stochastic Frontier Approach, Distribution Free Approach and Thick Frontier Approach) and non-parametric (Free Disposal Hull and Data Envelopment Analysis). The Stochastic Frontier Approach (SFA) and the Distribution Free Approach (DFA) are the most widely used parametric approaches while DEA is the dominant non-parametric approach particularly in banking efficiency studies.

[2] One of the reasons that the parametric method is not utilized in this paper is that input and output prices cannot be derived from financial statements of banks in the four SEE countries under investigation. Non-parametric methods often ignore prices and, therefore, account only for technical efficiency.

[3] Unlike econometric methods which describe the results 'on average' and are based on central tendencies, the DEA is based on extreme observations or the 'best' achieved results.

The original DEA formulation by Charnes, *et al*. (1978) assumed constant returns to scale (CRS), i.e. all firms operate at their optimal scale. This assumption has been criticized since, for example, it has been found that in practice the banking sector exhibits non-constant returns to scale (McAllister and McManus, 1993; Wheelock and Wilson, 1999). Factors that may cause banks not to operate at the optimal scale include market power, regulatory requirements, M&As, etc. Banker, *et al*. (1984) extend the CRS version of DEA to take into account the possibility of variable returns to scale (VRS). Assuming firms using multiple inputs have a single input and firms producing multiple outputs as having a single output, the CRS and VRS cases can be depicted in two-dimensional space as illustrated in Figure 1.

With the CRS assumption, the frontier will be linear and identifies efficiency regardless of the firm scale size. For a firm to be CRS efficient, it must be both scale and technical efficient. With the VRS assumption, the frontier will be convex measuring pure technical efficiency at a given scale of production. The presence of the convexity assumption reduces the determined efficiency region from the conical hull in CRS to a convex hull in VRS, enveloping the data more closely than CRS. As a result, VRS efficiency scores may be equal or larger than CRS scores. In Figure 1 the measure of technical inefficiency for the firm F is given by the ratio O′F″/O′F in the CRS case and by O′F′/O′F in the VRS case. The measure of scale efficiency will be the ratio of these two (O′F″/O′F′). If a firm is efficient in CRS then it is efficient in VRS as well (as is B in Figure 1), but the reverse may not be true. For example, the firm A is technically efficient (under VRS assumption) but not scale efficient as an increase in its input use would result in greater than proportionate increase in output; thus, this firm is operating in the increasing returns to scale portion of the curve.

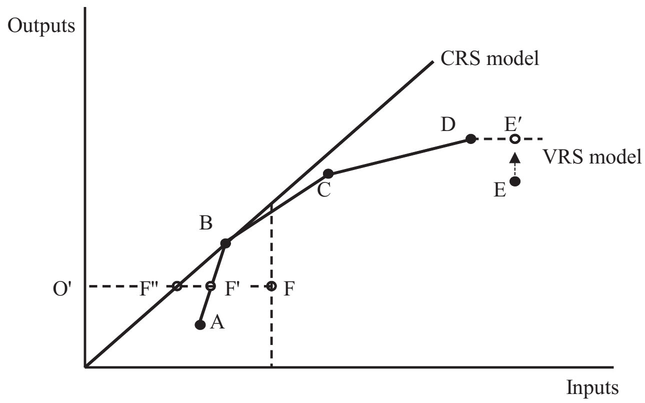

Figure 1. CRS and VRS DEA models

Scale efficiency (S_e) can be measured as a ratio of CRS and VRS efficiency scores, with S_e = 1 indicating cases when firms operate at the most efficient scale (size). If $S_e < 1$ then firms operate at a sub-optimum ('wrong') scale. $1 – S_e$ indicates the relative scale inefficiency (S_i) of the particular firm. The higher the S_i value the higher the scale problem of firms in the industry under investigation. In terms of Figure 1, all firms to the left of B exhibit increasing returns to scale (IRS) and to the right of B decreasing returns to scale (DRS). If IRS prevails, a firm would have to increase its size in order to increase its efficiency (because it can achieve greater economies of scale if increases its volume of operation). If DRS prevails, a firm would have to decrease its size to increase its efficiency.

The formal treatment of the methodology in a multiple input-multiple output case follows the standard exposition (Cooper *et al*., 2000; Ramanathan, 2003). Denoting with y_j the vector of outputs, x_i the vector of inputs, v_j and u_i the output and input weights, respectively, n the number of firms to be evaluated and m the particular firm whose efficiency is to be measured (E_m), in the output-oriented case formally we have:

$$MaxE_m = \frac{\sum_{j=1}^{J} v_{jm} y_{jm}}{\sum_{i=1}^{I} u_{im} x_{im}} \qquad (1)$$

subject to

$$\frac{\sum_{j=1}^{J} v_{jm} y_{jn}}{\sum_{i=1}^{I} u_{im} x_{in}} \leq 1 \qquad (2)$$

$n = 1,2,\ldots,N;\ v_j, u_i > 0$

In DEA, multiple inputs and outputs are linearly aggregated using weights and the efficiency of the firm is defined as a ratio of weighted outputs to weighted inputs. DEA assigns a unique (or the best) set of weights to each firm which are determined so as to maximize its efficiency (*1*), subject to the condition that the efficiency of other firms (calculated using the same set of weights) is constrained to less than or equal to unity (*2*). This mathematical program produces the efficiency of only one firm, *m*. For *n* firms in the sample, *n* such programs have to be solved. However, this mathematical function has an infinite number of solutions. The problem can be reformulated into a linear programming format by constraining the numerator or the denominator of the efficiency ratio to be equal to unity:

$$MaxE_m = \sum_{j=1}^{J} v_{jm} y_{jm} \qquad (3)$$

subject to

$$\sum_{i=1}^{I} u_{im} x_{im} = 1 \qquad (4)$$

$$\sum_{j=1}^{J} v_{jm} y_{jn} - \sum_{i=1}^{I} u_{im} x_{in} \leq 0 \qquad (5)$$

$n = 1,2,\ldots,N;\ v_{jm},\ u_{im} > 0$

In the output-oriented DEA, the objective function is to maximize the weighted sum of outputs for firm *m* (*3*), while keeping the weighted sum of inputs constrained to unity (*4*); thus the ratio of weighted outputs to weighted inputs for other firms is constrained to be less than one (*5*).[4] This linear programme is an output-maximization DEA programme which implies that other firms cannot produce more output than the reference firm *m*, if it is efficient.

The DEA programmes involving weights for inputs and outputs (v_j and u_i) are called 'multiplier DEA' programmes. Those involving weights for firms (λ – denoting the vector of weights) and the efficiency measure for the firm under evaluation (Θ) are 'envelopment DEA' programmes. For each firm under investigation, the linear program finds the set of weights that maximize efficiency

[4] This is equivalent to the constraint 5, since: $\left[\sum_{j=1}^{J} v_{jm} y_{jn} \Big/ \sum_{i=1}^{I} u_{im} x_{in} \leq 1\right] = \left[\sum_{j=1}^{J} v_{jm} y_{jn} - \sum_{i=1}^{I} u_{im} x_{in} \leq 0\right]$.

subject to constraints. For the m^{th} firm, the general envelopment DEA programme corresponding to the output-oriented CRS model can be presented as follows:

$$\underset{\Theta,\lambda}{Max}\ \Theta_m \qquad (6)$$

subject to

$$\Theta_m y_{jm} \leq \sum_{j=1}^{J} y_{jn}\lambda_n; \quad j = 1, 2, \ldots, \mathrm{J} \qquad (7)$$

$$x_{im} \geq \sum_{i=1}^{I} x_{in}\lambda_n; \quad i = 1, 2, \ldots, \mathrm{I} \qquad (8)$$

$$\lambda_n \geq 0, \quad n = 1, 2, \ldots, \mathrm{N}.$$

The objective function is the identification of the maximum feasible expansion of outputs for the firm *m* (*6*), without violating best practice since those firms will have the weighted linear combination of output at least as great as that of firm *m*. So, the firm *m* is inefficient if the linear combination of other firms can be found which produce more output (*7*) and the weighted linear combination of inputs will not exceed the input usage of the firm *m* (*8*). This implies that the output of the firm *m* should not exceed the linear combination of other firms, unless it is efficient. If the maximum Θ is unity then the firm *m* is efficient and will lie on the frontier and its output would equal to that of other firms forming the frontier. If this is the case then $\Theta_m y_{jm} = \sum_{j=1}^{J} y_{jn}\lambda_n$ and $x_{im} = \sum_{i=1}^{I} x_{in}\lambda_n$ i.e. no linear combination of firms in a dataset can be found which produce more output levels, by utilizing the same input levels. The firms fulfilling this condition will create the efficiency frontier enveloping all other data points. So λ and Θ are variables which need to be calculated, and the linear programming problem must be solved for each firm in order to obtain its respective Θ. Each efficiency score will be either $\Theta = 1$, those units that form the frontier and imply benchmark efficiency, or $0 < \Theta < 1$ implying relative inefficiency compared to the benchmark. Relative efficiency implies that there is no absolute measure of efficiency. Having $\Theta = 1$ does not necessarily imply that firms are efficient, but they are not less efficient than other firms in the sample.

As considered above, the CRS model is appropriate when firms operate at the optimal scale. Banker, *et al*. (1984) proposed an extension of this model to account for variable returns to scale. This necessitates one more restriction for convexity of envelopment surface: $\sum_{n=1}^{N} \lambda_n = 1$. The introduction of $\sum_{n=1}^{N} \lambda_n = 1$ in VRS takes into account the variation in efficiency with respect to scale of operation and measures pure technical efficiency.

DEA measures in input or output orientation estimate the same frontier and the results for efficient entities are the same. For inefficient entities the projected efficiency point on the frontier may differ between input and output orientation. Given that linear programming cannot suffer from statistical problems such as simultaneous equation bias, the choice of an appropriate orientation (input or output) is not a crucial issue as it is in econometric modeling (Fried *et al*., 1993). Often the choice of orientation depends on the objective of the study. Given the interest in the intermediary role of banks, a more natural choice is the output orientation, i.e. given the deposits, how much increase in lending to the domestic real sector can be attained.[5]

Compared to parametric approaches, an advantage of DEA is that it performs well with small samples, although some rules of thumb must be followed, does not require the specification of the functional form, does not suffer from the possibility of misspecification error of the production function and simultaneous equation bias. Rather, the function is generated from the actual data under investigation. DEA can analyze multiple input-multiple output models which econometric methodology cannot. Additional strengths of the DEA approach are that it can identify the sources of inefficiency, i.e. whether a bank has an output shortfall, an excess use of inputs or scale problems and, hence, how the firm can improve its performance to become more efficient. The most important difference between the non-parametric DEA approach and the econometric approach is that the former does not take into account any noise (random errors) and the difference between the efficiency score of an entity and the frontier is all attributed to inefficiency. However, this drawback of the methodology can be checked with some tests such as stability of the efficiency scores over time and the sensitivity of the efficiency scores to outliers.[6]

2.2. A DEA-based Malmquist Total Factor Productivity Change Index

Efficiency frontiers are not static over time since the production technology may change, causing positive or negative shifts in the best practice efficiency frontier. Shifts in the frontier may emanate from technological progress which simplifies processes, innovations such as the introduction of new banking products and services, shocks to the economy, financial crises, change in regulations, etc. DEA results can show that there has been no substantial improvement in the average efficiency in the banking sector, which does not necessarily mean that the productivity has declined. The change in banks' technology stemming from the abovementioned factors may have led a few banks to take advantage of the new technology which shifted the efficiency frontier outwards while the average bank may have failed to catch-up and take advantage of the new technology, thus, becoming increasingly less efficient relative to frontier banks, though not necessarily less efficient in absolute terms. Hence a 'natural' extension of DEA is the Malmquist Total Factor Productivity Change Index (hereinafter M_I).

Caves, *et al*. (1982) introduced the M_I by using distance functions. Extensions to Caves, *et al*. (1982) entailed the use of DEA in measuring the distance functions and decomposing total factor productivity change into technical efficiency change and change in technology (Färe *et al*., 1994; Grifell-Tatjé and Lovell, 1997, 1999). Denoting with $x_{t,t+1}$ and $y_{t,t+1}$ the vector of inputs and outputs, respectively, in period *t* and *t+1*, $D_{t,t+1}$ the distance functions in the respective periods measuring the efficiency of a particular bank with respect to best practice frontier, the standard exposition of the M_I can be formally presented as follows:

$$M_I\left(x_{t+1}, y_{t+1}, x_t, y_t\right) = \frac{D_{t+1}\left(x_{t+1}, y_{t+1}\right)}{D_t\left(x_t, y_t\right)}\left[\left(\frac{D_t\left(x_{t+1}, y_{t+1}\right)}{D_{t+1}\left(x_{t+1}, y_{t+1}\right)}\right)\left(\frac{D_t\left(x_t, y_t\right)}{D_{t+1}\left(x_t, y_t\right)}\right)\right]^{1/2} \quad (9)$$

[5] In the case of intermediation approach where the volume of deposits is treated as input, conceptually one should choose output orientation. If input orientation is chosen then that would mean achieving same level of outputs (loans), while minimizing inputs employed (deposits), which is counterintuitive.

[6] There is no consensus among the researchers on which method is better because the true level of efficiency is unknown (Fung, 2006). Ferrier and Lovell (1990), Resti (1997), Eisenbeis, *et al*. (1997) and Weill (2003) found that efficiency scores obtained with parametric and non-parametric methods are comparable and consistent, while Bauer, *et al*. (1998) and Fiorentino, *et al*. (2006) have found the opposite. Bauer, *et al*. (1998) also found that parametric methods (SFA and DFA) give inconsistent results.

The expression above decomposes M_I into the product of two terms. The first term outside the square brackets measures the technical efficiency change and is the ratio of the distance to the efficiency frontier of a bank in period *t+1* to the distance to the efficiency frontier of a bank in period *t*. This shows how much closer the bank is to the period *t+1* frontier, compared to its position relative to the period *t* frontier. This is also known as a catching-up effect, reflecting the convergence towards the best practice efficiency. If the index is greater (lower) than unity then the bank is moving closer to (falling behind) the technical efficiency frontier in the period *t+1* as compared to period *t* frontier.

The expression inside the square brackets measures the frontier shift or change in technology. The first ratio measures the distance of the two frontiers at the output/input mix of the bank in period *t+1*. More specifically, it compares the ability of a bank to produce in period *t* with the input/output mix feasible in period *t+1* (numerator), relative to production possibilities existing in period *t+1* (denominator). The second ratio compares the performance of banks in period *t* (numerator) relative to the performance of banks in period *t+1*, i.e., ability to produce in *t+1* with the input/output levels feasible in period *t* (denominator); meaning that if for example there is technological improvement, the same input can produce a higher output when used in the period *t+1*. The geometric mean of the two ratios in square brackets represents the measure of technological progress. If the index is greater (lower) than unity then the technology best practice is improving (worsening). If, for example, in the period *t+1* frontier shifts outwards and is constructed by the same banks as in the period *t*, there is technology progress for those units and no efficiency change. The procedure for calculating M_I involves solving four linear programs. The calculation of $D_t\left(x_{t,}y_t\right)$ and $D_{t+1}\left(x_{t+1,}y_{t+1}\right)$ involves the calculation of technical efficiency scores using DEA for each bank in comparison with all banks in the same period. Calculation of $D_t\left(x_{t+1,}y_{t+1}\right)$ and $D_{t+1}\left(x_{t,}y_t\right)$ involves the calculation of technical efficiency scores using DEA for each bank in a time period in comparison with all banks in the other time period. M_I can be greater, equal to or less than unity depending on whether the bank experiences total factor productivity growth, stability or decline, respectively, between periods *t* and *t+1*.

Provided that the M_I is obtained by measuring distance functions using DEA, it can be decomposed into four components: technical efficiency change due to VRS assumption, i.e. pure technical efficiency change (ΔPTE), scale efficiency change (ΔSE), the product of the two giving technical efficiency change due to the CRS assumption (ΔTE), and the technological change or frontier shift effect (ΔT). The product of all four components gives total factor productivity change (M_I). Following Wheelock and Wilson (1999) and Isik and Hassan (2003), the DEA-based Malmquist Total Factor Productivity Change Index (M_I) can be decomposed as follows:

$$M_I\left(X_{t+1},Y_{t+1},X_t,Y_t\right)=\overbrace{\underbrace{\frac{D_{\mathrm{VRS}}^{t+1}\left(X_{t+1},Y_{t+1}\right)}{D_{VRS}^{t}\left(X_t,Y_t\right)}}_{\text{Pure technical efficiency }(\Delta\text{PTE})}\times\underbrace{\left[\frac{D_{CRS}^{t+1}\left(X_{t+1},Y_{t+1}\right)/D_{VRS}^{t+1}\left(X_{t+1},Y_{t+1}\right)}{D_{CRS}^{t}\left(X_t,Y_t\right)/D_{VRS}^{t}\left(X_t,Y_t\right)}\right]}_{\text{Scale efficiency }(\Delta\text{SE})}}^{\text{Technical efficiency }(\Delta\text{TE})}\times\overbrace{\left[\left(\frac{D_{CRS}^{t}\left(X_{t+1},Y_{t+1}\right)}{D_{CRS}^{t+1}\left(X_{t+1},Y_{t+1}\right)}\right)\left(\frac{D_{CRS}^{t}\left(X_t,Y_t\right)}{D_{CRS}^{t+1}\left(X_t,Y_t\right)}\right)\right]^{1/2}}^{\text{Technological change }(\Delta\text{T})} \qquad (10)$$

The first term outside the square brackets (ΔPTE) is a measure of pure technical efficiency change between two periods assuming VRS; the first term in square brackets (ΔSE) represents the change in scale efficiency. The product of ΔPTE and ΔSE is the overall technical efficiency change (ΔTE). The last term in the square brackets represents the frontier shift effect or change in the technology (ΔT) assuming CRS and the product of all the above gives the M_I. For example, if technical efficiency experiences a decline between the two periods or the scale of operation is away from technically optimal scale, then this negatively contributes to the change in M_I. M_I and each of its components can be calculated for each adjacent pair of years. For example, as in the case in this paper, for four year period (2002-2005) there will be M_I and its components for three pairs of years.

3. THE APPLICATION OF PARAMETRIC APPROACHES AND DEA IN MEASURING BANK EFFICIENCY IN TEs

The literature on the efficiency of banks in TEs is relatively scarce though growing, with the parametric approach dominating the non-parametric approach. In general, these parametric studies mainly focus on cost, revenue and/or profit efficiency based on the ownership structure of commercial banks and privatization effects as a determinant of efficiency. The studies cover the period when many TEs faced privatization challenges in the banking sector and banking crisis were almost the rule rather than exception. Policy decisions had to be made about whether or not to open the door to foreign owners controlling the banking industry in these countries. For example, anticipating that the presence of foreign banks in Hungary would improve the performance of domestic banks motivated the policymakers to encourage foreign banks to enter (Sabi, 1996). If foreign banks had already entered the market, the question was whether the decision to let foreign banks enter the market was the right one. Table 1 presents the studies, the methodology employed, period of the investigation, number of transition countries included in the analysis and if foreign banks were found to be more efficient. The majority of the studies support what has now become conventional wisdom in transition that foreign banks are more efficient than domestic banks, albeit with notable exceptions.

Table 1. Bank efficiency studies in transition employing parametric methods

Author(s)	Methodology	Period of investigation	Number of countries	Foreign banks found to be more efficient than domestic banks
Kraft and Tirtiroglu (1998)	SFA	1994-95	1	no
Kraft, *et al* . (2002)	SFA	1994-2000	1	yes
Nikiel and Opiela (2002)	SFA	1993-98	1	yes
Hasan and Marton (2003)	SFA	1993-97	1	yes
Green, *et al* . (2003)	SFA	1995-1999	9	no
Yildirim and Philipatos (2003)	SFA	1993-2000	12	yes
Weill (2003)	SFA	1997	2	yes
Bonin, *et al* . (2004)	SFA	1996-2000	11	yes
Matousek (2004)	DFA	1994-2001	8	yes
Fries and Taci (2004)	SFA	1994-2001	15	yes
Matousek and Taci (2005)	DFA	1993-1998	1	yes
Kasman and Yildirim (2006)	SFA	1995-2002	8	no

An exception worth discussing is Kraft and Tirtiroglu (1998) who find that state owned and old private banks in Croatia were more efficient than the newly established private and foreign banks. The authors relate this 'abnormality' to the limited competition and start-up difficulties of the new banks. Although this explanation seems reasonable, it should be noted that the period of investigation preceded the crisis of 1998. Systematic misreporting of data by the banks might have been the reason for that outcome. As Gregorian and Manole (2002) have pointed out, the early and mid-transition period was characterized by serious misreporting and non-compliance and this may have been the case in Croatia since the regulatory and supervisory mechanisms, accounting standards and an effective corporate governance framework were not yet in place in the banking sector. Also, Green, *et al*. (2003) employed SFA for measuring the efficiency of banks in nine TEs and found foreign banks did not differ from domestic banks in terms of their performance, i.e. foreign ownership did not imply cost efficiency in banking. More recently, Kasman and Yildirim (2006) utilizing SFA, found that foreign banks were not more cost efficient than domestic banks, but were more profit efficient. As they point out, foreign banks are able to generate strong profits possibly by operating in the high value-added segments of the markets while incurring higher costs at the same time. In addition, foreign banks may have incurred higher costs because of the start-up costs, costs involved in acquiring domestic banks, the need to expand and gain market share, etc. Also they are involved in building up further human capital and technology for modern banking which was lacking in TEs.

A potential problem with most of the surveyed studies is their coverage of banks by the dataset. The cross-country studies use the Bankscope database compiled by Bureau VanDijk. This database covers banks that have financial statements audited by reputable foreign auditing firms and does not cover all banks in each country and in some cases those included in the database represent well below 50 percent of the market. Banks that are mainly larger and sounder tend to be in this database. As a result, the frontier approach in these studies is probably measuring the efficiency of the most efficient banks but not giving an indication of the overall position of the sector in the respective countries. In addition, a criticism that applies to cost or revenue efficiency studies is that methods that do not account for both costs and revenues may not be entirely appropriate. For example, a banker's decision that raises both costs and revenues, but raises revenues by more than it raises costs, will appropriately be counted as an improvement in performance in profit maximization, but may be counted as deterioration under cost minimization (Berger and Mester, 2003). If the intermediation context is added to this observation, e.g. apart from maximizing profits the ability of banks to transform deposits into loans, then a multiple input-multiple output modelling of a banking firm may be more appropriate, which can be handled with non-parametric techniques.

The literature on the application of non-parametric approaches, specifically DEA, in measuring banking efficiency in TEs is scarce. Only a few studies employ this methodology and they are surveyed here. All the studies are dated after 2000, though generally utilizing data from the first decade of transition. Grigorian and Manole (2002) employ DEA for bank-level data for 17 TEs for the period 1995-1998. They estimate a common efficiency frontier for the sample of banks in these countries and also estimate common efficiency frontier for three sub-regions CEE, SEE and CIS. They found that banks in CEE outperform banks in SEE (and Baltics) and CIS. The authors also found that the privatization of banks, unless controlled by foreign owners, does not result in significant improvements in efficiency and that foreign ownership and control, associated with enterprise restructuring, enhances the banks' efficiency. As a result, they suggest that banking sectors with a few large, well capitalized banks are likely to generate better efficiency and higher rates of intermediation. Stavarek (2003) estimates a common efficiency frontier for commercial banks in Poland, Czech Republic, Hungary and Slovakia using DEA for the period 1999-2002, on samples of banks numbering from 59 to 72 in various years. The author found that no improvement in efficiency was evident in the period under review (except in Hungary). Greater efficiency is found in the Czech and Hungarian banking sectors and foreign and large banks tended to be more efficient. Many studies employing DEA (including Gregorian and Manole, 2002; Stavarek, 2003) use the Tobit model in a second stage, regressing the efficiency scores generated by DEA analysis against various bank-specific and environmental variables. However, this approach is subject to methodological problems. Casu and Molyneux (2000) recognize a problem with this approach originating from dependency among the efficiency scores. It may be recalled that the efficiency scores in DEA are generated as relative efficiency scores of entities existing within a sample. In doing so one of the basic assumptions of the regression analysis, i.e. the independence of observations in a sample, is violated.

Individual country cases applying DEA in measuring bank efficiency are also scarce. Jemric and Vujcic (2002) used DEA to analyze the efficiency of banks in Croatia in the period 1995-2000 according to size, ownership structure, date of establishment and the quality of assets. Contrary to the findings of Kraft and Tirtiroglu (1998), they found that foreign and new banks were more efficient than domestic and older banks and that a strong equalization in terms of average efficiency of banks had been experienced in Croatia, i.e. there has been a convergence in the sector, which may have been the result of the spillover effects of foreign banks, an increase in competition, etc. The sources of inefficiency in state-owned and old banks were attributed to their large number of employees and large fixed assets. Pawlowska (2003) used DEA to investigate the technical and scale efficiency and productivity in the Polish banking sector in 1997-2001. She found that foreign banks outperformed domestic banks in terms of efficiency. More recently, Havrylchyk (2006) investigated bank efficiency using DEA in Poland for 1997-2001 to study the ownership effect and the efficiency improvement of banks over time. His results suggest that foreign banks were more efficient than domestic banks, though this as a result of foreign banks acquiring the most efficient domestic institutions ('cherry picking') and they have not succeeded in enhancing their efficiency further.

To summarize, efficiency studies in transition yield mixed evidence in relation to the view that foreign banks are more efficient than domestic banks. The foreign bank contribution to the deepening of the financial intermediation in the domestic real sector has not been studied extensively in the multiple input-multiple output modelling of a banking firm using non-parametric DEA and related techniques. This is especially the case for the SEE region and Kosovo. Hence, the aim of this paper is to contribute to this literature by analyzing the differences between foreign and domestic banks' efficiency specifically related to their function as intermediaries. This investigation will be supplemented with the analysis of the efficiency of the banking sector by size of operation and cross-country differences in efficiency.

4. THE DEFINITION OF INPUTS AND OUTPUTS

Selecting appropriate input and output variables is perhaps the most important step in using DEA since it determines the evaluating context of the comparison (Yeh, 1996). There is a disagreement and an unresolved question about the correct definition of inputs and outputs due to the complexity of the banking firm. There is some agreement that loans and other interest bearing assets should be treated as outputs. However, there is a disagreement on the classification of deposits as the main ingredient for loan production and other earning assets (an input) or as a service provided to clients and resource consuming activity (an output).

In general, there are some approaches that most studies use and, to some extent, the choice may be settled depending on which approach is adopted. In addition, the availability of data is usually the factor influencing the choice of inputs and outputs by researchers. First, the *production approach* views banks as producers of services for depositors and borrowers, e.g. administering customer accounts and transactions, cashing cheques and issuing loans, while using some combination of labour and capital as inputs. In this approach, it is the number of loan transactions and deposit accounts that should be taken as a measure of bank output and principally it measures the operational efficiency of banks. A variant of the production approach, known in the literature as the value-added approach, treats as bank outputs those activities that have value added in the sense that they incur significant labour and capital costs. As a result, both asset and liability items may have input and output characteristics and outputs are defined on the basis of the resource consuming activity that a particular bank product represents. Another variant, the user-cost approach developed in Hancock (1985), does not make an *a priori* classification of bank inputs and outputs. Based on the premise that outputs contribute to net revenue and assuming profit maximization, in this approach a financial instrument is defined as output/input based on the difference between the opportunity cost and the holding revenue (cost) of an asset (liability). If a particular item produces net revenue, it is output; if there is a net cost then it is input.[7]

Second, the *intermediation approach*, pioneered by Sealey and Lindley (1977), views banks as intermediaries between the surplus units (savers) and deficit units (borrowers). Banks use some inputs, i.e. labour and capital, to transform deposits into earning assets. This view considers deposits as inputs which are the source of bank lending. It ignores the output characteristics of deposits in providing liquidity and payment services to customers, and as a resource consuming activity in the banking business. The input characteristics of deposits are due to their liquid, divisible, short-run and

[7] This approach empirically assesses inputs and outputs by regressing bank profits on different balance sheet items, with the sign (and significance) of coefficients defining the inputs and outputs of banking activities. The main criticism of this approach is that it is data driven and, for example, changes in interest rates can alter the status of particular products over time (Fixler and Zieschang, 1999).

riskless nature, while loans are considered indivisible, illiquid, longer-run and risky (Freixas and Rochet, 1997). A variant of the intermediation approach is the asset approach which treats loans and other interest bearing assets of banks as their main outputs. Another variant, the profit approach, is concerned with profit maximization where all cost and revenue components are decision variables to be optimized by bank managers (Mlima and Hjalmarsson, 2002). In this approach it is the ability of banks to maximise revenues at given costs, or minimize costs at given revenues, that ensures efficiency. The risk-management approach is a departure from the intermediation approach, incorporating risk management, information processing and monitoring activities of the bank (Colwell and Davis, 1992; Mester, 1996). Risk management characteristics were often ignored in previous studies. For example, banks could boost their lending activity by extending loans on unsound base resulting in bank instability and failure. Thus one of the missing ingredients in the intermediation approach is covered by the risk-management approach by introducing the quality of bank assets. If available, the data on NPLs can be used to correct for overall lending activity of the bank. However, usually the data on NPLs are difficult to obtain and approximations such as loans net of provisioning are considered.

The ability of banks to transform deposits into loans directed towards domestic real sector emphasizes the intermediary role of banks and as such is the main motivation for following the intermediation approach in this paper. The variables consist of two inputs and two outputs with deposits and total costs being considered as the bank inputs, and loans net of provisions and total revenues as outputs. Total costs include interest expenditures and non-interest expenditures such as salaries, expenditures related to fixed assets, administrative expenses and similar, excluding taxes to avoid any distortion. Total revenues include interest income and non-interest income such as fees and commission income, income from the trading portfolio, etc. Unlike some studies which take interest and non-interest revenues and expenditures separately, the data are aggregated into the total cost and total revenues for several reasons. First, it is debatable to what extent the data on inputs (or outputs) should be disaggregated. Apart from the unsettled problem of the input/output definition in banking, there is also the problem of the disaggregating measures used. On the input side, just to mention a few, there are labour and capital inputs. Banks spend resources on personnel which can be disaggregated into clerical and managerial. The capital input is usually taken to be a fixed asset (the balance sheet or income statement item), although banks also spend resources on information technology and marketing which are important parts of the cost structure in modern banking. On the output side, e.g. loans, the list of disaggregation may also be long. For example, loans may be broken down by economic sector, maturity, type of borrowers and all these may be considered as different products given their different input usage, specific risks, etc.

The degree of disaggregation of data also depends on the aims of the researcher. If the precise source of inefficiency is to be captured, then as detailed a breakdown as possible would be necessary. For example, disaggregating between labour and fixed assets would be appropriate for the management of the bank, e.g. if the source of the inefficiency is overstaffing, then this information may be very important for improving efficiency in this respect. However, if the interest is in more general characteristics of the banking sector as here, i.e. how the ownership structure and size (foreign *vs*. domestic banks; large *vs*. small banks) affect efficiency, then the detailed breakdown, even though informative, would not be of much of relevance. As a result, on the input side, total costs would capture all the operational spectrum of banking activity including staff, marketing, information technology, interest expenditures, etc. Another reason for aggregating the data is that the differences in accounting practices limit the choice of input/output variables in the aggregate country model. For example, non-interest expenditures include staff costs in some cases and are reported separately in some others. Therefore, given these considerations, the broad definition of cost and revenue variables is chosen.

To some extent this choice of inputs and outputs may be considered as a 'mixed approach' since some important elements of all approaches are taken into account. First, it is a version of the intermediation approach since deposits are defined as inputs and the role of banks in the intermediation process is captured by loans treated as outputs. Second, to control for banks undertaking too much risk (the risk-management approach), net loans after provisions are used, which assumes appropriate provisioning by banks which in turn depends on the supervisory capacity of the regulator. Given that excessive risk taking would imply a waste of resources and disintermediation rather than intermediation, the use of loans net of provisioning will take into account risk preferences. If under-provisioning is an issue, then this would not be captured by the data given that data on the quality of assets are not available. However, to some extent this is also picked up in the interest income (as part of total revenue) which would capture the actual returns on loans. Third, by having total costs as an input and total revenues as an output also some elements of the profit approach are taken on board. Berger and Mester (2003) argue that the use of the profit approach may help take into account unmeasured changes in the quality of banking services by including the higher revenues paid for improved quality. Fourth, given the focus on the efficiency of banking sector in intermediating funds to the real sector, only loans to the domestic real sector are considered as an output and assets held in government securities, banks abroad, and inter-bank loans are excluded. Where banks invest a significant part of their assets in low-risk low-return foreign or domestic government securities, from the intermediation point of view it is preferable not to treat this part of assets as bank output.

For an indicator to be qualified as output, it must be resource consuming (the value-added approach). It may be said that low-risk investments can be performed by a few asset managers and with very few infrastructural needs. As Berger and Humphrey (1992) point out, government securities and other non-loan investments can be regarded as unimportant outputs because their value-added requirements are very low. Also from the intermediation point of view non-loan assets incur little screening and monitoring costs and are excluded from the measures of financial development at the macroeconomic level. So in this context, net loans capture the output of banks from the intermediation point of view. Finally, the output nature of deposits (and non-loan earning assets) would be captured by the income from fees and commissions and interest income, respectively, which are incorporated in the total revenue variable. Hence, having total revenues on the output side would account for the output nature of banking services. Interest and non-interest expenses/revenues would capture the entire spectrum of banking activities, including off-balance sheet items, the lack of account of which is a criticism of the intermediation approach. Therefore, the ability of banks to transform deposits into loans and the ability to maximize revenues at given costs (and consequently better profits) would imply efficient intermediation.

5. THE INTERMEDIATION EFFICIENCY OF BANKS IN SEE: EMPIRICAL RESULTS

In this section, both the CRS and VRS models are used to analyze the relative efficiency of banks in SEE in the period 2002-2005. The relative efficiency of banks is assessed for individual countries as well as a common efficiency frontier for banks in the four SEE countries is estimated. The output oriented multi-stage DEA model is utilized, using the DEAP 2.1 software developed by Coelli (1996). The data for each bank are taken from the end-of-year balance sheet and income statements published by central banks in the respective countries. The database virtually covers the entire banking system in Bulgaria, Croatia, Kosovo and Montenegro. A strength of having the entire population of banks is that it would not suffer from the problem of DEA being a sample specific method, since the results obtained for a sample of banks may not be generalized for the entire population.[8] For Bulgaria and Croatia the data are in local currencies and the official exchange rate is used to convert them to euro, and for Kosovo and Montenegro they are in euro. The dataset contains 86 banks in 2002, 83 in 2003, 78 in 2004 and 84 in 2005. The sample size is increased in 2005 due to the inclusion of 10 banks from Montenegro. While the number of banks remained the same in Kosovo throughout the period, they continuously declined in Bulgaria and Croatia due to M&As and some bank closures. Two banks from Bulgaria and one from Croatia are excluded from the sample because they were either under the

[8] As mentioned, several studies employing DEA in transition (Gregorian and Manole, 2002; Stavarek, 2003) use the Bankscope database which in many cases covers not more than 50 percent of active banks in particular country.

bankruptcy proceedings and loans net of provisioning were negative, or they reported negligible amounts of net loans.

Table 2 presents the descriptive statistics of output and input variables in the respective countries. As can be observed from table, Kosovo and Montenegro have smaller banking sectors, while Croatia has the largest and the most dispersed sector in terms of outputs and inputs. Average outputs and inputs in Croatia are almost double as compared to Bulgaria, while the dispersion is even higher. While small banks tend to be similar in all the countries (the minimum output/input figures do not differ substantially), larger banks are more different. For example, Croatian banks show the highest maximum monetary values of inputs and outputs. In general, the data show notable variability among and within the banking sectors in respective countries.

Table 2. Descriptive statistics of inputs and outputs (in thousands of euros, average 2002-2005)[a)]

	Min	Max	Mean	Standard deviation
Bulgaria				
Output 1	7,870	915,468	203,901	231,272
Output 2	1,911	141,064	31,215	35,962
Input 1	9,130	1,334,655	335,532	371,966
Input 2	1,615	88,325	20,514	20,998
Croatia				
Output 1	7,575	3,612,221	427,420	832,179
Output 2	1,238	491,159	59,253	111,204
Input 1	6,782	6,287,726	692,575	1,393,441
Input 2	1,339	358,559	44,937	80,822
Kosova				
Output 1	13,537	89,876	41,417	31,436
Output 2	3,013	23,213	8,867	7,226
Input 1	26,151	300,500	90,485	98,520
Input 2	2,430	17,729	7,362	5,448
Montenegro[b)]				
Output 1	6,224	157,623	36,243	45,239
Output 2	1,464	25,198	7,779	6,990
Input 1	5,675	271,622	56,184	78,127
Input 2	1,300	14,696	5,400	3,867

Note: a) Output 1 is loans to domestic real sector net of provisions for loan losses; Output 2 is total revenues; Input 1 is deposits and other borrowings; Input 2 is total costs; b) Data for Montenegro are for 2005.

At the outset it should be noted that banking sectors in SEE countries continued the consolidation process in the 2002-2005 period. This is especially the case with the banking sector in Croatia where the consolidation process involved 19 banks in 12 M&As, and three bankruptcies. It is important to note that almost all banks involved in the consolidation process were foreign-owned. In Bulgaria the consolidation was less pronounced. It involved five banks undergoing M&As, three new entries and two exits. Usually motives for consolidation are attributed to the opportunities in exploiting economies of scale, such as spreading costs over a larger base, economies of scope, such as increasing the number of services offered, cross-selling, increasing customer base, etc. Other motives involve risk diversification, acquisition of the new technology or an increase in the market power – the latter may negatively affect efficiency. Two questions related to M&As will be addressed explicitly in this paper. First, whether there were gains in scale efficiency and second, whether there was a shift in technology in the period under review. On the other hand, Kosovo had stable structure of the banking sector in this period while the data for Montenegro are available only for one year.[9]

[9] Given that the banking sector in Kosovo was established from scratch, period 2000-2001 was characterized with new bank entries. In 2006 there was one bank bankruptcy and in 2007-2008 there were new entries and some M&As. Therefore, the period 2002-2005 was characterized with a stable structure of the banking sector making an interesting case for comparing countries with and without stable structures.

The development of the banking sector in Kosovo is one of substantial expansion in all dimensions, although from a low base. From the regulatory point of view, it is worth mentioning that in Kosovo the upper limit of loan to deposit ratio is at 80 percent, in Croatia the reserve requirements increased several times in the 2002-2005 period in an attempt to curb the rapid credit expansion while Bulgaria introduced such measures in 2005. These measures also may have had an impact on the intermediation efficiency of banks in the region.

5.1. Efficiency of banks in Bulgaria

The results of the estimation by CRS and VRS models are presented in Table 3. The CRS model identifies six out of the 33 banks as efficient in 2002. The average efficiency was 0.813 which may be interpreted as the average bank could produce around 18.7 percent more outputs with the given level of inputs to match its performance with best-practice banks in the sample. In subsequent years the number of efficient banks decreases to five in 2003-2004 and four in 2005. Also the average efficiency for the sector as a whole decreased from 0.813 in 2002 to 0.715 in 2005 with a striking drop in 2003 and recovery in 2004.

Table 3. DEA efficiency scores of banks in Bulgaria (2002-2005), CRS and VRS model

	CRS				VRS			
	2002	2003	2004	2005	2002	2003	2004	2005
Number of banks (*of which* foreign-owned)	33(24)	35(25)	35(24)	33(23)	33(24)	35(25)	35(24)	33(23)
Number of efficient banks (*of which* foreign-owned)	6(5)	5(4)	5(4)	4(3)	15(11)	10(9)	11(10)	9(8)
Average efficiency	0.813	0.709	0.763	0.715	0.885	0.818	0.837	0.803
Standard deviation	0.132	0.194	0.158	0.182	0.134	0.166	0.159	0.172
Weighted average efficiency	0.827	0.704	0.773	0.741	0.929	0.890	0.894	0.860
Average efficiency of foreign banks	0.828	0.750	0.799	0.750	0.896	0.856	0.873	0.831
Average efficiency of domestic banks	0.772	0.577	0.643	0.593	0.856	0.693	0.722	0.703
Efficiency Gap (*Foreign - Domestic*)	0.056	0.173	0.156	0.157	0.04	0.163	0.151	0.128
Scale inefficiency [1 - (CRS/VRS)]	-	-	-	-	0.082	0.133	0.089	0.109
Banks operating at IRS (%)	-	-	-	-	6.1	8.8	20.6	21.9
Banks operating at DRS (%)	-	-	-	-	75.8	70.6	61.8	65.6
Banks operating at optimal scale (%)	-	-	-	-	18.2	20.6	17.6	12.5

Overall, figures suggest that no efficiency gains are apparent in the banking sector in Bulgaria in the period under review. The drop in 2003 in the average efficiency score is mainly due to the decrease in the performance of domestic banks (by almost 20 percentage points), while the decrease in 2005 might be attributed to the introduction of supplementary reserve requirements by the Bulgarian National Bank aiming at slowing down the rapid credit growth.[10] The standard deviation shows whether there is convergence in efficiency among banks. As shown in Table 3, the divergence in the sector is large and increased in 2003, moderately decreased in 2004, and then again increased in 2005. The weighted average efficiency score is higher than the simple average (except in 2003) indicating that larger banks have higher efficiency scores compared to smaller banks, although the differences seem not to be substantial.

The results show that foreign banks appear to be more efficient than domestic banks in terms of the average efficiency scores and the number of banks dominating the frontier, and the divergence increased over time. For example, the gap in the efficiency scores between foreign banks and

[10] Supplementary reserve requirements were introduced for banks in which credit growth was higher than the growth in total assets (BNB, 2006).

domestic banks increased from five percentage points in 2002 to 16 percentage points in 2005. The fluctuation of efficiency scores from year-to-year is similar for foreign and domestic banks, although the drop is less substantial in foreign banks. When estimating the VRS model, the number of efficient banks and the average efficiency for the sector is higher than in the CRS case, implying that the main source of inefficiency is due to scale inefficiencies. In general the picture remains the same, i.e. number of efficient banks has decreased over time and the average efficiency shows a similar trend, although the drop in 2003 is less substantial than in the CRS case. The standard deviation shows a similar pattern and foreign banks appear to be more efficient than domestic banks in terms of the average efficiency scores and the number of banks dominating the frontier. As indicated in Table 3, scale inefficiencies were more prevalent in 2003. Most of banks in 2002 (75 percent) exhibited decreasing returns to scale (DRS) meaning that greater efficiency would have been achieved had they operated at lower scale. However, the scale of operation seems to have improved a little since the proportion of banks operating at DRS decreased from 75 percent in 2002 to 65 percent in 2005. The percentage of firms operating at the optimal scale decreased as a share in the total banking sector while firms with the possibility exploiting increasing returns to scale (IRS) increased over the period under review. This may suggest that scale inefficiencies resulted mainly from the excessive size, i.e. diseconomies of scale (although with declining tendency), and it seems that there was a little room for further mergers especially involving larger banks while there is scope for economies of scale involving small banks.[11]

In summary, it appears that there was no improvement in the intermediation efficiency in the 2002-2005 period in the banking sector in Bulgaria and no convergence in the sector is apparent. Foreign banks consistently record higher efficiency scores, and the gap between foreign and domestic banks seems large and increasing. The results suggest that larger banks are more efficient than the small ones, especially the differences are substantial in the VRS model. Thus, the main source of inefficiency is due to scale inefficiencies stemming from large banks.

5.2. Efficiency of banks in Croatia

The same input and output definition is followed and the results for Croatia are presented in Table 4 for CRS and VRS model.[12] The CRS model identifies four out of 46 banks as efficient in 2002 and also the average efficiency which was 0.728. In subsequent years the number of efficient banks increased to six in 2003, five in 2004 and six in 2005. Also the average efficiency for the sector as a whole increased from 0.728 in 2002 to 0.834 in 2003 and remained virtually stable thereafter. Jemric and Vujcic (2002) using DEA estimated an average efficiency score for banks in Croatia in the period 1995-2000 going from 0.445 in 1995 to 0.745 in 2000. They also report a substantial convergence in the sector with standard deviation going from 0.261 to 0.180. From the evidence provided here, it seems that the trend in Croatia continued from the years of the Jemric and Vujcic study.

As shown in Table 4, the standard deviation decreased in 2003 and then increased again in 2004 and 2005 showing that divergence in efficiency was present in the market. The weighted average efficiency score is higher than the simple average for entire period indicating that larger banks are more efficient compared to smaller banks and the gap shows an increasing tendency. Foreign banks, on average, appear to be more efficient than domestic banks throughout the period. However, the difference is not substantial and the gap on efficiency scores seems quite small, albeit widening. This may be attributed to the consolidation process that the Croatian banking sector

[11] In 2005 all larger banks (i.e. above average banks in terms of total assets) exhibited DRS.

[12] It should be pointed out that the efficiency of banks calculated from individual country datasets cannot be compared with each other, although many studies do, since DEA is sample specific and the frontier is constructed from the data.

underwent in the period under review. As mentioned 19 banks underwent consolidation through M&As and this process entirely involved foreign banks.

Table 4. DEA efficiency scores of banks in Croatia (2002-2005), CRS and VRS model

	CRS				VRS			
	2002	2003	2004	2005	2002	2003	2004	2005
Number of banks (*of which* foreign-owned)	46(22)	41(18)	36(14)	34(13)	46(22)	41(18)	36(14)	34(13)
Number of efficient banks (*of which* foreign-owned)	4(2)	6(2)	5(3)	6(4)	10(5)	13(6)	9(5)	10(6)
Average efficiency	0.728	0.834	0.827	0.832	0.862	0.879	0.867	0.878
Standard deviation	0.143	0.111	0.126	0.140	0.122	0.110	0.110	0.129
Weighted average efficiency	0.751	0.855	0.919	0.921	0.944	0.945	0.952	0.974
Average efficiency of foreign banks	0.734	0.839	0.851	0.885	0.877	0.890	0.889	0.931
Average efficiency of domestic banks	0.723	0.830	0.809	0.795	0.848	0.870	0.851	0.841
Efficiency Gap (*Foreign - Domestic*)	0.011	0.009	0.042	0.090	0.029	0.020	0.038	0.090
Scale inefficiency [1 - (CRS/VRS)]	-	-	-	-	0.155	0.052	0.047	0.053
Banks operating at IRS (%)	-	-	-	-	6.5	12.2	30.6	23.5
Banks operating at DRS (%)	-	-	-	-	82.6	68.3	55.6	58.8
Banks operating at optimal scale (%)	-	-	-	-	10.9	19.5	13.9	17.6

In the VRS model in general the picture remains the same. Foreign banks continuously improved their intermediation efficiency while domestic banks less so. As can be observed from the table, scale inefficiencies were more prevalent in 2002 than in following years. Most of banks in 2002 (82 percent) exhibited DRS, i.e. were operating at excessive size. However, the scale of operation improved since the proportion of banks operating at DRS decreased to 58 percent in 2005. The percentage of firms operating at the optimal scale and firms with the possibility exploiting IRS increased over the period under review. In sum, Croatian banking sector seems to have slightly improved its intermediation efficiency within the period, and foreign banks do show better performance compared to domestic banks despite the consolidation process in this period. Similar to the Bulgarian case, the scale inefficiencies resulted from excessive size.

5.3. Efficiency of banks in Kosovo

While the number of input and output variables used in this approach is four, the total number of banks in Kosovo is seven. In DEA the number of firms under investigation should be at least three times the sum of input and output variables (Charnes *et al*., 1994). One way of dealing with this problem, as proposed by Bowlin (1998), is to disaggregate yearly and use monthly data where each monthly operation can be considered as a separate bank. This procedure will increase the number of observations from the original seven banks to 84 and then the DEA monthly scores are averaged for a single year for the particular bank. It should be noted that this may result in no bank appearing as fully efficient. If a bank's efficiency score for only one month falls below one, the score for that year will be less than one – even if the bank is genuinely efficient. Monthly data for banks in Kosovo are used and the results for the intermediation efficiency are displayed in Table 5 for CRS and VRS models.

What can be observed from the results is that the average efficiency of the sector has increased over the period although a slight decrease can be seen in 2005 compared to 2004. This may be partially attributed to the regulatory limit on loan-to-deposit ratio which some banks have approached. The differences between the banks have diminished showing signs of convergence in the sector's efficiency (the standard deviation decreases from 0.235 in 2002 to 0.136 in 2005). The weighted average is lower than the simple average in CRS model indicating that smaller banks appear to be more efficient than larger ones. However, the opposite seems to be true in the VRS model where larger banks are more efficient than small banks, indicating that inefficiencies in large banks are mainly due to the scale problems. In the CRS model, on average, domestic banks appear to be more efficient than foreign banks; while in the VRS model this holds for 2002-2003 period only. Overall, it seems that there are efficiency improvements in the banking sector in Kosovo. Although scale inefficiencies seem to have improved over time, they remained substantial, especially for one bank (operating at larger than optimal scale) and another one (operating at smaller than optimal scale).

Table 5. DEA efficiency scores of banks in Kosovo (2002-2005), CRS and VRS model

	CRS				VRS			
	2002	2003	2004	2005	2002	2003	2004	2005
Number of banks (*of which* foreign-owned)	7(2)	7(2)	7(2)	7(2)	7(2)	7(2)	7(2)	7(2)
Number of efficient banks (of which foreign-owned)	na	na	na	na	na	na	na	na
Average efficiency	0.618	0.737	0.802	0.794	0.785	0.854	0.901	0.899
Standard deviation	0.235	0.179	0.152	0.136	0.184	0.092	0.065	0.062
Weighted average efficiency	0.402	0.603	0.710	0.753	0.835	0.985	0.924	0.899
Average efficiency of foreign banks	0.284	0.520	0.706	0.749	0.657	0.84	0.947	0.911
Average efficiency of domestic banks	0.751	0.824	0.841	0.812	0.836	0.859	0.882	0.894
Efficiency Gap (*Foreign - Domestic*)	-0.467	-0.304	-0.135	-0.063	-0.179	-0.019	0.065	0.017
Scale inefficiency [1 - (CRS/VRS)]	-	-	-	-	0.213	0.137	0.110	0.116
Banks operating at IRS (%)	-	-	-	-	14.3	42.9	57.1	71.4
Banks operating at DRS (%)	-	-	-	-	85.7	57.1	28.6	14.3
Banks operating at optimal scale (%)	-	-	-	-	0.0	0.0	14.3	14.3

5.4. Efficiency of banks in Montenegro

In DEA some firms may be self-identified as fully efficient not because they dominate other firms, but simply because no other firms are comparable to them in many dimensions as usually is the case in small samples (as in the case of Montenegro). Table 6 displays the results of efficiency scores for banks in Montenegro from the CRS and VRS model. The models identify a large number of efficient banks with high average efficiency scores. As can be seen from table, the weighted average efficiency score is higher than the simple average indicating that large banks are more efficient.

Table 6. DEA efficiency scores of banks in Montenegro (2005), CRS and VRS model

	CRS	VRS
Number of banks (*of which* foreign-owned)	10(7)	10 (7)
Number of efficient banks (*of which* foreign-owned)	5(4)	7(5)
Average efficiency	0.940	0.955
Standard deviation	0.092	0.083
Weighted average efficiency	0.964	0.970
Average efficiency of foreign banks	0.937	0.952
Average efficiency of domestic banks	0.947	0.960
Efficiency Gap (*Foreign - Domestic*)	-0.010	-0.008
Scale inefficiency [1 - (CRS/VRS)]	-	0.015
Banks operating at IRS (%)	-	10.0
Banks operating at DRS (%)	-	40.0
Banks operating at optimal scale (%)	-	50.0

The divergence in the sector, as measured with the standard deviation, stood at 0.092 in CRS and 0.083 in the VRS model, and scale inefficiencies do not seem large (half of the sector operates at optimal scale). Foreign banks dominate the efficiency frontier since four out of five banks (in CRS) and five out of seven banks (in VRS) are fully efficient. However, in terms of average efficiency, foreign banks have a slightly lower figure than domestic banks due to the underperformance of some foreign banks not at the frontier.

5.5. A common frontier of banks in SEE

In this section the efficiency of the SEE banking systems over the period 2002-2005 by estimating a common frontier of all banks in the four SEE countries is assessed. The advantage of this approach from the methodological point of view is that more observations are available, which increases the discriminatory power of DEA, gives the possibility of comparing banks with greater variation and make cross-country comparison.[13]

Some of the problems in constructing a common frontier for different countries arise from differences in macroeconomic, regulatory environment and accounting standards. If there are grounds for considering that countries may be treated as largely homogenous, then the procedure may be warranted. The period of analysis is characterized by a stable macroeconomic environment in the SEE countries under investigation. Kosovo and Montenegro have no independent monetary policy as they are euroised economies while Bulgaria is *quasi* euroised with a currency board. Croatia is also highly euroised and loans and deposits are largely indexed to the euro. Foreign banks dominate all banking markets in the region. From the regulatory point of view all the countries have 'deregulated' markets, i.e. there are no controls on interest rates, capital flows, etc. Regarding the differences in accounting standards, as mentioned previously, minimization of the problem is attempted by adopting broad definitions of inputs and outputs. Thus, to some extent these countries may be considered as a homogenous group.

Table 7 presents the evolution of banking sector intermediation efficiency in the four countries. The average efficiency scores in the CRS model for the whole region fluctuate in the four years reaching their minimum in 2003 (0.679) and maximum in 2004 (0.714). In general, between 2002 and 2005, there seems to have been some marginal improvement in the efficiency of banks in the region, although there have been no large efficiency gains. The divergence among banks, as measured by the standard deviation, seems not to be negligible and fluctuating from year to year. As can be seen, Bulgarian banks are, on average, more efficient in intermediation than Croatian banks, while banks in Kosovo appears to be the least efficient compared to other countries in the region.
Similar results seem to hold in 2005 when banks from Montenegro are included. Nonetheless, Montenegrin banks appear to be the most efficient ones, on average. The difference between the average of the least efficient banking system (Kosovo) and the most efficient system (Montenegro) in 2005 is around 22.1 percentage points. The efficiency spreads between Bulgaria and Croatia are not as large (varying between three to five percentage points in different years). In general, the VRS model tells the same story. An exception is that in 2002 banks in Croatia are more efficient than banks in Bulgaria, pointing to the scale inefficiencies in the Croatian banking sector.

[13] This approach was for the first time employed by Berg, *et al*. (1993) who computed a common frontier for banks in three Scandinavian countries to assess the banks' operational efficiency. Also a similar methodology is employed by Allen and Rai (1996) for 15 OECD countries, Pastor, *et al*. (1997) for eight OECD countries, Casu and Molyneux (2000) for EU countries, and Hauner (2005) for banks in Austria and Germany. In the transition context, the common frontier approach has been utilized by Gregorian and Manole (2002) for 17 TEs and Stavarek (2003) for four CEE countries.

Table 7. DEA efficiency scores of banks in SEE (2002-2005), CRS and VRS model

	CRS				VRS			
	2002	2003	2004	2005	2002	2003	2004	2005
Number of banks (*of which* foreign-owned)	86(44)	83(41)	78(39)	84(38)	86(44)	83(41)	78(39)	84(38)
Number of efficient banks (*of which* foreign-owned)	5 (3)	7(5)	7(5)	6(4)	15 (10)	18(13)	17(14)	17(14)
Average efficiency	0.684	0.679	0.714	0.693	0.812	0.780	0.791	0.778
Standard deviation	0.153	0.169	0.144	0.151	0.150	0.161	0.156	0.163
Country								
Average efficiency of banks in Bulgaria	0.699	0.708	0.751	0.708	0.818	0.808	0.822	0.789
Average efficiency of banks in Croatia	0.696	0.676	0.698	0.664	0.843	0.787	0.789	0.772
Average efficiency of banks in Kosova	0.532	0.556	0.618	0.593	0.574	0.604	0.654	0.659
Average efficiency of banks in Montenegro	na	na	na	0.814	na	na	na	0.844
Ownership								
Average efficiency of foreign banks	0.693	0.695	0.736	0.725	0.827	0.825	0.842	0.824
Average efficiency of domestic banks	0.672	0.658	0.687	0.649	0.792	0.720	0.727	0.714
Efficiency Gap (*Foreign - Domestic*)	0.021	0.037	0.049	0.076	0.035	0.105	0.115	0.110
Size								
First Quartile	0.700	0.718	0.748	0.718	0.796	0.755	0.778	0.764
Second Quartile	0.633	0.608	0.652	0.618	0.766	0.727	0.711	0.698
Third Quartile	0.673	0.705	0.774	0.760	0.876	0.917	0.929	0.930
Fourth Quartile	0.795	0.631	0.661	0.707	0.968	0.938	0.961	0.959

Regarding the breakdown of banks by ownership, the results suggest that foreign banks on average outperform domestic banks in terms of the number of banks dominating the frontier and average efficiency in both the CRS and VRS models and the gap was increasing over the years. To explore further the differences in efficiency scores between foreign and domestic banks statistically the non-parametric Mann-Whitney Rank-Sum test is used, as suggested by Cooper, *et al*. (2000), to test the null hypothesis that foreign and domestic banks are drawn from a population having the same distribution, i.e. whether the differences between the two groups are statistically significant. The results are presented in Table 8 for individual country cases and the SEE region as a whole.

Table 8. Foreign *vs* . Domestic bank DEA scores: Mann-Whitney Test

	2002	2003	2004	2005
Bulgaria				
CRS (z-stat)	1.135	2.399**	2.521**	2.145**
VRS (z-stat)	0.510	2.241**	2.148**	1.590*
Croatia				
CRS (z-stat)	0.594	0.209	1.478	1.614*
VRS (z-stat)	0.608	0.478	1.294	1.878*
Kosova				
CRS (z-stat)	-6.898***	-6.061***	-1.784*	0.891
VRS (z-stat)	-2.221***	0.164	2.612***	0.478
Montenegro				
CRS (z-stat)	na	na	na	-0.365
VRS (z-stat)	na	na	na	0.125
SEE				
CRS (z-stat)	0.683	1.116	1.591*	2.430***
VRS (z-stat)	1.260	2.856***	3.218***	2.973***

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

As can be observed from the table, the differences between efficiency scores of foreign and domestic banks are statistically significant at the five percent level in Bulgaria in 2003 and after (and at the ten percent level in the VRS model in 2005). In Croatia the differences are statistically significant only in 2005 at the ten percent level of significance, while in Kosovo the differences are statistically significant in favour of domestic banks. This is reversed in 2004 in the VRS model only. In 2005, the differences between the efficiency scores of foreign and domestic banks are not significant in Kosovo or Montenegro. In the common sample of efficiency scores for banks in SEE countries the results indicate that the differences between foreign banks and domestic banks are more apparent only after 2003 and it seems that the results are mainly driven by the difference between foreign banks and domestic banks in Bulgaria and in 2005 for Croatia, e.g. after the consolidation took place.

Regarding the difference in efficiency scores between banks of different size classes the evidence is not so clear (Table 7).[14] For example, in the CRS model small banks in the first quartile are more efficient than larger banks (except in 2002 compared to fourth quartile and 2004-2005 compared to third quartile); while in the VRS model banks in third and fourth quartile appear the most efficient. If we recall that CRS is a product of technical and scale efficiency while VRS is a measure of pure technical efficiency, with any difference between the two reflecting scale inefficiencies. Table 9 presents scale inefficiencies of banks in SEE. As can be seen, while scale inefficiencies are not substantial for small banks, they appear to be considerable for large banks which generally operate under DRS. Banks in Croatia have the largest scale inefficiencies, followed by banks in Bulgaria. Also foreign banks seem to have higher scale inefficiencies than domestic banks. The consolidation of the banking sectors in Croatia, and to some extent Bulgaria, may be an explanation for this outcome.

Table 9. Scale inefficiencies of banks in SEE, 2002-2005[a)]

	2002	2003	2004	2005
Average	0.157	0.130	0.097	0.109
Country				
Bulgaria	0.145	0.124	0.086	0.103
Croatia	0.174	0.141	0.115	0.140
Kosova	0.073	0.079	0.055	0.100
Montenegro	na	na	na	0.036
Ownership				
Foreign banks	0.162	0.158	0.126	0.120
Domestic banks	0.152	0.086	0.055	0.091
Scale inefficiency Gap (*Foreign - Domestic*)	0.011	0.071	0.071	0.029
Size				
First Quartile	0.121	0.049	0.039	0.060
Second Quartile	0.174	0.164	0.083	0.115
Third Quartile	0.232	0.231	0.167	0.183
Fourth Quartile	0.179	0.327	0.312	0.263

Note: a) Scale inefficiency = 1-[(CRS/VRS)]

In general, the evidence suggests that economies of scale are exploited early in banking in terms of the size and that there is a general consensus that consolidation through M&As is beneficial up to a certain size – relatively small – in order to reap economies of scale (Amel *et al*., 2004).[15] Consequently, the size of banks (in terms of total assets) exhibiting constant returns to scale (CRS) in Bulgaria and Croatia is explored. The average size of banks exhibiting CRS for the 2002-2005 period in Bulgaria was €116 million (minimum €63 million in 2002 and maximum €130 million in 2005). In Croatia the average size of banks exhibiting CRS was 141 million (minimum €20 million in 2002 and maximum €300 million in 2005), thus, confirming to some extent previous assertions that the scale

[14] Banks are divided into four quartiles in terms of total assets in ascending order (from smallest to largest).
[15] For example, Ferrier and Lovell (1990) find that scale economies are exhausted when the asset size of banks achieves US$100 million; McAllister and McManus (1993) found that returns to scale are not exhausted until banks reached the asset size of US$500 million and thereafter constant returns to scale prevailed; Mester (1994) analyzing scale and scope economies of banks in the U.S. finds that scale economies are exhausted when the asset size is between US$75 million to US$300 million.

economies in banking are not so large. However, there are two banks in Bulgaria with the asset size of around €400 million and two in Croatia with the asset size of around €1 billion (one of which was not involved in M&A) that exhibit CRS. These exceptional cases make it difficult to specify the optimal scale size of banks since it depends on the characteristics of the particular market.

While the optimal scale of operation in banking is difficult to ascertain, the results suggest that the greatest source of inefficiency in the SEE banks is scale inefficiency of large banks attributable to M&As. It should be noted, however, that it takes time for the positive effects of M&As to take place. This is because restructuring and integrating the acquired bank involves changes in policies and procedures, operations, and staff training to adapt to new policies. It also involves branch and staff rationalization, lay-offs and staff turnover, change in cultures which may cause losses in customer relationships. From the results in the period under review it may be said that little gain in efficiency would be attained through M&As, especially for large banks, given they are generally operating at DRS. The period under review in SEE is characterized by a growing economy and an increase in market demand that may have encouraged the banks' excessive size. It appears that some banks attempted to become larger for positioning in the market and increase the market share, to preserve margins at the expense of scale economies. However, another motive may have been the acquisition of new technologies (explored in Section 7) which may be reflected in cost inefficiencies (Section 6.3).

Several observations can be made so far. In the banking sectors in the SEE countries no substantial efficiency improvements are apparent and there seems to have no convergence in the banking market in terms of intermediation efficiency. A notable exception is Kosovo which is showing that the catching-up with other countries is maybe taking place, although still remaining the least efficient banking sector in the region. In general, foreign banks appear more efficient than domestic banks and the differences are widening. Regarding the performance of banks of different size, large banks are more efficient than small banks, though large banks suffer from scale inefficiencies and banking markets are characterized with excessive size.

6. SENSITIVITY TESTS

In this section, the sensitivity of the DEA results is tested in three ways. First, whether the constructed frontier is influenced by outliers; second, whether the efficiency scores are stable over time; and third, whether the DEA scores are consistent with financial ratio analysis.

6.1. Test for outliers

As shown in the previous section, in the CRS model the efficiency frontier was determined by between five and seven banks throughout the period. One possible problem with DEA is that the frontier may be defined by the outliers rather than the whole sample, e.g. because of data errors (Simar, 2003) and as such be susceptible to extreme observations. The results of the test for outliers are displayed in Table 10.

Table 10. Spearman rank-order correlation coefficients: test for outliers

	No. of efficient banks (original sample)	No. of efficient banks (reduced sample)	Rank-order correlation (all sample *vs* . reduced sample)
2002	5	7	0.8867***
2003	7	11	0.9397***
2004	7	10	0.8645***
2005	6	10	0.9830***

Note: ***, **, * denote significance at 1%, 5% and 10% level, respectively.

The first column shows the number of efficient banks that construct the frontier in the original sample. Next, these banks are deleted from the sample and the efficiency scores are re-estimated for the reduced sample (the number of efficient banks for the reduced sample is shown in the second column). Then the Spearman rank-order correlation is calculated between the two estimates of efficiency scores in the two samples and it is found that correlation coefficients are high (ranging from 0.86 to 0.98) and are statistically significant at the one percent level. Similarly, high correlation coefficients have been found in Berg, *et al*. (1993) ranging from 0.95 to 0.99 employing a similar procedure. This may indicate that the results are not sensitive to outliers, i.e. those banks that appeared as more efficient in the whole sample were likely to remain such in the reduced sample.

6.2. Test for stability over time

A test for the stability of efficiency scores over time is conducted since, as pointed out by Leong, *et al*. (2003), banks cannot genuinely be efficient in one year and then highly inefficient in the next year, except in extraordinary circumstances. If the DEA scores are stable over time, then the problem of noise due to measurement errors, luck and lack of comparable entities for banks dominating the frontier diminishes. Therefore, at least within a short period of time, it is desirable that the efficiency scores are reasonably stable. Leong, *et al*. (2003) find low stability of DEA efficiency scores over time in their study of the banking sector in Singapore (correlation coefficients ranging from 0.14 to 0.06 within a three year time span). On the other hand, Bauer, *et al*. (1998) and Fiorentino, *et al*. (2006) in their studies of the banking sector in the U.S. and Italy, respectively, find quite large correlation coefficients ranging from 0.92 to 0.76 in a three year time span, suggesting that relative repositioning in the banking industry neither appears to occur quickly nor to a large extent.

Table 11. Spearman rank-order correlation coefficients of efficiency measures over time

	One year apart (2005 *vs.* 2004)	Two years apart (2005 *vs.* 2003)	Three years apart (2005 *vs.* 2002)
CRS 2005	0.7875***	0.6905***	0.6276***
VRS 2005	0.8717***	0.7887***	0.6834***

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

Table 11 contains the Spearman rank-order correlation coefficients which represent the correlation of efficiency scores in 2005 with the scores in 2004, 2003 and 2002. As the results indicate, the coefficients are quite high and significant at the one percent level suggesting that many of the worst performers and best performers have tended to remain such over time. For example, the rank correlation coefficients for the CRS and VRS efficiency scores in 2005 with the CRS and VRS scores one year forward are 0.79 and 0.87, respectively. The correlation coefficients decrease over time as one would expect, but remain significant at one percent level suggesting that the model ranks banks fairly consistently over time.

6.3. DEA, financial ratios and sources of inefficiency

Financial ratio analysis is often used by the bank management, regulators, financial analysts as well as researchers to evaluate bank performance based on some 'benchmarks' for the industry. One disadvantage of the ratio analysis is that each ratio must be compared with some benchmark ratios, one at a time, while assuming that other factors are fixed and that the benchmarks chosen are suitable for the purpose of comparison (Yeh, 1996). Among the most frequently used accounting ratios are return on assets (ROA) and return on equity (ROE) which proxy for bank efficiency in generating profits; cost to total asset ratio (CTA), cost to income ratio (C/I) and revenue to asset ratio (RTA) which are indicators of optimization in terms of bank costs and revenues; loans to total assets (LTA) and loans to total deposits (L/D) which show the extent to which assets/deposits are devoted to loans as opposed to other assets; capital to total assets ratio (CAR) which shows capital adequacy, etc.

A desirable property of the DEA model is its usefulness for policy purposes in serving regulators in identifying the worst performing banks in the market.[16] As Bauer, *et al*. (1998) pointed out, a positive correlation between efficiency scores (generated in DEA or parametric methods) and the usual ratios would be desirable because the authorities could be more confident that the measured efficiencies are accurate indicators of performance and not just artefact of the assumptions made regarding the underlying optimization concept, the inexistence of random error and, for parametric methods, the functional form assumptions and distributional assumptions of efficiency scores and the random error.

Table 12. Spearman rank-order correlation coefficients of efficiency measures and financial ratios

		ROA	ROE	NIM	C/I	CTA	RTA	LTA	L/D	CAR
CRS										
	2002	0.3882***	0.2936**	0.4873***	-0.4409***	-0.0126	0.2592**	0.6846***	0.8311***	0.2912**
	2003	0.3195**	0.0211	0.4445***	-0.4705***	-0.0688	0.4434***	0.7439***	0.8735***	0.5007***
	2004	0.4100***	0.0842	0.4853***	-0.5323***	-0.0004	0.3907***	0.6064***	0.7555***	0.4719***
	2005	0.4845***	0.2074	0.4618***	-0.6110***	-0.1622	0.3600***	0.5851***	0.7873***	0.4555**
VRS										
	2002	0.4203***	0.3294***	0.2925**	-0.4505***	-0.0694	0.2089*	0.3932***	0.5159***	0.2170*
	2003	0.3515***	0.2759**	0.2139*	-0.5300***	-0.2285*	0.1782	0.4929***	0.5528***	0.1445
	2004	0.3381***	0.2526**	0.1857	-0.5528***	-0.2967**	0.0441	0.5075***	0.5541***	0.1803
	2005	0.4483***	0.3410***	0.3024**	-0.6092***	-0.3023**	0.1751	0.5904***	0.7155***	0.2693**

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively; ROA (return on assets) is the ratio of pre-tax profit to total assets; ROE (return on equity) is the ratio of pre-tax profit to total equity; NIM (net interest margin) is the difference between the interest income and interest expenditures divided by total assets; C/I is the ratio of total costs to total income; CTA is the ratio of total costs to total assets; RTA is the ratio of total revenues to total assets; LTA is the ratio of loans to total assets; L/D is the ratio of loans to deposits; CAR (capital adequacy ratio) is the ratio of total equity to total assets.

Table 12 presents the correlation coefficients of DEA efficiency scores with some broadly used financial ratios. As indicated in the table, the correlation coefficients are, in most cases, reasonably large and statistically significant. The largest correlation coefficients are exhibited with loan to deposit ratio (L/D) ranging from 0.52 to 0.87, loan to total assets ratio (LTA) ranging from 0.39 to 0.74, cost efficiency ratio (C/I) ranging from 0.44 to 0.61 – all statistically significant at one percent level – followed by profit to total assets ratio (ROA) ranging from 0.32 to 0.48. These correlation coefficients are higher than the ones reported in other studies. For example, Isik and Hassan (2002) find correlation coefficients of efficiency scores with ROA, CTA and C/I ratios in range 0.30-0.40, Bauer, *et al*. (1998) in range 0.10-0.20, while Fiorentino, *et. al*. (2006) find even weaker correlation coefficients.

Further, the average of selected ratios for the most efficient banks identified by DEA in the CRS and the VRS model are computed, i.e. frontier banks, and below average performers in the market, i.e. banks with below average DEA efficiency scores. As can be seen from the Table 13, on average, better DEA performers have also better financial ratios and the differences seem quite large. For example, more efficient banks have larger return indicators, are better in managing costs, are better capitalized, and are better in transforming assets/deposits into loans. Given the small sample size, the non-parametric Mann-Whitney test is conducted in order to draw inference on the differences in accounting ratios between the 'best' and the 'worst' DEA performers. As can be observed from Table 13, in the both CRS and VRS models, significant differences appear for almost all the accounting ratios.

[16] In banking studies, apart from the extensive use in efficiency measurement, DEA has also been proposed for use in monitoring and/or early warning systems by bank regulatory agencies since it has a strong empirical association with bank failures after the inefficiencies have been detected (Barr *et al*., 1994; Kao and Liu, 2004).

Table 13. Statistical tests of differences in financial ratios for the best and the worst DEA performers (2005)

	ROA	ROE	NIM	C/I	CTA	RTA	LTA	L/D	CAR
CRS									
Banks (DEA=1)	3.78	20.77	5.82	60.76	5.70	9.79	68.96	91.60	29.77
Banks (DEA<Average DEA)	0.89	1.52	3.57	84.93	6.98	8.23	47.06	54.91	10.84
Mann-Whitney Test									
z-stat	2.331**	2.310**	1.626	-2.923***	-1.367	0.849	2.310**	3.441***	3.365***
VRS									
Banks (DEA=1)	2.51	17.92	4.48	66.3	5.7	8.71	61.22	77.77	17.59
Banks (DEA<Average DEA)	0.89	0.92	3.74	85.82	7.74	8.69	48.28	56.85	11.42
Mann-Whitney Test									
z-stat	2.409**	1.880*	0.740	-3.791***	-3.041***	0.454	3.060***	3.791***	1.630

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively; ROA (return on assets) is the ratio of pre-tax profit to total assets; ROE (return on equity) is the ratio of pre-tax profit to total equity; NIM (net interest margin) is the difference between the interest income and interest expenditures divided by total assets; C/I is the ratio of total costs to total income; CTA is the ratio of total costs to total assets; RTA is the ratio of total revenues to total assets; LTA is the ratio of loans to total assets; L/D is the ratio of loans to deposits; CAR (capital adequacy ratio) is the ratio of total equity to total assets.

The above results may suggest that inefficiencies originate in the process of transforming deposits into loans and extending loans as opposed to other assets as well as cost inefficiencies. However, as discussed earlier in this chapter, the DEA method has the advantage of identifying the source of inefficiency directly. By constructing the frontier of best performers, best achievable output and input targets are computed. The difference between the actual outputs/inputs of inefficient units and outputs/inputs of best practice units may represent the sources of inefficiency. Calculating the mean values of output shortfalls for the sector and mean values of the excess use of inputs, and relating this to the mean value of actual outputs and inputs gives the value of inefficiencies for each input and output. By calculating this, results suggest that the greatest source of inefficiency are excess costs (2.60 percent), followed by a shortfall in loan extension (1.31 percent) – broadly in line with the ratio analysis. In all, the results show that the DEA model efficiency scores are comparable with most of the standard performance measures, indicating that using DEA in conjunction with the usual ratio analysis may be a useful tool.

7. TOTAL FACTOR PRODUCTIVITY CHANGE

Table 14 presents the results of the Malmquist Index (M_I) for the banking sector in SEE in the period 2002-2005.[17] As can be seen, it appears that there was a minor improvement in M_I (0.8 percent) in the SEE countries in terms of banking sector intermediation, driven by the change in technology (ΔT) rather than the improvement in technical (ΔPTE and ΔTE) and scale efficiencies (ΔSE) – which generally exhibit efficiency decline. The technology shift effect improved by 3.2 percent (ΔT), which is offset by the catching-up effect with the overall decline of 2.3 percent (ΔTE). The change in technology is positive in two years while negative in one and the opposite is true for other components.

Technological progress characterized banks of all classes (by ownership, size and country), although banks in Kosovo, smaller and domestic banks showed lower progress. In terms of M_I, however, the largest progress is apparent for the banks in Kosovo in all of its components in the period under review. This shows that Kosovo is catching-up with other countries in terms of financial intermediation. Croatia exhibits a declining M_I in the period under review and the primary source is the decline in the technical and scale efficiency, while there is a positive shift in technology. Bulgaria, on the other hand, exhibits a small improvement in M_I which is attributed entirely to the improvement

[17] The Malmquist Index requires balanced panel data, hence banks that are not present in all years are excluded from the sample. After computing the DEA scores by excluding banks that are not present in all the years and comparing the results with the whole sample and the Malmquist Index, the results and conclusions remain the same (results available upon request). Though, in the balanced panel DEA scores are on average higher and scale inefficiencies lower which may suggest that banks that exited the market, new entrants or those that were acquired were worse performers (i.e. may refute the 'cherry picking' hypothesis).

in technology. Foreign banks showed M_I growing, while domestic banks record a slight decline although the difference is not substantial. Both groups had an improvement in technology and for domestic banks the improvement is more apparent in the scale efficiency. Regarding the change in M_I by bank size, the results are not so clear. For example, all size groups recorded an improvement in technology, while larger banks (e.g. in third and fourth quartile) made an improvement in ΔPTE but faced a decline in ΔSE.

Table 14. Malmquist Total Factor Productivity Change Index, (2002-2005)

	ΔPTE	**ΔSE**	**ΔTE**	**ΔT**	**M_I**
Average	0.978	0.999	0.977	1.032	1.008
Year					
2003 *vs* . 2002	0.941	0.972	0.914	1.141	1.043
2004 *vs* . 2003	1.017	1.032	1.048	0.950	0.998
2005 *vs* . 2004	0.976	0.994	0.968	1.009	0.980
Country					
Bulgaria	0.979	0.998	0.977	1.035	1.011
Croatia	0.967	0.992	0.959	1.030	0.988
Kosova	1.022	1.050	1.064	1.029	1.096
Ownership					
Foreign banks	0.997	0.985	0.981	1.036	1.016
Domestic banks	0.955	1.019	0.972	1.028	0.998
Size					
First Quartile	0.962	1.009	0.970	1.019	0.988
Second Quartile	0.981	0.999	0.978	1.042	1.020
Third Quartile	1.004	0.993	0.997	1.044	1.040
Fourth Quartile	1.004	0.967	0.971	1.045	1.015

Note: ΔPTE is the technical efficiency change due to VRS assumption; ΔSE is the scale efficiency change; ΔTE is the technical efficiency change due to the CRS assumption; ΔT is the technological change and M_I is the total factor productivity change.

In sum, a minor improvement is apparent in M_I in the SEE banking sector, driven mainly by the change in technology. The largest improvement in all the M_I components is apparent for Kosovo in the period under review and foreign banks show some improvement in M_I as compared to their domestic counterparts. A shift in technology may be attributed to the fast technology advancement in Kosovo primarily because the banking sector had to introduce the whole set of banking products and services starting from branching network, ATMs, POS, e-banking, etc., which in turn were reflected in transitory cost inefficiencies. Other countries in the region were not subjected to the introduction of the banking products and services from scratch and, hence, exhibited slower technology advancement. Overall, it seems that few banks took advantage of introducing new technologies while the average bank failed to keep up, leading to the divergence in the sector.

8. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper the intermediation efficiency of banks in four SEE countries over the period 2002-2005 was explored employing the DEA technique. The intermediation efficiency was measured by utilizing a two input-two output model for banks under investigation. Several findings emerged from the analysis. First, in the period 2002-2005, the intermediation efficiency of banks in the region as a whole only showed a marginal improvement. This is particularly because banks, on average, failed to improve their efficiency as much as the few best performers that exhibited a shift in technology, giving a continuously widening divergence. Inefficiencies in the sector emanated from substantial scale and cost inefficiencies, lending shortfalls and possibly the regulatory measures imposed by the central banks in the region aimed at curbing the rapid credit expansion. Cost and scale inefficiencies are partly a reflection of the technology shift effect, i.e. due to transitory costs in the adoption of technological advances for upgrading banking products and services, a shift towards the segments of business such as the small business sector which are more costly to serve and partly due to mergers and acquisitions (M&As) that led to an inefficient scale of operation. Second, it was found that foreign banks (which are on average larger) were more efficient than domestic players and the gap had continuously widened. Foreign banks' superior efficiency is identified despite the consolidation process through M&As largely involving these banks as in Croatia; start-up costs or costs of acquiring domestic banks; costs adopting new technologies or building them from scratch as in Kosovo; and costs in further building human capital which was generally lacking in the SEE. Third, in most cases larger banks were found to be more efficient than small banks, although experiencing substantial scale inefficiencies and exhibiting decreasing returns to scale, i.e. larger banks operated at excessive size. Fourth, regarding individual countries, the Kosovo banking system was found to be the least efficient in intermediation compared to the systems in neighbouring countries, although improvement and a catching-up effect has taken place over time. This is particularly because of the young banking sector that needed to expand its activities reflected in substantial scale and cost inefficiencies in the short-run and the risk perception of bankers and/or the regulator entailing lending shortfalls and high provisioning.

Some important policy guidelines emerge from the analysis. Given scale inefficiencies detected in the banking sectors in the SEE in the period under review, especially for larger/foreign banks exhibiting decreasing returns to scale, policymakers should carefully examine any M&A proposal involving the large players. First, M&As should be assessed on the basis of whether they create efficiency gains or increase the market power in already concentrated markets. A common motive for consolidation is gains in scale and scope economies, cost saving and revenue enhancement. Evidence from this paper suggests that these aims may have not been fulfilled, at least in the short-run. The absence of efficiency improvement due to M&As may indicate some degree of market power exploitation. Although there may be positive benefits of consolidation over a longer period than considered in this study (with changing policies and procedures and staff training to adaptation to new conditions, staff turnover and lay-offs, changes in customer relationships, change in organizational cultures, etc.), the evidence presented here is an important factor for policy makers to take account of in decision making. In terms of efficiency improvements, it is possible that M&As involving small/domestic banks that generally exhibit increasing returns to scale would be more appropriate since the DEA results, in line with most of other findings in the literature, suggest that the scale efficiencies in banking are exhausted early.

Second, in so far as M&As lead to a small number of large players in the market, policy makers may be concerned that that the new large banks may be oriented towards lending to large corporate clients (e.g. Berger *et al*., 2001 and DeHaas *et al*., 2007 for recent evidence in TEs). Hence, the small business sector may be left relatively underserved and credit constrained. To the extent that large banks have a competitive disadvantage in lending to small firms, several lending technologies, other than those based on financial statement data which may be unavailable to small firms, has been proposed in order to overcome this disadvantage (Berger and Udell, 2006): collateral-based lending, credit-scoring, factoring, leasing, etc. However, institutional quality plays a crucial role in, among others, the ability of banks to adopt various lending technologies. For example, collateral-based lending depends directly on the enforcement of collateral laws and lending based on credit-scoring depends directly on the functioning of credit registers. Hence, poor institutions make it ambiguous whether these lending technologies can be adopted to overcome a competitive disadvantage of large banks to lending to small firms. In the view of competitive pressures from large/often foreign banks, on small/often domestic banks, the latter need to find market niches such as targeting small firms. Small domestic banks may have a competitive advantage serving the small business sector based on relationship lending and 'soft' information.

The central banks should pay careful attention to banks that fail to acquire new technologies and become increasingly inefficient as they may be forced to exit the market and create instability in the banking sector. This is particularly important as the detected inefficiencies in the literature using

DEA have been found to have a good predictive power for bank failures. As shown in this paper, the sensitivity tests indicate that the DEA efficiency scores are stable over time, not sensitive to outliers and broadly consistent with ratio analysis. For example, DEA-efficient banks have better return indicators, are better in managing costs, more capitalized and better in transforming deposits into loans. One implication for the central banks is that, apart from methods utilized in assessing bank performance such as the CAMEL technique (which is based on financial ratios), the adoption of DEA could be a supplementary early warning tool. However, this depends crucially on the appropriate statistical information and supervisory capacity in detecting misreporting on time.

One possible explanation for the intermediation inefficiencies detected using DEA was the regulatory measures imposed by the central banks to curtail credit expansion, such as supplementary reserve requirements for banks in which credit growth is higher than the growth in total assets. Given the predominance of household loans in bank portfolios, these measures may disproportionately affect credit to the enterprise sector and subsequently small firms. Hence, an implication for the central banks is that the imposed measures targeting the restrain of credit growth should discriminate between household lending and lending to the enterprise sector.

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