Efficiency and productivity growth in the banking industry of Central and Eastern Europe

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Abstract

We employ the directional technology distance function and present estimates of bank efficiency and productivity change in ten Central and Eastern European countries for the period 1998-2003. Our method allows the aggregation of individual bank inefficiency and productivity growth to the industry level and enables us to investigate potential differences in productivity across countries and across banks with different ownership status. Our findings suggest that productivity for the whole region declined in the first years, but improved afterwards, especially over the last years, while there are diverging trends in productivity growth across banking industries. Moreover, foreign banks outperform domestic private banks both in terms of efficiency and productivity.

EFM Classification Codes: 510; 620

JEL Classification: D24; G21; L25

Keywords: bank efficiency; productivity; directional technology distance function; Central and Eastern European countries

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1. Introduction

Central and Eastern European (CEE) countries have gone through significant economic and political transformations during the last fifteen years. As they moved away from a centrally-planed economy to a relatively free-market system, these countries launched wide-ranging economic and financial reform programs to stabilize their economies and to restructure their financial sectors. The initial efforts of transformation to market economies were reinforced later on by the goal of membership in the European Union (EU). Indeed, in March 1998 the EU formally launched a transition process that led to the enlarged union on 1 May 2004, when eight east European transition countries – the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic and Slovenia – joined the European Union, while Croatia and Romania hope to become members in the near future.

In particular, a catching up process, characterised by rapid financial development and high economic growth, has been taking place. Significant efforts were directed towards improving the legislation related to the banking sector in the transition countries, while there have been continuous amendments on the banking supervision regulative framework with the EU regulative system and the international standards of effective supervision. These laws have increased the attractiveness of the banking systems for foreign investment, strengthened prudent standards and practices in the banks' operations, enhanced corporate governance, and improved efficiency in banking operation and supervision.

Thus, the radical structural changes in the financial system following the collapse of the centrally planned economic systems, its catching up with EU levels,

characterized by rapid financial development and high economic growth, and the overall transition towards a market economy make the banking systems of these countries a distinct field of research. This paper investigates the effects of this restructuring process on the efficiency and productivity growth of the banking industries in ten Central and Eastern European countries, namely the Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia, over the period 1998 to 2003.

The investigation of bank efficiency has fueled a large body of literature globally, and is of vital importance from both a microeconomic and a macroeconomic point of view (Berger and Mester, 1997). From the micro perspective, the issue of banking efficiency is crucial given the enhancement of competition due to the strong, and increasing, presence of foreign banks – both as Greenfield and takeover investments – in the region and the improvement in the institutional, regulatory and supervisory framework. From the macro perspective, the efficiency of the banking industry influences the cost of financial intermediation and the overall stability of the financial markets, as banks constitute the spinal cord of financial markets in the new EU member states' economies (Rossi et al., 2005). Indeed, an improvement of banking performance indicates a better allocation of financial resources, and therefore an increase of investment that favors growth.

Research in cross-country efficiency performance comparisons in transition countries has intensified in recent years. Particular attention has been given to the questions of the effect of ownership on performance in light of the increasing presence of foreign investors in the financial systems of transition economies. Thus, several studies have examined cost and/or profit efficiency of banks, especially in Central and Eastern European countries, focusing primarily on the performance

differences between foreign and domestic financial institutions (i.e., Bonin et al., 2005; Dimova, 2004; Yildirim and Philippatos, 2002; Green et al., 2004; Fries and Taci, 2005; Grigorian and Manole, 2002; Rossi et al., 2005).

This paper fills a gap in the literature by departing from the analysis of the above-mentioned studies, which focus only on efficiency, and uses the directional technology distance function in order to estimate the Luenberger productivity indicator, which can be decomposed in efficiency and technical change. This methodology addressed several certain empirical problems that have been encountered in bank efficiency and productivity studies, as it allows the aggregation of individual bank inefficiency and productivity growth to the industry level (Färe and Primont, 2003; Färe and Grosskopf, 2004), contrary to the widely used Shephard (1974) output or input distance functions, which are not additive from the bank to the industry level, rendering minimal insight into industry performance over time. Moreover, the directional technology distance function allows for the simultaneous contraction of inputs and expansion of outputs and is dual to the profit function. In order to empirically estimate the directional distance function, we follow Färe, Grosskopf, Noh and Weber (2005) and employ a stochastic frontier method.

The rest of the paper is organized as follows. Section 2 presents a brief history of the reforms implemented in CEE countries. Section 3 describes the methodology, while Section 4 provides the description of the data. Section 5 develops the empirical results, while conclusions are drawn in Section 6.

2. The banking systems of CEE countries

During the last fifteen years the financial systems of Central and Eastern European countries have undergone fundamental changes that have fully transformed

their banking systems. The creation of viable, sound and efficient banking sectors, able to support economic growth, in these countries has been a fundamental issue of the transition to a market economy and one of the most challenging ones.

At the beginning of the transition process the countries under review faced the difficult task to embark on prudent macroeconomic stabilization efforts and transform their financial system, which had been little more than a book-keeping mechanism for recording the authorities' decisions about the allocation of resources among various sectors and enterprises under central planning (Schardax and Reininger, 2001). Most transition economies have followed the same broad paradigm for transformation of the banking sector, which involved the introduction of a two-tier banking system, the abolition of sectoral restrictions on specialized banks, the entry of new private banks, including foreign banking institutions, the restructuring and privatization of state banks, the liberalization of interest rates and the establishment of the legal and supervisory framework (Kager, 2002).

The reform of the financial sectors in the transition countries was a task fraught with difficulties. During the initial phase of the transition process, most countries adopted a quite liberal licensing policy, which gave rise to the establishment of a large number of newly founded banks, which often engaged in unsound practices. These practices were further supported by shortcomings in the legal framework and supervisory system. Moreover, the state-owned banks, which came from the old monobank system, suffered from an inherited burden of bad loans, which was further exaggerated due to the lack of adequate banking skills and insufficient management ability to assess credit risk (Schardax and Reininger, 2001). It is therefore not surprising that due to these deficiencies, coupled with the recessionary economic environment prevailing at the beginning of transition, all CEE countries experienced

one or even several banking crises during the first years of transformation[1], which lead to a sharp reduction in the number of banking institutions in the region. Indeed, as we can see from table 1 the number of banks in the CEE countries has been reduced significantly from 1998 to 2003.

(Please insert Table 1 about here)

In overcoming these crises and restructuring their banking sectors, these countries had to deal with several kinds of issues, which involved solving the problem of irrecoverable assets inherited from the past regime, recapitalizing the banking sector, introducing evaluation and accounting standards and adequate supervisory systems, and finally privatizing the banking sector[2] (Kager, 2002).

Central and Eastern European governments initiated large scale privatization programs that substantially diminished the state ownership in banking during the mid-1990s. The main motive behind privatization of state-owned banks was the desire to enhance competition and efficiency in the banking sector through increased foreign and domestic participation, while the banking crises that affected the region during this period have basically accelerated the privatization process.

Moreover, since the mid-90s significant efforts were directed towards improving the legislation related to the banking sector in all CEE countries. In all

[1] Indicatively, we can mention the crisis in Croatia, where five banks accounting for about 50 percent of banking system loans deemed insolvent, and were taken over by the Bank Rehabilitation Agency during 1996; the crisis in Estonia during 1992-1995, when insolvent banks accounted for 41 percent of financial system assets; the crisis in Latvia, where between 1994 and 1999 25 banks either saw their license revoked, were closed, merged with another bank, or ceased operations; the crisis in Lithuania in 1995 when out of 25 banks, 12 small banks liquidated, 3 private banks accounting for 29 percent of banking system deposits failed and three state-owned banks deemed insolvent; and the banking crisis in Poland in 1991 when seven out of nine treasury owned banks with 90 percent share of total credit market and the cooperative banking sector experienced solvency problems.

[2] For a detailed analysis of the transition process in each new member state see also Schardax and Reininger (2001), and Fries and Taci (2002).

countries, prudential banking laws and securities laws have been enacted to eventually bring them in line with Bank for International Settlements guidelines and EU directives. Indeed, the most important European banking directives have already been implemented in the new member states, while transitional arrangements are in place for some remaining issues. In addition, to enable arms-length lending relationships between banks and their borrowers and to foster confidence of depositors in banks, the legal framework, including commercial codes and laws on secured transactions and bankruptcy, were overhauled or introduced.

An overall measure of progress in reform of the banking sector is the transition indicator of the European Bank for Reconstruction and Development (EBRD) for banking reform.[3] This indicator provides a ranking of progress in liberalisation and institutional reform of the banking sector, on a scale of 1 (which represents little progress in reforming the socialist banking systems) to 4 (which represents a level of reform that approximates the institutional standards and norms of an industrialised market economy). From the ten former transition countries, only

[3] A score of 1 represents little change from a socialist banking system apart from the separation of the central bank and commercial banks, while a score of 2 means that a country has established internal currency convertibility and has liberalised significantly both interest rates and credit allocation. A score of 3 means that a country has achieved substantial progress in developing the capacity for effective prudential regulation and supervision, including procedures for the resolution of bank insolvencies, and in establishing hardened budget constraints on banks by eliminating preferential access to concessionary refinancing from the central bank. A score of 4+ represents a level of reform that approximates the institutional standards and norms of an industrialised market economy, as represented, for example, by the Basle Committee's Core Principles on Effective Banking Supervision and Regulation (EBRD Transition Report 2004). See the EBRD Transition Report (2004) for a more detailed definition and classification.

Hungary has achieved the highest score of 4, while the majority of the countries cluster around 3.3, coming from much lower levels in 1998 (Table 1).

Similarities in the economic histories and experiences, as well as comparable methods applied to build the market economies, lead to creation of not very divergent structures and institutions between CEE countries. In fact, all banking sectors in Central and East Europe share some common structural characteristics, including the dominance of the banking sector within the financial system, a low level of financial intermediation, and a high degree of foreign involvement in most sector segments. Particularly, the banking sector plays the most important role in financial intermediation, as capital markets are relatively small and underdeveloped in most countries. Thus, the financial systems in CEE countries have developed more as 'bank-based' than as 'market-based' systems, with the banking sector being the major provider of financial services. The share of banking assets in total assets of financial institutions exceeds 75 percent, while in Slovakia it reaches even 90 percent.

Nonetheless, the size of the banking sector is still generally small, both in relative and in absolute terms. The depth of the banking markets, as measured by total assets to GDP, is highly diversified across countries. It ranges between 32.6 per cent in Romania and 107 per cent in the Czech Republic in 2003, coming up from much lower levels in 1998. Penetration of the economy by loans is much more limited, as the ratio of domestic credit to the private sector as a percentage of GDP in 2003 ranges from 9.5 in Romania to 48.5 percent in Croatia, with the majority of the analyzed countries clustering between 25 and 40 percent (Table 1). The low level of banking intermediation can be mainly attributed to the economic environment (income level and creditworthiness), to persistent inefficiencies (insufficient law enforcement, lack of mortgage-backed collateral, inadequate legal protection for

lenders) and finally to high real interest rates. It is therefore not surprising that the Eastern European banking market is considered to be a major growth market, which is also why many Western European banks have been eager to gain a foothold in this market over recent years.

As an implication, foreign banks have expanded their presence in the CEE countries quite significantly over the last decade. On average, in 2003, nearly 70 per cent of banking assets were controlled by foreign banks, ranging from 16 per cent in Slovenia to about 98 per cent in Estonia (ECB, 2005). Foreign banks have played an important role in the development of banking markets in CEE countries, not only due to the capital investment from abroad, which decreased fiscal costs of banks' restructuring and provided a vote of confidence of international economy for the ongoing transformation of transition economies, but often because privatization to reputable foreign owners was the only way to decrease moral hazard problems induced by previous repetitive bailouts (Tang et al., 2000). Moreover, foreign banks brought expertise in risk management and higher culture of corporate governance (Bonin et al., 2005), while, through increased competition, they drove domestic banks to cut costs and further increase efficiency (Claessens et al., 2001). Finally, domestic banks have benefited from technological spillovers brought about by their foreign competitors (Havrylchyk and Jurzyk, 2005). Overall, according to ECB (2005) foreign ownership is widely believed to have contributed to an improvement of the risk profile, reputation and risk management of local banks and hence to financial stability in former transition countries and a convergence with western standards.

A look at Table 1 further reveals that the CEE countries' banking market is characterized by a relatively high degree of concentration. On average, in 2003, the largest five banks hold 72 per cent of total banking sector assets, ranging from 52 per

cent (in Poland and Hungary) to 99 per cent (in Estonia). Countries with a smaller market size generally present higher concentration figures. But even in countries with the lowest concentration ratios among their counterparts, market concentration is relatively high.

Overall, we can conclude that banks in CEE countries are operating in an increasingly competitive environment, as major players seek to accumulate additional market share and the sector consolidates further. Although competitive pressures and the degree of internationalization are already high today, competition is expected to intensify and to put additional pressure on the currently high profits of banks, and as revenues decline, efficiency will have to be increased to secure profitability.

3. Methodology- the directional distance function

To model the production process and measure inefficiency we use the directional technology distance function proposed by Chambers et al. (1996) as a generalization of the Luenberger (1992) benefit function. Technology (T) is defined as a set of desirable outputs (y) and inputs (x) such that the inputs can produce the outputs[4]:

$$T = \{(x, y): x \in R_+^n, y \in R_+^m, x \text{ can produce } y\} \quad (1)$$

Let a directional vector be represented by $g = (g_x, g_y)$, where $g_x \in R^N_+$ and $g_y \in R^M_+$. The directional technology distance function seeks the maximum simultaneous expansion of desirable outputs (y), and contraction of inputs (x) for the directional vector, g[5].

[4] It is assumed that the technology satisfies the axioms listed in Färe and Primont (1995), among which are convexity and strong disposability of outputs and inputs.

[5] Some of the basic properties of the directional technology distance functions include the translation property, the representation property and the independence of unit of measurement. For more details see Chambers, Chung and Färe (1998) and Färe and Grosskopf (2004).

$$\vec{D}_T(x, y; g_x, g_y) = \sup\{\beta : (x - \beta g_x, y + \beta g_y) \in T\} \quad (2)$$

Thus, the directional technology distance function projects the input/output vector (x, y) onto the technology frontier in the $g = (g_x, g_y)$ direction. The directional technology distance function mimics the fact that inputs and outputs are optimized simultaneously as in the case when we define a profit function, and also provides a unifying structure, since it includes the Shephard distance functions as special cases; the Shephard output distance function optimizes over output quantities, but not inputs ($g = (0, g_y)$) and the Shephard input distance function optimizes over input quantities but not outputs ($g = (g_x, 0)$). However, contrary to the Shephard distance functions, which use firm-specific directional vectors and cannot be aggregated to the industry level, in the case of the directional technology distance function when all banks are evaluated for a common directional vector, industry inefficiency equals the sum of the directional distance functions for the firms in the industry (Färe and Grosskopf, 2004).

In the paper, we take the directional vector to be $g = (g_x, g_y) = (1, 1)$. For this directional vector, the solution to (2) gives the maximum unit expansion in desirable outputs and simultaneous unit contraction inputs that is feasible given the technology. For a bank that is technically efficient, the value of the directional distance function would be zero. On the other hand, values of $\vec{D}_T(x, y, g_x, g_y) > 0$ indicate inefficient production.

In order to measure productivity growth, the directional distance function is evaluated in different periods. The Luenberger productivity indicator (L), which is constructed from the directional distance function, may be decomposed into efficiency change (LEC) and technical change (LTC), that is L = LEC + LTC. Efficiency change equals the difference in the directional distance function between

periods, while technical change equals the average ‘‘shift’’ in the frontier from period to period.

$$LEC = \overset{\rho}{D}_T^0(x^0, y^0; g) - \overset{\rho}{D}_T^1(x^1, y^1; g) \quad (3)$$

$$LTC = \frac{1}{2}((\overset{\rho}{D}_T^1(x^1, y^1; g) - \overset{\rho}{D}_T^0(x^1, y^1; g) + \overset{\rho}{D}_T^1(x^0, y^0; g) - \overset{\rho}{D}_T^0(x^0, y^0; g)) \quad (4)$$

Moreover, technical change can be further decomposed into input bias, output bias and a (neutral) magnitude term: $LTC = LOBTC + LIBTC + LMATC$. Values of the indicators greater than zero indicate productivity growth, while negative values indicate a decline in productivity.

To empirically implement the Luenberger indicator one may use either an activity analysis approach or a parametric distance function approach. In this paper, we follow Färe, Grosskopf, Noh and Weber (2005) and opt for a stochastic frontier method, originally proposed for production functions by Aigner, Lovel and Schmidt (1977) and Meeusen and van den Broeck (1977). In order to estimate a parametric directional distance function, a functional form has to be chosen, which ideally, should be flexible, easy to derive and permit the imposition of the translation property. The quadratic function satisfies these properties[6], and is defined here for a panel of i=1,…,I banks observed over t=1,…,T periods. This specification corresponds to a multi-output/ multi-input technology with technical progress defined in the usual form as a trend variable. More specifically, we estimate the following equation:

$$\overset{\rho}{D}_T(x, y; g_x, g_y, t, \theta) = \alpha_0 + \sum_{n=1}^{N} \alpha_n x_n + \sum_{m=1}^{M} \beta_m y_m + \frac{1}{2}\sum_{n=1}^{N}\sum_{n'=1}^{N} \alpha_{n'n} x_n x_{n'}$$

$$+ \frac{1}{2}\sum_{m=1}^{M}\sum_{m'=1}^{M} \beta_{mm'} y_m y_{m'} + \sum_{n=1}^{N}\sum_{m=1}^{M} \gamma_{mn} y_m x_n$$

[6] For a discussion of parameterizations of distance functions, see Färe and Lundberg (2005).

$$+\delta_1 t+\frac{1}{2}\delta_2 t^2+\sum_{n=1}^{N}\psi_n tx_n+\sum_{m=1}^{M}\mu_m ty_m+\varepsilon+u \qquad (5)$$

where θ is a vector of parameters and ε+u is the composite error term. u is bank-specific inefficiency, assumed to be half-normally distributed, u~iid $N^{+}(\mu,\sigma^2_u)$, and ε is the random error assumed to be independently and identically distributed according to standard normal distribution, ε~iid $N(0,\sigma^2_{\varepsilon})$.

The parameters of the function, indicated in Greek letters, must satisfy a set of restrictions, including the usual restrictions for symmetry ($a_{nn'}=a_{n'n}$, $\beta_{nn'}=\beta_{n'n}$) and the following restrictions to impose the translation property:

$\sum_{n=1}^{N}\alpha_n g_n+\sum_{m=1}^{M}\beta_m g_m=1$, $\sum_{n=1}^{N}\alpha_{nn'}g_{x_n}=0$, where n′=1,…,N, $\sum_{m=1}^{M}\beta_{mm'}g_{y_m}=0$, where m′=1,...,M, $\sum_{n=1}^{N}\psi_n=0$ and $\sum_{m=1}^{M}\mu_m=0$

Moreover, in the context of a cross-country comparison and in order to properly define a common frontier, it is important to allow for country-level variables that could influence the level of productivity and efficiency of the banking sector in each country. To examine the potential factors that are correlated with bank inefficiencies, we use the conditional mean model of Battese and Coelli (1993, 1995), which permits the simultaneous estimation of the frontier and the identification of the correlates of bank inefficiencies in a single-step estimation. Thus, the estimation procedure allows for bank inefficiencies to have a half-normal distribution that is independently but not identically distributed over different banks. The mean of the inefficiency term is then modelled as a linear function of a set of explanatory variables. As in Battese and Coelli (1995), the inefficiency, u_{ist}, can be formulated as:

$$u_{it}=\xi_i Z_{it}+w_{it} \qquad (6)$$

where w_{it} is assumed to be truncated normally distributed, with zero mean and variance σ^2_u, ξ is a vector of coefficients to be estimated, and Z is a vector of country-level factors.

4. Dataset and variable definition

Our data comprise of banks in ten Central and Eastern European countries, namely Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia, that are listed in the IBCA-Bankscope database[7] for the period 1998 to 2003[8]. We confine our analysis to banks that report positive equity capital. After reviewing the data for reporting errors and other inconsistencies, we result in an unbalanced panel of 871 observations, which includes a total of 186 different banks. Our sample is quite extensive and covers most important banks in each country, as defined by their balance sheet aggregates. Table 2 presents the number of banks by year and country[9].

(Insert Table 2 about here)

A variety of approaches have been proposed in the literature for the definition of bank inputs and outputs, i.e. the production, the intermediation, the asset, the value-added and the user-cost approach; yet, there is little agreement among economists, mainly as a result of the nature and functions of financial intermediaries. Berger and

[7] This database reports published financial statements from financial institutions worldwide, homogenized into a global format, which are comparable across countries and therefore suitable for a cross-country study. However, all countries suffer from the same survival bias.

[8] Bulgaria was excluded of the sample, as the Bankscope database did not report sufficient data for personnel expenses for this country.

[9] The additions to the sample are not necessarily new market entrants, but rather successful banks that are added to the database over time. Exits from the sample are due primarily to either bank failures or mergers with other banks.

Humphrey (1992, 1997) reviewed financial institution efficiency studies and the various methods used to define inputs and outputs in financial services.

Taking into account the advantages and disadvantages of each method, in this paper, we employ the value-added approach, which identifies any balance sheet item as an output if it absorbs a relevant share of capital and labour. According to this approach borrowed funds are considered as an output since they imply the creation of value added, as they are associated with a substantial amount of liquidity, safekeeping, and payments services provided to depositors. Particularly, we specify two inputs, labour and physical capital, and three outputs, net loans, other earning assets and borrowed funds. Due to lack of data on the number of employees, labour is measured by personnel expenses, while physical capital is defined as bank's fixed assets. Loans are expressed as total loans net of provisions.

Another aspect of efficiency measurement is the treatment of financial capital, which accounts for different risk preferences on the part of banks. Apart from the regulation environment, which requires banks to maintain minimum amounts of equity capital, some banks may be more risk averse than others and may hold a higher level of financial capital[10]. If financial capital is ignored, the efficiency of these banks would be mismeasured, even though they are behaving optimally given their risk preferences. In an analysis of bank profit efficiency, Färe et al. (2004) found that using bank equity capital as a quasi-fixed input is sufficient to account for both risk-based capital requirements and the risk-return trade-off that bank owners face. We follow the work of Färe et al. (2004) and include equity capital as a quasi-fixed input in estimating the directional distance function.

[10] Hughes, Lang, Mester, and Moon (1995, 1996a, b) and Hughes and Moon (1995) tested and rejected the assumption of risk neutrality for banks.

To allow for the effect of country features on banking technology, we include several country-level variables in the estimation of the directional distance function, which may be associated with the variations of inefficiency measures across banks and may affect incentives and/or managerial selection. These variables include the five-firm concentration ratio (CR5), the EBRD index of banking reform, the ratio of non-performing loans to total loans, the assets share of foreign-owned banks as a percentage of total banking assets, the capitalization ratio and the interest rate spread. More specifically, asset market concentration can have either a positive or a negative impact on efficiency. If market concentration reflects market power for some banks, it may increase the costs for the sector through slack and inefficiency. However, if concentration of the market reflects market selection and consolidation through survival of more efficient banks, market concentration would be associated with higher efficiency provided that the markets remain contestable.

To allow for variation in sector banking reform and institutional developments across countries we also included an index of banking sector reform published in the EBRD Transition Reports, which is expected to exert a positive impact on banking efficiency. Moreover, the share of foreign bank assets to total bank assets provides a proxy measure for the intensity of competition associated with foreign entry in the banking markets of the region and is expected to be positively associated with the efficiency of banking institutions, as foreign banks usually contribute to an improvement of the risk profile, reputation, corporate governance and risk management of local banks. To proxy for regulatory conditions, we also define an average capital ratio, measured by equity over total assets. Usually, a lower capital ratio leads to lower efficiency levels because less equity implies higher risk taken at greater leverage, which normally results in greater borrowing costs. Finally, the ratio

of non-performing loans is used to control for differences in banks' loan quality, while the interest rate spread is a proxy for competition for banking services.

Table 3 provides some descriptive statistics for the overall sample and by country over the period 1998-2003. Comparing the mean values across countries, we can observe significant variations regarding output and input prices, as well as other control variables.

(Insert Table 3 about here)

Latvia has the smallest banking system in the region and presents the lowest mean values of labour, physical capital, equity loans other earning assets and deposits (all expressed in millions of euros). On the other hand, the banking systems of the Czech Republic and Poland are the largest in our sample, as it is indicated by the mean values of bank inputs and outputs.

Regarding the various control variables we use in our analysis, we observe that Hungary is the only country which has achieved a score of 4 for the EBRD Index of banking reform, while the majority of the countries cluster around 3.3. Estonia has the highest concentration ratio, as the largest five firms control almost the entire banking system and are in the hands of foreign investors. On the other hand, foreign ownership is very limited in Slovenia, which presents an average asset share of foreign ownership in banks total assets of 17.8 per cent. The non-performing loan ratio also exhibits high variation across countries, ranging from 1.6 per cent in Estonia to 22.2 per cent in Slovakia. All banking systems appear to be well capitalized with capitalization ratios above 14 percent with the only exceptions being Poland and Slovenia with ratios of 13.4 and 12.8 per cent, respectively. Finally, the interest rate spread, which is a proxy for bank competition, ranges from 2.4 per cent in the Czech Republic to 17.7 per cent in Romania.

5. Empirical results

5.1 Stochastic directional distance function estimates

Table 4 presents the estimated parameters for the stochastic directional distance function described above. For the estimation, one of the inputs, *labour*, is selected as the dependent variable and as the variable of normalization for the other inputs and outputs.

(Insert table 4 about here)

As can be observed in Table 4, most of the maximum likelihood coefficients are accurately estimated. Technical inefficiency is correctly identified within the composed error term; the likelihood ratio test on the one-sided error is highly significant, the share of technical inefficiency in total variance is high ($\gamma = 0.850$), and the expected mean efficiency, $E[\exp(-u) |\varepsilon]$, is equal to 0.870. A look at the production parameters in Table 4 indicates that the first order coefficients on inputs have the expected values regarding economic behaviour.

Regarding the efficiency correlates, we observe several interesting findings. The five-firm concentration ratio (CR5) appears to be negatively associated with inefficiency, suggesting that banks in more concentrated markets operate more efficiently. This can be partly explained by the fact the concentration does not necessarily reflect lower competition, but rather reflects market selection and consolidation through survival or more efficient banks, which is probably the case in all CEE countries, which have rather concentrated banking systems, though not less competitive ones.

Moreover, we observe a statistically significant positive relationship between inefficiency and the ratio of non-performing loans, which is consistent with the ‘bad

management' or the 'bad luck' hypothesis, developed by Berger and DeYoung (1997). Under the 'bad management' hypothesis, loan quality is endogenous in the quality of bank management, indicating that managers, who are poor at dealing with day-to-day operations, are also poor at managing the bank's loan portfolio. An alternative explanation for the positive relationship between problem loans and inefficiency can also be explained by the 'bad luck' hypothesis, which assumes that an exogenous increase in nonperforming loans may force even the most efficient bank to purchase additional inputs necessary to administer these problematic credits.

On the other hand, the capitalization ratio appears to be negatively related to inefficiency, suggesting that to the extent that well-capitalized banks reflect both high quality management and aversion to risk-taking, these banks are likely to be more efficient in producing bank output. Moreover, under the 'moral hazard' hypothesis, the higher the degree to which shareholders have their own capital at risk, the more incentives they have to monitor management and assure that the institution operates efficiently (Eisenbeis et al., 1999).

Regarding the interest rate spread ratio, which is often used as a proxy for banking efficiency, it has the expected positive coefficient, suggesting that a higher interest rate spread raises the costs of financial intermediation, and thus reduces the efficiency of the banking system. Surprisingly, the asset share of foreign-owned banks in total banking assets appears to be positively related to inefficiency, while the EBRD index for banking reform does not appear to be significantly associated with banking efficiency.

5.2 Luenberger Productivity Indicator

Table 5 presents the estimates of productivity growth (L) for a panel of banks from all CEE countries and its decomposition into the sum of efficiency change (LEC) and technical change (LTC), while technical change is further decomposed into output-based technical change (LOBTC), input-based technical change (LIBTC) and neutral magnitude technical change (LMATC). As we have already mentioned, when all banks are evaluated for a common directional vector, industry inefficiency equals the sum of the directional distance functions for the firms in the industry (Färe and Grosskopf, 2004). Thus, the presented indicators are the sum of the directional distance functions for all banking institutions that operated in all 10 CEE countries during each period.

(Insert table 5 about here)

As we can see from the table, during the initial years of our sample, that is 1998-1999 and 1999-2000, we observe an overall decline in productivity for the CEE-10 banking market, which is attributed to a decline in both efficiency and technical change. The decline in productivity is much higher during 1998-1999, probably due to the fact that banking reforms had not been completed in many countries under investigation, and that several banking systems were affected by the Russian crisis. The picture is reversed when we look at the Luenberger productivity indicator for the period 2000-2001. Productivity growth is positive, boosted by an improvement in both efficiency and technical change. The improvement of technical change comes mainly from an enhancement of input-based technical change, suggesting that banks have managed to use their inputs more efficiently. However, during the period 2001-2002 the Luenberger indicator becomes negative, suggesting a slight decrease in productivity, due to a deterioration in banks' efficiency. Technical change remains positive, though it cannot offset the negative impact of the decrease in efficiency.

Finally, during 2002-2003 we observe a clear improvement in banks' productivity, as both efficiency and technical change reach their highest values. This might be the effect of completion of banking reforms in most countries and of the intensifying efforts of banking institutions to enhance their performance in light of the accession to the EU and the increasing competition they would have to face in the Single Market for financial services.

Table 6 presents the Luenberger productivity indicator for each individual CEE country, and can give us a more detailed picture regarding differences in productivity growth between countries over the years.

(Insert table 6 about here)

Overall, we observe different patterns in productivity growth across countries. Romania exhibits a decline in productivity over the entire period under investigation, as it is one of the countries that delayed banking reforms, and has been hit by severe banking crisis, even in the late 1990s, which have affected the efficiency of the banking industry. The Romanian banking sector is characterized by a significant share of state-ownership, as the state has only recently started to withdraw from the banking industry, by severe loan quality problems, and by a very low level of financial intermediation, even when compared with other to other CEE countries. All of the above can be considered as possible reasons for the decline in productivity over the years. Nevertheless, the problems surrounding the Romanian banking institutions cannot be viewed in isolation from the difficulties facing the enterprise sector, which still operates to a great extent under soft budget constraints, which in turn significantly delays the recovery of the banking sector.

Latvia also exhibits a steady decline in productivity during the examined period. This could be explained by the fact that Latvia was one of the countries that

probably faced the most difficult starting conditions among the newly emerging democracies in Central and Eastern Europe, and was particularly affected by the Russian crisis in 1997-1998 both directly, as many companies encountered serious repayment difficulties, and indirectly, following investors' loss of confidence in emerging markets. Moreover, Latvia lags behind in terms of foreign ownership, as the market share of foreign banks is just somewhat over one-half of total banking assets, and was also one of the very few countries with a significant share of state-ownership in the banking sector until recently.

The banking sector of Slovakia also faced a decline in productivity during the examined period. For many years the development of the Slovak banking sector reflected the generally uncertain macroeconomic environment, and only after the year 1999 was a comprehensive consolidation and privatization program initiated. Apparently the profitability of Slovak credit institutions has been and is still strongly affected by the ongoing restructuring efforts in the sector and the relatively high ratio of non-performing loans, and thus, there remains a lot of work to be done to improve the efficiency of the Slovak banks, as it is also pointed out by the Luenberger indicator.

On the other hand, Poland and Hungary, which are considered to be part of the most advanced group of transition economies and are among the swiftest reformers, exhibit a steady increase in productivity growth over the entire period. Productivity growth of the Polish banking system is mainly attributed to a positive technical change over the years, probably as a result of the technological spillover brought about by foreign investors, who dominate the industry. Nonetheless, in the context of the global economic downturn that also affected Poland's economy, banks felt the impact of recession both via weaker demand for banking services and indirectly via

the borrowers ability to repay a loan, which lead to a deterioration of their profitability during the last 3 years, as it is also indicated by a negative efficiency change, which was though offset by the steady technological improvement. The Hungarian banking sector, also exhibits an increase in productivity growth over the years (with the exception of the years 1998-1999), attributed to a positive tend in both efficiency and technical change. This is consistent with the fact that Hungary's banking market is considered to be as one of the top performers in Central and Eastern Europe, as well as one of the most profitable and developed ones, and exhibits a high level of stability, which is due above all to the strong presence of foreign institutions since the early years of reform.

Regarding the remaining countries under investigation (Croatia, the Czech Republic, Estonia, Lithuania and Slovenia), they do not exhibit any clear pattern in productivity change over the years. The diverging trends across CEE banking markets over the examined period may reflect the different approaches that have been followed through the years and among countries in terms of the timing and the implementation of banking reforms. However, we can observe a clear improvement in productivity growth for the years 2002-2003 in all the above countries, suggesting that the prospect of EU accession has indeed lead to positive efficiency and technical changes in most banking systems.

5.3 Luenberger Productivity Indicator by type of ownership

The sparse, though growing, literature on bank efficiency in emerging and transition markets primarily concentrates on questions associated with ownership divisions. Thus, we also incorporate in our analysis information on the ownership

structure of each credit institution and estimate the Luenberger indicator for banks with different ownership status.[11]

Following Bonin et al. (2005), we divide banking institutions into four mutually exclusive and collectively exhaustive categories, namely, majority state-owned banks, majority domestic private ownership, strategic foreign ownership, and other foreign majority ownership.[12] Regarding banks having majority foreign ownership, we distinguish between those that have a single majority owner or a single controlling owner (which are defined as strategic foreign ownership), and those that the foreign owners together hold more than 50 per cent of the shares, although no one of these has a controlling stake (which are defined as other foreign majority ownership).

Table 7 presents the Luenberger productivity indicator and its decomposition into efficiency and technical change for banks with different type of ownership and reveals some interesting findings.

(Insert table 7 about here)

As we can see from the table, banks of all types of ownership experienced deterioration in their productivity in the first years of our examined period, which is

[11] As Bankscope database reports ownership information only for one year, and particularly for year 2003, we make the relatively restrictive assumption that the ownership status of each bank has remained unchanged during the examined period. However, as Bonin et al. (2005) argue *"former government-owned banks that are designated as foreign-owned banks in 2003 but were privatized after 1998 were being prepared for privatization during this period so that the ownership designation does not do serious injustice to the data"*.

[12] If the percentages in the data do not add to 100 per cent, we infer the characteristics of the remaining owners, as we are interested only in the type of majority owner. If there is no majority owner and the stakes do not add up to 100 per cent, we assume that there are unreported domestic private owners as long as some private ownership is indicated. If no private ownership is indicated, we attribute the residual to the largest category of owners reported. In this way, we allocate 100 per cent of the banks shares to foreign, government or private owners for each observation.

consistent with our previous results. Moreover, banking institutions with a foreign strategic investor appear to have achieved the highest productivity growth among all types of credit institutions. Except from the initial years of 1998-1999 and 1999-2000, foreign banks have managed to increase their productivity and to outperform both domestic and state-owned financial institutions. After 2000, technical change becomes positive and steadily increases in magnitude, while it is persistently higher than the respective indicator for banks of other types of ownership. Although, foreign banks experienced a negative efficiency change during the period 2001-2002, as was also the case for both state-owned and domestic private credit institutions, this trend was reversed in the following years with a substantial increase in their efficiency indicator. Overall, our findings suggest that banks with a strategic foreign owner outperform in terms of productivity both government and domestic private banks, which is consistent with the findings of most studies (i.e. Bonin et al., 2005; Fries and Taci, 2005; Grigorian and Manole, 2002; Yildirim and Philippatos, 2002).

Regarding domestic private banks, we observe a negative trend in productivity over the examined period (except for the years 1999-2000). This trend is mainly due to a negative technical change, though after 2001 efficiency also decreases. The decline in efficiency is also evident in the case of state-owned banks for the entire period under investigation. However, majority-government banks experienced a positive technical change all over the period, which can be attributed to the fact that most state-banks were prepared for privatization during this period and were restructured in order to attract foreign investors. Finally, banks with other foreign-ownership show very small changes in productivity. The Luenberger indicator for this type of banks increases over the period, though at a small pace, but decreases slightly for the years 2002-2003.

6. Conclusions

This paper investigates the efficiency and productivity growth of the banking industry in ten Central and Eastern European countries over the period 1998 to 2003 using a stochastic directional technology distance function. During this period, prior to the accession to the EU, a large process of restructuring in the financial systems took place that has increased competitive pressures and has brought the issue of efficiency and productivity in the forefront.

Looking at the pooled sample of all CEE countries, our results indicate that during the initial years of our sample, that is 1998-1999 and 1999-2000, there was an overall decline in productivity, which is attributed to a decline in both efficiency and technical change. However, this picture is reversed during 2002-2003, when in anticipation of the EU accession and due to the completion of reforms in most countries, both productivity and efficiency increased. The estimated productivity indicators for each country separately reveal different patterns in productivity growth across banking industries. While Romania, Latvia and Slovakia exhibit a clear downward trend in productivity over the examined period, the opposite holds for Poland and Hungary. These diverging trends across CEE banking markets over the examined period may reflect the different approaches that have been followed through the years and among countries in terms of the timing and the implementation of banking reforms.

Regarding the effect of ownership on efficiency, banking institutions with a foreign strategic investor appear to have achieved the highest productivity growth among all types of credit institutions, while on the other hand domestic private banks exhibit deterioration in their productivity over the years.

Overall, our results suggest that policy makers in these countries can draw some lessons from our conclusions and promote productivity by enhancing their efforts to reform the regulatory and supervisory framework and to complete the restructuring process. At the same time, banking markets should remain open and contestable, encouraging the entry of foreign banks.

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Table 1: Banking sector indicators

	Number of banks		Concentration		Credit to the private sector		EBRD banking index	
Country	**1998**	**2003**	**1998**	**2003**	**1998**	**2003**	**1998**	**2003**
Croatia	60	41	53	61	26.6	48.5	2.7	3.7
Czech Rep.	45	35	66	66	44.0	17.9	3.0	3.7
Estonia	6	7	100	99	24.3	33.7	3.3	3.7
Hungary	44	38	54	52	24.2	42.3	4.0	4.0
Latvia	27	23	61	63	13.9	38.8	2.7	3.7
Lithuania	12	13	90	82	9.3	19.9	3.0	3.0
Poland	83	58	45	52	17.5	17.8	3.3	3.3
Romania	36	30	67	63	11.6	9.5	2.3	2.7
Slovak Rep.	27	21	60	68	42.1	25.0	2.7	3.3
Slovenia	30	22	63	66	30.6	43.3	3.0	3.3

Note: The table reports the number of banks, the percentage share of the five largest banks, the domestic credit to the private sector (as a percentage of GDP), and the EBRD banking reform index for each of the 10 CEE countries for years 1998 and 2003. The number of credit institutions in each country includes the credit institutions under the law of that country, regardless of whether they are subsidiaries of foreign banks or not. Concentration in measured as the percentage share of the five largest banks, ranked by assets, in the sum of the assets of all banks in that particular banking market. The set of the five largest banks may vary over time. The EBRD banking reform indicator provides a ranking of progress for liberalization and institutional reform of the banking sector, on a scale of 1 to 4+. A score of 1 represents little change from a socialist banking system apart from the separation of the central bank and commercial banks, while a score of 4+ represents a level of reform that approximates the institutional standards and norms of an industrialized market economy. Sources: European Central Bank, 2005; European Bank for Reconstruction and Development, 2004.

Table 2: Number of banks by country and year

	Year					
Country	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Croatia	15	18	24	25	25	25
Czech Republic	12	16	18	20	21	19
Estonia	4	4	5	5	6	5
Hungary	8	10	10	13	16	15
Latvia	12	14	15	16	18	17
Lithuania	6	7	8	9	9	9
Poland	24	25	26	26	29	28
Romania	4	9	15	17	22	21
Slovakia	8	9	12	14	15	14
Slovenia	8	10	11	14	15	16
CEE-10	*101*	*122*	*144*	*159*	*176*	*169*

Source: Bankscope database

Table 3: Descriptive statistics

Country	Croatia	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovakia	Slovenia	*CEE-10*
Inputs											
Labour (x1)	12.1	33.9	17.8	33.9	4.9	9.8	61.4	20.1	13.5	19.8	26.4
	(23.5)	*(60.2)*	*(25.6)*	*(46.5)*	*(5.9)*	*(10.2)*	*(94.7)*	*(37.1)*	*(18.1)*	*(29.4)*	*(54.2)*
Physical Capital (x2)	14.9	48.4	20.0	40.6	5.0	17.4	35.3	44.8	31.0	22.0	29.0
	(37.9)	*(103.6)*	*(23.2)*	*(63.4)*	*(6.9)*	*(18.7)*	*(62.8)*	*(92.0)*	*(39.5)*	*(36.2)*	*(62.2)*
Quasi-fixed input											
Equity (x3)	57.6	177.0	111.8	145.5	19.8	37.6	240.6	76.6	74.5	97.0	116.0
	(101.5)	*(262.1)*	*(162.1)*	*(167.9)*	*(28.2)*	*(52.3)*	*(338.7)*	*(159.8)*	*(92.8)*	*(120.9)*	*(209.6)*
Outputs											
Loans (y1)	380.4	1,131.0	723.3	1,220.8	135.0	241.9	1,555.1	225.4	457.5	657.9	746.5
	(690.3)	*(1,735.6)*	*(1,090)*	*(1,405.5)*	*(227.7)*	*(342.3)*	*(2,152.9)*	*(402.5)*	*(506.9)*	*(943.5)*	*(1,363.5)*
Other earning assets (y2)	341.4	1,840.7	310.1	890.2	123.1	143.7	1,402.9	316.4	652.4	534.3	766.4
	(663.4)	*(2,994.5)*	*(488.4)*	*(1,269.8)*	*(154.6)*	*(186.1)*	*(2,265)*	*(598)*	*(968.2)*	*(810.9)*	*(1,651.2)*
Deposits (y3)	598.0	2,673.7	896.7	1,857.6	246.2	392.6	2,725.8	503.8	1,053.0	1,057.4	1,369.3
	(1,138)	*(4,294.6)*	*(1,334.7)*	*(2,242.8)*	*(325.4)*	*(506.5)*	*(4,178.2)*	*(893.5)*	*(1,301.7)*	*(1,545.9)*	*(2,724.0)*
Control variables											
CR5	59.5	65.5	99.0	54.0	62.8	86.5	49.8	64.5	64.4	65.7	62.6
	(2.8)	*(0.6)*	*(0.1)*	*(1.4)*	*(1.5)*	*(3.5)*	*(4.2)*	*(1.7)*	*(3.1)*	*(2.3)*	*(11.1)*
EBRD Index (banking)	3.3	3.5	3.6	4.0	3.3	3.0	3.3	2.7	3.1	3.3	3.3
	(0.3)	*(0.3)*	*(0.1)*	*(0.0)*	*(0.4)*	*(0.0)*	*(0.0)*	*(0.1)*	*(0.3)*	*(0.1)*	*(0.4)*
Non-performing loan ratio	14.7	15.0	1.6	4.3	4.0	8.1	19.3	8.5	22.2	9.6	12.3
	(4.2)	*(7.2)*	*(1.2)*	*(1.5)*	*(2.1)*	*(3.6)*	*(4.9)*	*(14.8)*	*(11.5)*	*(0.3)*	*(9.3)*
Asset share of foreign-owned banks	72.7	73.2	95.8	75.9	62.1	69.7	57.1	52.9	71.7	17.8	62.9
	(29.1)	*(29.1)*	*(3.7)*	*(10.2)*	*(6.5)*	*(19.7)*	*(18.8)*	*(8.0)*	*(27.7)*	*(6.0)*	*(26.0)*
Capitalization ratio	17.9	14.3	15.0	14.6	14.2	16.5	13.4	22.9	17.0	12.8	15.8
	(2.7)	*(1.0)*	*(1.2)*	*(1.2)*	*(1.8)*	*(3.1)*	*(1.0)*	*(4.5)*	*(5.3)*	*(1.4)*	*(3.9)*
Interest rate spread	9.4	2.4	4.9	3.1	5.4	7.3	7.8	17.7	5.0	6.0	7.2
	(1.7)	*(0.4)*	*(2.1)*	*(0.5)*	*(3.0)*	*(1.4)*	*(0.5)*	*(2.3)*	*(0.6)*	*(1.1)*	*(4.4)*

Note: The table presents mean values and standard deviations in parentheses. All inputs, quasi-fixed inputs and outputs are expressed in million euros (€). Labor is measured by personnel expenses, as data for the number of employees was unavailable; physical capital is defined as fixed assets; loans are defined as total loans net of provisions. All control variables are in percentages (except from the EBRD Index for banking reform, which ranges from 1 to 4 and CR5, which is defined as the sum of market share of the five largest banks in terms of total assets).

Table 4: Stochastic Frontier Estimates

	Variables		*coefficient*	*t-ratio*
	Intercept	α_0	0.03391	2.13
Inputs	x_1	α_1	<u>0.22475</u>	
	x_2	α_2	0.26832	9.73
	x_3	α_3	-0.00426	-0.15
	x_1^2	α_{11}	<u>0.02173</u>	
	x_2^2	α_{22}	-0.24313	-11.86
	x_3^2	α_{33}	-0.03762	-1.98
	x_1x_2	α_{12}	<u>0.09189</u>	
	x_2x_3	α_{23}	0.15124	10.80
	x_1x_3	α_{13}	<u>-0.11362</u>	
Outputs	y_1	β_1	-0.34883	-4.00
	y_2	β_2	-0.40912	-3.53
	y_3	β_3	0.24675	1.26
	y_1^2	β_{11}	0.34166	1.91
	y_2^2	β_{22}	0.53423	2.09
	y_3^2	β_{33}	1.54450	2.00
	y_1y_2	β_{12}	0.33460	1.66
	y_1y_3	β_{13}	-0.68267	-1.87
	y_2y_3	β_{23}	-0.85810	-1.96
Inputs-outputs	y_1x_1	γ_{11}	<u>0.15602</u>	
	y_1x_2	γ_{12}	0.04177	1.25
	$y1x_3$	γ_{13}	-0.17303	-3.20
	y_2x_1	γ_{21}	<u>0.06512</u>	
	y_2x_2	γ_{22}	0.04662	1.02
	y_2x_3	γ_{23}	-0.11174	-1.83
	y_3x_1	γ_{31}	<u>-0.22114</u>	
	y_3x_2	γ_{32}	-0.06245	-0.84
	y_3x_3	γ_{33}	0.28359	2.57
Technical change	t	δ_1	0.00294	0.32
	t^2	δ_2	0.00036	0.14
	tx_1	ψ_1	<u>0.01453</u>	
	tx_2	ψ_2	-0.06363	-10.00
	tx_3	ψ_3	0.04910	7.34
	ty_1	μ_1	0.04113	2.16
	ty_2	μ_2	0.05999	2.37
	ty_3	μ_3	-0.09640	-2.26
Zs	CR5	ξ_1	-0.01861	-7.18
	EBRD Index	ξ_2	0.01338	0.73
	NPL ratio	ξ_3	0.00471	5.06
	Share of foreign-owned banks	ξ_4	0.00234	4.80
	Capitalization	ξ_5	-0.01293	-4.40
	Interest spread	ξ_6	0.06731	10.30
Other ML parameters		σ^2	0.03936	11.66
		γ	0.92685	110.82

Notes: Underlined parameters are calculated by applying the translation property; number of observations 871; Log-likelihood function= 957.25; LR (χ^2) test on one-sided error= 251.69; E[exp(-u) |ε]= 0.870.

Table 5: Decomposition of the Luenberger Productivity Indicator

Years	I	Luenberger Indicator	LEC	LTC	LOBTC	LIBTC	LMATC
1998-1999	98	-1.042	-0.425	-0.618	0.066	0.048	-0.732
1999-2000	117	-0.463	-0.081	-0.382	0.088	0.211	-0.681
2000-2001	136	1.024	0.432	0.593	-0.005	0.509	0.089
2001-2002	157	-0.384	-1.918	1.535	0.152	0.226	1.157
2002-2003	166	2.799	0.892	1.907	-0.015	0.143	1.779

Note: Industry Luenberger Indicator = $\sum_{i=1}^{I} D_T^i(x_i, y_i; g_x, g_y)$, LEC = efficiency change, LTC = technical change, LOBTC = output-based technical change, LIBTC = input-based technical change, LMATC = neutral magnitude technical change. I = number of banks used to calculate index.

Table 6: Decomposition of the Luenberger Productivity Indicator by country

Years		Croatia	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Romania	Slovakia	Slovenia
1998-1999	L	0.050	-0.442	0.124	-0.126	-0.122	-0.278	0.131	-0.112	-0.102	-0.165
	LEC	0.111	-0.318	0.141	-0.046	-0.007	-0.185	-0.050	-0.006	0.069	-0.134
	LTC	-0.061	-0.124	-0.017	-0.081	-0.116	-0.092	0.181	-0.106	-0.171	-0.031
1999-2000	L	0.049	-0.153	0.065	0.038	-0.111	-0.416	0.448	-0.179	-0.177	-0.028
	LEC	0.125	-0.188	0.070	0.067	0.022	-0.311	0.068	0.049	0.003	0.016
	LTC	-0.075	0.035	-0.005	-0.029	-0.133	-0.104	0.380	-0.228	-0.180	-0.043
2000-2001	L	-0.054	0.163	-0.038	0.193	-0.013	0.132	0.948	-0.012	-0.098	-0.198
	LEC	0.036	0.000	-0.047	0.147	0.090	0.218	-0.052	0.180	0.046	-0.188
	LTC	-0.090	0.163	0.009	0.046	-0.103	-0.086	1.001	-0.192	-0.144	-0.010
2001-2002	L	-0.621	-0.239	0.049	0.209	-0.057	-0.386	0.873	-0.206	-0.116	0.111
	LEC	-0.614	-0.637	-0.005	0.052	0.037	-0.303	-0.477	0.050	-0.055	0.032
	LTC	-0.007	0.397	0.054	0.157	-0.095	-0.083	1.350	-0.256	-0.061	0.079
2002-2003	L	0.606	0.638	0.090	0.439	-0.130	0.295	0.832	-0.066	-0.036	0.131
	LEC	0.509	0.120	-0.010	0.199	-0.052	0.379	-0.324	0.151	-0.051	-0.029
	LTC	0.097	0.518	0.099	0.240	-0.078	-0.084	1.156	-0.217	0.015	0.160

Note: Industry Luenberger Indicator (L) = $\sum_{i=1}^{I} \overrightarrow{D}_T^i(x_i, y_i; g_x, g_y)$, where I= number of banks in each country, LEC=efficiency change, LTC=technical change.

Table 7: Decomposition of the Luenberger Productivity Indicator by ownership type

Years		Government	Domestic private	Strategic foreign	Other foreign
1998-1999	L	-0.018	-0.091	-0.914	-0.020
	LEC	-0.043	0.080	-0.471	0.008
	LTC	0.025	-0.172	-0.443	-0.028
1999-2000	L	-0.015	0.337	-0.792	0.007
	LEC	-0.091	0.528	-0.527	0.010
	LTC	0.077	-0.191	-0.265	-0.003
2000-2001	L	0.055	-0.024	0.964	0.029
	LEC	-0.089	0.205	0.305	0.010
	LTC	0.144	-0.229	0.659	0.018
2001-2002	L	0.114	-1.017	0.505	0.013
	LEC	-0.194	-0.877	-0.801	-0.046
	LTC	0.308	-0.140	1.306	0.059
2002-2003	L	0.187	-0.594	3.209	-0.003
	LEC	-0.275	-0.504	1.708	-0.037
	LTC	0.462	-0.090	1.500	0.034

Note: Industry Luenberger Indicator (L) = $\sum_{i=1}^{I} \vec{D}_T^{\,i}(x_i, y_i; g_x, g_y)$, where I= number of banks in each ownership category, LEC=efficiency change, LTC=technical change.