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Banking Inefficiency in Central and Eastern European countries under a Quadratic Loss Function

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Abstract

This paper employs a specification of a quadratic loss function based on forward-looking rational expectations to model the underlying dynamics of efficiency scores in the banking industry of eleven Central and Eastern European countries over the period 1998-2005. Results show that there is considerable variation in the adjustment speed to the long run equilibrium across banking systems and over time, while it also appears that the recent accession to the EU has not led to the expected increase in the speed of adjustment to the long run equilibrium. Moreover, banks' ownership structure appears to assert an influence on the speed at which credit institutions correct their past-period inefficiency.

JEL Classification: D24; G21; L25

Keywords: Speed of adjustment, long run equilibrium, rational expectations, banking inefficiency.

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1. Introduction

Central and Eastern European (CEE) countries have gone through significant economic and political transformations during the last decades, as they moved away from a centrally-planned economy to a relatively free-market system. The initial efforts of transformation to market economies were reinforced later on by the goal of membership in the European Union (EU). The transition process that was launched in March 1998, resulted to the enlarged union on 1 May, 2004, when eight Central and East European transition countries – the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia – joined the European Union, while Bulgaria and Romania joined the EU on 1 January, 2007, and Croatia has been granted the status of the candidate country and started accession negotiations with the EU since 2005.

In particular, a catching up process, characterized 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 a series of amendments to the banking supervision framework have been put in place in compliance with the EU regulatory system and the international standards of effective supervision. These laws have increased the attractiveness of the banking system to foreign investment, strengthened prudent standards and practices in the credit institutions' operations, enhanced corporate governance, and improved efficiency in banking operation and supervision.

Thus, the radical structural changes in the financial system, the catching up process with the EU, and the overall transition towards a market economy make the banking systems of these countries a distinct field of research. Indeed, a growing part of the more recent literature focuses on transition economies, while particular

attention has been given to the efficiency of financial institutions and specifically to the questions regarding the effect of ownership on performance in light of the increasing presence of foreign investors in the financial systems of transition economies (Grigorian and Manole, 2002; Green et al., 2004; Bonin et al., 2005; Fries and Taci, 2005; Carvallo and Kasman, 2005; Yildirim and Philippatos, 2007 etc.).

This paper departs from the traditional efficiency literature and applies a multi-period forward looking rational expectations specification so as to measure the speed of adjustment to the optimal efficiency level in 11 CEE countries, namely Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia, over the period 1998-2005. In detail, we opt for the stochastic frontier analysis within a translog cost function framework, so as to derive bank-specific inefficiency scores, while as a second step we apply a multi-period forward looking rational expectations specification to measure the speed of adjustment to the optimal cost level. In particular, using a dynamic panel model we opt for a quadratic loss function to account for adjustment costs between the current level of inefficiency and the optimal one. To this end, the adjustment of banks' costs is seen as a dynamic process based on rational expectations, and not as a static procedure. This idea first came up in the literature of aggregate demand (Cuthbertson and Taylor 1990; Mizen 1994), while Huang and Chen (2006) follow a similar methodology in banking. One of main finding of the paper is the estimated different pace of banking adjustment across countries, providing some insights over the consequences of the various degrees of competition in the banking industries of the CEE countries.

The rest of the paper is organized as follows. Section 2 presents the theoretical specification, while Section 3 describes the data used in the analysis. Our main

findings are presented in Section 4, while some conclusions are offered in the final section.

2. A theoretical specification - the efficiency scores under a quadratic loss function

Our analysis of the dynamics of efficiency scores in the banking industry is based on a forward-looking rational expectations specification similar to the one found in the optimal money demand literature (see Cuthbertson and Taylor 1990; Mizen 1994; Huang and Shen 2002). According to this approach the typical bank is assumed to minimize the conditional expectation of a discounted quadratic loss function (L). This objective function takes the form:

$$L = E_t \left\{ \sum_{i=1}^n D^i \left[\gamma_1 (InC_{t+i} - InC_{t+i}^*)^2 + \gamma_2 (InC_{t+i} - InC_{t+i-1})^2 \right] \right\}, \quad (4)$$

where E_t is the conditional expectations operator on the information set at time t , D denotes a discount factor less than unity, and γ_i ($i=1, 2$) are the non-negative adjustment cost coefficients. More specifically, γ_1 represents the disequilibrium parameter, measuring the deviation of actual costs InC_{t+i} at time $t+i$ from its optimal (long-run equilibrium) value InC_{t+i}^* , while γ_2 counts for the short-run adjustment (transaction) between any two consecutive periods.

Taking a partial derivative of equation (4) with respect to InC_{t+i} and rearranging gives the following equation for operational costs:

$$InC_t = \lambda InC_{t-1} + (1-\lambda)(1-D\lambda) \sum_{i=1}^n (D\lambda)^j E_t(InC_{t+i}^*), \quad (5)$$

where λ is the stable root of the Euler equation and its value lies between zero and one.

We assume that InC_t^* approximates the functional form of the desired minimum inefficiency. Here, we assume that this functional form follows a simple stochastic process:

$$InC_t^* = \zeta InC_{t-1}^* + \varepsilon_t, \quad (6)$$

where ε_t is white noise.

The reduced form cost equation on the basis of (5) and (6) can then be expressed as:

$$InC_t = InC_t^* + \lambda InC_{t-1}^* + \varepsilon_t, \quad (7)$$

where InC_t^* is function of D , γ , and the parameter ζ of equation (6).

The above equation shows the identification of the underlying dynamic effect as measured by λ . In detail, λ captures the persistence of inefficiency scores over time, whilst $1-\lambda$ reflects the adjustment speed to equilibrium. The values of λ range between zero and unity. The higher the value of λ the longer the suboptimal inefficiency level persists, resulting in slower adjustment to the optimal cost level. A firm having a zero value of λ means that it could correct its past-period inefficiency instantly, while a unit value of λ corresponds to a bank that never adjusts its past-period inefficiency.

3. Data description

Our data comprises commercial, savings and cooperative banks in eleven Central and Eastern European countries, namely Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia that are listed in the IBCA-Bankscope database over the period 1998 to 2005. We confine our analysis to credit institutions that report positive equity capital. After reviewing the data for reporting errors and other inconsistencies, we obtain an

unbalanced panel dataset of 1402 observations, which includes a total of 240 different banks. As a result, our sample is quite extensive and covers the largest credit institutions in each country, as defined by their balance sheet aggregates.¹

For the definition of inputs and outputs in the stochastic frontier model, we follow the work of [Sturm and Williams \(2004\)](#) and assume that interest income and non-interest income are produced from financial capital and non-financial inputs. The price of financial capital is defined as the interest paid on funds divided by total funds, while the price of non-financial inputs is the ratio of operating (i.e. non-interest) expenses to assets.² Also, to capture capitalization and insolvency risk, we specify equity as a fixed netput. The issue of insolvency risk is of particular importance for transition economies due to the high proportion of non-performing loans in their credit portfolios. Total cost is defined as the sum of overheads (personnel and administrative expenses), interest, fee, and commission expenses.

To allow for the effect of country features on bank's underlying technology, we also include country-level variables in the estimation of the stochastic frontier, which may be associated with the variations of inefficiency measures across banks and may affect incentives and managerial decisions. In other words, by introducing country-specific variables in the estimated cost frontier, we are able to attribute differences in banking sectors across countries to the characteristics of the operating environment that are beyond the control of bank managers, thus effectively conditioning the frontier of the banking sector in each country in a way that is

¹ The year and number of included banks are: 1998-110, 1999-138, 2000-163, 2001-171, 2002-193, 2003-205, 2004-230, and 2005-192. 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.

² Due to the unavailability of firm-level data for personnel expenses, we use a broad measure for the price of non-financial inputs (labor and physical capital), that is the ratio of operating (i.e. non-interest) expenses to assets (see also Hasan and Marton, 2003; Fries and Taci, 2005; Bonin et al., 2005). According to Hasan and Marton (2003) one can assume that money spent on administrative expenses is, in some way, an indirect benefit to employees, and therefore, the whole non-interest expense can be a good substitute of employee benefits.

amenable for cross-country comparisons of bank performance. These variables include the five-firm concentration ratio, capturing asset market concentration, the EBRD index of banking reform, that allows for variation in banking reform and institutional developments across countries, and the ratio of non-performing loans to total loans to control for differences in banks' loan quality.³

(Please insert Table 1 about here)

Descriptive statistics for the pooled sample of banks are provided in Table 1. Comparing mean values across countries, we can observe significant variations regarding total cost, outputs and input prices, as well as country-level variables. In particular, the average cost to assets ratio for all CEE countries stands at 8.33 percent, ranging from 5.75 percent in Latvia to 13.92 percent in Romania. The still higher cost ratio of CEE banks compared to the EU level suggests that there is room for improvement and catching up in terms of cost efficiency. Moreover, the average interest income to assets ratio is 7.73 percent, fluctuating from 4.89 in Latvia to 12.89 in Romania. On the other hand, the average ratio of non-interest income is much lower and stands at 1.68 percent, ranging from 1.05 in Slovakia to 2.68 in Romania. This suggests that interest income comprises the main source of banks' revenues in CEE countries, whereas non-interest income lags far below the EU average. Regarding input prices, the price of financial capital stands at an average of 5.01, ranging from 2.33 in Latvia to 8.06 in Romania, while the average price of the non-

³ 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; if concentration reflects consolidation through survival of more efficient banks and markets remain contestable, it would be associated with higher efficiency (see Demsetz, 1973). The EBRD index is expected to exert a positive impact on banking efficiency, as reforms may impose capital adequacy requirements and other prudential constraints on risk taking, which may strengthen the incentive for efficiency improvements (Fries and Taci, 2005). Finally, the relationship between cost efficiency and the ratio of non-performing loans can be either positive or negative according to the 'bad management', the 'bad luck' or the 'skimping' hypotheses (see Berger and DeYoung, 1997).

financial input is 4.45, and ranges from 2.85 in the Czech Republic to 6.79 in Romania.

The average capital ratio for the whole CEE region remains relatively high, as it stands at 13.49 percent, suggesting that banks have managed to expand their credit without impairing their capital positions, despite the higher lending growth rates observed in most CEE countries recently. A possible explanation could be that credit institutions in the CEE countries may intend for a higher-than-required capital adequacy ratio to signal their solvency and, thereby attract funds for their credit expansion (Fries and Taci, 2002). Overall, we also observe significant variation across countries as the equity ratio ranges from 9.66 percent in the Czech Republic to 19.35 percent in Romania.

Moreover, CEE countries exhibit a high average ratio of non-performing loans (NPL) as a result of the burden of bad loans they inherited from the past regime. The non-performing loan ratio exhibits high variation across countries, ranging 1.19 in Estonia to 18.50 in Poland. However, as per standard practice NPL figures should be treated with caution owing to the different reporting practices across countries. CEE countries' banking markets are also characterized by relatively high degree of concentration. On average, the largest five banks held 61.19 percent of total banking sector assets, ranging from 49.99 per cent in Poland to 98.84 percent in Estonia. Finally, 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.⁴ From the countries under review, only Hungary has

⁴ This indicator provides a ranking of progress in liberalization 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 industrialized market economy, as represented, for example, by the Basle Committee's Core Principles on Effective Banking Supervision and Regulation).

achieved the highest score, while Romania stands at the other end of the spectrum with an average EBRD index of 2.76.

4. Empirical Results

4.1. *Inefficiency scores*

As a first step we estimate the inefficiency scores for each country based on a common frontier with country-specific environmental variables. In particular, cost inefficiency scores have been obtained from a stochastic translog cost function defined as in Eq. (A2) in the Appendix, which includes output levels, input prices and country-specific environmental variables.⁵ The estimated scores of cost inefficiency per country and over time are presented in Diagram 1. The results suggest the presence of substantial inefficiency in all countries. Overall, the average inefficiency level for all CEE countries is estimated at 0.23, suggesting that the average bank in the region could reduce its costs up to 23% by moving closer to the efficient frontier. Estonia presents the lowest average inefficiency score, while Romania has the highest. The structural reforms towards a market-based economy that the Estonia's banking industry had undergone have undoubtedly benefited its efficiency level, while the increased competition due to the large number of foreign investors has further boosted its performance. Romania, on the other hand, is one of the countries that delayed banking reforms, while it was unfortunate to experience severe banking crises that was not able to weather off due to, among other reasons, lack of reforms. In addition, the private sector of the economy in general and the private banking industry in specific faces the adverse consequences of soft budget constraints of state owned

⁵ Parameter estimates of the translog cost frontier can be provided upon request.

enterprises. As a result, the performance of Romania's banking industry is the poorest of all in the sample.

(Please insert Diagram 1 about here)

Regarding the evolution of inefficiency scores over time, we observe different patterns across countries. The highest improvement in terms of efficiency is observed in Bulgaria, where inefficiency is reduced by 15 percentage points over the examined period. The serious banking and financial system crisis in 1996/1997 has clearly affected the efficiency of Bulgarian banks in 1998, which exhibit the highest level of inefficiency among all countries; however, the subsequent consistent restructuring and privatization of state-owned banks and the recovery of the Bulgarian banking market have resulted in a significant improvement in banking efficiency, placing Bulgaria credit institutions among the best-performers of the region. Hungary also exhibits a significant reduction in inefficiency over time by 10 percentage points, which is consistent with the restructuring and cost rationalisation process undergone the Hungarian banking system. Poland and Estonia exhibit upwards trends in inefficiency towards the end of the sample, while Czech Republic faced a similar trend early in the sample. Note that periods of deterioration in inefficiency are followed by periods of speedily corrective adjustment. Other countries, including Croatia, Romania and Slovenia present little variation in their average inefficiency levels over time. Overall, no clear common pattern of inefficiency is observable across countries. These diverging trends may reflect the different approaches that have been followed through the years and across countries in terms of the timing and the implementation of banking reforms.

4.2. *Speed of adjustment across countries*

Next, we employ the GMM estimator for dynamic panel data models proposed by Arellano and Bond (1991) so as to estimate Equation (4), which includes the lagged dependent variable (C_{it-1}) as an endogenous explanatory variable.⁶ Based on Arellano and Bond (1991), we take first difference of Equation (4) on both sides and remove in this way the firm-specific effects. The lagged dependent variables with two or more periods are likely to be valid instruments for the equation in the first differences, depending on whether disturbance ε_{it} is serially correlated.⁷

Table 3 presents the estimated results for our sample and reports some relevant diagnostic tests.⁸ In our first unrestricted model (Model A), we estimate a different persistent parameter λ for each country, in order to compare the speed of adjustment across banking markets. In effect, λ identifies the persistence to some specific level of inefficiency, whereas $1-\lambda$ captures the adjustment speed to the long-run level of inefficiency, the equilibrium level. λ takes values from 0 to 1, whereas the longer the current suboptimal inefficiency level persists the higher the value of λ .

As we can see from Table 3, the vast majority of the persistent parameters are statistically significant. Moreover, we observe a significant variation in the estimated coefficients of λ across countries. In particular, the estimates range between 0.084 in Poland to 0.388 in Lithuania, indicating that the adjustment speed lies between 0.612 and 0.916. In other words, the average sample bank is able to adjust its previous

⁶ The least squares estimator of the fixed effects or random effects models in the presence of a lagged dependent variable among the regressors is both biased and inconsistent (see for example, Baltagi, 2001).

⁷ The chosen instrumental variables include the dependent variable lagged six to last periods.

⁸ The models seems to fit the panel data reasonably well, as the Wald tests indicate fine goodness of fit, while the Sargan tests imply no evidence of over-identifying restrictions. Arellano and Bond (1991) tests for autocorrelation, AR(1) and AR(2), show some evidence of first-order autocorrelation. Note, however, that for the cases that the AR(1) test indicate some evidence of autocorrelation in models A and B, the AR(2) rejects the existence second-order autocorrelation, implying that the estimates are consistent (see Table 3).

period's inefficiency levels at the rate of around 61% in Lithuania to 92% in Poland per period.

(Please insert Table 3 about here)

In detail, Poland, Estonia and Hungary exhibit the highest adjustment speed across all countries. Given the relatively well-developed nature of the Polish banking industry, the dominance of foreign ownership in the Estonian financial system and the pioneering status of the Hungarian banking market in terms of early reforms and swift privatization successes that have led to a high level of stability, this result does not come as a surprise. On the other hand, the low speed of adjustment observed in the Lithuanian banking industry, which ranks at the bottom of our country-list, could be the result of delays in banking sector restructuring and privatization. Indeed, Lithuania is lagging behind its neighbour Baltic countries, Estonia and Latvia, both in terms of banking development and level of financial intermediation. Moreover, the consolidation phase in the wake of privatization of state-owned credit institutions that has already led to a drastic decrease in the number of bank branches and employees in Estonia and Latvia, is still underway in Lithuania and has only recently begun to pave the way for greater profitability and efficiency.

Slovenia and Romania also rank low in terms of the adjustment speed of their banking markets. Slovenia has the lowest presence of foreign ownership in its financial system, which could imply that the competition among credit institutions is lower than the other CEE countries; this, in turn, could explain the low adjustment speed of the banking sector. Similarly, Romania, as already mentioned, is one of the countries that have delayed banking reforms, while its banking industry is still characterized by a substantial level of state ownership. This could imply a lower level of competition and might explain why Romania has a much lower adjustment speed

than the other Balkan countries in our sample, i.e. Bulgaria and Croatia, which have been enjoying a greater success in recent years in their efforts to reform their banking sectors. Indeed, Bulgaria ranks relatively high in terms of adjustment speed, with λ estimates similar to those of Latvia and the Czech Republic.

For comparison purposes, we also estimate a restricted model by imposing the single adjustment speed restriction, i.e., letting $\lambda_c = \lambda$ for all countries. The single persistence parameter by Model B is found to be 0.244. However, this result must be treated with caution given that most of the country specific parameters in Model A are significant. Thus, the imposition of $\lambda_c = \lambda$ for all countries on Model B might appear too restrictive.

Overall, we observe significant differences in the adjustment speed across countries. The different speed of adjustment across banking systems could reflect differences in the degree of competition among banks and also in the different pace and progress of banking reforms that have been followed through the years and across countries. For instance, Poland, Estonia and Hungary, which are considered among the pioneering reformers in the CEE region, are also among the best-performers in terms of adjustment speed. On the other hand, our evidence suggests that there is significant room for improvement in Lithuania and Romania, which need to adopt the necessary measures to make their banking systems more competitive so as to adjust faster their inefficiency levels.

4.3. *Speed of adjustment over time*

As a next step in our analysis, we also investigated whether the adjustment speed changes over the examined period. In order to do so, we first split our sample into two sub-periods 1998-2001 and 2002-2005. The estimated results are presented

in Table 4.⁹ We observe that the persistent parameter λ is estimated at 0.186 for the sub-period 1998-2001, while it increases at 0.222 for the period 2002-2005. Our findings suggest that the adjustment speed has decreased between the two periods. A possible explanation could be that the first sub-period coincides with a phase of intense restructuring in most banking systems, swift privatizations of state-owned banks and increasing competition resulting from the entry of foreign investors in most financial sectors. These developments have clearly led to a higher adjustment speed for 1998-2001 compared to the next sub-period.

(Please insert Table 4 about here)

In order to shed more light into the evolution of the adjustment speed over time, we also estimate different persistent parameters for the sub-periods 1998-1999, 2000-2001, 2002-2003 and 2004-2005. Overall, we observe that the speed of adjustment does not follow a clear upward or downward pattern over time. In particular, the persistent parameter is estimated at 0.194 for 1998-1999, it increases slightly at 0.216 for the subsequent period (2000-2001), while it reaches its minimum value (0.169) in 2002-2003. However, this downward trend is fully reversed during the last sub-period, 2004-2005, when λ reaches its highest value (0.314). Note that the period 2004-2005 coincides with the accession of most countries under investigation to the European Union. In detail, a higher value of λ for the period 2004-2005 means that the speed of adjustment to the long-run efficiency level diminishes. As a result, it appears at a first sight that the accession to the EU, despite the improvement in financial integration, does not benefit their overall performance over time. Moreover, the transition period prior to the EU accession has led to a significant number of

⁹ Due to the small number of bank-year observations in some countries, we could not estimate separate persistent parameters for each banking industry for each sub-period. For this reason, we choose to estimate a common persistent parameter for all CEE countries for the sub-periods 1998-2001 and 2002-2005, while we also estimate a separate dynamic regression for the sub-periods 1998-1999, 2000-2001, 2002-2003 and 2004-2005.

reforms in the banking sector in the process of adopting the relevant EU directives, that could have forced banks to adjust in a timely manner their underlying structure so as to compete. In addition, the elimination of regulatory barriers to foreign entry that fostered the presence of foreign investors, mainly from old-EU countries, since the early stages of the transition period, led to the creation of a very competitive level playing field even prior to the EU accession; so, when the EU enlargement finally took place, it had a less than expected impact on competition, as foreign financial institutions had already established a dominant position in CEE markets. Finally, in the short run the EU accession has imposed an adjustment cost to CEE banks that is referred to a lower speed of adjustment.

4.4. Speed of adjustment based on ownership structure

The sparse, though growing, literature on bank efficiency in emerging and transition markets primarily concentrates on questions associated with ownership divisions. Thus, as a final step in this analysis, we incorporate in our study information on the ownership status of each bank and investigate the potential effect of ownership structure on the speed of adjustment of credit institutions. To this end, we divide banks into three distinct categories; namely, majority state-owned banks, domestic private ownership and majority foreign owned banks.^{10,11} The estimated results of the persistent parameter are presented in Table 5.

¹⁰ As the Bankscope database reports ownership information only for 2005, we assume that the ownership status of each bank has remained unchanged during the examined period. 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*”.

¹¹ 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.

(Please insert Table 5 about here)

We expect the participation of an international or a domestic institutional investor to have a positive impact on the speed of adjustment of credit institutions, as it facilitates the transfer of technology and know how to the newly privatized bank. Indeed, we observe that domestic private banks appear to have achieved the highest speed of adjustment, outperforming both state and foreign credit institutions. On the other hand, state-owned banks have the lowest speed of adjustment. This is not surprising given that government-owned credit institutions usually suffer from significant cost rigidities inherited from the ‘old regime’ and are not flexible in adjusting their cost base.

5. Conclusion

This paper contributes to the analysis of efficiency performance by employing a specification of a quadratic loss function based on forward-looking rational expectations to model the underlying dynamics of efficiency scores in the banking industry of 11 Central and Eastern European countries over the period 1998-2005. Our results indicate significant differences in the adjustment speed across countries, which could reflect differences in the degree of competition among banks and also in the different pace and progress of banking reforms that have been followed through the years and across countries. Moreover, our findings suggest that the speed of adjustment has decreased over time. Regarding the potential effect of ownership structure on the speed of adjustment of credit institutions, we observe that domestic private banks appear to outperform both foreign and state-owned credit institutions, with the latter ranking last in terms of pace of adjustment.

Overall, our analysis suggests that banks, on average, could accelerate further the pace of restructuring of their efficiency performance over time especially in light of the closer integration of the European markets as well as the ongoing global financial liberalization. In response to growing domestic and international competitive pressures, banks are bound to further enhance their performance by minimizing the costs of operations, employing optimal production plans, adopting new technologies, and reducing excess capacity through mergers. Since only the most efficient institutions will survive these challenges, the inefficient banks with a slow adjustment pace will either be acquired or eventually be driven out of market by the competition.

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Table 1: Descriptive Statistics

	C/A	y1/A	y2/A	p1	p2	n1/A	CR5	EBRD	NPL
Bulgaria	7.25 (2.90)	6.40 (2.59)	1.71 (0.95)	2.97 (3.29)	5.38 (2.42)	17.58 (12.53)	53.13 (3.65)	3.23 (0.36)	7.44 (4.34)
Croatia	7.53 (2.70)	7.32 (2.31)	1.84 (1.63)	4.65 (2.99)	4.39 (2.23)	14.91 (9.94)	60.97 (3.46)	3.51 (0.41)	12.78 (4.69)
Czech Republic	6.24 (4.91)	5.36 (3.29)	1.20 (0.97)	4.51 (5.06)	2.85 (2.02)	9.66 (9.89)	65.21 (0.73)	3.59 (0.24)	16.40 (14.51)
Estonia	6.97 (3.17)	5.86 (2.01)	1.56 (0.50)	3.34 (1.68)	4.34 (2.25)	12.50 (9.09)	98.84 (0.34)	3.74 (0.19)	1.19 (1.14)
Hungary	9.69 (4.16)	9.47 (4.42)	1.43 (0.86)	7.20 (4.22)	4.93 (3.09)	12.06 (8.17)	53.68 (1.27)	4.00 (0.00)	4.12 (1.39)
Latvia	5.75 (3.19)	4.89 (2.33)	2.05 (1.08)	2.33 (1.69)	3.78 (2.36)	11.36 (7.91)	63.59 (2.10)	3.45 (0.33)	2.56 (2.09)
Lithuania	7.12 (2.92)	5.17 (1.86)	1.77 (0.93)	2.73 (1.27)	4.98 (2.22)	13.23 (7.76)	84.40 (4.28)	3.20 (0.25)	6.01 (4.22)
Poland	9.15 (3.70)	8.94 (4.30)	1.40 (1.03)	6.18 (3.39)	4.24 (2.00)	13.02 (10.94)	49.99 (3.29)	3.38 (0.12)	18.50 (4.64)
Romania	13.92 (8.24)	12.89 (8.46)	2.68 (1.88)	8.06 (6.20)	6.79 (3.42)	19.35 (10.70)	62.77 (3.03)	2.76 (0.19)	10.73 (14.15)
Slovakia	7.54 (3.11)	7.14 (2.93)	1.05 (0.65)	4.99 (3.21)	3.28 (1.62)	9.80 (7.22)	65.06 (2.93)	3.26 (0.34)	18.10 (12.28)
Slovenia	6.80 (1.77)	6.82 (1.99)	1.48 (0.54)	4.63 (1.59)	3.07 (0.79)	9.80 (3.86)	64.91 (2.11)	3.29 (0.10)	8.89 (1.21)
CEE	8.33 (4.89)	7.73 (4.77)	1.68 (1.25)	5.01 (4.12)	4.45 (2.62)	13.49 (10.09)	61.19 (10.27)	3.39 (0.41)	10.70 (9.62)

Note: The table presents mean values and standard deviations in *parentheses*. C/A: total cost to assets; y₁/A: interest income to assets; y₂/A: non-interest income to assets; p₁: interest expenses/deposits & short-term funding; p₂: overheads/total assets; n₁/A: equity to assets; CR5: 5-firm concentration ratio, defined as the sum of market share of the five largest banks in terms of total assets; EBRD: the index of banking sector reform published in the EBRD Transition Reports; NPL: country-level ratio of non-performing loans to total loans. All outputs, quasi-fixed netputs and total cost are expressed as percentages of total assets. All control variables are in percentages (except for the EBRD Index for banking reform, which ranges from 1 to 4; a score of 1 represents little change other than 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 open market economy, as defined by the Basle Committee's Core Principles on Effective Banking Supervision and Regulation.).

Table 2: Average Inefficiency scores by country

Note: The above graphs present the average cost inefficiency scores for each country and their evolution over time, as derived from a common stochastic cost frontier, where Log likelihood function=-397.01; $\sigma_v^2=0.073$; $\sigma_u^2=0.084$; $\sigma_v=0.271$; $\sigma_u=0.289$; $\sigma=\text{Sqr}[\sigma_v^2 + \sigma_u^2]=0.396$. Mean inefficiency=0.23. Inefficiency is assumed to follow a half-normal distribution and ranges between zero and unity.

Table 3: Estimates of persistence parameter λ for each country

Model A (unrestricted model)	λ	Std. Err.
Bulgaria	0.137**	0.066
Croatia	0.236***	0.086
Czech Republic	0.131*	0.082
Estonia	0.088	0.144
Hungary	0.097*	0.055
Latvia	0.106	0.107
Lithuania	0.388***	0.103
Poland	0.084*	0.046
Romania	0.325***	0.070
Slovakia	0.207***	0.064
Slovenia	0.252***	0.054
Wald test ^a	$\chi^2(13) = 3763.03$	
Sargan test ^b	$\chi^2(20) = 97.11$	
AR(1) ^c	$z = -3.74 (0.000)$	
AR(2) ^d	$z = 0.84 (0.399)$	
Model B (restricted model)	λ	Std. Err.
all CEE	0.244***	0.031
Wald test ^a	$\chi^2(3) = 3547.6$	
Sargan test ^b	$\chi^2(20) = 112.62$	
AR(1) ^c	$z = -6.07 (0.000)$	
AR(2) ^d	$z = -0.85 (0.393)$	

Note: ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. Model A is the unrestricted model, with separate persistent parameters (λ) for each country; Model B is the restricted model, with a common persistent parameter for all CEE countries. The speed of adjustment is defined as $1-\lambda$.

^a: Wald statistic is a test for the joint significance of the independent variables asymptotically distributed as $\chi^2_{(k)}$ under the null hypothesis of no relationship, where K denotes the number of slope coefficients estimated.

^b: Sargan test is the test for over-identifying restrictions in GMM dynamic model estimation.

^c: Arellano-Bond test that average autocovariance in residuals of order 1 is 0 (H_0 : No autocorrelation). p-values in parentheses.

^d: Arellano-Bond test that average autocovariance in residuals of order 2 is 0 (H_0 : No autocorrelation). p-values in parentheses.

Table 4: Estimates of persistence parameter λ over time

Time period	1998-2001	2002-2005
λ	0.186***	0.222***
Std. Err.	0.058	0.033
Wald test ^a	$\chi^2(3) = 1984.48$	$\chi^2(3) = 1933.33$
Sargan test ^b	$\chi^2(10) = 58.33$	$\chi^2(10) = 65.78$
AR(1) ^c	z = -4.16 (0.000)	z = -3.71 (0.000)
AR(2) ^d	z = 0.34 (0.733)	z = -1.11 (0.269)

Time period	1998-1999	2000-2001	2002-2003	2004-2005
λ	0.194***	0.216*	0.164***	0.314***
Std. Err.	0.067	0.128	0.043	0.055
Wald test ^a	$\chi^2(3) = 1693.37$	$\chi^2(3) = 578.90$	$\chi^2(3) = 1142.92$	$\chi^2(3) = 764.28$
Sargan test ^b	$\chi^2(5) = 5.75$	$\chi^2(5) = 12.95$	$\chi^2(10) = 24.54$	$\chi^2(5) = 52.81$
AR(1) ^c	z = -2.15 (0.031)	z = -2.73 (0.006)	z = -1.62 (0.105)	z = -3.48 (0.000)
AR(2) ^d	z = 0.00 (0.999)	z =0.31 (0.756)	z = -2.31 (0.021)	z = 0.74 (0.459)

Note: *** and * indicate 1% and 10% significance levels, respectively. We estimated separate dynamic regressions for each sub-period and for each type of ownership. The speed of adjustment is defined as $1-\lambda$.

^a: Wald statistic is a test for the joint significance of the independent variables asymptotically distributed as $\chi^2_{(k)}$ under the null hypothesis of no relationship, where K denotes the number of slope coefficients estimated.

^b: Sargan test is the test for over-identifying restrictions in GMM dynamic model estimation.

^c: Arellano-Bond test that average autocovariance in residuals of order 1 is 0 (H_0 : No autocorrelation). p-values in parentheses.

^d: Arellano-Bond test that average autocovariance in residuals of order 2 is 0 (H_0 : No autocorrelation). p-values in parentheses.

Table 5: Estimates of persistence parameter λ by type of ownership

Ownership structure	state-ownership	domestic private	foreign ownership
λ	0.316***	0.209***	0.242***
Std. Err.	0.048	0.072	0.046
Wald test	$\chi^2(3) = 537.90$	$\chi^2(3) = 793.48$	$\chi^2(4) = 1791.83$
Sargan test	$\chi^2(20) = 31.95$	$\chi^2(20) = 47.66$	$\chi^2(12) = 108.68$
AR(1)	$z = -0.29 (0.768)$	$z = -3.64 (0.000)$	$z = -4.04 (0.000)$
AR(2)	$z = -0.82 (0.413)$	$z = 1.84 (0.066)$	$z = -1.37 (0.171)$

Note: *** indicates 1% significance level. We estimated separate dynamic regressions for each type of ownership. The speed of adjustment is defined as $1-\lambda$.

^a: Wald statistic is a test for the joint significance of the independent variables asymptotically distributed as $\chi^2_{(k)}$ under the null hypothesis of no relationship, where K denotes the number of slope coefficients estimated.

^b: Sargan test is the test for over-identifying restrictions in GMM dynamic model estimation.

^c: Arellano-Bond test that average autocovariance in residuals of order 1 is 0 (H_0 : No autocorrelation). p-values in parentheses.

^d: Arellano-Bond test that average autocovariance in residuals of order 2 is 0 (H_0 : No autocorrelation). p-values in parentheses.

APPENDIX

A. Estimating cost efficiency - the Stochastic Frontier Approach

We employ the stochastic frontier approach (SFA), as developed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977), to estimate cost inefficiency. According to the SFA, total cost assumes the following specification:

$$TC_{it} = f(P_{it}, Y_{it}, N_{it}, Z_{it}) + v_{it} + u_{it} \quad (A1)$$

where TC_{it} denotes observed total cost for bank i at year t , P is a vector of input prices, Y is a vector of outputs of the firm, N is a vector of fixed netputs and Z stands for a set of control variables. This approach disentangles the error term in two components. The first one, v_i , corresponds to the random fluctuations and is assumed to follow a symmetric normal distribution around the frontier, while the second one, u_i , accounts for the firm's inefficiency and is assumed to follow a half-normal distribution. For our cost efficiency function, we opt for a translog specification. This representation gives:¹²

$$\begin{aligned} \ln TC_i = & \alpha_0 + \sum_i a_i \ln P_i + \sum_i \beta_i \ln Y_i + \frac{1}{2} \sum_i \sum_j a_{ij} \ln P_i \ln P_j + \frac{1}{2} \sum_i \sum_j \beta_{ij} \ln Y_i \ln Y_j + \\ & + \sum_i \sum_j \delta_{ij} \ln P_i \ln Y_j + \sum_i \varphi_i \ln N_i + \frac{1}{2} \sum_i \sum_j \phi_{ij} \ln N_i \ln N_j + \sum_i \sum_j \xi_{ij} \ln P_i \ln N_j \\ & + \sum_i \sum_j \zeta_{ij} \ln Y_i \ln N_j + \sum_i \eta_i \ln Z_i + kD_i + \theta_1 t + \frac{1}{2} \theta_2 t^2 + \sum_i \mu_i t \ln P_i + \sum_i \kappa_i t \ln Y_i + \\ & + \sum_i \nu_i t \ln N_i + v_i + u_i \end{aligned} \quad (A2)$$

Standard linear homogeneity and symmetry restrictions in all quadratic terms are imposed in accordance with economic theory, thus $\alpha_{ij} = \alpha_{ji}$; $\delta_{ij} = \delta_{ji}$; $\xi_{ij} = \xi_{ji}$; $\mu_{ij} = \mu_{ji}$, $\forall i, j$, while we also include both country and time effects. The cost frontier can be approximated by

¹² For simplification, we omit the subscripts for time (t).

maximum likelihood, and efficiency levels are estimated using the regression errors. Jondrow et al. (1982) show that the variability, σ , can be used to measure a firm's mean efficiency, where $\sigma^2 = \sigma_u^2 + \sigma_v^2$. Firm level inefficiency for the half normal model is then derived from the following function:

$$E[u_i | \varepsilon_i] = \frac{\sigma\lambda}{(1 + \lambda^2)} \left[\frac{\phi(\varepsilon_i \lambda / \sigma)}{\Phi(-\varepsilon_i \lambda / \sigma)} - \frac{\varepsilon_i \lambda}{\sigma} \right] \quad (A3)$$

where $\lambda = \sigma_u / \sigma_v$, Φ is the standard normal cumulative distribution function and $\phi(\cdot)$ is the density of the standard normal distribution.