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Cost efficiency of banks in transition: Evidence from 289 banks in 15 post-communist countries

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Abstract

To understand the transformation of banking in the post-communist transition, this paper examines the cost efficiency of 289 banks in 15 east European countries. The findings showed that banking systems in which foreign-owned banks have a larger share of total assets record lower costs and that the association between a country's progress in banking reform and cost efficiency is non-linear. Early stages of reform are associated with cost reductions, while costs tend to rise at more advanced stages. Private banks are more efficient than state-owned banks, but there are differences among private banks. Privatised banks with majority foreign ownership are the most efficient and those with domestic ownership are the least.

Keywords: Transition economies, banking, cost efficiency

JEL Classification Number: C30, G21, P20

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INTRODUCTION

In the post-communist transition, east European banking systems have undergone fundamental transformations. Like most industrial enterprises at the start of transition, socialist banks were in need of deep restructuring. Under communism and the command economy, the state directed credit allocation with scant regard for repayment capacity, using state banks to channel funds to state (or socially) owned enterprises for inputs and investments authorised under planning. To allocate resources in this way, banks specialised by economic sectors, rather than diversified across them. State savings banks specialised in collecting deposits from households, although most savings were forced and done by the state. The payment system consisted of a cash circuit for households and commercial transfers among enterprises handled by the central bank. At the same time, inputs used by state banks were not necessarily of the scale and mix that minimised costs, because there was no incentive for profit maximisation. Because of the structure of socialist banking systems, they had to restructure fundamentally both their outputs and use of inputs with the onset of transition.

Governments and central banks adopted several policies to promote the transformation of socialist banking systems into market-oriented ones. Banking systems were liberalised by freeing interest rates and decentralised by transferring commercial banking activities from the central bank to state banks, restructuring and privatising state banks and allowing entry of new private banks, both domestic and foreign. Moreover, 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 and the system of prudential regulation and supervision was initiated. The timing and sequence of these reforms, however, differed significantly across countries, as did the initial conditions at the start of transition in the banking systems and overall economies.

To learn how the transformation of banking has advanced in the post-communist transition, we examine the relative cost efficiency of banks for a sample of 289 banks from 15 east European countries over the years 1994–2001. The objective of the analysis is to identify factors both at the country level and bank level that are associated with greater relative cost efficiency in banking in these countries. Country-level variables are used to account for variation in banking technologies that may be related to macroeconomic conditions and to structural and institutional features of a country. Bank-level factors are used to examine variation in the distance from the estimated cost efficiency frontier.

There are at least three reasons for focusing on cost efficiency of banks as an indication of progress. First, greater relative cost efficiency may be associated with the changes in incentives and constraints in banking associated with structural and institutional reforms and with the more efficient provision of public services by the state, such as the rule of law. Second, efficiency gains reduce the resources associated with operation of payments systems and with intermediation of savings into investments. Like productivity gains in other economic sectors, greater cost efficiency in banking contributes directly to overall economic development. Third, cost efficiency may be associated with other dimensions of bank performance that contribute to overall development, such as the making of more productive loans, but that cannot be directly measured with available bank-level data. This association may exist if factors that contribute to greater cost efficiency also promote improvement in other aspects of banking performance.

With our panel dataset for banks in transition economies, unique in its coverage of time-varying bank ownership in transition economies, we estimate a stochastic cost frontier by assuming a specific functional form for the cost function, a standard translog cost function.

The main benefit from using this estimation approach is that it allows for random errors that can arise from measurement problems or luck that temporarily gives banks better or worse measured performance from one year to the next. The main drawback is it imposes an assumed functional form on the cost function. Alternative approaches, such as data envelopment analysis, have the advantage of not imposing a specific functional form on costs, but at the expense of assuming that there are no random errors. In transition economies, where measurement problems loom large and decision makers face considerable uncertainty in the economic environment, we judge that the advantage of allowing for random errors in specifying a specific functional form for costs out-weighs the disadvantages imposed by the restrictions of an assumed functional form for costs.[1]

To estimate the stochastic cost efficiency frontier for banks, we use the maximum likelihood procedure of Battesse and Coelli (1993 and 1995). This procedure permits the single-step estimation of the parameters of the cost function, the measures of bank inefficiencies and the correlates of bank inefficiencies. To our knowledge, this is the first application of the procedure in banking efficiency literature. Most if not all such studies based on the stochastic frontier approach use a two-step procedure. In this procedure, the estimated bank inefficiency measures obtained from the estimation of the stochastic cost efficiency frontier are regressed in a second step on a set of variables that may be associated with managerial selection and incentives at the bank level. Performing this analysis in two steps, however, violates the assumption made in the first step that the bank inefficiency components of the error terms from the cost efficiency frontier are independently and identically distributed.

The main findings of the paper relate to the parameters of the cost efficiency frontier, country-level factors that shift the position of the frontier and bank-level correlates of the distance from the frontier, that is, the measures of bank inefficiencies. Regarding the former, the average-sized bank in transition economies has operated with approximately constant returns to scale. For the smaller banks in the region, there are some unrealised economies of scale, pointing to an economic benefit from consolidation of the sectors. At the same time, banks appear to respond to increases in input prices by reducing their use.

Several country-level factors are significant in explaining variation in cost efficiency across countries. Banking systems with a higher share of majority foreign-owned banks in total assets and a larger ratio of capital to total assets tend to have lower costs. The former may be associated with the extent of competitive pressure and the latter with the degree of risk aversion. Progress in liberalising interest rates and credit allocation and in implementing a framework of prudential regulation and supervision, as measured by an index of banking reform, has a non-linear association with cost efficiency. Early stages of banking reform are associated with greater cost efficiency, while at more advanced stages of reform costs tend to rise.

At the bank level, we investigate the association between cost inefficiencies on the one hand and the origin and ownership structure of banks and their market power on the other. We find that private banks are significantly more efficient than state-owned banks, but that there is significant variation among different types of private banks. Privatised banks that are majority foreign-owned have the lowest cost inefficiencies, followed by newly established banks, both domestic and foreign, and then by privatised banks with majority domestic ownership. Moreover, banks with a larger share of the deposit market are more efficient than other banks. These findings point to *inter alia* the potential benefits in the post-communist transition of bank privatisation to a strategic foreign investor and the entry of newly established banks.

[1] Berger and Mester (1997) provide a comprehensive review of alternative bank efficiency measures and estimation methodologies.

1. LITERATURE ON COST EFFICIENCY IN TRANSITION BANKING

This paper contributes to the existing literature on cost efficiency in banking in transition economies, much of which focuses on variations in bank efficiency within a few transition economies.[2] These studies cover Croatia (Kraft and Tirtiroglu, 1998, and Jemric and Vujcic, 2002), the Czech Republic (Matousek and Taci, 2002), Hungary (Hasan and Marton, 2003) and Poland (Nikiel and Opiela, 2002). Weill (2003) covers both the Czech Republic and Poland. The estimation methodologies vary across these studies. Similar to this paper, Hasan and Marton, Kraft and Tirtiroglu, and Weill use the stochastic frontier approach, while Matousek and Taci and Nikiel and Opiela employ the distribution free approach. Jemric and Vujcic use date envelopment analysis. The sample periods for these studies lie within the years 1993 to 2000.

The findings from these studies, which examine primarily the associations between bank ownership and cost (and in some cases profit) efficiency, are mixed. Kraft and Tirtiroglu found that state-owned and privatised banks in Croatia between 1994 and 1995 had higher cost efficiency levels than did newly established private banks. Matousek and Taci observed greater efficiency in private banks in the Czech Republic for the period 1993 to 1998. No evidence of greater efficiency in foreign-owned banks was found in either study. However, the studies of Hasan and Marton in Hungary between 1993 and 1997, Jemric and Vujcic in Croatia between 1995 and 2000, Nikiel and Opiela in Poland between 1997 and 2000 and Weill in the Czech Republic and Poland in 1997 found that foreign-owned banks were significantly more efficient than domestically owned banks. However, none of these studies drew a distinction between privatised banks that are majority foreign-owned and newly established foreign private banks. Hasan and Marton, moreover, observed that increased entry of foreign banks was associated with greater cost efficiency in all banks, not just those with majority foreign ownership. The single-country studies of cost efficiency in banking, therefore, do not provide unambiguous evidence on the economic benefits of bank privatisation and entry of new domestic and foreign banks, the key policies that have been adopted with the aim of promoting the transformation of banking in transition economies.

In addition to the single country studies of cost efficiency in transition banking, there have been three recent cross-country studies: Grigorian and Manole (2002), Yildirim and Philippatos (2002) and Bonin, Hasan and Wachtel (2004). Like this paper, each used as its primary data source the *BankScope* database published by Bureau van Dyke, although the criteria for selecting banks from this database and the data cleaning procedures differed across the studies. Grigorian and Manole and Yildirim and Philippatos covered 17 and 12 east European countries for the periods 1995 to 1998 and 1993 to 2000, respectively. Bonin, Hasan and Wachtel included 11 countries between 1996 and 2000. However, none of these studies had the detailed breakdown of bank ownership used in our study (that is, state-owned, privatised or newly established private and majority foreign or domestic ownership). The efficiency measures and estimation methodologies also vary. Grigorian and Manole examine cost efficiency using date envelopment analysis, while Yildirim and Philippatos and Bonin, Hasan and Wachtel use the stochastic frontier approach to analyse cost (and profit) efficiency. Yildirim and Philippatos also employed the distribution free approach.

While each of these studies found significant variation across countries in average bank efficiency, only Grigorian and Manole and Yildirim and Philippatos sought to explain this variation by examining country-level variables as correlates of bank efficiency measures. Bonin, Hasan and Wachtel, which focused primarily on the effects of foreign ownership,

[2] Berger and Humphrey (1997) provides a comprehensive survey of bank efficiency results internationally. However, this survey does not cover the post-communist countries of eastern Europe.

simply allowed for fixed effects for both country and time. Grigorian and Manole observed that bank cost efficiency is significantly and positively correlated with GDP per capita and weakly and positively associated with a measure of progress in institutional reform. Yildirim and Philippatos found that greater competition in the banking system (measured by the Panzar and Rosse H-statistic) is associated with greater cost efficiency. Meanwhile, Grigorian and Manole found the higher banking market concentration was associated with greater cost efficiency. All three studies examined bank-level correlates with efficiency. Among these correlates, they found that foreign-owned banks are significantly more cost efficient than domestic banks. In addition, Grigorian and Manole observed that private banks newly established after the start of transition were no more cost efficient than old banks, although no distinction was drawn between state-owned and privatised banks. These cross-country studies, therefore, provide consistent evidence in support of foreign bank entry as part of a reform strategy aimed at transforming socialist banking systems into market-oriented ones.

2. DATA SOURCES AND VARIABLE DESCRIPTIONS

This paper uses a unique panel data set compiled at the EBRD on banks in transition economies. Unlike the other cross country studies on transition banking, it includes comprehensive annual data on bank ownership (state-owned, privatised or newly established private, and domestic or foreign majority holdings). The other studies either do not distinguish fully among these five potential ownership categories or do not have complete time series on ownership (or both).

2.1 DATA SOURCES

The primary source of data on the banks' balance sheets, income statements and ownership is the *BankScope* database produced by the Bureau van Dijk, which includes data on 10,227 banks world-wide. The database is updated monthly and the latest issue of the *BankScope* database used in this study was May 2003. The *BankScope* data are supplemented with the data and information from annual reports of the banks and from EBRD staff research on bank ownership. The central banks of the countries provided aggregate data on their banking systems for use in calculating market concentration, ratio of total deposits to total loans (intermediation ratio), ratio of equity to total assets and share of foreign bank assets in total bank assets. The sources of the macroeconomic data and measures of banking reform for the countries are the EBRD's *Transition Reports* and the IMF's *International Financial Statistics*.

In our sample, we include all banks in the *BankScope* database for which at least five years of data are available between 1994 and 2001. The minimum requirement of five years helps to distinguish reliably between random noise and bank inefficiency in the errors of estimated cost functions. In addition, where banks report according to both local accounting standards and international accounting standards for at least five years, we select data in international accounting standards rather than national accounting standards for banks. This accounts for 57 per cent of the banks in the sample. The sample includes 289 banks from 15 transition countries: 19 banks in Bulgaria, 35 in Croatia, 23 in the Czech Republic, four in Estonia, eight in FYR Macedonia, 24 in Hungary, 10 in Kazakhstan, 19 in Latvia, 10 in Lithuania, 36 in Poland, seven in Romania, 48 in Russia, 15 in the Slovak Republic, 17 in Slovenia and 14 in Ukraine. All bank accounting data are in nominal terms in US dollars converted at current exchange rates.

The composition of banks in our sample varies over the sample period of 1994 to 2001 (see Table 1). There are 92 banks for which data are available for the entire sample, while there are 136 banks that enter the sample after 1994 and 68 banks that exit from the sample before 2001. The additions to the sample are not necessarily new market entrants, but rather successful banks that are added to the *BankScope* scope database over time. Exits from the sample are due primarily to either bank failures or mergers with other banks. This method of selecting banks from the *BankScope* database introduces selection bias in the data, as does the selection by *BankScope* of banks to include in the data set. (These are primarily the larger and financially sounder banks in the region.) The estimation results are, therefore, representative not of the entire population of banks in transition economies, but rather of the relatively successful top tier of banks in the region.

2.2 VARIABLE DEFINITIONS FOR ESTIMATION OF THE COST EFFICIENCY FRONTIER

Total cost and outputs

We use the intermediation approach to measuring costs of a bank because a competitive and efficient institution would minimise the total operating and interest costs for any given output. Total cost is, therefore, the sum of interest expenses and general operating expenses. However, bank dividend payments are excluded from the measure of total cost, so the return to bank equity is not included in the measure of total cost. To determine which bank products to include as outputs, we use the criterion of value added. Banking activities that produce a flow of banking services associated with a substantial labour or physical capital expenditure are identified as outputs. We, therefore, use two bank outputs. One is loans to customers, which includes all loans to non-bank entities and loans to other banks. The second output is deposits. One characteristic of deposits is that they are remunerated in part by the provision of liquidity, transactions and payment services to depositors.

Input prices

Ideally, we would include two input prices, one for labour and the other for physical capital. However, while the bank-level data includes employee costs and other overheads for many but not all banks in the sample, they do not include comprehensive data on numbers of employees or branches that could be used to estimate unit prices for these inputs. We, therefore, follow Hasan and Marton (2003) and use the ratio of total non-interest to total assets as the best available proxy measure for the average cost of non-financial inputs to banks.[3]

Country-level and control variables

To allow for the effect of country features on banking technology, we include several country-level variables in the estimation of the cost function. Inclusion of these variables allows for the level of cost efficiency to vary systematically across countries. They include macroeconomic variables and measures of the structure of the banking industry. The macroeconomic variables are per capita GDP measured in US dollars, the level of nominal interest rates and the density of deposits (deposits in millions of US dollars per square kilometre). Per capita GDP serves as a proxy measure for the overall level of development, including the quality of state institutions and the level of skills. Costs may decrease with overall development because of corresponding improvements in the quality of state institutions. High nominal interests can raise the interest costs of banks and reduce efficiency in activities, such as risk management and evaluation of credit information through greater uncertainty and risk. Banking efficiency may be affected also by the density of demand. Banks operating in an economic environment with a lower level of deposits per square kilometre of land area may incur higher costs in mobilising deposits and making loans through their branches.

Another set of variables that may affect banking technology and service quality are those that characterise the structure of the banking industry. They include the degree of asset market concentration (measured as the ratio of assets of the five largest banks in the total assets of the sector), the share of majority foreign-owned banks in total banking system assets and the intermediation ratio of the banking industry (measured as the ratio of loans to deposits). Asset market concentration can lead to either higher or lower costs for the banks. If market concentration reflects market power for some banks, it may increase the costs for the sector in

[3] We also calculated both personnel costs to total assets as a proxy for the price of labour and other operating expenses to total assets as a proxy for the cost of physical capital. However, this resulted in the loss of about 300 observations because of missing values.

general 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 lower costs, provided that the markets remain contestable. 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. The intermediation ratio reflects differences among the banking sectors in terms of the extent to which they convert deposits into loans. This may be associated with bank holdings of government securities and crowding out of private borrowing by the public sector or inadequate institutions to support lending to the private sector (for example, the absence of effective secured transactions and bankruptcy laws).

To allow for variation in sector banking reform and related institutional developments across countries, we included an ordinal index of banking sector reform published in the EBRD *Transition Reports*. This measure of reform progress ranges in value from 1 (little progress in reforming the socialist banking systems) to 4.0 (reforms consistent with a well functioning market economy).[4] One channel through which banking reform may have an effect on the banking cost inefficiency level is through capital adequacy requirements and other prudential constraints on risk taking. When combined with private ownership of banks and an objective of profitability, these constraints may strengthen the incentive for efficiency improvements. The association between banking reform and cost efficiency, however, may be non-linear. In the early phases of reform, the socialist banks may undertake significant restructuring and rationalisation of their operations as interest rates and credit allocation are liberalised, use of directed credit is abandoned and entry of new private banks is permitted. At more advanced stages of reform, banks may focus more on improvements in service quality and innovation to develop their market shares and enhance their profitability, which may be associated with higher costs. In addition, the average capital ratio of the banking sector is used as a second proxy for differences in the regulatory requirements among countries. A higher average capital ratio may be associated with lower-cost banks because they can borrow at lower interest rates, since they are perceived as less risky.

We also include two bank-specific variables to control for non-traditional bank activities and differences in risk. This is because measured efficiency may reflect variation in the product quality and in risk taking across banks. As a proxy for product differences, we use the average ratio of non-loan assets to total assets. To control for variation in risk taking strategies among banks, we include the ratio of non-performing loans to total loans.

2.3 CORRELATES OF BANK INEFFICIENCIES

The variations of inefficiency measures across banks may be associated with a set of factors that affect incentives and/or managerial selection (in terms of quality) at the bank level. Factors that may affect the efficiency level of a bank are its origin and ownership, major operational changes within the bank itself (in particular, if a bank merged with other banks during the time period) and market power of a bank in the deposit market. Our analysis distinguishes between five types of origin and ownership categories: newly established

[4] The index essentially partitions the reform of the banking sector into three broad steps. The first is the separation of commercial banking activities from the central bank and partial liberalisation of interest rates and credit allocation. The second is establishment of a framework for prudential regulation and supervision, full liberalisation of interest rates and credit allocation. The third is significant progress towards implementation of Basle Committee core principles and banking regulation and supervision. The index also allows for no change from the previous regime, an index value of one. The index covers all countries and years covered by this paper. For more details, see the EBRD *Transition Report* (various issues).

private banks with majority domestic or foreign ownership, privatised banks with majority domestic or foreign ownership and state-owned banks.[5] In addition, higher bank capitalisation may affect bank efficiency through a greater incentive for sound banking and efficiency and less of an incentive for risk-taking in lending decisions. We also include a dummy for banks that report according to international accounting standards.

2.4 SUMMARY STATISTICS OF THE DATA

Table 2 summarises the dataset we use in the analysis. It reports sample means for the overall sample and by country (calculated for bank-year observations) for the dependent and explanatory variables. Table 3 reports the sample means by bank origin and ownership.

Comparing the summary statistics across countries, we see significant variations regarding total costs, outputs and input prices. Average cost efficiency as measured by the simple ratio of total costs to total assets of banks is broadly similar in many countries, in the range of 0.11 to 0.15. However, in Bulgaria, FYR Macedonia, Romania, Russia and Ukraine this ratio is significantly higher, ranging from 0.20 for FYR Macedonia to 0.30 for Bulgaria. Regarding the levels of outputs, the ratio of total loans to total assets varies from 0.32 in Latvia to 0.52 in Estonia and the ratio of total deposits to total assets from 0.54 in FYR Macedonia to 0.86 in the Slovak Republic. The average input prices, as measured by ratios of overhead costs to total assets and fixed assets to total assets also vary across countries, with Bulgaria, FYR Macedonia, Kazakhstan, Lithuania, Romania, Russia and Ukraine standing out with higher ratios.

Regarding the country-level factors, differences in average values of macroeconomic variables are significant, especially in the per capita GDP which ranges from US$ 750 in Ukraine to US$ 9,441 in Slovenia. The average nominal interest rate is relatively high in Russia, Bulgaria and Romania, while the Czech Republic, Poland and the Slovak Republic have higher densities of deposits. Regarding the structuring of banking systems, average asset concentration is relatively high in Estonia and Lithuania, while Hungary, Estonia, Latvia and Lithuania have the largest asset share of majority foreign-owned banks in the banking sector. The banking sector reform progress as measured by the EBRD transition indicator (see above) varies from an average of 1.9 in Ukraine and Russia to 3.7 in Hungary.

A comparison of descriptive statistics by bank ownership in Table 3 reveals that newly established foreign banks and privatised banks with majority foreign ownership have lower total cost to total asset ratios on average than do domestic banks (either private or state-owned). Foreign banks also have lower indicators of overhead costs to total assets. However, they are similar to the state banks in terms of engaging in other banking activities measured by ratio of earning assets other than loans to total assets. Newly established banks, both domestic and majority foreign-owned, have significantly smaller shares of the deposit market than do privatised or state-owned banks.

[5] Majority ownership is defined as ownership of at least 50 per cent of shares. Ownership data from *BankScope* is complemented by EBRD staff research. The ownership data vary over time reflecting the change in ownership of banks during the sample period.

3. METHODOLOGY

3.1 COST EFFICIENCY FRONTIER

Cost efficiency is determined by how close a bank's costs lie to the efficient cost frontier for a given technology. The efficient frontier is determined by two conditions, technical efficiency (minimum use of inputs) and allocative efficiency (optimal mix of inputs given relative factor prices). The absence of either technical or allocative efficiency (or both) necessarily leads to a departure from cost minimisation and creates inefficiency. But since cost functions are not known or directly observable, inefficiencies must be measured relative to an efficient cost frontier that is estimated from data. Therefore, the measurement of inefficiency is based on deviations from the minimal costs observed in the data rather than from a technologically feasible efficient frontier. Bank cost inefficiency is defined as the difference between observed costs and predicted minimum costs for a given scale and mix of outputs, factor prices and other country-level variables. In other words, each bank in the sample is benchmarked against the "best" bank in the sample.

Cross-country comparisons of banking efficiency require estimation of a common frontier for all banks in the countries under consideration. However, in cross-country comparisons it is important to allow not only for variation in relative factor prices across countries but also for country-level variables that could influence the level of efficiency for all banks in the country and the quality of services provided with loans and deposits. Simply pooling all banks across countries and ignoring factors in the economic environment that could influence technology efficiency and service quality variations would implicitly assume that efficiency differences across countries can be attributed entirely to managerial decisions within banks regarding the scale and mix of inputs. Country-specific factors, such as the level of economic development, legal and regulatory frameworks, household wealth and incomes, population densities and market structures in banking, can have significant effects on the level of technological efficiency and service quality. By allowing for country factors to influence the position of the efficient cost frontier, we recognise that technological efficiency and service qualities can vary systematically across countries.

These differences are potentially important in countries in transition. For example, a dysfunctional legal system can raise the cost of making and collecting a loan even if the credit skills and procedures of all banks in each of the countries is the same. If country-specific factors are important in explaining the efficiency differences across countries, the estimation of the common frontier – without taking them into account – would produce biased estimates of efficiency and may overstate the inefficiency of banks in some countries. A likelihood ratio test indicates that the cost function specification that includes country-level factors provides a better statistical fit than does the restricted specification that omits such variables. To identify the extent to which country-level factors affect the efficiency of banks, we report country average levels of bank efficiency both with and without allowing for country-factors to influence the position of the cost efficiency frontier.

3.2 PARAMETRIC APPROACHES TO MEASURING EFFICIENCY

There are two main parametric approaches to measuring efficiency of individual banks, the stochastic frontier approach (SFA) and the distribution-free approach (DFA).[6] The main difference between these techniques is how they separate the measure of inefficiency for an individual bank from random errors. Non-parametric approaches to measuring efficiency, such as data envelopment analysis and free disposal hull analysis, impose less structure on the

[6] A third parametric approach, the thick frontier approach (TFA), does not provide point estimates of inefficiencies for individual banks.

cost efficiency frontier than do parametric approaches. However, these approaches do not allow for random errors caused by luck, data problems or other measurement errors. This is a significant disadvantage to applying these methods in transition economies where uncertainty and measurement problems loom large.

The SFA, as developed by Aigner, Lovell and Schmidt (1977) and applied to banks by Ferrier and Lovell (1990), specifies a particular form for the cost function, usually a translog form, and allows for random errors. It assumes that these errors consist of inefficiencies which follow an asymmetric distribution, usually a truncated or half-normal distribution, and random errors that follow a symmetric distribution, usually the standard normal distribution. The reason for this particular structure of the composite error term is that, by definition, inefficiencies cannot be negative. Both the inefficiencies and random errors are assumed to be orthogonal to the input prices, outputs and country-level variables specified in the estimating equation.

The DFA, as applied to banks for example by Berger (1993), also assumes a functional form for the cost frontier, but separates the inefficiencies from random errors in a different way. This approach assumes that the inefficiency of each bank in a panel data set is constant over time, whereas the random errors tend to average out over time. The estimate of the inefficiency of each bank is then measured as the difference between its average residual from the estimated cost function and that of the bank on the cost efficiency frontier. The distribution of inefficiencies can follow almost any form, as long as they are non-negative. However, the assumption that inefficiency of each bank is persistent over time is strong, particularly in context of transition where the pace of organisational and technology change is significant. This is a significant drawback to the DFA, since our panel data set covers eight years of significant change.

3.3 STOCHASTIC FRONTIER APPROACH

The estimation of banks' relative efficiency using panel data is performed by estimating a cost function of the general form:

$$y_{ijt} = \alpha + X'_{ijt}\beta + Z'_{jt}\gamma + \nu_{ijt} + u_{ijt}, \qquad (1)$$

where y_{ijt} is total cost in logarithm form of bank *i* in country *j* in period *t*, X'_{ijt} is a matrix of outputs and of input prices in logarithm form, Z'_{jt} is the matrix of country-level variables for country *j* in period *t*, ν_{ijt} is a random error term and u_{ijt} >0 is the technical inefficiency term.

The specific form used for the cost function is a standard translog specification, which can be written as:

$$\ln TC_{ijt} = \alpha_0 + \sum_m^n \alpha_m \ln P_{m,ijt} + \sum_s^t \beta_s \ln Q_{s,ijt} + 1/2 \sum_m^n \sum_n^m \alpha_{m,n} \ln P_{m,ijt} \ln P_{n,ijt}$$

$$1/2 \sum_s^t \sum_t^s \beta_{s,t} \ln Q_{s,ijt} \ln Q_{t,ijt} + \sum_m^n \sum_s^t \phi_{m,s} \ln P_m \ln Q_{s,ijt} \qquad (2)$$

where P_m and P_n are input prices and Q_s and Q_t are output quantities. In estimating equation (1) with this specific functional form, we impose constraints on symmetry, $\alpha_{m,n} = \alpha_{n,m}$, and

$\beta_{s,t} = \beta_{t,s}$, homogeneity in prices, $\sum_m^n \alpha_m = 1$, and adding-up, $\sum_m^n \alpha_{m,n} = \sum_n^m \alpha_{n,m} = \sum_m^n \phi_{m,s} = 0$.[7] The composite error term also takes a specific functional form. The random components, v_{ijt}, are independently and identically distributed according to standard normal distribution, $N\left(0, \sigma_v^2\right)$, while the bank inefficiency components, $u_{ijt} > 0$ are identically and independently distributed according to a truncated-normal distribution, $N\left(\mu_u, \sigma_u^2\right)$. The SFA assumes that the inefficiency component of the error term is positive; that is, higher bank inefficiency is associated with higher cost.

The inefficiency of bank *i* in country *j* at time *t* is defined as $\exp(-\hat{u}_{ijt})$ where $\hat{u}_{ijt}$ is the estimated value of u_{ijt} . However, only the composite error term $\varepsilon_{ijt} = v_{ijt} + u_{ijt}$ can be observed from estimation of the cost function. The best predictor of u_{ijt} is, therefore, the conditional expectation of u_{ijt} given $\varepsilon_{ijt} = v_{ijt} + u_{ijt}$. To retrieve the inefficiency component from the composite error for each bank from the cost function estimation, we use the method of Jondrow et al. (1982) to calculate the conditional expectation.

To investigate factors that are correlated with bank inefficiencies, we use the so-called conditional mean model of Battese and Coelli (1993 and 1995), which permits in a single step estimation of the cost function and identification of the correlates of bank inefficiencies. In particular, the estimation procedure allows for bank inefficiencies to have a truncated-normal distribution that is independently, but not identically, distributed over different banks. The mean of the inefficiency term is modelled as a linear function of a set of bank-level variables. Specifically, the inefficiency terms, u_{ijt}, are assumed to be a function of a set of explanatory bank-specific variables, z_{ijt}, and a vector of coefficients to be estimated, ∂. In other words,

$$u_{ijt} = z_{ijt}\partial + w_{ijt}, \qquad (3)$$

where the random variable, w_{ijt}, has a truncated normal distribution with zero mean and variance, σ_u^2 . The point of truncation is $-z_{ijt}\partial$ so that $w_{ijt} > -z_{ijt}\partial$ and $u_{ijt} > 0$. The inefficiency component of the composite error term, therefore, has a truncated normal distribution, whose point of truncation depends on the bank-specific characteristics so that the inefficiency terms are non-negative. These factors, which may be associated with the quality of the managerial selection and incentives at the bank level, include the origin and ownership structure of banks (state-owned, privatised or newly established private, and foreign or

[7] In the reported estimation results, we include only one input price, the ratio of total operating expenses to total assets, which serves a proxy measure for both the cost of labour and physical capital. We also used both personnel costs to total assets as a proxy for the price of labour and other operating expenses to total assets as a proxy for the cost of physical capital. However, this resulted in the loss of about 300 observations because of missing values. For the estimation using the two input price proxies, we calculated the monotonicity and curvature conditions (non-decreasing and concave in prices of inputs and convex in outputs) at each data point. We found that the monotonicity constraint for the price of labour was always satisfied and the constraint for the price of capital was violated at less than 10 per cent of the data points. Using overhead costs to total assets as a proxy for the averaged price of inputs results in no violation of the monotonicity and curvature constraints of the cost function.

domestic majority holdings), their market shares as a measure of market power and the capital to asset ratio of each bank to control for variation in risk across banks.

To estimate the stochastic efficiency frontier, measures of bank inefficiency and correlates of bank inefficiencies given by equations (2) and (3), we use the Frontier econometric program developed by Coelli (1999) as incorporated in Stata release eight. A likelihood ratio test is used to compare this conditional mean model, which permits in a single-step the identification of the correlates of bank inefficiencies, with the two-step estimation of the correlates of bank inefficiencies. The latter approach assumes that bank inefficiencies components have a truncated-normal distribution that is independently and identically distributed over different banks, an assumption which is violated in the second step of the procedure. The likelihood ratio test indicates that the conditional mean model provides a better statistical fit.

The SFA can be applied either in a set of annual cross-section estimations or in a single panel estimation. The former allows for the estimated coefficients of the cost function to vary over time, variation that may reflect changing organisations and technologies and developments in the broader economic environment. However, using a set of annual cross-section estimations rather than a single panel estimation sacrifices estimation efficiency. This is because of reduced degrees of freedom and the estimated coefficients of a cost function being relatively more sensitive to sample outliers in each year. Using both estimation approaches, we calculated the means of the estimated bank efficiency levels both by country and ownership and found that these means are not sensitive to the estimation approach. We, therefore, report only the results from the estimations based on the panel approach.

4. EMPIRICAL RESULTS

4.1 ESTIMATION OF THE COST EFFICIENCY FRONTIER AND CORRELATES OF BANK INEFFICIENCIES

Table 4 reports two sets of estimation results based on the conditional mean approach. One specification allows for country-specific factors to influence the position of the cost efficiency frontier and the other does not. For each specification the potential correlates of banking inefficiency include the origin and ownership of a bank and its market power. The estimation results reveal a number of important characteristics of the cost function of banks and the correlates of bank inefficiencies in transition economies:

Outputs and input prices

The estimated elasticity of total costs with respect to customer loans is in the range 0.33 to 0.36, when evaluated at the sample mean for loans, deposits and input prices. The estimated elasticity of cost with respect to customer deposits is somewhat higher, in the range 0.63 to 0.65, also evaluated at the same sample means. Both estimated elasticities are significantly greater than zero. The multi-product economies-of-scale measure (essentially the ratio of average cost to marginal cost) is 1.02, which indicates that the average bank in the sample operates close to a point of constant returns to scale. The multi-product economies-of-scale measure for the smallest banks by asset size in the sample (lowest two deciles) is 1.11 to 1.12. The coefficient on the cross-product term between deposits and loans is statistically significant and negative. This indicates possible economies of scope in the joint production of deposit taking and lending services.

The estimated elasticity of total cost with respect to the proxy for the average price of inputs (the ratio of operating expenses to total assets) is 0.50 to 0.55, when evaluated at the sample mean. This means that banks tend to reduce their use of inputs as the average price of inputs increases.

Country-level factors

The nominal interest rate is positively associated with costs, reflecting the fact that interest makes up a significant share of total costs. An increase in the nominal interest rate of 1 percentage point increases total costs by 0.3 per cent. However, we find that the level of overall economic development is not significantly related to costs. This suggests that banking costs do not depend on the overall development, possibly reflecting a balance between wage costs and productivity across countries. These results differ significantly from those of Grigorian and Manole, who found a significant positive association between GDP per capita and banking costs, but no association between inflation and costs. The latter finding is questionable given the inclusion of interest expenses in total costs. Yildirim and Philippatos found a significant positive association between real GDP growth and costs.

Banking systems that have a higher share of foreign-owned banks, as measured by their share of majority foreign banks in total banking system assets, have lower costs.[8] For example, an increase in the share of foreign bank assets in a country's total bank assets of 1 per cent is associated with a 0.3 per cent reduction in the average total costs of all banks in that country. This is consistent with foreign banks exerting greater competitive pressures in the system than their domestic counterparts do, at least in this dimension of bank performance.[9] Hasan and

[8] We examine the causal relationship between foreign bank presence in a banking sector and total costs, using a Granger causality test. This shows that the presence of foreign banks causes the reduction in total bank costs, but not vice versa.

[9] The direct effect of foreign ownership on banks costs is allowed for in the single-step estimation procedure by the bank-level ownership variables. This effect is discussed in the section on the correlates with bank inefficiencies.

Marton found a similar association in their study of the Hungarian banking system. Banking market concentration, as measured by the asset share of the five largest banks, is not significantly associated with the bank costs. This is consistent with the findings of Yildirim and Philippatos. However, Grigorian and Manole found a significant positive association between more concentrated banking markets and greater cost efficiency.

Banking systems with a higher intermediation ratio (ratio of total loans to total deposits) have significantly lower costs. This may reflect developments in the legal and regulatory framework that support both the financial intermediation process and lower costs to banks. This could include, for example, the development of effective secured transactions laws and bankruptcy procedures that are necessary to support lending to customers.

Progress in banking reform as measured by the EBRD transition indicator is significantly associated with a decrease in banking costs in the early stages of reform (over the indicator range 1.0 to 2.3). However, as banking reforms progress further, costs tend to increase. This non-linear relationship between reform and cost efficiency may reflect the transition from defensive restructuring of banking operations (that is, cost cutting) to operating strategies based on service improvements and innovation as the economic environment for banking improves. The ratio of capital to total assets of the banking system is significantly and negatively related to total costs, with an increase in the capital to total assets ratio of 1 percentage points being associated with a reduction in costs of 5 per cent.

A higher share of non-loan assets in total assets of a bank is positively associated with higher costs. This variable may serve as a proxy for variations in banking service qualities that are not captured by the loan and deposit variables, which are traditional banking services. The ratio of non-performing loans to total loans of a bank is significantly and positively related to its total costs, with an increase in the ratio of non-performing loans to total loans of 1 percentage points being associated with a 1 per cent increase in total costs. This is consistent with higher ex-post risk (or observed risks) being positively associated with higher banking costs, including interest costs.

Correlates with bank inefficiencies

The coefficients of the ownership dummy variables indicate the difference in inefficiency between the ownership type indicated by the dummy variable and state-owned banks, which are omitted from the set of ownership dummy variables. Compared to state-owned banks, private banks are significantly more cost efficient. However, not all private banks are the same in terms of efficiency. When country-level factors are allowed to influence the position of the cost efficiency frontier, among the private-owned banks, privatised banks that are majority foreign-owned have the lowest inefficiency. They are followed by newly-established private banks that are majority owned by domestic investors, then by newly-established foreign banks. Privatised banks with majority domestic ownership have the lowest average cost efficiency among private-owned banks. This ordering of cost inefficiency by bank origin and ownership is broadly maintained when country level factors are not allowed to influence the position of the cost efficiency frontier. However, the size of the efficiency gains relative to state-owned banks becomes significantly larger. This suggests that bank privatisation and entry of new private banks may be positively correlated with country-level factors that are associated with lower banking costs. Our findings of the greater cost efficiency of foreign-owned banks, either privatised or newly established, are consistent with those of Grigorian and Manole, Yildirim and Philippatos, and Bonin, Hasan and Wachtel.

Banks with larger deposit market shares are more efficient than smaller banks. This association of market concentration with lower costs suggests that higher concentration reflects competitive selection and consolidation through survival of more efficient banks. Banks with higher ratios of equity to total assets have lower cost inefficiency. This may

reflect the impact of banking risks on interest expenses, which are included in total costs. Results similar to the latter were obtained both by Grigorian and Manole and by Yildirim and Philippatos.

4.2 AVERAGE BANK INEFFICIENCIES BY COUNTRY AND OWNERSHIP

Table 5 reports the bank efficiency averaged for each of the 15 countries in the sample using the panel estimation reported above. The measure of efficiency takes a maximum value of one, which corresponds to the most efficient bank in the sample. The average measures of bank efficiency, when country-level factors are not allowed to influence the position of the cost efficiency frontier, were considered first. In these cases, both country-level factors and bank-level factors reflect the measure of bank efficiency. The countries with the highest average level of bank efficiency are Estonia, Kazakhstan, Latvia, Lithuania, Slovakia and Slovenia with average measures in the range 0.75 to 0.86. This group is followed by Croatia, Hungary and Poland with average efficiency of 0.62 to 0.67. The countries with the least efficient banks on average are Bulgaria, the Czech Republic, FYR Macedonia, Romania, Russia and Ukraine, with average efficiency measures in the range 0.42 to 0.59. This grouping of countries reflects the statistically significant differences at the five per cent level, based on pair-wise t-test comparisons.

When country-level variables are allowed to determine the position of the cost efficiency frontier, the variation in average bank efficiency across countries diminishes. Most country average measures range from 0.72 in Croatia to 0.85 in Estonia. Only Bulgaria, the Czech Republic, FYR Macedonia and Romania lie outside this range, with an average measure between 0.47 and 0.62. This measure shows variation in bank efficiency that can be attributed primarily to bank level factors, such as ownership and control and market power.

The simple average of bank inefficiency across all countries, when country-level factors are not allowed to influence the position of the cost efficiency frontier, is 0.63. When country-level factors are allowed to influence the position of the cost efficiency frontier, the simple average of bank inefficiencies across all countries is 0.71. This comparison suggests that country-level factors account for a significant proportion of the relatively low bank efficiency observed in transition economies.[10]

Table 6 reports the average efficiency scores for banks grouped according to their origin and ownership, in particular for newly-established private banks, privatised banks and state-owned banks as well as for majority foreign-owned banks. Again, the averages are calculated for when the estimated cost efficiency frontier allows for country-level variables and does not allow for such variables. Pair-wise t-tests were used to examine whether differences between average efficiency levels for origin and ownership groups are statistically significant. When there is no allowance for country-level variables, state banks are significantly less efficient than private banks. Among private banks, those that have been privatised and have majority foreign ownership are the most cost efficient, followed by newly-established banks with majority foreign ownership. Those banks that have majority domestic ownership are the least efficient private banks, with no significant difference between privatised and newly established domestic banks.

[10] Berger and Humphrey (1997), in a survey of the bank cost efficiency studies in primarily OECD countries, found that the average measure of bank inefficiency in 110 US studies was 0.84 with a medium of 0.85 and a standard deviation of 0.13. The average measure of bank inefficiency in 131 non-US studies was 0.75 with a median of 0.81 and a standard deviation of 0.13.

Similar findings are observed when there is an allowance for country-level variables. The average efficiency level of state-owned banks is significantly lower than private banks. There is no significant variation among the average efficiency of various types of private banks.

5. CONSISTENCY CHECKS AND TESTING INEFFICIENCY PERSISTENCE OVER TIME

To check the methods used to estimate bank inefficiencies, we calculated the Spearman rank correlation between the ratio of total costs to total assets of banks and the cost inefficiency measures derived from the cost efficiency estimations using different sets of variables (with or without country-level variables). We expect that the rank of bank cost inefficiency levels to be correlated with the rank of cost to asset ratio. This is a simple measure of bank cost inefficiency that does not take into account differences in outputs and input prices across banks and variation in country-level factors.

For measures of inefficiency derived from the panel estimation without the country-level variables, the Spearman rank correlation with the total cost to total asset ratio is relatively high at 0.58. It is somewhat lower at 0.52 for the correlation between the measures of inefficiency derived from the panel estimation with the country-level variables in the cost efficiency frontier. This result is as expected because in the latter correlation the inefficiency measures are adjusted for variations in the country factors, while the cost to assets ratio is not adjusted for such differences.

To examine the degree of persistence in cross-sectional rankings of bank efficiency over time, we carry out Spearman rank correlation of the estimated efficiencies for consecutive years with the sample period under consideration. The correlations of the efficiency measures in consecutive years when country-level factors are allowed to influence the position of the cost efficiency frontier suggest that the ranking of bank-specific efficiency is highly persistent. The correlations between the rankings in consecutive years are in the range 0.64 to 0.82, except for that between in the years 1997 and 1998. Between these years, the rank order correlation dips to 0.56. This period includes the financial crisis in Russia. When country-level factors are not allowed to influence the position of the cost efficiency frontier in calculating bank inefficiency levels, the rank order correlation coefficients of these levels in consecutive years declines slightly to the range 0.63 to 0.79. This suggests that there is more persistence in the bank-level factors that contribute to the inefficiency levels than in the country-level factors.

6. CONCLUSIONS

To understand how the transformation of banking has advanced in the post-communist transition, this paper examines the relative cost efficiency of a sample of 289 banks in 15 east European countries for the years 1994 to 2001. We focus on cost efficiency of banks as an indication of progress because greater relative cost efficiency may be associated with the changes in incentives and constraints in banking associated with structural and institutional reforms. In addition, greater cost efficiency may be associated with the more efficient provision of public services by the state, such as the rule of law.

We find evidence that an average sized bank in the sample operates at a point that is close to constant returns to scales, while the smaller banks in the sample operate with significant unrealised economies of scale. This suggests that consolidation of smaller banks in the region would contribute to greater cost efficiency in banking. Banks also respond to relative prices of inputs by seeking to reduce their use as the price increases.

Country-level factors that increase cost efficiency are lower nominal interests, a greater market share of majority foreign-owned banks, and a higher intermediation ratio. In other words, greater macroeconomic stability and competition in banking from foreign entry, as well as development of the supportive institutions promote cost efficiency. Progress in banking reform has a non-linear association with cost efficiency. In the initial stages of banking reform, cost efficiency increases significantly, but it then declines as reforms advance further. This may reflect the transition by banks from defensive restructuring (that is, cost cutting) to deeper restructuring that increases the quality of and value added to banking services (that is, innovation). Banking systems with higher ratios of capital to total asset and banks with lower loan losses also tend to have lower costs. This may be associated with lower risks in banking sectors.

In addition, private banks are more cost efficient than state-owned banks, however, there are significant differences among private banks. Privatised banks with majority foreign ownership are the most cost efficient, followed by newly established private banks, both domestic and foreign-owned. Privatised banks with majority domestic ownership are the least efficient private banks, though they are still more efficient than state-owned banks.

Policies that many governments and central banks in eastern Europe adopted to promote the transformation of socialist banking systems into market oriented ones have, therefore, contributed to increased cost efficiency in the sectors, a useful indicator of progress. Looking ahead, some banking sectors will face major new challenges in the form of greater competitive pressures with their countries' accession to the European Union. In these countries, policy makers can drawn on lessons from the past and promote further cost efficiencies in banking. This can be done by sustaining progress in legal and regulatory reforms, completing the transition from state-owned banking systems to largely private systems and allowing for the market-led consolidation of smaller banks to achieve unrealised economies of scale. At the same time, banking markets should remain open and contestable, including through the entry of foreign banks. In other countries in eastern Europe, however, the banking systems remain at least partially mired in the past,[11] often because governments continue to use some banks to direct the allocation of resources. To make a clearer break with the past, there are useful lessons from the experience of the post-communist countries included in this analysis.

[11] See, for example, Berglöf and Bolton (2002) and Fries and Taci (2002) on the divergent paths of banking development in transition economies.

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Table 1: Data frequency distribution by country and ownership

	Total sample	Bulgaria	Croatia	Czech Republic	Estonia	FYR Macedonia	Hungary	Kazakhstan	Latvia	Lithuania	Poland	Romania	Russia	Slovak Republic	Slovenia	Ukraine
Total number of banks	289	19	35	23	4	8	24	10	19	10	36	7	48	15	17	14
Total number of observations	1897	117	235	154	27	57	174	52	128	64	254	38	285	105	120	87
Percentage of observations by bank origin and ownership																
Privatised, foreign ownership	7.5	7.6	4.6	10.0	24.1	3.1	20.7	0.0	6.3	6.3	8.9	10.3	0.0	9.5	0.0	8.0
Privatised, domestic ownership	18.0	4.2	17.2	13.3	13.8	23.1	5.2	28.8	0.8	23.4	11.7	0.0	27.7	19.0	32.2	27.6
Newly established private, foreign ownership	27.4	19.5	12.6	52.7	24.1	12.3	56.3	21.2	29.4	0.0	30.7	65.5	10.2	34.3	16.5	8.0
Newly established private, domestic ownership	26.0	28.8	49.6	8.7	24.1	38.5	0.6	34.6	54.0	59.4	20.6	0.0	48.8	0.0	28.1	52.9
State-owned	21.1	39.8	16.0	15.3	13.8	23.1	17.2	15.4	9.5	10.9	28.0	24.1	13.3	37.1	23.1	3.4

Table 2: Descriptive statistics of dataset – country average

Variable	Total sample	Bulgaria	Croatia	Czech Republic	Estonia	FYR Macedonia	Hungary	Kazakhstan
Bank size								
Total assets (in US$ millions)	929.04	318.83	438.88	2667.29	905.48	130.10	1150.12	312.6
Total costs, outputs and input prices								
Ratio of total costs to total assets	0.15	0.30	0.11	0.11	0.10	0.20	0.15	0.14
Ratio of total loans to total assets	0.42	0.36	0.45	0.38	0.52	0.42	0.44	0.46
Ratio of total deposits to total assets	0.73	0.73	0.61	0.79	0.72	0.54	0.77	0.76
Ratio of overhead costs to total assets (in per cent)	6.49	17.77	5.51	3.58	5.22	6.24	5.32	8.13
Country-level variables								
Per capita GDP (in US$)	3495.3	1495.43	4308.78	5323.46	3399.44	1911.21	4781.16	1281.76
Nominal market interest rate (in per cent)	25.98	38.25	14.46	9.58	9.13	13.55	16.18	31.64
Deposits per square kilometre (in US$/km^2)	0.14	0.04	0.16	0.47	0.03	0.03	0.21	0.001
Assets share of five largest banks (in per cent)	56.91	53.41	64.67	68.13	88.19	65.33	56.73	61.82
Asset share of majority foreign-owned banks (in per cent)	27.92	29.81	28.06	36.43	50.92	21.62	54.61	12.52
Average ratio of total loans to total deposits	0.98	1.14	0.86	1.01	0.90	0.64	1.03	0.80
Average ratio of capital to asset of the sector (in per cent)	17.9	15.3	22.3	17.3	15.8	33.0	9.4	25.2
EBRD transition indicator for banking reform (index, 1 to 4)	2.80	2.6	2.98	3.22	3.38	2.89	3.67	2.18
Control variables and inefficiency correlates								
Non-performing loans to total loan of individual banks (in per cent)	16.36	11.95	14.06	20.44	2.5	18.6	5.02	7.89
Other earning assets to total assets of individual banks (in per cent)	42.96	49.55	42.51	52.60	32.65	37.57	45.07	36.07
Equity to assets ratio of individual banks (in per cent)	15.39	18.71	21.70	8.62	10.67	31.19	9.99	12.02
Deposit market share of individual banks (in per cent)	6.38	6.84	3.59	6.15	37.49	14.39	5.02	11.33
Financial performance								
Return on average assets (in per cent)	1.39	2.97	0.77	-0.88	0.93	3.73	0.66	3.12
Return on average equity (in per cent)	8.49	7.37	-0.62	-6.89	7.14	10.42	9.05	25.90

Table 2 (continued): Descriptive statistics of dataset – country averages

Variable	Latvia	Lithuania	Poland	Romania	Russia	Slovak Republic	Slovenia	Ukraine
Bank size								
Total assets (in US$ millions)	181.93	303.30	1754.53	725.49	804.15	1102.48	765.81	204.21
Total costs, outputs and input prices								
Ratio of total costs to total assets	0.12	0.13	0.11	0.25	0.21	0.11	0.10	0.22
Ratio of total loans to total assets	0.32	0.43	0.45	0.34	0.39	0.42	0.51	0.42
Ratio of total deposits to total assets	0.81	0.76	0.76	0.71	0.66	0.86	0.78	0.73
Ratio of overhead costs to total assets (in per cent)	6.41	7.01	4.10	7.25	8.45	3.47	4.09	8.59
Country-level variables								
Per capita GDP (in US$)	2541.43	2722.3	3787.9	1649.56	2146.64	3638.43	9441.32	750.04
Nominal market interest rate (in per cent)	16.75	8.72	18.94	39.20	59.15	24.83	10.58	34.36
Deposits per square kilometre (in US$/km^2)	0.02	0.03	0.17	0.03	0.002	0.25	0.44	0.01
Assets share of five largest banks (in per cent)	57.17	84.14	50.20	69.81	39.55	67.18	63.52	38.38
Asset share of majority foreign-owned banks (in per cent)	54.69	42.82	31.34	23.28	6.65	26.92	7.52	7.36
Average ratio of total loans to total deposits	0.94	0.94	1.36	1.23	0.76	0.98	1.02	0.93
Average ratio of capital to asset of the sector (in per cent)	8.3	21.9	11.1	11.7	19.5	15.0	15.6	27.7
EBRD transition indicator for banking reform (index, 1 to 4)	3.08	2.89	3.17	2.64	1.93	2.87	3.13	1.92

Control variables and inefficiency correlates								
Non-performing loans to total loan of individual banks (in per cent)	10.22	18.43	18.41	32.75	17.41	33.06	9.88	33.77
Other earning assets to total assets of individual banks (in per cent)	51.81	28.87	42.61	51.99	35.12	49.11	40.43	38.60
Equity to assets ratio of individual banks (in per cent)	14.20	13.66	14.53	21.75	18.16	9.35	11.20	18.76
Deposit market share of individual banks (in per cent)	11.67	13.17	2.78	8.99	1.42	8.22	7.02	4.60
Financial performance								
Return on average assets (in per cent)	0.42	-0.47	1.59	1.65	2.80	0.21	1.08	4.07
Return on average equity (in per cent)	8.96	-1.80	10.63	8.83	21.71	4.16	9.37	14.42

Note: Sample means are for bank-year observations by country.

Table 3: Descriptive statistics of the dataset – averages by bank origin and ownership

Variable	Newly established private, foreign ownership	State-owned banks	Privatised, foreign ownership	Privatised, domestic ownership	Newly established private, domestic ownership
Bank size					
Total assets (in US$ millions)	521.1	2022.0	2360.5	1037.8	225.11
Total costs, outputs and input prices					
Ratio of total costs to total assets	0.11	0.17	0.12	0.16	0.18
Ratio of total loans to total assets	0.42	0.38	0.42	0.44	0.43
Ratio of total deposits to total assets	0.75	0.75	0.79	0.73	0.67
Ratio of overhead costs to total asset (in per cent)	4.4	6.63	4.72	6.28	8.60
Financial performance					
Return on average assets (in per cent)	1.33	1.09	1.1	1.02	1.98
Return on average equity (in per cent)	10.13	8.50	9.20	9.78	6.11

Note: Sample means are for bank-year observations by bank origin and ownership

Table 4: Panel estimation of stochastic cost efficiency frontier and correlates of bank inefficiencies

Dependent variable: Ln (total costs)	**With country-level variables and controls**	**Without country-level variables and controls**
Independent variables:		
Outputs and input prices		
Ln (Loans)	0.65***	0.58***
	(10.59)	(7.78)
(Ln (Loans)) ^{2}	0.28***	0.28***
	(10.80)	(9.94)
Ln (Deposits)	0.15***	0.18***
	(2.59)	(2.64)
(Ln (Deposits)) ^{2}	0.46***	0.42***
	(12.23)	(8.03)
Ln (Loans x deposits)	-0.17***	-0.16***
	(-12.01)	(-8.74)
Ln (Loans x cost of labour)	-0.04**	-0.03
	(-2.02)	(-1.07)
Ln (Deposits x cost of labour)	0.05**	0.04*
	(2.25)	(1.67)
Ln (Overhead costs to total assets)	0.18***	0.14*
	(2.25)	(1.95)
(Ln (Overhead costs to total assets)) ^{2}	0.38***	0.44***
	(9.98)	(11.40)
Country-level variables		
Per capita GDP (in US$ 1,000)	-0.01	
	(-0.86)	
Nominal interest rate (in per cent)	0.003***	
	(7.45)	
Density of demand (total deposits per square kilometre)	-0.17	
	(-1.11)	
Banking market concentration (share of five largest banks in total banking system assets)	-0.002	
	(-1.20)	
Share of majority foreign-owned banks in total system assets (in per cent)	-0.003***	
	(-4.94)	
Intermediation ratio (ratio of total loans to total deposits)	-0.26***	
	(-4.15)	
Equity to total assets of the banking sector (in per cent)	0.05**	
	(1.95)	
	-0.59***	
Index of banking reform	(-3.93)	
	0.13***	
Index of banking reform squared	(5.06)	

Table 4 (Continued): Panel estimation of stochastic cost efficiency frontier and correlates of bank inefficiencies

Dependent variable: Ln (total costs)	**With country-level variables and controls**	**Without country-level variables and controls**
Controls for variation in banking activities and risks		
Ratio of non-loan assets to total assets (in per cent)	0.002**	0.002*
	(1.96)	(1.81)
Share of non-performing loans to total loans for individual banks	0.01***	0.01***
	(8.28)	(10.30)
Constant	-1.16***	-1.20***
	(-4.39)	(-13.01)
Correlates with bank inefficiencies		
Privatised bank, foreign ownership	-3.01***	-4.12***
	(-3.29)	(-3.20)
Privatised bank, domestic ownership	-1.56***	-1.58**
	(-3.21)	(-2.39)
Newly established bank, foreign ownership	-1.59***	-2.20***
	(-3.86)	(-3.39)
Newly established, domestic ownership	-1.81***	-2.19***
	(-3.57)	(-3.08)
Deposit market share of bank	-0.17*	-0.23
	(-1.64)	(-1.10)
International accounting standards bank	0.94**	0.89
	(2.48)	(1.53)
Bank merger	-0.70	-1.79
	(-0.45)	(-0.83)
Ratio of equity to total assets	-0.02**	-0.02**
	(-2.44)	(-2.08)
Constant	-0.66*	-0.95**
	(-1.86)	(-2.05)
Number of observations	1615	1621
Wald chi-squared test	15083	10676.1

Note: T-statistics are given in parentheses and *** denotes statistical significance at the 1 per cent level, ** at the 5 per cent level and * at the 10 per cent level.

Table 5: Average bank efficiency levels by country

Bank efficiency levels	Bulgaria	Croatia	Czech Republic	Estonia	FYR Macedonia	Hungary	Kazakhstan	Latvia	Lithuania	Poland	Romania	Russia	Slovak Republic	Slovenia	Ukraine
Without country-level factors	0.42	0.67	0.42	0.82	0.47	0.62	0.78	0.75	0.80	0.66	0.47	0.46	0.76	0.75	0.59
	(1.05)	(0.33)	(1.62)	(0.13)	(0.85)	(0.27)	(0.09)	(0.4)	(0.16)	(0.39)	(0.33)	(0.62)	(0.16)	(0.11)	(0.30)
With country-level factors	0.62	0.72	0.47	0.85	0.60	0.76	0.83	0.76	0.82	0.74	0.55	0.70	0.78	0.78	0.73
	(0.56)	(0.26)	(1.52)	(0.13)	(0.67)	(0.17)	(0.06)	(0.36)	(0.12)	(0.31)	(0.32)	(0.03)	(0.15)	(0.09)	(0.19)

Note: Standard deviation of the averages is given in parentheses.

Table 6: Average bank efficiency levels by bank origin and ownership

Average bank efficiency levels	Newly established private, foreign ownership	State-owned banks	Privatised, foreign ownership	Privatised, domestic ownership	Newly established private, domestic ownership
Without country-	0.66	0.40	0.75	0.62	0.64
level factors	(0.47)	(1.28)	(0.22)	(0.55)	(0.36)
With country-	0.73	0.53	0.79	0.75	0.73
level factors	(0.37)	(1.09)	(0.19)	(0.29)	(0.23)

Note: Standard deviation of the averages is given in parentheses.