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Bank Efficiency in the Enlarged European Union

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Bank Efficiency in the Enlarged European Union[1]

(Bankrendszeri hatékonyság vizsgálata az Európai Unióban)

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Abstract

This paper aims to estimate bank efficiency differences across member states of the European Union and tries to explain their causes. We show on an empirical basis that the level and spread of bank efficiency in the EU and their changes are significantly determined by characteristics of operational environment and the "conscious" behaviour of management. In the long term, through the integration of financial markets and institutions, as well as the establishment of the Single European Banking Market, the impact of advantages and disadvantages underlying the operational environment is reduced or eliminated; therefore only managerial ability is of any relevance. Our findings suggest that there is a cost-efficiency gap and convergence between the old and new member states, irrespective of the specifications of the model. With respect to profit efficiency, however, differences in efficiency between the two regions are only established after controlling for some major characteristics of the varying operational environments. Our study also investigates the relevance of and the correlation between accounting-based and statistics-based efficiency indicators. We conclude that the accounting based efficiency indicators are inadequate for managing heterogeneity arising from institutional and operational environments. Hence such indicators only allow limited cross-sectional comparison through time.

JEL Classification: F36, G15, G21 and G34.
Keywords: parametric approach, X- and alternative profit-efficiency, Fourier-flexible functional form, banking system.

Összefoglalás

Kutatásunk során mérjük az Európai Unió tagállamainak bankrendszerei közötti hatékonyságbeli eltéréseket és megpróbáljuk megmagyarázni annak okait. Empirikusan bizonyítjuk, hogy a tagállamok közötti hatékonyságkülönbségek mértékét és időbeli alakulását nagyban befolyásolják a működési környezet adottságai és a menedzsment tudatos viselkedése. Hosszú távon csak a menedzsment tudatos magatartásának van relevanciája, hiszen a pénzügyi piacok, intézmények integrációjával és az Egységes Európai Piac létrejöttével a működési környezetben rejlő előnyök és hátrányok nagyságai mérséklődnek vagy eliminálódnak. Eredményeink alapján létezik egy költséghatékonysági rés és konvergencia a régi és új tagországok között, függetlenül a modell specifikációjától. Profithatékonyság tekintetében azonban csak az eltérő működési környezet hatásait kiszűrve található a két régió között hatékonyságbeli különbség. Kutatásunkban ugyancsak megvizsgáljuk a számvitel és statisztikai alapú hatékonysági mutatók relevanciáját és kapcsolatát. Rámutatunk, hogy csak a számviteli alapú hatékonysági mutatók nem képesek kezelni az intézményi és működési környezetből eredő heterogenitást, ezért ezek a mérőszámok időben és keresztmetszetben csak korlátozottan összehasonlíthatók.

1. Introduction

The banking sectors of the EU countries have faced numerous challenges in the past decade. With regard to old EU members as a result of the Second European Banking Directive and the Single European Passport the speed of deregulation accelerated, and with the elimination or lowering of barriers market-entry costs substantially decreased, favouring competition and the creation of a Unified Banking Market. Economic monetary union also encouraged the abolition of operational obstacles. The introduction of the euro opened the way for the further deepening of banking sector integration, whereby local banks gradually lost their competitive edge to foreign banks, mainly in terms of financial services. The rapid development of information technology, the appearance of new competitors exploiting opportunities offered by a global capital market and the creation of new markets linked to rapid innovations also promoted the intensification of competition and the accelerated consolidation of the European banking system.

Following the collapse of the centrally planned economic regime and the break-up of the mono-bank system in the new EU members, financial market liberalisation as well as economic privatisation laid the foundations of the modern financial institutional system. Considerable foreign capital inflow, market consolidation and the creation of an efficient regulatory framework contributed to the rapid transformation and development of the banking system and the market-based pricing and lending activity of banks. The integration of the banking system into the Single Banking Market commenced in parallel with the transformation of the financial intermediary system. Economic convergence, the harmonisation of regulations and the enlargement of the EU further accelerated the consolidation and integration of the banking systems of the new EU member states.

Several factors can generate efficiency differences and change their measure across banking sectors of EU members. On the one hand, discrepancies in operational environment, i.e. country-specific elements and, on the other, the different managerial abilities may cause an efficiency gap. National discrepancies in operational environment can derive from macroeconomic differences or dissimilar characteristics of financial infrastructure and institutional system, as well as from other country-specific factors. Managerial ability is defined in terms of adequate resource allocation and beneficial utilisation of technological opportunities. While operational environment exogenously explains efficiency differences, the executive and professional competence of management endogenously contributes to them.

Our study focuses on the estimation of the efficiency scores of member countries' banking systems and the impact of exogenous (out of managerial control) and endogenous (under the control of management) factors upon it. For this purpose we attempt to separate these two types of effects by controlling for some factors of home bias. Furthermore, we also investigate the level and change of the efficiency gap between sub-regions of the EU. With this we estimate the speed of efficiency convergence among banks within and between member states. As far as we are aware, in the empirical literature there is no work which investigates both X- and alternative profit-efficiency in all 25 member states of the EU.

Two types of efficiency indicators are derived: so called X-efficiency and alternative profit efficiency. X-efficiency gives a measure of how managers are able to minimise cost and thus maximise profit by input allocation and exploration of technological opportunities alongside given output and input prices. Alternative profit-efficiency is measured by how managers are able to maximise profit if the output price is not given. We empirically confirm that the results produced from the measurement of cost- and profit-efficiency, as well as the conclusions vary to a major degree depending on whether selected exogenous factors, i.e. operational characteristics are controlled or not.

Our study underlines the importance of accounting for heterogeneity in operational environment. Due to profit-maximisation, only managerial ability in efficiency improvement is of particular relevance from the point of view of financial stability. Due to high profitability led by an insufficient level of competition or other market distortions, management may not pay enough attention to cost rationalisation or to cost reduction, i.e. cost-efficiency improvement.[2, 3] Yet this involves risks. Only "conscious" efficiency improvement can permanently contribute to the banks' income generating capability, since

[2] This is suggested by the "Quiet life" hypothesis.

[3] The terms of X-efficiency and cost-efficiency are consistently used in this paper.

in the long term, as a consequence of the Unified European Banking Market the efficiency differences caused by market distortions will probably disappear. The improvement of banking efficiency may have not only stability- but also welfare- related implications. Due to the "efficiency surplus" an efficiently operating banking sector can charge on average lower credit and higher deposit rates compared to less efficient banking systems. Owing to the important financing role of the banking sector in the economy, a narrowing net interest margin enhances investment activity and stimulates economic growth. Furthermore, it also contributes to an increase in consumer surplus, as lower credit rates entail a decreasing debt service burden and higher deposit rates trigger rising financial wealth.

The study is organised as follows: Section 2 overviews the empirical literature on efficiency measurement; Section 3 illustrates the methodological background; Section 4 describes the framework of our empirical investigation as well as the results; finally Section 5 summarises and concludes.

2. Overview of bank efficiency studies

The roots of efficiency research originate from the institutional approach of corporate microeconomics. The measurement of efficiency was therefore initially performed in relation to the various industrial sectors of the real economy. In the past 15 to 20 years, the focus has shifted to the financial sector, with an emphasis on researching the efficiency of banks.

The research into efficiency serves the purpose of estimating the so-called "efficient frontier" and analysing deviations from such frontier corresponding to the loss of efficiency.[4] The methods are distinguished on the basis of the procedures applied to produce the frontier, and the assumptions made, for example, in relation to the distribution of the inefficiency term. The creation of the "efficient frontier" serves the purpose of distinguishing well performing (efficiently operating) production units from the group of poor performers. In the literature two major concepts are frequently used in generating this frontier: non-parametric and parametric approaches.

The non-parametric methods first proposed by Farrell (1957) select efficient production units in order to create the "efficient production frontier". The procedure was first applied by Charnes et al. (1978) who used linear programming techniques (DEA – Data Envelopment Analysis).[5] The method offers the advantage of simple application and restrictive assumptions are not required in advance with regard to the functional form. Its main disadvantage lies in the fact that this technique is unable to decompose the deviations of certain banks from the efficient production frontier into components: inefficiency and random error parts. The deviation as a whole is considered as inefficiency, irrespective of whether it derives from inefficient operation or exogenous effects independent of management. An additional problem is that the method disregards prices. The procedure rather focuses on measuring technological efficiency, based on technological and not economic optimisation.

Parametric methods are considered to be more sophisticated compared to non-parametric techniques, whereby the estimation of efficiency is based on economic optimalisation, given the underlying assumption of a stochastic optimal frontier. Parametric methods are capable of incorporating both input allocative and technical efficiencies. The two most frequently used parametric techniques are the Stochastic Frontier Approach (SFA) and the Distribution Free Approach (DFA).[6] The SFA was independently developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977). While the non-parametric DEA method regards all deviations (including errors and imperfections) from the frontier to constitute a loss of efficiency, the SFA attempts to decompose such differences into inefficiency and noise by making explicit assumptions about the inefficiency component's distribution. Thus, the procedure only analyses differences in efficiency measured in relation to the optimal frontier which – with an unbiased estimate – are independent of exogenous shocks that are beyond the control of the bank's management. The necessity of prior distributional assumptions regarding the inefficiency component represents the main shortcoming of the SFA.[7, 8]

[4] There are also two main non-frontier approaches to estimate relative efficiency: simple regression analysis (parametric approach) and the calculation of index numbers (non-parametric method). See Sarafidis (2002) for more detail.

[5] DEA is a non-parametric method for calculating relative efficiency scores in a multi input-output production environment. It measures the performance of all decision-making units compared to the generated efficient frontier. Best-practice banks, which constructs the DEA frontier, produce given output combinations with the lowest level of inputs or achieve the highest level of output with a given level of inputs, i.e. operates with an optimal input-output combination. Firms, which do not operate on the optimal frontier, suffer a certain level of efficiency loss.

[6] Another interesting but more rarely used technique is the so called thick frontier approach (TFA). This approach divided banks into four quartiles regarding their average cost or profit. Then the cost or profit curve is estimated separately for all groups of the banks. The estimated cost/profit function for banks in the smallest/largest average cost/profit quartile is interpreted as the cost/profit efficient frontier. A disadvantage of the TFA is that the result is very sensitive to the selection on the number of quantiles. In addition econometric problems may arise since the banks are pre-sorted using average cost or profit, which are essentially dependent variables.

[7] According to Allen and Rai (1996), assumptions about the distribution of the efficiency component are somewhat restrictive.

[8] According to Sarafidis (2002) outliers can cause problems in both SFA and DEA but for completely different reasons: while SFA can fail to find any inefficiency at all, DEA is likely to find too much inefficiency in the sample. The deterministic nature of DEA can cause significant problems in the measurement of efficiency when there are outliers in the industry, because the method envelops the outermost observations without asking whether these observations are genuine or the result of an error. In addition, the presence of outliers (that is, the presence of large residual variation) in the sample can cause the stochastic frontier model to perceive that there is too much noise in the data and therefore may find little or no inefficiency in the sample, even in the cases where there is some.

The DFA of Schmidt and Sickles (1984) and Berger (1993) is based on similar logic, though is distinguished from the former method by not applying assumptions as to the distribution of the inefficiency component. The disadvantage of the DFA is the requirement of persistent efficiency level for banks over time. However, if the time period of the sample increases the assumption of invariant efficiency level becomes untenable. On the other hand, in the case of short time horizon the inefficiency proxied by the average of residual over time may be biased, as the random noise may not average out.

Parametric methods are subject to economic optimalisation and therefore are of more relevance in the frontier specification. Parametric methods are most commonly used for estimating X-efficiency; the study of alternative profit efficiency has gained ground in recent years. X-efficiency plays an important role in banks' pricing and earnings.[9] The definition of X-efficiency was first introduced by Leibenstein (1966), who focused on differences in economic agents' ability and their effects on banking cost management, i.e. input allocation and technological utilisation. Allocative efficiency as an element of X-efficiency measures whether the manager has the ability to optimally react to relative input price changes, i.e. to substitute the relative expensive resources with cheaper ones over a short period of time. The technological component of X-efficiency measures the ability of establishing appropriate production plans, developing new products and distribution channels.

The estimation of alternative profit efficiency comprises a relatively new area in efficiency literature. Following Berger and Mester (1997) alternative profit efficiency can be defined as how close a bank comes to earning maximum profits given its output level rather than its output prices. The alternative profit efficiency can be considered as superior to X-efficiency, given that it takes into account the management's behaviour in pricing decisions and "conscious" choosing of other non-price factors (i.e. quality of banking services, portfolio mix). The "conscious" efforts of the management can result in a different quality of services, dissimilar pricing behaviour and therefore diverse mark-ups and the disparate role of non-interest incomes.

Most of the publications covering the theme study the banking system of the USA. Relatively few European studies have been published on efficiency, and the analysis of the financial systems of transition economies from an efficiency point of view has been very limited.[10] Comparative research analysing the efficiency of banking systems in different countries is also very scarce, possibly owing to the difficulty of managing problems arising from different operational environments and their impact on efficiency.

[9] Berger and Hannan (1993), Berger (1995), Goldberg and Rai (1996), Berger and Hannan (1998), Punt and van Rooij (2001) and Vennet (2002) confirmed that X-efficiency influenced banks' profit much more than scale and scope efficiency.

[10] As emphasised by Berger and Humphrey (1997), of the 122 efficiency studies, encompassing 21 countries, only roughly 5% study transition economies.

The table below provides a brief overview of the literature.[11]

Authors	Methodology	Result[12]
USA		
Sinan and Register (1989) USA	Stochastic/parametric; SFA	(1983) average X-inefficiency: 23%
Ferrier and Lovell (1990) USA	Stochastic/parametric; SFA Deterministic/non-parametric; DEA	(1984) average X-inefficiency: 26%; average technological inefficiency: 21%
Aly, Grawbowski, Pasurka and Ragan (1990) USA	Deterministic/non-parametric; DEA	(1986) average technological inefficiency: 35%
Kaparakis, Miller and Noulas (1994) USA	Stochastic/parametric; SFA	(1986) average X-inefficiency: 12%
Berger (1995) USA	Stochastic/parametric; DFA	(1980-1989) average X-inefficiency: 39%
Berger and Mester (1997) USA	Stochastic/parametric; DFA	(1990-1995) average X-inefficiency: 13%; average profit-inefficiency: 9%
Developed European countries		
Berg (1992) NO	Deterministic/non-parametric; DEA	(1984-1990) average technological inefficiency: 44%
Lang and Welzel (1996) DE	Deterministic/non-parametric; DEA	(1989-1992) average technological inefficiency: 43%
Bos and Kool (2001) NL	Stochastic/parametric; SFA	(1992-1998) average X-inefficiency: 26% average profit-inefficiency: 44%
Koetter (2004) DE	Stochastic/parametric; SFA	(1994-2001) average X-inefficiency: 9-27%
Among old EU member states		
Allen and Rai (1996) AT, BE, DE, DK, FI, FR, GB, IT, SW	Stochastic/parametric; SFA; DFA	(1988-1992) average X-inefficiency: 20%
Bikker (1999) BE, DE, FR, IT, LU, NL, ES, UK	Stochastic/parametric; SFA	(1989-1999) average X-inefficiency: 53%
Dietsch and Weill (2000) DE, FR, IT	Stochastic/parametric; SFA; DFA	(1993-1997) average X-inefficiency: 16%; average profit-inefficiency: 17%
Lozano-Vivas, Pasto and Hasan (2001) AT, BE, DE, DK, FI, FR, GB, IT, LU, PT	Deterministic/non-parametric; DEA	(1993) average technological inefficiency: 34%
Bikker (2002) AT, BE, DE, DK, FI, FR, GB, GR, IE, IT, LU, NL, PT, ES, SE	Stochastic/parametric; SFA	(1990-1997) average X-inefficiency: 30%;
Weil (2004) AT, BE, DE, DK, FI, FR, GB, GR, IT, LU, PT, ES	Stochastic/parametric; SFA; DFA	(1994, 2000) average X-inefficiency: 35%;
Transition economies		
Tóth (1999) HU	Deterministic/non-parametric; DEA	(1996-1997) average technological inefficiency: 40%
Király et al. (2000) HU	Stochastic/parametric; SFA	(1994-1997) average X-inefficiency: 14%
Kasman (2002) TR	Stochastic/parametric; SFA	(1988-1998) average X-inefficiency: 25%
Hasan and Marton (2003) HU	Stochastic/parametric; SFA	(1993-1997) average X-inefficiency: 25%; average profit-inefficiency: 30%
Among transition economies		
Yildirim and Philippatos (2002) BU , CZ, CRO, EE HU, KAZ, LV, LT, MAC, PL, RO, RUS, UCK, SI, SK	Stochastic/parametric; SFA; DFA	(1993-2000) average X-inefficiency: 24%; 36% average profit-inefficiency: 38%; 54%
Grigorian and Manole (2002) ARM, BEL, BU, CRO, CZ, EE, HU, KAZ, LV, LT, MO, PL, RO, RUS, SI, SK, UKR	Deterministic/non-parametric; DEA	(1995-1998) average technological inefficiency: 47%
Among old and new EU member countries		
Kosak and Zajc (2004) AT, BE, CY, CZ, DE, EE, HU, IT, LT, LV, MT , NL, PL, SI, SK	Stochastic/parametric; SFA	(1996-2003) average X-inefficiency: 16.7%
Tomova (2005) BU, CRO, CZ, EE, FR, HU, PL, PT, RO, ES, SI, SK	Deterministic/non-parametric; DEA	(1993-2002) average technological inefficiency: 55%

Notes: USA (United States of America), EU (European Union), ARM (Armenia), AT (Austria), CRO (Croatia), CY (Cyprus), CZ (Czech Republic), BE (Belgium), BEL (Byelorussia), BU (Bulgaria), DE (Germany), DK (Denmark), EE (Estonia), ES (Spain), FR (France), FI (Finland), GB (Great Britain), GR (Greece), HU (Hungary), IE (Ireland), IT (Italy), KAZ (Kazakhstan), LT (Latvia), LU (Luxemburg), LV (Lithuania), MAC (Macedonia), MO (Moldova), MT (Malta), NL (The Netherlands), NO (Norway), PL (Poland), PT (Portugal) RO (Romania), RUS (Russia), SI (Slovenia), SK (Slovakia), SE (Sweden), TR (Turkey), UKR (Ukraine). DEA: Data Envelopment Analysis; SFA: Stochastic Frontier Approach; DFA: Distribution Free Approach.

[11] In the table, transition economies in Europe comprise a separate category, irrespective of the geographical location of the country.

[12] The inefficiency is measured on a scale from 0% to 100%. Bank without inefficiency term has efficiency score of 100% and inefficiency score of 0%.

Notice that the results from different empirical research are comparable only to a limited extent. The efficiency scores are influenced by several factors: the different methods (parametric, non-parametric), the dissimilar sample and considered distorting factors. Non-parametric approaches are unable to distinguish the inefficiency component from the random error term; therefore the inefficiency component can be over-calculated. Thus we cannot make a comparison between efficiency scores generated by non-parametric and parametric methods even if identical samples are used.[13]

Applying the same method the efficiency levels allow much easier comparison with each other for an identical sample. In the pioneering work of Berger and Mester (1997), the authors investigated and compared the results of the parametric methods under different assumptions on inefficiency components, functional form and model specification. Their results suggest that, the prior assumptions are of not much relevance in determining the efficiency scores in the case of same sample and period. In case of different samples, despite using the same approaches the level of efficiency becomes at once not comparable. A serious problem is raised namely the estimated efficient frontiers are not identical across samples.

Finally the comparison of different countries banking systems is quite problematic in that with the measurement of X- and alternative profit efficiency there are a lot of country specific factors on which the management has no influence. These elements can distort the outcomes and raise several difficulties in comparing countries' banking systems. A significant part of the empirical literature making cross-country comparison such as Yildirim and Philippatos (2002), Weill (2004), Kosak and Zajc (2004) and Tomova (2005) did not take home bias on efficiency into consideration. This may cause bias in estimation of efficiency level since it may capture both the effects of operational environment and managerial ability.

The ultimate goal of efficiency research is to decompose the effects of managements' ability and operational environment on banks' operation. That is the reason why efforts should be made regarding controlling for factors which are exogenous from the point of view of management behaviour. Those considerations that suggest that the effects of these factors are incorporated in the random error component cannot be accepted. Several examples can be found in the literature, which tried to decompose the effects of operational environment and managerial ability on efficiency. In the papers of Bikker (1999), (2002) and Maggi and Rossi (2003) the initial generation of the inefficiency components was conditioned by the inclusion of country dummy variables. Note that, however, country dummy variables may capture not only the discrepancies in operational environment, but may also filter the average efficiency differences among countries driven by dissimilar managerial quality. As a different approach Grigorian and Manole (2002) as well as Bos and Kool (2004) estimated efficiency scores in the first stage, then in the second stage regressed them on a set of local market and macroeconomic variables. In the SFA framework, however, this approach has a serious econometric problem. It assumes in the first stage that the inefficiencies are identically distributed, but this assumption is contradicted in the second stage regression in which predicted efficiencies are assumed to have a functional relationship with the explanatory variables.[14]

[13] Non-parametric approaches measure technical, while parametric approaches measure both technical and allocative efficiencies.

[14] In the DEA and DFA frameworks it is not a problem since we do not have to take any prior distributional assumption on inefficiency term. See Kumbhakar and Lovell (2000) for details.

3. Methodological background

In this section we give a short technical overview of the parametric approaches (i.e. functional form, the estimation of inefficiency component). We attempt to briefly summarise the advantages and disadvantages of such methods, which serve as the basis for selecting the appropriate procedure.

3. 1. POSSIBLE FUNCTIONAL FORMS USED FOR ESTIMATING THE EFFICIENT FRONTIER

We preferred to apply the so-called parametric approach in the course of our research, on the assumption that the efficient frontier is generated by a certain functional form. In the literature there is no consensus about this functional form. However this is a fundamental question, since the efficiency scores can be generated by the decomposition of the error terms of the estimated cost-(profit) function.

In estimating cost function and measuring banks' X-efficiency a certain relationship between operational cost, input prices and output quantities has to be assumed. The general form of the cost function is the following:

$$\ln TC_i = C\left(y_i, w_i; \beta\right) + \varepsilon_i \tag{1}$$

where TC_i is the total cost of bank i, y_i is the natural logarithm of the output, w_i is the natural logarithm of input prices, $\boldsymbol{\beta}$ is the unknown parameter vector to be estimated.

A prior assumption about the form of $C(y_i, w_i, \beta)$ has to be taken. Most studies of X-efficiency compute efficiency scores from Translog cost equations. The translog functional form was first introduced by Christensen, Jorgenson and Lau (1971). This form has several advantages a) it is compatible with multiple output production without violating the curvature conditions of the cost(profit) function; b) it provides a second-order Taylor series approximation of an arbitrary function at the mean of the data. The main disadvantage of this functional form as pointed out by White (1980) is that it is a local approximation method and the least squares estimates of the translog polynomial might produce biased estimates of the series expansions. McAllister and McManus (1993) found that the high level of sample heterogeneity (the sample includes small, medium and large banks) causes White-type bias. Furthermore, the multi-colinearity between independent variables limits the accuracy of parameter estimates, likely also affecting those which we use in the process of decomposing error components. Thus the cost of flexible application is statistically insignificant parameter estimates. For the above reason, the translog cost (profit) frontier is seldom applied as a single equation method; parameters are rather estimated within a system, jointly with factor demand functions derived with the help of the Shepard lemma. However, multiple-equation estimation does not treat the problem of sample's heterogeneity and may produce the aforementioned White-type bias.

A possible alternative to the translog is the Fourier-flexible functional form. This is a semi-nonparametric approach, which is able to represent the relationship among variables, when the true functional form in unknown.[15] Another advantage of Fourier-flexible form compared to the translog is that this is a global approximation estimation method. The estimation procedure adjusts distortions arising from heterogeneity with the help of normalizing size and other selected variables.

Gallant (1981) designed the combination of second-ordered polynomials and truncated Fourier-series as Fourier-flexible functional form.[16] The most substantial criticism formulated in relation to the procedure is that an infinite number of trigonometric terms are required for the exact representation, requiring an infinite number of observations. Given a finite number of observations the optimal subset of trigonometric terms should be found.[17] Gallant (1981) highlighted that the second-order polynomial also has a Fourier-series representation and therefore the unknown function can achieve a given level of approximation error with fewer trigonometric terms.

[15] Gallant (1981), Elbadawi, Gallant and Souza (1983) and Eastwood and Gallant (1991) study the Fourier flexible functional form.
[16] In the Fourier-flexible form the representation of the second order polynomial is the translog.
[17] More detail can be found in Technical appendix 1.

In the article of Mitchell and Onvural (1996), several estimates were performed by changing the number of trigonometric components. Their findings suggested that the cost function of the banking industry cannot have the translog form.[18] The conclusions question the credibility of earlier translog based approaches. Nevertheless, many researchers prefer to apply the translog form, particularly with reference to the study of Berger and Mester (1997). For the above reasons, our research applies the Fourier-flexible form.[19] Our estimate of the Fourier-flexible cost and alternative profit function is as follows[20]:

$$\ln\left(\frac{\pi}{w_3}\right);\ln\left(\frac{TC}{w_3}\right)=\beta_0+\sum_m\alpha_m\ln y_m+\sum_n\beta_n\ln\left(\frac{w_n}{w_3}\right)+\frac{1}{2}\sum_m\sum_p\alpha_{mp}\ln y_m\ln y_p+\frac{1}{2}\sum_n\sum_r\beta_{nr}\ln\left(\frac{w_n}{w_3}\right)\ln\left(\frac{w_r}{w_3}\right)+$$
$$+\sum_n\sum_m\gamma_{nm}\ln\left(\frac{w_n}{w_3}\right)\ln y_m+\sum_m\left[\delta_m\cos z_m+\theta_m\sin z_m\right]+\sum_m\sum_p\left[\delta_{mp}\cos\left(z_m+z_p\right)+\theta_{mp}\sin\left(z_m+z_p\right)\right]+\varepsilon \tag{2}$$

where TC corresponds to total cost, π is the pre-tax profit, y_m is the m^{th} output (m=1, 2, 3), w_n is the n^{th} input price (n=1, 2, 3), w_3 is the price of financial input, ε is the error term (p, r equal to 1, 2, 3 based on the number of outputs and inputs). Indices applied to banks have been omitted for the purpose of simplification. Symmetry and linear homogeneity require the following parameter restrictions:

$$\alpha_{mp}=\alpha_{pm},\ \beta_{nr}=\beta_{rn},\ \sum_{n=1}^{3}\beta_n=1,\ \sum_{r=1}^{3}\beta_{nr}=0,\ \sum_{n=1}^{3}\gamma_{nm}=0 \tag{3}$$

For the application of Fourier-flexible form the scaling of data is also necessary.[21] Following Altunbas et al (2001) normalization of bank outputs shows the following formula:

$$z_m=0.2\pi+(1.6\pi)\frac{\ln y_m-\ln y_{m,\min}}{\ln y_{m,\max}-\ln y_{m,\min}} \tag{4}$$

3. 2. DECOMPOSITION OF X- AND ALTERNATIVE PROFIT EFFICIENCY[22]

The efficiency scores can be derived from the error terms of the above described cost-(profit) function. The most commonly used estimation techniques are the Stochastic Frontier Approach (SFA) and the Distribution Free Approach (DFA).[23]

With regard to the stochastic frontier approach (SFA), we isolate the inefficiency component from random error by assuming a two-sided normal distribution for the random error component and one-sided distribution for the inefficiency component. By following the SFA procedure, the definition of X-efficiency is as follows:

$$X-eff_i=\frac{C\left(y,w,\beta\right)\exp\left(v_i^{X-eff}\right)}{TC_i}\approx E\left[\exp(-u_i^{X-eff}\mid\varepsilon_i^{X-eff})\right]\text{, where} \tag{5}$$

$$TC_i\geq c\left(y,w;\beta\right)\rightarrow 0\leq X-eff_i\leq 1 \tag{6}$$

[18] The authors tested the significance of trigonometric parameters and found that these parameters differed significantly from zero.

[19] However in our empirical analysis the robustness of results steaming from Fourier flexible function form was tested by restricting the Fourier terms to be zero, i.e. by switching to translog functional form.

[20] The alternative profit function is unique in the sense that its explanatory variables correspond to its cost function; its dependent variable, however, corresponds to profit. Since profit may not be a negative value, it may cause problems in relation to logarithmisation. The problem may be remedied by adding a constant to each profit value, which is at least as high as the highest loss in the sample.

[21] More detail can be found in Technical appendix 2.

[22] This chapter is based on the works of Kumbhakar and Lovell (2000) and Greene (1993), (1997).

[23] The stochastic frontier approach may be applied to both cross-section and panel samples, the distribution free approach only to panel samples.

The X-efficiency is the ratio of minimum incurred cost to observed expenditure for bank *i*.[24] The first half of the numerator – identical for all banks – represents the deterministic component; the second component is the bank-specific random term. The error term of equation (2) can be decomposed as follows: $\varepsilon_i^{X-eff}=v_i^{X-eff}+u_i^{X-eff}$, where v_i^{X-eff} is the two-sided random noise and u_i^{X-eff} is the non-negative X-inefficiency component. The u_i^{X-eff} inefficiency term is added to the random noise, since the estimated frontier represents the minimal cost of production. Banks with small u_i^{X-eff} are closest to the frontier, while the distance grows from the frontier with the rise in u_i^{X-eff}, entailing the rise in X-efficiency loss.

The alternative profit efficiency is formulated as follows:

$$\pi - eff_i = \frac{\pi_i}{\pi\left(y, w; \beta\right) \exp\left(v_i^{\pi - eff}\right)} \approx E\left[\exp(-u_i^{\pi - eff} \mid \varepsilon_i^{\pi - eff})\right] \tag{7}$$

$$\pi_i \leq \pi\left(y, w; \beta\right) \rightarrow 0 \leq \pi - eff_i \leq 1 \tag{8}$$

Alternative profit efficiency corresponds to the ratio of observed profit and maximum feasible profit. During the decomposition of the error term, the inefficiency component is subtracted from the random noise: $\varepsilon_i^{\pi-eff}=v_i^{\pi-eff}-u_i^{\pi-eff}$. The obvious explanation for the above is that in this case the profit frontier incorporates the maximum feasible profit. Those banks that have lower $u_i^{\pi-eff}$ (inefficiency term), are closer to the best-practice bank, while banks with higher $u_i^{\pi-eff}$ can be found farther from the optimal frontier. The deviation is negative, since moving toward this direction the banks experience profit loss. The case of the cost frontier is reversed. Deviation from the frontier is positive, since the frontier represents the minimal cost of production. Moving toward the positive direction banks' inefficiency is on rise.

In the distribution free approach prior assumptions about the distribution of the inefficiency component is not required. If panel data are available, the X-efficiency term can be produced using the following from:

$$X - eff_i = \frac{C\left(y_i, w_i, \beta\right) \exp\left(v_i^{X-eff}\right)}{TC_i} \approx \exp\left[-(\hat{\varepsilon}_i^{X-eff} - \min(\hat{\varepsilon}_i^{X-eff}))\right], \text{ where} \tag{9}$$

$$\hat{\varepsilon}_i^{X-eff} = \frac{1}{T}\sum_t \hat{\varepsilon}_{it}^{X-eff} \tag{10}$$

With an analogous way the alternative profit efficiency can be generated as well.

The main criticism of the approach is that based on the prior assumption inefficiency term does not vary over time. This becomes less tenable if the time dimension of the sample is long, since the inefficiency component would certainly not remain constant due to the adaptation processes. In this respect the sample with a relatively short time horizon is more adequate. However, if the time period is short the random error might not average out and may bias the inefficiency component.

Equations (5) and (7) well indicate that the relationship between X-efficiency and alternative profit efficiency is unambiguous if we consider a clearly competitive market structure or control for any market imperfections in the microeconomic sense. In this case alternative profit efficiency arises from X-efficiency and vice versa, since the management is not able to influence prices and market prices are not biased by informational asymmetry. In "real life" the link is not obvious. In the short run because of non-competitive banking behaviour and other distorting factors, profit efficiency cannot be derived from X-efficiency and vice versa. In the long run, however, only banks with similar X-efficiency and alternative profit efficiency may operate on the market due to the exit and liquidation of inefficient competitors.

[24] As the formula indicates the efficiency is measured on a scale from 0 (or 0%) to 1 (100%). Bank without inefficiency term (*u* equals to zero) has efficiency score of 1 (or 100%).

3. 3. THE MEASUREMENT OF CONVERGENCE

Although many works have been published on efficiency research, few studies deal with efficiency convergence. However, convergence provides substantial information about the evolution of heterogeneity among banks. In the EU the speed of convergence in the financial system is particularly relevant from the perspective of the degree of integration.

This section follows the notation of *T.* Young et al. (2003), who compares the two major indicators of convergence: σ- and β-convergence. The σ-convergence[25] measures the change of standard deviation of a given variable over time, while β-convergence determines the correlation between growth in efficiency over time and its initial level. The following derivation well illustrates the relation between the two concepts:

$$\ln(eff_{it}) = a + (1+\beta)\ln\left(eff_{i,t-l}\right) + \varepsilon_{it} \tag{11}$$

by forming equation (11),

$$\ln\left(\frac{eff_{it}}{eff_{it-l}}\right) = a + \beta\ln\left(eff_{i,t-l}\right) + \varepsilon_{it} \tag{12}$$

where $eff_{i,t}$ corresponds to the efficiency score of bank *i* at period *t,* $eff_{i,t-l}$ is the efficiency score of bank *i l* period before. β-convergence exists if the coefficient β is negative. This means that if the efficiency improves 1% the efficiency gap will close with β%. Since the variance of the sample is the following:

$$\sigma_t^2 = \left(\frac{1}{N}\right)\sum_i\left[\ln(eff_{it}) - \overline{\ln(eff_{it})}\right]^2 \tag{13}$$

thus,

$$\sigma_t^2 = (1+\beta)^2\sigma_{t-l}^2 + \sigma_\varepsilon^2 \tag{14}$$

As equation (14) shows, the β-convergence $(-1<\beta<0)$ is necessary, but due to the presence of noise component there is insufficient condition for σ-convergence.[26] In our study we measure β-convergence, since it proves to be a less restrictive approach than σ-convergence, and the method is widely used in empirical literature.[27]

[25] In much empirical literatures the standard deviation is used instead of relative standard deviation. In the measurement of convergence the level is of no relevance therefore employment of relative standard deviation is more appropriate.

[26] In the relationship of the two types of convergence the prior assumption of the constant standard deviation and the correlation of the "noise" play an important role.

[27] Weill (2004) and Tomova (2005), among others, applied β-convergence in their studies.

4. Empirical analysis

In the empirical analysis we first compare the operational environment of EU banking systems, then define variables used in the econometric model; after this, we describe the main characteristics of the sample. Finally we review our empirical results, including the estimation of efficiency and convergence.

4. 1. EUROPEAN UNION WIDE COMPARISON OF BANKING SYSTEMS' OPERATIONAL ENVIRONMENT

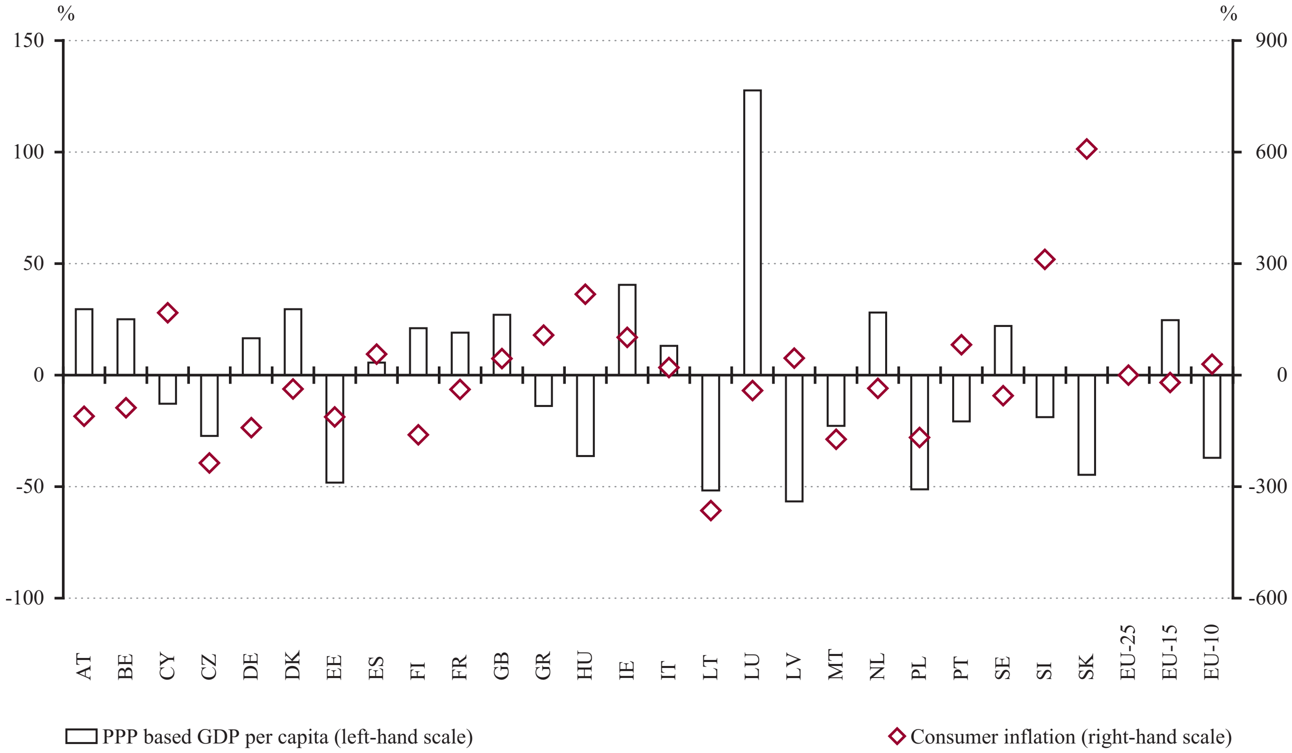
The enlargement of the EU substantially increased heterogeneity among member countries' banking systems. As a consequence of the common economic convergence path and regulatory harmonisation imposed by the "Acquis Communautaire", the integration of the newcomers' banking systems has strengthened over the last decade. However, in terms of macroeconomic and regulatory environment, depth of financial intermediation and market structure several differences across EU member countries still persist. Since the characteristics of a financial system's operational environment – often shaped independently of the "conscious" behaviour of management – may have an impact on the results and conclusions of efficiency measurement, on investigation of the main causes of home bias is required.

4. 1. 1. Macroeconomic environment

The EU member countries have entrenched macroeconomic stability over the last decade. The majority of old member states fulfilled nominal convergence, the Maastricht criteria, and introduced the common currency, the euro, in 1999. In eight of the ten new member countries the transition from a centrally planned to a market-based economic regime and the rapid economic growth accompanying it opened the way for real convergence with the EU and nominal convergence

Chart 1

Distance of economic development and inflation from the EU-25 average denoted in percentages (2003)



Note: EU-15 encompasses old EU members, while EU-10 denotes new EU members.
Source: Eurostat.

with the five pillars of euro standards (price and exchange rate stability, fiscal balance, low general government debt, convergence of long-term interest rates). However, despite the rapid catching-up process, major economic differences remain, particularly between old and new member states.

Regarding the real economic convergence it should be noted that although in the new member countries economic and productivity growth far exceeds that of the old members, the level of development still falls behind. The average level of new members' development measured with GDP per capita in PPP terms is approximately two thirds that of old ones. Only the Cyprus, Malta and Slovenia pass this level.

With respect to nominal convergence it should be highlighted that, prior to the introduction of euro, the inflation of old member countries had dropped sharply and reached the level of price stability. Furthermore, over the transition period sound macroeconomic and structural policies succeeded in lowering inflation in the new member countries as well. Thus, at aggregated level the gap between the average pace of inflation in old and new member states has substantially narrowed. However, the inflationary dispersion between member countries remains virtually unchanged in relative terms. Regarding the old members, the dispersion is mainly caused by existing differences in economic openness and competitiveness. As for the newcomers, the high relative standard deviation of inflation is explained by the fact that only six out of the ten countries (i.e. excepting Cyprus, Hungary, Slovakia and Slovenia) achieved price stability as imposed by the Maastricht criteria as early as 2003.

The common monetary policy has decreased the dispersion of interest rates across euro-area countries and led to higher price homogeneity. In relation to long term interest rates, all new EU member states have fulfilled the convergence criteria, with the exception of Hungary. In the case of short-term interest rates, however, high variability across newcomers can still be observed due to the differences in inflation rates as well as risk premiums influenced by fiscal balance and exchange rate fluctuations.

The majority of EU countries complies with the threshold for the budget deficit and public debt ratio. In some larger old member states (Germany, France) and in half of the new member countries (Czech Republic, Hungary, Malta, Poland and Slovakia), however, a deterioration in the fiscal balance can be observed. For the old members the Stability and Growth Pact, and in the case of new members the required introduction of the euro may curb further fiscal divergence.

4. 1. 2. Regulatory environment

After the 1980s the EU financial sector underwent considerable changes due to several waves of liberalisation (free flow of capital) and deregulation (establishment, activity and liquidation of credit institutions). Following the European Commission's White Paper (1986), the Second European Directive (1989) with the two parallel Directives on Solvency Ratios and Own Funds, the introduction of the Single European Licence (1993) and the Financial Service Action Plan (1999), the convergence of regulatory systems was considerably accelerated.[28] Since the new EU members already complied with the most important European directives, the EU enlargement slowed down but did not suspend the continuous harmonisation of financial regulations and the creation of a suitable supervisory architecture.[29]

It is essential to highlight that, although accomplishment of the majority of European directives has eased heterogeneity in regulation and standards in recent years, some differences still persist. The stringency of regulation shows significant dispersion among EU countries, reflecting the variety of domestic financial markets, legislations and supervisory practices.[30] In addition, within financial regulation but above the directives, i.e. over the level of minimum standards, notable differences can be observed as well. Mention can be made here of consumer protection schemes, safeguarding of minority shareholders' interests, corporate governance, stimulation of disclosure, competition and efficiency improvement.

[28] In the future the largest challenges for the EU are linked to the harmonisation of different regulations concerning mortgage lending, fund management, financial advisory services, money laundering and insurance as well as the implementation of Basel II and, in the case of new members, the adoption of the euro.

[29] However, several EU countries are yet to fully adopt common guidelines regarding credit co-operations and deposit insurance schemes. In addition, some new member states must proceed with harmonisation with European directives on regulation-related capital adequacy, operation of branches and subsidiaries, and bankruptcy laws.

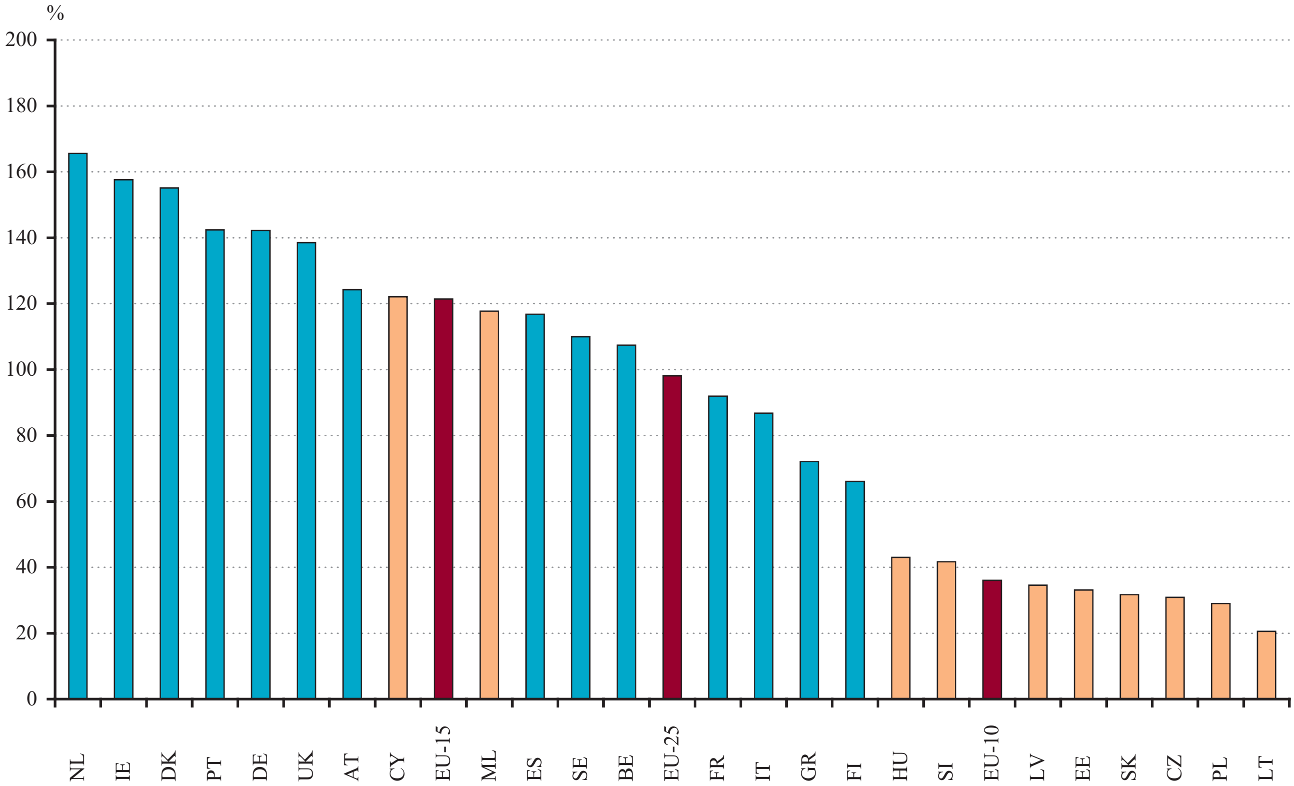
[30] Cervalatti (2003) investigates this issue in detail.

4. 1. 3. The depth of financial intermediation

Among the major factors linked to the operational environment, the largest differences among EU member states arise in relation to financial intermediation. The average total loans to GDP ratio of new members (36%) is less than one third of the rate of old members (125%).

Chart 2

Banks' lending to the private sector as a percentage of GDP in the EU member countries (2003)



Note: Luxemburg was not represented in the Chart 2 as in this country the private sector loans to GDP ratio is very high, above 500%.
Source: ECB: Report on EU Banking Structure (November 2004).

In terms of the level and the development of financial intermediation new members can be divided into three well definable groups. The GDP-proportionate level of loans provided by the banking system to the private sector in Cyprus and Malta had reached the average rate of old EU member states as early as 2001. The rapid growth of the banks' economic role in these two countries is attributed to the early wave of privatisation, accelerated financial liberalisation and the stable growth rate of the economy. The second group includes the Czech Republic and Slovakia, where the depth of financial intermediation approximated the minimum level of old member states (60%) as early as 1998 due to intense financing of state-owned enterprises and early capital liberalisation. Nevertheless, private sector loans to GDP was roughly halved by 2003 (30%) due to, firstly, the considerable portfolio-cleaning and tightening regulation and, secondly, the strong knock-out effect of the budgetary sector. In the third group can be ranged the Baltic countries (Estonia, Lithuania[31] and Latvia), Poland, Hungary and Slovenia where the financial intermediation has constantly gained depth only since 1999. However, despite the upward trend, the lag of these countries relative to the old members' average has not diminished measurably.

The low depth of financial intermediation witnessed in the majority of new EU members is linked to numerous common factors. The Central-Eastern European countries and the Baltic States suffered from renewed recession and experienced output loss during the transition from socialist to market economy, which weakened loan demand and

[31] The depth of financial intermediation is the lowest in Lithuania, due to – over and above common factors – to numerous bank crises.

also supply through the increasing level of non-performing exposure. In the stabilisation phase following the macroeconomic and bank crises, the privatisation and recapitalisation of banks and the establishment of an adequate and essential regulatory architecture consumed several years. The low depth of financial intermediation observed in new EU member states may also be explained by the fact that the banking sector is competing on the international corporate financing market linked to the predominant role of foreign-owned multinational corporations. Furthermore, another feature of banking markets which needs to be addressed is the accelerating disintermediation. Banks' intermediation on the liability side is gradually decreasing, owing to the increasing role of non-bank financial intermediation. Falling bank interest rates and the development of financial culture are resulting in growing proliferation of non-bank forms of savings.

Finally it should be stressed that a strong discrepancy in the depth of banking intermediation can also be observed among the old members. The private sector loans to GDP ratio is lower in Finland, Greece and France, and higher in the Netherlands, Ireland, Denmark, Portugal and Germany compared to the average. The cross-sectional dispersion of financial depth is probably caused by the varying role assigned to the capital market in financing, the dissimilar stringency of regulation and other country-specific characteristics.

4. 1. 4. Market concentration

As a result of the consolidation process, the new EU member states have not only succeeded in narrowing the gap between themselves and old member states in economic and regulatory areas and in financial intermediation, but also in relation to market structure. Even so, considerable differences in market concentration still persist across the member states.

In the new member states, following the creation of a two-tier banking system the privatisation and recapitalisation of state-owned banks as well as several new entries fostered the break-up of the initial monopolistic market structure.

Chart 3

The concentration of banking systems in the EU member countries (2003)

Note: Concentration is defined as the sum of the five largest banks' market share in terms of total assets.
Source: ECB: Report on EU Banking Structure (November 2004).

Higher competition and the dominant degree of foreign ownership[32] encouraged the implementation of best practices (advanced risk management, corporate governance techniques and accounting methods) and the transfer of know-how and well educated labour forces enhanced productivity gains and integration.[33] In the second half of the 1990s, mergers and acquisitions as well as numerous bank liquidations suspended the falling concentration of the banking system and stabilised the oligopolistic market structure.

By comparing the sum of the five largest banks' market share in terms of total assets, only Poland and Hungary among the newcomers have market concentration as low as that of the old member states' average, owing to the relatively large size of their banking systems.[34] Mainly due to small market size and an inherited distorted market structure, the rest of the new EU member countries have banking sectors characterised by strong concentration (the sum of the five largest banks' market share spreads between 63% and 100%).

The market structure of old EU member states is also undergoing transformation. Contrary to trends in the group of new EU member countries, the average concentration in old member states is at relatively low level. However, it has constantly edged higher in the recent years, in parallel with an increasing number of mergers and acquisitions, which aimed at boosting market power and/or improving efficiency. Nevertheless, the concentration of the old members' banking sectors remains relatively low, while its dispersion (the concentration ranges from 22% to 84%), which is closely related to the significant differences in market size, still exceeds that of the new members.

4. 2. VARIABLES

When selecting variables of equation (2) the first difficulty is posed by the definition of costs, input prices and outputs, i.e. the components of bank production. In the related literature two concepts have been adopted: "the intermediation approach" and the "production approach". The intermediation approach considers banks' deposits as inputs in the production process. Contrary to the above, the production approach claims that deposits and various bank liabilities are also outputs.[35] In our study following Sealey and Lindley (1977), we employ the intermediation approach. We suppose a multi-output production model. In our model the firms produce three outputs with three inputs. The outputs are defined as loans[36], other earning assets and non interest revenues, while the inputs are defined as labour, physical capital and borrowed funds. As data on the number of employees are not available, labour cost for every bank is measured by the ratio of personnel expenses to total assets. The price of physical capital is approximated by the ratio of the difference of non-interest and personal expenses to fixed assets.[37] The price of borrowed funds of a certain bank is equal to the average of the cost of funds paid by the remaining banks in the same country. Cost of funds corresponds to the ratio of interest expenses to interest-bearing liabilities.[38] The total cost is defined as the sum of interest paid and non-interest expenses for every bank. We use pre-tax profit for the estimation of the profit frontier.

In addition to the selection of output and input variables, the other major challenge is linked to the selection of the auxiliary variable serving to reduce the heterogeneity arising between countries and banks. The application of a Fourier-flexible functional form can moderate the heterogeneity related to size.[39] For the purpose of further reducing the distorting

[32] Among the new members the degree of foreign involvement can be considered low (36%) only in Slovenian banking sector. Among the rest of the new EU members 50-99% of the banking sector is in foreign hands.

[33] The effect on efficiency of the connection between parent banks and subsidiaries can be regarded as a very important feature. This could be a theme for future research.

[34] In large countries more banks may be able to reach the adequate scale, while in small markets only fewer banks may achieve the optimal scale of production.

[35] A lesser known, but interesting aspect of the literature is the user cost approach. It is based on the following premise: the net income generating capability of a monetary instrument determines whether it is an input or an output in the production process. According to Hancock (1991) if the financial returns on an asset exceed the opportunity cost of funds, the given instrument is deemed to be a financial output; otherwise it corresponds to input. The problem with this approach is that interest rates and user costs fluctuate over time. It is possible that an item which is deemed to be an input in a given period may correspond to output in another period.

[36] The database does not enable us to separate loans into categories.

[37] We assume that unit labour cost is exogenous to the banks' behaviour. The ratio of personnel expenses and the number of employees does not take the productivity of the labour force into account.

[38] We attempt to measure exogenous deposit prices. Koetter (2004) finds that average cost-efficiency is sensitive to endogenous or exogenous specifications for deposit prices.

[39] It is not unambiguous that in all cases the size differences bias the measurement of efficiency. A large bank compared to a small or medium sized firm might be more scale-efficient, and may attract higher qualified management. At the same time, managing a larger firm is a more complex task. The counter-effects may "extinguish" each other.

effect of varying size and other operational bias (macro and regulatory environment, market structure), the use of environmental variables, such as inflation, depth of financial intermediation, market concentration, level of liberalisation and banking reform is also warranted.[40] The first equation (uncontrolled model) only contains the input and output variables and trigonometric terms, while the second alternative equation (controlled model) is expanded with the above mentioned country-specific variables.[41, 42]

4. 3. DATA DESCRIPTION

Data are taken from Bankscope[43] and cover 2459 banks from the 25 member states of the EU. Our sample includes commercial, cooperative and saving banks.[44] We attempted to establish our database from unconsolidated data; if this was not possible we collected consolidated data. Banks whose dependent or independent variables were not available were removed from the sample. The period of observations runs from 1999 to 2003 on account of data quality.[45] The descriptive statistics, attached as an annex 2, clearly indicate that, according to the number of banks and asset size, the coverage of banking systems in the new and old member states is different. In the old member states large banks are over-represented and small banks are under-represented. Our sample contains 20-50% of operating banks in the old EU member states; nevertheless the coverage of the banking system according to total assets is between 70% and 90%. Sweden and England comprise an exception, enabling coverage of only 40-50% due to insufficient data. Conclusions drawn in relation to these countries should be interpreted with caution. With regard to the new EU member states, the banking systems are well represented with respect to both bank number and balance sheet total.

The descriptive statistics further suggest that the differences in bank size among the countries are quite significant, warranting the use of a Fourier-flexible functional form and selected environmental variables. In the new EU member countries the average bank size is nearly one tenth of the size in the old member states. This average size is particularly high in Great Britain, the Netherlands and Finland, suggesting a significant economic role of bank financing and a rapid consolidation process. In contrast, in the Baltic States, due to their small size of economies and low level of financial intermediation, the average asset size of banks is very low.

4. 4. ESTIMATION RESULTS[46]

First SFA is applied. We compute the relative efficiency scores from the controlled and uncontrolled models[47] for every year under investigation, assuming exponential distribution of X- and alternative profit-inefficiency components. We check the robustness of the results by re-estimating the two equations with other prior assumptions about the distribution (i.e. half-normal, truncated normal) of inefficiency components. We also test the robustness of SFA result by applying different measurement methods, including use of DFA versus SFA, specification of the Fourier-flexible functional form versus the translog form. Furthermore, convergence in banks' efficiency within and across member states is assessed. Finally we analyse the relevance of accounting ratios and their correlation with statistical efficiency indicators.

[40] Due to the strong correlation (0.8) between levels of development and depth of financial intermediation PPP based GDP per capita was not used in cost and profit function as a control variable. Levine, Loayza and Beck (1999) empirically evidenced that the depth of financial intermediation correlates positively with the level of development and economic growth.

[41] In the basic equation the number of input and output variables and cross products is 20, the number of trigonometric terms is 18. In the expanded equation a further 5 parameters are estimated (parameters of inflation, depth of financial intermediation, market concentration, level of liberalisation and banking reform). Variables of uncontrolled and controlled model can be seen in Appendix 1.

[42] If independently of the operational environment the banks' main aim is to reach the lowest cost and highest profit function as soon as possible, then in the case of using proper control variables the efficiency scores measure only managerial ability. However, if banks have other strategic aims, such as a short-term profit target, we can only partially capture exogenous effects as we cannot control for the extent of pressure on efficiency improvement explained by operational environment. Overall, in the latter case we can only capture the direct and miss the indirect effects of operational environment on efficiency.

[43] Bureu van Dijk (2004).

[44] In our view using various banking types does not cause any significant heterogeneity problem since the applied model with three outputs and three inputs covers the main part of banking activities.

[45] We checked for outliers in the whole sample with the method of Hadi (1992), which identifies multiple outliers in multivariate data. Number of outliers varied between 128 and 186 during the sample period. However we did not remove outliers from the database for two reasons. First, outlier filtering would substantially decrease the coverage ratio of banking systems, particularly that of new EU countries. Second, removing outliers would considerably shrink the sample pool, i.e. degrees of freedom. All in all, the problem caused by outliers in our case is equivalent to the question of heterogeneity. The Fourier flexible functional form attempts to manage this problem in case of outputs, which is the main source of heterogeneity.

[46] For the estimation of SFA and DFA Frontier 4.1 (Coelli (1996)) and Stata 9.0 were employed.

[47] We used the Maximum Likelihood method to solve the parameters.

4. 4. 1. Efficiency scores

We first estimate X-efficiency scores of the individual banks generated by the uncontrolled model for every year, then compose the average efficiency for the various member states as well as for the old and new member countries and for the whole EU. Table 1 presents results, which indicate that over the investigated period the banking systems of the EU witnessed an average, a very moderate rise in X-efficiency. Our result confirms the existence of an efficiency gap between the two regions in favour of old members.[48]

Table 1

X-efficiency scores from the uncontrolled model

	1999	2000	2001	2002	2003	Average	Rank
AT	0.87	0.86	0.81	0.85	0.84	0.84	7
BE	0.87	0.88	0.81	0.85	0.86	0.85	6
CY	*0.62*	*0.65*	*0.66*	*0.65*	*0.68*	0.65	20
CZ	*0.61*	*0.64*	*0.63*	*0.67*	*0.67*	0.64	22
DE	0.88	0.87	0.88	0.89	0.90	0.89	2
DK	0.85	0.87	0.85	0.86	0.85	0.86	4
EE	*0.78*	*0.79*	*0.80*	*0.81*	*0.82*	0.80	12
ES	0.83	0.81	0.79	0.79	0.81	0.80	10
FI	0.90	0.88	0.88	0.87	0.88	0.89	1
FR	0.85	0.83	0.82	0.80	0.83	0.82	8
GB	0.84	0.82	0.79	0.77	0.81	0.81	9
GR	0.84	0.80	0.79	0.78	0.81	0.80	11
HU	*0.59*	*0.61*	*0.65*	*0.69*	*0.71*	0.65	21
IE	0.76	0.80	0.76	0.73	0.71	0.75	16
IT	0.87	0.85	0.85	0.87	0.89	0.86	3
LT	*0.67*	*0.64*	*0.65*	*0.69*	*0.73*	0.68	18
LU	0.79	0.70	0.75	0.77	0.80	0.76	14
LV	*0.58*	*0.58*	*0.63*	*0.60*	*0.65*	0.61	24
MT	*0.74*	*0.73*	*0.73*	*0.78*	*0.78*	0.75	17
NL	0.85	0.85	0.83	0.88	0.88	0.86	5
PL	*0.74*	*0.76*	*0.75*	*0.77*	*0.81*	0.76	15
PT	0.64	0.62	0.68	0.60	0.63	0.64	23
SE	0.81	0.77	0.77	0.75	0.80	0.78	13
SI	*0.59*	*0.64*	*0.68*	*0.66*	*0.70*	0.65	19
SK	*0.51*	*0.54*	*0.60*	*0.62*	*0.66*	0.59	25
EU-25	0.85	0.84	0.84	0.85	0.86	0.85	
EU-15	0.87	0.85	0.85	0.86	0.87	0.86	
EU-10	0.64	0.65	0.67	0.69	0.72	0.67	
Efficiency gap	*0.23*	*0.20*	*0.18*	*0.17*	*0.15*	*0.19*	

LogL	418.26	567.63	384.34	133.66	407.97
Ln(sigv_2)	-4.36	-4.63	-4.22	-4.31	-4.06
Ln(sigu_2)	-3.06	-3.12	-2.80	-3.02	-3.26
Sigma_v	0.11	0.10	0.12	0.12	0.13
Sigma_u	0.22	0.21	0.25	0.22	0.20
Sigma2	0.06	0.05	0.08	0.06	0.06
Lambda	1.92	2.13	2.04	1.90	1.49

Notes: SFA approach, with the prior assumption of exponential distribution regarding inefficiency component. In the table logL is the value of log-likelihood, σ_v is the standard deviation of the noise, σ_u is the standard deviation of the inefficiency component, $\sigma^2=\sigma_u^2+\sigma_v^2$, and $\lambda=\sigma_u/\sigma_v$.
The efficiency gap is the difference of average efficiency scores between the old and new EU member states' banking systems.

[48] Earlier, Kosak and Zajc (2004) supported the existence of an efficiency gap between the group of selected Western and Eastern European counties as well.

In the old EU member states, a stagnation in efficiency on a high level can be experienced, while in the new member states there has been a rapid catching-up process from a relatively low level. In the period examined, the efficiency gap between the two regions experienced a sharp fall from 23 percentage points in 1999 to 15 percentage points in 2003. Analysing the relative position from the common EU frontier Slovakia (59%), Lithuania (61%), Portugal (64%) can be mentioned as the least efficient, while Finland (89%), Germany (89%), and Italy (86%) can be rated as having the most efficient banking sectors on a five year average. The mean efficiency of the whole EU, old and new member states amounted to 85%, 86% and 67% respectively.

Table 2

X-efficiency scores from the controlled model

	1999	2000	2001	2002	2003	Average	Rank
AT	0.88	0.88	0.87	0.86	0.89	0.88	7
BE	0.89	0.88	0.86	0.87	0.90	0.88	6
CY	*0.87*	*0.81*	*0.79*	*0.80*	*0.86*	0.82	20
CZ	*0.82*	*0.84*	*0.81*	*0.83*	*0.84*	*0.83*	*18*
DE	0.95	0.94	0.92	0.90	0.92	0.93	1
DK	0.91	0.93	0.88	0.90	0.91	0.91	2
EE	*0.90*	*0.88*	*0.84*	*0.85*	*0.85*	0.87	11
ES	0.89	0.87	0.85	0.86	0.90	0.87	8
FI	0.90	0.90	0.89	0.88	0.89	0.89	3
FR	0.84	0.86	0.82	0.85	0.89	0.85	14
GB	0.82	0.87	0.85	0.86	0.85	0.85	15
GR	0.88	0.87	0.84	0.86	0.89	0.87	10
HU	*0.85*	*0.86*	*0.83*	*0.85*	*0.87*	0.85	13
IE	0.85	0.86	0.86	0.86	0.91	0.87	9
IT	0.90	0.88	0.85	0.88	0.90	0.88	5
LT	*0.67*	*0.64*	*0.65*	*0.69*	*0.73*	0.68	18
LU	0.80	0.77	0.76	0.80	0.80	0.79	22
LV	*0.75*	*0.76*	*0.75*	*0.73*	*0.74*	0.74	25
MT	*0.86*	*0.86*	*0.80*	*0.81*	*0.85*	0.84	17
NL	0.88	0.90	0.88	0.88	0.91	0.89	4
PL	*0.83*	*0.85*	*0.89*	*0.86*	*0.89*	0.86	12
PT	0.82	0.80	0.79	0.82	0.85	0.82	21
SE	0.87	0.84	0.84	0.84	0.87	0.85	16
SI	*0.74*	*0.83*	*0.76*	*0.74*	*0.80*	0.77	23
SK	*0.76*	*0.77*	*0.70*	*0.74*	*0.80*	0.75	24
EU-25	0.90	0.90	0.88	0.88	0.90	0.89	
EU-15	0.91	0.91	0.88	0.88	0.90	0.90	
EU-10	0.81	0.82	0.80	0.80	0.83	0.82	
Efficiency gap	*0.10*	*0.08*	*0.08*	*0.08*	*0.07*	*0.08*	

LogL	491.33	687.12	518.02	243.31	484.70
Ln(sigv_2)	-3.80	-3.89	-3.78	-3.34	-3.60
Ln(sigu_2)	-3.92	-3.90	-3.40	-3.57	-3.93
Sigma_v	0.15	0.14	0.15	0.19	0.17
Sigma_u	0.14	0.14	0.18	0.17	0.14
Sigma2	0.04	0.04	0.06	0.06	0.05
Lambda	0.94	0.99	1.21	0.89	0.85

Note: SFA approach, with the prior assumption of exponential distribution regarding inefficiency component.

Table 2 lists the results obtained from an alternative, i.e. controlled model, in which some "exogenous effects" that can influence costs were controlled.[49] The mean efficiency scores of the enlarged EU and old member states exhibit stability over time. It is noteworthy, however, that in 1999, the old and particularly the new members "started" from a higher efficiency level in comparison to the previous model. The efficiency gap between the old and new member states fell from 10 percentage points in 1999 to 7 percentage points in 2003, in contrast to the previous model. In the investigated period the mean efficiency scores amounted to 89% in the EU as a whole, 90% in the old member states and 82% in the new EU countries. Between 1999 and 2003, countries with the three least efficient and most efficient banking systems are as follows: Lithuania (74%), Slovakia (75%), Slovenia (77%) and Germany (93%), Denmark (91%), Finland (89%).[50] In the investigated period the mean efficiency scores amounted to 89% in the EU as a whole, 90% in the old member states and 82% in the new EU countries. The banking system of the EU has still room for improvement, as it could produce the same level of output with, ceteris paribus, 12.4% lower costs or, equivalently, with the same level of cost it could produce more output. Annual cost surplus for the entire EU corresponds to 0.7% of aggregate GDP.[51]

The results of the controlled and uncontrolled models reveal consistency in the sense that narrowing of the X-efficiency gap is observed in both cases. Nevertheless, the size of efficiency gap is smaller in the controlled than in the uncontrolled case.

No matter which the prior distributional[52] assumptions concerning the inefficiency component are used, our results remain relatively stable. The level of efficiency and the rank-ordering of countries did not change substantially under different SFA specifications. The rankings also remained relatively unchanged when we employed the distribution free approach. The rank-order correlations between exponential and other alternative cases ranged between 0.8 and 0.95.[53]

We also wanted to evaluate the effects of switching to the translog form in place of the Fourier-flexible form. Compared to Fourier model the translog specification provided lower level of efficiency scores and narrower efficiency gaps in all cases and slightly changed the rank ordering of countries. However, the conclusion drawn from estimated efficiency gaps of uncontrolled and controlled models remain consistent with that of the "Fourier-based" specifications.[54]

The models of the estimated alternative profit function fully correspond to the cost functions estimated in relation to X-efficiency, with the difference that in this case the dependent variable of our models is pre-tax profit.

[49] Appendix 6 suggests that selected country specific variables are of high relevance.

[50] The result for Germany reveals surprising finding. One rational explanation might be that German banks face very keen competition on the atomistic market, therefore closely focus on optimal allocation of resources and exploits technological opportunities. High cost-efficiency is accompanied by low profit-efficiency (shown later for uncontrolled case). However, one may think that cooperative banks are more cost-efficient than large banks since state guarantees give them access to cheaper funds, therefore due to the high number of "Landesbanks" Germany seems to have the most X-efficient banking system in the EU. We tested this hypothesis and found that dropping cooperative banks from the sample German banking system still remained the most cost-efficient.

[51] However, firms can only approach 100 percent efficiency level. Normally none of them can appear to be 100 percent efficient in SFA.

[52] We also estimated the efficiency scores besides alternative distributional assumptions about inefficiency (truncated normal and half normal distribution).

[53] The detailed results can be found in Appendix 3.

[54] The detailed result can be found in Appendix 5.

Table 3

Alternative profit efficiency scores from the uncontrolled model

	1999	2000	2001	2002	2003	Average	Rank
AT	0.71	0.70	0.69	0.69	0.70	**0.70**	**8**
BE	0.70	0.70	0.68	0.69	0.71	**0.69**	**10**
CY	*0.70*	*0.70*	*0.69*	*0.70*	*0.72*	**0.70**	**6**
CZ	*0.68*	*0.69*	*0.68*	*0.67*	*0.69*	**0.68**	**19**
DE	0.69	0.69	0.68	0.68	0.69	**0.69**	**16**
DK	0.69	0.70	0.68	0.68	0.70	**0.69**	**11**
EE	*0.76*	*0.72*	*0.73*	*0.75*	*0.79*	**0.75**	**1**
ES	0.70	0.69	0.68	0.69	0.69	**0.69**	**12**
FI	0.71	0.70	0.67	0.67	0.69	**0.69**	**17**
FR	0.69	0.69	0.68	0.68	0.69	**0.69**	**14**
GB	0.71	0.66	0.62	0.62	0.67	**0.66**	**25**
GR	0.68	0.68	0.66	0.67	0.73	**0.69**	**15**
HU	*0.74*	*0.72*	*0.71*	*0.73*	*0.79*	**0.74**	**2**
IE	0.68	0.67	0.67	0.66	0.65	**0.67**	**23**
IT	0.68	0.69	0.69	0.69	0.70	**0.69**	**13**
LT	*0.66*	*0.65*	*0.68*	*0.68*	*0.69*	**0.67**	**22**
LU	0.72	0.70	0.66	0.65	0.70	**0.68**	**18**
LV	*0.70*	*0.66*	*0.68*	*0.66*	*0.70*	**0.68**	**20**
MT	*0.70*	*0.71*	*0.69*	*0.68*	*0.71*	**0.70**	**9**
NL	0.69	0.71	0.70	0.70	0.71	**0.70**	**5**
PL	*0.69*	*0.68*	*0.69*	*0.71*	*0.72*	**0.70**	**7**
PT	0.70	0.68	0.65	0.64	0.69	**0.67**	**21**
SE	0.71	0.68	0.62	0.60	0.70	**0.66**	**24**
SI	*0.73*	*0.73*	*0.71*	*0.71*	*0.74*	**0.72**	**3**
SK	*0.72*	*0.71*	*0.70*	*0.70*	*0.74*	**0.71**	**4**
EU-25	**0.69**	**0.69**	**0.68**	**0.68**	**0.70**	**0.69**	
EU-15	**0.69**	**0.69**	**0.68**	**0.68**	**0.69**	**0.69**	
EU-10	**0.71**	**0.69**	**0.69**	**0.70**	**0.73**	**0.70**	
Efficiency gap	*-0.02*	*-0.01*	*-0.01*	*-0.02*	*-0.03*	*-0.02*	

LogL	1949.16	2241.28	1734.92	1636.51	2494.51
Ln(sigv_2)	-5.09	-5.90	-4.32	-5.80	-6.07
Ln(sigu_2)	-5.15	-4.81	-3.73	-4.08	-5.03
Sigma_v	0.08	0.05	0.12	0.06	0.05
Sigma_u	0.08	0.09	0.15	0.13	0.08
Sigma2	0.01	0.01	0.04	0.02	0.01
Lambda	0.97	1.73	1.34	2.36	1.68

Note: SFA approach, with the prior assumption of exponential distribution on inefficiency component.

Table 3 shows that the average profit efficiency scores of old and new member country groups seem to be very close to each other. Therefore, the efficiency gap is consequently very small in a five year average. An interesting result was produced with regard to the uncontrolled model; the efficiency advantage of old member states was not evident in the period of 1999-2003. New member states appeared slightly more profit-efficient in all years. Over the sample period the three least efficient banking systems were represented by Great Britain (66%), Sweden (66%) and Ireland (67%), while the three best-performers were Estonia (75%), Hungary (74%) and Slovenia (72%). The profit efficiency of the EU and sub-regions averaged at around 69-70% in the investigated period.

Table 4

Alternative profit efficiency scores from the controlled model

	1999	2000	2001	2002	2003	Average	Rank
AT	0.74	0.72	0.72	0.70	0.72	0.72	4
BE	0.72	0.70	0.69	0.69	0.70	0.70	10
CY	*0.67*	*0.68*	*0.67*	*0.64*	*0.69*	0.67	22
CZ	*0.69*	*0.69*	*0.63*	*0.67*	*0.73*	0.68	16
DE	0.75	0.73	0.75	0.71	0.73	0.73	1
DK	0.72	0.73	0.69	0.71	0.73	0.72	5
EE	*0.71*	*0.70*	*0.69*	*0.70*	*0.71*	0.70	8
ES	0.70	0.68	0.67	0.65	0.69	0.68	17
FI	0.74	0.71	0.71	0.72	0.74	0.72	2
FR	0.70	0.69	0.66	0.65	0.70	0.68	15
GB	0.70	0.69	0.69	0.68	0.71	0.69	11
GR	0.71	0.72	0.69	0.70	0.72	0.71	7
HU	*0.67*	*0.69*	*0.67*	*0.67*	*0.71*	0.68	14
IE	0.68	0.66	0.65	0.67	0.66	0.66	24
IT	0.73	0.72	0.70	0.70	0.72	0.71	6
LT	*0.66*	*0.66*	*0.65*	*0.65*	*0.67*	0.66	25
LU	0.72	0.70	0.65	0.66	0.71	0.69	13
LV	*0.70*	*0.66*	*0.66*	*0.64*	*0.69*	0.67	20
MT	*0.70*	*0.69*	*0.65*	*0.67*	*0.68*	0.68	18
NL	0.74	0.71	0.73	0.70	0.73	0.72	3
PL	*0.69*	*0.71*	*0.70*	*0.69*	*0.72*	0.70	9
PT	0.69	0.67	0.65	0.64	0.69	0.67	21
SE	0.71	0.68	0.62	0.65	0.70	0.67	19
SI	*0.68*	*0.67*	*0.67*	*0.66*	*0.66*	0.67	23
SK	*0.69*	*0.68*	*0.70*	*0.67*	*0.70*	0.69	12
EU-25	0.73	0.72	0.71	0.69	0.72	0.71	
EU-15	0.73	0.72	0.71	0.70	0.72	0.72	
EU-10	0.68	0.69	0.67	0.67	0.70	0.68	
Efficiency gap	*0.05*	*0.03*	*0.04*	*0.03*	*0.02*	*0.04*	

LogL	2153.07	2549.94	2018.00	1849.39	2607.07
Ln(sigv_2)	-5.10	-4.78	-4.30	-5.21	-6.11
Ln(sigu_2)	-3.47	-3.65	-3.51	-3.79	-3.57
Sigma_v	0.08	0.09	0.12	0.07	0.05
Sigma_u	0.18	0.16	0.17	0.15	0.17
Sigma2	0.04	0.03	0.04	0.03	0.03
Lambda	2.26	1.75	1.48	2.03	3.58

Note: SFA approach, with the prior assumption of exponential distribution regarding inefficiency component.

The results of alternative profit efficiency using the controlled model are presented in Table 4.[55] It is interesting to note that, as with the estimation of X-efficiency, a profit-efficiency gap in favour of the old member states emerges. Eliminating the home bias is likely to account for the difference between controlled and uncontrolled models. This efficiency gap between the two groups of countries slightly dropped in the period under review and averaged 4 percentage points.

[55] Appendix 6 suggests that selected country specific variables are of high relevance.

The three worst-performer countries in terms of profit efficiency were: Latvia (66%), Ireland (66%) and Slovenia (67%). Countries that yielded the highest profit efficiency scores were: Germany (73%), Finland (72%) and the Nederland (72%). The average efficiency level of the EU as a whole amounted to 71% as old and new members totalled at 72% and 68% respectively. The mean score of the enlarged EU indicates an annual 40.8% loss in profit efficiency, which is equivalent to 0.5% of GDP.

We also checked the robustness of results stemming from alternative profit efficiency estimation and found that the efficiency ranking of countries independently of the specification was relatively stable. The bilateral rank-order correlation between our benchmark model and other distributional assumptions ranged between 0.6 and 0.9.[56] However, the level of efficiency varied depending on the prior assumptions regarding the distribution of inefficiency component.

In the case of profit-efficiency we also investigated the effect of applying the translog functional form on efficiency scores. Efficiency gaps are also detected with the same sign and approximately the same size as in the "Fourier-based" specifications.[57] However, the profit-efficiency levels and ranking of countries changed.

Comparing the empirical findings of X-and alternative profit efficiency estimation, it can be stated that the value of rank-order correlation of 0.7 calculated on the results of the controlled model is considered as relatively strong. This means that, taking into account only the managerial ability, the majority of X-efficient countries are also more profit efficient and vice versa.[58] In the uncontrolled case, however, the counter-effects of domestic characteristics, however, weakened rank-order correlation to -0.1.

Charts 4 and 5 give a graphical illustration of the relation between cost-and profit-efficiency. Scatter plots demonstrate the distances in X- and alternative profit-efficiency scores from the "benchmark"[59] states. The countries are sorted into the quarters of the Cartesian plane. In the upper right part X-and profit-efficient countries are classified. In the lower left quarter are those states positioned that prove to be inefficient according to both indicators. The other two sections include only X- or only profit-efficient countries. Scatter plots provide evidence in support of our claim that distortion effects are of high importance. The standard deviation of efficiency scores is much lower in the controlled (Chart 5) than in the uncontrolled (Chart 4) case.

In general, countries located in the upper right part are characterised by a sustainable financial position and strong income generating capacity. By contrast, the upper and lower left as well as the lower right parts represent unsustainable states from the perspective of banks' long term operation. X-inefficient but profit-efficient banking systems, which can be found in the upper left part of the scatter plot, may face two alternatives. By gaining a competitive edge on the X-efficiency and therefore the profit-efficiency side, banks can move to the right. If firms do not implement efficiency improvements, however, banking sectors shift into the lower left quarter as the continuous homogenisation of markets leads to the deterioration of profit-efficiency. With respect to countries lacking X-efficiency and alternative profit efficiency, a major restructuring of the banking sector is expected in the long term.[60]

X-efficiency improvement allows banks to leave the lower left part of the scatter plot. More X-efficient firms are able to charge lower loan and higher deposit rates and thus produce more output as a function of demand and supply elasticity. Since X-efficiency improvement is accompanied by a profit-efficiency gain, banks can jump directly into upper right from the lower left quarter. Equally X-efficient but due to market heterogeneity, less profit-efficient banks can be found in the lower right part of the Cartesian plane.

In the long run, the effects of market distortions can be reduced or made to disappear, favouring the evaluation of perfect competition. Since, in a perfectly competitive case, firms are operating on the same X- and profit-efficiency level, relative efficiency scores are no longer of any relevance.

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56 The detailed results can be found in Appendix 4.

57 The detailed results can be found in Appendix 5.

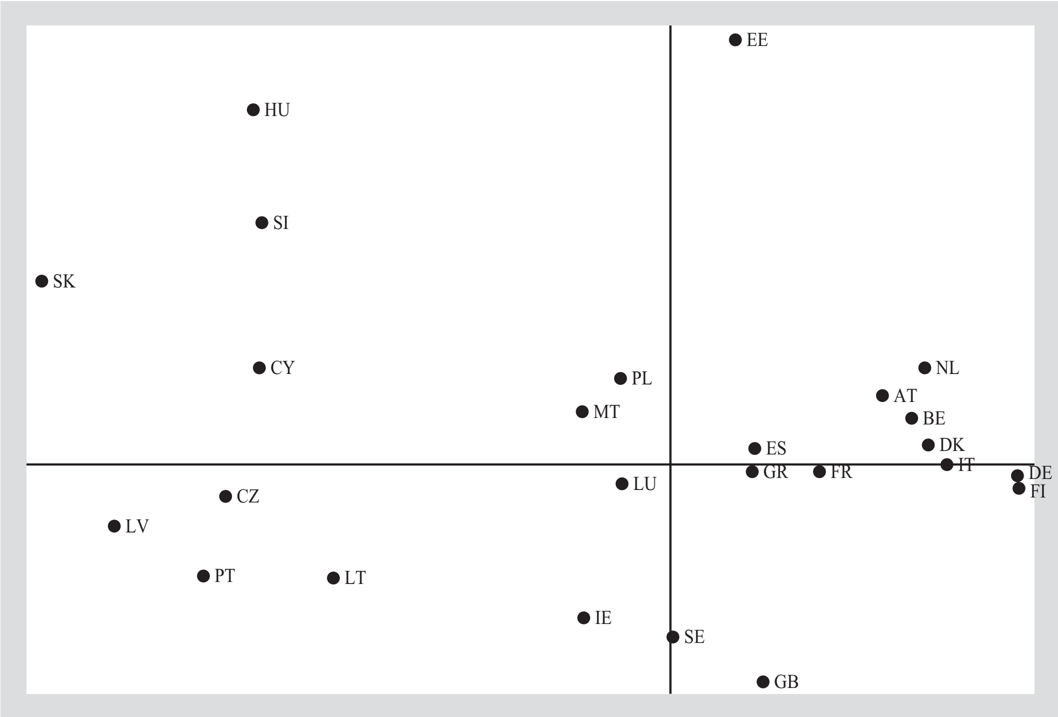
58 If we had perfectly controlled for market distortions the rank-order correlation of X-and alternative profit efficiencies would have approached 1.

59 The construction of the scatter plots in Charts 4 and 5 is the following: we ranked countries in relation to both X-efficiency and alternative profit efficiency. The "benchmark" country is the one in the middle (13). Those countries' banking systems that were above this level were considered as efficient, otherwise inefficient. We subtracted the efficiency scores from this "benchmark" value and multiplied them with minus 1. The benchmark countries in the uncontrolled case were: Sweden and Italy; in the controlled case were: Hungary and Luxembourg.

60 In the new member countries this may be of no relevance because of the presence of subsidiaries.

Chart 4

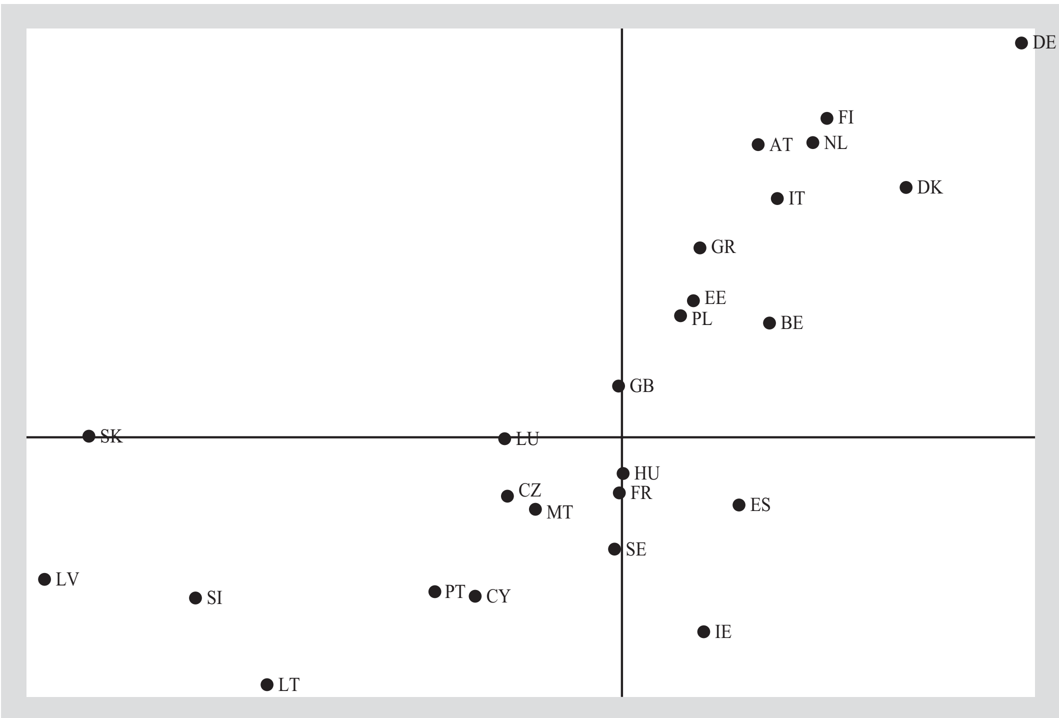
Cross-country comparison of X-and alternative profit-efficiency in the case of the uncontrolled model (average between 1999 and 2003)



Note: On the horizontal/vertical axis distances of X-/profit efficiency from the "benchmark" are portrayed.

Chart 5

Cross-country comparison of X-and alternative profit-efficiency in the case of the controlled model (average between 1999 and 2003)



Note On the horizontal/vertical axis distances of X-/profit efficiency from the "benchmark" are portrayed.

Analysing Charts 4 and 5, we primarily focus on the new EU members. Chart 4 demonstrates that the majority of new member states are located to the left of the y axis. This means that these countries produce poor efficiency in relation to both indicators, or "just" X-efficiency. Banking systems operate X-inefficiently but profit-efficiently in Cyprus, Hungary, Malta, Poland, Slovakia and Slovenia. Managerial inefficiencies in terms of cost and profit are found in Czech Republic, Latvia and Lithuania.

A substantial restructuring can be seen in Chart 5; the results derive from models controlled in relation to the effects of distorting factors. Several countries which were previously located in the upper left quarter shift to the lower left section. This implies that, should no measures be taken to improve X-efficiency in the majority of new member states, they may lose their apparent competitive edge on profit-efficiency as a result of the expected long-term elimination of the distorting factors, i.e. with the strengthening of Common European Banking Market.

4. 4. 2. Convergence in efficiency

We assign relevance to the question as to whether, beyond the integration of financial systems, there is an efficiency convergence process among banks in EU countries and within individual member states and sub-regions. The results indicate, that in relation to both X- and alternative profit efficiency, in most cases convergence exists. Nevertheless, it is important to emphasize that, in comparison to alternative profit efficiency, convergence is greater in relation to X-efficiency.

Table 5

Convergence in efficiency between 1999 and 2003

	Convergence in X-efficiency		Convergence in alternative profit efficiency	
	uncontrolled model log(eff99)	controlled model log(eff99)	uncontrolled model log(eff99)	controlled model log(eff99)
AT	-0.043***	-0.079***	-0.056***	-0.023**
BE	-0.063**	-0.111***	-0.09	-0.114**
CY	*-0.120****	*-0.174****	*-0.016***	*-0.048****
CZ	*-0.154****	*-0.153****	*-0.082***	*-0.114****
DE	-0.111***	-0.078***	-0.008***	-0.103***
DK	-0.136**	-0.18	-0.017***	-0.116***
EE	*-0.16*	*-0.25*	*0.076**	*-0.23*
ES	0.045**	0.073*	0.00	0.09
FI	-0.035**	-0.031***	-0.002**	-0.015**
FR	-0.037***	-0.011***	-0.01	-0.033**
GB	0.077**	0.116**	0.10	0.007**
GR	-0.137**	-0.205***	-0.18	-0.093*
HU	*-0.238****	*-0.197***	*0.03*	*-0.085****
IE	-0.065***	-0.097***	-0.009*	-0.001**
IT	-0.059***	-0.075***	0.013***	-0.036***
LT	*-0.098****	*-0.148****	*-0.01*	*-0.007**
LU	-0.035***	-0.053***	-0.05	0.02
LV	*-0.132****	*-0.199****	*-0.02*	*-0.019***
MT	*0.02*	*0.06*	*-0.01*	*-0.04*
NL	-0.025**	-0.038***	0.00	-0.016**
PL	*-0.213**	*-0.147**	*-0.004**	*-0.159****
PT	0.01	-0.01	0.00	0.00
SE	0.056**	0.084*	0.01	0.048**
SI	*0.05*	*0.07*	*-0.073***	*-0.01*
SK	*-0.04*	*-0.057***	*0.01*	*-0.048***
EU-25	-0.105***	-0.075***	-0.09	-0.068***
EU-15	-0.072***	-0.067***	-0.07	-0.074***
EU-10	-0.112***	-0.169***	-0.011***	-0.051***

*Note: *, **, *** denote an estimate significantly different from zero at the 10%, 5%, or 1% level.*

In the process of analysing convergence we investigate the gap between the current and the balanced path of efficiency. We employed the data of the first and the last year under investigation to produce the β-convergence.[61] The dependent variable of the regression is the difference of the natural logarithm of efficiency values in year 2003 and 1999, the independent variable being the natural logarithm of the efficiency value in 1999. There is β-convergence if the estimated coefficient is negative.

Irrespective of whether results deriving from controlled or uncontrolled models are used, in the case of X-efficiency there is significant β-convergence in the majority of the countries and regions. Within the whole of the EU, X-efficiency convergence is faster in relation to new member states than old members, due to the greater distance measured from the average EU level. Convergence is observed not only within the whole EU, but also within the groups of old and new member countries respectively.

In relation to the uncontrolled model, the highest level of convergence is produced by Hungarian banks (-0.238%), while the strongest divergence is revealed in the case of Great Britain (0.077%). The speed of convergence corresponds to -0.105% for the whole of the EU, -0.072% in relation to old member states and -0.11% for new members. In relation to the controlled model, the fastest convergence among banks in X-efficiency is observed in Greece (-0.205%), while the fastest divergence rate is linked to the British firms (0.116%) as well. The speed of catching up for the whole of the EU reached -0.075%, -0.067% for old member states and -0.169% for new members. With regard to the "impetus" of the speed of convergence, no major changes in ranking may be observed among the results originating from the two models. Ranking correlation reveals a high value (0.9).

The conclusions drawn in relation to alternative profit efficiency are varied. There are fundamental discrepancies between the results of the two model specifications, as well as the significance of convergence. In the uncontrolled case, the most intensive convergence characterises the Czech Republic (-0.082%), while in Italy (0.013%) a slight divergence can be seen. In the whole EU the speed of convergence is slow, -0.09% (insignificant), compared with -0.07% (also insignificant) in relation to old member states and -0.011% for new members. In the controlled model the most intensive catching-up is in Poland (-0.159%), while the strongest divergence can be observed in Sweden (0.048%). The speed of convergence corresponds to -0.068% within the EU, with a -0.074% rate for old member states and -0.051% for new members. The ranking of countries is substantially rearranged. The rank-order correlation is very low (0.1).

4. 4. 3. The comparison of accounting and statistical based efficiency ratios

We compare below accounting and statistical based efficiency indicators. We shall demonstrate that the accounting based indicators do not constitute efficiency measures in the classical sense of the term, and do not incorporate information content which is commonly attributed to such indicators. The statistical indicators used in this study are not only more sophisticated approaches to efficiency than accounting based ones, but also offer greater reliability in measuring efficiency, providing a real view of the performance of a certain bank. Statistical indicators enable the accurate monitoring of specific factors (prices, outputs) through costs and profit, and thereby allow optimal decision making. Statistical based efficiency indicators are not perfect, but, despite their methodological disadvantages, give a better proxy of efficiency than the so widely used accounting based measures.

When examining efficiency, the simplest accounting method comprises the analysis of changes occurring on the level of costs and profit – an inadequate approach in many respects. For example, cost reduction does not always imply an increase in efficiency. An inadequate cut in personnel expenses and other operating costs may entail a shrinking market share and thereby falling profitability. Cuts in wage costs in banks may result in worsening profitability if a considerable rate of income originates from commission and fee revenues linked to high personnel costs. If a bank is inaccurate in assessing local demand, the termination of branches may also lead to growing efficiency loss.

A rise in profit does not always indicate improved efficiency, either. If the growth rate of profit falls short of the growth in output, the decrease in profit per unit induces a loss in efficiency. Beyond the above, the cutting of costs is generally the result of "conscious" behaviour, while the operational environment plays a more determining role in shaping profit independently of management behaviour. Since it is more difficult for management to improve the revenue component of profit, the focus is shifted to the rationalization of costs.

[61] We did not measure the widely used σ-convergence because of the facts mentioned in the methodological description and the length of the sample period.

As opposed to the simple analysis of trends in profit and costs, the derivation of accounting based financial indicators offers a more adequate approach.[62] Accounting indicators represent relative indices; they most often compare the rate of cost or profit to bank performance or output. The main advantage of accounting indices lies in their easy application and derivation. The main disadvantage, however, is related to the difficult interpretation of indicators and their limited comparability. Banks frequently misinterpret the improved values of the indicators as corresponding to an efficiency gain. Moreover, the comparison of institutions often prompts management to draw misleading conclusions about disparities in efficiency. The above is due to the limited comparability of accounting based indicators, for these do not take into account differences in the production structure as well as the shifting in activity.[63] In addition, it is often implicitly assumed that the cost of assets used in the production process is similar, independently of operational environment. Finally these ratios are basically unable to distinguish the different types of efficiency.

For the purpose of facilitating comparison, analysts commonly compare the performance of banks conducting roughly similar activities in the form of peer group analyses.[64] Differences between indicators, however, do not necessarily constitute bank-specific differences, but may derive from (country-specific) variations related to the operational environment. On the basis of the above, we may argue that the content of information acquired from the cross-sectional comparison of accounting based indices through time is questionable from an efficiency point of view. If the given accounting indicator of a bank is explicitly worse than that of another bank, this does not necessarily imply it is less efficient, and vice-versa.

A frequently used “profit efficiency” indicator is the cost/income ratio. This is often considered as a proxy of profit efficiency. The reason is that this index is not asset based and general costs are associated with the whole (i.e. balance sheet and off-balance sheet) banking activity. The cost/income ratio, however, does not offer a perfect instrument for measuring the profit efficiency of banks, for the denominator of the quotient contains net income which may be sensitive, for example, to changes in the maturity structure of interest and to the banks’ market power in pricing.

The cost/total assets accounting indicator is also commonly used by bank analysts for measuring cost-efficiency. Its interpretation is difficult because the value may fall not only as a result of lower costs, but also as a consequence of a growth in total assets. The deepening of financial intermediation may cause not “conscious”, but “natural” improvement in efficiency. The varying cost/total assets indicators of banks operating in two countries does not in all cases imply that the management of one bank is less qualified than the management of the other. The difference may arise from the countries’ varying level of development and the closely related, dissimilar depth of financial intermediation.

An alternative of real efficiency measurement is the cost (profit) frontier analysis. When estimating the cost-profit frontier, we attempt to estimate the maximum amounts that a given bank could reduce costs and increase profit with the same product mix, quality and quantity of financial services. Variation from the optimal level is termed X-efficiency and alternative profit efficiency loss. The main advantage of cost (profit) frontier analysis is that it does not require constructing a peer group of banks with similar characteristics. An estimated cost (profit) frontier is able to incorporate all the factors (portfolio mix, input prices, branches[65], regulation, economic environment, technology etc.), that can influence banks’ costs and profit. The derivation of cost-profit frontiers furthermore allows the simulation of the impact of various factors on costs and profit, and the derivation of indicators which are consistent and comparable from the aspect of efficiency.

It is important to note that the problem of inconsistency in time may arise in relation to both accounting and statistical indices. This means that instances may occur in which a bank implements efficiency-enhancing investments in the present for the purpose of establishing efficient and competitive operations in the long term.[66] One-time expenditures in high amounts may worsen efficiency indicators in the short term, but improve these in the long term. The above implies that only an analysis of efficiency in the long term is of relevance.

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[62] CAMEL indicators belong to this group.

[63] The rise in commission and fee based activities can substantially modify the relationship between non-interest expenses and total assets.

[64] Similar banks signify firms nearly identical in relation to production mix, size and other factors determining the operational costs and profit.

[65] Number of branches is not used in the estimation of the frontiers, due to lack of data.

[66] Such investments may include, for example, the adoption of modern risk management systems, development of IT systems, expansion of ATM and branch networks, etc.

Table 6 indicates the correlation between accounting and statistical indices.

Table 6

The correlation of accounting and statistical based efficiency indicators in the EU between 1999 and 2003

	Operating costs/Net income	Operating costs/Total assets	ROA	X-efficiency (uncontrolled)	Alternative profit efficiency (uncontrolled)	X-efficiency (controlled)	Alternative profit efficiency (controlled)
Operating cost/Net income	1						
Operating cost/Total assets	0.716	1					
ROA	-0.115	0.041	1				
X-efficiency (uncontrolled)	-0.135	-0.329	0.098	1			
Alternative profit efficiency (uncontrolled)	0.245	0.351	0.182	-0.122	1		
X-efficiency (controlled)	0.105	0.080	-0.075	0.766	-0.085	1	
Alternative profit efficiency (controlled)	-0.124	-0.285	-0.095	0.659	0.148	0.692	1

We didn't find a significant relationship between accounting based and statistical based efficiency indexes in the sample.[67] Among accounting based indicators the correlation between cost/income and cost/total asset revealed a higher than moderate positive correlation, while ROA correlated with none of the other financial "efficiency" indicators.

Among statistical indicators, there is a relatively strong correlation between the controlled and the uncontrolled X-efficiency indicator and between the controlled alternative profit and the controlled X-efficiency indicators. In the first case, the filtering of distorting factors did not significantly modify the efficiency ranking of banks, it only reduced the standard deviation of efficiency scores. Table 1 and Table 2 clearly indicate that, following the filtering of distortions, the standard deviation of cost inefficiency (σ_u) is narrowed. In the second case, the relatively strong correlation is caused by the fact that, with ignoring of all distorting factors, alternative profit efficiency follows from X-efficiency according to economic theory. In a hypothetical case (i.e. output and input prices are given) the banks with the lowest cost curve also produce on the highest profit curve. There is no significant correlation between alternative profit efficiency scores of the controlled and uncontrolled models since distortion factors substantially changed efficiency levels and ranks. Tables 3 and 4 demonstrate that filtering of distorting factors boosts the standard deviation of profit inefficiency (σ_u). Finally, no significant correlation between the uncontrolled X-and alternative profit efficiency scores were found due to the counter-effects of exogenous factors.

On the basis of the correlation table, we may establish that far-reaching conclusions may not be drawn from the accounting indicators in relation to bank efficiency values and their changes. The financial indicators only enable limited cross-sectional comparison through time; firstly, in the accounting approach, we cannot distinguish the impact of conscious behaviour and the operational environment on efficiency; secondly, when comparing banks, in most instances we are unable to derive homogenous peer groups based on the characteristics of the market environment and bank operation. The statistical approach remedies most of the deficiencies of the accounting methods, thus, despite its complexity it comprises a more adequate means of measuring efficiency.[68]

[67] Berger and Mester (1997) received similar results in relation to the banking system of the USA.

[68] De Young (1997) suggests a hybrid approach combining accounting and statistical methods. One possible way is to regress the accounting based efficiency variables on a set of explanatory variables, including those that can cause the bias. Using the estimated parameters of this regression for each bank, corrected and comparable hybrid efficiency indicators can be produced.

5. Conclusions

In this paper, under a common best-practice frontier we estimated and ranked X- and alternative profit-efficiency scores for banking systems of the 25 EU member states between 1999 and 2003. We focused on investigating the efficiency gap between old and new member states, and analysing the related trends. Finally, we measured the speed of convergence in the whole EU, in old and new member states and within individual countries. In the course of producing X-efficiency and alternative profit-efficiency scores we applied a Fourier- flexible functional form. Inefficiency components were modelled by the stochastic frontier approach.

Our results lead us to the conclusion that controls for selected distorting factors (inflation, depth of financial intermediation, market concentration, regulatory regime) originating from the operational environment or the absence of such controls may modify results. When evaluating banks, we accordingly assign importance to the distinction and assessment of impacts on performance deriving from managerial ability the external environment.

Independently of the consideration of home bias our empirical findings provide evidence about the existence of an X-efficiency gap as well as suggesting that the competitive edge of old EU members in relation to cost-efficiency is decreasing over time due to the (β-) convergence process. Controls (or lack thereof) for distorting country-specific factors reduces (or increases) the size of the actual gap between the old and new member states, and decelerates (or accelerate) the speed of convergence. Beyond proof of convergence within the European Union, it may also be established that the efficiency levels of banks within the group of old and new member states are approaching each other.

As for estimating alternative profit-efficiency, a narrowing gap is also detected in favour of old member states between 1999 and 2003, but only if the impact of home market conditions on profitability is controlled. In contrast, if factors originating from the operational environment are not controlled, the results suggest that there is a competitive edge in profit efficiency in favour of new members and very slow convergence takes place between the sub-regions. In sum, country specific factors appear to have influence not only on the size and the dynamics of the profit efficiency differences but on the sign of the gap, i.e. on the rank ordering of the groups of old and new member states.

Looking ahead, it should be stressed that the unbiased X-efficiency gap may produce an adverse impact on the long-term competitiveness of financial systems in new EU member states. The X-efficiency gap may be narrowed through the higher "internal efficiency reserves" of banks in new EU member states compared to old ones, i.e. from a lower efficiency level, banks in new member countries have larger room for improvement. There is the risk, however, that the absence of competitive pressures may result in a lesser effort on the part of managers to minimise costs. Cost-minimising pressure may be further weakened by the fact that banks of less developed countries also have large "external efficiency reserves", for the gradual development and integration of the economy through the deepening of financial intermediation results in a "natural" efficiency gain. It is also a discouraging factor that the "conscious" improvement of efficiency involves higher expenditures in the short term and produces the desired impact only in the long term. Advantages and disadvantages associated with specific market characteristics in old and new member states are expected to ease as a result of the further integration of financial markets and the financial institutional systems within the EU. Consequently, the managerial ability will gain even larger role in determining efficiency.

Furthermore, in our research we analysed the relevance of accounting and statistical based efficiency indices. We suggested that far-reaching conclusions may not be drawn on the basis of accounting indicators with respect to bank efficiency, for a cross-sectional comparison through time is unable to produce an indicator appropriate for managing the problem of institutional heterogeneity. Statistical indices can moderate home bias arising from heterogeneity, producing a more accurate picture of banking operation. Therefore, in addition to the analysis of simple accounting indicators, a statistical approach to efficiency in the banks' decision-making processes should gain ground.

Information regarding the bank efficiency in the EU is of high relevance, as it enables policy-makers to understand deficiencies of banking operation and prioritise areas for action. Our findings stress the prime importance of policy response to enhance the efficient operation of banking systems and thereby achieve welfare gains. In the lack of pressure on efficiency improvement the cost of financial intermediation can remain relatively high particularly in the new member states which can be a drag on the evaluation of a flexible and resilient economy.

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Appendix

APPENDIX 1 VARIABLES OF UNCONTROLLED AND CONTROLLED MODELS

Independent variables	
uncontrolled	controlled
Intercept	Intercept
ln(y1)	ln(y1)
ln(y2)	ln(y2)
ln(y3)	ln(y3)
ln(w1/w3)	ln(w1/w3)
ln(w2/w3)	ln(w2/w3)
$(\ln y1)^2$	$(\ln y1)^2$
$(\ln y2)^2$	$(\ln y2)^2$
$(\ln y3)^2$	$(\ln y3)^2$
$(\ln(w1/w3))^2$	$(\ln(w1/w3))^2$
$(\ln(w2/w3))^2$	$(\ln(w2/w3))^2$
(lny1)(lny2)	(lny1)(lny2)
(lny1)(lny3)	(lny1)(lny3)
(lny2)(lny3)	(lny2)(lny3)
(ln(w1/w3))(ln(w2/w3))	(ln(w1/w3))(ln(w2/w3))
(lny1)(ln(w1/w3))	(lny1)(ln(w1/w3))
(lny1)(ln(w2/w3))	(lny1)(ln(w2/w3))
(lny2)(ln(w1/w3))	(lny2)(ln(w1/w3))
(lny2)(ln(w2/w3))	(lny2)(ln(w2/w3))
(lny3)(ln(w1/w3))	(lny3)(ln(w1/w3))
(lny3)(ln(w2/w3))	(lny3)(ln(w2/w3))
cosZ1	cosZ1
cosZ2	cosZ2
cosZ3	cosZ3
sinZ1	sinZ1
sinZ2	sinZ2
sinZ3	sinZ3
cos(Z1+Z1)	cos(Z1+Z1)
cos(Z1+Z2)	cos(Z1+Z2)
cos(Z1+Z3)	cos(Z1+Z3)
cos(Z2+Z2)	cos(Z2+Z2)
cos(Z2+Z3)	cos(Z2+Z3)
cos(Z3+Z3)	cos(Z3+Z3)
sin(Z1+Z1)	sin(Z1+Z1)
sin(Z1+Z2)	sin(Z1+Z2)
sin(Z1+Z3)	sin(Z1+Z3)
sin(Z2+Z2)	sin(Z2+Z2)
sin(Z2+Z3)	sin(Z2+Z3)
sin(Z3+Z3)	sin(Z3+Z3)
	ln(inf)
	ln(depth)
	ln(ce5)
	ln(her)
	ln(ref)

The y1 is defined as loans, y2 is other earning assets and y3 denotes non interest revenues. w1 is defined as price of labour, w2 is the price of physical capital and w3 is the price of borrowed funds. z is the normalised output. Inflation (inf) is the yearly change in consumer prices. Depth (depth) is measured by total loans/GDP. Concentration (ce5) is defined as the sum of the five largest banks' market share. The indicator of restrictions in banking and finance is produced by Heritage Foundation (her). Scores range between 1 (high level of liberalization) and 5 (low level of liberalization). EBRD index for banking sector reforms (ref) varies between 1 (low quality of regulatory architecture) and 4 (high quality of regulatory architecture).

APPENDIX 2 DESCRIPTIVE STATISTICS

	Number of banks	Total assets	Total assets		Loans		Other earning assets		Wage costs		Price of fixed capital		Price of int.-b. liabilities		Total costs		Pre-tax profit		Non interest revenues	
		Aver. (M.)	Aver. (M.)	Rel. stdev	Aver. (M.)	Rel. stdev	Aver. (M.)	Rel. stdev	Aver.	Rel. stdev	Aver.	Rel. stdev	Aver.	Rel. stdev	Aver. (M.)	Rel. stdev	Aver. (M.)	Rel. stdev	Aver. (M.)	Rel. stdev
AT	111	460146.1	4145.5	0.3	1993.5	0.3	1843.9	0.3	0.009	0.13	1.338	0.2	0.071	0.3	222.1	0.2	17.0	0.5	128.4	0.9
BE	44	845732.8	19221.2	0.2	7780.4	0.2	10184.1	0.2	0.008	0.10	1.070	0.0	0.010	0.3	1034.9	0.2	123.6	0.3	574.6	0.0
CY	*16*	*27569.2*	*1819.9*	*0.4*	*934.2*	*0.3*	*807.3*	*0.5*	*0.014*	*0.08*	*0.854*	*0.2*	*0.112*	*0.3*	*128.6*	*0.3*	*24.2*	*1.2*	*61.9*	*0.6*
CZ	*22*	*59893.1*	*2807.4*	*0.3*	*1033.5*	*0.4*	*1465.6*	*0.4*	*0.012*	*0.09*	*1.417*	*0.6*	*0.180*	*0.4*	*238.3*	*0.5*	*-1.9*	*-4.0*	*104.9*	*0.0*
DE	1080	3267259.2	3025.2	0.2	1492.7	0.2	1420.9	0.3	0.007	0.07	2.810	0.2	0.072	0.2	180.0	0.2	10.4	1.1	45.4	1.1
DK	67	222817.6	3325.6	0.3	1484.4	0.3	1528.7	0.4	0.008	0.10	2.100	0.1	0.064	0.3	156.5	0.2	32.5	0.4	103.0	0.2
EE	6	3608.5	605.2	0.4	354.0	0.5	208.2	0.5	0.010	0.11	1.650	0.2	0.133	0.4	42.1	0.3	13.7	1.0	17.0	0.2
ES	108	1183427.9	10962.2	0.2	5967.2	0.3	3725.9	0.2	0.013	0.09	1.155	0.2	0.101	0.3	611.6	0.2	115.9	0.3	327.3	0.3
FI	6	200244.6	33374.1	0.3	20333.7	0.4	9428.7	0.3	0.008	0.35	1.230	0.8	0.112	0.3	1537.6	0.3	355.6	0.3	1339.0	0.0
FR	208	3045919.6	14643.8	0.2	5094.0	0.2	8238.1	0.3	0.007	0.07	1.500	0.1	0.041	0.2	960.5	0.2	68.8	0.6	263.6	0.9
GB	50	1975420.2	39508.4	0.3	20213.8	0.4	14869.5	0.4	0.011	0.09	0.936	0.1	0.039	0.3	2097.0	0.3	451.3	0.4	790.2	0.0
GR	16	93594.5	5925.8	0.4	2916.2	0.5	2622.2	0.3	0.015	0.07	0.781	0.1	0.113	0.5	404.0	0.3	90.5	0.7	232.0	0.0
HU	*23*	*29129.8*	*1268.9*	*0.3*	*633.1*	*0.5*	*531.4*	*0.2*	*0.014*	*0.09*	*2.300*	*0.2*	*0.135*	*0.3*	*131.2*	*0.3*	*20.5*	*0.6*	*56.6*	*0.1*
IE	21	318523.5	19712.0	0.2	8969.8	0.4	7799.0	0.3	0.010	0.28	0.605	1.0	0.080	0.3	916.8	0.3	137.5	0.5	601.7	0.0
IT	459	1520534.9	3312.7	0.2	1788.9	0.3	1171.4	0.3	0.013	0.02	1.226	0.1	0.059	0.2	206.3	0.2	26.7	0.6	49.7	0.8
LT	*9*	*3312.1*	*368.0*	*0.5*	*169.1*	*0.6*	*122.0*	*0.5*	*0.019*	*0.22*	*0.608*	*0.3*	*0.150*	*0.5*	*27.8*	*0.3*	*2.7*	*1.7*	*19.7*	*0.3*
LU	70	423150.7	6045.0	0.2	1384.6	0.3	4453.3	0.2	0.003	0.02	0.897	0.1	0.053	0.2	438.4	0.3	40.6	0.5	118.9	0.0
LV	*20*	*4477.9*	*224.9*	*0.5*	*101.1*	*0.7*	*97.8*	*0.6*	*0.013*	*0.23*	*1.105*	*0.2*	*0.135*	*0.5*	*16.5*	*0.4*	*2.4*	*2.2*	*10.0*	*0.8*
MT	*6*	*8069.2*	*1360.4*	*0.2*	*632.7*	*0.2*	*671.2*	*0.2*	*0.010*	*0.04*	*0.790*	*0.4*	*0.167*	*0.2*	*72.8*	*0.2*	*12.6*	*0.4*	*48.3*	*0.5*
NL	25	1083013.6	43320.5	0.2	26178.7	0.2	7366.4	0.3	0.012	0.03	1.136	0.2	0.077	0.3	2642.9	0.2	292.1	0.3	1083.0	0.9
PL	*34*	*87862.2*	*2608.9*	*0.3*	*1189.5*	*0.3*	*1107.2*	*0.3*	*0.019*	*0.06*	*0.962*	*0.1*	*0.110*	*0.5*	*288.4*	*0.4*	*33.9*	*0.8*	*71.5*	*0.0*
PT	15	156724.6	10448.3	0.3	5908.3	0.4	3002.7	0.2	0.007	0.07	4.138	0.2	0.053	0.2	1077.1	0.3	100.5	0.4	343.4	0.0
SE	12	242021.9	20185.7	0.2	8182.8	0.2	7880.7	0.2	0.007	0.11	2.400	0.3	0.073	0.4	1358.8	0.1	129.8	0.5	403.4	0.1
SI	*16*	*15642.5*	*982.5*	*0.3*	*485.3*	*0.4*	*291.5*	*0.3*	*0.017*	*0.18*	*2.600*	*0.2*	*0.139*	*0.2*	*83.0*	*0.3*	*13.7*	*0.6*	*37.1*	*0.1*
SK	*15*	*16960.1*	*1130.7*	*0.2*	*456.7*	*0.4*	*582.3*	*0.4*	*0.013*	*0.04*	*1.500*	*0.6*	*0.157*	*0.5*	*111.4*	*0.3*	*8.9*	*3.4*	*42.2*	*0.0*
EU-25	2459	2142075.8	6261.5	0.2	2937.4	0.2	2725.2	0.3	0.0	0.1	2.0	0.2	0.07	0.2	377.8	0.2	42.6	0.8	132.9	0.8
EU-15	2292	2295486.1	6603.8	0.2	3100.4	0.2	2872.9	0.3	0.009	0.1	2.0	0.2	0.07	0.2	394.7	0.2	44.5	0.8	138.6	0.8
EU-10	167	36587.9	1563.2	0.4	699.2	0.4	699.1	0.4	0.015	0.1	1.4	0.3	0.14	0.4	146.1	0.3	15.3	0.6	54.1	0.2

Notes: Category denoted by bold shows the period average of the sum of the banks' total assets in a given country between 1999 and 2003. Categories denoted by italic show the period average of cross-sectional average in a given country between 1999 and 2003. Numbers are in EUR, M. is million. Aver. is abbreviation of simple arithmetical average and Rel. stdev is abbreviation of relative standard deviation.

APPENDIX 3 LEVELS AND RANK OF X-EFFICIENCY SCORES UNDER DIFFERENT ASSUMPTIONS REGARDING INEFFICIENT COMPONENTS

	X-efficiency scores 1999-2003															
	SFA(uncontrolled)						SFA(controlled)						DFA(uncontrolled)		DFA(controlled)	
	Exponential		Half-normal		Truncated normal		Exponential		Half-normal		Truncated normal					
	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank
AT	0.84	7	0.77	9	0.87	8	0.88	7	0.90	6	0.86	6	0.75	7	0.86	7
BE	0.85	6	0.80	2	0.88	5	0.88	6	0.90	5	0.86	5	0.78	5	0.86	6
CY	*0.65*	*20*	*0.64*	*23*	*0.81*	*12*	*0.82*	*20*	*0.78*	*24*	*0.68*	*25*	*0.63*	*19*	*0.68*	*25*
CZ	*0.64*	*22*	*0.64*	*22*	*0.61*	*21*	*0.83*	*18*	*0.86*	*18*	*0.80*	*20*	*0.59*	*21*	*0.80*	*20*
DE	0.89	2	0.80	3	0.90	2	0.93	1	0.95	2	0.91	1	0.78	3	0.91	1
DK	0.86	4	0.78	6	0.87	7	0.91	2	0.96	1	0.85	8	0.77	6	0.86	5
EE	*0.80*	*12*	*0.71*	*16*	*0.77*	*15*	*0.87*	*11*	*0.88*	*12*	*0.85*	*10*	*0.68*	*16*	*0.85*	*10*
ES	0.80	10	0.74	13	0.82	11	0.87	8	0.88	14	0.85	7	0.72	11	0.85	8
FI	0.89	1	0.80	4	0.91	1	0.89	3	0.91	3	0.87	3	0.79	2	0.87	3
FR	0.82	8	0.79	5	0.87	6	0.85	14	0.89	8	0.83	15	0.75	9	0.83	15
GB	0.81	9	0.76	10	0.86	9	0.85	15	0.87	16	0.83	14	0.74	10	0.83	14
GR	0.80	11	0.73	14	0.80	13	0.87	10	0.88	11	0.85	9	0.70	13	0.85	9
HU	*0.65*	*21*	*0.66*	*20*	*0.62*	*19*	*0.85*	*13*	*0.87*	*15*	*0.83*	*13*	*0.64*	*18*	*0.83*	*13*
IE	0.75	16	0.75	12	0.80	14	0.87	9	0.90	4	0.83	12	0.70	12	0.83	12
IT	0.86	3	0.77	8	0.89	4	0.88	5	0.89	9	0.86	4	0.78	4	0.86	4
LT	*0.68*	*18*	*0.67*	*19*	*0.56*	*22*	*0.79*	*22*	*0.82*	*21*	*0.76*	*21*	*0.57*	*22*	*0.76*	*21*
LU	0.76	14	0.76	11	0.72	18	0.83	19	0.85	19	0.81	17	0.68	15	0.81	17
LV	*0.61*	*24*	*0.63*	*24*	*0.55*	*24*	*0.74*	*25*	*0.81*	*22*	*0.73*	*24*	*0.57*	*23*	*0.72*	*24*
MT	*0.75*	*17*	*0.72*	*15*	*0.76*	*16*	*0.84*	*17*	*0.87*	*17*	*0.80*	*19*	*0.68*	*14*	*0.80*	*19*
NL	0.86	5	0.85	1	0.89	3	0.89	4	0.90	7	0.87	2	0.80	1	0.87	2
PL	*0.76*	*15*	*0.71*	*17*	*0.73*	*17*	*0.86*	*12*	*0.89*	*10*	*0.84*	*11*	*0.66*	*17*	*0.84*	*11*
PT	0.64	23	0.67	18	0.55	23	0.82	21	0.83	20	0.81	18	0.61	20	0.81	18
SE	0.78	13	0.78	7	0.85	10	0.85	16	0.88	13	0.83	16	0.75	8	0.83	16
SI	*0.65*	*19*	*0.62*	*25*	*0.61*	*20*	*0.77*	*23*	*0.79*	*23*	*0.75*	*22*	*0.56*	*25*	*0.75*	*22*
SK	*0.59*	*25*	*0.64*	*21*	*0.47*	*25*	*0.75*	*24*	*0.76*	*25*	*0.75*	*23*	*0.57*	*24*	*0.75*	*23*
EU-25	0.85		0.78		0.86		0.89		0.91		0.87		0.76		0.87	
EU-15	0.86		0.78		0.88		0.90		0.92		0.88		0.77		0.88	
EU-10	0.67		0.66		0.64		0.82		0.84		0.78		0.61		0.78	
Efficiency gap	*0.19*		*0.12*		*0.24*		*0.08*		*0.08*		*0.09*		*0.16*		*0.09*	

Notes: First we composed the country average of individual efficiency scores for every year then calculated the period average between 1999 and 2003. In the case of SFA methods the efficiency scores were estimated for cross-section samples, while DFA were applied for panel data. In the SFA(uncontrolled) and DFA(uncontrolled) models we did not control for different country-specific characteristics.

APPENDIX 4 LEVELS AND RANK OF ALTERNATIVE PROFIT EFFICIENCY SCORES UNDER DIFFERENT ASSUMPTIONS REGARDING INEFFICIENT COMPONENTS

	Alternative profit efficiency 1999-2003															
	SFA(uncontrolled)						SFA(controlled)						DFA(uncontrolled)		DFA(controlled)	
	Exponential		Half-normal		Truncated normal		Exponential		Half-normal		Truncated normal					
	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank	Average	Rank
AT	0.70	8	0.68	10	0.62	15	0.72	4	0.66	4	0.79	13	0.69	8	0.78	7
BE	0.69	10	0.67	15	0.56	22	0.70	10	0.62	14	0.80	10	0.68	9	0.80	5
CY	*0.70*	*6*	*0.70*	*6*	*0.64*	*12*	*0.67*	*22*	*0.61*	*17*	*0.75*	*18*	*0.68*	*11*	*0.73*	*17*
CZ	*0.68*	*19*	*0.67*	*19*	*0.65*	*11*	*0.68*	*16*	*0.61*	*16*	*0.75*	*20*	*0.68*	*12*	*0.78*	*11*
DE	0.69	16	0.70	6	0.65	10	0.73	1	0.66	3	0.81	7	0.63	16	0.82	1
DK	0.69	11	0.67	16	0.61	16	0.72	5	0.64	5	0.85	2	0.71	3	0.80	6
EE	*0.75*	*1*	*0.73*	*2*	*0.74*	*3*	*0.70*	*8*	*0.62*	*12*	*0.79*	*11*	*0.72*	*2*	*0.81*	*4*
ES	0.69	12	0.67	17	0.59	19	0.68	17	0.57	24	0.80	8	0.70	7	0.73	16
FI	0.69	17	0.59	24	0.57	20	0.72	2	0.63	6	0.83	4	0.65	14	0.82	2
FR	0.69	14	0.64	21	0.56	23	0.68	15	0.60	19	0.77	16	0.61	20	0.78	8
GB	0.66	25	0.56	25	0.51	25	0.69	11	0.58	21	0.82	6	0.59	23	0.78	9
GR	0.69	15	0.60	22	0.63	14	0.71	7	0.61	18	0.83	3	0.59	22	0.78	10
HU	*0.74*	*2*	*0.70*	*6*	*0.73*	*4*	*0.68*	*14*	*0.58*	*22*	*0.80*	*9*	*0.70*	*6*	*0.74*	*14*
IE	0.67	23	0.67	18	0.52	24	0.66	24	0.56	25	0.78	15	0.61	18	0.72	20
IT	0.69	13	0.68	13	0.68	7	0.71	6	0.89	2	0.82	5	0.62	17	0.77	12
LT	*0.67*	*22*	*0.68*	*12*	*0.68*	*8*	*0.66*	*25*	*0.63*	*7*	*0.68*	*25*	*0.61*	*19*	*0.72*	*19*
LU	0.68	18	0.67	14	0.59	18	0.69	13	0.63	10	0.75	19	0.60	21	0.72	22
LV	*0.68*	*20*	*0.68*	*11*	*0.63*	*13*	*0.67*	*20*	*0.59*	*20*	*0.76*	*17*	*0.66*	*13*	*0.72*	*21*
MT	*0.70*	*9*	*0.72*	*3*	*0.70*	*6*	*0.68*	*18*	*0.63*	*9*	*0.73*	*22*	*0.65*	*15*	*0.72*	*23*
NL	0.70	5	0.70	6	0.67	9	0.72	3	0.90	1	0.91	1	0.74	1	0.81	3
PL	*0.70*	*7*	*0.73*	*1*	*0.70*	*5*	*0.70*	*9*	*0.62*	*13*	*0.79*	*12*	*0.68*	*10*	*0.76*	*13*
PT	0.67	21	0.65	20	0.60	17	0.67	21	0.62	15	0.73	23	0.57	25	0.71	24
SE	0.66	24	0.60	23	0.57	21	0.67	19	0.58	23	0.79	14	0.59	24	0.71	25
SI	*0.72*	*3*	*0.71*	*5*	*0.75*	*2*	*0.67*	*23*	*0.63*	*11*	*0.71*	*24*	*0.70*	*4*	*0.74*	*15*
SK	*0.71*	*4*	*0.71*	*4*	*0.80*	*1*	*0.69*	*12*	*0.63*	*8*	*0.75*	*21*	*0.70*	*5*	*0.73*	*18*
EU-25	0.69		0.68		0.64		0.71		0.69		0.81		0.64		0.79	
EU-15	0.69		0.68		0.63		0.72		0.69		0.81		0.64		0.79	
EU-10	0.70		0.70		0.70		0.68		0.61		0.76		0.68		0.75	
Efficiency gap	*-0.02*		*-0.02*		*-0.06*		*0.04*		*0.08*		*0.05*		*-0.04*		*0.05*	

Notes: First we composed the country average of individual efficiency scores for every year then calculated the period average between 1999 and 2003. In the case of SFA methods the efficiency scores were estimated for cross-section samples, while DFA were applied for panel data. In the SFA(uncontrolled) and DFA(uncontrolled) models we did not control for different country-specific characteristics.

APPENDIX 5 LEVELS OF EFFICIENCY SCORES FOR THE PERIOD OF 1999-2003 USING TRANSLOG FUNCTIONAL FORM AND EXPONENTIAL DISTRIBUTIONAL ASSUMPTION OF INEFFICIENCY COMPONENTS

	X-efficiency				Alternative profit efficiency			
	uncontrolled		controlled		uncontrolled		controlled	
	Average	Rank	Average	Rank	Average	Rank	Average	Rank
AT	0.77	4	0.76	9	0.65	9	0.66	6
BE	0.74	10	0.74	13	0.65	10	0.65	9
CY	*0.64*	*21*	*0.73*	*17*	*0.64*	*12*	*0.61*	*23*
CZ	*0.58*	*23*	*0.65*	*24*	*0.62*	*23*	*0.61*	*21*
DE	0.78	3	0.78	8	0.64	11	0.67	3
DK	0.78	2	0.80	3	0.63	16	0.66	4
EE	*0.73*	*14*	*0.80*	*6*	*0.67*	*4*	*0.65*	*7*
ES	0.73	13	0.74	12	0.65	8	0.62	14
FI	0.79	1	0.80	2	0.63	19	0.69	1
FR	0.75	8	0.74	11	0.64	15	0.61	20
GB	0.74	9	0.73	16	0.61	24	0.62	18
GR	0.77	5	0.80	4	0.64	14	0.65	8
HU	*0.65*	*20*	*0.74*	*15*	*0.69*	*2*	*0.64*	*13*
IE	0.72	15	0.72	19	0.63	18	0.60	24
IT	0.76	6	0.78	7	0.63	17	0.66	5
LT	*0.65*	*19*	*0.74*	*14*	*0.63*	*21*	*0.64*	*12*
LU	0.66	17	0.70	20	0.64	13	0.64	11
LV	*0.61*	*22*	*0.68*	*22*	*0.62*	*22*	*0.62*	*19*
MT	*0.74*	*11*	*0.72*	*18*	*0.66*	*5*	*0.62*	*17*
NL	0.75	7	0.80	1	0.66	6	0.67	2
PL	*0.73*	*12*	*0.80*	*5*	*0.66*	*7*	*0.64*	*10*
PT	0.57	25	0.64	25	0.63	20	0.61	22
SE	0.70	16	0.69	21	0.53	25	0.55	25
SI	*0.66*	*18*	*0.75*	*10*	*0.67*	*3*	*0.62*	*16*
SK	*0.58*	*24*	*0.68*	*23*	*0.71*	*1*	*0.62*	*15*
EU-25	0.76		0.76		0.64		0.65	
EU-15	0.76		0.77		0.64		0.65	
EU-10	0.65		0.73		0.66		0.63	
Efficiency gap	*0.11*		*0.04*		*-0.02*		*0.03*	

Note: Tranlog functional form can be generated by restricting the Fourier terms to be zero in the Fourier flexible function form. Cross sectional SFA method was applied with exponential distributional assumption on inefficiency component. First we composed the country average of individual efficiency scores for every year then calculated the period average between 1999 and 2003.

APPENDIX 6 LIKELIHOOD RATIO AND WALD TESTS

	X-efficiency	Alternative profit efficiency
	LR test statistic	
1999	146.1	407.8
2000	239.0	617.3
2001	267.3	566.2
2002	219.3	425.7
2003	153.5	225.1

Likelihood ratio is calculated as $-2(LogL_{uncontrolled}-LogL_{controlled})$. Likelihood-ratio test statistic follow chi-squared distribution with degree of freedom equal to the number of restrictions. In this case we imposed 5 restrictions. The 95 percent critical value is 11.07. Since the computed values fairly exceeds the critical value in every year, H_0 i.e. the coefficients of the environmental specific variables are jointly zero, is rejected.

	X-efficiency	Alternative profit efficiency
	Wald test statistic	
1999	17.8	136.1
2000	16.9	393.0
2001	35.5	192.2
2002	25.0	116.9
2003	25.2	206.8

In large samples Wald statistic has a chi-squared distribution with degrees of freedom equal to the number of restrictions. In our case the number of restrictions was 5. The 95 percent critical value is 11.07. Since the computed values exceeds the critical value in every year, H_0 i.e. the coefficients of the environmental specific variables are jointly zero, is rejected.

TECHNICAL APPENDIX 1

The combination of sine and cosine functions is known as Fourier-series. The Fourier series with infinite trigonometric terms takes the following form: $f(z)=\sum_{k=1}^{\infty} a_k \sin kz + \sum_{k=0}^{\infty} b_k \cos kz$. The right hand side of the equation is the Fourier-series of *f(z),* and coefficients a_k, b_k are the Fourier-coefficients. As a finite number of observations are available the optimal subset of trigonometric terms should be found. To determinate a_g, and b_g in the following polynomial with finite trigonometric terms: $S_h(z)=\sum_{1}^{h} a_g \sin gz + \sum_{0}^{h} b_g \cos gz$; the square error of the approximation $E=\frac{1}{2\pi}\int_0^{2\pi}\left[f(z)-S_h(z)\right]^2 dz$ in (0,2π) interval has to be minimised.

TECHNICAL APPENDIX 2[69]

The scaling of the data is important, since the Fourier series is a periodic function. A Fourier-series approximation of a function is *f*(z)* on the region of *H* set, where $z_{m=1}^{N}$ in the range of [0,2π]. The approximation will diverge from *f*(z)* on $z_{m=1}^{N}\left[0,2\pi\right]\sim H$, due to its periodic nature. This problem can be solved by normalising of the variables. A possible way of scaling is the following: $z_m = 0.2\pi + (1.6\pi)\frac{\ln y_m - \ln y_{m,\min}}{\ln y_{m,\max} - \ln y_{m,\min}}$, where y_m is the m^{th} output (m=1, 2, 3). This formula assures that the scaled variables satisfy $0 < \min z_m < \max z_m < 2\pi$. In the light of these remarks the region of approximation is then: $H = z_{m=1}^{N}\left(\min z_m,\ \max z_m\right)$.

[69] Gallant (1981) and Altunbas et al. (2001) investigate this issue in detail.

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