Integration and efficiency convergence in EU banking markets

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Abstract

Evidence of financial integration and convergence are considered of importance in assessing the outcome of EU deregulation policies aimed at improving the efficiency and performance of banking sectors. This paper evaluates the recent dynamics of bank cost efficiency by means of Data Envelopment Analysis (DEA). Borrowing from the growth literature, we apply dynamic panel data models (GMM) to the concepts of β-convergence and σ-convergence to assess the speed at which banking markets are integrating. We also employ a partial adjustment model to evaluate convergence towards best practice. Results seem to provide supporting evidence of convergence of efficiency levels towards an EU average. Nevertheless, there is no evidence of an overall improvement of efficiency levels towards best practice.

Keywords: Efficiency, Convergence, Banking, Data Envelopment Analysis.

JEL classification: G21; D24

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Acknowledgments: The authors wish to thank Tianshu Zhao and John O.S. Wilson for helpful comments and suggestions.

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1. Introduction

During the past two decades, the deregulation of financial services in the European Union (EU), together with the establishment of the Economic and Monetary Union and the introduction of the euro, aimed at fostering integration through the creation of a level-playing-field in the provision of banking services across the EU. The plan was to remove entry barriers and to promote both competition and efficiency in national banking markets. Indeed, in the calculation for gains from European integration in financial services, it was assumed that banks in different countries would become equally efficient with the removal of cross-border restrictions (Altunbas and Chakravarty, 1998). It was also expected that deregulation-induced competition would foster efficiency by providing incentives to managers to cut costs in order to remain profitable. EU regulators believe that a well integrated financial system is necessary to increase the efficiency of the euro area economy by reducing the cost of capital and improving the allocation of financial resources (see ECB, 2005). While it is generally agreed that deepening financial integration is beneficial on the whole, it might also have negative effects. For example, integration in a particular market segment might lead to a high degree of consolidation which might hinder competition.[1] Furthermore, integration has significant implications for financial regulation and the issue of financial stability has assumed an increasingly international dimension. As a consequence, it is important to monitor and understand the process of financial market integration.[2] In addition, as further integration is promoted at the EU level, it is also crucial to measure accurately the state of integration in various segments of the single market.

In this context, an integrated financial market is defined as a market where participants with the same relevant characteristics: (a) face a single set of rules; (b) have equal access to financial instruments and/or services; and (c) are treated equally when they are active in the market (Baele et al., 2004). The above definition of financial integration is closely related to the law of one price, which states that if assets have identical risks and returns, then they should be priced identically

[1] Financial integration does not necessarily have implications for consolidation in all market segments. While integration may lead to consolidation in an industry, there is no direct causal link between integration and consolidation (Baele et al., 2004).

[2] The European Central Bank "Financial Integration in Europe" reports (published in March 2007, April 2008 and April 2009) aim at providing a dynamic evaluation of the process of economic integration of EU member states. Specifically, the ECB (2009) report focuses on the effects of the 2007-08 financial turmoil on the state of financial integration in the euro area. The report finds evidence of some disruption to the integration process in 2008, which has resulted in a retrenchment within national borders (cross-border disintegration). However, as the crisis is still unfolding, it is difficult to assess the long term impact on the integration of financial markets once more stable conditions return.

regardless of where they are traded. Based on the law of one price it is possible to derive measures of integration. For example, the cross-sectional dispersion of relevant variables (such as interest rate spreads or asset return differentials) is often used as an indicator of integration. The concepts of β-convergence and σ-convergence can also be used to assess the speed at which markets are integrating. In addition, measuring the degree of cross-border price or yield variation relative to the variability within individual countries may be informative with respect to the degree of integration in different markets.[3]

This study aims to contribute to the current debate by investigating the impact of integration on the efficiency of EU banking markets. As our definition of financial integration is closely related to the law of one price, this allows us to examine the link between the dynamics of efficiency and financial integration. The concept of price convergence implies that, in case of increased integration, price differentials for the same financial asset should be either eliminated or greatly reduced overtime. This should also apply to the factors of production. Consequently, if factor input prices (i.e. the cost of capital, labour and deposits) are converging across the European Union, so should banks' cost structures, reflected in a convergence of cost efficiency scores. On the other hand, if country differences in observed cost efficiency levels remain (that is, if there is no evidence of increased convergence), it would imply that the regulatory removal of cross border restrictions alone was not sufficient to equalise the cost structure of EU banking systems and that country-specific structural differences remain relevant.

Measuring convergence towards a European average efficiency level is relevant in the context of the single market for financial services, as evidence of convergence would indicate a reduction in the coefficient of variation within countries (i.e. it would indicate increased integration). However, this could occur either because the least efficient banking systems improve their efficiency (i.e. they are "catching up") or because the most efficient ones see a decline in their efficiency levels (i.e. they are "lagging behind). Färe et al. (1994) re-formalised the notion of "catching up/lagging behind" as the decrease (increase) over time of the distance between a unit actual performance and its potential (i.e. its best practice frontier).[4] From a regulatory point of view, measuring convergence towards best practice (that is, towards the maximum attainable efficiency) is important, as increased integration is supposed to bring about improvements in cost efficiency via increased competition

[3] See Baele et al. (2004) for a review of different measures of financial market integration.

[4] In DEA, the concept of best practice frontier is more general than the concept of a "production function" in economics. The frontier results from the linear combination of the efficient units and it accommodates the possibility of multiple production functions, one for each DMU, with the frontier boundaries consisting of "supports" which are "tangential" to the more efficient members of the set of such frontiers (see Cooper et al., 2004).

(Guiso et al., 2004). If the process of EU integration had a positive impact on bank cost efficiency, this should result in convergence towards best practice (i.e. an overall improvement of efficiency levels over time).

In this study, we evaluate cost efficiency by means of Data Envelopment Analysis (DEA) for the EU-15 countries prior to the latest round of accessions in 2004. In this context, DEA has the advantage of allowing us to compare banks of different size in different countries with respect to one EU-wide frontier without imposing any specific parametric functional form.[5] At present, formal statistical tests to assess convergence in a DEA framework do not exist (see Henderson and Zelenyuk, 2007). Therefore, we borrow the concepts of β-convergence and σ-convergence from the growth literature (see Barro and Sala-i-Martin, 1991, 1992 and 1995; Quah, 1996) and we apply a dynamic panel data analysis. To test for convergence towards best practice we use a variant of the classic partial adjustment model (see also Flannery and Rangan, 2006; Gropp and Kashyap, 2009, Zhao et al., 2009). Results seem to provide supporting evidence of convergence of efficiency levels towards an EU average. Nevertheless, the results also indicate persistence of inefficiency, evidenced by a decrease in the overall efficiency levels.

The remainder of the paper is structured as follows. Section 2 reviews the main literature on integration and efficiency in banking. Section 3 describes data and empirical methods used. Section 4 discusses the results and Section 5 concludes.

2. Literature review

Several studies investigate the existence and implications of financial convergence in Europe, especially in relation with the deregulation process, the creation of the single market for financial services and the introduction of the euro. Convergence in banking is often analysed by testing the time trends of a number of aggregate and micro level indicators. For example, recent studies of price convergence include Martín-Oliver et al. (2005, 2007), De Graeve et al. (2007), Vajanne (2007), Gropp et al. (2007) and Affinito and Farabullini (2006). Recent empirical evidence suggests that the sustained legislative changes at the EU level, as well as other major developments such as the introduction of the euro in 1999, have contributed towards the integration of European banking and financial markets (Goddard et al., 2007). There is some evidence of integration in money, bond and equity markets (Emiris, 2002; Hartmann et al., 2003; Baele et al., 2004; Manna, 2004; Guiso et

[5] Formally, DEA is a methodology directed to frontiers rather than central tendencies. In this context, we define a unit 100% efficient (relative efficiency) on the basis of available evidence if and only if the performance of other units does not show that some of the inputs or outputs can be improved without worsening some of the other inputs or outputs. (see Cooper et al., 2004).

al., 2004; Cappiello et al., 2006) and in wholesale banking (Cabral et al., 2002). However, most empirical evidence suggests that significant barriers to the integration of retail banking markets still exist (Berger, 2003; Berger et al., 2003). Gropp and Kashyap (2009) propose a new test of integration based on convergence in banks' profitability (Return On Assets or ROA), based on the assumption that in equilibrium (with well functioning markets) the expected returns of comparable assets in an economy should be similar (Stigler, 1963). Overall, they conclude, banking markets in Europe appear far from being integrated. A robust alternative to using banks' profitability is to check for convergence in banks' profit or cost efficiency.

There is a vast literature on the measurement of cost structure and efficiency in banking and on the determinants of efficiency (see the reviews by Goddard et al., 2001, 2007; Berger, 2007; Hughes and Mester, 2009). Efficiency is commonly estimated by employing parametric methods (such as Stochastic Frontier Analysis, SFA) or non-parametric methods, the most popular of which is Data Envelopment Analysis (DEA). The early bank efficiency literature shows that before deregulation EU banking markets were often characterised by the presence of many institutions operating at a non-optimal scale with relatively high excess capacity (see Berger and Humphrey, 1997). Inefficient banks could survive mainly because of the lack of competitive pressures and the fact that, in some cases, the domestic authorities, while acting as protectors of their banking sectors, were keen on maintaining a large number of banks in their systems. With deregulation and higher competition, EU bank efficiency improved, particularly over the late 1990s, as banks were under pressure to cut costs (see, among others, Amel et al., 2004 and Casu et al., 2004). However, more recent studies indicate a decreasing trend in bank efficiency (Casu and Girardone, 2006; Berger 2007). While there are a number of studies that carry out comparisons of bank efficiencies in different countries based either on the use of a common efficient frontier or of nation-specific frontiers, only a handful of studies directly address the issue of the relationship between EU integration and efficiency. Tortosa-Ausina (2002) examines the convergence in efficiency of Spanish banks following deregulation through a model of distribution dynamics and find evidence of decreased dispersion of efficiency scores at the end of the deregulation period. Murinde et al. (2004) investigate the convergence of the banking systems in Europe following the launch of the single market programme in 1993. They find weak evidence of convergence and only for specific products. Weill (2009) attempts to provide evidence of financial integration by estimating the convergence of cost efficiency derived from the application of SFA methodology. His results indicate an on-going process of convergence at the EU level. Finally, Mamatzakis et al. (2008) investigate the convergence in cost and profit efficiency (estimated by means of SFA) for banks in the ten new European Union member states over the period 1998-2003. Their results indicate some convergence in cost efficiency (but not in profit efficiency) across the new member states.

This study departs from the existing literature as it evaluates the dynamics of bank cost efficiency by means of DEA and it extends the analysis of financial sector integration to convergence both towards a EU-wide frontier and towards best practice.

3. Data and Methodology

3.1 Data

Our data set is primarily drawn from BankScope and includes annual information for an unbalanced panel of 11,000 observations between 1997 and 2003. The choice of an unbalanced panel is justified mainly to account for mergers and acquisitions during the period. We use data from consolidated accounts, where available, to avoid double-counting. As a result, the banking market for country X is defined as the hypothetical market where banks from country X operate and not the national borders of a country (see Bikker and Haaf, 2002). The sample comprises commercial and savings banks operating in the EU-15 area. We focus on these two banking categories as they comprise the largest segment of depository institutions in all European banking markets. Further, the services they offer are reasonably homogeneous and comparable across countries. The time period 1997-2003 allows us to include the countries which joined in the so-called Fourth Enlargement (Austria, Finland and Sweden joined in 1995) but exclude the effects of the Fifth Enlargement in 2004[6], as there is not sufficient data availability as yet. The data were analysed for inconsistencies, reporting errors, missing values and outliers. The final sample is shown in Table 1, which lists the total and average number of banks in the sample by country and year.

< Insert Table 1 here >

3.2 Evaluating bank efficiency

Following the work of Debreu (1951), Koopmans (1951), Shephard (1953, 1970) and Farrell (1957) the efficiency of a firm can be defined and measured as the radial distance of its actual performance from a frontier. In a production function context, this frontier is defined as the maximum feasible level of outputs given the inputs levels, or alternatively as the minimum feasible level of inputs

[6] The Fifth Enlargement (Part I) occurred in May 2004, when Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia were admitted to the EU. The Fifth Enlargement (Part II) occurred in January 2007, when Romania and Bulgaria joined the EU.

given the outputs levels; a firm's inefficiency will respectively be measured as the radial inputs contraction or radial outputs expansion necessary to reach the frontier.

There is a very large and well-established literature on the measurement of efficiency frontiers which can be divided in two main streams: parametric techniques, such as the Stochastic Frontier Analysis (SFA) and non-parametric techniques such as Data Envelopment Analysis (DEA).

In this study, we follow the non-parametric DEA approach to measure inefficiency with an input-minimisation orientation. The advantage of the DEA approach is that it allows us to compare banking systems of different size with respect to one frontier without imposing any specific parametric functional form. The choice of an input orientation is based on the assumption that during periods of regulatory changes and increased competition market participants strategically focus on cutting costs; therefore we would expect changes in inputs use to be closely associated with the changes in market structure. The measure of input efficiency reflects the extent to which the input levels of the unit concerned can be lowered through improved performance and no output reduction, while maintaining its input mix (Thanassoulis, 2001). The existing literature (see Goddard et al., 2001) has traditionally focused on the estimation of input or cost based efficiency, assuming that bank management has more control over costs rather than over outputs.

DEA is a mathematical linear programming technique developed by Charnes, Cooper and Rhodes in 1978 (CCR) which identifies the efficient frontier from the linear combination of those units/observations that (in a production space) use comparatively less inputs to produce comparatively more outputs. In particular, if N firms use a vector of inputs to produce a vector of outputs, the input-oriented CCR measure of efficiency of a particular firm is calculated as:

$$\begin{aligned} & \min_{\theta,\lambda} \theta_i \\ s.t. \quad & \sum_{r=1}^{N} y^t{}_{mr} \lambda^t{}_r \geq y^t{}_{mi} \\ & \sum_{r=1}^{N} x^t{}_{kr} \lambda^t{}_r \leq \theta_i x^t{}_{ki} \\ & \lambda^t{}_r \geq 0 \end{aligned} \tag{1}$$

where $\theta_i \leq 1$ is the scalar efficiency score for the i-th unit. If θ_i =1 the i-th firm is efficient as it lies on the frontier, whereas if θ_i < 1 the firm is inefficient and needs a (1-θ_i) reduction in the inputs levels to reach the frontier. The CCR model assumes constant returns to scale (CRS), which is the optimal scale in the long run. The additional convexity constraint $\sum \lambda_i = 1$ can be included in (1) to allow for variable returns to scale (VRS) (see Banker, Charnes and Cooper (1984) or BCC model). This latter is used in this paper since several factors such as imperfect competition and regulatory requirements may cause a unit not to be operating at the optimal scale.[7]

Choosing the appropriate definition of bank output is a relevant issue for research into banks' cost efficiency. The approach to output definition used in this study is a variation of the *intermediation approach*, which was originally developed by Sealey and Lindley (1977) and posits that total loans and securities are outputs, whereas deposits along with labour and physical capital are inputs. Specifically, the input variable used in this study is Total Costs (Personnel Expenses + Other Administrative Expenses + Interest Paid + Non-Interest Expenses) whereas the output variables capture both the traditional lending activity of banks (total loans) and the growing non-lending activities (other earning assets).

In this study, therefore, DEA measures of efficiency are based on estimates of the degree to which the unit under analysis could have used less input for its output levels. Since the objective of this analysis is to estimate the overall performance of a specific bank relative to "best practice" rather than its sources of inefficiency, only overall efficiency estimates, rather that their detailed decomposition, are estimated. The last issue to be resolved before running the analysis is to identify potential outliers among the units to be assessed. For this purpose, we used the concept of "super-efficiency" (see Andersen and Petersen, 1993).

3.3 Modelling convergence

To investigate the convergence of bank efficiency levels across the EU-15 countries over the period of analysis, we employ the concepts of β-convergence and σ-convergence (Barro and Sala-i-Martin, 1991, 1992 and 1995; Quah, 1996).

To estimate unconditional β-convergence or "catch-up effect", we employ the following equation:

$$\Delta y_{i,t} = \alpha + \beta(\ln y_{i,t-1}) + \rho \Delta y_{i,t-1} + \varepsilon_{i,t} \tag{2}$$

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[7] For an introduction to DEA methodology see, among others, Coelli et al. (2005), Cooper et al. (2004) and Thanassoulis (2001). Recent advances in DEA methodology include bootstrapping individual DEA efficiency estimates to obtain bias corrected efficiency scores (see, among other Simar and Wilson, 2000). In this context, we apply standard DEA efficiency measurement as the issue of the advantages of bootstrapping when applying second stage DEA analysis are controversial (see Banker and Natarajan, 2008). Finally, recent DEA studies are taking into account the impact of environmental conditions (see for a review Avkiran and Rowlands, 2008; and more recently Lozano-Vivas and Pastor, 2009; Delis, 2009).

where i=1,…15 and t=1,…7; $y_{i,t}$ = the mean efficiency of the banking sector of country *i* at time *t*; $y_{i,t-1}$ = the mean efficiency of the banking sector of country *i* at time *t*-1; $\Delta y_{i,t} = \ln(y_{i,t}) - \ln(y_{i,t-1})$; α, β and ρ are the parameters to be estimated and $\varepsilon_{i,t}$ = error term. A negative value for the parameter β implies convergence; the higher the coefficient in relative terms the greater the tendency for convergence. Equation (2) is first estimated without including the lagged dependent variable ($\Delta y_{i,t-1}$) as in the conventional growth theory models. The β-convergence equations are estimated by pooled OLS regression and Generalised Method of Moments (GMM) to introduce dynamic behaviour in the time series and cross-sectional variation (Blundell and Bond, 1998).

To estimate cross sectional dispersion or σ-convergence, that is to estimate how quickly each country's efficiency levels are converging to the European average, we adopt the following autoregressive distributed lag model specification[8]:

$$\Delta E_{it} = \alpha + \sigma E_{i,t-1} + \rho \Delta E_{i,t-1} + \varepsilon_{i,t} \tag{3}$$

where $E_{i,t} = \ln(y_{i,t}) - \ln(\bar{y}_t)$; $E_{i,t-1} = \ln(y_{i,t-1}) - \ln(\bar{y}_{t-1})$; $y_{i,t}$ and $y_{i,t-1}$ are defined as before; $\bar{y}_t$ = the mean efficiency of the EU-15 banking sectors at time *t*; $\bar{y}_{t-1}$ = the mean efficiency of the EU-15 banking sectors at time *t*-1; $\Delta E_{it} = E_{i,t} - E_{i,t-1}$; α, σ and ρ are parameters to be calculated and $\varepsilon_{i,t}$ is the error term. σ < 0 represents the rate of convergence of $y_{i,t}$ towards $\bar{y}_t$; the larger is σ in absolute value, the faster the rate of convergence. The model in equation (3) is estimated initially without the inclusion of the lagged dependent variable (ΔE_{it-1}), as we did for the β-convergence in equation (2).

To measure the adjustment of efficiency scores towards the best practice frontier, we employ a variation of the standard partial adjustment model (PAM). In the standard PAM it is assumed that the dependent variable is a "desired" or "target" level (y*) and that economic agents are only able or willing to partially adjust the value of y towards the target, as follows:

$$y_t - y_{t-1} = \gamma(y_t^* - y_{t-1}) \qquad \text{with } 0 < \gamma < 1 \tag{4}$$

[8] Similar specifications have been estimated, among others, by Fung (2006), Parikh and Shibata (2004) and Weill (2009).

If γ = 1, then $y_t = y_t^*$; if γ = 0, then $y_t = y_{t-1}$. Each year, the typical firm closes a proportion γ of the gap between its actual and its desired levels, as it trades off its adjustment costs against the costs of operating a suboptimal or inefficient levels (Flannery and Rangan, 2006).

Since in this context, the "optimal" or "target" level is known (i.e. the best practice frontier) and y* = $y_{\max,}$, we can evaluate the convergence of efficiency levels towards best practice by specifying the adjustment mechanisms as follows[9]:

$$y_y - y_{i,t} = \gamma(\ln y_{\max} - \ln y_{i,t-1}) + \delta R(\ln y_{\max} - \ln y_{i,t-1}) + \varepsilon_{it} \tag{5}$$

where: $y_{i,t}$ and $y_{i,t-1}$ are defined as before; $y_{\max}$ = maximum attainable efficiency, i.e. unity. ε_{it} is the error term. R is a dummy to indicate the introduction of the Euro as the single currency of 12 of the 15 countries; R takes value 0 for until 1998 and value 1 after 1999. γ is the adjustment parameter as defined above; it measures the speed of adjustment towards the best practice frontier (i.e. towards the maximum attainable efficiency score). A negative value of γ signifies lack of convergence towards best practice, or persistence of inefficiency. δ is the interaction term between R and $(\ln y_{\max} - \ln y_{it})$; it allows for a change in the speed of adjustment after the introduction of the Euro ($0 < \gamma + \delta < 1$). A significant positive δ would imply a faster adjustment towards best practice after 1999, when the exchange rate between member States' currencies and the euro was fixed. Rearranging equation (5) and substituting $\kappa = (1-\gamma)$ and $\lambda = -\delta$ we obtain:

$$\ln y_{i,t} = \kappa(\ln y_{i,t-1}) + \lambda R(\ln y_{i,t-1}) + \varepsilon_{it} \tag{6}$$

κ= (1-γ) measures the persistence of y_{it-1} into y_{it}. In other words, it signifies lack of convergence towards best practice. A significantly negative value for λ, corresponding to a significantly positive δ, would suggest an increase in the speed of convergence of efficiency levels toward best practice after the introduction of the euro. Equation (6) is estimated by pooled OLS.

9 A variant of the classical partial adjustment model specification has been estimated, among others, by Zhao et al., 2009; Flannery and Rangan, 2006; Gropp and Kashyap, 2009.

4. Results

4.1 Efficiency results

The yearly DEA results for the countries in our sample, as well as the average efficiency over the period are shown in Table 2.

< Insert Table 2 here>

The average overall efficiency score for the EU banking industry over the whole sample period is 76.5%, indicating a 23.5% average potential reduction in inputs utilisation. The results for the different EU countries in 2003, vary between 59.6% in Sweden and 80% in Portugal, with an average inefficiency score of about 20%, a result that is in line with the main literature on bank efficiency (see Berger, 2007). The yearly results seem to indicate, for most countries, an improvement in input utilisation in the first years of the analysis and an increase in input wastage from 2000-2001 onwards. This trend could be explained by the initial effort towards cutting costs fostered by deregulation and increased competition; the wave of mergers and acquisitions that followed might have imposed higher costs on banks, thereby decreasing their cost efficiency. [10]

In a DEA framework, we can define:[11]

i) efficiency *catching up/ lagging behind* (within a group) – a situation where the average efficiency for the group is increasing/decreasing;
ii) efficiency *convergence/divergence* (within a group) – a situation where the range (or coefficient of variation) of efficiency scores is decreasing/increasing.

Before empirically investigating the issue of convergence, we analyse the distribution, dispersion, range and trends of efficiency levels across European countries. Figure 1 plots the standard deviation of the efficiency scores by year for all EU-15 countries included in our sample. The figure indicates that the dispersion from the average values has decreased considerably (p = 0.085) over

[10] It is necessary to point out that our results are static estimates obtained from yearly DEA frontiers, which allow for cross sectional comparisons, rather than considering the changes over time.
[11] See Handersen and Zelenyuk (2006, p. 1016).

the period thereby suggesting a trend towards convergence across countries.

< Insert Figure 1 here >

Figure 2 analyses EU banks' efficiency range and trends over the period 1997-2003. Panel (a) shows that the average efficiency scores across EU-15 countries (± standard deviation) decreases over time (p = 0.023). Panel (b) illustrates the range (highest average efficiency score – lowest average efficiency score across EU-15 countries). It shows that while the lowest average efficiency scores each year have remained fairly constant (p = 0.852), the highest average scores have decreased significantly over time (p = 0.034). This trend is also picked up by the decline in average efficiency levels towards the end of the period. On the one hand, the findings illustrated in Figures 1 and 2 indicate that the efficiency scores for the EU-15 banking sector have tended to converge towards a common average. On the other hand, this preliminary analysis seems to suggest a decrease in average efficiency levels. In other words, there is evidence of "lagging behind" rather than "catching up" with best practice.

< Insert Figure 2 here>

To further investigate these results, we have analysed the distribution of bank efficiency scores by means of non-parametric Kernel density estimation techniques, following Pagan and Ullah (1999) and Henderson and Zeleynuk (2007).[12] This method is particularly useful in our context since we did not impose distributional assumptions on the efficiency scores across countries. The preliminary results are confirmed by the Kernel density estimations relative to 1997 and 2003, reported in Figure 3. By comparing the densities, a decrease in efficiency can be noted, since there is evidence of a shift of the mass towards the left.

< Insert Figure 3 here>

Figure 3 shows that, although differences in efficiency levels decreased between 1997 and 2003 (evidenced by a reduction of the thickness of the tails), it is not because the least efficient improved

[12] Some adjustments have to be made to adapt Kernel density estimation techniques to graphically illustrate DEA efficiency results (for more detail, see Simar and Zelenyuk, 2006). In addition, to carry out the Kernel density estimations, DEA efficiency scores have been recalculated across all EU banks with all observations for 1997 and 2003.

but rather because a significant fraction of the upper-middle "performers" became worse. The Kernel density estimates reveal some evidence of changes in the shape of the distribution over time. The statistical significance of these changes can be assessed by means of a standard non-parametric Kruskal-Wallis test (K-W) or a Li (1996) test. In this case, the value of the K-W test is 480.5 ($p < 0.0001$), thereby indicating that the two distributions are significantly different.

4.2 Evaluating convergence of EU banking sector efficiency

To examine to what extent the econometric application confirms the preliminary evidence discussed above, we evaluate β-convergence for our cross-section of EU countries by estimating equation (2) by OLS and GMM. Table 3 shows regression estimates of the convergence coefficient β for the period 1997-2003. The results from equation (2) that exclude the lagged dependent variable are reported in the first column. The beta coefficient is always negative and statistically significant, thus indicating that convergence in efficiency scores has occurred across countries in the EU-15 area. The results are confirmed in all three models although the goodness of fit for the SYS-GMM (last column) shows that the p-value for AR(1) is greater than 5%.

< Insert Table 3 here>

Figure 4 shows the broad pattern of convergence of efficiency scores, indicating a strong negative correlation (-0.883) between the growth rate of efficiency scores over 1997-2003 to the log of the initial average efficiency in the base year (1997) for the EU-15 countries. It shows that countries that displayed the lowest efficiency values in 1997 improved faster, thereby providing preliminary evidence of efficiency catch-up among EU-15 countries.

< Insert Figure 4 here>

Table 4 reports the results for the σ-convergence. In our case sigma convergence indicates how quickly each country's efficiency levels are converging to the EU average. Recall that $\sigma<0$ represents the rate of convergence of $y_{i,t}$ towards $\bar{y}_t$; the larger is σ in absolute value, the faster the rate of convergence. We firstly estimated the model with pooled OLS and fixed effects (Hausman test χ^2 =29.33 for the model that does not include the lagged dependent variable and χ^2 =16.92 for equation (3) allows us to reject random effects). Potential problems with these two models are addressed by the estimation of a dynamic GMM model. The last column of Table 4 reports the SYS-GMM estimations results (equation 3). Following Arellano and Bover (1995) and Blundell and Bond (1998) the use of a GMM estimator should help mitigate possible endogeneity problems and omitted variable bias. Results for all the estimations suggest an increase in the speed of convergence as the σ coefficient is always negative and statistically significant. Further, the SYS-GMM results satisfy the three additional conditions: a significant AR(1) serial correlation, lack of AR(2) serial correlation and a high Sargan/Hansen test .

< Insert Table 4 here>

Table 5 presents the results of our partial adjustment model (equation 6). The assumption behind such model is that if bank efficiency scores have improved over the period under observation, this should be reflected in a convergence towards best practice. Specifically, we regress the natural logarithm of the efficiency level (lny_{it}) on its lagged value, and on the interaction of the lagged value with a dummy variable R, controlling for the introduction of the euro. The estimated parameter on the interaction term is expected to offer information on the difference in speed of convergence after the introduction of the single currency.

< Insert Table 5 here>

The estimated coefficient of the one period lag of the change in efficiency is κ for the period 1997-1999 and is $\kappa + \lambda$ for the period 2000-2003. The coefficient κ is positive and significant (at 1% level) therefore indicating a persistence of inefficiency. In other words, there is no evidence of convergence of efficiency levels towards best practice. The coefficient λ, on the other hand, although positive is not statistically significant, thus indicating that the introduction of the single currency had no effect towards increasing convergence and improving efficiency levels across EU countries. These findings support the preliminary graphical evidence reported in Section 4.1, thereby indicating convergence of bank efficiency levels towards a European average. However, convergence seems to have occurred not because of "catching up" of less efficient banks but because of a general decline in efficiency levels. The results of the partial adjustment model estimation indicate persistence of inefficiency over the period of analysis. Overall, our findings seem to indicate that increased convergence has not translated into an improvement of efficiency level across EU banking markets.

5. Conclusions

It is a commonly held belief among EU regulators that a well integrated financial system is necessary to increase the efficiency of the euro area economy. In the overall calculation of potential gains from European integration in the financial services, it is often assumed that banks in different countries will become equally efficient with the removal of cross-border restrictions.

This paper provides evidence on the dynamics of cost efficiency in the EU-15 banking sectors in the period 1997-2003, prior to the latest round of accession. Cost efficiency is evaluated by means of Data Envelopment Analysis (DEA). The yearly results seem to indicate, for most countries, an improvement in input utilisation in the first years of the analysis and an increase in input wastage from 2000-2001 onwards. To assess the direction and speed of banking markets' integration, we apply dynamic panel data models to the concepts of β-convergence and σ-convergence. Consistently with the current literature, we find evidence of convergence towards a European average. However, convergence does not translate into improvement of efficiency levels across the EU-15 countries in our sample. Our results indicate that convergence is due to a "lagging behind" rather than "catching up" with best practice. The on-going process of EU integration does not seem to have had a positive impact on bank cost efficiency over the period of analysis, as the results indicate persistence of inefficiency or lack of convergence towards best practice.

References

Affinito M, Farabullini F. An empirical analysis of national differences in the retail bank interest rates of the euro area, Temi di discussione Bank of Italy 589 (2006).

Altunbas Y, Chakravarty S. Efficiency measures and the banking structure in Europe. Economics Letters, 60 (1998) 205-208.

Amel D, Barnes C, Panetta F, Salleo C. Consolidation and efficiency in the financial sector: a review of the international evidence. Journal of Banking and Finance 28 (2004) 2493-2519.

Andersen P, Petersen NC. A procedure for ranking efficient units in Data Envelopment Analysis. Management Science 39 (1993) 1261-1264.

Arellano M, Bover O. Another look at the instrumental variables estimation of error components models. Journal of Econometrics 68 (1995) 29-51.

Avkiran NK, Rolands T. How to better identify the true managerial performance: state of the art using DEA. OMEGA The International Journal of Management Science 36 (2008) 317-324.

Baele LM, Ferrando A, Hordahl P, Krylova E, Monnet C. Measuring financial integration in the euro area. ECB Occasional Paper 14 (2004).

Banker RD, Charnes A, Cooper WW. Some models for the estimating technical and scale inefficiency in Data Envelopment Analysis. Management Science 30 (1984) 1078-92.

Banker RD, Natarajan R. Evaluating contextual variables affecting productivity using Data Envelopment Analysis, Operations Research 56, 1 (2008) 48-58.

Barro RJ, Sala-i-Martin XX. Convergence across states and regions. Brookings Papers on Economic Activity 1 (1991) 107-182.

Barro RJ, Sala-i-Martin XX. Convergence. Journal of Political Economy 100 (1992) 223-251, April.

Barro RJ, Sala-i-Martin XX. Economic growth, New York, McGraw Hill (1995).

Berger AN, Humphrey DB. Efficiency of financial institutions: international survey and directions for future research. European Journal of Operational Research 98 (1997) 175-212.

Berger AN. The efficiency effects of a single market for financial services in Europe. European Journal of Operational Research 150, 3 (2003) 466-481, November.

Berger AN, Dai Q, Ongena S, Smith DC. To what extent will the banking industry be globalized? A study of bank nationality and reach in 20 European nations. Journal of Banking and Finance 27, 3 (2003) 383-415, March.

Berger AN. International comparisons of banking efficiency. Financial Markets, Institutions and Instruments 16, 3 (2007) 119-144, August.

Bikker JA, Haaf K., Competition, concentration and their relationship: an empirical analysis of the banking industry. Journal of Banking and Finance 26 (2002) 2191-2214.

Blundell R, Bond SR. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87 (1998) 115-43.

Cabral I, Dierick F, Vesala J. Banking integration in the euro area. ECB Occasional Paper Series 6 (2002).

Cappiello L, Hordahl P, Kadareja A, Manganelli S. The impact of the euro on financial markets. ECB Working Paper 598 (2006).

Casu B, Girardone C. Molyneux, P. Productivity change in European banking: a comparison of parametric and non-parametric approaches. Journal of Banking and Finance 28 (2004) 2521-2540.

Casu B, Girardone C. Bank Competition, concentration and efficiency in the Single European market. The Manchester School 74 (2006) 441-468.

Charnes A, Cooper WW, Rhodes E. Measuring efficiency of decision making units. European Journal of Operational Research 2 (1978) 429-44.

Coelli T, Rao DSP, O'Donnell CJ, Battese GE. An introduction to efficiency and productivity analysis. 2nd ed., New York: Springer (2005).

Cooper WW, Seiford LM, Zhu J. Handbook on Data Envelopment Analysis (2004) Springer (Kluwer Academic Publishers) Boston.

De Graeve F, De Jonghe O, Vander Vennet R. Competition, transmission and bank pricing policies: Evidence from Belgian loan and deposit markets. Journal of Banking & Finance 31(2007) 259-278.

Debreu G. The coefficient of resource utilisation. Econometrica 19 (1951) 273-292.

Delis MD. Competitive conditions in the Central and Eastern European banking systems. OMEGA The International Journal of Management Science (2009) in press.

Emiris M. Measuring capital market integration. BIS Papers 12 (2002) 200-221.

European Central Bank. Indicators of financial integration in the euro area. September (2005) http://www.ecb.de/pub/pdf/other/indicatorsfinancialintegration200509en.pdf.

European Central Bank. Financial integration in Europe. March (2007) http://www.ecb.de/pub/pdf/other/financialintegrationineurope200703en.pdf.

European Central Bank. Financial integration in Europe. April (2008) http://www.ecb.eu/pub/pdf/other/financialintegrationineurope200804en.pdf.

European Central Bank. Financial integration in Europe. April (2009) http://www.ecb.europa.eu/pub/pdf/other/financialintegrationineurope200904en.pdf.

Färe R, Grosskopf S, Norris M, Zhang Z. Productivity growth, technical progress, and efficiency change in industrialized countries. American Economic Review, 84 (1994) 66-83.

Farrell MJ. The measurement of productive efficiency. Journal of the Royal Statistical Society 120 (1957) 253-290.

Flannery MJ, Rangan KP. Partial adjustment toward target capital structures. Journal of Financial Economics 79 (2006) 469-506.

Fung MK. Scale economies, X-efficiency, and convergence of productivity among bank holding companies. Journal of Banking and Finance 30 (2006) 2857-2874.

Goddard JA, Molyneux P, Wilson JOS, Tavakoli M. European banking: an overview. Journal of Banking and Finance 31 (2007) 1911-1935.

Goddard JA, Molyneux P, Wilson JOS. European banking. Efficiency, technology and growth. John Wiley and Sons (2001) England.

Gropp R, Kok Sorensen C, Lichtenberger JD. The dynamics of bank spreads and financial structure. ECB Working Paper 714 (2007) January.

Gropp R, Kashyap A. A New metric for banking integration in Europe. NBER Working Paper Series. Working Paper 14735 (2009).

Guiso L, Jappelli T, Padula M, Pagano M. Financial market integration and economic growth in the EU. Economic Policy 40 (2004) 523-577.

Hartmann P, Maddaloni A, Manganelli S. The euro area financial system: structure, integration and policy. Oxford Review of Economic Policy 19 (2003) 180-213.

Henderson DJ, Zeleynuk V. Testing for (Efficiency) Catching-up. Southern Economic Journal, 73, 4 (2007) 1003-1019.

Hughes JP, Mester L. Efficiency in banking: theory, practice and evidence. In: Berger AN, Molyneux P, Wilson JOS. (Eds) The Oxford Handbook of Banking. Oxford University Press, Oxford, October 2009.

Koopmans TC. An analysis of production as an efficient combination of activities. In: Koopmans TC (Ed.) Activity analysis of production and allocation, Cowles Commission for research in economics, Monograph 13, John Wiley, New York (1951).

Li Q. Nonparametric testing of closeness between two unknown distributions. Econometric Reviews, 15 (1996) 261-274.

Lozano-Vivas A, Pastor JT. Do performance and environmental conditions act as barriers for cross-border banking in Europe? OMEGA The International Journal of Management Science (2009) forthcoming.

Mamatzakis E, Staikouras C, Koutsomanoli-Filippaki A. Bank efficiency in the new European Union member states: Is there convergence? International Review of Financial Analysis 17 (2008) 1156-1172.

Manna M. Developing statistical indicators of the integration of the euro area banking system. ECB Working Paper 300 (2004).

Martín-Oliver A, Saurina J, Salas-Fumás V. Interest rate dispersion in deposit and loan markets. Documentos de Trabajo N.º 0506. Banco de España (2005).

Martín-Oliver A, Salas-Fumás V, Saurina J. A test of the law of one price in retail banking. Journal of Money, Credit and Banking 39 (2007) 2021-2040.

Murinde V, Agung J, Mullineux AW. Patterns of corporate financing and financial system convergence in Europe. Review of International Economics 12 (2004) 693-705, September.

Pagan A, Ullah A. Nonparametric econometrics. Cambridge University Press (1999) Cambridge, UK.

Parikh A, Shibata M. Does trade liberalisation accelerate convergence in per capita incomes in developing countries? Journal of Asian Economics 15(2004) 33-48.

Quah D. Twin peaks: growth and convergence in models of distribution dynamics. Economic Journal 106 (1996) 1045-1055, July.

Sealey C, Lindley JT. Inputs, Outputs and a theory of production and cost at depositary financial institutions. Journal of Finance 32 (1977) 1251-1266.

Shephard RW. Cost and production functions. Princeton University Press, Princeton (1953).

Shephard RW. The theory of cost and production functions. Princeton University Press, Princeton (1970).

Simar L, Wilson P. A general methodology for bootstrapping in nonparametric frontier models. Journal of Applied Statistics 27 (2000) 779-802.

Simar L, Zelenyuk V. On testing equality of two distribution functions of efficiency scores estimated via DEA. Econometric Reviews 25 (2006) 497-522.

Stigler GJ. Capital and rates of return in manufacturing industries. Princeton University Press (1963) Princeton, NJ.

Thanassoulis E. Introduction to the theory and application of Data Envelopment Analysis. A foundation text with integrated software. Kluwer Academic Publishers (2001) USA.

Tortosa-Ausina E. Exploring efficiency differences over time in the Spanish banking industry. European Journal of Operational Research 139, 3 (2002) 643-664, June.

Vajanne L. Integration in Euro area retail banking markets. Convergence of credit interest rates. Bank of Finland Research Discussion Paper 27 (2007).

Weill L. Convergence in banking efficiency across European countries. Journal of International Financial Markets, Institutions & Money (2009) in press.

Windmeijer F. A finite sample correction for the variance of linear efficient two-step GMM estimators. Journal of Econometrics 126, 1 (2005) 25-51.

Zhao T, Casu B, Ferrari A. The impact of regulatory reforms on cost structure, ownership and competition in Indian banking. Journal of Banking and Finance (2009) forthcoming.

Table 1

Sample used for the empirical analysis

Countries	*Average # of banks 1997-2003*	*Total # of banks*	*% over total*	*Average size of banks (mil Euros) 2003*
Austria	101	706	6.4	4,509.07
Belgium	37	261	2.4	14,831.24
Denmark	84	590	5.4	40,951.35
Finland	8	53	0.5	22,431.03
France	150	1,047	9.5	24,475.70
Germany	686	4,805	43.7	6,092.81
Greece	14	98	0.9	11,675.19
Ireland	21	147	1.3	21,448.58
Italy	145	1017	9.2	10,873.20
Luxembourg	84	587	5.3	7,080.05
Netherlands	22	156	1.4	68,049.62
Portugal	17	121	1.1	16,236.84
Spain	100	703	6.4	15,036.03
Sweden	39	271	2.5	66,513.11
UK	63	438	4.0	42,280.57
EU-15	1,571	11,000	100	16,928.29

Source: Authors' calculations.

Table 2

DEA efficiency scores by year and country (%)

Countries	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*Average 1997- 2003*
Austria	71.30	85.30	81.30	84.40	78.60	73.10	76.30	78.60
Belgium	76.40	74.00	77.10	75.50	74.50	71.20	67.10	73.70
Denmark	76.40	79.40	75.90	70.30	76.90	77.40	70.90	75.30
Finland	97.80	95.30	97.80	69.70	85.40	85.30	68.60	85.70
France	55.70	68.00	55.70	71.20	67.60	78.00	75.70	67.40
Germany	67.20	63.50	67.20	67.00	69.30	68.30	71.80	67.80
Greece	91.60	85.30	91.60	89.30	91.00	88.40	76.70	87.70
Ireland	79.90	91.10	79.90	83.80	79.80	78.50	75.30	81.20
Italy	62.40	66.30	62.40	74.20	79.60	66.50	69.10	68.60
Luxembourg	66.40	66.10	66.40	72.80	54.50	62.30	61.10	64.20
Netherlands	82.40	74.50	82.40	86.30	86.90	84.90	76.20	81.90
Portugal	85.40	85.50	85.40	88.30	90.40	93.50	80.00	86.90
Spain	84.30	75.80	84.30	82.30	80.30	69.80	78.60	79.30
Sweden	91.60	87.40	91.60	57.00	51.20	77.40	59.60	73.70
UK	77.00	79.60	77.00	77.30	66.90	73.20	73.40	74.90
EU-15	77.72	78.47	78.40	76.63	75.53	76.52	72.03	76.46

Table 3

Beta convergence (dependent variable Δy)

Coefficients	*Equation (2) without lagged dependent variable*	*Equation (2)*	
	Pooled OLS Robust	Pooled OLS robust	SYS-GMM two step robust
β	-.4466***	-.3692***	-.5702***
	(.1048)	(.1321)	(.2221)
ρ	-	-.2816*	-.1955
		(.1617)	(.1388)
α	-.1311***	-.1162***	-.1676**
	(.0299)	(.0376)	(.0697)
Goodness of fit:			
R2	0.2538	0.3153	
m1 p-value			0.082
m2 p-value			0.227
Sargan/Hansen			0.298

Note: OLS= Ordinary Least Squares; SYS-GMM= System GMM. *,**,*** indicates significance at the 10%, 5% and 1% levels. Asymptotic standard error in parentheses. Two-step estimates are Windmeijeier corrected (Windmeijer, 2005). m1 and m2 are tests for first-order and second-order serial correlation. Sargan/Hansen is a test of the over-identifying restrictions for the GMM estimators.

Table 4

Sigma convergence (dependent variable ΔE)

Coefficients	*Equation (3) without lagged dependent variable*		*Equation (3)*		
	Pooled OLS robust	Fixed effects	Pooled OLS robust	Fixed effects	SYS-GMM two step robust
σ	-.4487***	-.8759***	-.3751***	-.9593***	-.5709***
	(.0982)	(.1121)	(.1241)	(.1673)	(.2061)
ρ			-.2699*	-.01733	-.1651
			(.1545)	(.1227)	(.1486)
μ	-.0029	-.0068	-.0023	-.00764	-.0050
	(.0109)	(.0100)	(.0121)	(.0113)	(.0142)
Goodness of fit:					
R2	0.2648		0.3197		
F-test		61.02***		29.42***	
m1 p-value					0.038
m2 p-value					0.217
Sargan/Hansen					0.447

Note: OLS= Ordinary Least Squares; SYS-GMM= System GMM. *,**,*** indicates significance at the 10%, 5% and 1% levels. Asymptotic standard error in parentheses. Two-step estimates are Windmeijeier corrected (Windmeijer, 2005). m1 and m2 are tests for first-order and second-order serial correlation. Sargan/Hansen is a test of the over-identifying restrictions for the GMM estimators.

Table 5

Convergence towards best practice (Dependent variable: y)

Coefficients	*OLS robust*	
Constant	-.1307*** (.0302)	--
κ	.4998*** (.1087)	.8745*** (.0802)
λ	.0659 (.0831)	.07934 (.0984)
Goodness of fit:		
R2	0.3462	0.8459

Figure 1

Dispersion of efficiency scores (all countries)

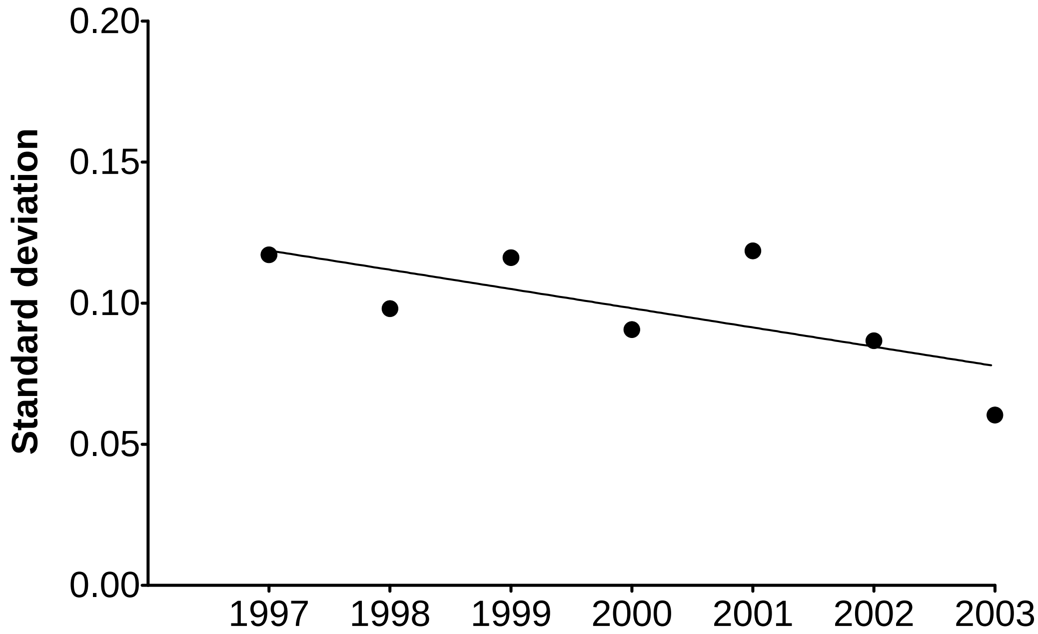
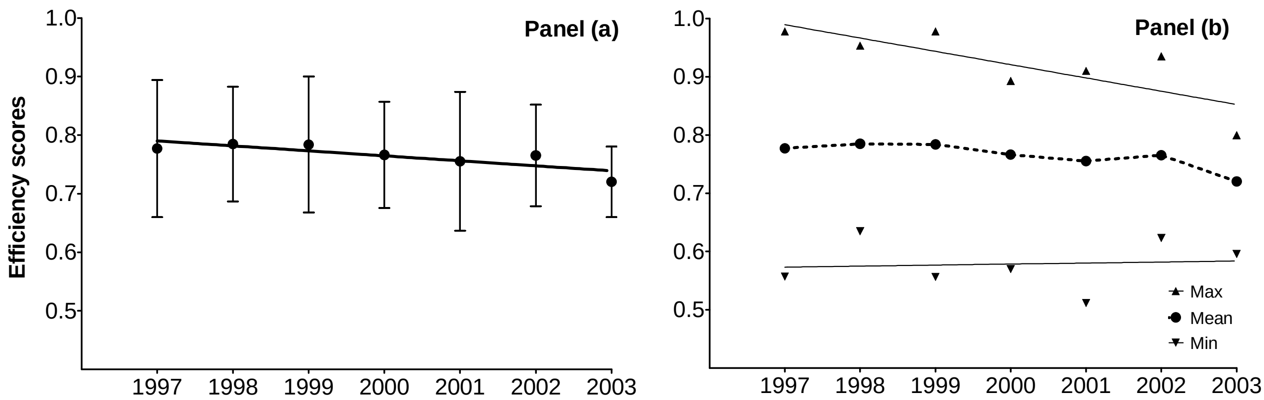


Figure 2

EU-15 efficiency range and trends over 1997-2003



Panel (a): average efficiency scores across EU-15 countries (± standard deviation).
Panel (b): range of average efficiency scores across EU-15 countries. Range = highest average efficiency score – lowest average efficiency score across EU-15 countries.

Figure 3

Kernel Distribution of Efficiency Scores

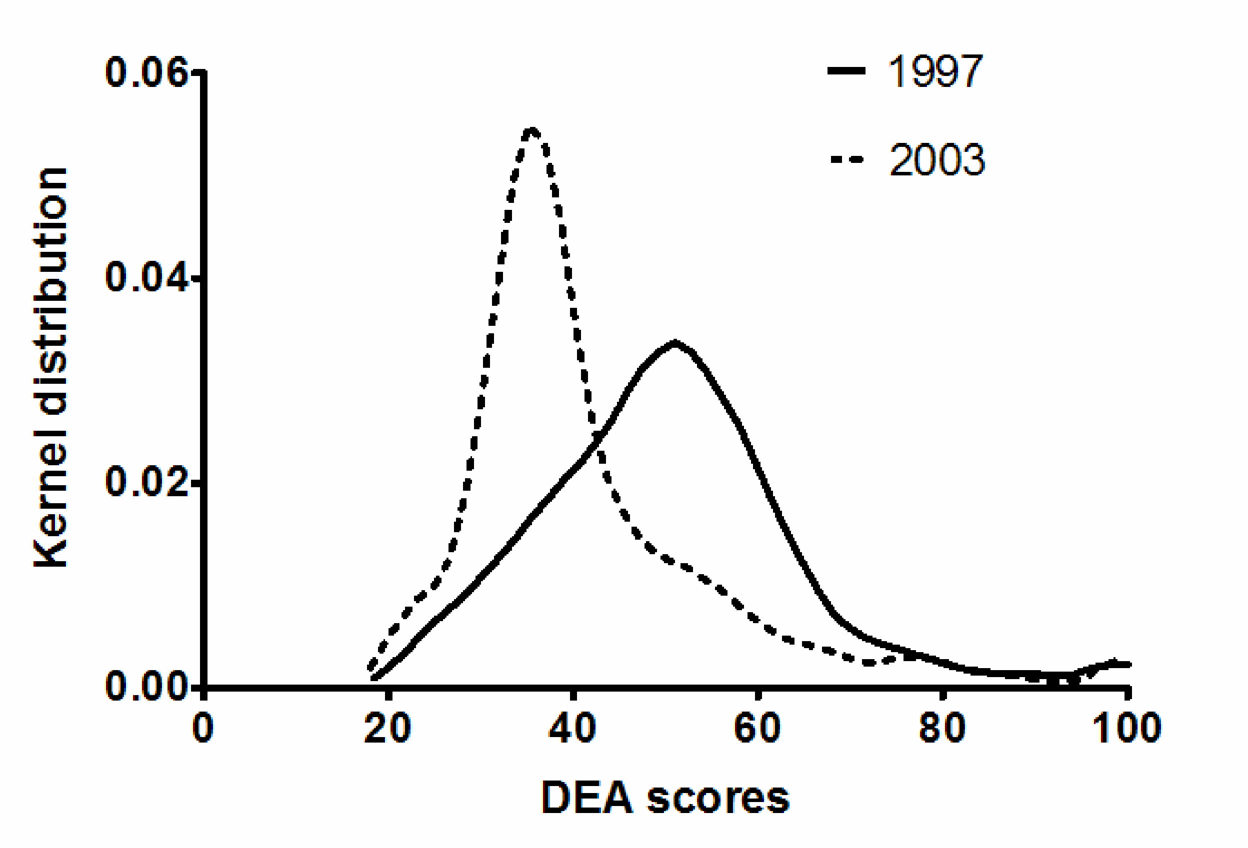
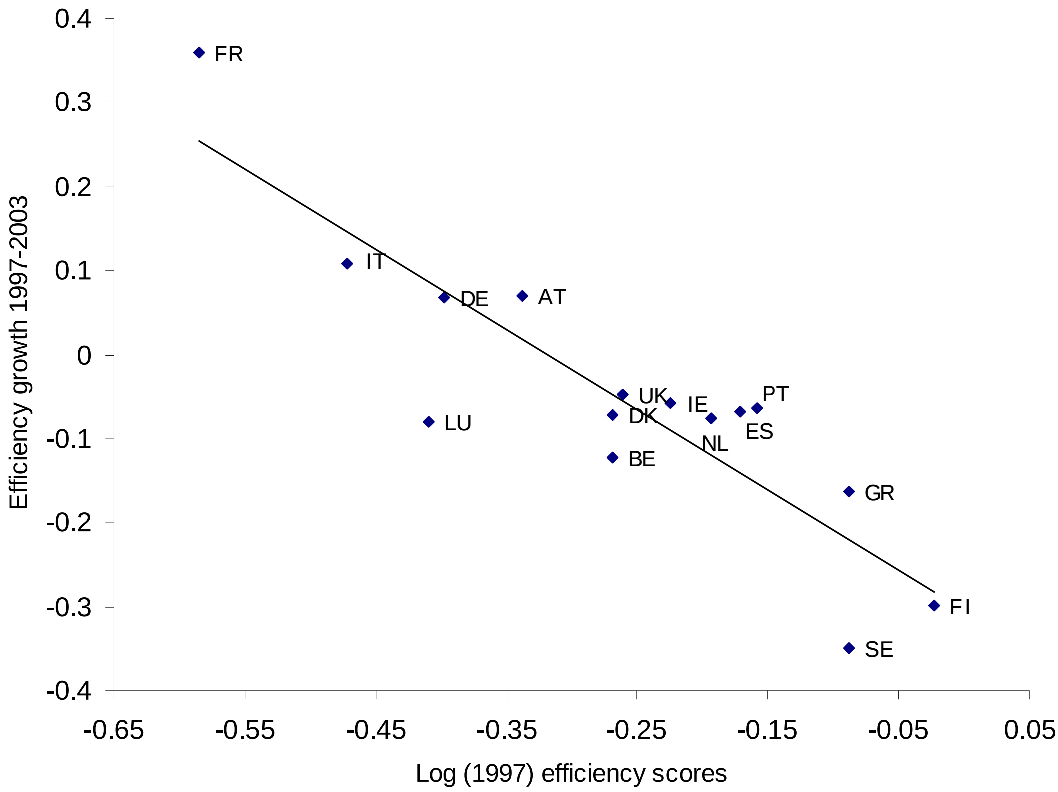


Figure 4

Convergence of efficiency levels across EU banking markets: 1997-2003[a]



[a] AT= Austria; BE= Belgium; DK =Denmark; FI = Finland; FR = France; DE = Germany; GR = Greece; IE = Ireland; IT = Italy; LU = Luxembourg; NL = Netherlands; PT = Portugal; ES = Spain; SE= Sweden; United Kingdom = UK.