Convergence in banking efficiency in the European Union

Abstract

This paper assesses the process of banking integration in the EU27 countries by analysing the convergence process in banking efficiency among a panel of almost 300 commercial banks across the EU27 countries over the period 2005-2011. The hypothesis is that, if integration is indeed underway in the European banking sector, then it should translate into convergence in i) technical efficiency ii) allocative efficiency and iii) cost efficiency. The three types of efficiency scores are constructed by applying the Data Envelopment Analysis. The Phillips and Sul (2007) panel convergence methodology, which has not previously been used in this area, is used to investigate the convergence process in European banking. Our analysis includes the 2008 global financial crisis period and looks at competition in European banking prior and post 2008. We do not find evidence of group convergence in European banking efficiency and at the same time, we find that competition levels are markedly lower during the crisis years. But on the other hand, we find the presence of club convergence when the size of each bank is factored in. The transition paths for the individual countries show clear clustering for technical efficiency and to a lesser extent for allocative and cost efficiencies prior to the financial crisis. Thereafter, the paths for all EU27 countries diverge.

JEL Classification: F36, G21, C33

Keywords: Convergence; European banking; banking efficiency; Data Envelopment Analysis; Phillip and Sul convergence method.

1. Introduction

Since the launch of the Single Market by the European Commission in 1992, several initiatives and regulatory reforms have been implemented with the aim of creating a fully functioning single market. The integration of the European banking sector is integral to this ambition. There are several studies[1]. that investigate the process of integration in European banking by predominantly using interest rate data as an indicator of integration These studies tend to analyse the integration process amongst the old European member states, the EU15[2] group of countries.

The enlargement of the European Union to 27 member countries has been a significant step in the history of the European Union and the ramifications in terms of the integration process are profound. In theory, a single market in banking across the 27 member states should enable greater consumer choice and boost competition and banking efficiency. Indeed, if a homogenous banking market and competition do lead to further integration, then the impact should be felt on the cost structures and performance of banks (i.e banking efficiency) which should subsequently translate into convergence in product prices (interest rates). In particular, as noted by Kasman et al (2010), with the goal of joining the EU, the new EU member countries embarked on large-scale privatisation programmes in the mid 90s in order to boost banking competition and efficiency. As a result, bank consolidation among the Central and Eastern European (CEE) countries peaked in the 2000s and the countries' banking systems are now viable and efficient (Kasman et al, 2010). Hence a higher level of competition and the presence of an integrated market should translate into convergence in banking efficiency. There are only a few studies (Weill (2009), Casu and Molyneux (2003) and Casu and Girardone (2010)) that investigate the process of European banking integration by using banking efficiency as an indicator for integration. All three studies investigate banking

[1] See Sander and Kleimeier (2003), Baele et al (2006), Affinito and Farabullini (2006), Vajanne (2007) and Rughoo and Sarantis (2012).
[2] The new EU member states tend not be to be included in the studies to a lack a data.

efficiency among countries within the EU15 group for up to 2005 whilst a specific convergence methodology is applied only by Weil (2009) and Casu and Girardone (2010).

The main contributions of this paper are as follows. Firstly, the Data Envelopment Technique (DEA) is applied to individual banks across all the EU27 countries to measure technical, allocative and cost efficiency scores. The sample includes a total of 265 commercial banks from all the EU member countries for the period 2005-2011. Secondly, an analysis of European banking integration process is presented by applying robust panel data methodologies, namely the Phillips and Sul (2007) convergence tests, to the three types of banking efficiency scores. We choose to test for convergence in the European banking sector by focusing on banking efficiency because it provides a critical window through which the impact of competitive pressures emanating from the efforts by the Commission to establish a single market in banking can be analysed. In addition, the level of competition within the EU27 countries is measured by applying the Rosse-Panzar model. Whilst the indicator of integration is usually aggregated pricing data on deposit and lending rates in most studies in this area, in this paper, the analysis is taken a step further by focusing on micro-data, i.e efficiency scores of individual commercial banks. The Phillips and Sul convergence method has not been previously employed to banking efficiency. This convergence technique will not only identify whether group convergence is present but also whether sub-clusters of banks are converging. The convergence methodology also enables the construction of the transition coefficients and visual inspection of the transition paths derived from the mean efficiency scores for each country which provides additional information on the speed of the convergence process over time.

The paper is organised as follows: section 2 discusses competition and efficiency in the EU banking sector while Section 3 discusses the Data Envelopment Technique and the Phillips and Sul (2007) convergence methodology. Section 4 describes the datasets used and Section 5 presents the empirical results, while Section 6 concludes.

2 Competition and efficiency in the European banking sector

It is often argued that an integrated retail banking market should promote competition and thus efficiency in this sector. The measurement of efficiency and competition in the European banking sector has widely been investigated (see Molyneux et al (1997), Tomova (2005), Goddard et al (2007), Mamatzakis and Koutsomanoli (2009), amongst others). In general, it is agreed that greater competition, faster technologies and financial innovations have driven banks to minimise costs and improve their efficiencies (see Hasan et al (2009) and Fiordelisi et al (2010), amongst others). Hence, given the link between competition and the growing focus on improving efficiency, it can therefore be hypothesised that within an integrated or integrating retail banking sector, these forces should translate into convergence in banking efficiency.

Several studies have been conducted on European banking efficiency; more specifically on its measurement and the analysis of cross-country differences. However, a review of the literature identifies only three studies [Casu and Molyneux (2003); Weill (2009) and Casu and Girardone (2010)] that have specifically attempted to investigate the convergence of efficiency measures within the European retail banking sector. However, it must be noted that among these studies; it is only the one by Weill (2009) and Casu and Girardone (2010) that actually apply a specific convergence technique to estimated efficiency measures.

In their study, Casu and Molyneux (2003) employ the non-parametric Data Envelopment Analysis (DEA) approach to investigate whether productive efficiency in European banking for the period 1993 and 1997 has converged to a common European frontier. The DEA methodology is applied to 750 banks from France, Germany, Italy, Spain, and the UK. In defining the inputs and outputs of banks, Casu and Monyneux (2003) follow the intermediation approach whereby deposits are defined as inputs. The authors define total loans and other assets as the total outputs in their model. Based on their results for the DEA relative to the European common frontier[3], Casu and Molyneux (2003) report that over the period 1993 to 1997, an improvement in the average efficiency scores can be observed for all the banks in all the countries, except for Italy which shows a slight deceleration. However, the results mostly show that the efficiency gap between the countries has widened over this period and thus conclude that there is little evidence of convergence.

Weill (2009) argues that cost efficiency convergence provides another framework for the analysis of retail banking integration as otherwise the convergence process can be thwarted by large differences in banking costs. Weill (2009)[4] applies the beta and sigma convergence test to mean cost efficiency scores that were estimated for banks from ten[5] European countries for the period 1994 to 2005. The results[6] obtained by Weill (2009) from the β-test and σ-test find evidence in support of convergence in cost efficiency in the EU banking. In an attempt to test whether the increase in cost efficiency is the result of an increase in competition within the EU banking sector, Weill (2009) also runs a Rosse-Panzar model to measure the level of competition in the EU banking. He concludes that a monopolistic market structure prevails in the EU banking markets and that banking competition did not actually increase during the period investigated.

Casu and Girardone (2010) apply the Data Envelopment Analysis to assess cost efficiency in the EU15 countries during the period 1997 to 2003. Their definition of bank output follows a

[3] Calculated by pooling the data set for all the banks in the 5 countries

[4] Cost efficiency is measured through the use of a stochastic frontier approach whereby a system of equations consisting of a Fourrier-flexible cost function is derived. For the definition of inputs and outputs, Weill (2009) takes the intermediation approach whereby it is assumed that banks collect deposits to transform them into loans.

[5] Austria, Belgium, Denmark, France, Germany, Italy, Luxembourg, Portugal, Spain, UK

[6] These findings are also subject to several robustness checks including two other frontier techniques namely, a time-varying WITHIN model and a distribution free approach (DFA) model as well as the use of the production approach instead of the intermediation approach in the event that the specifications of inputs and outputs have biased the results.

variation of the intermediation approach. Subsequently, the authors apply the β-and σ-convergence tests to mean efficiency scores to test for the convergence process towards a European average. In order to test whether efficiency levels are improving, the authors also test for convergence towards "best practice" frontier which is defined as the maximum attainable efficiency score The convergence results show that convergence in efficiency scores is present across the EU15 countries and that there is even an increase in the speed of convergence. However, the authors find no evidence of convergence in efficiency levels towards the best practice level and, surprisingly, that the introduction of the single currency has had no effect on convergence and improvement in efficiency levels in the EU15 countries.

3. Empirical methodology

3.1 Data Envelopment Technique

We apply Data Envelopment Analysis (DEA) to individual commercial banks in order to measure technical efficiency (the ability of a firm to maximise output from a given set of inputs), allocative efficiency (the ability of a firm to use these inputs in optimal proportions, given the respective prices) and cost efficiency (combining the two measures). We apply the distance function approach that provides a convenient way to describe a multi-input, multi-output production technology without the need to specify functional forms or behavioural objectives, such as cost-minimization or profit-maximization (see Fried et al., 1993).

Using the distance function specification, our problem can be formulated as follows. Let $\mathbf{x}=(x_1,...,x_N) \in \boldsymbol{R}^N_+$, and $\mathbf{y}=(y_1,...,y_M) \in \boldsymbol{R}^M_+$ be the vectors of inputs, and output, respectively, and define the technology set by $P^t=\{(\mathbf{x}^t, \mathbf{y}^t)$: $\mathbf{x}^t$ can produce $\mathbf{y}^t\}$.

DEA is a set of nonparametric mathematical programming techniques for estimating the relative efficiency of production units and for identifying best practice frontiers. Our DEA formulation under constant returns to scale by solving the following optimization problem:

$$\begin{aligned} &\max_{\varphi,\lambda} \varphi \\ &s.t. \quad -\varphi y_{it} + \mathrm{Y}_t\lambda \geq 0 \\ &\qquad\; x_{it} - \mathrm{X}_t\lambda \geq 0 \\ &\qquad\; \lambda \geq 0 \end{aligned}$$

where λ is a N × 1 vector of constraints. Inverted value of φ is technical efficiency. To calculate cost efficiency with respect to this DEA dual reference technology, we solve the following linear program:

$$\begin{aligned} &\min_{\varphi,\lambda,x_i^*} w_i' x_i^* \\ &s.t. \quad -y_{it} + \mathrm{Y}_t\lambda \geq 0 \\ &\qquad\; x_i^* - \mathrm{X}_t\lambda \geq 0 \\ &\qquad\; \lambda \geq 0 \end{aligned}$$

where w_i is the *ith* vector of input prices and x_i^* is the cost-minimising vector of input quantities given the input price vector w_i and the output vector y_i. The ratio $(w_i' x_i^* / w_i' x_i)$ measures the cost efficiency of the *i*th vector.

The ratio of minimum to observed cost, $[(w_i' x_i^* / w_i' x_i)^{-1}]$, measures the amount cost is increased due to both types of technical and allocative inefficiency. The allocative efficiency is calculated by dividing cost efficiency by technical efficiency. Alternatively, multiplication of technical and allocative efficiency is cost efficiency.

3.2 Phillips and Sul convergence methodology

In this paper, we take the view that the integration of EU banking markets should promote efficiency and competition by affecting the cost structures of banks. The Phillips and Sul panel convergence methodology is ideally suited as it is based on a time varying factor representation and therefore allows for both common and individual heterogeneity over time. Given the context of the study, this feature is of the test makes it superior to the beta and sigma convergence test.

3.2.1 Relative transition paths

Panel data for a variable X_{it} can normally be decomposed into two components comprising systematic components, g_{it}, and transitory components, a_{it}, as follows:

$$X_{it} = g_{it} + a_{it} \tag{1}$$

The main procedure in the Phillips and Sul convergence test is to calculate the time-varying loadings, g_{it} and to do so, Phillips and Sul (2007) reformulates equation (1) such that common and idiosyncratic components are separated as follows:

$$X_{it} = \left(\frac{g_{it} + a_{it}}{\mu_t} \right) \mu_t = \delta_{it} \mu_t \text{ for all } i \text{ and } t, \qquad (2)$$

Where μ_t is a single common component and δ_{it} is a time varying idiosyncratic element. Hence, δ_{it} measures the economic distance between the common trend component μ_t and X_{it}. To test whether the components of δ_{it} are converging, Phillips and Sul (2007) define the transition coefficient as h_{it} and information about the time varying factor loadings δ_{it} can be extracted as follows:

$$h_{it} = \frac{X_{it}}{\frac{1}{N}\sum_{i=1}^{N} X_{it}} = \frac{\delta_{it}\mu_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}\mu_{it}} = \frac{\delta_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}} \qquad (3)$$

The so-called *relative transition parameter* h_{it} measures δ_{it} in relation to the panel average at time *t* and therefore describes the transition path for country *i* relative to the panel average. Moreover, the convergence process can be graphically illustrated by plotting the transition parameter for each country over time.

3.2.2. The Log t regression

The log *t* regression test of convergence tests for the null hypothesis of convergence:

$$H_0 : \delta_i = \delta \text{ and } \alpha \geq 0$$

Against the alternative

$$H_1 : \delta_i \neq \delta \text{ for all } i \text{ or } \alpha < 0$$

Phillips and Sul's (2007) procedure involves three steps, as listed below.

Step 1: The cross sectional variance ratio $\frac{H_1}{H_t}$ is calculated as follows:

$$H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{it}-1)^2 \qquad (4)$$

Step 2: The following OLS regression is performed:

$$Log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = \hat{a} + \hat{b}\log t + \hat{u}_t \qquad (5)$$

Where L(t) = log(t+1) and the fitted coefficient of log t is $\hat{b} = 2\hat{\alpha}$, where $\hat{\alpha}$ is the estimate of α in H_0. The data for this regression starts at t =[rT] with some r > 0. Based on the results of their Monte-Carlo simulations, Phillips and Sul (2007) recommend r = 0.3.

Step 3: A one-sided t test of null $\alpha \geq 0$ using $\hat{b}$ and a standard error estimated using a heteroskedasticity and autocorrelation consistent (HAC) estimator. The test statistic $t_{\hat{b}}$ is normally distributed and hence at the 5% level, the null hypothesis of convergence is rejected if $t_{\hat{b}}$<-1.65.

3.2.3. Club convergence algorithm

Following Phillips and Sul's (2007) argument that a strict rejection of the null of convergence may not necessarily rule out the existence of sub-group convergence within the panel, the authors have developed a club convergence algorithm to detect such units of clusters. In the scope of this paper, this methodology will bring new insight into the convergence process within the EU27 banking sector by revealing whether clusters of convergence in banking efficiency are present. If present, then the relationship within the clusters based on economic or structural characteristics can be further explored.

Phillips and Sul (2007) clustering algorithm is based on repeated log t regressions and contains four main steps which are described below.

Step 1: The X_{it} series in the panel are ordered according to the last observation, X_{iT}.

Step 2: A core group is formed by selecting the first k highest panel members to form the subgroup G_k for some N>$k \geq 2$ and the convergence test statistic $t_{\hat{b}}(k)$ is calculated for each

k. The core group size k* is chosen by maximising $t_{\hat{b}}(k)$ under the condition that min{ $t_{\hat{b}}(k)$} > -1.65.

Step 3: Once the core group is formed, each remaining country is then added separately to the core group and the log t test is run. If the corresponding test statistic, $t_{\hat{b}}$ is greater than a chosen critical value, c[7], then the country is included in the current subgroup to form a new group. The log t test is run for this subgroup and if $t_{\hat{b}}$ is > -1.65, the formation of this subgroup is completed. Otherwise, the critical value c is raised and the procedure is repeated.

Step 4: The log t test is run on the group of countries not selected in step 3 and if convergence is detected within this new cluster, a second club is formed. Otherwise, in the case of rejection, steps 1, 2 and 3 are repeated on the remaining countries. If no other subgroups can be detected, it can be concluded that the remaining countries diverge.

4. Data

The dataset used in this study was obtained from BankScope database. The data comprises the inputs, input prices and outputs variables for the period 2005 to 2011. All data were deflated to 2010 prices. We construct aggregate efficiency and bank productivity measures. Banks are assumed to produce three outputs: other earning assets, customer loans and bad loans by using three inputs: labour, deposits and premises.

There are several approaches to modelling the bank production process. The standard methods are the intermediation and production approaches. Under the intermediation approach, banks use purchased funds together with physical inputs to produce various assets (measured by their value). According to the production approach, banks use only physical inputs such as labour and capital to produce deposits and various assets (measured by the number of deposit and loan accounts at a bank, or the by the number of transactions for each product). We adopt the intermediation approach to model bank production and consider

[7] Phillips and Sul (2009) suggest setting c to zero when T is small to ensure that it is highly conservative. However, for large T, c can be set at the asymptotic 5% critical value of -1.65. Given that the number of observations in this paper ranges from 72 to 142, c is set at 0.

banks to be intermediaries of financial services that purchase input in order to generate earning assets (Sealey and Lindley, 1977). Berger and Humphrey (1997) suggest the intermediation approach is best suited for evaluating bank efficiency, whereas the production approach is appropriate for evaluating the efficiency of bank branches.

5. Empirical results

5.1 Efficiency scores

In the following part we discuss the changes in allocative efficiency (AE) and technical efficiency (TE). In other words, we look at the ability of bank managers to maximize bank outputs from defined inputs, i.e.,TE. We also examine managers' ability to optimally combine the volume of inputs to be used in the production process by taking into account their price, i.e. AE.

We start our discussion by reporting the results for technical efficiency. From Table A we can see that the average efficiency level for EU 27 countries reached the maximum level in 2008. Since then, the level considerably decreased. This should reflect the impact of the global financial crisis on bank performance. If we split up the sample into two categories, i.e. new and old EU countries we can see that the drop in the efficiency levels was even more pronounced in the segment of old EU countries. The technical efficiency levels declined from its peak of 76,95per cent to 65,84 per cent in 2008 and 2011 respectively. The gap between old and new EU countries in terms of AE has been significantly reduced to 0.04 percent from 2010 to 2011. Nevertheless, the relatively low levels of AE may indicate the underlying problem of bank management to efficiently utilized employed inputs in the production process during the financial crisis in old and new EU countries.

However, if one analyzes the changes in technical efficiency the results are at odd with the reported results for allocative efficiency. In particular, we may observe that new EU countries report remarkably lower technical efficiency than old EU countries not only after the financial crisis but throughout the whole observed period. As we see from Table B, the gap between the efficiency scores is up to 10 per cent. There is also evident that the technical efficiency levels deteriorated after 2008 that indicates the impact of the Global Financial Crisis on bank performance. We also see the largest drop in technical efficiency from 2010 to 2011. Nevertheless, the lack of observations does not allow us to recognise if this is trend or just a temporary decline.

Based on our results we may conclude that banks in new EU countries are marginally better in terms of allocation of their inputs and less efficient in their output maximization

Table A: Allocative Efficiency

	2005	2006	2007	2008	2009	2010	2011
EU27	0.6597	0.6874	0.7420	0.7570	0.7096	0.6469	0.6596
New EU	0.6291	0.6647	0.7165	0.7309	0.7450	0.6792	0.6620
Old EU	0.6744	0.6983	0.7543	0.7696	0.6925	0.6314	0.6585

Table B: Technical Efficiency

	2005	2006	2007	2008	2009	2010	2011
EU27	0.7984	0.8198	0.8625	0.8861	0.8639	0.8459	0.7621
New EU	0.7309	0.7474	0.7953	0.8327	0.8130	0.8014	0.7049
Old EU	0.8308	0.8546	0.8947	0.9117	0.8884	0.8673	0.7896

5.2 *Phillips and Sul (2007) log t-test*[8]

The t-statistics obtained for the convergence test for the 3 types of banking efficiency scores, i.e 1) technical efficiency; 2) allocative efficiency; and 3) cost efficiency, for the panel of 265 commercial banks across the EU27 countries for the period 2005-2011 are tabulated in Tables 1 and 2. We test for convergence in efficiency separately among the banks from the

[8] The Gauss codes for the computation of the logt test and convergence clubs are available from Sul's website, http://homes.eco.auckland.ac.nz/dsul013/.

old EU countries (EU15) and among the new EU countries (EU12) as well as for the whole panel banks from the EU27 countries. Of noteworthy importance is the fact that the magnitude of the convergence coefficient, $\hat{b}$, provides key information on the rate of convergence. Basically, the higher the value of $\hat{b}$, the faster the rate of convergence.

The null hypothesis of group convergence is rejected for all three types of banking efficiency for the panels of efficiency scores for the EU27, the EU15 and EU12 banks. In addition, we run the group convergence test on a panel of 1) large banks across the whole EU27 and 2) all other banks based on asset-size[9] to test whether size is a determining factor behind the convergence process. However, we find that, once more, the log t test rejects the presence of group convergence for all 3 types of efficiency and for both types of bank size. So based on the results obtained, we find no evidence of convergence in banking efficiency across the commercial banks' in the European Union. Our results for the panel of EU15 banks contrast with those of Weill (2009)[10] and of Casu and Girardone (2010) who find evidence of convergence in cost efficiency for the EU15 banks for an earlier period, i.e 1994 -2005 and 1997-2003. The lack of group convergence across the EU27 countries can be explained by two main reasons. Firstly, cross-country heterogeneity in European banking in the form of various national legislations, limitations in the sharing of cross-border data, national institutional characteristics, and country-specific macroeconomic variables, among others, can explain the rejection of the null of convergence. Secondly, the onslaught of the global financial crisis which occurred during the period investigated, have necessitated large bail-outs of national banks in order to avoid the spread of systemic risk. Subsequently, many of these banks who received financial assistance are undergoing a major restructuring of their activities. Inevitably, the impact on banking efficiency is likely to differ not just within and across countries during the period investigated but also across different bank size.

[9] Large banks are those with assets above average asset levels. The banks with asset below the average level are classified as medium/small banks.
[10] Weill (2009) finds evidence of convergence at the 1% significance level in all tests.

Both explanations given above can be verified by analysing the competition level in the EU27 banking market. Intuitively, one would expect competitive pressures to lead to an increase, and ultimately convergence, in efficiency levels. Therefore, the dismal results for group convergence in efficiency could be the result of lower competition in the EU banking sector due to the existence of cross-country heterogeneity and the occurrence of the global financial crisis. To investigate this hypothesis, we run the Rosse-Panzar model to obtain the H-statistic (see table 3) for the group of EU banks for each year from 2006 to 2011. The results show that the banks in the old EU countries belong to a monopolistic market structure. However, a clear decline in the H-statistic indicating a reduction in competition can be observed for 2 critical years of the sample period, i.e between 2008 and 2009.. Indeed, we find that the competition level as indicated by the H-statistic has declined for the overall period. As for the new EU countries, we obtain $H<0$ which indicates that the banks are operating under a monopoly or oligopoly. These results would also explain why we find no group convergence in efficiency.

5.3 Club clustering test

Phillips and Sul (2007) argue that group convergence may not be identified because of the presence of divergence members in the panel but that club-convergence may still be possible. Therefore, the next step in the analysis is the application of the Phillips and Sul (2007) clustering algorithm test which would potentially identify countries that are converging within different clusters and also identify divergent members. Hence, banking integration measured through efficiency should not be ruled out just on the basis of the log *t*-test but must be analysed together with the club clustering test results. The test is applied to a panel of large banks and one with the rest of the banks with each panel consisting of asset-sized weighted scores for individual countries. The test statistics are reported in Table 4. Contrary to the log t test results obtained for group convergence, we find the strong presence of club formation in all the three types of banking efficiency.

The club clustering results for technical efficiency for the large banks reveals the presence of 4 distinct convergent clubs. The first club consists of Denmark, Finland, Netherlands, Sweden and seems to indicate that regional proximity, implying similar institutional characteristics, is the driving factor behind convergence for these large banks. The second club consists of France and UK, the third club groups Germany and Italy while the fourth club comprises Austria, Belgium and Ireland. Spain is the divergent country. For these 3 clubs, regional proximity is again the common factor. As for the rate of convergence, $\hat{b}$ is negative for the first 3 clubs indicating weak convergence and positive but low for the last club. As for the panel of medium and small sized banks, 3 convergent clubs and four divergent countries are identified, with the biggest club converging weakly ($\hat{b}$ =-1.39) with banks from 12 countries. The composition within the clubs is interesting as they regroup banks from across the old EU and new EU countries. For instance, the strongest convergence club consists of Germany, Finland, and Bulgaria ($\hat{b}$ = 1.2). So as opposed to large bank, regional proximity does not seem to be the driving factor behind the club formation.

The club clustering results for allocative efficiency for the large banks reveals the presence of only one convergent club consisting of Austria and Belgium ($\hat{b}$ = 1.360). Once more, geographical proximity seems to be a determining factor in club formation. The rest of the countries form one club but convergence is rejected. As for the panel with the medium and smaller banks, 5 convergent clubs and 2 divergent countries (Ireland and Sweden) are identified. The magnitude of convergence is strongest for the club grouping Czech Republic and Latvia ($\hat{b}$ = 3.064) followed by the club regrouping Germany, Finland, Netherlands, Portugal, Spain and Bulgaria ($\hat{b}$ = 1.834). Weak convergence is observed for the remaining clubs.

The club convergence results for cost efficiency for the large banks reveal 2 convergent clubs. The first one regroups Denmark, Germany, Finland, France, Ireland, Netherlands, Sweden, Spain, UK but the rate of convergence is weak ($\hat{b}$ =-2.048). The second club consists of Austria and Italy while Belgium is the divergent country. No marked pattern in the club formation is discernible here. As for the medium and small banks, 3 clubs are identified. The first club groups Germany, Finland, Spain and Bulgaria with the highest rate of convergence ($\hat{b}$ = 1.232). The other clubs show weak convergence and 5 countries are divergence. The overall picture here is of diversity.

5.4 Transition paths for individual countries

The third component of the Phillips and Sul (2007) test consists of the calculation of each country's relation transition coefficient, h_{it}. The transition coefficient is constructed by using each country's mean efficiency score per year relative to the panel cross-section average. Figures 1-3 illustrate the paths taken by each country's mean efficiency score vis-à-vis the panel average over the period 2005-2011. This procedure provides a visual display of, as well as, additional information on the convergence process in European banking efficiency.

Looking at the technical efficiency transition paths for all the 27 countries (see Figure 1), it can clearly be seen that, starting in 2005, the paths for all the countries are closely clustered and converging towards the cross section average, one. However, this convergent behaviour abruptly stops in 2008 where thereafter, the paths for all the countries diverge away and are heterogeneous. It can thus be argued that the global financial crisis has negatively impacted on the convergence process of EU banks in the area of technical efficiency. In addition, it can be noted that the transition paths for certain new EU member countries such as Bulgaria, Romania, Cyprus and Estonia are, from the start, away from the main cluster of countries.

Looking at the allocative efficiency transition paths for the EU27 countries (see Figure 2), it can be seen that at the start of the sample period, 2005, there is a lot of heterogeneity present with some countries starting well above or below the cross section average of one. Notably, the transition paths for Cyprus, Slovakia, Bulgaria and Italy start at the bottom half of the cross-section average while the paths for Belgium, Estonia, and Ireland start at the higher end. However, the paths for most of the countries gradually move towards one up to 2008/9 and then once more take diverse trajectories. It can be argued that it is the recent financial crisis that has thwarted the slow convergence in allocative efficiency observed earlier in the sample.

The cost efficiency transition paths for the EU27 countries (see Figure 3) show very similar trends to the allocative efficiency paths. The paths for countries such as Bulgaria, Romania, Slovakia, Estonia, Malta are far from the cross section average at the start of the period but a gradual move towards one is clearly discernible. However, once the paths hit the year of the financial crisis, heterogeneity once more sets in.

6. Conclusion

The aim of this paper is to conduct a thorough empirical investigation of the convergence process in European retail banking sector by analysing banking efficiency across the EU27 countries for the period 2005 to 2011. An important contribution of this paper is the construction of three types of banking efficiency scores for all members of the European Union and the application of the Phillips and Sul (2007) convergence methodology, which detects the presence of convergence and provides an estimate of the speed of convergence. The log t test show that group convergence in banking efficiency is not present across the whole EU and neither within the old and new member states. The panel of large banks as well as medium and small banks also show no convergence. However, club formation among the EU banks is prevalent, albeit with most clusters showing a slow rate of convergence. The club formation for the large banks seems to be driven by regional proximity, especially for technical and allocative efficiency. The transition paths highlight the convergence patterns obtained under the club clustering tests with the paths clearly showing gradual convergence towards the cross-section average. However, following the global financial crisis, this trend is reversed and widespread heterogeneity is reinstated.

References

Affinito M. and Farabullini F. (2006), "Does the law of one price hold in retail banking? An analysis of national interest rate differentials in the euro area", *Bank of Italy, Economic Research Department*, August.

Antzoulatos A., Panopoulou E., Tsoumas C. (2011), "The enigma of non-interest income convergence", *Applied Financial Economics*, Vol. 21, Issue 17.

Baele L. (2006), "Real interest rates in an integrating Europe", *Tilburg University, CentER and Netspar*, February version.

Caporale G. M.; Erdogan B.; and Kuzin V. (2009), Testing for Convergence in Stock Markets: A Non-Linear Factor Approach, CESifo Working Paper Series, No. 2845, Munich.

Casu B. and P. Molyneux (2003), "A Comparative Study of Efficiency in European Banking" *Applied Economics* , Vol. 35, pp. 1856 -1876.

Casu, B, and Girardone, C.,(2010), "Integration and Efficiency in EU banking markets", *Omega*, Vol 38 Issue 5 October.

Doornik, J.A. (2006), *Object-Oriented Matrix Programming Using Ox*, 3rd ed. London: Timberlake Consultants Press and Oxford, Available from : www.doornik.com.

Fiordelisi F. Marquez-Ibanez D. Molyneux P. (2010), "Efficiency and risk in European banking", *ECB Working paper series* No. 1211.

Fischer C. (2009), "Price convergence in the EMU? Evidence from micro data", *Deutsche Bundesbank, Research Centre*, Discussion Paper Series 1: Economic Studies, No. 06/2009.

Fried, H.O., C.A.K. Lovell and S.S. Schmidt (eds.) (1993) The Measurement of Productive Efficiency: Techniques and Applications, Oxford University Press, New York.

Goddard J., Molyneux P., Wilson J.O.S and Tavakoli M. (2007), "European Banking: an overview:" *Journal of Banking and Finance*, No. 31, 1911-1935.

Hasan I. Schmiede H. Song L. (2009), "Return to retail banking and payments", *ECB working paper series* No. 1135.

Higson C., Holly S. And Petralla I. (2009), "The financial integration of the European Union: common and idiosyncratic drivers", Working paper D.1.1d, *European Commission, 7th Framework Programme*.

Kasman A., Tunc G., Vardar G., and Okan B. (2010), "Consolidation and commercial bank net interest margins: Evidence from the old and new European Union members and candidate countries;" *Economic Modelling*, Volume 27, Issue 3, May, Pages 648–655.

Kleimeier S. and Sander H. (2003), "European financial market integration: Evidence on the emergence of a single eurozone retail banking market". *Research in Banking and Finance*, 3, 13-91.

Mamatzakis E. and Koutsomanoli A. (2009), "European banking integration under a quadratic loss function" University of Piraeus, *Munich Personal RePEc Archive*.

Molyneux P. Altunbas V. Gardner E. (1997), *Efficiency in European Banking* John Wiley & Sons.

Phillips P. C. B. and Sul D. (2007), "Transition modelling and econometric convergence tests", *Econometrica* 75(6), 1771-1855.

Phillips P. C. B. and Sul D. (2009), "Economic Transition and Growth", *Journal of Applied Econometrics*, Vol. 24, Issue 7, pp 1153-1185.

Rughoo, A. and Sarantis, N. (2012), "Integration in European retail banking: Evidence from savings and lending rates to non-financial corporations," *Journal of International Financial Markets, Institutions and Money*, Vol. 22(5), pages 1307-1327.

Tomova M. (2005), "X-efficiency of European Banking - Inequality and Convergence", *Free University of Brussels*.

Vajanne L. (2007), "Integration in euro-area retail banking markets –convergence of credit interest rates", *Bank of Finland Research Discussion paper* No. 27.

Weill L. (2009), "Convergence in banking efficiency across European countries", *Journal of International Financial Markets, Institutions & Money*, Vol. 19, pp 818-833.

Table 1. Phillips and Sul (2007) Log *t* test

Data series	$\hat{b}$	*t*-statistics
Technical efficiency		
EU27 countries	-2.956	-3.780*
EU15 countries	-3.919	-5.509*
New EU countries	-2.137	-1.957*
Allocative efficiency		
EU27 countries	-2.215	-12.652*
EU15 countries	-2.377	-9.000*
New EU countries	-1.802	-5.480*
Cost efficiency		
EU27 countries	-2.350	-8.984*
EU15 countries	-2.640	-11.123*
New EU countries	-1.783	-3.431*

Note: a) The Phillips and Sul (2007) log t-test were run in OxEdit using the Gauss code programmed by Sul (2007); b)* Indicates rejection of the null hypothesis of convergence at the 5% significance level; c) The results are generated using Ox version 4.00 (see Doornik, 2006); d) There are 265 banks in total across the EU27 countries.

Table 2. Phillips and Sul (2007) panel convergence test for a) large and b) medium and small sized banks

Data series	$\hat{b}$	*t*-statistics
Technical efficiency		
Large banks	-2.258	-6.956*
Medium and small banks	-3.021	-3.397*
Allocative efficiency		
Large banks	-3.489	-12.474*
Medium and small banks	-2.154	-14.621*
Cost efficiency		
Large banks	-3.163	-12.759*
Medium and small banks	-2.276	-8.447*

Note: a) The 265 EU27 banks have been categorised as large (n=50) or medium and small banks (n=215) according to asset size. b) The Phillips and Sul (2007) log t-test were run in OxEdit using the Gauss code programmed by Sul (2007); c)* Indicates rejection of the null hypothesis of convergence at the 5% significance level; d) The results are generated using Ox version 4.00 (see Doornik, 2006).

Table 3: H – statistics in EU countries

	2005	2006	2007	2008	2009	2010	2011
EU27		0.3701	0.4097	-0.0203	-0.3955	0.2959	-0.0432
Old EU		0.6142	0.7567	0.2619	0.0245	0.2802	0.2863
New EU		-0.0324	-0.4356	-0.8489	-0.9296	-0.6903	-0.7323

Table 4. Phillips and Sul (2007) club convergence test for weighted scores

Data series	$\hat{b}$	*t*-statistics
Technical efficiency: large banks		
Club 1: Denmark, Finland, Netherlands, Sweden	-1.760	-0.681
Club 2: France, UK	-2.059	-0.498
Club 3: Germany, Italy	-3.291	-1.175
Club 4: Austria, Belgium, Ireland,	0.619	0.295
Divergent country: Spain		

Technical efficiency: medium and small banks		
Club 1: Germany, Finland, Bulgaria	1.200	1.608
Club 2: Denmark, France, Italy, Luxembourg, Portugal, Spain, Czech Rep., Latvia, Lithuania, Malta, Poland, Slovenia	-1.386	-1.561
Club 3: Austria, Greece, UK, Cyprus, Hungary, Romania, Slovakia	0.153	0.292
Divergent countries: Ireland, Netherlands, Sweden, Estonia	-4.862	-5.800*
Allocative efficiency: large banks		
Club 1: Austria, Belgium	1.360	0.868
Club 2: Denmark, Germany, Finland, France, Ireland, Italy, Netherlands, Sweden, Spain, UK	-2.087	-1.646*
Allocative efficiency: medium and small banks		
Club 1: Germany, Finland, Netherlands, Portugal, Spain, Bulgaria	1.834	2.354
Club 2: Austria, France, Greece, Luxembourg, Cyprus, Hungary, Lithuania, Poland, Romania, Slovenia	-0.234	-0.362
Club 3: Czech Rep., Latvia	3.064	1.054
Club 4: Denmark, Italy, Malta, Slovakia	-0.542	-0.692
Club 5: UK, Estonia	0.342	0.076
Divergent countries: Ireland, Sweden	-2.052	-4.514*
Cost efficiency: large banks		
Club 1: Denmark, Germany, Finland, France, Ireland, Netherlands, Sweden, Spain, UK	-2.048	-1.593

Club 2: Austria, Italy **Divergent country:** Belgium	0.196	0.125
Cost efficiency: medium and small banks		
Club 1: Germany, Finland, Spain, Bulgaria	1.232	2.171
Club 2: Austria, France, Greece, Italy, Luxembourg, Cyprus, Czech Rep., Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovenia	-1.148	-1.315
Club 3: Denmark, Slovakia	0.220	0.033
Divergent countries: Ireland, Netherlands, Portugal, Sweden, UK	-2.613	-31.165*

Note: a) The club convergence tests have been run on a panel of asset-size based weighted scores calculated for each EU27 country. For large banks, n=12, and for medium/small banks, n=26; b) The Phillips and Sul (2007) log t-test were run in OxEdit using the Gauss code programmed by Sul (2007); c)* Indicates rejection of the null hypothesis of convergence at the 5% significance level; d) The results are generated using Ox version 4.00 (see Doornik, 2006).

Figure 1: Transition paths for the EU27 technical efficiency scores

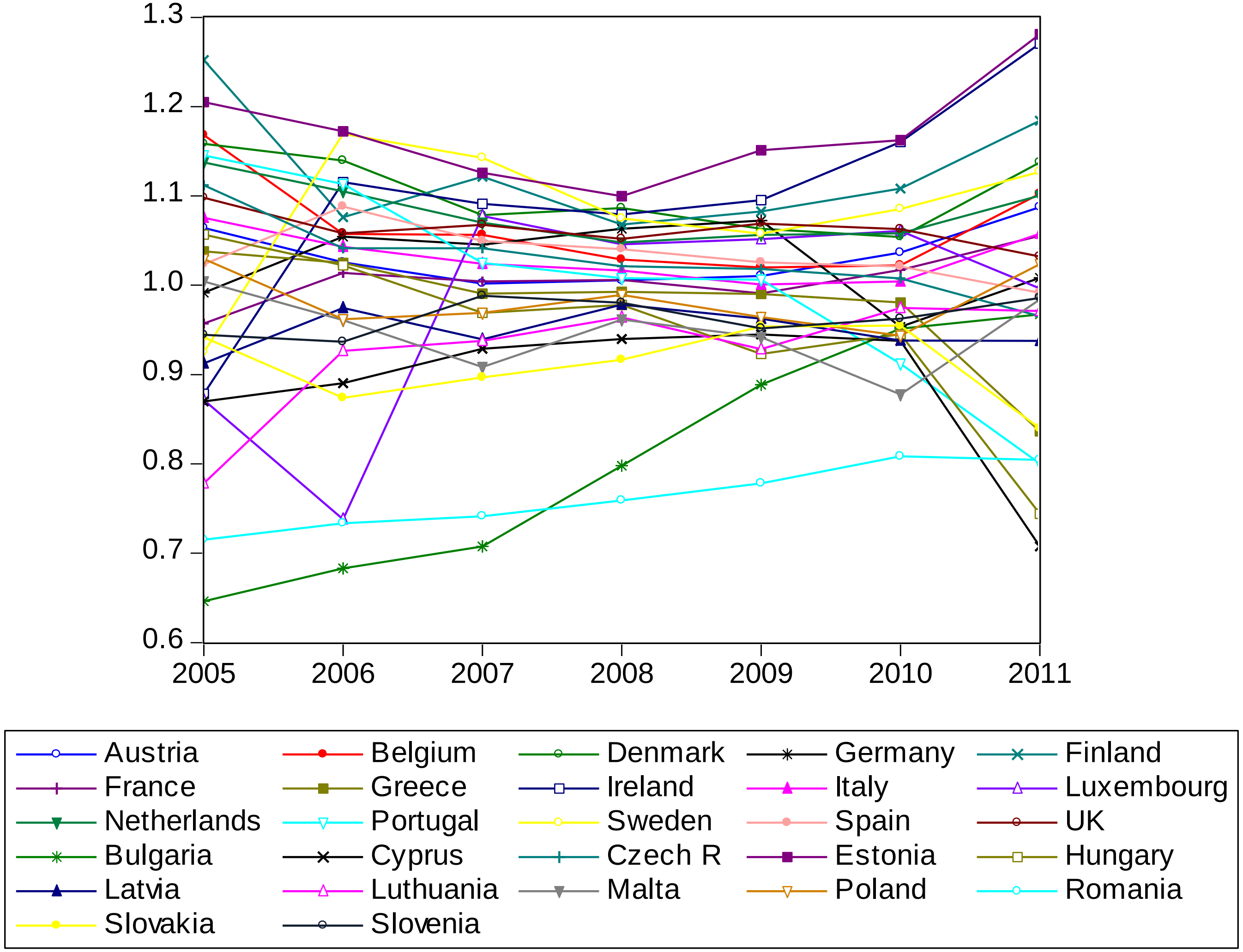

Figure 2: Transition paths for the EU27 allocative efficiency scores

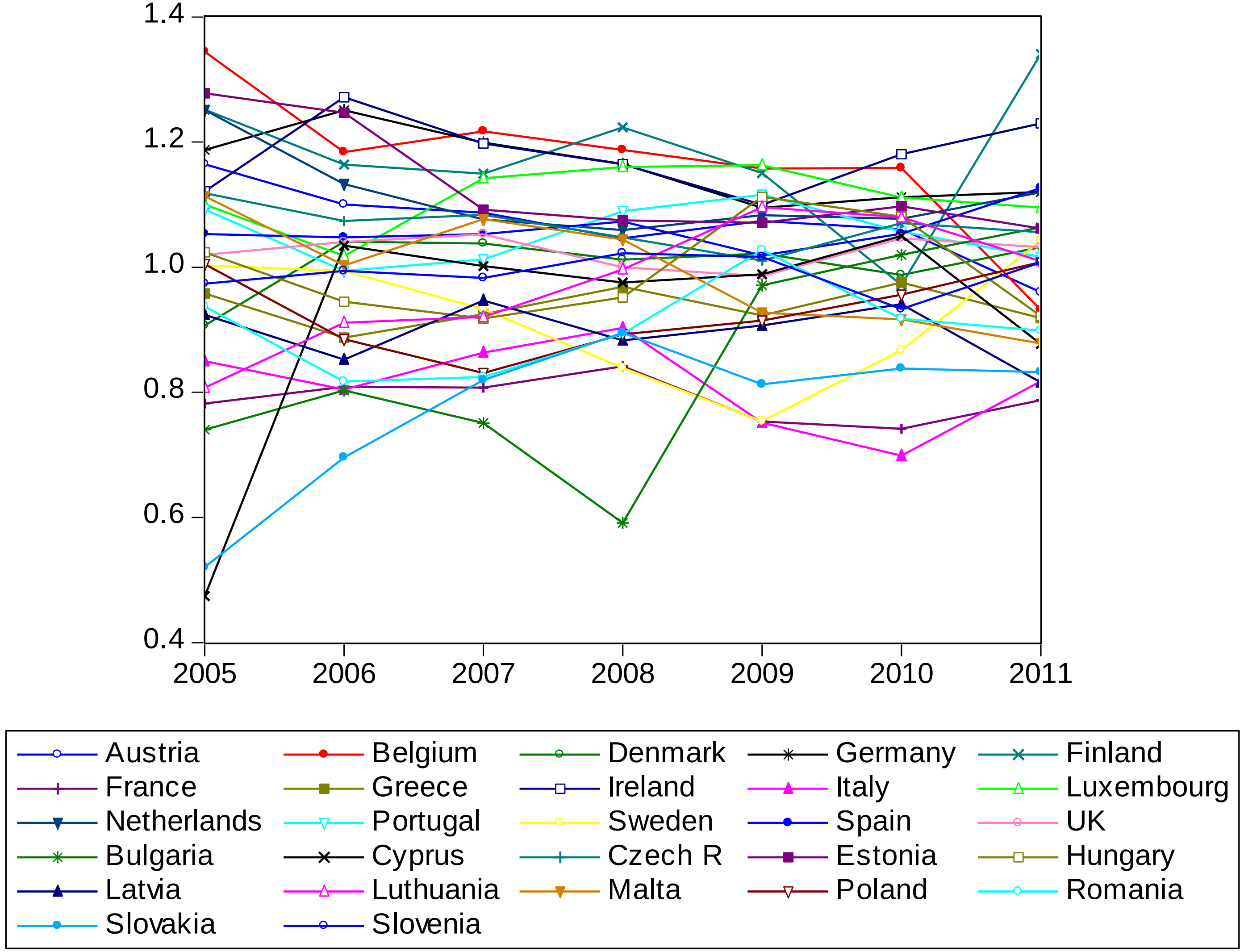

Figure 3: Transition paths for the EU27 cost efficiency scores