Bank performance and convergence during the financial crisis: Evidence from the ‘old’ European Union and Eurozone

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Abstract

This paper investigates the process of banking integration in the EU15 countries and the Eurozone by testing for convergence in bank efficiency among commercial banks. We use a two-step approach: First we estimate efficiency by applying an innovative methodological approach that treats banks’ non-performing loans as an undesirable output. Second, we apply the Phillips and Sul (2007) panel convergence methodology to assess the convergence process in European banking. Our results indicate an overall decline in efficiency and no evidence of group convergence following the financial crisis. However, we find the presence of club formation with typically weak convergence. The heterogeneity displayed by the transition parameters for the individual countries and the notable decrease in competition levels post 2008 highlight the impact of the financial crisis on the integration process.

JEL Classification: F36, G21, C33

Keywords: Convergence; European banking; banking efficiency; Parametric Distance Function; Phillip and Sul convergence method.

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1. Introduction

Following the introduction of the Single Market by the European Commission in 1992, several initiatives and regulatory reforms have been implemented to create a fully functioning single market. The integration of the European banking sector is integral to this ambition. Evidence from recent studies based on data prior to the financial crisis show that while the European banking sector has been integrating, some fragmentation are still inherent due to national characteristics (Baele, 2006; Affinito and Farabullini, 2006; Vajanne, 2007, and Rughoo and Sarantis, 2012).

As widely reported, the Global Financial Crisis (GFC) has uncovered several systemic weaknesses amongst European banks which have resulted in higher credit, refinancing and sovereign risks. A current analysis of European banking integration would provide a deeper insight into the impact of the GFC on the functioning of the single banking market. We argue that the unprecedented scale of governmental bailouts could distort the competitiveness within the Euro area and Eurozone. The competitiveness could be distorted above all by the fact that some key market players have received unfair advantages through cheaper capital and funding. For example, the UK's estimated package could reach US $1.1 trillion in order to restore confidence in the banking system. In Denmark, 13 of the country's 140 banks were bailed out by the central bank or acquired by their competitors. The expected volume of the rescue package is estimated to be EUR 593.9 billion (European Commission, 2012, Bloomberg, 2009).

This paper contributes to the ongoing empirical research on banking integration in several ways. Firstly, assuming that the integration process has been significantly undermined and to some extent undergone a reversal due to the GFC, we investigate whether the single market initiative for a homogenous and competitive banking market has extended to the cost structures and efficiency of banks. In particular, we examine the impact of the GFC and the ensuing Eurozone sovereign debt crisis on bank efficiency. Secondly, we analyse and estimate the convergence of the European banking system using the Phillips and Sul convergence technique which provides an empirical assessment of long-run equilibrium within a heterogeneous set-up without necessitating any assumptions about stationarity. Thirdly and finally, we estimate the competition level in European banking pre-and post- crisis by deploying the Rosse-Panzar method.

To estimate bank efficiency, we apply a parametric distance function approach using both desirable and undesirable outputs in the production process (i.e. NPLs). This novel approach of measuring bank efficiency is motivated by the fact that ignoring NPLs can bias the efficiency results (Assaf et al. 2013; Fujii et al. 2014). The inclusion of NPLs in our estimation is even reinforced by the fact that the average bank asset quality for most EU member states has plummeted significantly following the economic recession. To test bank convergence, we propose the Phillips and Sul (2007) methodology which provides important advantages over the widely used β-convergence and σ-convergence methods.[7]. The β-convergence, for instance, is uninformative on the behaviour of the dispersion of the entire cross-section, while the σ-convergence does not allow for cases where individual countries may be transitionally divergent (Quah, 1996; Islam, 2003). The Phillips and Sul convergence technique, on the other hand, identifies whether group convergence is present and whether sub-clusters of countries are converging. It also enables the estimation of the relative transition parameters for each country in relation to the panel average. This gives us additional information on the speed of the convergence process over time.

[7] See Adam *et al*.2002; Vajanne,2007 and Weill,2009.

Finally, to provide a full picture of bank performance and convergence, we also examine the degree of competition within the banking systems. We apply a standard non-structural approach based on the Rosse-Panzar methodological framework. The rest of this paper is organised as follows: Section 2 reviews the literature on efficiency and integration in the EU banking sector. Section 3 and 4 describe the methods and data used. Section 5 presents the empirical results, and finally Section 6 concludes.

2. Literature review on bank efficiency and convergence in the EU

Brouwer (2005) defines financial market integration as a process whereby financial markets become increasingly integrated through the linkages created by prices and returns on financial assets. As discussed by Stavarek et al (2012), one crucial conduit for financial integration is the integration of financial infrastructure which consists of a set of inter-connected systems such as payment systems[8] and credit registers that facilitate financial market operations. Consequently, the integration of financial infrastructure should lead to cost savings and create a more efficient financial market. Empirical research focusing on the efficiency of European banks has attracted considerable attention over the last decade. Studies have linked the efficiency of the banking industry to several interesting hypotheses such as integration and convergence, competitiveness and systemic stability within the European Union. In general, there is support that greater competition, faster technologies, financial innovations, economic and financial freedom have driven banks to minimize costs and improve their efficiencies (Fiordelisi and Molyneux,2010; Chortareas et al, 2013). Given the link between competition and the growing focus on improving efficiency, it can be said that within an integrated or

[8] In the Euro area, the Single Euro Payments Area (SEPA) which aims to provide an integrated payment system was rolled out between 2006-2008 and in 2011, the SEPA started processing card payments.

integrating retail banking sector, these forces should translate into convergence in bank efficiency.

The link between efficiency and integration in the European banking sector has been widely investigated (Molyneux et al. 1997; Goddard et al. 2007; Brissimis et al. 2010, Fiordelisi et al.. 2011, among others). Berger (2003) examines the potential efficiency effects of a single market for financial services in Europe, but does not find support for a positive effect on efficiency. He attributes this finding to the consolidation of the banking sector which disrupted the supply of relationship credit and led to the loss of relationship information. Casu and Molyneux (2003) do not find support either for the integration of the banking sector across several European countries.

Some mixed findings are however reported in other related studies (Altunbas et al. 2001; Lozano-Vivas et al. 2001; Casu and Girardone, 2010; Carbo et al. 2007; Maudos and Fernandez de Guevara, 2007; Weill, 2009). Using the β- and σ convergence tests[9] on cost efficiency scores for the period 1994 to 2005, the study by Weill (2009), for example finds evidence of convergence[10] and concludes that a monopolistic market structure exists in the EU banking markets and that banking competition did not actually increase during the period investigated. Supporting this, Casu and Girardone (2010), who also apply the β- and σ convergence tests on estimated cost efficiency for the EU 15 countries during 1997 to 2003, find evidence for efficiency convergence. However, they do not support that the hypothesis that the introduction of the single currency had an effect on convergence and improvement in efficiency levels.

[9] The β-convergence is drawn from the growth literature and models the "catch-up effects" by regressing the growth rate of a variable on the initial level while σ-convergence looks at the dispersion of the cross-section. Convergence is evident is the dispersion decreases over time.

[10] These findings are also subject to 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.

Our study aims to provide additional evidence on the above using a more robust efficiency measure that accounts for NPLs, and also a more robust test of convergence. Furthermore we focus on the impact of the GFC which has largely been ignored in existing studies, and estimate the competition level in European banking pre- and post- crisis using the Rosse-Panzar method. We elaborate on these contributions in the remaining sections of this paper.

3. Methodology

3.1. Bank Efficiency with undesirable outputs: A parametric distance function

Several studies have provided evidence that ignoring NPLs as an undesirable output in the production process can bias and potentially inflate the efficiency results (Fernandez et al. 2002; Atkinson and Dorfman, 2005; Park and Weber, 2006; Assaf et al, 2013; Fujii et al. 2014). The famous framework proposed by Berger and DeYoung (1997) also suggests a strong relationship between loan quality and efficiency in both directions. A bank with low NPLs for example, might seem to be low performing in comparison to another bank with high NPLs just because the production process did not clearly differentiate between good and undesirable outputs.

We can write the production process $P(x,y,b)$ with undesirable outputs as follows:

$$P(x,y,b)=\{(x,y,b): x \text{ can produce } y \text{ and } b\} \tag{1}$$

where x is a vector of inputs $x=(x_1,...,x_N)\in R_+^N$, y is a vector of good outputs $y=(y_1,...,y_M)\in R_+^M$, and $b=(b_1,...,b_P)\in R_+^P$ is a vector of undesirable outputs.

Following Cuesta et al. (2009), we represent production process in (1) using the hyperbolic distance function[11]:

$$D_H(x, y, b) = \inf\{\theta > 0: (x\theta, y/\theta, b\theta) \epsilon P\}. \tag{2}$$

This enhanced hyperbolic distance function has the advantage of dealing with both desirable and undesirable outputs asymmetrically, thus providing a more comprehensive representation of the production process[12].

The model in (2) can become even more flexible if we adopt the hyperbolic translog distance function, which, in a panel data context, can be expressed as follows

$$\ln(D_H/y_{Mit}) = TL(x_{it}, y^*_{it}, b^*_{it};\ \beta) + \omega_{it} \qquad (i = 1,2, \dots N; t = 1, .. T) \tag{3}$$

where y^*_{it}, b^*_{it} are the normalized good and undesirable outputs to ensure homogeneity[13], and ω_{it} is an error term. We can also add to (3) another one sided error u_i representing inefficiency:

$$-\ln y_{Mit} = TL(x_{it}, y^*_{it}, b^*_{it};\ \beta) + (\omega_{it} - u_i) \qquad (i = 1,2, \dots N;\ t = 1, .. T) \tag{4}$$

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[11] Cuesta et al. (2009) also derive the enhanced hyperbolic function following Färe et al. (1989).
[12] The function is non-increasing in undesirable outputs, and non-increasing in inputs
[13] For more details, see Cuesta el al. (2009).

The efficiency estimates each bank can be calculated by substituting these values into the following equation:

$$Eff_{\mathrm{i}} = \exp\left[\ln D_H\left(x_{it}\,, y_{it}^{*}, b_{it}\,;\ \beta\right)\right] = \exp(-u_i\,). \tag{5}$$

3.2 Phillips and Sul convergence methodology

The main view we adopt in this paper is that integration is beneficial to the EU banking markets as in theory; it should improve efficiency and competition by affecting the cost structures of banks. The Phillips and Sul panel convergence methodology[14] we use in this paper consists of a log *t* regression test of convergence. This approach is well suited in the context of this study as it is based on a time-varying assumption which allows for both common and individual heterogeneity over time. This convergence approach thus enables us to identify whether the EU banks' are converging on the efficiency front and if so, we can analyse the speed of convergence over time. The convergence method also includes a club convergence algorithm which detects possible clusters of convergence. We believe that using such a test in this paper will enrich the analysis and provide new insight about whether clusters of convergence in banking efficiency exist in our sample. The Phillips and Sul's (2007) clustering algorithm is based on repeated log *t* regressions and consists of four steps. For details on each of these steps, refer to Rughoo and Sarantis (2012).

[14] See Technical Appendix A for an outline of the Phillips and Sul approach.

3.3 Market competitiveness: Rosse-Panzar Model

Several studies in the literature test for competitiveness conditions in European banking industry (Nathan and Neave, 1989; Perrakis, 1991; Molyneux and Forbes, 1995; DeBandt and Davis, 2000; Matthews et al. 2007). The market competitive conditions are measured by estimating a reduced from log-linear revenue equation:

$$\ln REV_{it} = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln q_{mit} + \sum_{n=1}^{N} \beta_n \ln X_{nit} + \varepsilon_{it} \qquad (6)$$

Where *REV* is the ratio revenue to total assets of a bank *i* at time *t*, q_m represents the input prices and X_n are bank specific variables that may determine bank's revenue and cost functions. We deploy the following two variables: The asset size of banks *(Assets)* can be seen as a proxy for scale economies and we also include bank liquidity (Liq) provided by Bankscope and defined as net loans to total assets that captures asset liquidity risk. ε_{it} is a stochastic disturbance term. Market power is measured by the extent to which a change in factor input prices ($dq_{m,i}$) for m = 1,..., n is reflected in a change in equilibrium revenue ($dREV^*_{it}$). Panzar and Rosse (1987) define a measure of competition H as the sum of the elasticities of the reduced-form revenue function with respect to factor prices:

$$H = \sum_{m=1}^{M} \alpha_m \qquad (7)$$

where

- H ≤ 0 indicates monopoly or short-run oligopoly
- 0 < H < 1 indicates a monopolistic competition.

- H = 1 indicates a perfect competition.

One problem with Rosse-Panzar model, however, is that the H-statistic can be misleading if the market is in long-run equilibrium. This suggests that competitive capital markets will equalise risk-adjusted rates of return across banks such that, in equilibrium, rates of returns should not be significantly correlated with input prices (for details see Matthews et al., 2007; Molyneux and Forbes, 1995 and Shaffer, 2004).

The equilibrium test defines the dependent variable as pre-tax profit to total assets:

$$\ln ROA_{it} = \alpha'_0 + \sum_{m=1}^{M} \alpha'_m \ln q_{mit} + \sum_{n=1}^{N} \beta'_n \ln X_{nit} + v_{it}\,, \qquad (8)$$

Equilibrium (E) has to satisfy:

$E = \sum_{m=1}^{M} \alpha'_m = 0$, E<0 indicates that the market is in long run disequilibrium and E=0 indicates the market equilibrium. Shaffer (2004) argues that this condition is necessary only for perfect competition.

4. Data

This study uses the intermediation approach to modelling bank production. As suggested by Berger and Humphrey (1997), the intermediation approach is best suited for evaluating bank efficiency, whereas the production approach is appropriate for evaluating the efficiency of bank branches. The dataset used in this study was obtained from the BankScope database. The data include 400 commercial banks in the 'old' European Union[15] covering the 2005-2012 period. All data are deflated to 2010 prices.

In Table 1, we list the variables in our model. Input variables include total personnel expenses, total interest expenses and total operating expenses. The output variables include total net loans, total securities, other earning assets and non-performing loans. We follow Klein

[15] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK

(2013), who uses impaired loans as a proxy for non-performing loans. Bankscope provides a level of impaired loans. Impaired loans are used in accounting and indicate the volume of loans that are unlikely to be paid back by debtors. This differs from NPLs that are defined by the regulatory body as loans that are more than 90 days past due. All these variables are well supported in the literature (Berger and Humprey, 1997; Altunbas et al. 2001; Fu and Heffernan, 2007; Assaf et al., 2013 among others).

As for the variables in the Rosse-Panzar model, we follow Matthews at al. (2007) and use the ratio of total revenue to total assets. The price elasticities include the price of labour (PL) defined as personnel expenses to fixed assets, the price of funds (PF) defined as total interest expenses on total deposits to total deposits and the price of capital defined as operating expenses to fixed assets.

<Insert Table 1 here>

5. Empirical results

5.1 Efficiency scores

Prior to discussing the convergence results, we focus on the efficiency results. In Table 2, we report the estimated coefficients of the translog model. We note that all inputs have the expected negative signs and are statistically significant at the 1% level. We also observe that the elasticities of the desirable outputs are positive and statistically significant at the 1% level. Surprisingly, the elasticity of other earning assets is higher and hence more important in the production process than loans. The coefficient of the undesirable output (b) has the correct sign, i.e. negative and statistically significant at the 1% level.

<Insert Table 2 here>

In Table 3 we report the average efficiency measures. We can see that the majority of countries experienced lower efficiency around the GFC (i.e. 2008 and/or 2009). The estimated bank efficiency levels across all the analysed countries are considerably lower in 2008 and 2009, except for Belgium, Sweden and Portugal (in 2008) and Germany and Portugal (in 2009). Ireland has the lowest efficiency level among the 'old' EU countries. Bank efficiency levels are only 50.73% and 49.16% in 2009 and 2010, respectively. In 2012, the highest efficiency level is found in Greece, confirming the fact that the crisis in Greece was not primarily triggered by the banking sector. The results also show that the banking sector in the UK was strongly hit by the GFC, even more than all other countries. This drop in bank efficiency occurred despite the unprecedented level of financial support from the UK government.

<Insert Table 3 here>

A further interesting observation is the reaction of commercial banks across the 'old' EU countries to the GFC. We would expect that shortly after the peak of GFC, banks would restructure their operational activities to improve or recover their efficiency. Surprisingly, however none of the listed countries show such an increase in efficiency or even a recovery back to the pre-crisis level of efficiency. Banks seem to be relatively slow to respond to endogenous and/or exogenous shocks in terms of adjusting their efficiency levels. This finding is in line with Tsionas (2006) who argues that efficiency does not quickly adjust following shocks to the system. In this case, the GFC has also been a unique event that bank managers may not have been able to handle in the best possible way. This crisis was further reinforced by the rapidly deteriorating balances and strict regulatory policies shortly after the crisis unfolded. Bank balance sheets were substantially shrunk because of the credit crunch and an increase in NPLs. Consequently banks had to write off a large volume of assets. Although a number of large banks across the EU countries significantly reduced their labour costs in particular as well as operational expenses, this measure was insufficient to restore banks' technical efficiency.

5.2 *Phillips and Sul (2007) log t-test*[16]

In the next step in our analysis, we test for convergence in banking efficiency, firstly among the banks from the old EU countries (EU15); secondly among the banks from the 12 Eurozone countries[17]; thirdly on a panel of asset-weighted country scores; and finally among the ten largest banks across the EU. The latter two sets are used to test whether size is a determining factor behind the integration process. 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 t-statistics obtained for the convergence test for technical efficiency scores for the panel of commercial banks within the EU15 and the 12 Eurozone countries for the period 2005-2012 are tabulated in Table 4.

<Insert Table 4 here>

Our results show a lack of convergence in European banking efficiency as the null hypothesis of group convergence is rejected for all four panels of efficiency scores.

[16] 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/.

[17] The EU15 except for Denmark, Sweden and UK

Interestingly, we find that size, as a common factor, does not necessarily translate into convergence in bank efficiency during this period.

Our results for the panel of EU15 banks contrast with those of Weill (2009)[18] and of Casu and Girardone (2010) who found evidence of convergence in cost efficiency, but for the pre-2008 financial crisis periods of 1994-2005 and 1997-2003 respectively. For robustness checks, as per Weill (2009), we run the following equation to estimate β-convergence for our panel of commercial banks:

$$lnEff_{i,t} - lnEff_{i,t-1} = \alpha + \beta lnEff_{i,t-1} + \sum_{i=1}^{n} D_i + \varepsilon_{i,t} \tag{9}$$

where $Eff_{i,t}$ is the efficiency score of bank *i* at period *t*, $Eff_{i,t-1}$ is the efficiency score at period *t*-1. D_i are bank dummies and include fixed effects. β-convergence is present if the coefficient β is negative. The results for the β-convergence test (see Table 5) show that there is no evidence of convergence in banking efficiency as the coefficient of $lnEff_{i,t-1}$ is positive for all 4 panel sets. These results therefore reinforce our results from the Phillips and Sul methodology.

<Insert Table 5 here>

The lack of group convergence across the EU15 countries can be explained by two main reasons. Firstly, the cross-country heterogeneity in European banking in the form of various national legislations, limitations in the sharing of cross-border data, national institutional

[18] Weill (2009) finds evidence of convergence at the 1 % significance level in all tests.

characteristics, and country-specific macroeconomic variables, and secondly, the onslaught of the GFC which necessitated large bail-outs to avoid the spread of systemic risk.

In order to provide a deeper analysis of the impact of the GFC on European banking, we estimate the competition level for the following periods, 2005-2007 (pre-crisis), 2008-2010 (crisis) and 2011-12 (off-peak crisis). As discussed in our methodology, we measure competitiveness using the Rosse-Panzar model.

Before starting the analysis it is important to emphasize the assumption about the long-run equilibrium. Shaffer (2004) argues that the condition of long-run equilibrium is only requested for perfect competition. In other words, the results are not biased if the condition of market equilibrium does not hold. In Tables 6 and 7 we report the test for market equilibrium. We see that the condition is fulfilled for the whole period for the EU banking sector. However, if we test the hypothesis about the long-run equilibrium we cannot confirm it in our sub-samples. As for the Eurozone we do not obtain clear evidence for the whole period. The F-statistics on the restriction rejects the market equilibrium at the 5% level of significance but not at 1%. Similar results are obtained even for the periods 2005-2007 and 2010 -2011. For the period 2011-2012 we confirm the existence of the long-run equilibrium.

Next, we shed light on the H statistics reported in Tables 6 and 7. The estimated H-statistics lie between zero and one and are not significantly different over the analyzed periods. The sign of coefficients is consistent across estimations The estimated H statistics indicate that commercial banks operate under monopolistic competition. The H statistics is 0.2445 and 0.1975 for EU countries and the Eurozone respectively. The H statistics for the individual sub-sample shows that during the peak period of GFC, i.e. 2008-2010, competition decreased. This might partially explain the drop in efficiency. Although, we report an increase in the H statistics between 2011 and 2012 these results need to be confirmed with a longer period. Our results can be partially compared with a few studies such as Casu and Girardone (2006). However, the main difference in our study is that we do not include savings banks and cooperative banks. In our view, cooperative banks and savings banks operate exclusively in domestic market and their business activities are not affected by internationalization factors. Therefore, the reported levels of the H statistics in our study reflect the true competitive conditions within the market. This is more in line with Molyneux et al (1994).

<Insert Table 6 and 7 here>

5.3 Club clustering test

Phillips and Sul (2007) argue that the absence of group convergence may be due to the presence of some divergent members in the panel. 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 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 the panel of asset-weighted technical efficiency scores for the 15 EU countries and to the group of ten top European banks[19]. The test statistics are reported in Table 8. Contrary to the log *t*-test results obtained for group convergence, we find the presence of club formation in both panels. The first club consists of Greece, Ireland, Italy, and Netherlands but shows relatively low level of convergence ($\hat{b}$ =0.890). The composition of the first club is revealing given that the first 3 countries have been severely hit by the crisis and engulfed in the Euro sovereign crisis. The second club regroups all the remaining 11 countries but exhibit

[19] The top 10 EU banks are Crédit Agricole CIB (FR), HSBC (UK), Danske Bank A/S (DK), Société Générale (FR), Commerzbank AG (DE), UniCredit SpA (IT), ING Bank NV (NL), Banco Bilbao Vizcaya Argentaria SA (ES), Barclays Bank Plc (UK), and Standard Chartered Bank (UK)

weak convergence ($\hat{b}$ = -2.90). As for the panel consisting of the top 10 EU banks, we find the presence of 2 clubs. The first club comprises HSBC (UK) and Crédit Agricole (FR) but the magnitude of convergence is weak ($\hat{b}$ = -1.267), while all remaining 8 banks in the second club are divergent. So overall, we find that although group convergence is not present across the EU15 or Eurozone countries, the results for club convergence, albeit weak, suggest that the global financial crisis has not brought the integration process in the European banking sector to a complete standstill but that nonetheless, it has seriously impaired it.

<Insert Table 8 here>

5.4 Relative transition parameters for individual countries

The third component of the Phillips and Sul (2007) test consists of the estimation of each country's relative transition coefficient, h_{it}. The transition coefficients (see Table 9) are estimated from each country's asset-weighted efficiency score per year relative to the panel cross-section average. Typically, if all loadings converge to the same value, $\delta_{it} \rightarrow \delta$, then the relative transition parameters converge to one, $h_{it} \rightarrow 1$ as the cross-sectional variance goes to zero. The relative transition coefficients for the EU15 countries indicate a noticeable convergence towards one between 2005 and 2008. However, starting in 2008, the gap between the countries' coefficients starts to widen and follow on this trajectory up to the end of the sample period, 2012. This heterogeneity is attributed to the occurrence of the GFC and its detrimental impact on the convergence process. Interestingly, it is also observed that the parameters for Finland, Sweden and Denmark exhibit a common path. Regional proximity could be the driving factor here. The path for Greece, a country besieged by financial turmoil is also clearly separate from the rest of the group while the path for Luxembourg is actually the furthest away from the group. The country's strong economic performance and resilient banking sector during the crisis seems to have demarcated it from the rest of the EU15.

<Insert Table 9 here>

6. Conclusion

This paper provides several important contributions to the ongoing empirical research on banking integration. Firstly, we use an advanced and comprehensive approach to measure bank efficiency. Secondly, we apply robust panel methodology to assess the convergence process in European banking. An integral part of the study is to investigate changes in bank efficiency before and during the GFC.

Our results show that the majority of countries experienced a fall in efficiency around the crisis period. The log *t*- test indicates that group convergence in bank efficiency is not present neither within the group of EU15 or within the Eurozone as a whole. The panel consisting of the top ten banks also show lack of convergence, although, club formation within the panels is present. However, all the clusters display weak convergence.

We attribute the lack of group convergence to the impact of the financial crisis on the European banking sector. The twin effects of the global crisis and the Eurozone sovereign debt crisis have challenged the European banking sector in numerous ways. Instability has transpired through deteriorating loan portfolio quality and necessitating the bail-outs of large institutions across the EU15. European banks now face the challenges of re-regulation including higher capital requirements and lower leveraging, amongst others. These banks will have no choice but to attempt to regain the losses by improving their efficiency. In addition, given the drive by the European Commission to reform the European banking sector into an efficient and stable system, European banks will have to utilise their assets more efficiently and with increased competition, the integration of European banking may well re-emerge.

The presented results also have important policy implications. The study unambiguously confirms that the GFC has undermined bank performance. The question that remains is whether the impact of the GFC is temporary or whether it will cause deeper problems for the integration process. The crisis has caused the collapse or an almost collapse of a large number of well-established EU banks. The main weakness of the integration process has been a weak and not fully implemented integrated framework for bank supervision and regulation. We have witnessed a typical systemic crisis across the individual EU countries. With the benefit of hindsight, it is now evident that the financial crisis has thrown the financial integration process into reverse. The extensive rescue packages to the individual banks across the EU countries provided by EU authorities and domestic governments have not yet been fully materialized. We assume that the process of stabilising and consolidating the banking system will be longer than expected. Our results further reveal that the process of bank integration has been severely destabilised. When it comes to regulation, national regulators should play a pivotal role in the restructuring and tuning up the domestic banking sector. This argument is mainly supported by the fact the national financial regulator have detailed knowledge not only about the individual banks but also about the economic environment that has to be taken into account during this recovery period. In other words, a more individualistic approach should be adopted during this transition and recovery period.

The study can be further extended by conducting an analysis of productivity convergence over time and during the crisis years. Fuji et al. (2014) propose a new methodological framework that quantifies the contribution of individual components (outputs/inputs) to bank efficiency and TFP change. Application of such a methodological framework might help better understand the bottlenecks of the convergence process. Last but not least, it would also be important to expand the analysed sample to include the new EU countries.

Acknowledgement

We are grateful to two anonymous referees, Franco Fiordelisi and participants at the AIDEA's conference in Lecce, Italy for their constructive comments and suggestions on an earlier version of this study. The authors are responsible for any remaining errors.

*The author gratefully acknowledges the support of the Czech Science Foundation within the project GAČR 13-03783S "Banking Sector and Monetary Policy: Lessons from New EU Countries after Ten Years of Membership".

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Technical Appendix A

An outline of the Phillips and Sul approach

A.1 Relative transition parameters

Using panel data on X_{it} we can decompose in two components comprising systematic components, g_{it}, and transitory components, a_{it}, as follows:

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

To estimate the time-varying loadings, g_{it} using the Phillips and Sul (2007) we rewrite (1) such that the common and idiosyncratic components are separated as follows:

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

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:

$$h_{it} = \frac{X_{it}}{\frac{1}{N}\sum_{i=1}^{N} X_{it}} = \frac{\delta_{it}\mu_t}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}\mu_t} = \frac{\delta_{it}}{\frac{1}{N}\sum_{i=1}^{N} \delta_{it}} \tag{3}$$

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.

A.2. The log t regression

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

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

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

The null hypothesis is rejected at the 5% significance level.

To conduct the Phillips and Sul's (2007)[20] procedure we use the following three steps:

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

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

Step 2: Perform an OLS regression as follows:

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

[20] The log t regression is also described in detail in Rughoo and Sarantis (2012).

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: Estimate 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. As the test statistic $t_{\hat{b}}$ is normally distributed we reject the null hypothesis of convergence at $t_{\hat{b}}$<-1.65.

Table 1. Descriptive statistics (mil EUR)

Variables	Interest expenses x_1	Operating expenses x_2	Personnel expenses x_3	Loans y_1	Securities y_2	Other earning assets y_3	Nonperforming loans b
Mean	1037302	286913.2	315640.6	2.12e+07	1.85e+07	2.61e+07	2151469
Max	1.06e+08	1.65e+07	1.71e+07	8.17e+08	1.74e+09	9.47e+08	8.54e+07
Min	0.1961761	5.139053	8.655822	0.218113	0.1090565	4.334257	4.391906
Std	4538902	1205949	1338040	8.00e+07	1.03e+08	9.44e+07	7218409

TABLE 2
Technical Efficiency -Estimation

VARIABLES	-ly2
lnx1	-0.179***
	(0.00702)
lnx2	-0.0687***
	(0.0126)
lnx3	-0.254***
	(0.0137)
lny1	0.150***
	(0.0157)
lny3	0.265***
	(0.0162)
Lnb	-0.0193***
	(0.00514)
lnx11	-0.0495***
	(0.00445)
lnx22	-0.0362***
	(0.0109)
lnx33	-0.0913***
	(0.0129)
lny11	-0.0201
	(0.014)
lny33	0.0193
	(0.0163)
lnbb	-0.0016
	(0.00219)
lnx1lnx2	-0.00548
	(0.0051)
lnx1lnx3	0.0505***
	(0.00608)
lnx2lnx3	0.0443***
	(0.00997)
lnx1lny1	-0.0001
	(0.00579)
lnx1lny3	-0.00476
	(0.00604)
lnx2lny1	0.0401***
	(0.0114)
lnx2lny3	-0.0343***
	(0.0123)
lnx3lny1	-0.0581***
	(0.0129)
lnx3lny3	0.0618***
	(0.0139)
lnx1lnb	0.00686***
	(0.00211)
lnx2lnb	-0.00302
	(0.00442)
lnx3lnb	-0.0031
	(0.00446)
lny1lny3	0.0178
	(0.0145)
lny1lnb	0.0277***
	(0.00448)
lny3lnb	-0.0257***
	(0.00466)
year_2012	0.112***
	(0.0243)
year_2011	0.0868***
	(0.0205)
year_2010	0.0266
	(0.0174)
year_2009	0.0564***
	(0.0148)
year_2008	0.150***
	(0.0141)
year_2007	0.116***
	(0.012)
year_2006	0.0515***
	(0.0104)
Intercept	0.288***
	(0.0365)
Observations	2,072
Number of id	400

* Significant at the 10%.
** Significant at the 5%.
*** Significant at the 1%.

Table 3: Technical efficiency levels

	2012	2011	2010	2009	2008	2007	2006	2005
Austria	0.6084	0.6017	0.6155	0.6290	0.6608	0.6731	0.6774	0.6893
Belgium	0.6551	0.6673	0.7151	0.7257	0.7360	0.6874	0.6991	0.7105
Denmark	0.6034	0.6169	0.6092	0.6218	0.6314	0.6617	0.6687	0.6811
Finland	0.5485	0.5629	0.5770	0.5665	0.5805	0.6408	0.6530	0.6418
France	0.6455	0.6544	0.6752	0.6884	0.7103	0.7120	0.7132	0.7290
Germany	0.6719	0.6328	0.7006	0.7313	0.7263	0.7435	0.7381	0.6988
Greece	0.6895	0.7012	0.7118	0.7230	0.7350	0.7706	0.7728	0.7897
Ireland	0.5351	0.5221	0.4916	0.5073	0.5502	0.5739	0.5826	0.6127
Italy	0.6229	0.6420	0.6502	0.6673	0.6721	0.6795	0.6939	0.7185
Luxembourg	0.6138	0.6092	0.5763	0.6226	0.6846	0.7483	0.8123	0.8734
Netherlands	0.5773	0.5898	0.6036	0.6157	0.6402	0.6884	0.6636	0.6524
Portugal	0.6876	0.7141	0.7352	0.7429	0.7345	0.7053	0.7239	0.7411
Spain	0.5651	0.5762	0.5568	0.5706	0.6160	0.6609	0.6282	0.6208
Sweeden	0.5664	0.5866	0.6006	0.5973	0.6271	0.5769	0.5922	0.6016
United Kingdom	0.5738	0.5937	0.6089	0.6275	0.6528	0.6583	0.6753	0.6722
European Union	0.6151	0.6256	0.6364	0.6518	0.6717	0.6807	0.6869	0.6957
Eurozone	0.6282	0.6359	0.6472	0.6627	0.6811	0.6917	0.6937	0.7075

Table 4: Phillips and Sul Log*t* test

Data sets	$\hat{b}$	*t*-statistics
Technical efficiency		
EU15 countries	-1.767	-70.274*
Eurozone countries	-1.762	-69.356*
Asset-weighted country efficiency scores	-1.751	-67.433*
Top 10 EU15 banks	-1.770	-70.978*

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 113 banks in total across the EU15 countries and 84 for the Eurozone countries.

Table 5: β-convergence

Panel data sets	Coefficient
EU15 banks’ efficiency scores	0.048
Eurozone banks’ efficiency scores	0.048
Asset weighted country efficiency scores	0.047
Top 10 EU15 banks	0.048

Note: The coefficient for the β-convergence test is positive implying that there is no convergence.

Table 6
Tests of competitive conditions in EU 15 countries (Dependent variable lnREV/TA)

EU	2005-2012	2005-2007	2008-2010	2011-2012
Intercept	1.3158***	0.9780	2.5761***	2.7670
Ln PL	-0.1745***	-0.3778***	-0.3246***	-0.0109
Ln PF	0.3881***	0.4434**	0.3829***	0.2536***
Ln PC	0.0309***	0.0514**	0.0381***	0.0146
Ln Liq	-0.0357**	-0.0014**	-0.0491***	-0.0289
Ln Assets	-0.2223***	-0.2506***	-0.3495***	-0.3117***
H0: H=0	F(1,1640)=136.98***	F(1,401)=5.04**	F(1,485)=6.05**	F(1,222)=12.33***
H1: H=1	F(1,1640)=1306.87***	F(1,401)=286.63***	F(1,485)=531.23***	F(1,222)=102.76**
H	0.2445	0.1171	0.0964	0.2573
H0: E=0	F(1,2240)=0.60	F(1,570)=7.10**	F(1,622)=4.91***	F(1,290)=4.05***
R^2 within	0.6488	0.6284	0.7276	0.3715

* Significant at the 10%.
** Significant at the 5%.
*** Significant at the 1%.

Table 7
Tests of competitive conditions in the Eurozone (Dependent variable lnREV/TA)

Eurozone	2005-2012	2005-2007	2008-2010	2011-2012
Intercept	1.4253***	0.9609*	3.5663***	2.1096**
Ln PL	-0.2473***	-0.3785***	-0.3195***	-0.0459
Ln PF	0.4139***	0.4849***	0.4129***	0.3834
Ln PC	0.0309**	0.0497**	0.0338***	0.0153
Ln Liq	-0.0431***	-0.0007	-0.0652***	-0.0409*
Ln Assets	-0.2437	-0.2417*	-0.4023	-0.2396
H0: H=0	F(1,1248)=49.85***	F(1,334)=7.38***	F(1,353)=6.65**	F(1,152)=20.03***
H1: H=1	F(1,1248)=823.48**	F(1,334)=215.51***	F(1,353)=312.5**	F(1,152)=675.32***
H	0.1975	0.1561	0.1272	0.3528
H0: E=0	F(1,1681)=4.96**	F(1,436)=6.25**	F(1,467)=6.22**	F(1,206)=1.39
R^2 within	0.6784	0.6438	0.7019	0.5415

* Significant at the 10%.
** Significant at the 5%.
*** Significant at the 1%.

Table 8. Phillips and Sul (2007) club convergence test

Data series	$\hat{b}$	*t*-statistics
Country asset-weighted scores		
Club 1: Greece, Ireland, Italy, Netherlands	0.890	0.154
Club 2: Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, Portugal, Spain, Sweden, UK	-2.900	-0.596
10 Top EU banks		
Club 1: Crédit Agricole CIB(FR), HSBC (UK)	-1.267	-1.494
Divergent: Danske Bank A/S (DK), Société Générale (FR), Commerzbank AG (DE), UniCredit SpA (IT), ING Bank NV (NL), Banco Bilbao Vizcaya Argentaria SA (ES), Barclays Bank Plc (UK), Standard Chartered Bank (UK)	-1.760	-61.510*

Table 9: Relative transition parameters

Yr	AT	BE	DK	FIT	FR	DE	GR	IE	IT	LUX	NL	PT	ES	SE	UK
2005	1.11	0.95	0.87	0.77	1.06	0.99	1.13	0.92	1.04	1.23	1.02	1.06	1.03	0.87	0.97
2006	1.11	0.94	0.86	0.76	1.07	0.99	1.13	0.92	1.04	1.24	1.02	1.06	1.03	0.86	0.97
2007	1.12	0.94	0.86	0.75	1.07	0.99	1.14	0.92	1.04	1.25	1.02	1.06	1.03	0.85	0.96
2008	1.13	0.94	0.85	0.74	1.07	0.99	1.15	0.91	1.04	1.26	1.02	1.06	1.03	0.85	0.96
2009	1.13	0.93	0.84	0.73	1.08	0.99	1.15	0.91	1.04	1.28	1.02	1.07	1.03	0.84	0.96
2010	1.14	0.93	0.83	0.72	1.08	0.99	1.16	0.90	1.04	1.29	1.02	1.07	1.03	0.83	0.96
2011	1.14	0.93	0.83	0.70	1.08	0.98	1.17	0.90	1.05	1.31	1.03	1.07	1.03	0.82	0.96
2012	1.15	0.92	0.82	0.69	1.09	0.98	1.18	0.89	1.05	1.32	1.03	1.07	1.03	0.82	0.95