Efficiency and Risk Convergence of Eurozone Financial Markets

Joerg Wild

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Author: Joerg Wild

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Highlights

- Convergence of financial markets is evaluated with respect to efficiency and risk.
- Commercial, savings, and cooperative banks across 12 Eurozone countries from 1999-2012 build the sample.
-Two measures of efficiency (DEA and SFA) and two measure of risk (E/TA and Z-score) are considered.
- Eurozone financial markets converge mainly for commercial banks but to a much lesser degree for savings and cooperative banks.

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Joerg Wild

Shanghai University of Finance and Economics, 777 Guoding Road, 200433 Shanghai

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Abstract

This paper discusses beta and sigma convergence of commercial, savings, and cooperative banks in the Eurozone from 1999 to 2012. For this purpose, concepts of the growth and efficiency convergence literature are consulted and GMM, fixed effects models, and OLS are applied. Convergence is analyzed by calculating two efficiency metrics – data envelopment analysis (DEA) and stochastic frontier analysis (SFA) – and two risk metrics – equity to total assets (E/TA or EQTOAS) and Z-scores (ZSCORN). For commercial banks, efficiency convergence of both metrics is found, however, savings banks show no signs of convergence and cooperative banks only show signs of SFA convergence. Banks of all three specializations show E/TA convergence, but only savings banks convergence with respect to Z-scores. Nevertheless, the EU's Single Market Program still has a long way to go to create identical conditions for all member countries' financial markets. The discovery that there are considerable differences between banks' specializations, and even more, that there is convergence with respect to E/TA as a risk metric are among the main academic contributions of this paper.

Keywords: Bank efficiency, Financial risk, Convergence, DEA, SFA, Eurozone

2014 MSC: 14-10, 15-01

1. Introduction

A key driver of the construction of the EU was the hope to unleash the potential of a common market with respect to goods and services, as well as the introduction of a common currency. With the creation of the EMU in 1999, the euro was widely expected to become a catalyst for economic integration and convergence within Europe, not to mention a key driver of economic prosperity. In order to secure the functioning of the common market, economic and social cohesion became fundamental and has been a goal of the EU from the early beginnings. The Treaty on the Functioning of the EU already defines economic, social and territorial cohesion in the form of reducing disparities in development as one of the main operational priorities.[1] The EU commission's publication of the Commission Communication on Cohesion Policy and the Environment in 1995 can be seen as a first major milestone that led to the creation of the European Cohesion Policy.[2]

The sovereign debt crisis and, more generally, the differential macroeconomic performance across euro area members in the aftermath of the 2008-2009 recession has called into question the positive impact of the creation of a monetary union and the existence of a common economic growth development. Some commentators argued that the adoption of a common currency may have been a factor of divergence and, in particular, a source of a growing gap between a "virtuous core" and a "sinful periphery" (Estrada et al., 2013). The years of crisis have moreover underlined that the financial market should not only be viewed as a driver of growth but also a potentially destabilizing risk factor due to the interconnected structure of modern financial markets.[3]

The aim of this paper is therefore to check whether harmonization and integration among Eurozone countries' financial markets has taken place with respect to efficiency and risk. It was not until June 29, 2012 that the Euro-area leaders "affirm that it is imperative to break the vicious link between banks and sovereigns" and called for a single supervisory mechanism (SSM) under the direction of the ECB.[4] However, the SSM only directly supervises the largest and systemically relevant banks and the great majority of especially savings and cooperative banks remain under supervision of national authorities. The question under scrutiny therefore is to analyze to what degree the banking market is integrated on a Eurozone level since the creation of the monetary

[1] The TFEU also known as the Treaty of Rome (1958) is one of two principal treaties on which the EU is based with the other being the Treaty on European Union, or Maastricht Treaty, that became effective in 1993, as outlined in Part 3, Union policies and internal actions, of the TFEU deals with economic, social and territorial cohesion. Further, the treaties are enhanced with 37 protocols, 2 annexes and 65 declarations that are to elaborate the details, some are directed at specific countries, without being in the full legal text, of which Protocol 28 deals with economic, social and territorial cohesion.

[2] The identified key targets are to promote growth-enhancing conditions and reduce disparities between the levels of development of EU regions and member states in order to achieve cohesion. The objective of the European Cohesion Policy is defined in Articles 2 and 4 and Title XVII of the Treaty establishing the European Community. According to Article 2, Cohesion Policy should "promote economic and social progress as well as a high level of employment, and achieve balanced and sustainable development". Article 158 adds, "in particular, the Community aims to reduce the disparities between the levels of development of the different regions and the backwardness of the least favored regions or islands, including rural areas".

[3] Unlike prior crises, contagion following the 2008 global financial crisis is not confined to emerging markets. The U.S. as well as other mature financial markets as is the case for the Eurozone, transmit and receive contagion (Luchtenberg & Vu, 2015). Other studies conclude that contagion form the U.S. is uni-directional with respect to spot and future equity markets (Inci et al., 2011). Apart form the internationalization of equity markets, firms are nowadays also increasingly depended on market liquidity of debt (Mac an Bhaird, 2013).

[4] Source: Euro Area Summit Statement, Brussels, June 29, 2012.

union.

Tests of beta and sigma convergence of financial and economic variables are conducted for 12 Eurozone countries from 1999 till 2012. Convergence rates are calculated by applying the generalized method of moments approach (GMM), a fixed effects model (FE), and an ordinary least square model (OLS) for commercial, savings, and cooperative banks. Briefly, convergence is assumed if the estimated beta is significant and negative, and at the same time, the estimated sigma – which is an indication of how fast the convergence takes place – is also significant. The application of different models allows for a general robustness check of the results. All the data is further split into a period before and after the onset of the Global Financial Crisis of 2007/2008, the pre- and post- crisis shock period, which allow for a comparison of the development of convergence.

This paper's analysis of convergence of the Eurozone's financial market contributes to the existing research in several ways: Although previous studies were dealing with convergence of efficiency of commercial banks in the EU, none has focused on checking for convergence in the Eurozone as a subset of the EU. Some studies presented inconclusive results as to whether convergence has taken place; moreover, the countries under scrutiny were generally EU15, E22 or some other random mix of European countries, whereas the following research exclusively deals with Eurozone countries to assess the progress of the Single Banking Market. Due to the higher degree of economic, regulatory and supervisory integration of the Eurozone countries compared the EU countries, convergence is of particular interest. Asynchronous shock have posed a severe risk for the cohesion of the euro area, partially as Eurozone member countries were unable to mitigate weak economic growth by the means of currency devaluation.

Although the application of convergence to bank efficiency data of commercial banks in the EU is nothing new, no previous study has included savings and cooperative banks on an international scale. Unlike the case of commercial banks for which some studies found proof of a common banking market, the existing literature has rarely included savings and commercial banks, despite the fact that banks of these specializations account for roughly 30% of the total assets of the Eurozone banking market.[5] The last study employing non-parametric efficiency measurement and tests of convergence was undertaken by Andrieş & Căpraru (2012b) for commercial banks of EU countries

[5]Status: end of 2012 figures. Commercial banks account for approx. 50% of total assets of the banking market and represent the largest homogeneous sub-population of banks. Source: BvD Bankscope, author's calculations.

from 2003 to 2009.[6] The present research includes data from the inception of the euro in 1999 until 2012, thereby including the years of the Eurozone sovereign debt crisis. Valuable information is expected from results spanning over these years of financial upheaval and ensuing regulatory and economic harmonization. Moreover, the samples are divided into two sub-periods: 1999-2006, the years following the inception of the common currency and 2007-2012, marking the period before the onset of the US subprime crisis and the years of crisis, first marked by the collapse of the US housing market and followed by the sovereign debt crisis of the Eurozone. Lastly, no previous study has dealt with the conversion of financial markets with respect to risk, which is surprising, especially considering the large amount of literature focusing on efficiency and growth convergence. New insights to the functioning of financial markets are expected by the extension of convergence literature.

2. Literature review

The concept of beta and sigma convergence is directly related to the neo-classical growth theory of Solow (1956) where one key assumption is that factors of production, particularly capital, are subject to diminishing returns. Beta convergence is defined here as a process in which poorer regions grow faster than richer ones and eventually both regions reach the same level. Accordingly, the growth process should lead economies to a long-run steady-state characterized by a rate of growth which solely depends on the exogenous rates of technological progress and the growth rate of the working population. Diminishing returns also implies that the growth rate of poor economies should be higher and their income and per capita GDP levels should catch up with those of rich economies.

The ensuing seminal papers by Barro & Sala-i Martin (1991) and Mankiw et al. (1992) have triggered myriads of research papers attempting to empirically detect and measure the extent of beta convergence in various contexts. As pointed out by Sala-I-Martin (1996), one of the striking results obtained is the regularity of the estimated speed with which economies converge to their steady-state, namely around 2% a year, though it is uncertain whether these suspiciously similar results are indeed a persistent econometric parameter or merely an artifact of cargo cult science.

[6] Andrieş & Căpraru (2012a) conducted a study on banking efficiency convergence of central and eastern European countries. As the focus of this research paper is on the Eurozone, aforementioned study appears even less relevant than Andrieş & Căpraru (2012b) in this context.

Monfort (2008) analyzed economic convergence among EU regions using several methodologies like the coefficient of variation, the Gini coefficient, the Atkinson index, the Theil index and mean logarithmic deviation (MLD). The objective was to conduct an updated assessment of regional disparities in the EU bringing together the most frequent instruments used in the analysis of convergence and inequalities. The examination of these metrics suggested that growth convergence among EU regions is stronger than that which is indicated by summary measures of distributions. In particular, it revealed that convergence is taking place even within groups of regions like the EU-15.

Starting from the hypothesis that closer economic integration between countries may lead to increased real income per capita convergence, Borsi & Metiu (2013) investigated convergence in real incomes between the 27 current member states of the EU for the period 1970-2010 by employing an empirical, non-linear latent factor framework convergence test derived from a neoclassical growth model augmented with endogenous technological progress which differs across countries and over time. Their results offer important insights on the economic catch-up exhibited by the new EU members in light of the institutional changes and macroeconomic adjustment processes experienced in recent decades. However, no overall real income per capita convergence in the EU is found in their study. Instead, the authors discover country groups that converge to different income levels in the long-run: a South-East vs. North-West division of European economies by the mid-nineties is observed.

Since the preparation of the Single Market Program (SMP) in the 80s, financial integration in Europe has been expected to provide gains in growth by favoring competition and efficiency on financial markets.[7] These gains should result from price reductions in financial services leading to direct gains for consumers and indirect gains through the reduction of loan interest rates. It is therefore of paramount interest not only to assess convergence with respect to GDP growth, but also to analyze whether financial integration in the form of efficiency and risk convergence has taken place in the EU.

[7]The SMP has begun to remove the market rigidities and barriers to mobility which in the mid-1980s gave rise to persistent economic under-performance, reflected in rising unemployment and poor competitiveness. The Communication of 1996 titled "The impact and effectiveness of the single market" concluded that he SMP has transformed the conditions under which cross-border business is carried out. Most of the principal obstacles to integration of product, service and capital markets have been removed. The First Banking Coordination Directive (1977), the EU White Paper (1985) and the Second Banking Coordination Directive (1988) finally led to the establishment of the Single Market for Financial Services on January 1, 1993.

Casu & Molyneux (2003) are among the first researchers to analyze convergence of banking efficiency for the European banking system since the start of the SMP. The authors employ a non-parametric DEA approach to investigate whether the productive efficiency of European banking systems has improved and converged towards a common European frontier between 1993 and 1997, the years following the introduction of the SMP. Their results suggest that there has been a small improvement in bank efficiency levels, although they find weak evidence to support the hypothesis that bank efficiency has converged; most of the efficiency differences found across European banking systems are due to country-specific aspects of the banking technology. The results were believed to reflect legacy of different banking regulations and the managerial strategies implemented to face up to the new challenges brought about by information technology, financial innovation and greater competition within the European banking market.

Bos & Schmiedel (2007) apply a meta-frontier model that permits to assess the existence of a single and integrated European banking market for commercial banks. The authors attempt to answer this question by analyzing if commercial banks in 15 European countries share a common benchmark, that is, a common cost or profit frontier for the period 1993–2004. They find evidence in favor of a single European banking market characterized by cost and profit meta-frontiers. However, compared to the meta-frontier estimations, pooled frontier estimations tend to underestimate efficiency levels and correlate poorly with country-specific frontier efficiency ranks.

Tortosa-Ausina (2002) examines the convergence in efficiency of Spanish banks following deregulation through a model of distribution dynamics and finds 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 Program in 1993. They find weak evidence of convergence and only for specific financial products. Mamatzakis et al. (2008) analyze the convergence in cost and profit efficiency, estimated by means of SFA, for banks in the 10 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.

Weill (2009) determines whether financial integration has taken place on the EU banking markets, by investigating the convergence in banking efficiency for European countries between 1994 and 2005. They provide evidence of cross-country differences in cost efficiency and an improvement in cost efficiency for all EU countries and convergence tests for panel data show a process in convergence in cost efficiency between EU countries. Robustness checks with alternative specifications confirm their findings. These results support the view that financial integration has taken place in the EU banking markets from 1994 to 2005.

Casu & Girardone (2010) evaluate the recent dynamics of bank cost efficiency by means of DEA. Borrowing from the growth literature, the dynamic panel data models to the concepts of beta- and sigma convergence is applied to assess the speed at which banking markets are integrating. Moreover, they 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, they find no evidence of an overall improvement of efficiency levels towards best practice.

Andrieş & Căpraru (2012a) conducted a study of commercial banks for Central and Eastern European countries from 2004 to 2010. They observe large differences in the level of cost efficiency between national banking systems and notice an increase in banking efficiency for all banking systems until 2008. In 2009, however, the average scores of cost efficiency started to decline. They find beta and sigma convergece in the form of a "catching up" process. The same author team, Andrieş & Căpraru (2012b), investigate the impact of European integration process on the cost efficiency of EU27 banking markets over the period 2003 to 2009. The results provide evidence of both types of convergence, beta- and sigma-convergence, for the entire period, but ampler during crisis period (2008-2009) than pre-crisis period (2003-2007). These differences are attributed to a "catching up" process during the pre-crisis period and a "lagging behind" process during the crisis period. Overall, their findings suggest that the European integration had a positive impact on cost efficiency and their convergence during the pre-crises period, but in the crises period, European integration does not seem to have an evident impact. The crises struck EU countries' banking systems differently and there were differences in affecting cost efficiency in old member countries versus new member countries.

3. Methodology

3.1. Modeling convergence

The theory of convergence and its applications have been widely studied in the growth literature during the last decade with Barro & Sala-i Martin (1991) proposing two concepts of convergence: beta and sigma convergence which are generally applied to a panel of country-wise GDP growth data, or, in the context of this research, to efficiency scores. Beta convergence tests aim to regress the mean country efficiency levels on the initial level; the test result is positive if the efficiency is negatively correlated with the initial level, which implies that countries with low initial level have faster efficiency improvements than countries with high initial level, and hence convergence occurs.

The limits of this test for beta convergence have been pointed out by Quah (1996) in the case of growth convergence: The first drawback is that, if countries with low initial level grow faster than those with high initial level, a situation can arise where the former surpasses the latter, resulting in

information on the evolution of the dispersion of the cross-section.

The methodology used to measure beta convergence of bank efficiency generally involves estimating an equation in the following form:

$$\ln EFF_{i,t} - \ln EFF_{i,t-1} = \alpha + \beta \ln EFF_{i,t-1} + \sum_{i=1}^{9} D_i + \varepsilon_{i,t} \qquad (1)$$

where $EFF_{i,t}$ is the mean efficiency of country i in year t; $EFF_{i,t-1}$ is the mean efficiency of country i in year $t-1$; D_i the country dummies, ε_i the error term, and α and β the parameters to be estimated. Country dummies incorporate fixed effects for the countries in the equation in order to disentangle the country effects. There is then beta convergence, or a catching-up process present if the coefficient β of the initial level is significant and negative. A high coefficient in relative terms signifies a greater tendency towards convergence.

While beta convergence focuses on detecting possible catching-up or lagging behind processes, sigma convergence indicates a reduction of disparities among countries over the years. The two concepts are closely related. Formally, beta convergence is necessary but not sufficient for sigma convergence. Intuitively, this is either because economies can converge towards one another but random shocks push them apart or because, in the case of conditional beta convergence, economies can converge towards different steady-states.

For the estimation of cross sectional dispersion, or sigma convergence, an autoregressive distributed lag model is applied through the estimation of the following equation, following the specification for panel data.

$$\Delta W_{i,t} = \alpha + \beta W_{i,t-1} + \sum_{i=1}^{9} D_i + \varepsilon_{i,t} \tag{2}$$

where

$$W_{i,t} = \ln EFF_{i,t} - MEFF_t$$
$$\Delta W_{i,t} = W_{i,t} - W_{i,t-1}, D_i$$

and $\ln EFF_{i,t}$ is the logarithm of the mean efficiency score of banks of country i in year t, $MEFF_t$the mean of $\ln EFF_{i,t}$for each period, country dummies, ε_i the error term, and α and β the parameters to be estimated. Country dummies incorporate fixed effects for countries in the equation to disentangle the country effects. There is then sigma-convergence if the coefficient β of the initial level in Equation 2 is significant and negative. While beta convergence aims to investigate a possible catching-up process, sigma convergence refers to a decrease of disparities across the Eurozone banking systems in time. Eq. 1 and Eq. 2 are part of a commonly accepted framework to asses beta and sigma convergence as it was used notably by Parikh & Shibata (2004); Fung (2006); Weill (2009); Casu & Girardone (2010); Andrieş & Căpraru (2012b) and Andrieş & Căpraru (2012a). In the context of this research, *EFF* refers to mean, per country and year, efficiency scores derived by DEA and SFA. The research on efficiency convergence is then extended to risk and the two risk metrics E/TA (or EQTOAS) and Z-score (ZSCORN) are averaged, per country and year, and tested in the same form; hence, in this case, *EFF* proxies risk.

3.2. Regression models

As for the methodology, generalized method of moments (GMM) is used as the tool for the estimation of beta- and sigma convergence; fixed effects model (FE) and pooled ordinary least squared (OLS) serve as a robustness check. The GMM estimation takes into consideration the problem of endogeneity of explanatory variable and the risk of omitting an explanatory variable and consequently producing biased estimation of the least squares parameter, since the omitted variables are correlated with one of the regressors. To cope with this endogeneity problem, dynamic panel data estimators developed by Arellano & Bond (1991) and Arellano & Bover (1995) are used for the test of convergence.

An augmented version of the system GMM was proposed by Arellano & Bond (1991). They used moment conditions to build up a two stage model; the first step yields independent and homoscedastic error terms and the second uses the first step's residuals to estimate a consistent estimate of the variance-covariance matrix. Therefore, the estimation of the two-step is technically more efficient and results in better, independent and homoscedastic estimates that are consistent and efficient, but nevertheless less reliable.

Monte Carlo studies have shown that the two-step GMM estimator has the disadvantage of converging to its asymptotic distribution relatively slowly. In finite samples, the asymptotic standard errors associated with the two-step GMM estimators can be seriously biased downwards, and thus form an unreliable estimation (Bond et al., 2001). The inference from the one-step estimator might be more reliable especially when the number of instruments is equal to or larger than the number of cross-sectional units.

In the following analysis, the system estimator is used, since it assumes the initial conditions of moment conditions that remain informative even for persistent series, and it has been shown to perform well in simulations. Therefore Bond et al. (2001) recommend the consideration of system GMM estimators in empirical growth-related research in particular and in models where endogeneity is expected. The advantage of the system GMM over FE and OLS is its feature of combining a equations with both first-differences and levels, where the instruments used in the levels equations are lagged first-differences of the series. These instruments are valid under restrictions on the initial conditions; finally, the method also considers the extension of the estimators to the cases of temporary measurement error and endogenous regressors. In order to ensure validity of the instruments, Bond et al. (2001) suggest to use the Sargan-Hansen tests of over-identifying restrictions.

3.3. Data and variables

As for the efficiency score, two distinct methods are used: the data envelopment analysis (DEA) and the stochastic frontier approach (SFA). The basic DEA and SFA model, the inputs and outputs, as well as the specifications of both, are presented in detail in Appendix A and Appendix B. High values of efficiency are associated with a narrow margin of a particular bank with best-practice banks that lie on the efficient frontier. The calculation of equity to total assets (E/TA or EQTOAS) is straight forward. Higher values are synonym with less risk in the capital structure. The Z-score

(ZSCORN) is defined as the ratio of the return on assets plus the capital ratio divided by the standard deviation of the return on assets and widely used in the literature as bank risk taking measure.

$$ZSCORN_{it} = \frac{ROAA_{it} + CAR_{it}}{\sigma_{ROA_i t}} \quad (3)$$

with: $ROAA_{it}$ being the average return to assets, the CAR is the ratio of total equity over total assets, and σ_{ROA} being the standard deviation of return on assets of bank i in period t. Transcripts i and t indicate bank and time. The Z-score combines in one single indicator the banks' profitability, capital ratio and return volatility. Evidently, the Z-score will increase with the banks' profitability and capital ratio, and decrease with increasing return volatility. Thus, from an economic viewpoint the Z-score initially measures the probability of a bank becoming insolvent when the value of assets becomes lower than the value of debt. Hence, a higher Z-score implies a lower probability of insolvency risk and vice versa. The calculations are performed on bank level basis using BvD Bankscope data; for calculation of the standard deviation, the five-year moving average (2-1-2) is used.

The three types of banks were selected as they account for 83% of the total number of banks and over 69% of all total assets as of 2012. The remaining banks like real-estate banks, governmental banks, etc. were excluded in order to create a more homogeneous samples of banks with similar technologies, access to resources, and production functions.

As mentioned in the introduction, the Eurozone is defined as the group of the following countries: Austria, Belgium, Germany, Spain, Finland, Ireland, Italy, Luxembourg, the Netherlands, and Portugal. Greece introduced the euro in 2001 and is therefore included in the dataset from this year on.[8] All following regressions and test will be conducted with this data for each type of specialization of bank.

The data set used is composed of individual bank data sourced from unconsolidated statements of banks operating in Eurozone countries, as made available through the Bankscope database of Bureau van Dijk. The study includes banks that follow IFRS as well as local GAAPs. This decision

[8]Due to consistency concerns, the following countries were excluded, although they joined the group of the Eurozone meanwhile. The year in the parenthesis marks the year of the introduction of the euro: Cyprus(2007), Estonia(2010), Latvia(2013), Malta(2007), Slovenia(2006), and Slovakia(2008).

was warranted as IFRS was not mandatory, nor followed by the majority of cooperative and savings banks before 2005. As the data here utilized is based on the main accounting categories and ratios, no distortion due to a potential change in accounting principle is expected. The data has undergone

Table 1 Distribution of observations by specialization and country

Country	Commercial banks	Cooperative banks	Savings banks	Total
Austria	446	1,031	1,018	2,495
Belgium	211	21	7	239
Germany	1,150	13,502	6,818	21,470
Spain	433	588	558	1,579
Finland	83	-	14	97
France	1,040	941	334	2,315
Greece	146	9	2	157
Ireland	32	-	-	32
Italy	1,176	6,671	680	8,527
Luxembourg	818	21	22	861
Netherlands	95	-	6	101
Portugal	185	12	35	232
Total	5,815	22,796	9,494	38,105

Number of bank observations over 13 years.

substantial editing in order to avoid inconsistencies, reporting errors and double counting; in detail the following steps were undertaken: First, observations with missing data were removed. As opposed to similar studies, not only the "survivors" were kept, but also banks with missing data for some years or who ceased to exist in 2012. This decision is justifiable as the efficiency frontier is calculated on a yearly basis, survivor bias is not much of an issue, and, for the subsequent analysis, yearly, country averaged scores are used. Second, only observations with positive inputs, outputs, and prices were kept; this step is mandated as DEA as well as SFA are only solvable for positive values. Third, a certain minimal threshold for inputs and outputs were imposed. Fourth, the first two years, 1999-2000, were excluded for Greece as they had not yet introduced the euro. Finally, a test of four standard deviations from the mean was conducted and no outliers were observed. The result is a total of 38,105 annual bank observations that have fulfill all criteria.

Table 1 displays the combined observations grouped by country and specialization; the results show that cooperative banks are by fare the largest group by number with 22,796 observations (59.8%), followed by savings banks with 9,494 observations (25.9%) and commercial banks with 5,815 observations (15.3%). Commercial banks appear to be the most representative with observations for each country, but especially for Germany and Italy, cooperative banks outnumber commercial banks, the same holds for savings banks compared to commercial banks in Germany.[9]

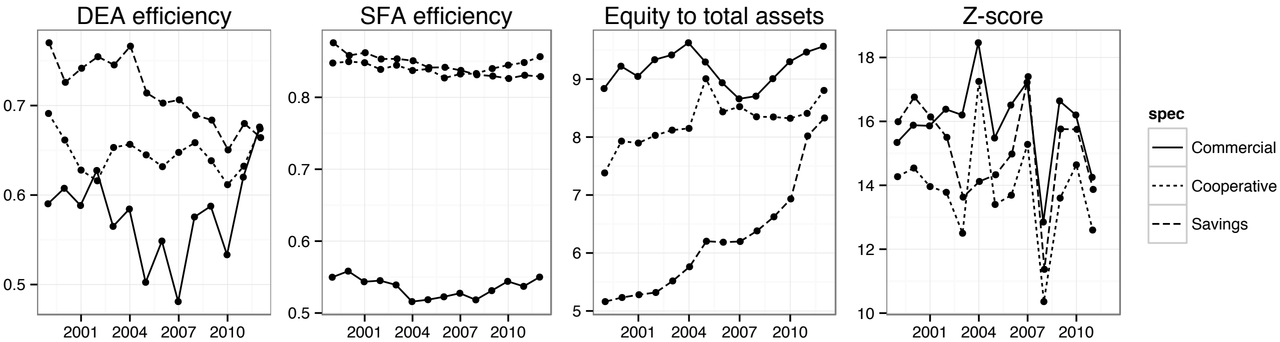

Figure 1 Yearly development of average efficiency and risk measures from 1999 to 2012 across Eurozone countries.

Figure 1 displays the development of the four matrices over time and gives an indication of the differences between the specializations. The DEA model reviles that the average efficiency is decreasing for cooperative and savings banks but a net increase is observable for commercial banks. The SFA model shows a small increase for commercial and savings banks. Equity to total assets are improving from historically low levels in 1999 reflecting a general trends towards higher capitalization; Z-scores that also take account of the fluctuating volatility are at their lowest in 2008 when Lehmen Brothers went bankrupt. Commercial banks are generally less efficient and risky compared to savings and cooperative banks.

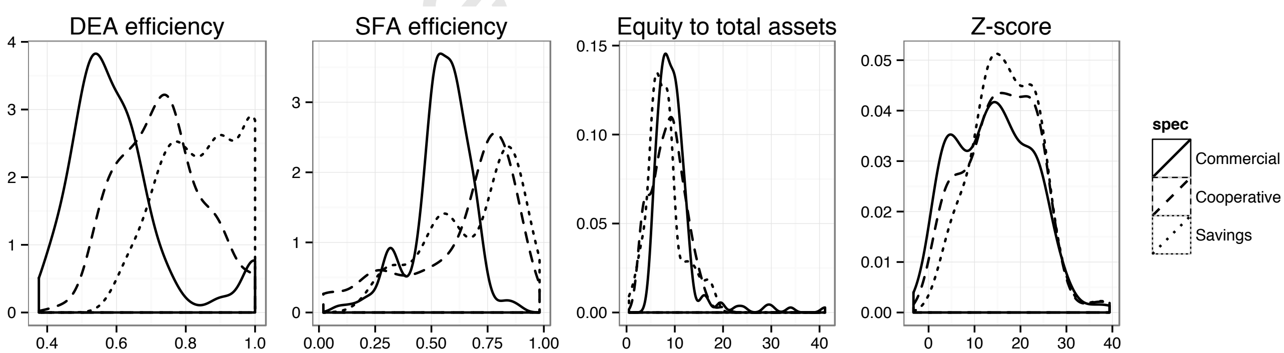

Figure 2 Kernel densities of average efficiency and risk measures from 1999 to 2012 across Eurozone countries.

[9]Countries such as Finland, Ireland, and the Netherlands do not have observations for the specialization cooperative banks; the countries Belgium, Greece, Luxembourg and Portugal do have cooperative banks but their number remains rather low. In the case of savings banks, only Ireland has no observations; Finland, Greece, Luxembourg, Netherlands and Portugal have a very limited number of observations, bearing in mind the date spans over 13 years.

Figure 2 displays the kernel densities of the four variables under scrutiny for each specialization. The graphical analysis of efficiency scores confirm the on average lower efficiency values and the higher capitalization of commercial banks. Moreover it can be seen that the observations cooperative banks more concentrated around their median.

A preliminary graphical test of convergence can be found in Figure 3 where correlation between the initial log levels of 1999 and the growth rate form 1999 - 2012 is visualized by the slop of the OLS regression. A negative trend shows that countries with low initial levels demonstrate higher growth rates, which provides evidence of a catching-up process. As can be seen in Figure 3, the all the regression lines are falling with the exception of cooperative banks in the DEA model.

4. Empirical results

4.1. Efficiency convergence

In the following analysis, country-wise averaged efficiency scores are tested for convergence by applying the system-GMM, the fixed effect (FE) and the pooled ordinary least square (OLS) model. System-GMM method is generally considered the best choice to check for beta and sigma convergence, however, in order for the GMM to return valid results, the Arellano-Bond test for AR(1) in first differences should not be higher then 10% and the Arellano-Bond test for AR(2) and the Hansen test of over-identification are to be higher than 10% to consider the results viable; otherwise, the results of the FE and OLS model are deemed to be superior to the system-GMM and are analyzed.[10] In this case, both FE and OLS model have to give the same results to demonstrate existence of beta or sigma convergence. Moreover, efficiency convergence is assumed to be present if both, DEA and SFA efficiency are confirmed. Table 2 and 3 display the results of beta and sigma convergence of DEA and SFA efficiency scores, first, for the entire period 1990–2012, second 1999–2006, third 2007–2012. The top tier shows the results of the commercial banks, middle tier of the savings banks and the last tier of the cooperative banks.

Applying the above stated rules on the efficiency scores, both DEA and SFA combined, beta as well as sigma convergence for the entire period under investigation is found in the case of commercial banks. As far as the sub-periods are concerned, the GMM is only valid for the period 1999-2006

[10]The FE allows for controlling unobserved heterogeneity when heterogeneity is constant over time and correlated with independent variables, and inference is appropriate for countries under study. Hausman test was conducted to choose between FE and random effect; χ^2-statistic was significant and hence the FE was deemed appropriate.

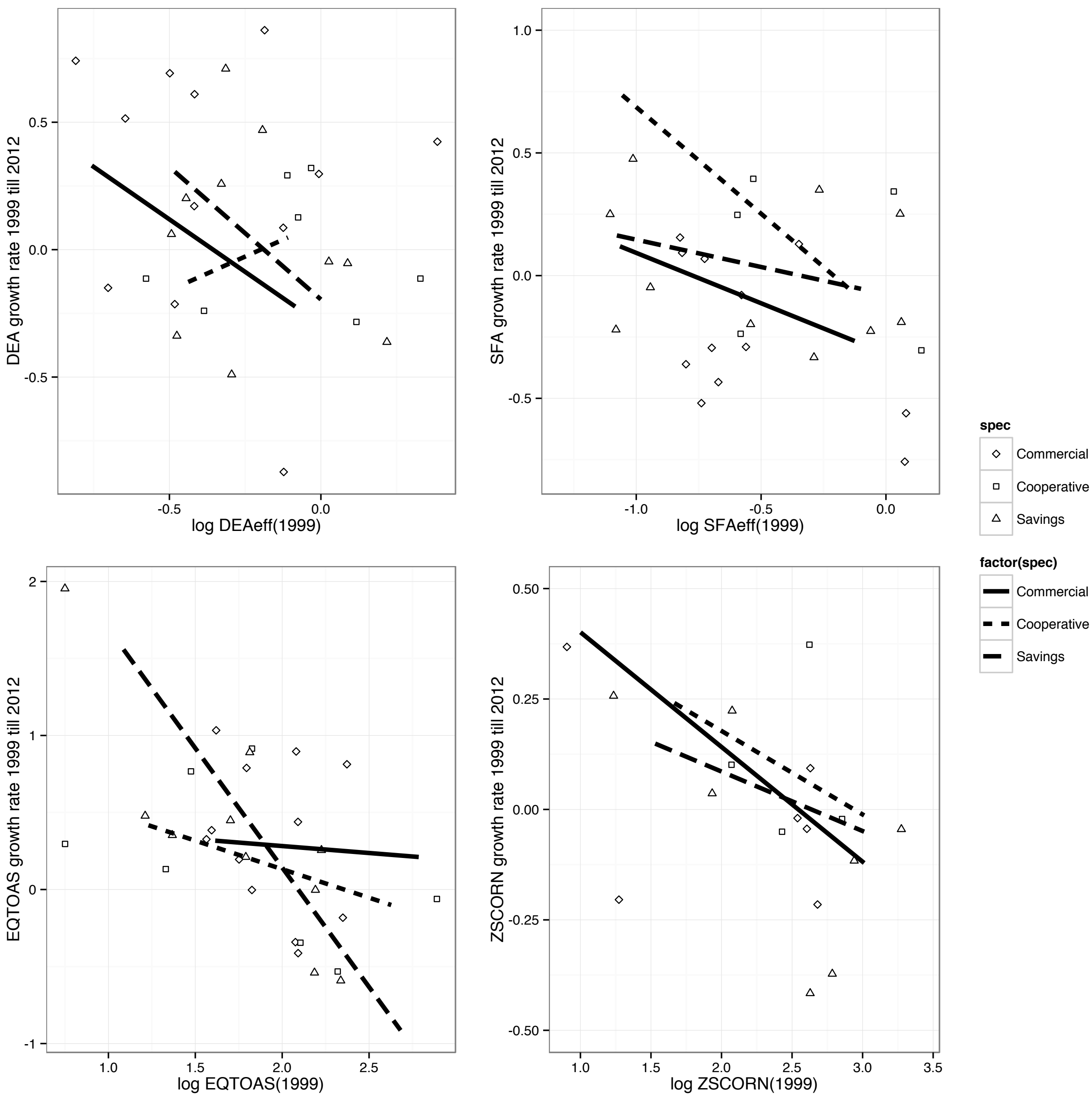

Figure 3 Convergence of efficiency and risk levels across Eurozone financial markets: Average efficiency and risk measures from 1999 to 2012 A negative trend is an indication that countries with a low initial levels of efficiency or risk have high corresponding growth rates, ergo converge, and vice versa. Such a trend is widely considered a first indicator of convergence. (Compare, e.g. Casu & Girardone (2010)).

in the SFA model; hence, for the other models, the results of the FE and OLS are decisive. Both sub-periods show beta and sigma convergence, the absolute value of the sigma coefficient is generally higher in 2007-2012, which indicates a slightly faster speed of adjustment compared to 1999-2006. It remains unclear, whether it was the increased competitive pressure or the change in regulation and supervision that lead to efficiency convergence of commercial banks in that time. The results for commercial banks are moreover in line with the existing literature on the convergence of bank efficiency in Europe (Weill, 2009; Casu & Girardone, 2010), though it should be pointed out that the samples and time frames of those studies are not identical to the ones applied in this research.[11]

As far as savings banks are concerned, the GMM provide valid results for 1999-2012 in both DEA and SFA models; for the sub-periods, the results of the FE and OLS models are considered. No sign of either beta nor sigma convergence is evident for banks of this specialization as the OLS does not confirm the results of the FE. A lack of convergence in efficiency can be attributed to a lack of a common market for these banks and that the Single Banking Market is not yet realized for apparently nationally fragmented savings banks.

When considering at the results of the cooperative banks, no valid GMM could be established and the results of the FE and OLS are therefore decisive. Interestingly, the DEA and SFA lead to diverging results. An explanation for this effect could be found in the model parameters of the two frontier models with the DEA resulting in overall efficiency and SFA in cost related efficiency. Despite the promising results of the SFA in favor of convergence for the entire period as well as the two sub-periods, the null hypothesis of no efficiency convergence could not be rejected. Overall, the FE in the DEA model hints in several cases of savings and cooperative banks in favor of convergence, however, the lack of significance in either the OLS or the FE/OLS in the SFA model does not allow for a clear statement of efficiency convergence confirmed by both DEA and SFA. More research should therefore target efficiency convergence of Eurozone banks other than commercial banks.

As an indication of the pretense of the newly established Single Banking Market, cooperative banks showed signs of both beta and sigma convergence for the years 1999-2006. However, after the onset of the crisis, the speed of adjustment remains indeterminable, which is manifested in a lack

[11] Maghyereh & Awartani (2012) found significant convergence, for instance, in the case of Gulf Cooperation Council during the period 2003-2009, in which these countries underwent substantial reforms. Evidentially, reforms have a positive influence on convergence and harmonization of banking markets' efficiencies, whereas crises generally lead to divergence of the former. The author leaves the concrete proof of this statement open to further research as it goes beyond the scope of this research paper.

of sigma convergence for this specialization. One possible explanation for the existence of pre-2007 convergence, but absence of post-2007 convergence can be seen in the fact that some Eurozone countries experienced tremendous economic hardship and even had to bail out systemically relevant banks, whereas other countries also suffered form the crisis but to a much lesser degree. Also, there is a certain diverging adjustment speed of banks in the crisis period, when some institutions were trying to adapt to new circumstances while others were beginning to recover.

4.2. Risk convergence

Table 4 and 5 display the results of the risk convergence analysis. Again, convergence is assumed to take place if both beta and sigma coefficients are negative and significant; moreover, the same rules for the validity of the GMM and the FE and OLS regressions apply. The results of the commercial banks reveal that although EQTOAS shows convergence for the periods 1999-2012 and 1999-2006, none of these could be confirmed by the Z-score analysis since the parameters beta and sigma were not significant. Commercial banks are the only instance where the validity criteria for the GMM - that are AR(1) p-value below 5% and AR(1) and Hansen-Test p-value above 10% - are fulfilled for the period 1999-2006, though the GMM confirms a lack of beta convergence for this period.

As far as savings banks are concerned, both risk metrics, EQTOAS and ZSCORN, find convergence for the period 1999-2012; the analyses of the sub-period give, however, mixed results with the EQTOAS favoring convergence in the years 1999-2007 and ZSCORN in 2007-2012. The analysis of cooperative banks reveals beta and sigma convergence for the years from 2007 to 2012, though EQTOAS displays convergence for all periods in the FE and OLS models, which could however not be confirmed by the ZSCORN analysis. Overall, the GMM seems to perform poorly for the risk analysis, where it provides valid results only in one case.[12] The FE and OLS of the EQTOAS generally yield more instances of convergence than the ZSCORN. Hence, beta and sigma convergence for risk - considering both metrics at the same time - is only evident for savings banks during 1999-2012 and for cooperative banks during 2007-2012.

[12]The GMM model parameters, AR(1), AR(2), and the Hansen test statistic indicate a correct model specification of the test for convergence of commercial banks' Z-scores of form 1999-2006.

Table 2 Beta and sigma convergence of DEA efficiency scores using GMM, FE and OLS

	1999-2012			1999-2006			2007-2012		
	GMM	FE	OLS	GMM	FE	OLS	GMM	FE	OLS
Commercial Banks									
beta	-0.706***	-0.671***	-0.170***	-0.434	-0.888***	-0.148**	-1.023***	-0.876***	-0.223***
	(0.19)	(0.09)	(0.05)	(0.43)	(0.13)	(0.06)	(0.29)	(0.13)	(0.06)
constant	-0.363**	-0.352***	-0.079***	-0.236	-0.482***	-0.081**	-0.480**	-0.419***	-0.065*
	(0.13)	(0.05)	(0.03)	(0.26)	(0.07)	(0.04)	(0.19)	(0.07)	(0.04)
AR(1)	0.05			0.07			0.51		
AR(2)	0.11			0.06			0.29		
Hansen-Test	0.97			0.33			0.06		
R-sq between		0.03			0.04			0.40	
R-sq		0.30	0.08		0.42	0.06		0.50	0.17
sigma	-0.419**	-0.591***	-0.119***	-0.150	-0.789***	-0.091*	-0.187	-0.991***	-0.168***
	(0.18)	(0.08)	(0.04)	(0.26)	(0.13)	(0.05)	(0.36)	(0.12)	(0.05)
constant	-0.469*	-0.667***	-0.130***	-0.173	-0.898***	-0.103*	-0.180	-1.104***	-0.167***
	(0.22)	(0.09)	(0.04)	(0.30)	(0.14)	(0.06)	(0.42)	(0.14)	(0.06)
AR(1)	0.06			0.07			0.06		
AR(2)	0.18			0.17			0.58		
Hansen-Test	0.97			0.33			0.11		
R-sq between		0.03			0.04			0.40	
R-sq		0.29	0.06		0.36	0.03		0.59	0.16
	⇒GMM: beta and sigma convergence			⇒FE+OLS: beta and sigma convergence			⇒FE+OLS: beta and sigma convergence		
Savings Banks									
beta	-0.072	-0.324***	-0.059*	-0.179	-0.349***	0.001	-0.060	-1.138***	-0.111*
	(0.11)	(0.06)	(0.03)	(0.19)	(0.13)	(0.04)	(0.26)	(0.09)	(0.06)
constant	-0.010	-0.055***	-0.011	-0.018	-0.052**	0.002	0.003	-0.207***	-0.023*
	(0.02)	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)	(0.05)	(0.02)	(0.01)
AR(1)	0.10			0.06			0.10		
AR(2)	0.25			0.89			0.15		
Hansen-Test	1.00			0.87			0.26		
R-sq between		0.00			0.06			0.11	
R-sq		0.24	0.03		0.15	0.00		0.81	0.08
sigma	0.047	-0.340***	-0.045	-0.166	-0.309**	0.004	0.189	-1.160***	-0.080
	(0.11)	(0.06)	(0.03)	(0.24)	(0.13)	(0.04)	(0.21)	(0.10)	(0.05)
constant	0.053	-0.346***	-0.044	-0.158	-0.312**	0.009	0.193	-1.180***	-0.077
	(0.11)	(0.06)	(0.03)	(0.25)	(0.13)	(0.04)	(0.20)	(0.10)	(0.05)
AR(1)	0.05			0.10			0.14		
AR(2)	0.93			0.96			0.52		
Hansen-Test	1.00			0.74			0.28		
R-sq between		0.04			0.04			0.07	
R-sq		0.26	0.02		0.12	0.00		0.79	0.05
	⇒GMM: no convergence			⇒GMM: no convergence			⇒FE+OLS no convergence		
Cooperative Banks									
beta	-0.241	-0.335***	-0.025	-0.375*	-0.547***	-0.053	-0.046	-0.481**	0.008
	(0.21)	(0.09)	(0.04)	(0.16)	(0.12)	(0.06)	(0.20)	(0.19)	(0.05)
constant	-0.081	-0.120***	-0.019	-0.119*	-0.188***	-0.030	-0.024	-0.171**	-0.010
	(0.06)	(0.03)	(0.01)	(0.06)	(0.04)	(0.02)	(0.05)	(0.06)	(0.02)
AR(1)	0.17			0.11			0.12		
AR(2)	0.04			0.08			0.82		
Hansen-Test	1.00			0.69			0.29		
R-sq between		0.10			0.29			0.07	
R-sq		0.14	0.00		0.30	0.01		0.18	0.00
sigma	-0.036	-0.243***	-0.005	-0.173	-0.403***	-0.010	0.133	-0.586***	0.009
	(0.20)	(0.08)	(0.03)	(0.15)	(0.12)	(0.05)	(0.21)	(0.17)	(0.05)
constant	-0.045	-0.266***	-0.014	-0.185	-0.431***	-0.017	0.118	-0.636***	-0.008
	(0.21)	(0.08)	(0.03)	(0.17)	(0.13)	(0.05)	(0.20)	(0.18)	(0.05)
AR(1)	0.06			0.08			0.08		
AR(2)	0.05			0.18			0.45		
Hansen-Test	0.99			0.57			0.15		
R-sq between		0.12			0.40			0.10	
R-sq		0.09	0.00		0.19	0.00		0.29	0.00
	⇒FE+OLS no convergence			⇒FE+OLS no convergence			⇒FE+OLS no convergence		

GMM:two-step system-GMM with Windmeijer (2005) corrected standard error. FE: fixed effect model; OLS: ordinary least squares.
AR(1) and AR(2) are tests for the first-order and second-order serial correlation in first differences. Hansen-Test: Sargan-Hansen test of overidentifying restrictions in the GMM estimators.
*, **, *** indicate significance at the 10%, 5%, 1% levels.

Table 3 Beta and sigma convergence of SFA efficiency scores using GMM, FE and OLS

	1999-2012			1999-2006			2007-2012		
	GMM	FE	OLS	GMM	FE	OLS	GMM	FE	OLS
Commercial Banks									
beta	-0.211***	-0.267***	-0.143***	-0.288**	0.019	0.018	-0.531*	-0.447***	-0.327***
	(0.03)	(0.05)	(0.04)	(0.11)	(0.09)	(0.06)	(0.28)	(0.07)	(0.05)
constant	-0.140***	-0.183***	-0.102***	-0.203***	-0.025	-0.026	-0.323	-0.286***	-0.201***
	(0.03)	(0.04)	(0.03)	(0.06)	(0.05)	(0.04)	(0.22)	(0.05)	(0.04)
AR(1)	0.02			0.06			0.26		
AR(2)	0.13			0.61			0.35		
Hansen-Test	0.97			0.34			0.46		
R-sq between		0.00			0.00			0.34	
R-sq		0.15	0.08		0.00	0.00		0.47	0.39
sigma	-0.250***	-0.274***	-0.139***	-0.347*	-0.005	0.011	-0.441	-0.448***	-0.326***
	(0.05)	(0.06)	(0.04)	(0.17)	(0.10)	(0.06)	(0.25)	(0.07)	(0.05)
constant	-0.290***	-0.331***	-0.170***	-0.421*	-0.026	-0.008	-0.483	-0.527***	-0.378***
	(0.06)	(0.07)	(0.05)	(0.20)	(0.11)	(0.08)	(0.31)	(0.08)	(0.07)
AR(1)	0.04			0.07			0.17		
AR(2)	0.10			0.59			0.25		
Hansen-Test	1.00			0.31			0.31		
R-sq between		0.00			0.00			0.34	
R-sq		0.14	0.07		0.00	0.00		0.49	0.40
	⇒GMM: convergence			⇒GMM: convergence			⇒FE+OLS convergence		
Savings Banks									
beta	-0.137	-0.688***	-0.086**	-0.275*	-1.501***	-0.101	0.127	-0.547***	-0.052
	(0.12)	(0.10)	(0.04)	(0.13)	(0.13)	(0.07)	(0.15)	(0.13)	(0.06)
constant	-0.055	-0.296***	-0.036	-0.092*	-0.658***	-0.043	0.041	-0.240***	-0.031
	(0.05)	(0.04)	(0.02)	(0.05)	(0.06)	(0.04)	(0.05)	(0.06)	(0.03)
AR(1)	0.10			0.33			0.30		
AR(2)	0.20			0.16			0.48		
Hansen-Test	0.99			0.85			0.62		
R-sq between		0.10			0.00			0.01	
R-sq		0.35	0.04		0.77	0.05		0.32	0.02
sigma	-0.077	-0.654***	-0.077*	-0.207*	-1.481***	-0.092	0.135	-0.517***	-0.043
	(0.12)	(0.10)	(0.04)	(0.09)	(0.14)	(0.06)	(0.17)	(0.13)	(0.06)
constant	-0.083	-0.727***	-0.085*	-0.220*	-1.647***	-0.095	0.150	-0.579***	-0.050
	(0.12)	(0.11)	(0.05)	(0.11)	(0.16)	(0.07)	(0.17)	(0.15)	(0.07)
AR(1)	0.08			0.27			0.28		
AR(2)	0.16			0.30			0.57		
Hansen-Test	0.99			0.56			0.33		
R-sq between		0.08			0.00			0.02	
R-sq		0.33	0.03		0.73	0.04		0.29	0.01
	⇒GMM: no convergence			⇒FE+OLS: no convergence			⇒FE+OLS: no convergence		
Cooperative Banks									
beta	-0.261***	-0.361***	-0.130***	-0.798**	-0.984***	-0.239***	-0.205***	-0.833***	-0.082*
	(0.06)	(0.08)	(0.04)	(0.31)	(0.16)	(0.09)	(0.05)	(0.17)	(0.05)
constant	-0.129*	-0.213***	-0.073*	-0.454	-0.561***	-0.152**	-0.076*	-0.542***	-0.012
	(0.06)	(0.06)	(0.04)	(0.25)	(0.09)	(0.07)	(0.04)	(0.13)	(0.05)
AR(1)	0.29			0.37			0.26		
AR(2)	0.24			0.83			0.19		
Hansen-Test	1.00			0.55			0.70		
R-sq between		0.34			0.02			0.22	
R-sq		0.17	0.08		0.46	0.12		0.44	0.08
sigma	-0.244***	-0.352***	-0.126***	-0.799**	-0.992***	-0.235***	-0.182***	-0.851***	-0.076*
	(0.05)	(0.08)	(0.04)	(0.34)	(0.16)	(0.09)	(0.05)	(0.17)	(0.04)
constant	-0.299***	-0.433***	-0.153**	-0.962*	-1.195***	-0.297**	-0.185***	-1.095***	-0.062
	(0.08)	(0.11)	(0.06)	(0.47)	(0.19)	(0.11)	(0.04)	(0.22)	(0.07)
AR(1)	0.30			0.38			0.26		
AR(2)	0.26			0.99			0.19		
Hansen-Test	0.99			0.55			0.54		
R-sq between		0.37			0.02			0.17	
R-sq		0.16	0.08		0.46	0.11		0.47	0.07
	⇒FE+OLS: convergence			⇒FE+OLS: convergence			⇒FE+OLS: convergence		

GMM:two-step system-GMM with Windmeijer (2005) corrected standard error. FE: fixed effect model; OLS: ordinary least squares.
AR(1) and AR(2) are tests for the first-order and second-order serial correlation in first differences. Hansen-Test: Sargan-Hansen test of overidentifying restrictions in the GMM estimators.
*, **, *** indicate significance at the 10%, 5%, 1% levels.

Table 4 Beta and sigma convergence of equity to total assets ratios using GMM, FE and OLS

	1999-2012			1999-2006			2007-2012		
	GMM	FE	OLS	GMM	FE	OLS	GMM	FE	OLS
Commercial Banks									
beta	-0.204	-0.715***	-0.239***	-0.061	-0.782***	-0.286***	-0.330	-0.997***	-0.113
	(0.22)	(0.08)	(0.06)	(0.41)	(0.12)	(0.07)	(0.26)	(0.17)	(0.09)
constant	0.466	1.604***	0.548***	0.137	1.758***	0.644***	0.742	2.235***	0.293
	(0.50)	(0.19)	(0.12)	(0.91)	(0.28)	(0.17)	(0.60)	(0.37)	(0.20)
AR(1)	0.04			0.08			0.13		
AR(2)	0.18			0.45			0.24		
Hansen-Test	0.97			0.43			0.36		
R-sq between		0.02			0.31			0.14	
R-sq		0.34	0.11		0.36	0.16		0.43	0.03
sigma	-0.364***	-0.572***	-0.528***	-0.207***	-0.622***	-0.578***	-1.506***	-0.792***	-0.544**
	(0.03)	(0.08)	(0.08)	(0.05)	(0.11)	(0.10)	(0.12)	(0.29)	(0.23)
constant	-2.981***	-4.562***	-4.223***	-1.631***	-4.984***	-4.626***	-11.439***	-6.266***	-4.479***
	(0.24)	(0.62)	(0.58)	(0.37)	(0.91)	(0.84)	(0.90)	(2.12)	(1.66)
AR(1)	0.05			0.06			0.02		
AR(2)	0.00			0.00			0.00		
Hansen-Test	0.94			0.29			0.04		
R-sq between		0.01			0.02			0.14	
R-sq		0.26	0.24		0.31	0.28		0.14	0.09
	⇒FE+OLS: convergence			⇒FE+OLS: convergence			⇒FE+OLS: no convergence		
Savings Banks									
beta	-0.252*	-0.264***	-0.231***	-0.105	0.012	-0.140*	-0.303*	-1.039***	-0.280***
	(0.12)	(0.07)	(0.04)	(0.12)	(0.14)	(0.08)	(0.14)	(0.13)	(0.06)
constant	0.543**	0.566***	0.503***	0.232	0.021	0.301**	0.695**	2.170***	0.650***
	(0.22)	(0.13)	(0.09)	(0.21)	(0.25)	(0.14)	(0.31)	(0.27)	(0.13)
AR(1)	0.09			0.29			0.47		
AR(2)	0.21			0.09			0.29		
Hansen-Test	0.99			0.80			0.62		
R-sq between		0.88			0.59			0.70	
R-sq		0.15	0.21		0.00	0.06		0.63	0.31
sigma	-0.424***	-0.345***	-0.266***	-0.372***	-0.462**	-0.403**	-0.570	-1.045***	-0.560***
	(0.08)	(0.09)	(0.07)	(0.06)	(0.18)	(0.15)	(0.44)	(0.09)	(0.09)
constant	-2.695***	-2.223***	-1.751***	-2.107***	-2.587***	-2.283***	-4.200	-7.353***	-4.116***
	(0.45)	(0.52)	(0.44)	(0.30)	(0.96)	(0.79)	(2.88)	(0.61)	(0.58)
AR(1)	0.01			0.01			0.56		
AR(2)	0.02			0.01			0.02		
Hansen-Test	0.98			0.72			0.12		
R-sq between		0.14			0.41			0.67	
R-sq		0.14	0.11		0.13	0.12		0.78	0.48
	⇒FE+OLS: convergence			⇒FE+OLS: no convergence			⇒FE+OLS: convergence		
Cooperative Banks									
beta	-0.319**	-0.341***	-0.119***	-0.251	-0.181*	-0.104***	-0.072	-0.925***	-0.195**
	(0.14)	(0.07)	(0.03)	(0.18)	(0.10)	(0.03)	(0.12)	(0.06)	(0.07)
constant	0.659*	0.725***	0.268***	0.533	0.382*	0.224***	0.172	1.976***	0.448***
	(0.29)	(0.15)	(0.07)	(0.37)	(0.21)	(0.07)	(0.25)	(0.13)	(0.16)
AR(1)	0.17			0.09			0.35		
AR(2)	0.32			0.42			0.16		
Hansen-Test	1.00			0.80			0.77		
R-sq between		0.25			0.40			0.03	
R-sq		0.19	0.12		0.06	0.14		0.88	0.16
sigma	-0.662***	-0.593***	-0.437***	-0.701***	-0.611***	-0.463***	-1.367***	-0.846***	-0.563***
	(0.04)	(0.08)	(0.07)	(0.05)	(0.12)	(0.11)	(0.25)	(0.11)	(0.10)
constant	-4.487***	-3.991***	-2.966***	-4.723***	-4.080***	-3.103***	-9.306***	-5.827***	-3.929***
	(0.37)	(0.56)	(0.50)	(0.41)	(0.82)	(0.71)	(1.66)	(0.74)	(0.70)
AR(1)	0.01			0.03			0.76		
AR(2)	0.01			0.01			0.02		
Hansen-Test	0.99			0.58			0.15		
R-sq between		0.03			0.00			0.07	
R-sq		0.34	0.25		0.34	0.25		0.66	0.44
	⇒FE+OLS: convergence			⇒FE+OLS: convergence			⇒FE+OLS: convergence		

GMM:two-step system-GMM with Windmeijer (2005) corrected standard error. FE: fixed effect model; OLS: ordinary least squares.
AR(1) and AR(2) are tests for the first-order and second-order serial correlation in first differences. Hansen-Test: Sargan-Hansen test of overidentifying restrictions in the GMM estimators.
*, **, *** indicate significance at the 10%, 5%, 1% levels.

Table 5 Beta and sigma convergence of Z-scores using GMM, FE and OLS

	1999-2012			1999-2006			2007-2012		
	GMM	FE	OLS	GMM	FE	OLS	GMM	FE	OLS
Commercial Banks									
beta	-0.395*	-0.586***	-0.049	-0.147	-0.727***	-0.070	-0.763**	-1.190***	-0.040
	(0.19)	(0.09)	(0.04)	(0.22)	(0.12)	(0.05)	(0.28)	(0.17)	(0.07)
constant	0.918*	1.412***	0.099	0.392	1.807***	0.182	1.731*	2.761***	0.002
	(0.49)	(0.21)	(0.10)	(0.52)	(0.29)	(0.13)	(0.82)	(0.41)	(0.17)
AR(1)	0.04			0.08			0.85		
AR(2)	0.36			0.30			0.05		
Hansen-Test	0.93			0.52			0.04		
R-sq between		0.55			0.33			0.21	
R-sq		0.27	0.01		0.36	0.02		0.60	0.01
sigma	-0.853***	-0.956***	-0.615***	-0.570***	-0.660***	-0.313***	-1.266***	-1.575***	-1.174***
	(0.07)	(0.10)	(0.09)	(0.09)	(0.11)	(0.09)	(0.05)	(0.09)	(0.13)
constant	-9.959***	-11.157***	-7.133***	-7.006***	-8.085***	-3.948***	-13.622***	-16.940***	-12.396***
	(0.74)	(1.22)	(1.09)	(1.09)	(1.35)	(1.02)	(0.66)	(1.08)	(1.51)
AR(1)	0.00			0.00			0.82		
AR(2)	0.04			0.86			0.00		
Hansen-Test	0.92			0.29			0.03		
R-sq between		0.62			0.47			0.35	
R-sq		0.41	0.25		0.33	0.14		0.90	0.65
	⇒FE+OLS: no convergence			⇒GMM: no convergence			⇒FE+OLS: no convergence		
Savings Banks									
beta	-0.456*	-0.806***	-0.135**	-0.597*	-0.628***	-0.186**	-0.618	-1.240***	-0.148
	(0.22)	(0.10)	(0.06)	(0.27)	(0.13)	(0.08)	(0.37)	(0.16)	(0.09)
constant	1.234*	2.223***	0.369**	1.696**	1.793***	0.559**	1.561	3.262***	0.323
	(0.60)	(0.28)	(0.16)	(0.73)	(0.37)	(0.24)	(0.97)	(0.42)	(0.24)
AR(1)	0.09			0.32			0.51		
AR(2)	0.73			0.48			0.09		
Hansen-Test	0.98			0.73			0.08		
R-sq between		0.42			0.02			0.01	
R-sq		0.43	0.05		0.35	0.09		0.71	0.07
sigma	-0.736***	-0.717***	-0.705***	-0.739***	-0.612***	-0.591***	-1.244***	-1.242***	-1.134***
	(0.04)	(0.11)	(0.11)	(0.02)	(0.12)	(0.12)	(0.12)	(0.10)	(0.10)
constant	-10.342***	-10.072***	-9.901***	-11.112***	-9.238***	-8.940***	-16.015***	-15.971***	-14.457***
	(0.57)	(1.64)	(1.55)	(0.33)	(1.81)	(1.71)	(1.75)	(1.38)	(1.42)
AR(1)	0.01			0.01			0.68		
AR(2)	0.06			0.01			0.00		
Hansen-Test	0.98			0.73			0.06		
R-sq between		0.32			0.27			0.00	
R-sq		0.32	0.31		0.37	0.34		0.86	0.78
	⇒FE+OLS: convergence			⇒FE+OLS: convergence			⇒FE+OLS: no convergence		
Cooperative Banks									
beta	-0.508*	-0.654***	-0.056	-0.208	-0.605***	-0.011	-1.254***	-1.064***	-0.122*
	(0.27)	(0.08)	(0.03)	(0.21)	(0.12)	(0.04)	(0.16)	(0.15)	(0.06)
constant	1.289	1.696***	0.145	0.582	1.576***	0.036	2.852***	2.708***	0.296*
	(0.71)	(0.22)	(0.09)	(0.59)	(0.31)	(0.12)	(0.69)	(0.39)	(0.16)
AR(1)	0.10			0.27			0.82		
AR(2)	0.48			0.48			0.09		
Hansen-Test	1.00			0.85			0.38		
R-sq between		0.05			0.46			0.13	
R-sq		0.40	0.03		0.34	0.00		0.68	0.12
sigma	-1.472***	-1.486***	-1.182***	-1.244***	-1.374***	-0.637***	-1.215***	-1.585***	-1.401***
	(0.05)	(0.09)	(0.10)	(0.13)	(0.13)	(0.13)	(0.07)	(0.06)	(0.11)
constant	-19.630***	-19.563***	-15.565***	-16.115***	-17.777***	-8.300***	-15.939***	-20.767***	-18.281***
	(0.60)	(1.18)	(1.32)	(1.63)	(1.72)	(1.71)	(1.22)	(0.89)	(1.52)
AR(1)	0.01			0.02			1.00		
AR(2)	0.04			0.72			0.03		
Hansen-Test	0.99			0.55			0.10		
R-sq between		0.64			0.40			0.00	
R-sq		0.75	0.59		0.69	0.29		0.96	0.84
	⇒FE+OLS: no convergence			⇒FE+OLS: no convergence			⇒FE+OLS: convergence		

GMM:two-step system-GMM with Windmeijer (2005) corrected standard error. FE: fixed effect model; OLS: ordinary least squares.
AR(1) and AR(2) are tests for the first-order and second-order serial correlation in first differences. Hansen-Test: Sargan-Hansen test of overidentifying restrictions in the GMM estimators.
*, **, *** indicate significance at the 10%, 5%, 1% levels.

5. Conclusions

One of the main motives for the creation of the Single Market Program (SMP) was to improve competitiveness of the Eurozone financial markets. In addition to the SMP, great macroeconomic impulses were expected from the introduction of the single currency, which are commonly believed to have been realized; however, unequal economic development lead to asynchronous shocks in the form of unemployment, labor productivity, GDP growth, but also financial shocks in form of the spreading of volatility via the equity market and the drying up of liquidity in the credit market. Efficiency and risk metrics are considered two quantitative determinants of financial institutions' competitiveness. In this paper, the focus is on variables related to efficiency – measured by DEA and SFA – and risk – measured by equity to total assets and Z-score. Special consideration was given to the three most prevalent types of banks with respect to total assets: commercial, savings, and cooperative banks.

The results show that commercial banks have been the prime beneficiaries of the SMP as can be seen by their increased efficiency levels - evidenced by both DEA and SFA metrics - and lowered risk, that is higher equity to total assets in 2012 compared to 1999. Moreover, commercial banks appear to have also benefited from both, efficiency and risk convergence, which is not surprising since commercial banks often operate more internationally and are exposed to higher competitive pressure than savings and cooperative banks. However, the period 2007-2012 shows no significant risk conversion, which can be seen as a sign of asynchronous development with respect to national capital requirement, unequal regulatory pressure to re-capitalize, but also unbalanced earnings or increased volatility of earnings. The reason for the lack of conversion in this period may be found in the fact that different Eurozone countries were hit by the Subprime crisis at different times.

As for savings and cooperative banks, efficiency convergence appears largely absent, which can be seen as a proof that there is limited pressure to operate on the same level of efficiency, though, the overall efficiency levels of banks of both specializations are higher than the levels of commercial banks. The pressure to operate on the same level of efficiency generally depends on competition and the threat of a takeover or increased market concentration through cost pressure. In order to remedy this situation, policy makers are to facilitate market entry, to open the border for cross-country expansions, and mergers and acquisitions. Therefore, the first step would involve to harmonize supervision and regulation on EU or Eurozone level with respect to these issues for both types of banks. Just as commercial banks, savings and cooperative banks are risk converging with respect to equity to total assets, however only limited convergence is found for Z-scores. The conversion of former would indicate that no additional capital regulation is needed to stimulate conversion of Eurozone banks; the lack of the latter shows that there are considerable differences between savings and cooperative banks when it comes to earnings' volatility and the Z-score. The contradictory development of Z-score convergence justifies a differentiated consideration of these banks in empirical studies; however, it is for now an important indicator that the Single Banking Market has not yet been fully realized in the Eurozone for all types of banks.

AppendixA. Model and parameter selection for DEA model

Efficiency scores are calculated using an input-oriented DEA approach, which is prevalent in the literature of banking efficiency. The input-oriented approach is equivalent to input-minimization. As banks are expected to operate in a highly competitive environment, they are assumed to be price-takers, implying the input-minimization approach. The alternative is output maximization which is valid for industries' outputs are not solely determined by market forces and can be controlled for, implying an output-maximization approach to production (Sealey & Lindley, 1977; Ferri et al., 1999). The variable returns to scale VRS approach developed by Banker et al. (1984) is used, which allows for the possibility that the production technology of banks in the sample may exhibit increasing, constant or decreasing returns to scale.

If the number of observed banks is limited, an overestimation of efficiency estimates is possible. This is, however, not an issue in this sample because the sample size is large enough to encompass all banks reporting to Bankscope data base. The question of how many of inputs and outputs in the DEA model should also be addressed here: A DEA model with a higher number of variables will have higher efficiency estimates than if less input and/or outputs are used. If more inputs and outputs are used, efficiency scores are generally higher. That is why only three inputs and three outputs are used. The inputs used consist of personnel expenses, fixed assets, and deposits; outputs consist of loans, other earning assets, and fee income. Table A.6 displays select descriptive statistics of the inputs and outputs for each bank specialization as well for all specializations combined combined.

It becomes apparent that commercial banks are on average twice as big compared to savings banks and 8 times as big compared to cooperative banks when taking total fixed assets as a proxy for size. Even more pronounced is the size advantage of the commercial banks over the other two specializations when comparing total deposits (approx. 14:2.7:0.8) or total fees (approx. 106:19:8.3).

Table A.6 Inputs and outputs used for DEA

		PersEx	FixedA	Deposits	Loans	OEA	Fees
Commercial	mean	132.05	80.52	14077.46	8302.63	9966.60	106.37
	p50	16.30	8.01	1284.10	710.60	540.70	14.90
	sd	492.26	271.99	59365.47	30470.09	53100.86	386.80
	min	0.10	0.01	1.50	0.20	0.90	0.07
	max	7107.00	3618.00	1168000.00	585200.00	1507000.00	5985.00
Savings	mean	33.46	42.13	2727.58	2041.64	1130.18	18.95
	p50	16.15	18.00	1104.60	743.30	425.25	7.60
	sd	76.46	128.61	7028.11	6759.34	2888.42	51.88
	min	0.30	0.05	1.53	1.34	1.12	0.08
	max	1996.40	3508.30	176000.00	198600.00	65567.30	1373.50
Cooperative	mean	11.41	10.99	882.95	649.62	439.77	8.33
	p50	4.20	4.60	224.50	172.90	89.70	1.90
	sd	32.04	26.88	4438.30	2400.89	4641.27	30.26
	min	0.20	0.03	7.20	0.30	0.50	0.10
	max	1092.80	618.30	198000.00	94038.70	232100.00	1000.70
Total	mean	35.31	29.36	3356.09	2164.33	2065.63	25.94
	p50	6.70	6.60	401.10	282.10	157.40	3.40
	sd	202.03	128.38	24148.08	12791.36	21366.52	158.85
	min	0.10	0.01	1.50	0.20	0.50	0.07
	max	7107.00	3618.00	1168000.00	585200.00	1507000.00	5985.00

PersEx, Personnel expenses; FixedA, Total fixed assets; Deposits,Deposits and short-term funding; Loans, Total loans; OEA, Total other earning assets; Fees, Fee-based income.
p50, median; min, minimum; max, maximum; *million EUR*

Despite these findings, commercial banks also comprise the overall smallest banks for any input or output. This is also reflected in the much lower median compared to the mean by roughly 10 times. Some commercial banks are clearly among the largest and possibly stock market listed banks in the Eurozone.

AppendixB. Model and parameter selection for SFA model

The SFA efficiency score are estimated using a two output (loans and securities) three input (wages, interest costs and other operating costs), translog cost function specification, following, among others, Altunbas et al. (2007):

$$
\begin{aligned}
\ln TC =& \alpha_0 + \tau_1 t + \frac{1}{2}\tau_1 t^2 + \sum_{i=1}^{2}(\alpha_i + \varphi_i t)\ln Q_i + \sum_{h=1}^{3}(\beta_h + \theta_h t)\ln P_h \\
& + \frac{1}{2}\left[\sum_{i=1}^{2}\sum_{j=1}^{2}\delta_{ij}\ln Q_i lnQ_j + \sum_{i=1}^{3}\sum_{j=1}^{3}\gamma_{ij}\ln P_h \ln P_m\right] \\
& + \sum_{i=1}^{2}\sum_{j=1}^{3}\rho_{im}\ln Q_i \ln Q_m + \varepsilon
\end{aligned}
\tag{B.1}
$$

where

- $\ln TC$ is the natural logarithm of total costs (operating and financial cost);
- $\ln Q_i$ the natural logarithm of bank outputs, total loans and total securties;
- $\ln P_h$ the logarithm of ith input prices (i.e. wage rate, interest cost and physical capital price).

The choice of the translog form was primarily motivate by identified problems associated with the Fourier functional form especially when dealing with heterogenous data sets (Altunbaş et al., 2001). The descriptive statistics for the inputs, outputs, and prices of the SFA model can be found in Table B.7. The size advantage of the commercial banks is here as well obvious.

Table B.7 Inputs, outputs, and prices used for SFA

		TC	Q1	Q2	P1	P2	P3
Commercial	mean	755.44	8302.63	5538.70	1.28E-05	0.0261	0.0250
	p50	75.90	710.60	141.40	1.07E-05	0.0222	0.0201
	sd	2896.84	30470.09	36920.75	1.29E-05	0.0196	0.0341
	min	0.80	0.20	0.06	3.54E-08	0.0000	0.0002
	max	50877.00	585200.00	1273165.00	2.72E-04	0.2610	1.1165
Savings	mean	137.26	2041.64	678.28	1.26E-05	0.0238	0.0214
	p50	58.80	743.30	314.90	1.25E-05	0.0242	0.0212
	sd	350.10	6759.34	1772.77	3.33E-06	0.0076	0.0055
	min	0.80	1.34	0.10	3.87E-08	0.0012	0.0001
	max	11726.40	198600.00	52350.30	9.93E-05	0.0881	0.1638
Cooperative	mean	46.65	649.62	244.92	1.45E-05	0.0210	0.0250
	p50	13.10	172.90	57.50	1.46E-05	0.0206	0.0248
	sd	212.51	2400.89	2298.01	3.73E-06	0.0072	0.0064
	min	0.50	0.30	0.06	3.89E-07	0.0011	0.0008
	max	10018.00	94038.70	125304.00	4.76E-05	0.0713	0.1038
Total	mean	177.39	2164.33	1160.75	1.38E-05	0.0225	0.0241
	p50	22.60	282.10	90.10	1.37E-05	0.0216	0.0233
	sd	1183.04	12791.36	14677.14	6.10E-06	0.0104	0.0146
	min	0.50	0.20	0.06	3.54E-08	0.0000	0.0001
	max	50877.00	585200.00	1273165.00	2.72E-04	0.2610	1.1165

TC, total costs; Q1, total loans ; Q2 total securities; P1, wage rate; P2 interest cost; P3, physical capital price.
p50, median; min, minimum; max, maximum; *million EUR*

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