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Financial crisis and bank efficiency: An empirical study of European banks

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ABSTRACT

This article uses the frontier technique to highlight the differences in the impact of the global financial crisis on the efficiency of 783 commercial banks from the EU during the period 2004–2010. We emphasise the distinctions between large and small banks, publicly traded and privately held banks, as well as the statuses of banks' country of origin, especially for the year in which they joined the EU and held eurozone membership. Our results show that the crisis has a significant and positive impact on both the cost and profit inefficiencies of the commercial banks from the EU, and that this impact is higher on eurozone banks. In terms of cost efficiency, the most affected by the crisis are the large publicly traded banks, operating in old members of the EU. With regard to the profit inefficiency, the global financial crisis seems to have had a lower impact on the large public banks.

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1. Introduction

The crisis of 2008–2010, or the global financial crisis, is commonly viewed as the worst financial crisis since the Great Depression. Its unprecedented global reach and importance for the world economy is reflected by the large number of banks and financial institutions that collapsed, were bailed out or faced major restructurings in its aftermath.

The global financial crisis had a significant impact on the performance of financial institutions and the competition within the financial systems. This brought back, both on the policy agenda and in the academic literature, the discussion of the sensitive relationship between macroeconomics and the commercial banks' performance, which are seen as the most important financial institutions for the local economies. Existing studies on describing the relation between the business cycle and bank performance (Albertazzi & Gambacorta, 2009; Athanasoglou, Brissimis, & Delis, 2008; Bolt, de Haan, Hoeberichts, van Oordt, & Swank, 2010) were followed by new evidence on the determinants of bank performance during the financial crisis (Beltratti & Stulz, 2012; Berger & Bouwman, 2011; Dietrich & Wanzenried, 2011). Moreover, in some regions, such as the EU, the deepening of the crisis and continuing banking fragilities, requiring state support arrangements, created the need for a reassessment of the banking systems performance (Efthyvoulou & Yildirim, 2014).

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Research on the performance of financial institutions focus especially on the *frontier efficiency*, a concept measuring the performance deviations of some companies from the efficiency frontier already built based on best practices. The frontier efficiency measures how efficient the financial institution is compared to the most efficient institution on the market (Andrieş & Cocriş, 2010). The frontier quantifies the cost efficiency of financial institutions with a greater precision than financial rates (DeYoung, 1997). The information obtained can be used to guide the government policy by assessing the effects of deregulation, mergers, or market structure on efficiency, and to improve managerial performance by identifying best practices and worst practices associated with high and low measured efficiency (Berger & Humphrey, 1997). For banks, efficiency implies improved profitability, greater amount of funds channelled in, better prices and services quality for consumers and greater safety in terms of improved capital buffer in absorbing risk (Berger, Hunter, & Timme, 1993). Previous studies (Humphrey & Pulley, 1997; Isik & Hassan, 2003b; Kumbhakar, Lozana-Vivas, Lovell, & Hasan, 2001; Leightner & Lovell, 1998) suggest that frontier techniques could be used to assess the impact of major economic events, such as economic crisis or financial liberalisation, on the performance of banking firms.

Information concerning the extent and trend towards efficiency plays an important role in the formulation of policies to enhance the performance of the banking industry. It is no surprise that the measurement of efficiency and performance of the banking firm has been of interest to academics, practitioners, and regulators. This field's literature consists mostly of studies on bank efficiency, with a large part focusing on the banking systems of the developed countries, especially the US and the EU. Only a limited number of studies analyse the efficiency of banks in developing and emerging countries, and even less are focused on the banks in Central and Eastern Europe. In papers pertaining to developed countries, attention has been centred on the analysis of the market structure or the deregulation of financial institutions, and their impact on efficiency. In studies concerning emerging countries, the focus has generally been on the analysis of the banking reforms, the privatisation of the state banks, the foreign direct investment in the banking industry, and the effects of public and regulatory policies on the efficiency of banking firms (Andrieş, Mehdian, & Stoica, 2013).

Despite its importance from both a policy and research perspective, only a few papers analyse the impact of the global financial crisis on the efficiency of the European banks. To the best of our knowledge, Isik and Hassan (2003a), Sufian (2010), Luo, Yao, Chen, and Wang (2011), Chortareas, Girardone, and Ventouri (2013) and Moradi-Motlagh and Babacan (2015) are the only authors who used the frontier technique while performing empirical research in order to examine the impact of the financial crisis on bank efficiency

This article contributes to the existing literature in several ways. First, we use a bank-level dataset consisting of 783 commercial banks from 27 member countries of the EU for the 2004–2010 period. Secondly, we explore a large set of bank features which allow us to draw important policy implications for the EU banking system. Thirdly, one of the main contributions of our article is the assessment of the impact of crisis on the banks' efficiency scores. Using the interaction of all the bank characteristics with a crisis dummy allow us to find different influences of several variables on the banks' efficiency in stress periods in comparison with the tranquil ones. The results are useful for policymakers when designing a proper institutional framework.

The structure of the rest of the article is as follows. Section 2 describes the methodology and data used to investigate the impact of crisis on banks' performance across EU countries. Section 3 discusses the empirical results and Section 4 concludes.

2. Methodology and data used

We use the stochastic frontier approach (SFA) to generate cost and profit efficiencies for each bank along the sample during the analysed period. This is the common approach for the measurement of banking efficiency (Asaftei & Kumbhakar, 2008; Fries & Taci, 2005; Hasan & Marton, 2003; Weill, 2003; Yildirim & Philippatos, 2007). More specifically, we employ the model of Battese and Coelli (1995) that provides estimates of efficiency in a single-step, in which bank effects are directly influenced by a number of variables. This is assumed to be superior to a two-step procedure, in which the estimated efficiency scores, obtained from the stochastic frontier, are regressed, in a second stage, on a set of explanatory variables (see Coelli, Prasada Rao, O'Donnell, & Battese, 2005). This approach allows us to estimate a global frontier, while accounting for cross-country differences, and to obtain an unbiased systematic measure of efficiency across countries, based on the assumption that efficiency differences between banking industries are determined by country-specific characteristics. This specification allows us to control for general environmental factors by simultaneously estimating the parameters of the stochastic frontier and the inefficiency model.

Following Andrieș and Căpraru (2014), we estimate two sets of alternative models, one for cost efficiency, where we use the *Total Cost* (COST) as the dependent variable, and one for profit efficiency, where we use the *Profit before Taxes Adjusted* (PROF) as the dependent variable. Because some of banks in the sample exhibit losses, the dependent variable in the profit model (PROF) is rescaled to ensure that PROF>0 for all banks. Following previous studies (e.g., Berger & Mester, 1997; Kasman & Yildirim, 2006; Lozano-Vivas & Pasiouras, 2010; Maudos, Pastor, Perez, & Quesada, 2002; Vander Vennet, 2002), the dependent variable is adjusted as $PROF = PTPIT + |\min(PTPIT)| + 1$, where PTPIT represent *Pre-Tax Profit*, and $|\min(PTPIT)|$ is the minimum absolute value of PTPIT over all banks in the sample.

Using the multi-product translog specification, the cost function in the case of the Model on Cost Efficiency is given as in Andrieș and Căpraru (2014), as follows:

where *i* and *t* denote bank and time, respectively.

$$
\begin{aligned}
\ln\frac{COST_{it}}{W_{3it}} = {} & b_0 + b_1 \ln\frac{W_{1it}}{W_{3it}} + b_2 \ln\frac{W_{2it}}{W_{3it}} + b_3 \ln(Q_{1it}) + b_4 \ln(Q_{2it}) + b_5 \ln(Q_{3it}) + b_6 \ln(Q_{4it}) + \\
& + b_7 \frac{1}{2}(\ln(Q_{1it}))^2 + b_8 \frac{1}{2}(\ln(Q_{2it}))^2 + b_9 \frac{1}{2}(\ln(Q_{3it}))^2 + b_{10} \frac{1}{2}(\ln(Q_{4it}))^2 + \\
& + b_{11} \ln(Q_{1it}) \ln(Q_{2it}) + b_{12} \ln(Q_{1it}) \ln(Q_{3it}) + b_{13} \ln(Q_{1it}) \ln(Q_{4it}) + \\
& + b_{14} \ln(Q_{2it}) \ln(Q_{3it}) + b_{15} \ln(Q_{2it}) \ln(Q_{4it}) + b_{16} \ln(Q_{3it}) \ln(Q_{4it}) + \\
& + b_{17} \frac{1}{2}(\ln(\frac{W_{1it}}{W_{3it}}))^2 + b_{18} \frac{1}{2}(\ln(\frac{W_{2it}}{W_{3it}}))^2 + b_{19} \ln(\frac{W_{1it}}{W_{3it}}) \ln(\frac{W_{2it}}{W_{3it}}) + \\
& + b_{20} \ln(\frac{W_{1it}}{W_{3it}}) \ln(Q_{1it}) + b_{21} \ln(\frac{W_{1it}}{W_{3it}}) \ln(Q_{2it}) + b_{22} \ln(\frac{W_{1it}}{W_{3it}}) \ln(Q_{3it}) + b_{23} \ln(\frac{W_{1it}}{W_{3it}}) \ln(Q_{4it}) + \\
& + b_{24} \ln(\frac{W_{2it}}{W_{3it}}) \ln(Q_{1it}) + b_{25} \ln(\frac{W_{2it}}{W_{3it}}) \ln(Q_{2it}) + b_{26} \ln(\frac{W_{2it}}{W_{3it}}) \ln(Q_{3it}) + b_{27} \ln(\frac{W_{2it}}{W_{3it}}) \ln(Q_{4it}) + \\
& + b_{28} \frac{1}{2} T_t^2 + b_{29} \ln(\frac{W_{1it}}{W_{3it}}) T_t + b_{30} \ln(\frac{W_{2it}}{W_{3it}}) T_t + \\
& + b_{31} \ln(Q_{1it}) T_t + b_{32} \ln(Q_{2it}) T_t + b_{33} \ln(Q_{3it}) T_t + b_{34} \ln(Q_{4it}) T_t + \\
& + b_{35} \ln(Eq\_Ta_{it}) + b_{36} \ln(\frac{W_{1it}}{W_{3it}}) \ln(Eq\_Ta_{it}) + b_{37} \ln(\frac{W_{2it}}{W_{3it}}) \ln(Eq\_Ta_{it}) + b_{38} \ln(Q_{1it}) \ln(Eq\_Ta_{it}) + \\
& + b_{39} \ln(Q_{2it}) \ln(Eq\_Ta_{it}) + b_{40} \ln(Q_{3it}) \ln(Eq\_Tait) + b_{41} \ln(Q_{4it}) \ln(Eq\_Ta_{it}) + \\
& + b_{42} \ln(Eq\_Ta_{it}) T_t + v_{it} + u_{it}
\end{aligned}
\tag{1}
$$

We assume that banks have four outputs, namely *Loans* (Q1), *Loans and Advances to Banks* (Q2), *Other Securities* (Q4) and *Off-Balance Sheet Items* (Q4). In both models, we consider that a bank uses three inputs to produce outputs. Inputs used in our article are *Fixed assets* (X1), *Labour* (X2) and *Total Borrowed Funds* (X3). In all models, we use three input prices: *Cost of Physical Capital* (W1), calculated by dividing overhead expenses, other than personnel expenses, by the book value of fixed assets; *Cost of Labour* (W2), calculated by dividing the personnel expenses by total assets; and *Cost of Funds* (W3), calculated as the ratio of *Total Interest Expenses* (TIE) to *Total Borrowed Funds* (Total Customer Deposits, Total Deposits from Banks, Other Interest Bearing Liabilities and Long Term Funding). In determining the output and input variables, we adopted the intermediation approach that treats bank deposits as an input. According to the intermediation approach, banks are considered intermediaries that transfer the financial resources from the agents with fund surplus to those with fund deficit. This intermediation approach is argued to be particularly appropriate for banks where most activities consist of turning large deposits and funds purchased from other financial institutions into loans or financing, and investments (Favero & Papi, 1995). To impose linear homogeneity restrictions, we normalise the dependent variable and all input prices by *the Cost of Funds* (W3). We include a time trend (T = Year – 2003) in each specification, to allow for technological change, using both linear and quadratic terms as in Lensink, Meesters, and Naaborg (2008) and Lozano-Vivas and Pasiouras (2010). Following Berger and Mester (1997), we specify *Equity to Total Assets* (EQ_TA) as a quasi-fixed input to control for differences in risk preferences.

The main focus of the article is to investigate the impact of the global financial crisis on bank efficiency. Therefore, we specify an empirical model in which the inefficiency variable, u_{it}, is the dependent variable, and we introduce a dummy variable for the financial crisis, as the independent variable, and several control variables that may also influence the bank's inefficiency. The Battese and Coelli model (1995) allows us to simultaneously estimate the parameters of the stochastic frontier and the country specific, banking system specific and bank-specific determinants of inefficiency in one step using maximum likelihood.

The inefficiency effects u_{it} from Eq. (1) are specified using the following alternative versions of the inefficiency equation (Models 2.1–2.6):

$$u_{it} = \delta_0 + \delta_1 GDP\_C_{jt} + \delta_2 INF_{jt} + \delta_3 FIN\_INT_{jt} + \delta_4 CR5_{jt} + \delta_5 TCR_{jt} + \varepsilon_{it} \quad (2.1)$$

$$u_{it} = \delta_0 + \delta_1 CRISIS_t + \delta_2 GDP\_C_{jt} + \delta_3 INF_{jt} + \delta_4 FIN\_INT_{jt} + \delta_5 CR5_{jt} + \delta_6 TCR_{it} + \varepsilon_{it} \quad (2.2)$$

$$u_{it} = \delta_0 + \delta_1 CRISIS_t + \delta_2 GDP\_C_{jt} + \delta_3 \mathrm{CRISIS}_t * \mathrm{EURO}_j + \delta_4 INF_{jt} + \\ + \delta_5 FIN\_INT_{jt} + \delta_6 CR5_{jt} + \delta_7 TCR_{it} + \varepsilon_{it} \quad (2.3)$$

$$u_{it} = \delta_0 + \delta_1 CRISIS_t + \delta_2 GDP\_C_{jt} + \delta_3 \mathrm{CRISIS}_t * \mathrm{PUBLIC}_i + \delta_4 INF_{jt} + \\ + \delta_5 FIN\_INT_{jt} + \delta_6 CR5_{jt} + \delta_7 TCR_{it} + \varepsilon_{it} \quad (2.4)$$

$$u_{it} = \delta_0 + \delta_1 CRISIS_t + \delta_2 GDP\_C_{jt} + \delta_3 \mathrm{CRISIS}_t * \mathrm{SIZE}_i + \delta_4 INF_{jt} + \\ + \delta_5 FIN\_INT_{jt} + \delta_6 CR5_{jt} + \delta_7 TCR_{it} + \varepsilon_{it} \quad (2.5)$$

$$u_{it} = \delta_0 + \delta_1 CRISIS_t + \delta_2 GDP\_C_{jt} + \delta_3 \text{CRISIS}_t * \text{MEMBER}_j + \delta_4 INF_{jt} + \\ + \delta_5 FIN\_INT_{jt} + \delta_6 CR5_{jt} + \delta_7 TCR_{it} + \varepsilon_{it} \quad (2.6)$$

where *i, j* and *t* denote bank, country and time, respectively.

In model 2.1 we estimate the level of bank inefficiency by controlling for a set of common explanatory variables. A positive coefficient implies an inefficiency increase, whereas a negative coefficient means an association with inefficiency decrease. In models 2.2–2.6 we include crisis as an explanatory variable. In these models, the variable *CRISIS* represents a dummy variable that has a value of 0 for the pre-crisis period (2004–2007) and a value of 1 for the crisis period (2008–2010). Models 2.3–2.6 analyse whether the relationship between financial crisis and inefficiency is conditional on the status of the country – member or not of the eurozone (EURO) and old or new members of the EU (MEMBER), the bank type – public or not (PUBLIC) and the size of the bank (SIZE). All four variables are dummy variables, with the variable SIZE having a value of 1 for large banks (with total assets in excess of 10 billion EUR) and a value of 0 for the other banks.

The financial structural differences between new and old members of the EU, as well as the strong ownership links of their credit institutions, have profound implications for the competition, efficiency, and financial stability and soundness of the new European financial system (Staikouras & Koutsomanoli-Fillipaki, 2006). Using model 2.6 we analyse whether banks operating in old member states were affected more by the global financial crisis than the banks from new member states. In addition, model 2.4 is designed to highlight any potential differences between the publicly traded and the non-listed banks in the EU, with regard to the impact of crisis. These prospective differences will also be useful when comparing the results of previous studies on the US banking system, which showed that the public banks have been more affected than the private banks (Berger, Imbierowicz, & Rauch, 2013).

In all six models we use three categories of variables to control for differences in bank inefficiency: macroeconomic variables, banking system specific variables and bank-specific variables. In line with the previous literature (Dietsch & Lozano-Vivas, 2000; Kasman & Yildirim, 2006; Maudos et al., 2002; Pasiouras, Tanna, & Zopounidis, 2009), we include the following macroeconomic variables in our model: *GDP* per capita – PPP current USD (GDP_C) to measure income differences, *Inflation rate* – change in the annual average consumer price level in per cent (INF) and *Level of financial intermediation* – domestic credit provided by banking sector percentage of GDP (FIN_INT). Following previous studies that focus on bank performance (Barth, Caprio, & Levine, 2004; Fries & Taci, 2005; Pasiouras, 2008), we control for cross-country differences in the national structure and competitive conditions of the banking sector, using the percentage share of the five largest banks, ranked according to assets, in the sum of the assets of all the banks in that banking system (CR5), and we use the Total Capital Ratio (TCR) to reflect bank capital adequacy.

The efficiency level of the individual bank would be calculated as $EFF_{it} \approx \exp(-u_{it})$. For the Profit Efficiency Model, we make two changes. In Eq. (1) we replace the COST variable by the PROF variable, whilst in Eq. (2), the sign of the inefficiency becomes negative ($-u_{it}$).

The data-set used in our research is composed of individual bank data of commercial banks operating in the member countries of the EU. The sample consists of an unbalanced data-set of 4803 observations, comprised of 783 commercial banks from 27 member states

of the EU for the 2004–2010 period. In the sample we included only active banks with information from at least five years (i.e., banks with missing, negative or zero values for inputs or outputs were excluded).

Descriptive statistics of the variables used in the cost and profit functions are presented in Table 1.

All bank-level data used are obtained from the BankScope database and are reported in euros, while data regarding banking systems characteristics and macroeconomic variables have been taken from World Bank and European Central Bank reports.

3. Results

3.1. Efficiency levels

First, we test for stationarity in panel data, using a unit root test for unbalanced panels. Based on the Fisher ADF and PP tests results, the null of non-stationarity hypothesis is rejected at the 10 % level for all variables.

Secondly, using models 2.1–2.6, we estimate the cost and profit efficiency levels for commercial banks from the EU. Table 2 presents the level of banks' efficiency for the entire sample and for different sub-samples. In panels A and B, we present the values of cost efficiency, and of profit efficiency, respectively.

Our findings show a significant decrease in 2009 in both levels of efficiency scores, cost and profit. As seen in Table 2, there is a wide range of values for cost and profit efficiency levels across groups of banks or countries. The average cost efficiency of the banks included in our sample is 0.9624. We observe significant differences between groups of banks. The result shows that, on average, the cost and profit efficiency scores at the level of large banks are significantly higher than the efficiency scores of medium and small banks. At the same time, the publicly traded banks are more efficient. The banks from the eurozone are more efficient in terms of profit efficiency, but less efficient in terms of cost efficiency. Also, the banks from old member states of the EU are more profit efficient than the banks from countries that are new members of the EU.

We use the nonparametric tests Wilcoxon/Mann-Whitney and van der Waerden to assess the statistical significance of the differences in the median level of efficiency scores, between the models that use and the models that do not use the crisis as an explanatory variable of inefficiency levels.

The results provided in Table 3 show that in both cases of cost and profit efficiency, the median scores obtained from models 2.2, which incorporate the crisis, are significantly different than those obtained from models 2.1.

3.2. Determinants of inefficiency

With respect to the inefficiency equations, we start the analysis by including three categories of variables to control for differences in bank inefficiency: macroeconomic variables, banking system specific variables and bank-specific variables. We used this set of variables in all our six models.

A country's development level, measured through the level of GDP per capita, has a negative and significant impact on banks' cost and profit inefficiency levels. Our results are in

Table 1. Descriptive statistics of variables used in our models.

Year	No Banks		COST	PROF	TR	W1	W2	W3	Q1	Q2	Q3	Q4	EQ_TA	TA
2004	516	Mean	4.994	13.929	993.14	9.290	0.016	0.026	3212.19	10526.21	4953.86	3837.22	11.88	21750.37
		St. Dev.	1.529	0.641	4548.64	22.951	0.019	0.036	15333.03	51125.31	24542.47	23864.54	12.42	103462.90
2005	689	Mean	5.049	13.871	1731.97	9.032	0.015	0.024	5225.99	18314.91	9932.68	6143.99	10.32	39573.70
		St. Dev.	1.524	1.202	6446.26	19.657	0.021	0.042	20936.01	69593.22	40889.35	33438.64	10.43	153513.90
2006	730	Mean	4.897	13.660	2230.20	10.721	0.016	0.028	5969.50	20856.07	12976.97	10521.07	10.33	47264.40
		St. Dev.	1.554	1.519	8352.71	32.773	0.027	0.033	23598.41	77285.27	60411.68	94569.20	11.09	183503.70
2007	731	Mean	4.747	13.473	2730.79	11.283	0.015	0.037	6386.69	24173.98	15179.73	10381.20	10.09	55397.41
		St. Dev.	1.460	1.520	10133.76	34.294	0.025	0.061	25736.45	91698.82	71350.80	53719.34	11.13	222852.70
2008	724	Mean	4.765	13.517	2690.27	11.184	0.015	0.042	5592.52	24966.04	12351.82	10444.33	9.60	60329.60
		St. Dev.	1.481	0.586	10097.94	27.231	0.025	0.063	18396.34	89504.04	57988.23	55229.19	10.71	248552.70
2009	742	Mean	5.236	13.655	2168.70	11.974	0.015	0.025	6289.73	24575.48	10944.59	9030.44	10.13	54022.77
		St. Dev.	1.790	2.371	7907.22	31.551	0.026	0.022	23138.63	89518.64	49509.85	50426.41	10.21	209,150.20
2010	671	Mean	5.625	14.419	2329.35	15.982	0.015	0.018	6852.01	27854.05	12878.13	10403.37	10.39	61976.92
		St. Dev.	1.934	1.515	8592.03	58.780	0.027	0.017	26338.64	97991.26	55909.47	51211.30	10.76	232492.50
ALL	4,803	Mean	5.041	13.773	2175.80	11.409	0.015	0.029	5746.05	22058.53	11591.55	8895.52	10.33	49726.84
		St. Dev.	1.644	1.517	8363.44	34.719	0.025	0.044	22463.97	83462.15	54410.96	56925.30	10.93	202299.80

Notes: COST=Total cost; PROF=Profit before taxes adjusted; TR=Total revenue/ Total assets; W1=Cost of physical capital; W2 = cost of labour; W3 = Cost of funds; X1 = Fixed assets; X2 = Personnel Expense; X3 = Total borrowed funds; Q1 = Loans and Advances to banks; Q2 = Loans; Q3 = Other Securities; Q4 = Off-Balance Sheet Items; Eq_ta = Equity/ Total Assets; TA=Total assets;.
Source: own calculations.

Table 2. Cost and Profit efficiency scores by groups of countries and type of banks.

		Non-Euro	Euro-zone	Large banks	Medium banks	Small banks	New members	Old Members	Non-public	Public	All
Panel A: COST EFFICIENCY											
2004	Mean	0.9624	0.9610	0.9835	0.9708	0.9483	0.9642	0.9607	0.9599	0.9690	0.9615
2005	Mean	0.9639	0.9631	0.9837	0.9690	0.9476	0.9628	0.9636	0.9616	0.9712	0.9634
2006	Mean	0.9635	0.9623	0.9830	0.9677	0.9450	0.9626	0.9627	0.9607	0.9712	0.9627
2007	Mean	0.9634	0.9618	0.9824	0.9665	0.9417	0.9628	0.9622	0.9603	0.9709	0.9623
2008	Mean	0.9639	0.9619	0.9818	0.9646	0.9430	0.9627	0.9625	0.9606	0.9707	0.9625
2009	Mean	0.9631	0.9599	0.9816	0.9657	0.9392	0.9616	0.9608	0.9588	0.9708	0.9610
2010	Mean	0.9641	0.9623	0.9814	0.9654	0.9422	0.9623	0.9631	0.9609	0.9712	0.9629
All	Mean	0.9635	0.9618	0.9823	0.9668	0.9440	0.9627	0.9623	0.9604	0.9708	0.9624
Panel B: PROFIT EFFICIENCY											
2004	Mean	0.5143	0.5437	0.6152	0.5610	0.4877	0.5070	0.5411	0.5344	0.5254	0.5327
2005	Mean	0.5289	0.5445	0.6345	0.5419	0.4859	0.5016	0.5489	0.5363	0.5514	0.5392
2006	Mean	0.5313	0.5446	0.6236	0.5519	0.4764	0.5043	0.5493	0.5367	0.5548	0.5402
2007	Mean	0.5297	0.5489	0.6161	0.5484	0.4784	0.5049	0.5518	0.5402	0.5521	0.5425
2008	Mean	0.5311	0.5475	0.6092	0.5411	0.4849	0.5027	0.5520	0.5406	0.5487	0.5421
2009	Mean	0.5286	0.5344	0.6053	0.5411	0.4650	0.4981	0.5413	0.5295	0.5455	0.5325
2010	Mean	0.5241	0.5433	0.6005	0.5341	0.4810	0.4973	0.5466	0.5341	0.5482	0.5369
All	Mean	0.5273	0.5438	0.6140	0.5449	0.4799	0.5022	0.5476	0.5360	0.5476	0.5382

Source: own calculations.

Table 3. Test of equality of medians between Model 1 and Model 2 for Cost and Profit Efficiency.

Test	Wilcoxon/Mann-Whitney	van der Waerden
Model 1 vs Model 2 for cost efficiency	3.437858***	13.28837***
Model 1 vs Model 2 for profit efficiency	44.48163***	1,595.631***

Source: own calculations.

line with previous studies (Mamatzakis, Staikouras, & Koutsomanoli-Filippaki, 2008; Weill, 2009) that showed that banks from developed countries are more efficient than banks from emerging markets. Contrary to Pasiouras (2008), our results show that a higher level of capitalisation and concentration determine a reduction of banks' inefficiency. Also, in line with Pasiouras et al. (2009) and Spulbăr and Niţoi (2014), our results reveal that the level of financial intermediation has a positive impact on banks inefficiency scores.

In Tables 4 (Panel A and Panel B) Models 2.2–2.6, we introduce a dummy for financial crisis as an explanatory variable. The results show that the financial crisis is always strongly statistically significant and that it has a positive impact on cost and profit inefficiency. This means that the financial crisis has a negative impact on banking efficiency. This is due to the fact that the economic crisis reduced the industry's business volume in European economies and affected the borrowers' ability to repay loans, forcing the banks to reduce costs and make provisions for credit losses.

To further explore if the impact of the crisis on cost and profit inefficiency scores depends on the banks and market's characteristics, we interact some explanatory variables with a crisis dummy. Table 4 (Panel A and Panel B) models 2.3–2.6 present the empirical results, including interaction terms between the determinants and the crisis period.

In Models 4, we include a separate variable measuring the interaction term of both CRISIS and the status of the country – member or non-member of the eurozone (EURO).

Table 4.

Panel A: Cost inefficiency estimation.

Dependent Variable – Cost inefficiency

Model	1	2	3	4	5	6
Constant	.1342***	.1005*	.0769	.0997*	.0865	.0805
	(.0474)	(.0530)	(.0574)	(.0531)	(.0564)	(.0573)
Crisis		.1248***	.0805**	.1226***	.1025***	.0820**
		(.0255)	(.0318)	(.0258)	(.0259)	(.0358)
Crisis*Euro			.0972***			
			(.0281)			
Crisis*Public				.0143		
				(.0295)		
Crisis*Size					.0924***	
					(.0353)	
Crisis*Member						.0969***
						(.0358)
GDP_C	-.0007***	-.0009***	-.0001***	-.00009***	-.0001***	-.0001***
	(.0001)	(.0001)	(.00001)	(.00,001)	(.00,001)	(.00001)
INF	-.0032*	-.0042*	-.0002*	-.0042	-.0031*	-.0020*
	(.0044)	(.0044)	(.0049)	(.0044)	(.0046)	(.0048)
FIN_INT	.0004*	.0003*	.0005**	.0003**	.0004*	.0003*
	(.0004)	(.0003)	(.0004)	(.0003)	(.0003)	(.0003)
CR5	-.0010**	-.0009**	-.0007*	-.0009*	-.0008	-.0004**
	(.0013)	(.0014)	(.0014)	(.0014)	(.0014)	(.0015)
TCR	-.0004*	-.0004**	-.0004*	-.0004*	-.0004*	-.0004**
	(.0006)	(.0007)	(.0008)	(.0007)	(.0008)	(.0008)

Panel B: Profit inefficiency estimation.

Dependent Variable – Profit inefficiency

Model	1	2	3	4	5	6
Constant	-.7563	-.7092	-1.0649	-1.1196	-.5784	1.7307**
	(.8103)	(.8106)	(.9694)	(.8015)	(.8033)	(.8188)
Crisis		.4611* (.2735)	.8755*	.7854***	.7704***	.71957***
			(.6430)	(.2675)	(.2723)	(.18089)
Crisis*Euro			2.2572***			
			(.6328)			
Crisis*Public				-3.5958**		
				(1.4015)		
Crisis*Size					-2.1402***	
					(.6783)	
Crisis*Member						8.4384***
						(1.5113)
GDP_C	-.0001***	-.00013***	-.00016***	-.00013***	-.00014***	-.00017***
	(.00001)	(.00001)	(.00001)	(.00001)	(.0001)	(.00001)
INF	-.1246*	-.1247*	-.0200	-.0946*	-.1037*	.0923
	(.1038)	(.1032)	(.1151)	(.0994)	(.1015)	(.1045)
FIN_INT	.0252***	.0242***	.0277**	.0254***	.0247 (.0092)	.01007*
	(.0094)	(.0092)	(.0113)	(.0093)		(.0055)
CR5	-.0970***	-.0988***	-.1006***	.0917***	-.0984***	-.0886***
	(.0267)	(.0269)	(.0282)	(.0260)	(.0264)	(.0273)
TCR	-.0669***	-.0681***	-.0630***	-.0628**	-.0622***	-.0588***
	(.0139)	(.0139)	(.0145)	(.0134)	(.0137)	(.0146)

Notes: CRISIS = represents a dummy variable that has a value of 0 for the pre-crisis period (2004–2007) and a value of 1 for the crisis period (2008–2010); EURO = represents a dummy variable that has a value of 1 for banks from member countries of the eurozone and 0 otherwise; MEMBER = represents a dummy variable that has a value of 1 for banks from old members of the EU and 0 otherwise; PUBLIC = represents a dummy variable that has a value of 1 for public listed banks and 0 otherwise; SIZE = represents a dummy variable that has a value of 1 for large banks (with total assets in excess of 10 billion EUR) and a value of 0 for the other banks; GDP_C = GDP per capita; INF = Inflation rate; FIN_INF = Level of the financial intermediation; CR5 = the percentage share of the five largest banks in the sum of the assets of all the banks in that banking system; TCR = Total Capital Ratio (TCR).

Source: own calculations.

The results show a significant positive sign for CRISIS, confirming the results found in Models 2 and, more importantly, the results show a positive and significant result for the interactive term CRISIS*EURO. We interpret this as supporting evidence for the idea that the positive impact of financial crisis on bank inefficiency is higher at the level of banks from member countries of the eurozone, countries that were more affected by the global financial crisis.

In line with Tsionas, Assaf, and Matousek (2015), our results for Model 5 Panel A show that the impact of crisis on cost inefficiency is higher in the case of large banks. This corresponds to the fact that the group of large banks was more severely hit by the global financial crisis. In case of the profit inefficiency, the interactive term CRISIS*SIZE has negative and significant coefficients, meaning that large banks were less affected by the crisis in terms of profit efficiency. Our results are similar to Beltratti and Stulz (2012) that showed that large banks performed better during the crisis.

Results for the interactive terms CRISIS*MEMBER are positive and significant for both types of efficiency. In line with Matousek, Rughoo, Sarantis, and Assaf (2015), this is evidence that the impact of the crisis on cost inefficiency is higher in case of the banks from 'old' members of the EU.

4. Conclusion

Using the frontier technique, this article presents new findings on the impact of the global financial crisis on banks' efficiency across the EU.

The originality of this study consists in assessing efficiency not only for the EU27 banking systems as a whole, but also for the old members' banking systems compared with the new members' banking systems, and for the banking systems of eurozone countries compared to the banking systems from non-members of the eurozone. Our analysis reveals the importance of the macroeconomic variables in explaining the efficiency differences among countries. Also, we filled the gap in the banking literature by providing evidence on the evolution of the banking efficiency in the EU during the most recent global crisis.

This article provides several important contributions to the ongoing empirical research on banking efficiency. First, the results show that the crisis has a significant and positive impact on the cost and profit inefficiency of banks from the EU. Secondly, this impact is higher on banks from member countries of the eurozone. In terms of cost efficiency, the most affected by crisis are banks that are publicly traded, large banks and banks from the old members of the EU. In the case of profit inefficiency, the publicly traded banks and large banks were less affected by the crisis.

Overall, policymakers in the EU countries can learn some lessons from the results of our study in order to promote efficiency, by enhancing their efforts to continue the reform of the financial services regulatory and supervisory framework. For a sustainable improvement of bank efficiency, the focus should be on the improvements of managerial practices, especially in the case of large banks. Policymakers should also be concerned with improving the capitalisation level.

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