The efficiency of European banking groups and its determinants

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1. Introduction

Over the last two decades, harmonization of financial services in the EU and increasing globalization and integration of financial markets emphasized the importance of cross-country bank competitiveness to influence the opportunity if future cross-border mergers and acquisitions. Further, the increasing competitive pressure and the consequences of the recent financial crisis have led banks to pay more attention on efficiency and productivity and to focus on their determinants.

This paper has two main objectives. First, it aims to measure and compare the relative efficiency of the most important European banking groups over the period 2005-2012 by employing a parametric approach (Stochastic Frontier Analysis – SFA). We want to analyse banking group efficiency pre- and post-crisis to determine the effects of the recent financial crisis on efficiency, so we consider the universe of banking groups of the five most industrialised European countries (Italy, France, Germany, Great Britain and Spain)[1]. Our analysis focuses also on scale economies in order to understand if groups are able to make the most of their size or, on the contrary, the high level of complexity reveals a problem of scale diseconomies. Unlike most literature that usually considers individual banks even if they belong to the same financial conglomerate, our units are banking groups. This methodological choice should reduce the distortions caused by intercompany accounting policies.

[1] In order to define the crisis period, see Bank of International Settlements (2010).

Second, the paper studies the internal and environmental determinants of banking groups efficiency through a regression model.

The present work aims to answer to several research questions: are European banking groups improving efficiency? Which country has the most competitive banking system and which one has recorded the most significant improvement over the last years? How did the financial crisis and the European integration of financial markets affect European banking groups efficiency? Are we witnessing an efficiency convergence in the analysed countries?

What are the determinants of bank efficiency? Are there differences in efficiency between small and large banking groups from the countries analysed?

This research advances the literature by analysing the efficiency of European banks in recent years in the context of financial crisis and cross-border aggregation movements, by focussing exclusively on banking groups and by comparing the cross-country performance of small and large groups. Unlike most literature on the topic, which usually considers banks as individual entities even if they belong to the same financial conglomerate, as said, our units are banking groups.

Our study of efficiency changes in the major European banking systems is valuable for several reasons. First, cross-country banking group competitiveness in integrated markets can influence future cross-border mergers and acquisitions and the future structure of the financial markets. Second, the evolution of bank efficiency can influence the economic conditions of each country and thus the decrease or increase in productive investment. Further, the growing competition and supply inelasticity mean that banks must pay more attention to cost rationalisation in order to improve performance. Policymakers also need to be aware of efficiency issues because they affect the financial system stability.

The paper is organized as follows: Section 2 reviews the literature while Section 3 outlines the methodology and Section 4 describes the data and variables used for the empirical analysis. Section 5 illustrates the empirical results. Section 6 concludes.

2. Literature review

Following early research on the measurement of efficiency and productivity of individual firms by Farrel (1957), who defined inefficiency as the distance of a firm from a frontier production function considered as a benchmark, the literature on efficiency and productivity at a micro level began to analyse banking systems only in the 1990s.

Over the years, many studies have concentrated on measuring the cost efficiency and productivity of banks from a single country, focusing on the sources of inefficiency and the role of both internal factors such as size, type, geographical location, ownership, risk, capital, financial structure, relationship lending, organisational structure, business model, and diversification, and environmental factors. Many authors focus on the efficiency trends in national banking systems worldwide, including: France (Jimborean and Brack, 2010), Germany (Koetter, 2008), Italy (Resti, 1997; Girardone et al., 2004), Spain (Pastor, 1999), the US (Berger and De Young, 1997; De Young, 1997; Berger and Mester, 1997; Barr et al. 2002; Akhigbe and McNulty, 2003; Elyasiani and Wang, 2012), Australia (Sathye, 2002), China (Wang et al., 2014) and Japan (Assaf et al., 2011).

Some studies dealing with bank efficiency focus on methodological issues, comparing estimates produced by parametric (Stochastic Frontier Analysis - SFA and Distribution Free Analysis - DFA) and non-parametric (Data Envelopment Analysis - DEA) approaches, with contradictory results (Allen and Rai, 1996; Berger and Mester, 1997; Bauer et al., 1998; Coelli et al., 1998; Beccalli et al., 2006).

Besides studies of banks in a single country, there are international comparisons of bank efficiency and productivity. Allen and Rai (1996), in comparing the cost structures of 15 countries between 1988 and 1992, find large differences between countries explained by national barriers. The process of consolidation of the European Union markets has led researchers to investigate the differences among the EU member states through the construction and the comparison of separate production frontiers (Beccalli, 2004; Bos and Schmiedel, 2007; Lozano-Vivas and Pastor, 2010) or through the construction of a common production frontier (Pastor, 2002; Casu and Molyneux, 2003; Girardone et al., 2009; Kenjegalieva et al, 2009; Delis and Papanikolaou, 2009; Girardone and Casu, 2010). Beyond the methodological differences, the bulk of these studies find a slow and incomplete harmonization among European financial systems, where the efficiency differences among the banks are largely explained by country-level characteristics (Dietsch and Lozano-Vivas, 2000; Barros et al., 2007).

Some studies empirically analyse the relationship between bank efficiency and shareholder value creation, focussing both on publicly listed and non-listed banks and typically providing evidence of a positive relationship between bank efficiency and stock market returns (Beccalli et al., 2006; Abuzayed et al., 2009; Fiordelisi and Molyneux, 2010).

The literature has also produced studies on the relationship between efficiency and risk management, assessing the link between efficiency and asset quality (Berger and De Young, 1997; Kwan and Eisembeis, 1997; Pastor, 1999; Altunbas et al., 2007), and the construction of efficiency scores adjusted for credit risk (Berg et al., 1992; Hughes and Mester, 1993; Hughes et al., 1996; Berger and De Young, 1997; Pastor, 2002), and analysing the influence of efficiency on bank default risk (Koutsomanoli-Filippaki and Mamatzakis, 2009; Fiordelisi et al., 2011).

This paper extends the literature by examining the efficiency of banking groups of the most industrialised European countries in recent years in the context of financial crisis and cross-border

aggregation movements, by focussing exclusively on banking groups and by comparing the cross-country performance of small and large groups. The efficiency analysis is integrated with a focus on scale economies in order to understand if banking groups are able to exploit the complexity of their business. Therefore, the paper analyses the determinants behind banking group efficiency.

3. Methodology

The methodology applied in this analysis is concerned with the concept of X-efficiencies and the construction of efficient frontiers. This technique is based on the comparison between the efficiency level of each unit and the efficient frontier (which represents the best practice) other things being equal (especially environmental variables). The profitability of each observed unit may depend both on the skills of the manager and on external factors; for this reason, we implement a model based on the measurement of X-efficiencies that is able to take into account many variables representing the microeconomic environment in which the firm operates. The measurement of X-efficiencies is a two-stage approach: first you must choose the model for evaluating the efficiency and second you must define a function for the frontier estimate. Regarding the first point we decided to use a parametric approach for two reasons: the high flexibility of the parametric model and the possibility to compare the results with some recent empirical studies[2]. The most important differences between the parametric and non-parametric approach are attributable to the following three factors: first, the non-parametric models do not allow the possibility of measurement errors; second, they do not consider that sometimes the performance may be influenced by random factors that have nothing to do with the strategies of the manager; lastly, the nonparametric models do not consider the possibility that the use of different accounting principles may cause deviations between the estimated values and the real

[2] For a detailed overview of the differences between the two approaches, see Berger and Humphrey 1997.

ones. Not being able to manage these "exogenous" factors, the non-parametric models conclude that any difference between the efficiency estimate for each unit and the efficiency estimate for the best practices firm is entirely attributed to inefficiency.

After the choice of a parametric model, the second stage deals with it the functional form of the production function an algebraic function that represents the technology with which the firm transforms inputs into outputs. Our study deals with cost efficiency where cost efficiency measures the difference between the cost of each firm and the cost of the best practice firm to produce the same output bundle under the same conditions.

The cost function model (in natural logs) is:

$$\ln TC_i = TC\left(Q_i, P_j, B\right) + \varepsilon_i$$

It is derived from a cost function where the observed total costs of production for bank i (TC_i) depend on the prices of variable inputs (P_j) for bank j, on the quantities of variable outputs (Q_i) for bank i, on any other variable parameter (*B*) such as, for example, environmental factors. The main charachteristic of the parametric approaches is ε_i a two-components error term that for the i-th firm can be written as:

$$\varepsilon_i = v_i + u_i$$

where v_i is a two-sided error term representing statistical noise which is assumed to be independently and identically distributed; and u_i is a non-negative (or one-sided) random variable representing inefficiency and assumed to be distributed independently of the v_i. It is also assumed that the v_i are normally distributed with mean zero and variance σ_v^2, and the u_i are the absolute values of a variable that is normally distributed with mean μ and variance σ_u^2. In our study we assume $\mu = 0$ so that the u_i are half-normal random variables that can vary with time.

With regard to the algebraic formulation of the cost function to use in the SFA model, the literature proposes various solutions that differ from each other for the flexibility (or the ability to

represent different production technologies) and for the ability to comply with certain properties[3]. They are the Cobb-Douglas, the Constant Elasticity of Substitution and the translog function (Transcendental Logarithmic). The first two functions are characterized by an excessive rigidity, while the third is more suitable since it allows variability in the elasticity of production and of substitution between the input and allows average cost curves in the form of a U. For these reasons - and the fact that it is widespread in the literature which inspired this work - we decided to represent the cost function with a translog. In our case the translog cost function takes the following form:

$$\ln TC = \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln Q_i + \sum_{j=1}^{n} \beta_j \ln P_j + \lambda_E \ln E + \frac{1}{2}\left[\sum_{i=1}^{m}\sum_{j=1}^{n} \delta_{ij} \ln Q_i \ln Q_j + \sum_{i=1}^{m}\sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \varphi_{EE} \ln E \ln E\right] + \sum_{i=1}^{m}\sum_{j=1}^{n} \rho_{ij} \ln Q_i \ln P_j + \sum_{j=1}^{n} \kappa_{jE} \ln P_j \ln E + \sum_{i=1}^{m} \varsigma_{iE} \ln Q_i \ln E + \tau_G \ln GDPCAP + \chi_M \ln MKCAP + \eta_P \ln PUBDEBT + \varepsilon_i$$

where TC is the total cost of production and α, β, λ, δ, γ, ρ, κ, ς, τ, χ and η are the parameters to be estimated. In order to have linear homogeneity in factor prices we impose: $\sum_{j=1}^{3} \beta_j = 1$ $\sum_{i=1}^{3} \gamma_{ij} = 0$ $\sum_{j=1}^{3} \rho_j = 0$ $\sum_{j=1}^{3} \kappa_j = 0$ while to have standard symmetry we assume: $\delta_{ij} = \delta_{ji}$ and $\gamma_{ij} = \gamma_{ji}$.

4. Data and variables

Because of the peculiar function of banking activity, there is no general agreement about the identification of inputs and outputs that have to be adopted in modelling the frontier. Two

[3] Coelli et al. (1998).

approaches are generally adopted in the literature: the production approach (Berger and Humphrey, 1997; Altunbas et al., 2001; Pastor, 2002) and the intermediation approach (Casu and Molyneaux, 2003; Beccalli et al., 2006; Assaf et al., 2011). The debate between the two approaches consists in the different concept of the bank transformation process. According to the production approach, banks use capital and labour to produce loans and deposits, which are thus considered an output. The intermediation approach, introduced by Sealey and Lindley (1977), treats banks as intermediators of financial services rather than producers of loans and deposits: banks collect deposits from customers and transform them, through labour and capital, into loans and investments for clients.

Even if the literature underlines that neither of this two approaches is perfect, because banks fulfil both producer and intermediary functions, we adopt the intermediation approach because it better captures the decisions to minimise the cost of financing mix (Berger and Humphrey, 1997).

According to the intermediation approach, we consider three main inputs such as human capital, financial capital and physical capital and three outputs[4] such as loans, financial assets and off-balance sheet items. We also include the equity capital E in order to account different preferences in term of risk taking[5]. Table 1 describes our input and output variables.

In order to ensure linear homogeneity in prices we normalize our data dividing TC, P1 and P2 by the price P3.

[4] We added 1 to each bank output in order to avoid taking the log of zero.
[5] Huges and Mester, 1993 and Mester 1996.

Tab. 1 – Inputs and outputs

TC = total cost of production	Financial costs (interests paid on deposits) and operating costs
Outputs:	
Q1 = loans	gross loans
Q2 = financial assets	total securities
Q3 = off-balance sheet items	off-balance sheet items
Inputs prices:	
P1 = human capital	Personnel expenses / total assets
P2 = financial capital	Interest expenses / total funds
P3 = physical capital	Depreciation and other expenses / fixed assets
K = equity capital	
Environmental variables:	
GDPCAP	Gross domestic product per capita
MKCAP	Market capitalization of listed companies
PUBDEBT	General government gross debt in % of GDP

The model comprises three environmental variables because we implement a single frontier for the whole panel so we need to control for specific microeconomic differences among countries[6].

For the same reason we deflated all the input and output variables taken from the banks' balance sheets.

After the estimation of efficiency for each unit of the sample and the estimation of the parameters, it is possible to evaluate scale economies. Scale economies represent the possibility to increase the output production with a less proportional increase in costs; the level of economies of scale is represented by the elasticity of total cost with respect to each output and it can be evaluated as follow:

$$SCALE = \sum_{i=1}^{m} \frac{\partial \ln TC}{\partial \ln Q_i}$$

In our analysis the sum of individual cost elasticites can be written as:

$$SCALE = \sum_{i=1}^{m} \alpha_i + \sum_{i=1}^{m}\sum_{j=1}^{n} \delta_{ij} \ln Q_j + \sum_{i=1}^{m}\sum_{j=1}^{n} \rho_{ij} \ln P_j + \sum_{i=1}^{m} \varsigma_{iE} \ln E$$

[6] Dietsch, Lozano-Vivas, (2000).

We can conclude that there are economies of scale if SCALE<1, diseconomies of scale if SCALE>1 and constant return to scale if SCALE=1.

After evaluating the efficiency level of each banking group and its degree of scale economies, we tested weather some strategic choices of the manager and the business model of the bank can influence the level of efficiency. The purpose of this analysis is to find what are the most important variables that have a positive or a negative impact on efficiency.

To analyse the determinants of bank efficiency this study takes into account five control variables which represent the bank business model, the level of liquidity, the capitalization and credit risk exposure. For each variable we implement either a univariate or a multivariate quintile analysis based on the following OLS regression:

$$SCLAE_{it} = \alpha_0 + \alpha_1 GLTA_{it} + \alpha_2 LATA_{it} + \alpha_3 EQTASS_{it} + \alpha_4 TIER1_{it} + \alpha_5 NLGL_{it} + \varepsilon_{it}$$

where $SCALE_{it}$ is the degree of scale economy for the bank group "I" at time "t". $GLTA_{it}$ is the ratio of gross loans over total assets which represents the aptitude of the bank "i" at time "t" to concentrate its core business on commercial banking activities instead of investment banking activities. $LATA_{it}$ is the ratio of liquid assets over total assets and characterizes the aptitude of the bank "i" with respect to liquidity risk at time "t". $EQTASS_{it}$ is the ratio of total equity over total assets which is also the inverse of the leverage of bank "i" at time "t". $TIER1_{it}$ is an indicator of capital strength referred to bank "i" at time "t". $NLGL_{it}$ is the ratio of net loans over gross loans and can be interpreted as a proxy of the credit risk of the bank "i" at time "t".

We complete the analysis of the efficiency determinants taking into account the squared terms and the lagged terms of these variables in order to test the existence of nonlinear relationships or long life relationships.

We collected data from the BvD Bankscope database. The sample consists of the universe of banking groups belonging to five European countries: Italy, United Kingdom, Germany, France and Spain. The observation period is from 2005 to 2012 and it comprises a pre-crisis sub-period and a post-crisis sub-period. The geographical composition of our sample is presented in table 2; it accounts for a total of 566 observations. France and Italy are the countries with the highest number of banking groups. Table 3 and 4 show the sample distribution in terms of size.

Tab. 2 – Composition of the sample. Number of groups.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Panel**
DE	4	6	7	6	6	7	7	6	**49**
ES	10	11	12	12	12	12	11	11	**91**
FR	16	21	21	23	23	35	35	35	**209**
GB	4	4	4	4	4	4	4	4	**32**
IT	21	22	22	23	23	24	25	25	**185**
Panel	**55**	**64**	**66**	**68**	**68**	**82**	**82**	**81**	**566**

Tab. 3 – Group size with respect to countries in terms of total assets. Millions of €.

	N	**mean**	**median**	**sd**	**min**	**max**
DE	49	437,000	5,537.58	660,000	210	2,200,000
ES	91	194,000	58,200	312,000	566.80	1,270,000
FR	209	139,000	11,600	408,000	650.10	2,080,000
GB	32	10,400	6,833.23	9,536.32	589.32	25,200
IT	185	98,300	17,900	218,000	74.20	1,050,000
Panel	**566**	**153,000**	**13,300**	**372,000**	**74.20**	**2,200,000**

With respect to the variables that are supposed to influence the efficiency level of banking groups table 5 illustrates some descriptive statistics

Tab. 4 – Distribution of groups in size classes. Thousands of €.

	N	mean	median	sd	min	max
quint1 *piccolissime*	117	1,909,953.91	1,656,000.00	1,422,340.77	74,200.00	5,696,500.00
quint2 *piccole*	113	7,723,514.08	7,780,200.00	2,151,788.31	2,538,000.00	11,477,900.00
quint3 *medie*	113	14,137,135.83	13,552,000.00	3,228,876.47	7,791,400.00	23,454,500.00
quint4 *grandi*	113	43,777,100.79	36,299,400.00	24,073,600.26	14,289,800.00	129,290,100.00
quint5 *grandissime*	110	717,639,152.73	612,406,500.00	563,879,585.81	77,697,700.00	2,202,423,000.00
Panel	**566**	**152,969,677.10**	**13,250,150.00**	**372,452,314.42**	**74,200.00**	**2,202,423,000.00**

Tab. 5 – Descriptive statistics of control variables

	N	Mean	Std. dev	Min	Max
GLTA	566	0.628	0.215	0.027	0.927
LATA	564	0.172	0.156	0.000	0.931
EQTASS	566	0.092	0.058	0.011	0.473
TIER1	356	10.930	6.588	4.600	54.900
NLGL	566	0.976	0.027	0.694	1.255

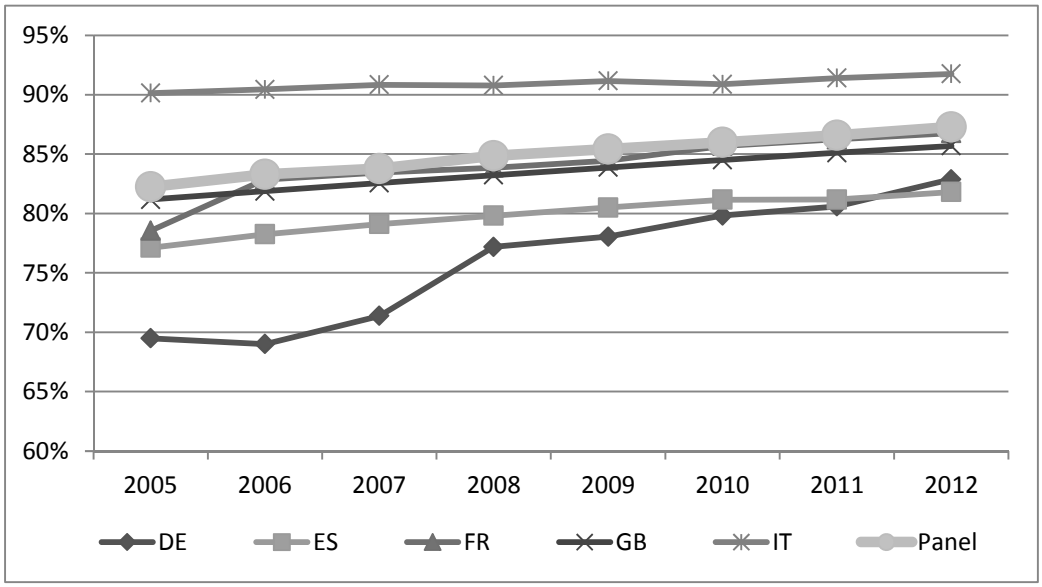
5. Empirical results

The analysis of banking groups efficiency reveals a huge difference among the groups belonging to different countries even if the indicator is always increasing (table 6). Italian banking groups show the highest results for the whole period while German groups account for the lowest scores (Figure 1). Although German groups seems less efficient, the indicator shows a quick increase so that in the second part of the observed period their efficiency is quite similar to Spanish groups. No structural break appear between the estimates of the pre and post crisis period, except for Germany.

Tab. 6 – Efficiency estimates for different countries

	2005	2006	2007	2008	2009	2010	2011	2012	Panel
DE	69.5%	69.0%	71.4%	77.2%	78.0%	79.8%	80.6%	82.9%	**76.4%**
ES	77.1%	78.3%	79.1%	79.8%	80.5%	81.2%	81.2%	81.8%	**79.9%**
FR	78.5%	82.8%	83.5%	83.9%	84.4%	85.7%	86.2%	86.8%	**84.6%**
GB	81.2%	81.9%	82.6%	83.2%	83.9%	84.5%	85.1%	85.7%	**83.5%**
IT	90.1%	90.4%	90.8%	90.8%	91.2%	90.9%	91.4%	91.8%	**91.0%**
Panel	**82.2%**	**83.3%**	**83.8%**	**84.9%**	**85.4%**	**86.0%**	**86.6%**	**87.3%**	**85.1%**

Fig. 1 – Efficiency estimates for different countries

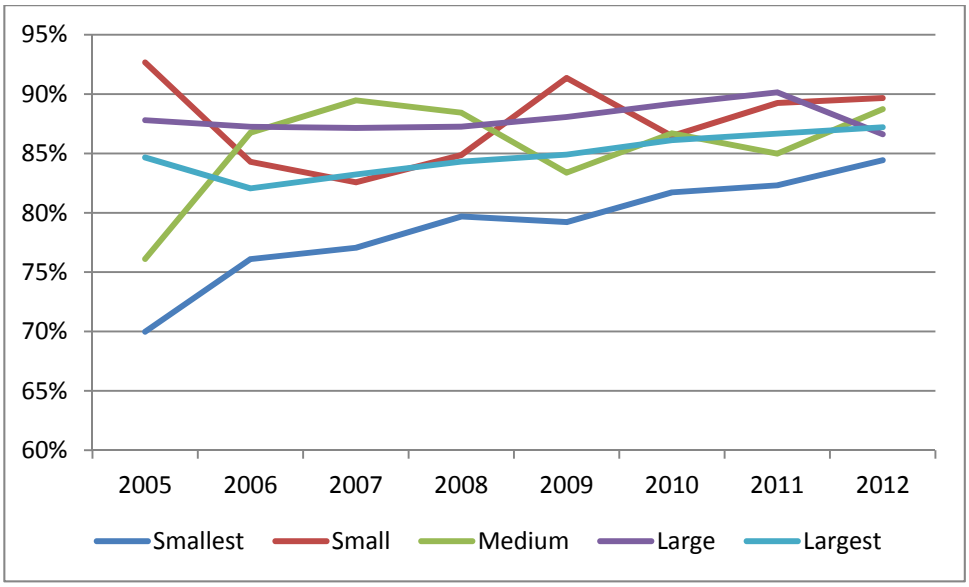


Further analysis was conducted with respect to the size of each unit. The groups were divided in quintiles in terms of total assets and the efficiency estimates are presented in table 7 and figure 2.

Tab. 7 – Efficiency with respect to size quintiles

	2005	2006	2007	2008	2009	2010	2011	2012	Panel
quint1	70.0%	76.1%	77.1%	79.7%	79.2%	81.7%	82.3%	84.4%	**79.4%**
quint2	92.7%	84.3%	82.6%	84.9%	91.4%	86.5%	89.2%	89.7%	**87.6%**
quint3	76.1%	86.8%	89.5%	88.4%	83.4%	86.7%	85.0%	88.7%	**85.8%**
quint4	87.8%	87.3%	87.1%	87.2%	88.1%	89.2%	90.2%	86.6%	**88.0%**
quint5	84.7%	82.1%	83.2%	84.3%	84.9%	86.1%	86.7%	87.2%	**85.1%**
Panel	**82.2%**	**83.3%**	**83.8%**	**84.9%**	**85.4%**	**86.0%**	**86.6%**	**87.3%**	**85.1%**

Fig. 2 – Efficiency scores by size quintiles



The first quintile represents the smallest banking groups while the fifth quintile accounts for the largest. The groups belonging to the first quintile reveal the lowest efficiency scores but their indicator grows faster than the others. Small and medium groups show high variability (with symmetric trends) while large and largest groups show a regular trend.

A second stage analysis was conducted to measure the extent of scale economies for banking groups on the basis of the coefficient estimates of the stochastic frontier. The results are shown in table 8.

Tab. 8 – Economies of scale

	2005	2006	2007	2008	2009	2010	2011	2012	Panel
DE	0.911	**0.953**	0.921	0.921	0.874	0.681	0.890	0.874	0.874
ES	**1.001**	**1.024**	1.047	**1.048**	**0.993**	**0.978**	**0.985**	**0.980**	**1.007**
FR	**0.993**	**1.008**	1.033	**1.050**	1.029	1.032	1.043	1.034	1.031
GB	0.828	0.853	0.829	0.847	0.771	0.753	0.753	0.749	0.798
IT	0.914	**0.949**	**0.984**	**1.033**	**0.999**	**0.931**	0.932	0.916	**0.957**
Panel	**0.946**	**0.976**	**0.995**	1.021	**0.984**	**0.951**	**0.974**	**0.964**	**0.976**

Values in bold are statistically significant at the 95% level.

As stated before, a value higher than one reveals that the group is characterized by diseconomies of scale; this means that an increase of the production output generates a more than proportional increase in the cost of production. For example for Spanish groups the score is 1.007 and this means that an increase of 1% in the output requests an increase of 1.007% in total costs.

The overall sample reveals the existence of positive returns to scale for the whole period (except for 2008) but the results are quite different if we analyze single countries. French groups are always characterized by diseconomies of scale for the entire period, Spanish groups show a similar result only for the first part of the observing period while in the post crises period thy show positive (and significant) scale economies. Also Italian groups show positive scale economies (except for 2008).

The trend of scale economies either for the entire sample or for single countries shows a structural break after 2008: in the pre-crisis period banking groups expand their activity so much that diseconomies of scale appear in some countries, while in the post crisis period the decrease of the overall banking activity reveals increasing returns to scale that groups can exploit.

The comparison of scale economies among size classes shows similar results (table 9).

Tab. 9 – Scale economies by size quintiles

	2005	2006	2007	2008	2009	2010	2011	2012	Panel
quint1	0.838	0.890	0.883	0.929	0.866	0.810	0.811	0.829	0.854
quint2	**0.949**	**0.955**	**0.977**	**1.008**	**1.011**	0.914	1.024	**0.990**	**0.979**
quint3	**0.933**	**0.986**	**1.023**	**1.047**	**0.989**	1.028	1.021	1.002	**1.006**
quint4	0.988	1.020	1.043	1.064	1.037	0.984	**0.993**	**0.991**	1.014
quint5	1.023	1.032	1.057	1.061	1.020	1.022	1.029	1.018	1.032
Panel	**0.946**	**0.976**	**0.995**	1.021	**0.984**	**0.951**	**0.974**	**0.964**	**0.976**

Values in bold are statistically significant at the 95% level.

Only the smallest groups always operate with positive scale economies, while largest ones show a persistent degree of diseconomies (even if both data are not statistically significant). This means

that small banks are not successful in exploiting all the opportunities on the contrary large banks enlarged their business too much.

5.1 Determinants of efficiency

Through this analysis we want to test if there are some banks specific characteristics that can impact on their level of efficiency in order to provide useful information for strategic choices.

In this paragraph we first provide a univariate analysis of the variables illustrated before and then we implement a multivariate regression that takes into account not only those variables but also their squared terms and their lagged terms so as to discover if there are non linear relationships or intertemporal relationships.

Tab. 10 – Determinants of efficiency

VARIABLES	(1) COSTEFF	(2) COSTEFF	(3) COSTEFF	(4) COSTEFF	(5) COSTEFF	(6) COSTEFF	VIF
GLTA	0.0384***					0.0526***	2.53
	(0.0137)					(0.0160)	
LATA		-0.0834***				-0.0656***	2.11
		(0.0119)				(0.0131)	
EQTASS			-0.103**			-0.145***	3.81
			(0.0406)			(0.0465)	
TIER1				0.000916**		0.00189***	4.12
				(0.000360)		(0.000361)	
NLGL					-0.179***	-0.167***	1.09
					(0.0309)	(0.0279)	
Constant	0.827***	0.866***	0.861***	0.839***	1.026***	0.985***	
	(0.00861)	(0.00214)	(0.00378)	(0.00402)	(0.0301)	(0.0310)	
Observations	566	564	566	356	566	354	
R-squared	0.016	0.093	0.013	0.021	0.065	0.291	
Number of INDEX	84	84	84	56	84	56	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
VIF values < 10 ensure no collinearity problem

Table 10 shows the results of the univariate and multivariate analysis taking into account only the strategic variables; all of them appear significant in both the models (univariate or multivariate). The impact of the business model based on traditional loans is positive meaning that traditional banks can achieve higher level of efficiency. The relationship between efficiency and liquidity is negative and it is due to the fact that a high level of liquid assets contributes to decrease liquidity risk but represents an opportunity cost for the bank. For the same reason also the relationship between efficiency and capitalization is negative since equity is another opportunity cost. On the contrary the level of TIER1 reveals a positive impact on efficiency and this is probably due to the fact that it is considered a protection against many kinds of risk. Eventually, the relationship between efficiency and loan quality is significant but negative: the sign is opposite as expected.

Tab. 11 – Efficiency: analysis of non linear relationships

	(1)	
VARIABLES	COSTEFF	s.e.
GLTA	0.245***	(0.0441)
LATA	-0.0745***	(0.0246)
EQTASS	-0.207**	(0.0895)
TIER1	0.00372***	(0.000645)
NLGL	-0.296	(0.274)
GLTAsq	-0.174***	(0.0362)
LATAsq	0.0234	(0.0390)
EQTASSsq	0.137	(0.179)
TIER1sq	-2.67e-05**	(1.13e-05)
NLGLsq	0.0901	(0.145)
Constant	0.970***	(0.131)
Observations	354	
Number of INDEX	56	
R-squared	0.385	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The analysis that takes into account the strategic variables and their squared terms shows that only the business model (GLTA) and the TIER1 indicator should have a significant non linear

relationship with the level of efficiency (table 11). With respect to long term relationships table 12 shows that the efficiency score depends only on two lagged variables: the previous value of efficiency and the previous value of the ratio of gross loans on total assets.

Tab. 12 – Efficiency: analysis of intertemporal relationships

	(1)	
VARIABLES	COSTEFF	s.e.
GLTA	0.000926*	(0.000476)
LATA	0.000956**	(0.000387)
EQTASS	0.00181	(0.00140)
TIER1	-3.29e-05***	(1.22e-05)
NLGL	0.00124	(0.000763)
L.COSTEFF	0.982***	(0.00162)
L.GLTA	-0.00172***	(0.000497)
L.LATA	-0.000529	(0.000383)
L.EQTASS	-0.000334	(0.00143)
L.TIER1	-6.49e-06	(1.17e-05)
L.NLGL	7.74e-05	(0.000797)
Constant	0.0205***	(0.00193)
Observations	296	
Number of INDEX	53	
R-squared	1.000	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Some strategic variables seem to have an impact also on scale economies. Table 13 show that scale economies are positively related to the (traditional) business model, to the presence of liquid assets, to the bank capitalization and to the (good) quality of the credit portfolio.

Tab. 13 – Determinants of scale economies

VARIABLES	(1) SCALE	(2) SCALE	(3) SCALE	(4) SCALE	(5) SCALE	(6) SCALE	VIF
GLTA	0.239***					0.194***	2.53
	(0.0616)					(0.0614)	
LATA		0.108*				0.206***	2.11
		(0.0571)				(0.0501)	
EQTASS			0.501***			0.772***	3.81
			(0.184)			(0.178)	
TIER1				-8.93e-06		-0.00125	4.12
				(0.00127)		(0.00138)	
NLGL					0.222	0.279***	1.09
					(0.145)	(0.107)	
Constant	0.826***	0.958***	0.930***	0.960***	0.760***	0.488***	
	(0.0388)	(0.0103)	(0.0172)	(0.0141)	(0.141)	(0.119)	
Observations	566	564	566	356	566	354	
R-squared	0.030	0.007	0.015	0.000	0.005	0.162	
Number of INDEX	84	84	84	56	84	56	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
VIF values < 10 ensure no collinearity problem

In order to test if the crisis caused some change in the strategic behavior of banking groups and in the importance of determinants variables on efficiency and scale economies we implemented a Chow test to see if the coefficients of the regressions on the two separated periods can be considered equal or not. If we can reject the null hypothesis that coefficients do not change in the two periods than we can conclude that the crisis event caused a change in the way those variables impact on efficiency.

Tables 14 (a, b, c, d and e) show that the relationship between efficiency and the strategic variables analyzed before has a structural break in the two sub-periods before and after the crisis. It is to be noticed that three variables, in particular, reveal an opposite sign; they are related to business model, capitalization and capital strength. With regard to business model we notice that in the pre-crisis period efficiency was positively related to the core traditional credit business

while in the post crisis period appear the contrary. This is probably due to the fact that a huge amount of loans became bad loans with a negative impact on profitability and efficiency. Also the capitalization variable changes its sign from positive, in the pre-crisis period, to negative in the subsequent period and it is probably due to the fact that in the last years equity capital became more expensive and increased its opportunity cost. On the other hand the relationship between efficiency and TIER1 shows the opposite path: it was negative in the pre-crisis period and positive after. The reason is that in the last years more attention is given to financial stability and capital strength, so banks with good (high) ratios are preferred.

Tab. 14.a – Crisis impact on business model (gross loans on total assets)

VARIABLES	**Overall COSTEFF**	**Pre-crisis COSTEFF**	**Post-crisis COSTEFF**
GLTA	0.0384***	0.0565***	-0.0185
	(0.0137)	(0.0168)	(0.0130)
Constant	0.827***	0.797***	0.873***
	(0.00861)	(0.0103)	(0.00826)
Observations	566	185	381
R-squared	0.016	0.087	0.007
Number of INDEX	84	66	83
Chow test: F(1,480)			184.32

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tab. 14.b – Crisis impact on liquidity (liquid assets on total assets)

VARIABLES	**Overall COSTEFF**	**Pre-crisis COSTEFF**	**Post-crisis COSTEFF**
LATA	-0.0834***	-0.0477**	-0.0131
	(0.0119)	(0.0199)	(0.0118)
Constant	0.866***	0.842***	0.863***
	(0.00214)	(0.00383)	(0.00200)
Observations	564	183	381
R-squared	0.093	0.047	0.004
Number of INDEX	84	66	83
Chow test: F(2,478)			206.77

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tab. 14.c – Crisis impact on capitalization (equity on total assets)

VARIABLES	**Overall COSTEFF**	**Pre-crisis COSTEFF**	**Post-crisis COSTEFF**
EQTASS	-0.103**	0.0657	-0.0604
	(0.0406)	(0.0409)	(0.0375)
Constant	0.861***	0.825***	0.866***
	(0.00378)	(0.00404)	(0.00337)
Observations	566	185	381
R-squared	0.013	0.021	0.009
Number of INDEX	84	66	83
Chow test: F(2,480)			93.00

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tab. 14.d – Crisis impact on capital strength (TIER1)

VARIABLES	**Overall COSTEFF**	**Pre-crisis COSTEFF**	**Post-crisis COSTEFF**
TIER1	0.000916**	-0.000137	0.00190***
	(0.000360)	(0.000586)	(0.000416)
Constant	0.839***	0.837***	0.834***
	(0.00402)	(0.00612)	(0.00470)
Observations	356	116	240
R-squared	0.021	0.001	0.102
Number of INDEX	56	43	55
Chow test: F(2,298)			120.00

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tab. 14.e – Crisis impact on credit quality (net loans on gross loans)

VARIABLES	**Overall COSTEFF**	**Pre-crisis COSTEFF**	**Post-crisis COSTEFF**
NLGL	-0.179***	-0.00270	-0.0854***
	(0.0309)	(0.0662)	(0.0228)
Constant	1.026***	0.834***	0.944***
	(0.0301)	(0.0649)	(0.0222)
Observations	566	185	381
R-squared	0.065	0.000	0.045
Number of INDEX	84	66	83
Chow test: F(1,480)			358.54

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. Concluding remarks

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References

Abuzayed, B., Molyneux, P. and Al-Fayoumi, N. (2009), "Market value, book value and earnings: is bank efficiency a missing link?", *Managerial Finance*, Vol. 35 No. 2, pp.156 -179

Akhigbe, A. and McNulty, J.E. (2003), "The Profit Efficiency of Small U.S. Banks", *Journal of Banking and Finance,* Vol. 27 No. 2, pp. 307-325.

Allen, L. and Rai, A. (1996),"Operational efficiency in banking: An international comparison", *Journal of Banking and Finance*, Vol. 20 No. 4, pp. 655–672.

Altunbas, Y., Carbo, S., Gardener, E.P.M. and Molyneux, P. (2007), "Examining the relationships between capital, risk and efficiency in European banking", *European Financial Management,* Vol. 13 No. 1, pp. 49-70.

Altunbas, Y., Gardener, E.P.M., Molyneux, P. and Moore, B. (2001), "Efficiency in European Banking", *European Economic Review,* Vol. 45 No. 10, pp. 1931-1955.

Assaf, A.G., Barros, C.P. and Matousek, R. (2011), "Productivity and efficiency analysis of Shinkin banks: Evidence from bootstrap and Bayesian approaches", *Journal of Banking and Finance*, Vol. 35 No. 2, pp. 331-342.

Bank of International Settlements (2010), "80th Annual Report 12", Basel.

Bank of Italy (2008), "Annual report for 2007", Rome.

Banker, R.D., Charnes, A. and Cooper, W.W. (1984),"Some models for estimating technical and scale inefficiencies in data envelopment analysis", *Management Science,* Vol. 30 No. 9, pp. 1078-1092.

Barr, R.S., Killgo, K.A., Siems, T.F. and Zimmel, S. (2002), "Evaluating the productive efficiency and performance of US commercial banks", *Managerial Finance*, Vol. 28 No. 8, pp. 3-25.

Barros, C. P., Ferreira, C., and Williams, J. (2007). “Analysing the determinants of performance of best and worst European banks: A mixed logit approach”, *Journal of Banking and Finance*, 31(7), 2189-2203.

Barth, J. R., Lin, C., Ma, Y., Seade, J., and Song, F. M. (2013), “Do bank regulation, supervision and monitoring enhance or impede bank efficiency?”, *Journal of Banking and Finance*, 37(8), 2879-2892.

Bauer, P.W., Berger, A.N, Ferrier, G.D. and Humphrey, D.B. (1998), “Consistency Conditions for Regulatory Analysis of Financial Institutions: A Comparison of Frontier Efficiency Methods”, *Journal of Economics and Business*, Vol. 50 No. 2, pp. 85-114.

Beccalli, E. (2004), “Cross-country comparisons of efficiency: Evidence from the UK and Italian investment firms”, *Journal of Banking and Finance,* Vol. 28 No. 6, pp. 1363-1383.

Beccalli, E., Casu, B. and Girardone, C. (2006), “Efficiency and Stock Performance in European Banking”, *Journal of Business, Finance and Accounting,* Vol. 33 No. 1-2, pp. 245-262.

Berg, S., Førsund, F. and Jansen, E. S. (1992), “Malmquist indices of productivity growth during the deregulation of Norwegian banking 1980-89”, *Scandinavian Journal of Economics,* 94, S211-S228.

Berger, A.N., and Mester, L.J. (1997), “Inside the black box: What explains differences in the efficiencies of financial institutions”, *Journal of Banking and Finance,* Vol. 21 No. 7, pp. 895–974.

Berger, A.N. and De Young, R. (1997), “Problem loans and cost efficiency in commercial banking”, *Journal of Banking and Finance,* Vol. 21 No. 6, pp. 849–870.

Berger, A.N. and Humphrey, D.B. (1997), “Efficiency of financial institutions: International survey and directions for future research”, *European Journal of Operational Research,*Vol.98 No. 2*,* pp. 175-212.

Casu, B., Girardone, C. and Molyneux, P. (2004), "Productivity change in European banking: A comparison of parametric and non-parametric approaches", *Journal of Banking and Finance,* Vol. 28 No. 10, pp. 2521-2540.

Casu, B. and Girardone, C. (2010), "Integration and efficiency convergence in Eu Banking Market", *Omega– The International Journal of Management Science,* Vol. 38 No. 5, pp. 260-267.

Casu, B. and Molyneaux, P. (2003), "A comparative study of efficiency in European banking", *Applied Economics,* Vol. 35 No. 17, pp. 1865-1876.

Casu, B., and Girardone, C. (2009), "Testing the relationship between competition and efficiency in banking: a panel data analysis", *Economics Letters*, Vol. 105 No. 1, pp. 134–137.

Caves, D. W., Christensen, L. R., Diewert, W. E., 1982. "Multilateral comparisons of output, input, and productivity using superlative index numbers". *Econometrica*, Vol. 50 No. 6, pp. 1393-1414.

Charnes, A., Cooper, W. W. and Rhodes, E. (1978), "Measuring the efficiency of decision making units", *European Journal of Operational Research,* Vol. 2 No. 6, pp. 429-444.

Coelli, T., Rao, D.S.P., Battese, G.E. (1998), "An introduction to efficiency and productivity analysis", Norwell, Kluwer Academic Publishers, Boston.

Debreu, G. (1951), "The coefficient of resource utilization", *Econometrica*, Vol. 19 No. 30, pp. 273-292.

Delis, M.D., Papanikolaou, N.I. (2009), "Determinants of bank efficiency: evidence from a semi-parametric methodology", *Managerial Finance*, Vol. 35 No. 3, pp.260 - 275

DeYoung, R. (1997), "Bank Mergers, X-Efficiency, and the Market for Corporate Control", *Managerial Finance*, Vol. 23 No.1, pp.32 - 47

Dietsch, M. and Lozano-Vivas, A. (2000), "How the environment determines the efficiency of banks: a comparison between French and Spanish banking industry", *Journal of Banking and Finance*, Vol. 24 No. 6, pp. 985-1004.

Drake, L., Hall, M.J.B. and Simper, R. (2006), "The impact of macroeconomic and regulatory factors on bank efficiency: A non-parametric analysis of Hong Kong's banking system", *Journal of Banking and Finance,* Vol. 30 No. 5, pp. 1443–1466.

Elyasiani, E. and Wang, Y. (2012), "Bank holding company diversification and production efficiency", *Applied Financial Economics*, Vol. 22 No. 17, pp. 1409-1428.

Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994), "Productivity Growth, Technical Progress and Efficiency Change in Industrialized Countries", *The American Economic Review*, Vol. 84 No.1, pp. 66-83.

Farrell, M.J. (1957), "The Measurement of Productive Efficiency", *Journal of the Royal Statistical Society,*Vol. 120 No. 3, pp. 253-290.

Fiordelisi, F. and Molyneux, P. (2010), "The determinants of shareholder value in European Banking", *Journal of Banking and Finance,* Vol. 34 No. 6, pp. 1189-1200.

Fiordelisi, F., Marques-Ibanez, D. and Molyneux, P. (2011), "Efficiency and risk in European banking", *Journal of Banking and Finance,* Vol. 35 No. 5, pp. 1315-1326.

Girardone, C., Molyneaux, P. and Gardener, E.P.M. (2004), "Analysing the determinants of bank efficiency: the case of Italian banks", *Applied Economics,* Vol. 36 No. 3, pp. 215-227.

Girardone, C., Nankervis, J.C. and Velentza, E. (2009), "Efficiency, ownership and financial structure in European banking: A cross-country comparison", *Managerial Finance,* Vol. 35 No. 3, pp. 227-245.

Goddard, J. A., Molyneux, P. and Wilson, J. O. S. (2001). "European Banking Efficiency, Technology and Growth", London, Wiley.

Gorton, G., and Huang, L. (2004), "Liquidity, Efficiency and Bank Bailouts", *The American Economic Review*, Vol. 94 No. 3, pp. 455-483.

Hughes, J. P. and Mester, L. (1993), “A quality and risk-adjusted cost function for banks: evidence on the 'too-big to-fail' doctrine”, *The Journal of Productivity Analysis,* Vol. 4 No. 3, pp. 293-315.

Hughes, J.P. and Mester, L.J. (1998), “Bank capitalization and cost: evidence of scale economies in risk management and signaling”, *The Review of Economics and Statistics,* Vol. 80 No. 2, pp. 314-325.

Hughes, J.P. and Moon, C. (1995), “Measuring bank efficiency when managers trade return for reduced risk”, Working paper 20/95, Department of Economics Rutgers University, New Jersey.

Hughes, J.P., L.J. Mester, and Moon C. (2001), “Are scale economies in banking elusive or illusive? Evidence obtained by incorporating capital structure and risk-taking into models of bank production”, *Journal of Banking and Finance,* Vol. 25 no. 12, pp. 2169–2208.

Hughes. J. P., Lang, W., Mester, L.J. and Moon, C. (1996), “Efficient banking under interstate branching”, *Journal of Money Credit and Banking,* Vol. 28 No. 4, pp. 1045-71.

Jimborean, R., Brack, E. (2010), “The cost-efficiency of French banks, *Bankers, Markets and Investors”,* MPRA Paper No. 23471, Ludwig Maximilians University, Munich.

Kenjegalieva, K. A., Simper, R., and Weyman-Jones, T. G. (2009), “Efficiency of transition banks: inter-country banking industry trends”, *Applied Financial Economics*, Vol. 19 No. 19, pp. 1531-1546.

Koetter M. (2008), “The stability of bank efficiency rankings when risk preferences and objectives are different”, *The European Journal of Finance,*Vol.14 No. 2, pp. 115-135.

Koutsomanoli-Filippaki, A., Mamatzakis, E. and Staikouras, C. (2009), “Structural reforms and banking efficiency in the new EU States”, *Journal of policy modeling,* Vol. 31 No.1, pp. 17-21.

Krishnasamy, G., Ridzwa, A. H., and Perumal, V. (2004), “Malaysian post merger banks’ productivity: application of Malmquist productivity index”, *Managerial Finance*, 30(4), 63-74.

Kwan, S. and Eisenbeis, R. (1997), “Bank risk, capitalization and operating efficiency”, *Journal of Financial Services Research,* Vol. 12 No. 2-3, pp. 117–131.

Malmquist, S., (1953). “Index numbers and indifference surfaces”. *Trabajos de Estadistica y de Investigacion Operativa*, Vol. 4 No. 2, pp. 209-242.

Mester, L.J. (1996), “A study of bank efficiency taking into account risk-preference”, *Journal of Banking and Finance,* Vol. 20 No. 6, pp. 1025-1045.

Pastor, J. (1999), “Efficiency and risk management in Spanish banking: a method to decompose risk”, *Applied Financial Economics*, 9, pp. 371-384.

Pastor, J. (2002), “Credit risk and efficiency in the European banking system: A three-stage analysis”, *Applied Financial Economics*, Vol. 12 No. 12, pp. 895-911.

Pastor, J.M., Pérez, F. and Quesada J. (1997), “Efficiency analysis in banking firms: An international comparison”, *European Journal of Operational Research,* Vol. 98 No. 2, pp. 395-407.

Resti, A. (1997), “Evaluating Cost-Efficiency of the Italian Banking System, What Can Be Learned from the Joint Application of Parametric and Non-Parametric Techniques”, *Journal of Banking and Finance,* Vol. 21 No. 2, pp. 221–250.

Sathye, M. (2002), “Measuring productivity changes in Australian banking: an application of Malmquist indices”, *Managerial Finance*, 28(9), 48-59.

Sealey, C. and Lindley, J.T. (1977), “Inputs, Outputs and a Theory of Production and Cost at Depositary Financial Institutions”, *Journal of Finance,* Vol. 32 No. 4, pp. 1251–66.

Simar, L. and Wilson, P.W. (2000), “A general methodology for bootstrapping in non-parametric frontier models”, *Journal of Applied Statistics,*Vol. 27 No. 6, pp. 779–802.

Simar, L., and Wilson, P.W. (2007), “Estimation and inference in two-stage, semi-parametric models of production processes*”, Journal of Econometrics,* Vol. 136 No. 1, pp. 31-64.

Wang, K., Huang, W., Wu, J. and Liu, Y.N., (2014), “Efficiency measures of the Chinese commercial banking system using an additive two-stage DEA”. *Omega– The International Journal of Management Science*, Vol. 44, pp. 5-20.

Wheelock, D. C., and Wilson, P. W. (1999), “Technical Progress, Inefficiency, and Productivity Change in US Banking, 1984-1993”. *Journal of Money, Credit and Banking*, Vol. 31 No. 2, pp. 212-234.

Williams, J. (2004), “Determining management behaviour in European banking”, *Journal of Banking and Finance*, Vol. 28 No. 10, pp. 2427–2460.