European Bank´s Performance and Efficiency

Abstract

The research interest in bank profitability and efficiency is linked to the economic situation and an important issue for policy makers is to ensure economic stability. Nevertheless, managerial decisions and environment could play a critical role in ensuring proper and efficient allocation of the resources. The purpose of this study is to understand which are the main factors that can influence performance and efficiency of the 94 listed banks from Eurozone countries through a dynamic evaluation, in the period between 2011- 2016. To achieve this aim, the Generalized Method of Moments estimator technique is used to analyze the influence of some bank-specific characteristics, controlled by management, on the profitability as a measure of bank performance. After that, through the Value-Based DEA methodology, those factors are considered in determining the efficient banks. The results show that banking efficiency depends on set bank-specific characteristics, and that the effect of determinants on efficiency differs, considering the macroeconomic conditions.

JEL classification: G21, G15, C33, C44, C61

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1- Introduction

The research interest in bank efficiency has been recognized for a long time, since banks play a central role in the economy development and growth of a country. The presence of an increasingly competitive market reinforces the great importance of assessing banks' performance to continuously improve their financial condition (Beck et al., 2000; Rajan and Zingales, 1998). However, an efficient and profitable banking system is even more important for countries characterized as belonging to the civil law model, more oriented to the banking system and less to the capital market system[1].

[1] For an interesting seminal paper which attempt to combine insights from the theory of corporate finance, institutional economics

Due to liberalization and internationalization, competition in the financial sector has increased and, consequently, the pressure to obtain higher levels of profitability and efficiency increased as well (Meles et al., 2016). In this context it is necessary to better understand which factors are determinant for bank efficiency, i.e, which variables could be more relevant for manager´s decisions in order to improve bank performance. According to Varmaz (2007) the factors that most influence the profitability of banks are market conditions regarding competition as well as service production capability. Therefore, profitability corresponds to how the company is managing its resources to create value. To measure the profitability of banks the Return on Average Equity (ROAE) and Return on Average Assets (ROAA) ratios are traditionally used, because they are connected with some advantages. The ROAE provides a direct assessment of the financial return for shareholder's investment (Lee and Kim, 2013) and the ROAA, shows the bank's ability to generate revenue through the better asset utilization (Ongore and Kusa, 2013). Trujillo-Ponce (2013) argues that ROAA is perhaps the most important measure for comparing the efficiency and the operational performance of banking institutions. This is because the ROAA explain the success of the management in obtaining results with the assets that bank holds. The ROAE considers the contribution of all equity and off-balance sheet events, while the ROAA disregards off-balance sheet activities (Athanasoglou et al., 2008), as commitments assumed by the bank, which generate income but are not recorded in the accounts of the bank. The world banking sector, with the recent global financial crisis, had difficulty accessing financing, causing problems in terms of financial autonomy. This event has given greater importance to the banking sector in relation to the global economy. Therefore, Athanasoglou et al. (2008) displayed that profitability is also important for the survival of banks, since the higher their profitability, the greater their economic capacity to cope with unfavorable situations. The new challenge to banker is focused on balance sheet management, in their loan pricing discipline with a strong control of operating expenses. Thus, this leads to suggest that ROAA could be the best measure to capture bank performance. Moreover, also efficiency is a perception that guarantees the survival of the banks and that should be explained. This concept is often used as a synonym for productivity, however is a relative concept. It compares what was produced, given the resources available, with what could have been produced considering the same resources. There are different ways to evaluate the quantity aforementioned. The parametric methods, that assumes a pre-defined functional relationship between the resources and the products. Usually, they use averages to determine what could have been produced. And the non-parametric methods, among which is the

and different legal and economic systems, see La Porta et al. (1998). See also Levine (2002) for a summary of the theoretical views on bank-based and market-based systems.

Data Envelopment Analysis (DEA), that do not make any functional assumptions and that considers the maximum that could have been produced is obtained by observing the most productive units. The underlying idea is to compare a set of similar units and then identify those that show best practices. Although the efficiency concept is not always accurate, in most of the cases the Pareto-Koopmans definition is usually followed. The formal definition stated by Charnes et al. (1978) says that "A unit is full efficient if and only if it is not possible to improve any input or output without worsening some of other input or output." This definition avoids the need for explicitly specifying the formal relations that are assumed to exist between inputs and outputs and there is no need to have prices or other assumptions of weights, which are supposed to reflect the relative importance of the different inputs or outputs. The experience in banking sector reveals that it is extremely difficult to compare productivity of different banks as distinct and the need of global indicators is recognized to eliminate restrictive productivity indices associated with each factor. DEA is a technique for measuring the relative efficiency of peer decision making units (DMUs) doing business under the same operating conditions and allows the consideration of multiple inputs and multiple outputs in global performance evaluation. As an efficiency measure for a given DMU, the DEA uses the maximum of a weighted outputs to weighted inputs. The concept of frontier analysis that began with Farrell´s (1957) paper forms the basis of the DEA, which was triggered by the work of Charnes et al. (1978). It has been recognized that DEA is a benchmarking tool (Charnes et al., 1994), because permits to identify reference DMUs on the efficiency frontier, whose performance scores serve as a benchmark for the inefficient DMUs. The information that results from this type of analysis can be used to help the managers to identify the gaps of inefficiency, i.e the factors in which further improvements are needed, to set future development strategies and to identify the best targets for the inefficient DMUs. Without discharge the importance of the traditional ratio measures, it is known that each of the ratios examines only part of the activities of the DMU under analysis, leading to insufficient information on the global performance. It is confirmed by several authors that the DEA is one of the most successful operational research techniques used in evaluating banks' performance (Fethi and Pasiouras, 2010; Paradi and Zhu, 2013). The purpose of this study is to investigate how intrinsic characteristics of banks in Eurozone countries, have an impact on bank efficiency for a period covering 6 consecutive years, 2011- 2016. Member countries should have similar levels of economic performance, especially in the banking system, as European Union regulatory changes are designed to push industry into the direction of a single market, especially in countries with a common currency. The dynamic evaluation of bank performance uses the Generalized Method of Moments (GMM) method (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and

Bond, 1998) and the Value-Based DEA method (Gouveia et al., 2008). Firstly, the GMM system provides a new evidence about which bank-specifics variables are important to explain banks´ profitability. After that, the Value-Based DEA method, considering these specifics variables, identifies which banks of the dataset are the best performers. The performance of the organization reflects the behavioral decisions of management; however, the managing effort may be conditioned by the intensity of the operating environment (Button and Weyman-Jones, 1992). The relative comparison of bank performance across Eurozone countries enables to identify the best practices in a way that policies could be established to improve the efficiency of less efficient banks, understand the impacts of constant regulatory changes on banking operations and their ability to realign their business with banking operations.

The results show that management decisions, reflected in the specific characteristics of the bank, are important factors explaining profitability. In addition, the results highlight that banks that are efficient more than once, are German banks in a universe of 94 Eurozone banks, for the time interval 2011-2016. Such exposure can be relevant for managers, regulators and potential investors. The remainder of the paper is organized as follows: Section 2 surveys the relevant literature on banking profitability and reviews the hypotheses to test. Section 3 is dedicated to the data and methodological framework. The results for the dynamic evaluation are presented in section 4 and Section 5 provides some final considerations.

2- Literature Review and Hypothesis

According to extensively previous studies, the importance of factors determining the banks' performance is not new and was strengthened in the last two decades due to the fall in banking earnings, accelerated by the global financial crisis (Ghosh, 2016).

These earlier studies have focused their analyses on individual country specific studies like Athanasoglou et al. (2008); Dietrich and Wanzenried (2011); García-Herrero et al. (2009); Rumler and Waschiczek (2016), among others. Further authors already consider a cross country data, as for instance, Bitar et al. (2018); Dietrich and Wanzenried (2014); Nguyen (2018); Pasiouras and Kosmidou (2007); Staikouras and Wood (2004).

According to Trujillo-Ponce (2013), the determinants of bank performance could be dichotomized. First, there is a group of bank-specific determinants, resulting directly by the managerial decisions, such as asset composition, capitalization, operational efficiency or size. The second group of determinants includes factors relating to the macroeconomic environment or industry specificity, such as industry concentration, economic growth, inflation, and interest rates.

In this paper, it will be considered, on the one hand, a model with specific characteristics of the

bank, in order to understand which are determinant in the achievement of profitability. From there, using the Value-Based DEA method, it will be possible to observe how important these variables are in the definition of an efficient bank, using a cross-country comparison. Therefore, this article starts from a set of variables widely debated in the literature to estimate the bank's profitability and ends with the efficiency evaluation of banks, via Value-based DEA, which confirms the importance of the economic environment.

2.1. Bank-specific Characteristic's to determine Profitability

2.1.1. Asset Composition

The bank asset structure is an interesting bank-specific factor and the relationship with profitability is far to be conclusive.

Also referred to as asset diversification, the ratio of total loans to total assets have a positive relationship in the literature, since asset diversification, e.g. hedge funds or other assets, is considered to increase profitability (Saona, 2016). So, in general, loans have a positive influence on profitability, because as a bank's core business, they are a major generator of interest income (Bikker and Hu, 2002).

Based on this assumption authors, like Bourke (1989); García-Herrero et al. (2009); Saona (2016); Trujillo-Ponce (2013) refer a positive relationship between the relative percentage of loans in the assets of a bank and its profitability.

However, other authors pointed out that an ambiguous effects depending on the profitability measure is considered (Valverde and Fernández, 2007; Tan et al., 2017; Trabelsi and Trad, 2017), while a negative relationship between the asset structure of banks and its profitability was obtained by Bikker and Hu (2002) or Rumler and Waschiczek (2016). In fact, a large set of loans implies higher operating costs and probably the premium put on the long-term interest rate, as included in the credit rate, insufficient cover for processing costs, credit losses and the cost of required capital reserves.

Consistent with this empirical evidence, the first hypothesis is stated:

Hypothesis 1: *There is a relationship between the asset bank's composition and its performance*

2.1.2. Equity

There are reasons to believe that a better capitalized bank should be more profitable, because banks with higher capital to assets are considered relatively safer to financial institutions with

lower capital ratios. A bank with higher capital will have more flexibility to absorb negative shocks, so this positive impact on bank performance can be due to the fact that capital acts as a safety net in the case of adverse developments (Athanasoglou et al., 2008; Beltratti and Stulz, 2012). In addition, a high level of capital can lead to a lower cost of debt, once to finance their assets banks will not need as much interest-bearing funds. In other words, this relation would help the bank to finance its assets at the more favorable interest rates, increasing expected profitability and offsetting the cost of equity, considering the most expensive bank liability in terms of expected return (Garcia and Guerreiro, 2016; Tran et al., 2016). García-Herrero et al. (2009) also argue that more capitalized banks have a high value, so they have incentives to remain well capitalized and to engage in prudent lending. Following these arguments, it seems that banks with higher capital-to-assets ratios normally have a reduced need for external funding, which again has a positive effect on their profitability (Kosmidou, 2008; Pasiouras and Kosmidou, 2007). Thus, the empirical evidence indicates that the best performing banks are those who maintain a high level of equity in relation to their assets. Consistent with these influences, a direct association between capital and profitability is expected, and the following hypothesis is established:

H*ypothesis 2*: *There is a positive relationship between the equity ratio of a bank and its performance*

2.1.3. Operational efficiency

Traditionally, the operational efficiency for the bank sector is measured by using cost-to-income ratio (CIR), and a higher CIR reflects more cost inefficiency. In order to increase profitability, it is necessary to increase the efficiency of the financial institution management (Athanasoglou et al., 2008; Dietrich and Wanzenried, 2011), that is, the reduction of operational costs (administrative expenses, salaries of employees, property costs) and, at the same time, to increase revenues, that could lead to a high level of bank profitability. Therefore, this ratio is usually negatively related to profitability, see for example, Azam and Siddiqui (2012); Dietrich and Wanzenried (2011); García-Herrero et al. (2009); Garcia and Guerreiro (2016); Guru et al. (2002); Pasiouras and Kosmidou (2007) among others.

Based on this assumption, the following hypothesis is considered:

Hypothesis 3: *There is a positive association between the operational efficiency of a bank and its performance*

2.1.4. Size

There is a wide range of studies that associate bank dimension with profitability. The Economies

of scale are often cited as the reason why bank size may have a positive effect on bank profits (e.g., Diamond, 1984), that is, the larger is a bank, the more easily it can achieve economies of scale because, having a large dimension can increase its services with the same fixed costs, thus reducing expenses (Boyd and Runkle, 1993). However, a too large bank may also incur diseconomies of scale as it will have an increase in costs, such as operational, bureaucratic and marketing expenses or inertia, thus negatively affecting the bank profitability (see, for example, (Athanasoglou et al., 2008; Dietrich and Wanzenried, 2011; Djalilov and Piesse, 2016; Kosmidou, 2008). According to García-Herrero et al. (2009) the increase on the size of the bank, can also make bank management difficult due to the occurrence of aggressive competitive strategies.

Therefore, empirical research on the existence of economies of scale in banking does not come to a clear conclusion. In this context, there are some studies that reveal a positive relationship between profitability and size (Ahamed, 2017; Albertazzi and Gambacorta, 2009; Altunbaş et al., 2001; Dietrich and Wanzenried, 2014; Kosmidou, 2008[2]; Petria et al., 2015), and others that reveal a negative relationship (Berger et al., 1987; Pasiouras and Kosmidou, 2007). In addition some authors like Athanasoglou et al. (2008), Bikker and Vervliet, (2017) and Goddard et al. (2004), among others found that bank size had no statistically significant influence on bank performance.

Once the literature is unclear regarding the sign of the relationship between bank size and profitability, the overall effect needs to be investigated empirically. Therefore, the following hypothesis is proposed:

Hypothesis 4: *There is a relationship between the bank size and its performance*

3. Data and Methodological framework

3.1. Data

The sample comprises 94 active banks listed on Main stock Exchange from 19 Eurozone Countries for the period between 2011 and 2016. An unbalanced panel was constructed with the 94 European banks whose information was available for at least five consecutive years. This is important in order to test for second-order serial correlation, as Arellano and Bond (1991); Arellano and Bover (1995) and Blundell and Bond (1998) stated. The test for second-order serial correlation was realized, because the estimation method GMM is based on this assumption (Neves, 2018). The data were collected from the Bankscope database (Bureau Van Dijk's

[2] This author shows positive effects of size on Greek bank's performance only when the macroeconomic and financial structure variables are introduced in the model

company) and it was used to test the hypotheses established in the previous section. Regarding the variables used in the model (1), since there is no consensus about which variables best explain the bank profitability, the ROAA will be considered as the dependent variable, following, for instance, Trujillo-Ponce (2013). In fact, the banks with high competition and high operating costs from increase regulation, and fewer opportunities to raise fees to offset these costs, include an intense balance sheet management. So, in the author's opinion, ROAA could be the best way to explain bank performance, because it is a measure which depends in large way to the management decisions. The explanatory variables selected in this study are related with factors that are specific to banks. These variables are controlled by management and reflect the different policies and managerial decisions; consequently, they command the bank´s performance (Dietrich and Wanzenried, 2014, 2011; Djalilov and Piesse, 2016; Guru et al., 2002). Table 1 displays more details about the selected explanatory variables.

Table 1. Description of the explanatory variables.
Bank-specific characteristics - as determinants of bank ROAA

Asset Composition	The ratio of net loans to total assets (NLTA) measures asset composition between both loans and asset portfolios. The bank asset composition measure follows, for instance, Guru et al., (2002) or Trujillo-Ponce (2013).
Equity	The equity to assets ratio (ETA) is included to control for the degree of financial leverage. This is a measure of capital adequacy. The higher the ratio, the lower the risk of bank. The capital adequacy as considered, for example, by Bourke (1989); Athanasoglou et al. (2008), or Kosmidou (2008).
Cost-to Income	The Cost-to income ratio (CIR) represents the total expenses over total generated revenues as a measure of operational efficiency (%). The model include CIR following, for instance, Kosmidou (2008); Garcia and Guerreiro (2016)
Bank Size	The bank size (SIZE) is the logarithm of the number of employees; (see, for example, Sabatier, 2015 or Dang and Yang, 2018)

3.2. Methodological framework using GMM system

Considering the ROAA as the dependent variable, and the independent variables defined before, the model (1) is established:

$$ROAA_{it} = \beta_0 + \beta_1 NLTA_{it} + \beta_2 ETA_{it} + \beta_3 CIR_{it} + \beta_5 SIZE_{it} + \varepsilon_{it} \qquad (1)$$

where ε_{it} is the random disturbance.

The model was estimated by using the panel data methodology. Two issues are considered in

making this choice. First, unlike cross-sectional analysis, panel data allow controlling for individual heterogeneity and this fact is very important because the ROAA depends on management decisions and this circumstance could be very closely related to the specificity of each bank. The second issue addressed by using the panel data methodology is the endogeneity problem. This methodology accommodates the possible endogeneity between the dependent variable and some of the explanatory variables in the model by means of appropriate instruments. In particular, the GMM system estimator uses lagged values of the dependent variable in levels and in differences as instruments, as well as lagged values of other repressors, which could potentially suffer from endogeneity. The latter problem would lead to a correlation between those endogenous variables and the error term and too inconsistent estimates if they are not duly taken into account (Dietrich and Wanzenried, 2014). Therefore, the model was estimated using certain instruments, following Blundell and Bond (1998) suggestion, when deriving the system estimator used in this paper. Note that the system GMM estimator also controls for unobserved heterogeneity and for the persistence of the dependent variable. The regression was performed by using a two-step dynamic panel with equations at levels as suggested by the same authors. García-Herrero et al. (2009) also say that the GMM system for unbalanced panel model employs all possible instruments, and thus non-significant independent variables will be suppressed in a way that results are more efficient.

3.3 Methodological framework using Value-Based DEA method

It is acknowledged and confirmed by several studies that Multiple Criteria Decision Aiding (MCDA) approaches are widely used in finance (for a comprehensive review see Zopounidis et al., 2015). The Value-Based DEA method developed by Gouveia et al. (2008) is a variant of the additive DEA model (Charnes et al. 1985) with oriented projections (Ali et al. 1995), in order to overcome some of its drawbacks by applying concepts from Multi-Attribute Utility Theory (MAUT). MAUT is one of the most popular analytic tools associated with the field of decision analysis (Keeney and Raiffa, 1976). In the spirit of MAUT, the inputs (factors to be minimized) and outputs (factors to be maximized) are firstly converted into value functions. This transformation allows to deal with negative data, which is a difficulty in classical DEA models (CCR and BCC).

The set of *n* DMUs to be evaluated is: $\{DMU_j: j = 1, \dots, n\}$. Each DMU_j is evaluated on m factors to be minimized x_{ij} $(i = 1, \dots, m)$ and p factors to be maximized y_{rj} $(r = 1, \dots, p)$.

The measure of performance on criterion c is: $\{v_c(DMU_j), c = 1, \dots, q,$ with $q = m + p,\ j = 1, \dots, n\}$ based on a value function (or utility function) $v_c(.)$.

Considering that p_{cj} is the performance of DMU *j* in factor *c*, the value functions must be defined such that, for each factor *c* the worst $p_{cj}, j = 1, \dots, n,$ has the value 0 and the best $p_{cj}, j = 1, \dots, n,$ has the value 1, resulting in a maximization of all factors. Therefore, the value functions are defined in the range [0,1], which overcomes the scale-dependence problem of the additive DEA model.

A preliminary phase of Value-Based DEA method comprises the assessment of marginal (partial) value functions on each criterion to establish a global value function. According to the additive MAUT model, the value obtained is $V(DMU_j) = \sum_{c=1}^{q} w_c v_c (DMU_j)$, where $w_c \geq 0$, $\forall c = 1,\dots,q$ and $\sum_{c=1}^{q} w_c = 1$ (by convention). The weights $w_1, \dots, w_q$ considered in the aggregation are the scale coefficients of the value functions and are established such that each alternative minimizes the value difference to the best alternative (bank), according to the "min-max regret" rule.

After the preliminary phase in which the factors (to be minimized and to be maximized) are converted into value scales, the Value-Based DEA method can be described in two phases:

Phase 1: Compute the efficiency measure, d_k^*, for each DMU, $k = 1,\dots,n$, and the corresponding weighting vector w_k^* by solving the linear problem (2).

Phase 2: If $d_k^* \geq 0$ then solve the "weighted additive" problem (3), using the optimal weighting vector resulting from Phase 1, w_k^*, and determine the corresponding projected point of the DMU under evaluation.

Formulation (2) considers the super-efficiency concept (Andersen and Petersen, 1993), which allows the discrimination of the efficient units, when assessing the *k*-th DMU (Gouveia et al., 2013):

$$\min_{d_k, w} d_k$$

$$s.t. \sum_{c=1}^{q} w_c v_c(DMU_j) - \sum_{c=1}^{q} w_c v_c(DMU_k) \leq d_k, j = 1, \dots, n; j \neq k \qquad (2)$$

$$\sum_{c=1}^{q} w_c = 1$$

$$w_c \geq 0, \forall c = 1, \dots, q$$

The efficiency measure, d_k^* , for each DMU *k* ($k = 1,\dots,n$) and the corresponding weighting vector are computed via formulation (2). The score d_k^* is the distance defined by the value difference to the best of all DMUs (note that the best DMU will also depend on *w*), excluding itself from the reference set. If the optimal value d_k^* of the objective function in (2) is not positive, then the DMU *k* under evaluation is efficient, otherwise it is inefficient.

In case the DMU is inefficient, Phase 2 finds an efficient target by solving the linear problem (3):

$$\min_{\lambda,s} z_k = -\sum_{c=1}^{q} w_c^* s_c$$

$$s.t. \sum_{j=1, j\neq k}^{n} \lambda_j v_c(DMU_j) - s_c = v_c(DMU_k), c = 1, \dots, q \qquad (3)$$

$$\sum_{j=1, j\neq k}^{n} \lambda_j = 1$$

$$\lambda_j, s_c \geq 0, j = 1, \dots, k-1, k+1, \dots, n;\ c = 1, \dots, q$$

The variables λj, j=1,…,k-1,k+1,…,n define a convex combination of the value score vectors associated with the n-1 DMUs. The set of efficient DMUs defining the convex combination with λj >0 are called the "peers" of DMU k under evaluation. The convex combination corresponds to a point on the efficient frontier that is better than DMU k by a difference of value of s_c (slack) in each criterion c.

4. Results for the Dynamic Evaluation

4.1. GMM Results

In this section the results are discussed according to the literature review and the formulated hypotheses.

Table 2 presents the main descriptive statistics (mean, standard deviation, minimum and maximum) of the variables used in this study.

Table 2. Summary Statistics.

	Mean	*Std. Dev.*	*Minimum*	*Maximum*
ROAA	.357	1.376	-13.41	7.401
NLTA	53.157	22.691	.022	90.91
ETA	8.824	7.481	-3.931	99.988
CIR	65.01	19.825	14.654	287.69
SIZE	7.988	1.975	3.611	12.175

The results of the estimation model are presented using a two-step dynamic panel with equations at levels. The data used are from 19 Eurozone banks which information is available between 2011 and 2016. The resultant unbalanced panel comprises 94 banks.

Table 3 summarizes the empirical results for the profitability measure used, ROAA.

Table 3. Estimation results of the model (1)

	Coefficient	*STD.Error*	*Z*	*P value*	
const	5.234	(.5696)	9.19	0.000	***
L1.	.0756	.0145	5.20	0.000	***
NLTA	-.0011	(.0055)	-0.20	0.843	
ETA	.0045	(.0131)	0.34	0.731	
CIR	-.0407	(.00344)	-11.82	0.000	***
SIZE	-.2683	(.05915)	-4.54	0.000	***
Sargan			15.052 (13)	0.3041	
Wald			222.35 (5)	0.0000	
AR (1)			-2.1307	0.0331	
AR (2)			-1.3925	0.1638	

The variables are defined in Table 1. The remainder information needed to read this table is as follows: i) Heteroscedasticity consistent asymptotic standard error in parentheses; ii) *, **, and *** indicates significance levels at 10%, 5% and 1% respectively; (iii) The Sargan test with a *p value* greater than 5% shows that the instruments are valid, and the values in parentheses of the test represent degrees of freedom; (iv) The Wald test has a *p value* less than 5% which means that the joint significance and the coefficients are significant distributed asymptotically as $\chi 2$ under a null hypothesis without significance, with degrees of freedom in parentheses. The table shows that there is no first or second order correlation problem in the model see AR (1) and AR (2). Test AR(1) and AR(2) refer to the Arellano– Bond test that average autocovariance in residuals of order 1 respectively of order 2 is 0 (H0: no autocorrelation)

As expected, the negative and significant coefficient of the cost-to-income ratio shows that the poor expenses management is one of the main contributors to poor profitability performance. This evidence corroborates hypothesis 3 following for example, Guru et al. (2002); Garcia and Guerreiro (2016) among others.

As we can see in the table, bank size is negatively related to profitability based on the view that the higher the number of employees, the higher the salary of the bank and therefore the lower its operating profitability. For example, García-Herrero et al., (2009) suggest that higher bank profitability could lead to more employees and less efficiency.

The results obtained are not surprising especially taking into account that the sample is characterized, in general, by being civil law system. In fact, in the bank-based system, the economy is predominantly financed by banks, and in our sample period, the regulatory environment changed because the Eurozone has affected by the global financial crisis and the sovereign debt crisis. Under an ever-changing environment, and new rules of Basel III Risk Agreement, banks have to reinvent themselves to improve their profitability; therefore, in this context, it seems natural that banks management wants to use all the synergies taking advantage of economies of scale. For this reason is not surprising that the variables related to bank costs are the

most significant in the model.

4.2. Value-Based DEA Results

The Value-Based DEA was applied for the evaluation of the 94 banks, for the time interval 2011-2016, considering that the factors to be minimized (inputs) and factors to be maximized (outputs) are the same considered in the GMM, attending to the negative and positive coefficient signals (Table 4). The ROAA is on the side of factors to be maximized because is the assumed measure of profitability. Therefore, is considered to be the *"more-the-better"* type of performance measure.

Table 4. Direction of optimization for factors.

Factors to minimize	**Factors to maximize**
x_{SIZE}: Logarithm of the number of employees	y_{ROAA}: Return on Average Assets
x_{CIR}: Cost-to-Income Ratio	y_{ETA}: Equity to Total Assets
x_{NLTA}: Net Loans to Total Assets	

Let DMU_j, j = 1,…,94 be observed in t = 1,…,6 consecutive years. Then the sample used has 6x94 DMUs (DMU_j^t). The matrices of inputs and outputs of the 564 DMUs in evaluation are $X = (x_1^1, x_2^1, \dots, x_{94}^1, x_1^2, x_2^2, \dots, x_{94}^2, \dots, x_1^6, x_2^6, \dots, x_{94}^6)$ and
$Y = (y_1^1, y_2^1, \dots, y_{94}^1, y_1^2, y_2^2, \dots, y_{80}^2, \dots, y_1^6, y_2^6, \dots, y_{94}^6)$, respectively.
Considering that the value p_{cj}^t is the performance of DMU j in factor c, for the year t, the factors performances are converted into values in a linear way following the procedure: Firstly, two limits, M_c^L and M_c^U, are defined for each factor, such that $M_c^L < min\{p_{cj}^t, j = 1, \dots, 94; t = 1, \dots, 6\}$ and $M_c^U > max\{p_{cj}^t, j = 1, \dots, 94; t = 1, \dots, 6\}$, for each $c = 1, \dots, 5$. Secondly, the values for each DMU are computed using:

$$v_c^t(DMU_j) = \begin{cases} \dfrac{p_{cj}^t - M_c^L}{M_c^U - M_c^L}, & if\ the\ factor\ c\ is\ to\ maximize \\ \dfrac{M_c^U - p_{cj}^t}{M_c^U - M_c^L}, & if\ the\ factor\ c\ is\ to\ minimize \end{cases}, j = 1, \dots, 94; t = 1, \dots, 6; c = 1, \dots, 5 \quad (4)$$

The M_c^L and M_c^U values of the factors to minimize and the factor to maximize that were considered for all DMUs and for the interval 2011-2016 are displayed in Table 2.
The different DEA models have been widely used for performance evaluation in different practical applications, however it is very common to find factors that have negative or zero values. For radial measures of efficiency, as the classical models (CCR and BCC), the presence of

negative data is a problematical matter. The Valued-based DEA overcomes this drawback by converting the performances on each factor into a value scale. Hence after being converted into value functions all factors are to be maximized.

Value functions could also be obtained from the DMs' preferences and this may lead to piece-wise and nonlinear value functions (see, for instance, Almeida and Dias, 2012; Gouveia et al., 2015, 2016 and Gouveia and Clímaco, 2018).

For the purpose of this study a unifying reference set for the whole period was considered, and then the optimal value difference d_k^* has been computed for each bank *k*, in each year, making it possible to compare all of them across years.

The statistic of the scores d^* obtained with the evaluation of DMU's efficiency across the six years, using the Value -Based DEA method is depicted in Table 5. Attending to the results of problem (2), the lower the value of d^* is, the better, and if d^* is negative then the DMU under analysis is efficient. The DMUs that have $d^* = 0$ are weakly efficient and the ones that have $d^* > 0$ are inefficient (Gouveia et al., 2013).

Table 5. Score statistics.

	2011	**2012**	**2013**	**2014**	**2015**	**2016**
# efficient banks	4	3	3	4	3	3
Average of d^* for the efficient banks	-0.069	-0.024	-0.026	-0.010	-0.014	-0.010
Std. Dev. of d^* for the efficient banks	0.123	0.033	0.041	0.011	0.007	0.008
Average of d^* for the inefficient banks	0.089	0.086	0.081	0.080	0.080	0.085
Std. Dev. of $d^*$for the inefficient banks	0.046	0.046	0.044	0.036	0.039	0.038
Overall Average of $d^*$of all banks	0.0810	0.0823	0.0774	0.0754	0.0765	0.0814
Std. Dev. of $d^*$of all banks	0.0609	0.0496	0.0486	0.0406	0.0421	0.0415

The years 2011 and 2014 are the ones that shows more efficient banks, however displaying the a very different average of d^*. The year 2011 has the banks with a highest average score (more negative values of d^*) for the efficient banks, however it also has the banks with the highest average of d^* for the inefficient banks (more positive values). The overall average of the bank scores, considering the different years, are better for 2011, 2012 and 2016 (>0.8).

There are 3 efficient banks for the remaining years, but the scores of the efficient banks are in average better for 2012 and 2013.

Probably these results are reflective of the financial help that banks were getting, gradually, after the global financial crisis (Gulati and Kumar, 2016). Faced with serious economic difficulties in Greece, the European Union has adopted an aid plan, including loans and supervision of the European Central Bank.

The largest number of efficient banks in 2011 can be explained by the fact that these banks are German (3 banks) and French (2 banks) - See Table 6. Data from the Statistical Office of the European Communities (Eurostat) show that in 2011, in spite of the severe sovereign debt crisis in some countries, Europe accelerates expansion through Germany and France. The two biggest heads of the European Union's economy announced quarterly and annualized growth data above all analysts' forecasts. Both countries had an increase in the Gross Domestic Product (GDP).

Table 6 exhibits the banks that were classified as efficient at least once in 2011-2016. The negative values of the efficient DMUs are highlighted in bold. We decide to designate DMUs by banks to make it easier to follow.

Table 6. The scores of the banks classified as efficient at least once in 2011-2016.

Bank	**Country**	d^* (2011)	d^* (2012)	d^* (2013)	d^* (2014)	d^* (2015)	d^*(2016)
Bank 1	DE	0.0008	0.0197	0.0011	**-0.0076**	0.0115	0.0125
Bank 2	GR	0.0761	0.1596	**-0.0738**	0.1144	0.0886	0.0680
Bank 3	DE	**-0.0050**	**-0.0013**	**-0.0025**	0.0018	0.0059	0.0018
Bank 4	IT	0.0052	**-0.0076**	0.0078	0.0006	0.0015	**-0.0083**
Bank 5	ES	0.0097	0.0155	0.0022	**-0.0019**	**-0.0074**	0.0153
Bank 6	DE	**-0.0053**	**-0.0619**	0.0020	**-0.0263**	**-0.0123**	**-0.0029**
Bank 7	MT	**-0.2531**	0.0222	**-0.0018**	**-0.0023**	0.0007	**-0.0194**
Bank 8	HR	0.0537	0.0678	0.0516	0.0546	**-0.0219**	0.0394
Bank 9	AT	**-0.0122**	0.0267	0.0129	0.0318	0.0233	0.0322

The best ranked bank, in terms of annual performance, was the Bank 7, a bank of Malta. This bank has the best performance value for the Return on Average Assets and Equity to assets factors in 2011, when compared to all others in this and other years. This is likely to be related to the good risk management practices necessarily implemented after the crisis. But it also has a good performance value for the number of employees, which guaranties to be classified as efficient in the following years. This is likely to be related to the good risk management practices necessarily implemented after the crisis (Bezzina, Grima and Mamo, 2014).

It should be noted that, besides the Bank 7, banks that are efficient more than once, are German banks. However, the Bank 4, an Italian bank, appears as often as efficient as Spain's Bank 5.

In Table 7 the results of Value-Based DEA formulation (2) are presented. Each DMU chooses its

best feasible weights for factors in order to be classified as well as possible relatively to the set of all DMUs (banks). That is, the efficiency scores were obtained by allowing DMUs to ignore some factors from the assessment, since the DMU under evaluation is free to choose the weights associated with factors (value functions) that minimize the difference of value to the "best" DMU (bank), according to the "min-max regret" rule.

Considering the banks that were classified as efficient in 2011, it could be observed that most of them disregard y_{ROAA} and y_{ETA} (w^*_{ROAA}= 0 and w^*_{ETA} = 0). In the context of the economic and financial crisis, the profitability of banks suffered a significant reduction and, in some banks, fell to negative values. This may justify the fact that banks do not consider the Return on Average Assets factor in their evaluation, they are not "good" enough in it. Most of the efficient banks chose the y_{NLTA} as a relevant factor. In fact, this factor is the one that is more times chosen for the efficiency status and only 4 banks disregard it from evaluation (Bank 7 (2011), Bank 9 (2011), Bank 2 (2013) and Bank 8 (2015)). The German banks are placed at the efficiency frontier because they are the ones with the best performances associated with the risk factor and elect it as the most prevalent.

Table 7. Results of Value-Based DEA (Efficiency Score and optimal weights) and number of times as benchmarks, for efficient banks

	d^*	w^*_{ROAA}	w^*_{ETA}	w^*_{EMPL}	w^*_{CIR}	w^*_{NLTA}	**N^{er} of times as benchmark**
Bank 7 (2011)	**-0.253**	0.594	0.406	0.000	0.000	0.000	289
Bank 2 (2013)	**-0.074**	0.213	0.000	0.000	0.787	0.000	152
Bank 6 (2012)	**-0.062**	0.000	0.205	0.000	0.000	0.795	9
Bank 6 (2014)	**-0.026**	0.107	0.000	0.457	0.038	0.398	1
Bank 8 (2015)	**-0.022**	0.000	0.000	0.181	0.819	0.000	234
Bank 7 (2016)	**-0.019**	0.131	0.000	0.242	0.341	0.287	16
Bank 6 (2015)	**-0.012**	0.000	0.000	0.133	0.000	0.867	0
Bank 9 (2011)	**-0.012**	0.000	0.000	0.871	0.129	0.000	9
Bank 4 (2016)	**-0.008**	0.000	0.000	0.000	0.896	0.104	195
Bank 4 (2012)	**-0.008**	0.000	0.000	0.089	0.204	0.708	7
Bank 1 (2014)	**-0.008**	0.000	0.000	0.000	0.212	0.788	6
Bank 5 (2015)	**-0.007**	0.212	0.161	0.043	0.000	0.584	11
Bank 6 (2011)	**-0.005**	0.000	0.000	0.834	0.132	0.033	3
Bank 3 (2011)	**-0.005**	0.414	0.000	0.000	0.039	0.547	7
Bank 6 (2016)	**-0.003**	0.089	0.000	0.826	0.000	0.086	0

Bank 3 (2013)	**-0.003**	0.000	0.000	0.095	0.011	0.894	3
Bank 7 (2014)	**-0.002**	0.009	0.000	0.752	0.165	0.075	0
Bank 5 (2014)	**-0.002**	0.073	0.000	0.194	0.234	0.500	5
Bank 7 (2013)	**-0.002**	0.000	0.007	0.463	0.363	0.167	1
Bank 3 (2012)	**-0.001**	0.000	0.124	0.004	0.099	0.773	1

In order to find the cases where a DMU emphasizes the pure self-evaluation, in detriment of being evaluated as an organizational unit with a balanced set of factors, it is common to use a measure, which consists of recording the frequency that this DMU appears in the peer group of other DMUs (see last column of Table 7). The greater the number of times that a DMU belongs to the linear combination that generates the projected points of other DMUs, the more likely it will be a good performance model (Charnes et al., 1985). Thus, in the set of inefficient banks the bank that appears most often (289 times) in the linear combination that comprises the projected point (the target) is the Bank 7 (2011). This bank is followed by the Bank 8 (2015), which is the second most chosen by inefficient banks. The inefficient banks choose as peers those who form the efficient frontier, the ones that have the best practices, and those who are similar to them in the way that they want to make the smallest effort on the factors towards improvement.

The solution obtained from formulation (3) of the Value-Based DEA method is a proposal of an efficiency target (projection) for each inefficient bank. To attain an efficiency status these inefficient banks must change their value in each factor by the amount indicated by s^*. Table 8 shows the results of Phase 2 only for the first 12 inefficient banks. It is interesting to observe that in the first 12 banks classified as inefficient, 11 were already classified as efficient in other years.

All the banks in Table 8, being close to the efficiency frontier, need to make a small effort on the factors towards improvement, however, all need to increase the y_{ROAA}. In fact, across the sample there are 457 banks that need to improve on this factor, considering that the same bank has 6 years of evaluation, appears 6 times represented. The positive slacks with higher average values are the ones associated with the factor y_{CIR}, which may indicate that most important sources of inefficiency is the Return on Average Assets and Cost-to-Income Ratio.

Considering all the inefficient banks, the factor that most often appears with null slacks is the y_{EMPL} (186 times). This result is noteworthy insofar as the banks listed in the sample are also considered the largest banks in each country and throughout this article it is possible to verify that the size of the banks is determinant in the profitability and consequent efficiency of the banks.

Table 8. Results of Value-Based DEA (Phase 2) for the first 12 inefficient banks

Banks	d^*	w^*_{ROAA}	w^*_{ETA}	w^*_{EMPL}	w^*_{CIR}	w^*_{NLTA}	s^*_{ROAA}	s^*_{ETA}	s^*_{EMPL}	s^*_{CIR}	s^*_{NLTA}
Bank 4 (2014)	0.001	0.000	0.190	0.000	0.280	0.529	0.001	0.004	0.003	0.005	0.000
Bank 7 (2015)	0.001	0.000	0.000	0.523	0.326	0.151	0.001	0.017	0.058	0.001	0.000
Bank 1 (2011)	0.001	0.000	0.000	0.000	0.347	0.653	0.001	0.013	0.020	0.344	0.002
Bank 1 (2013)	0.001	0.000	0.025	0.000	0.000	0.975	0.001	0.006	0.000	0.008	0.032
Bank 4 (2015)	0.001	0.455	0.000	0.023	0.116	0.407	0.001	0.003	0.011	0.000	0.000
Bank 3 (2014)	0.002	0.147	0.097	0.000	0.000	0.756	0.002	0.000	0.000	0.005	0.002
Bank 3 (2016)	0.002	0.000	0.000	0.035	0.145	0.820	0.002	0.005	0.015	0.000	0.012
Bank 6 (2013)	0.002	0.000	0.000	1.000	0.000	0.000	0.002	0.111	0.273	0.002	0.204
Bank 5 (2013)	0.002	0.470	0.019	0.047	0.000	0.464	0.002	0.002	0.000	0.026	0.008
Bank 4 (2011)	0.005	0.000	0.000	0.108	0.112	0.779	0.005	0.016	0.009	0.000	0.046
Bank 3 (2015)	0.006	0.095	0.000	0.025	0.102	0.778	0.006	0.004	0.004	0.000	0.000

5. Conclusions and further research

Over the last two decades a number of important changes occurred in the European banking industry, leading to increased competition and pressure bank profitability.

On the whole, the findings of this work highlight that if banks managers want to protect their performance, they will have to improve cost management efficiency.

In a very difficult economic and financial environment, the challenges of banks in a bank-oriented system are enormous and include low interest rates, intense pricing competition for commercial and mortgage loans and higher operating costs, particularly related to regulatory compliance, technology and health care. For this reason the use of economies of scale is important and the management decisions, specific factors of each bank, are determinant for bank performance and efficiency.

This work point out the factors that make a bank classified as efficient change, which confirms the importance of the economic environment in a way that could affect the bank performances, besides the bank level features.

The new European regulation has been important, but the fact that in a universe of 564 DMUs (94 banks used in DEA method observed in 6 consecutive years) only 20 have been considered efficient shows that there is still a long way to go.

The main limitation of this study is related to the number of banks listed by country. So, for future research it would be interesting to analyze other markets and integrate institutional and ownership

factors, with very different characteristics in civil law and common law countries; to compare the determinants of efficiency in the bull and bear periods also considering different external factors such as macroeconomic and market sentiment factors.

The results obtained could help managers, investors or governments to know how to improve the efficiency of their banking sector, which is the engine of the economy for civil law countries.

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