On the Sources of Heterogeneity in Banking Efficiency Literature

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Abstract This study reviews the empirical literature on banking efficiency by conducting a meta-regression analysis. The metadata-set consists of 1,661 observations retrieved from 120 papers published over the period 2000-2014. While the role of study-design and method-specific characteristics of primary studies is evaluated, a focus concerns regulation in banking. Results are fourfold. Firstly, parametric methods always yield lower levels of banking efficiency than nonparametric studies. Secondly, banking efficiency is high in studies using the value added approach instead of the intermediation method. Thirdly, efficiency scores also depend on the ranking journals and on the number of observations and variables used in the primary papers. Finally regulation matters: primary papers focusing on countries with a liberalized banking industry provide high values of efficiency scores.

JEL classification: C13, C14, C80, D24, G21, G28, L25, L43, K20
Keywords: Banking, Frontier Models, Efficiency, Meta-analysis, Regulation, Study design

1. Introduction

Efficiency in banking is a long-standing topic of discussion in economics which has received considerable attention over the last 25 years. Two main forces have brought about the great interest in this subject.

Firstly, even though theory clearly explains whether a decision unit is efficient or not (Farrell 1957), controversy has surrounded the empirics of much of the research. This is because the efficiency frontier is unknown and no consensus exists on the superiority of one estimating method over others, as argued by Berger and Humphrey (1997), Coelli and Perelman (1999) and Fethi and Pasourias (2010) (appendix Table A1 reports a breakdown of the methods used to estimate efficiency). The sensitivity of results to model specifications has been addressed in several individual studies which compare the results that different methods (i.e., parametric *vs* nonparametric methods) yield from a fixed sample of banks (Beccalli et al. 2006; Casu and Girardone 2004; Ferrier and Lovell 1990; Goddard et al. 2014; Huang and Wang 2002; Kumar and Arora 2010; Mobarek and Kalonov 2014; Resti 1997; Weil 2004; Yildirim and Philippatos 2007). Beside this, the reviews by Berger (2007), Berger and Humphrey (1997), Fethi and Pasiouras (2010) and Paradi and Zhu (2013) offer valuable arguments as to why results differ. However, not one quantifies the impact of methodological choices on the variability of efficiency scores.

Secondly, the structures of many banking industries have changed rapidly since 1990s, experiencing great deregulation and consolidation processes. The reforms have considerably

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liberalized bank structural and conduct rules over the world. This has been accompanied by an increase in prudential regulation, particularly in relation to a minimum capital adequacy. Important reforms have also regarded the relaxing of geographic constraints – so inducing a territorial diversity in bank organization – and ownership structure with the result that the current market configuration in many countries involves private commercial big-banks and small and medium-sized cooperatives. Based upon theory, predictions about the impact of regulatory and supervisory policies on bank performance are conflicting and range from the "public interest view" to the "private interest view" (see, i.e, Barth et al. 2004, 2006, 2007, 2010). Some authors have emphasized the role of capital standards in preventing bank failure and in safeguarding customers and the whole economy from negative externalities (e.g., Hovakimian and Kane 2000; Gorton and Winton 1995; Rochet 1992). However, if regulation restricts bank activities, then it affects banks' business conduct and, therefore, the efficiency with which they operate. This occurs as banks react to a higher regulatory burden by engaging in riskier activities and investing in ways that circumvent regulation (Jalilian et al. 2007). Whatever the case, the motivation for deregulation and reforms has been the drive for higher efficiency. This introduces the second issue that we try to address in this paper. On one hand, efficiency in banking has become a concern in many policy-oriented papers as they aim to evaluate the effectiveness of any country specific restructuring process (Barth et al. 2004; 2006; 2008; 2013; Chortareas et al. 2012). On the other hand, there is still high cross-country banking industry variability, as revealed, for instance by the world index of credit market regulation (Gwartnwy et al. 2014). In 2012, this index was, on average, equal to 8.46, ranging from 2.67 (Zimbabwe) to 10 (i.e., Hong Kong, Norway, Singapore and USA). In brief, it is reasonable to assume that this observed heterogeneity in market conditions translates into heterogeneity in banking efficiency.

This said, the purpose of this paper is to measure the impact of methodological choices and country-specific factors on efficiency score variability. To this end, we perform a Meta-Regression Analysis (henceforth MRA), which is a statistical method that reveals more about a phenomenon which has been studied in a large set of empirical works. By investigating the relationship between the dependent variable (i.e., the efficiency scores of primary studies) and some features of every paper, MRA provides a systematic synthesis of a substantial number of studies and quantifies the role specific aspects of original papers have in explaining the heterogeneity in results (Stanley 2001; Glass 1976; Glass et al. 1981; Stanley and Jarrell 1989). As Glass (1976:3) says, MRA "connotes a rigorous alternative to the casual, narrative discussions of research studies which typify our attempt to make sense of the rapidly expanding research literature". Compared to standard qualitative literature surveys, MRA does not suffer from potential bias in selecting the studies to be reviewed because it can cover all the literature without restrictions accruing from the reviewer's judgments. As will become evident later, this study utilizes a very large sample of papers, so ensuring an ample coverage of banking efficiency literature.

Given the increased interest in MA in economics[1] and the fact that the literature on banking industry efficiency lends itself well to being summarized through this approach, it is

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[1] Even though MA was originally applied to other disciplines, such as medicine and psychology (Egger et al. 1997; Hedges and Olkin 1985; Rosenthal 1984), it has recently been used in a number of papers covering a very wide spectrum of economic subjects. Poot (2012) counts 626 papers which applied MRA to economics between 1980 and 2010, with an exponential growth in the 2000s. About three quarters of these MRA applications were published in field-specific journals; several appeared in "top" journals (*American Economic Review, Journal of Banking & Finance, Journal of Political Economy, Review of Economics and Statistics*, and *Economic Journal*), whilst the remainder are working-papers or book-chapters. In order to give an idea of the wide spectrum of recent MA applications in economics, it is sufficient to say that they have been used with regard such topics as the tax impact on corporate debt financing (Feld et al. 2013), the financial liberalization-growth nexus (Bumann et al. 2013), misalignments in real exchange rates (Ègert and Halpern 2006), the demand for gasoline (Havránek et al. 2012), labor supply elasticities (Chetty et al. 2011), the

noteworthy that no exhaustive work has explored the heterogeneity in results.[2] In attempting to fill this gap, this paper uses different MRA specifications and refers to a meta-data set which is comprised of 1,661 observations from 120 papers published between 2000 and 2014 (which were available in April 2014). At this stage of the discussion, it is important to understand how we address an issue, known as publication bias, which is common to any MRA as a result of the fact that journals tend to publish papers whose evidence is robust.[3] In order to control for this issue, many scholars weight the observations by using appropriate measures of the estimates' variability (Bumann et al. 2013; Cipollina and Salvatici 2007; Doucouliagos and Stanley 2009; Feld et al. 2013; Stanley 2008). From an empirical perspective, these studies indicate that the Random Effect Multilevel Model (REML) and the weighted-cluster data analysis (WLS) are robust to publication bias. After controlling for publication bias, we proceed by using the REML technique because it controls not only for within-study variability, but also for between-study heterogeneity. However, we also run some WLS regressions as a check.

Due to its main research focus, i.e. measuring the impact of potential sources of heterogeneity on banking efficiency - this article contributes to the debate in two ways. One of these regards the role of methodological choices in banking empirics, and the other investigates the impact of two sector-specific effects, that is regulation and how researchers specify the banking frontier. Paper contributions are threefold.

Firstly, by applying the MRA to such a wide set of observations, we are able to address the following relevant issues: whether parametric studies yield different results from nonparametric studies; whether the approach regarding the variables to be included in frontiers has an impact on the average level of efficiency; whether the impact differs when considering cost instead of profit or production efficiency**.** As these questions refine the identification of the problem to be studied, they address the so-called "*apples and oranges*" MA problem which arises when bringing together studies which are different from one another (Glass et al. 1981).

Secondly, an important novelty of this paper is that regulation enters into an MRA specification as a potential source of banking efficiency heterogeneity. The empirical literature suggests that little attention has been paid to understanding the link between regulatory environment and efficiency, as opposed to other measures of bank performance (Barth et al 2008; Pasiouras et al. 2009). Furthermore, the evidence is mixed and depends upon the type of regulation. On one hand, banking regulations that enhance market discipline, empower the public supervisory power and increase capital requirements, increase cost and profit efficiency (Chortareas et al. 2012; Pasiouras et al. 2009). On the other hand, tighter restrictions are negatively associated with bank efficiency (Barth et al 2013; Chortareas et al. 2012). Departing from this, we try to understand whether the heterogeneity that we retrieve from collecting data from different papers is related to the level of regulation revealed for the

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relationship between FDI and taxation (Feld and Heckemeyer 2011), the effect of active labor market policies (Card et al. 2010), aid effectiveness (Doucouliagos and Paldam 2009), the role of distance in bilateral trade (Disdier and Head 2008), the 2% β-Convergence (Abreu et al. 2005) and a variety of other environmental and transport issues (summarized in van den Bergh and Button 1997).

[2] Here, it is worth noting that few MRA deal with efficiency. Bravo-Ureta et al. (2007) examine the efficiency scores of 167 farm level studies published over the last four decades. Thiam et al. (2001) review 34 articles on agricultural efficiency in developing countries. While Brons et al. (2005) focus on 45 urban transport studies, Odeck and Bråthen (2012) analyze the efficiency of seaports using 40 published papers. Nguyen and Coelli (2009) focus on hospital efficiency by referring to 95 studies published over 1987-2008. Finally, Havránek and Iršová (2010) review 32 efficiency studies - and just 53 observations - on banking in the US published in 1977-1997.

[3] Another potential source of bias concerns the fact that authors publish results that satisfy their *a-priori* expectation. While this is a relevant issue in empirical economics - with hard solutions -, it forces us to be cautious in interpreting the role of publication bias in any MRA paper.

country analyzed in every primary study. In other words, the aim here is to understand whether efficiency studies for countries with highly regulated banking industries are expected to yield results which differ from those obtained when focusing on more liberalized countries.

Last but not least, we consider two additional factors that are meant to be good predictors of heterogeneity in results in the banking efficiency literature. As MRA may suffer from the assigning of the same weight to the results of different works regardless of quality of the publication, a common practice is to use a dummy variable, distinguishing between journal papers and works published as working papers (Disdier and Head 2008). This paper addresses the quality of publication issue by controlling for a continuous variable based on the Impact Factor (IF) of each journal at the time of publication of the primary paper. To the best of the authors' knowledge, this is the first work that uses IF as explanatory variable of an MRA. There is another potential source of heterogeneity which is sector-specific. It regards the choice of the variables to be included in the frontiers. The extreme options are the value added and the intermediation approaches (Berger and Humphrey 1992; 1997; Sealey and Lindley 1977). These basically differ in how they treat deposits. The value added approach considers loans and deposits as outputs, while labor and physical capital are inputs. Therefore, the bank is thought of in the same way as other manufacturers of products and services. In contrast, the intermediation approach identifies loans as the output, while labor, capital and deposits are inputs. In this case, the bank is seen as a company which collects and manages funds to provide loans to customers. Between these two extremes, there is a combination of them, in the sense that deposits are used as outputs and inputs, as in Berger and Humprey (1992), Pasiouras et al. (2009) and Williams (2012). We label this mixed approach as hybrid.

The paper is structured into 5 Sections. Section 2 describes the criteria adopted to create the meta-dataset and highlights the efficiency heterogeneity in efficiency scores. Section 3 presents the MRA, while Section 4 presents and discusses the results. Section 5 concludes.

2. The Bank-Efficiency Meta Dataset

A delicate phase of an MRA is the creation of the database. The number of potential papers in banking literature is impressive: for instance, when searching through Google for "banking efficiency", one obtains more than 45,000 results (as of 24th April, 2014) which diminished to 10,800 after controlling for "frontier" (Figure 1). Therefore, in order to collect a representative sample of works, we employ some criteria to identify relevant academic studies from the large pool of papers on bank efficiency. Both the authors searched, read and coded the research literature. The search was conducted in two phases.

Firstly, we refer to the EconBiz, Repec, ScienceDirect, IngentaConnect and Econlit archives. The key-words used in the baseline search in the title, abstract or keywords are "bank", "efficiency" and "frontier". At the beginning, the search was not restricted and provided a sample of 1,322 published works and working papers that encompass a very broad set of hypotheses and empirical works. Before filtering this sample of works, we ensured that they (a) focused on bank efficiency; (b) included sufficient information for the performing of an MA (efficiency scores and standard deviations); (c) ran specific models for estimating the frontier (DEA, SFA, others); (d) were written in English; (f) were published in a journal or as working papers after 2000; (g) conducted analysis at bank (not branch) level. In this phase, we excluded the papers with the same efficiency score result as were reported in other papers by the same author/s and papers that do not report efficiency estimates.

Secondly, we (a) manually consulted the principal field journals (the *Journal of Banking and Finance*, *Journal of Productivity Analysis*, *Review of Financial Studies*, *Journal of Financial Economics*, *European Journal of Operational Research*, *Applied Financial Economics* and *Journal of Business Finance & Accounting*); (b) explored additional databases such as the Google

Scholar and Social Science Research Network (SSRN) and (c) verified that we had not overlooked efficiency studies by scanning the references of qualitative surveys dealing with issues strictly relating to our research question that were published after 2000, i.e., Berger (2007), Fethi and Pasiouras (2010), Paradi and Zhu (2013). The second round of the search yielded twenty-nine additional studies. The dataset was concluded on the 24th April, 2104 with a set of 120 papers and 1,661 observations (Figure 1).

Appendix Table B1 presents the list of the studies which make up the meta-dataset, including the authors' name, the year of publication, the type of publication, the journal, the number of estimates, the average efficiency and some measure of variability (standard deviation, maximum and minimum values). In order to save space in the table, we just display the average for the primary studies reporting different measures of efficiency (i.e., profit or cost efficiency). Nevertheless, the econometric analysis uses all the information from every paper. As can be seen, the number of estimated efficiency scores varies greatly from one study to another, ranging from 1 to 162 estimates. Similarly, the un-weighed average value of the efficiency is extremely varying, falling in the range between 0.279 and 1.025.

A synthesis of the collected estimates is reported in Table 1, where different sub-samples of scores have been considered according to the approach used in estimations (parametric or nonparametric), the approach followed in selecting the variable for the frontiers (intermediation, value added or hybrid approaches), the structure of data (panel or cross-section), the functional form of the frontier (Cobb-Douglas, translog or Fourier) and, finally, on the basis of the hypotheses regarding returns to scale (constant or variable).

Overall, the sample of 1,661 observations yields an (un-weighted) average efficiency of 0.69. Some differences emerge by efficiency type: the average of the 726 cost-efficiency scores is 0.73, while it is 0.62 for 288 observations based on profit frontiers. In the case of the 647 observations of efficiency in production, the average is 0.69. Data also highlight that the overall mean of the 872 observations from parametric studies is always lower than that of the 789 observations of nonparametric papers: the difference in mean is 0.0599 (0.7313-0.6714) and is statistically significant.

Differences between the efficiency of nonparametric and parametric studies remain positive and significant, whatever type of efficiency we refer to (cost, profit or production). Again, there are 907 observations referring to studies using the intermediation approach, more than 50% of the entire sample, while the dataset includes 361 observations from studies using the value added approach. Between these two extremes, there is the hybrid approach, which differs in that researchers consider deposits either as input or output. The hybrid approach is made up of 391 observations. The difference in means is only high when considering the cost-frontier where the production approach yields a higher (0.7913) average efficiency than the intermediation (0.7238) and the hybrid (0.7039) choices. With regards the structure of data used in primary studies, the analysis shows that about two-thirds of the observations come from estimations obtained from panel data and the other one-third refers to cross-section data. What clearly emerges is that there is no difference in means when considering the entire sample of observations, while cost and profit efficiency scores are higher, on average, when using cross-section instead of panel data.

The opposite holds for the other measures of efficiency. Furthermore, in the sample of parametric studies, another difference is that few (111 in the full sample) observations refer to a Cobb-Douglas specification of the frontier, while the majority use more flexible functional forms (526 adopt a translog frontier and 235 a Fourier one). While Cobb-Douglas specifications yield a higher level of efficiency when studying cost efficiency (0.8246 compared with 0.6731 from translog and 0.7746 from Fourier), the translog form applied to profit frontier yields a higher value of efficiency (0.5964 compared with 0.5341 from Cobb-Douglas and 0.5795 from Fourier). Finally, an interesting pattern is observed when referring to the hypothesis of returns to scale of nonparametric-studies. Overall, the assumption of VRS translates to an average level of efficiency (0.7452) which is higher than that (0.7035) associated with the observations using the hypothesis of CRS. However. results differ according to the frontier. For instance, when considering profit frontiers, we find that the average level of efficiency obtained in the primary studies using CRS is 0.8320, that is to say a much higher value than that (0.6675) associated with the studies based on VRS. In addition, the heterogeneity in banking efficiency literature is confirmed when looking at the distributions of the estimated scores by group. What clearly emerges is that these distributions follow different shapes and forms (these graphs are available upon request). A lesson learnt from this discussion is that the study-design of primary papers plays an important role in determining differences in the means and distributions of banking efficiency scores.

Figure 1. The dataset assembling process

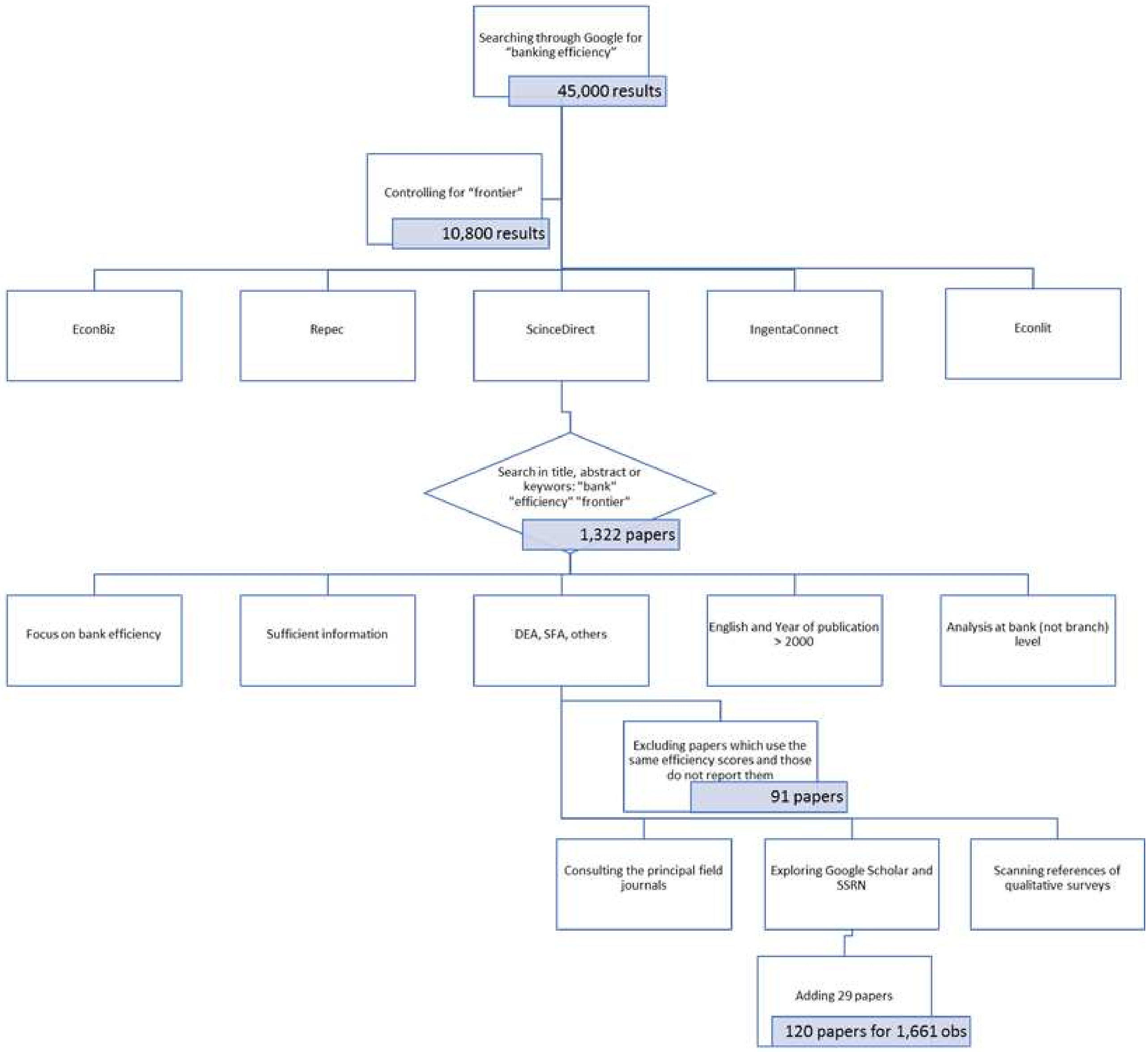

Table 1 Average, standard deviation and number of observations in bank efficiency literature, by group (averages are un-weighted)

		All sample	Cost	Profit	Production
All	Mean	0.6999	0.7301	0.6245	0.6995
	SD	0.1820	0.1873	0.1739	0.1696
	Obs	*1661*	*726*	*288*	*647*
Approach					
Parametric	Mean	0.6714	0.7092	0.5892	0.6511
	SD	0.1937	0.1993	0.1611	0.1716
	Obs	*872*	*541*	*221*	*110*
Nonparametric	Mean	0.7313	0.7911	0.7411	0.7095
	SD	0.1626	0.1289	0.1644	0.1676
	Obs	*789*	*185*	*67*	*537*
Variables of the frontier					
Intermediation	Mean	0.7045	0.7238	0.6587	0.6964
	SD	0.1991	0.2058	0.1824	0.1918
	Obs	*907*	*485*	*157*	*265*
Value added	Mean	0.7186	0.7913	0.6414	0.6996
	SD	0.1166	0.1043	0.0747	0.1116
	Obs	*361*	*107*	*51*	*203*
Hybrid	Mean	0.6712	0.7039	0.5467	0.7012
	SD	0.1872	0.1572	0.1790	0.1889
	Obs	*391*	*134*	*80*	*179*
Functional form in parametric studies					
Cobb-Douglas	Mean	0.7132	0.8246	0.5341	0.6460
	SD	0.1712	0.0843	0.0065	0.1767
	Obs	*111*	*43*	*2*	*66*
Translog	Mean	0.6585	0.6731	0.5964	0.7742
	SD	0.2103	0.2202	0.1758	0.1289
	Obs	*526*	*370*	*132*	*24*
Fourier	Mean	0.6807	0.7746	0.5795	0.5201
	SD	0.1593	0.1146	0.1381	0.0688
	Obs	*235*	*128*	*87*	*20*
Data					
Panel	Mean	0.7043	0.7206	0.6144	0.7479
	SD	0.1899	0.1921	0.1847	0.1633
	Obs	*1080*	*574*	*235*	*271*
Cross section	Mean	0.6916	0.7658	0.6695	0.6647
	SD	0.1663	0.1638	0.1042	0.1657
	Obs	*581*	*152*	*53*	*376*
Returns to scale in nonparametric studies					
CRS	Mean	0.7035	0.7935	0.8320	0.6586
	SD	0.1650	0.1592	0.1116	0.1531
	Obs	*263*	*49*	*30*	*184*
VRS	Mean	0.7452	0.7903	0.6675	0.7360
	SD	0.1597	0.1168	0.1644	0.1689
	Obs	*526*	*136*	*37*	*353*

3. Meta-analysis of banking efficiency: methodological issues

Previous section highlights that heterogeneity is relevant when grouping observations by different criteria. Given this, providing a systematic explanation of the variability of efficiency becomes an important issue to be addressed on econometric grounds. This section focuses on the MRA carried out to explain heterogeneity in banking efficiency scores.

There are two main issues to be addressed in our empirical analysis. The first regards heteroschedasticity, while the second relates to publication bias.

The dependent variable of the MA regression is bank efficiency retrieved from the primary literature. As we have seen before, in creating the meta-dataset we have collected all the information from each paper and many papers provide more than one estimations of efficiency. From an econometric perspective, this means that the unit of observation is the individual value of the estimated efficiency with the result that there is a within study heterogeneity to control for. As for publication bias, the success of a paper depends greatly on the study results, in the sense that the probability of a paper's being published increases the more its conclusions are based on highly significant evidence and thus they are conclusive. A simple method for detecting publication bias is to regress the key-variable of the meta-analysis - bank efficiency in our case - against its precision in primary estimations (Egger et al. 1997). If this regression yields significant results, then there is evidence of publication bias in the meta-data set which must be controlled for in the meta-regression.

This said , in order to provide answers to the research questions raised throughout the paper, we refer to the following equation:

$$\mathrm{E_i} = \beta_1 + \beta_0 S_i + \sum_{\mathrm{j}} \beta_{\mathrm{j}} \mathrm{X_j} + \chi REG_{ct} + \varepsilon_i \qquad [1]$$

where the dependent variable E_i is the i-*th* efficiency score. Equation (1) is known as the FAT-PET (Funnel Asymmetry Test – Precision Effect Test) MRA (Stanley, 2005; 2008). X_j is comprised of the explicative variables that summarize various model characteristics of the primary studies, while REG_{ct} is an index of banking regulation in country *c* at time *t*. Furthermore, S_i is a measure of variability of E_i, that is the standard deviation of the efficiency scores, as estimated in primary papers. It enters into the meta-regression to control for publication bias as proposed by Egger et. al. (1997) and applied by Bumann et al. (2013), Cipollina and Salvatici (2007), Feld et al. (2013) and Stanley (2008). ε is the error of the model, which is clearly heteroschedastic because the variance of individual estimates changes in the sample and the estimates are not independent within the same study. This issue is addressed by weighting the observation through a measure S of the variability of each observation:

$$\begin{aligned} \frac{\mathrm{E_i}}{S_i} &= \beta_0 + \beta_1 \frac{1}{S_i} + \sum_{\mathrm{j}} \beta_{\mathrm{j}} \frac{\mathrm{X_j}}{S_i} + \chi \frac{REG_{ct}}{S_i} + e_i \\ E_i^* &= \beta_0 + \beta_1 S_i^* + \sum_{\mathrm{j}} \beta_{\mathrm{j}} X_i^* + \chi REG_{ct}^* + e_i \end{aligned} \qquad [2]$$

where the disturbance $e = \varepsilon / S$ is corrected for heteroschedasticity. The test for publication bias will be carried out on the constant β_0, as in Cipollina and Salvatici (2007), Doucouliagos and Stanley (2009), Fed et al. (2013) and Stanley (2008).

The method to be used in estimating eq. [2] may be a fixed-effects or a random-effects model. While both methods provide results that are robust to publication bias (Stanley 2008), they differ in terms of their treatment of heterogeneity. In particular, a fixed-effects meta-regression assumes that all the heterogeneity can be explained by the covariates and leads to excessive type I errors when there is residual, or unexplained, heterogeneity (Harbord and

Higgins, 2008; Higgins and Thompson, 2004; Thompson and Sharp, 1999). Instead, a random-effects meta-regression allows for such residual heterogeneity (the between-study variance not explained by the covariates) and therefore extends the fixed-effects model. Formally, under the random-effects framework, eq. [2] becomes:

$$E_i^* = \beta_0 + \beta_1 S_i + \sum_j \beta_j X_i^* + \chi REG_{ct}^* + u_i + e_i \qquad [3]$$

where $e_i \sim N(0, \sigma^2{}_i)$ is the disturbance and $u_i \sim N(0, \tau^2)$ is the primary-study fixed-effect. The parameter τ^2 is the between-study variance, which must be estimated from the data as in Harbord and Higgins (2008).[4] Finally, we run some regressions by using the WLS estimator just for reference.[5]

The right-hand side of eq. [3] includes the matrix X_i, which relates to the observed characteristics used to explain the variability in bank efficiency that we have identified on the basis of a systematic comparison of original papers.

The first distinguishing element to be considered relates to the approach used to estimate the frontier. We made a broad distinction between papers using a parametric method and papers following a nonparametric approach. To this end, the dummy variable used is *Parametric* (*PA*), which is equal to unity for the first group of studies and zero for the others. As we have already said (*cfr.* Introduction), scholars use deposits as inputs or outputs in banking literature. In this respect, we include the dummies *Intermediation* (*INT*) and *Value added* (*Y*), which are unity when efficiency scores are derived from primary-studies using the intermediation or the value added approach (the controlling group comprises the point-observations from papers using the hybrid approach, *HY*). Thus, when the focus of the analysis is on the method to estimate the frontier and on the variable approaches, the eq. [3] has to include is the interacting terms PA*INT and PA*Y and thus becomes:

$$\begin{aligned} E_i^* = \beta_0 + \beta_1 S_i^* + \beta_2 PA^* + \beta_3 INT^* + \beta_4 Y^* + \beta_7 (PA * INT)^* + \beta_8 (PA * Y)^* + \\ + \sum_j \beta_j X_j^* + \chi REG_{ct}^* + u_i + e_i \end{aligned} \qquad [4]$$

Furthermore, in order to control for efficiency-type we include two dummies, *Cost (CE*) and *Profit (PE*), with the value 1 if the efficiency score refers to cost or profit efficiencies (the controlling group is the efficiency obtained from production frontiers).

The literature on Meta-Regression helps to select the other controlling variables. A distinction to be made is between the efficiency obtained in papers using cross-sectional data and that derived from studies based on panel data. The dummy variable *Panel* is equal to unity if original works used panel data and zero otherwise. Furthermore, in order to separate estimates reported in published works from others, we use the dummy *Published* which is one for published papers and zero otherwise. In order to better control for any potential quality-

[4] Technically, REML first estimates the between-study variance τ^2 and then estimates the coefficients, β, with the weighted least squares procedure and using as weights $1/(\sigma_i^2 + \tau^2)$, where σ_i^2 is the standard error of the estimated effect in study i. The word "multilevel" refers to the structure of the metadata set which combines observations at single estimates level and observations at study level (Harbord and Higgins 2008; Thompson and Sharp 1999).

[5] The choice of using REML is also driven by the structure of data we have. As our dataset is with high variability of primary studies, the fixed effect estimator is expected to not perform well because it does not allow for between study variability. Conversely, REML would fit well our case. The evidence we find supports the use of random effects model as the between studies variance results to be high and significant (*cfr* Table 2). This holds despite the potential caveat of REML, whose results are reliable if the random effects variance is properly estimated (Oczkowski and Doucouliagos (2014). Importantly, Stanley and Doucouliagos (2014) compare REML and WLS and their analysis is not conclusive, depending on additional extra heterogeneity and publication bias effect.

effect of primary paper, we also build the variable *IF* which is a continuous variable relating to the Impact Factor of the particular journal at the time of the publication of the paper. IF is equal to zero for journals without impact factor and when the efficiency score comes from book chapters, working papers and unpublished papers. We also consider the variable *Sample Size,* i.e. the number of observations used in primary papers when estimating the efficiency score. The variable *Dimension* is given by the sum of the number of inputs and outputs of the frontier. As size is a typical variable in MAR literature on efficiency (see footnote 2), it allows to pursue two aims. On one hand we address the issue of statistical power of our MRA results as proposed by Hedges and Pigott (2001). On the other hand by interacting Size and the dummy *Parametric* we will verify if the asymptotic efficiency differs between parametric and nonparametric studies.

There are two other choices in the study design which are related to the functional form of the frontier and the returns to scale. The dummy variable *Cobb Douglas* is unity if the Cobb-Douglas functional form is used in modeling the frontier (the reference category comprises translog and Fourier specifications), while *VRS* is a dummy variable equal to one if the primary study assumes variable returns to scale and zero otherwise. Finally, MRA includes the dummy D_{All} which distinguishes between efficiency observations for a specific sample of banks (D_{All}=0) from observations referring to the banking industry as a whole (D_{All}=1). The underlying idea is as follows: the coefficient of D_{All} is expected to be negative because when using a homogeneous sample of banks (for instance, listed banks, commercial banks, cooperatives, small or big-banks), the estimated efficiency score is expected to be higher than that obtained from heterogeneous samples (i.e. the all banks of a specific country): other thinks being fixed, similar banks have similar behavior and thus are more clustered around a frontier than different banks with divergent goals. Additionally, in order to control for geographical differences, we consider the dummy variables Africa, Asia, East Europe, EU, Latin America, Oceania and the USA, which are equal to one if the study used data from that specific part of the world (in estimating the MRA, USA is the controlling group).[6] A final element which should be considered is the time period analyzed. This is because, national context is expected to gradually lead to improvements in how banks work, other things being equal. This time-effect is meant to be gauged by the dummies $Y_{2000-2004}$ and $Y_{2005-2009}$, which are equal to one if the paper was published in the corresponding years and zero otherwise (the controlling group is comprised of the studies published in the years 2010-2014).

While previous regressors refer - except for geographical and time dummies - to the study-design of primary papers, the variable REG_{ct} is defined at country level. It is the index of credit market regulation as calculated in Gwartnwy et al. (2014). It combines there components. The first relates to the ownership of banks: countries with larger shares of privately held deposits receive higher ratings. The second component takes into account the extent of government borrowing relative to private sector borrowing. In such a case, greater government borrowing indicates more central planning and results in lower ratings. Finally, REG_{ct} incorporates the credit market controls and regulations, in the sense that countries with

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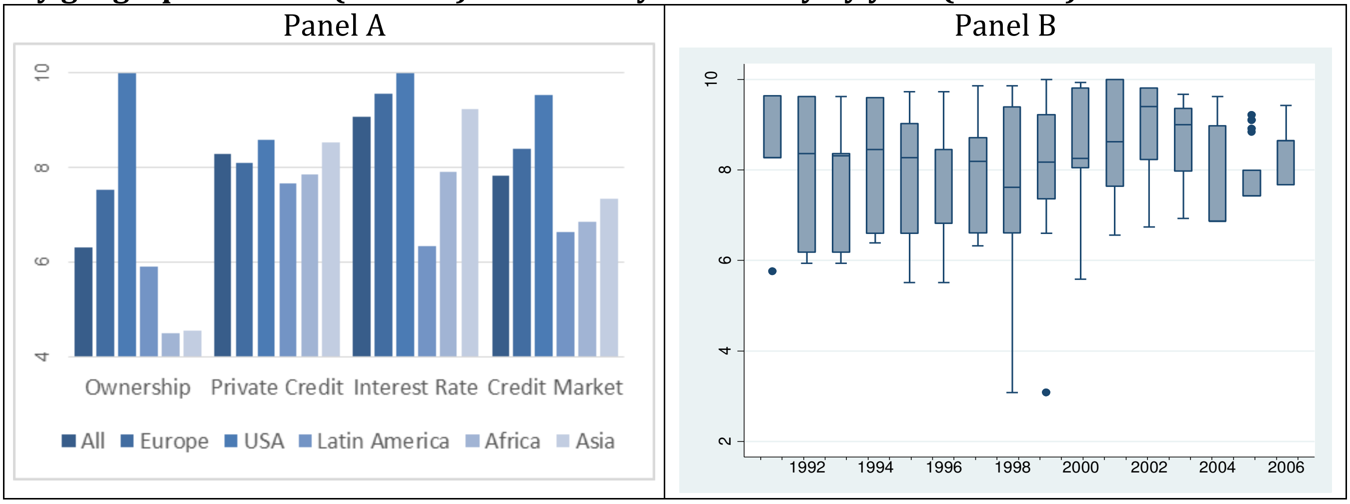
[6] Here, it is noteworthy to mention that the numerous different ways to perform an efficiency study (see appendix table A1) render difficult to have conclusive expectation of the impact of each regressor. Indeed, despite the high degree of specialization in the use of various methods, the effect of some methodological choices is still not certain. For example, efficiency in parametric studies may be higher or lower than that obtained in nonparametric papers, depending on the nature of disturbances from the frontier (Nguyen and Coelli 2009). The use of panel data would generate higher efficiency levels than those from cross-section. An analogous impact is expected when using second order functional forms instead of the Cobb-Douglas. Finally, efficiency would increase with the number of variables included in the frontier, while it would decrease with small sample-size and the assumption of constant returns to scale (Berger and Humphrey 1997; Coelli 1995; Fethi and Pasourias 2010; Nguyen and Coelli 2009). However, while the theory predicts the likely impact of any choice, the actual measure of how the results are sensitive to the study design is an issue to be addressed empirically.

interest rates determined by the market, stable monetary policy and reasonable real deposits and lending rates spreads receive higher ratings. In brief, higher values of Reg_{ct} signal higher level of economic freedom in banking. Figure 2 reports the Reg_{ct} index of the countries analyzed in primary papers. It highlights between-country differences in regulation averaged over the years 2000-2012 (Panel A) and high country-heterogeneity year-by-year (Panel B). It is expected that this country differences in regulation impact on the variability of results that we have observed in banking literature.

Figure 2 Banking regulation over the world in 1990-2012. Average values by geographical area (Panel A) and country-variability by year (Panel B)



4. Fitted models and analysis

4.1. Fitted models

In presenting the results, we start from a basic regression, which includes just the dummies relating to the methodological choices made when performing an estimation of bank efficiency. The underlying idea is to test the robustness of results (sign, magnitude and significance) when moving from basic to extended regressions. In table 2, Model 1 considers just the variables Parametric, Intermediation and Value added. Model 2 controls for the type of efficiency effect and, to this end, adds the variables Cost and Profit to Model 1. In order to better identify the origin of the heterogeneity in banking efficiency, Model 3 includes the interacting terms PA*Y and PA*INT, the bank regulation index and the other explanatory variables as already defined.[7] As the role of regulation may differ country-country, Model 4 adds the interactions between the bank regulation index and the geographical dummies. The last column displays the results obtained when estimating the Model 4 with the WLS method instead of REML (Model 5).

Table 3 reports the evidence we find for specific sub-samples of observations belonging to the class of parametric and nonparametric studies (columns 1 and 2 respectively) or to the studies using the intermediation approach (column 3) or the value added approach (column 4). Evidence from the sample of hybrid studies is not shown as it is poor for the few observations of the group.[8] Finally, Table 4 displays the results obtained from

[7] The Model 3 of Table 2 refers to eq. [4] and might be augmented by including all implicit interactions. For instance, by taking into account the efficiency type (cost, profit and technical efficiency) it could be augmented with ten additional interacting terms (6 doubles and 4 triples). This expanded specification has the caveat that many "interactions" are full of zeros (the sample becomes with few observations when we increases the number of interactions), thereby implying that many coefficients are not estimated. As this exercise is poor in econometrics terms (results are available upon request) we overcome the shortcomings of including all implicit interactions by performing another check, whose results are displayed in Table 3.

[8] It is interesting to point out that splitting the sample should allow better evaluation of the role of specific methodological choices. For instance, when running an MRA only for parametric studies

a sensitivity analysis, which was carried out to test whether the evidence is robust to the exclusion of 1%, 5% and 10% tails of the efficiency and sample size distributions.[9]

Before the results are presented, it is worthwhile commenting on some diagnostics. The main evidence regards $\hat{\beta}_0$, the parameter used as a test for publication bias. A test of $\beta_0 = 0$ (FAT) is a test of the existence of asymmetry in the estimates and publication selection (Stanley, 2005; 2008). $\hat{\beta}_0$ is significant in Model 1,2 and 5 and not in Models 3 and 4. These findings indicate that there is no evidence of publication bias when covariates enter into regressions to explain the heterogeneity in efficiency if REML method if used for the estimations. The same applies after excluding the tails of the key variable of our study, that is to say the efficiency distribution (Table 4). Furthermore, we present some statistics at the bottom of each table that we retrieved from the Stata-command "metareg" developed by Harbord and Higgins (2008). As can be seen, the proportion of the residual variance that is attributable to between-study heterogeneity is very high. In Model 4, it is 98.58%. Again, in the same regression, the proportion of between variance explained by the covariates is 57.71%, the measure of within-study sampling variability. Finally, the joint-significance of explanatory variables is high in each model.

Here it is also important to say that WLS and REML estimations differ in size but not for what concerns the signs of the parameters. However, the negative and highly significant value of the constant is not interpretable in WLS regression. Furthermore, another advantage of REML comes from the fitted value of efficiency. As we learnt from Table 1, the observed efficiency is on average 0,69. Importantly, the average of fitted efficiency is 0.69 in REML model and 0.79 in WLS (data are available upon request for replication).

In order to ensure clarity in the presentation of results, the discussion is divided into two sub-sections. The first devotes attention to the role of estimating methods and approaches in the choice of variables, while the second sub-section looks at the effects exerted by the other variables included in the meta-regression.

(Model 1 of Table 3) the "zeros" of the dummy Cobb-Douglas only refer to functional forms other than Cobb-Douglas and not to point-observations from nonparametric studies, as in Model 3, 4 and 5 of Table 2. The same applies for the dummy VRS for the sub-sample of nonparametric studies (Model 2 of Table 3). Even though assumptions on return to scale are possible whatever the method, many parametric studies do not report which return to scale they use and there is no way to understand the assumption. While the procedure followed in Models 1 and 2 of Table 3 is more appropriate compared with Models 3, 4 and 5 of Table 2, it is fruitful to point out that the results do not change moving from Table 2 to Table 3 (full results of Table 3 are available upon request).

[9] In performing a sensitivity analysis, we restrict the sample to 1%-99%, 5%-95% and 10%-90% intervals of the distribution of efficiency scores (Model 1, 2 and 3 of table 4) and sample size (Model 4, 5 and 6 of table 4).

Table 2 Meta-regression of banking efficiency scores.

Variable		Model 1	Model 2	Model 3	Model 4	Model 5
Constant	β_0	0.6519 ***	0.6498 ***	-0.0050	-0.8838	-5.3870 ***
1/S	β_1	0.000043 ***	0.000038 ***	0.000056 ***	0.000056 ***	0.000001 ***
Parametric (PA)	β_2	-0.0845 ***	-0.1278 ***	-0.0573	-0.0113	-0.1026 *
Intermediation (INT)	β_3	0.1018 ***	0.0800 ***	0.3637 ***	0.3960 ***	0.3534 ***
Value added (Y)	β_4	0.1089 ***	0.1108 ***	0.4967 ***	0.5290 ***	0.3340 ***
Cost (CE)	β_5		0.1012 ***	0.1466 ***	0.1536 ***	0.1695 ***
Profit (PE)	β_6		-0.0126	0.0550 ***	0.0599 ***	0.0601 ***
PA*INT	β_7			-0.2643 ***	-0.2685 ***	-0.3957 ***
PA*Y	β_8			-0.2165 ***	-0.2107 ***	-0.1273 ***
Panel	β_9			0.0116	0.0025	-0.0406 ***
Published	β_{10}			-0.1750 ***	-0.1829 ***	-0.0249 ***
ln(IF)	β_{11}			-0.2099 ***	-0.2341 ***	-0.0744 ***
ln(IF)*PA	β_{12}			0.2986 ***	0.3221 ***	-0.0143
ln(Dimension)	β_{13}			0.4584 ***	0.4587 ***	0.3982 ***
ln(Dimension)*PA	β_{14}			-0.1578 ***	-0.1705 ***	0.2339 ***
ln(Sample Size)	β_{15}			-0.0432 ***	-0.0403 ***	0.0018
ln(Sample Size)*PA	β_{16}			0.0559 ***	0.0524 ***	-0.0018
D2000-2004	β_{17}			-0.0365 **	-0.0485 ***	-0.2610 ***
D2005-2009	β_{18}			-0.1677 ***	-0.1693 ***	-0.1765 ***
Cobb Douglas	β_{19}			0.2015 ***	0.1944 ***	0.1806 ***
VRS	β_{20}			0.0744 ***	0.0832 ***	-0.0042
D_{All}	β_{21}			-0.0174	-0.0210 *	-0.0149 ***
Bank Regulation (Reg)	β_{22}			0.0112 **	0.1007 *	0.5512 ***
Reg*EU	β_{23}				-0.0746	-0.5276 ***
Reg*Eastern Europe	β_{24}				-0.2277 ***	-0.5573 ***
Reg*Latin America	β_{25}				-0.2300 ***	-0.9274 ***
Reg*Africa	β_{26}				-0.1079 *	-0.5519 ***
Reg*Asia	β_{27}				0.1083	-0.8353 ***
Reg*Oceania	β_{28}				-0.0607	-0.5430 ***
EU	β_{29}			0.0718 ***	0.7969	5.1046 ***
Eastern Europe	β_{30}			0.0765 **	0.6836	5.1204 ***
Latin America	β_{31}			0.0731	1.9912 ***	5.3803 ***
Africa	β_{32}			0.1120 ***	1.9108 ***	7.8115 ***
Asia	β_{33}			0.0127	0.9982 *	5.4557 ***
Oceania	β_{34}			0.1119 ***	-0.9648	8.0134 ***
Observations		1165	1165	1043	1043	1043
tau^2 (between-study variance)		0.0241	0.0225	0.0123	0.0119	-
% residual variation due to heterogeneity		98.64%	98.55%	98.58%	98.58%	-
Adj R-squared		11.82%	17.79%	56.33%	57.71%	-
F- Fisher		24.98	27.61	29.36	25.29	-
Goodness-of-fit						70912.13

Legend: * $p<0.2$; ** $p<0.1$; *** $p<0.05$.

Note: Models 1-4 are estimated through REML, Model 5through WLS method.

Table 3 Meta-regression of banking efficiency scores for sub-samples. REML estimations.

	Parametric Studies		Nonparametric Studies		Studies based on the Intermediation approach		Studies based on the value added approach	
1/S	0.0001	***	0.0022	***	0.0001	***	0.0002	***
Parametric (PA)					-1.0676	***	§	
Cost Efficiency (CE)	0.2012	***	0.5917	***	0.0542	**	-0.0538	
Profit Efficiency (PE)	0.0326		0.3420		-0.0093		0.0648	*
Intermediation (INT)	0.0454		0.6480	***				
Production (Y)	0.3438	***	0.8661	***				
CE*INT	0.0486		-0.4941	***				
CE*Y	§		§					
PE*INT	0.1744	***	§					
PE*Y	0.0086		-0.1511					
PA*CE					0.1459	***	§	
PA*PE					0.1750	***	-0.2819	
Controlling variables (study design and regulation)	YES		YES		YES		YES	
Time-Fixed Effect	YES		YES		YES		YES	
Country-Fixed Effect	YES		YES		YES		YES	
Observations	593		450		652		292	

Legend: * p<0.2; ** p<0.1; *** p<0.05.
Note: § dropped for collinearity.

Table 4 Meta-regression of banking efficiency scores. A sensitivity analysis. REML estimations.

		Efficiency distribution			Sample Size distribution		
		Model 1 1%-99%	Model 2 5%-95%	Model 3 10%-90%	Model 4 1%-99%	Model 5 5%-95%	Model 6 10%-90%
Constant	β_0	-0.8029 *	-0.4015	-0.2859	-0.5211	-0.4535	0.0625
1/S	β_1	0.0007 ***	0.0005 ***	0.0003 ***	0.0001 ***	0.0001 ***	0.0001 ***
Parametric (PA)	β_2	-0.0828	-0.0407	0.0482	-0.1462	-0.0894	-0.1640
Intermediation (INT)	β_3	0.3507 ***	0.2561 ***	0.2175 ***	0.3505 ***	0.3200 ***	0.3762 ***
Value added (Y)	β_4	0.4830 ***	0.3940 ***	0.3632 ***	0.4839 ***	0.4790 ***	0.5057 ***
Cost (CE)	β_5	0.1504 ***	0.1663 ***	0.1562 ***	0.1550 ***	0.1580 ***	0.1421 ***
Profit (PE)	β_6	0.0770 ***	0.0589 ***	0.0394 **	0.0653 ***	0.0819 ***	0.0777 ***
PA*INT	β_7	-0.2061 ***	-0.1037 **	-0.0827 *	-0.2301 ***	-0.1935 ***	-0.1930 ***
PA*Y	β_8	-0.1559 ***	-0.1149 **	-0.1581 ***	-0.1578 ***	-0.1544 ***	-0.1382 **
Panel	β_9	-0.0023	-0.0112	-0.0131	0.0150	0.0315 *	-0.0194
Published	β_{10}	-0.1867 ***	-0.1216 ***	-0.0605 **	-0.2103 ***	-0.2311 ***	-0.2216 ***
ln(IF)	β_{11}	-0.2608 ***	-0.2063 ***	-0.1699 ***	-0.2326 ***	-0.2476 ***	-0.2974 ***
ln(IF)*PA	β_{12}	0.3623 ***	0.2655 ***	0.2770 ***	0.3180 ***	0.3595 ***	0.3591 ***
ln(Dimension)	β_{13}	0.4484 ***	0.3431 ***	0.2856 ***	0.4348 ***	0.4343 ***	0.4598 ***
ln(Dimension)*PA	β_{14}	-0.1805 ***	-0.1627 ***	-0.1501 ***	-0.1483 ***	-0.1602 ***	-0.0906
ln(Sample Size)	β_{15}	-0.0419 ***	-0.0269 ***	-0.0164 ***	-0.0591 ***	-0.0452 ***	-0.0483 ***
ln(Sample Size)*PA	β_{16}	0.0582 ***	0.0430 ***	0.0295 ***	0.0605 ***	0.0498 ***	0.0451 ***
D2000-2004	β_{17}	-0.0533 ***	-0.0396 ***	-0.0104	-0.0423 ***	-0.0506 ***	-0.0654 ***
D2005-2009	β_{18}	-0.1842 ***	-0.1303 ***	-0.0829 ***	-0.1810 ***	-0.1925 ***	-0.1976 ***
Cobb Douglas	β_{19}	0.1909 ***	0.1629 ***	0.1234 ***	0.1902 ***	0.1887 ***	0.0996 ***
VRS	β_{20}	0.0952 ***	0.0745 ***	0.0828 ***	0.0645 ***	0.0775 ***	0.0936 ***
Dall	β_{21}	-0.0156	-0.0140	0.0084	-0.0188	0.0016	-0.0215
Bank Regulation (Reg)	β_{22}	0.1019 *	0.0645	0.0478	0.0895 *	0.0763	0.0192
Reg *EU	β_{23}	-0.0647	-0.0358	-0.0255	-0.0623	-0.0800	-0.0416
Reg *Eastern Europe	β_{24}	-0.0646	-0.0363	-0.0185	-0.0535	-0.0450	0.0262
reg *Latin America	β_{25}	-0.2318 ***	-0.1581 *	-0.1332 *	-0.1981 **	0.0846 *	0.0673
Reg *Africa	β_{26}	-0.0774	-0.0672	-0.0571	-0.2116 ***	-0.2187 ***	-0.1686 *
Reg *Asia	β_{27}	-0.1203 **	-0.0933 *	-0.0768	-0.0990 *	-0.0828	-0.0473
Reg *Oceania	β_{28}	0.1159	-0.0249	-0.2345	0.1484	0.2140	0.5296 **
EU	β_{29}	0.6836	0.4033	0.2766	0.6368	0.7417	0.3496
Eastern Europe	β_{30}	0.6983	0.4133	0.2551	0.5648	0.4720	-0.1646
Latin America	β_{31}	1.9721 ***	1.3436 *	1.0855	1.7303 **	§	§
Africa	β_{32}	0.8917	0.7590	0.6690	1.7219 ***	1.7477 ***	1.2521 *
Asia	β_{33}	1.0637 **	0.8119 *	0.6695	0.8694 *	0.7399	0.3542
Oceania	β_{34}	-1.0877	0.3217	2.4288	-1.4107	-2.0746	-5.0932 **
Observations		1022	931	842	1013	937	843
tau^2 (between-study variance)		0.0083	0.0059	0.0033	0.0116	0.0115	0.0098
% residual variation due to heterogeneity		77.89%	60.73%	33.11%	98.62%	98.71%	97.96%
Adj R-squared		66.22%	61.28%	64.54%	59.41%	58.36%	63.57%
F- Fisher		30.26	19.39	14.98	26.06	24.18	25.08

Legend: * p<0.2; ** p<0.1; *** p<0.05.

Note: § dropped for collinearity.

5.2 The roles of the method of estimation and model specification

The first finding to be discussed regards the role of using parametric or nonparametric methods. This issue is important because the majority of parametric studies in our sample use SFA and, similarly, almost all nonparametric studies are based on DEA, which is expected to determine higher efficiency indexes than stochastic models do (Ekanayake and Jayasuriya, 1987). According to our estimates, parametric techniques generate significantly lower efficiency scores than nonparametric models do: the coefficient associated with the dummy *Parametric* is negative and highly significant in Models 1 and 2, indicating that, other things being fixed, the efficiency scores are lower for parametric than for nonparametric techniques. This is in line with a high and positive movement of the random component, as depicted by Nguyen and Coelli (2009). This finding is confirmed after controlling for the approach used in selecting the variables, as can be seen from Model 3 (see the results displayed in table 5 below). It is also worth pointing out that the parametric effect in the other MA applications is found to be neutral with respect to the counterpart, as documented by the inconclusive evidence provided by Thiam et al. (2001) for agriculture in developing countries, Nguyen and Coelli (2009) for hospitals, Brons et al. (2005) for transport and Kolawole (2009) for Nigerian agriculture. Conversely, some similarity with our evidence is found in Bravo-Ureta et al (2007) with regard the agricultural efficiency in developed and developing economies and in Odeck and Bråthen (2009) for efficiency in seaports.

We also show that the approach (value added, intermediation or hybrid) followed in choosing inputs and outputs of the frontier is relevant in the evaluation of banking efficiency. Estimations of Models 1 and 2 indicate that the dummy variable *Intermediation* is always positive, suggesting that studies based on the intermediation approach provide, all being equal, efficiency scores which are higher than those generated by the hybrid approach. The same applies for the value added approach. The order between the effect exerted by the intermediation and the value added approaches depends upon the model we refer to. When considering Model 1, both value added and intermediation approaches over-perform compared with the hybrid and share the same effect ($\hat{\beta}_3 = 0.10; \hat{\beta}_4 = 0.11$). In moving to Model 2, we find that, on average, the value added approach yields the highest level of efficiency, followed by the intermediation and the hybrid approaches ($\hat{\beta}_4 = 0.11$ and $\hat{\beta}_3 = 0.08$). The main conclusions to be drawn are that the hybrid approach generates low levels of efficiency, followed by the intermediation approach. Papers based on the value added approach yield the highest average level of banking efficiency.

The discussion presented so far concerns the effects on the efficiency due to a particular methodological choice rather than another, excluding the possible effects relating to choices that combine the different methods. For instance, it is fruitful to test whether efficiency scores differ when combining the parametric and variable approaches (intermediation, value added or hybrid). Similarly, it appears important to understand whether efficiency differs when using parametric or nonparametric methods, provided that the variables of the frontier are chosen according to one of the three approaches. These issues may be addressed by using the evidence related to the dummies PA, INT and Y and the the interacting terms PA*INT and PA*Y. Results are displayed in Table 5 (the Appendix C shows how calculations have been made).

By referring to the evidence of Model 4 - as displayed in Table 2 - , in Table 5 we report the differences in efficiency obtained when using one variable approach over another, within the class of parametric or nonparametric studies (panel A). The findings confirm the role played by the approach to be followed when selecting the variables of the frontier. The intermediation and the value added approaches yield higher efficiency scores than the hybrid approach does. This holds true in both parametric and nonparametric estimates, although the difference is significant in the latter group. Indeed, when comparing the average level of efficiency resulting from the intermediation and the hybrid approaches, we find a difference of 0.13 in parametric studies and of 0.40 in nonparametric methods. Similarly, while the difference between the value added and the hybrid approaches is 0.32 in parametric studies, it becomes 0.53 in the nonparametric group. The conclusion we can draw is that use of the hybrid approach generates a lower level of efficiency scores than the intermediation and the value added approaches, whatever the method chosen to estimate the frontier. There are also some differences between the intermediation and the value added approaches: on average, the first generates lower levels of efficiency than the second, in both the parametric and nonparametric classes. The difference is equal to -0.19 in parametric studies and to -0.13 for nonparametric methods (Table 5, panel A).

Another finding provided by the estimations of Model 4 regards the evaluation of choosing a parametric instead of a nonparametric method, assuming that the approach taken to select the variables is fixed (Table 5, panel B). What clearly emerges is similar to what is found in Models 1 and 2. While Models 1 and 2 refer to an overall effect of parametric *versus* nonparametric methods, the use of Model 4 disaggregates the evidence by intermediation, value added and hybrid approaches. According to our computations, parametric studies yield, on average, an efficiency level of -0.27 less than nonparametric studies when using the intermediation approach. The difference becomes -0.21 when the value added approach is taken into account. No difference exists within the hybrid approach: indeed the coefficient β_2 in Model 4 is not significant.

Table 5 Differences in average banking efficiency by estimating method and variable approaches

Panel A			
Variable Approach Effects			
	INT *vs* Y	INT *vs* HY	Y *vs* HY
Parametric studies (PA)	-0.1907	0.1276	0.3183
Nonparametric studies (NON PA)	-0.1330	0.3960	0.5290

Panel B	
Estimating Method Effects	
	PA *vs* NON PA
Intermediation (INT)	-0.2685
Value added (Y)	-0.2107
Hybrid (HY)	0

4.3 The role of the other explanatory variables

We proceed by discussing if estimation results differ by efficiency type. Other things being equal, performing a study of cost efficiency yields, on average, higher scores than when estimating a profit or a production frontier. This holds true whatever model we refer to. Furthermore, the size of this effect is also high: in Model 2, the parameter associated with the variable *Costs* is about 0.10 and becomes 0.15 when the complete regression is considered (Model 4). Regressions also indicate that studies focusing on profits generate levels of efficiency that are higher than the production frontier, but lower than the average cost efficiency (i.e., in Model 3 $\hat{\beta}_5 = 0.15$ and $\hat{\beta}_6 = 0.06$). This efficiency ranking deserves attention as it differs from what one expects. Theory states that technical efficiency is higher than cost and profit efficiency with input-oriented technology (Kumbhakar and Lovell 2000; 54) which is an assumption of few papers of our metadata set. Thus, in order to verify if our efficiency ranking is robust to the sample composition, we perform a test by running the MRA for specific sub-samples of observations. This procedure overcomes the shortcomings related to the MRA with all implicit interacting terms (*cfr*. Footnote 7). What clearly emerges from Table 3 is that cost efficiency is higher than the technical efficiency (the controlling group) in parametric and nonparametric studies (columns 1 and 2 of Table 3). The same applies when considering the sub-sample of studies based on the intermediation approach (column 3). Finally, when referring to the studies using the value added approach the evidence is unsatisfactory for the Cost efficiency, thereby meaning that is does not differ from technical efficiency. Interesting, in such a case profit efficiency is, ceteris paribus, the highest (column 4, Table 3).

We find that efficiency obtained from cross-sectional data is not different from that which uses panel data, as $\hat{\beta}_9$ is not significant in all the estimated models of tables 2 and 4. This evidence contrasts with the argument according to which panel data yield more accurate efficiency estimates given that there are repeated observations of each unit (see, among many others, Greene, 1993) and with the empirical results of Bravo-Ureta et al. (2007) and Thiam et al. (2001).

With regard the effect exerted by publication type, results show that the variable *Published* is always negative (i.e., it is -0.18 in Model 4 of table 2) and significant, indicating that the average level of efficiency reported in journal papers is lower than that of studies published as working papers. Following this line of reasoning, further evidence emerges from the attempt to investigate whether the revealed efficiency scores depend upon the type of journals papers appear in. To this end, we use the journal IF and include the interaction *IF*PA* in order to capture possible differences between parametric and nonparametric studies. As the effect of IF may be nonlinear, we take the logs and transform IF into (IF +1) in order to include all observations. According to Model 3, the parameter $\hat{\beta}_{11}$ is -0.23, implying that the level of banking efficiency within the group of nonparametric studies decreases as the IF of the journal increases. In other words, high IF ranked journals tend to publish nonparametric papers which report lower levels of banking efficiency. Results diverge as far as the parametric studies are concerned. Indeed, $\hat{\beta}_{12}$ is 0.32, implying that the relationship between IF and bank efficiency becomes positive for parametric studies (the net effect is about 0.09). It is worthwhile noting that the sign of the relationship between efficiency and IF is robust to the sample of estimates referred to. As table 4 highlights, the effect of IF on the average level of banking efficiency does not change when 1%, 5% and 10% tails of efficiency and sample size distributions are removed. Furthermore, as IF is expressed in logs, the marginal effect of IF decreases as IF increases. For instance, when IF is 0.4 (a value close to the average of IF in both parametric and nonparametric subsamples), the marginal effect will be -0.59 in nonparametric studies. This means that publishing a banking efficiency paper in a journal with a higher IF, say 0.5, determines a decrease of about =0.1*0.59 in the predicted efficiency. Similarly, with IF=0.4, the marginal effect is 0.22 in the parametric sample. However, in such a case, the 0.1 increase (from 0.4 to 0.5) in IF will determine an increase in efficiency of =0.1*0.22. The marginal effect of IF on efficiency is displayed in Figure 3a.

With regard the role of *Dimension*, we find that $\hat{\beta}_{13} = 0.46$ is positive: an increase in the number of inputs and/or outputs included in the nonparametric banking frontiers translates to an increase in the mean efficiency, so confirming the hypothesis of a positive link between the goodness of fit and the level of efficiency. The same applies for parametric studies ($\hat{\beta}_{14} = 0.17$ and the net effect becomes 0.29=0.46-0.17). A positive impact of *Dimension* on efficiency has been found by Nguyen and Coelli (2009), Kolawole (2009) and Thiam et al. (2001). Due to the use of logs, the marginal effect for nonparametric studies is 0.09 when *Dimension* is 5 (close to the overall mean of 5.5). For the parametric group, if *Dimension*=5 the marginal effect will be 0.06. Figure 3b highlights the pattern of the marginal effect on mean banking efficiency when *Dimension* ranges between its minimum and maximum values: given the number of inputs and outputs, the marginal effect in nonparametric is always higher than in parametric studies.

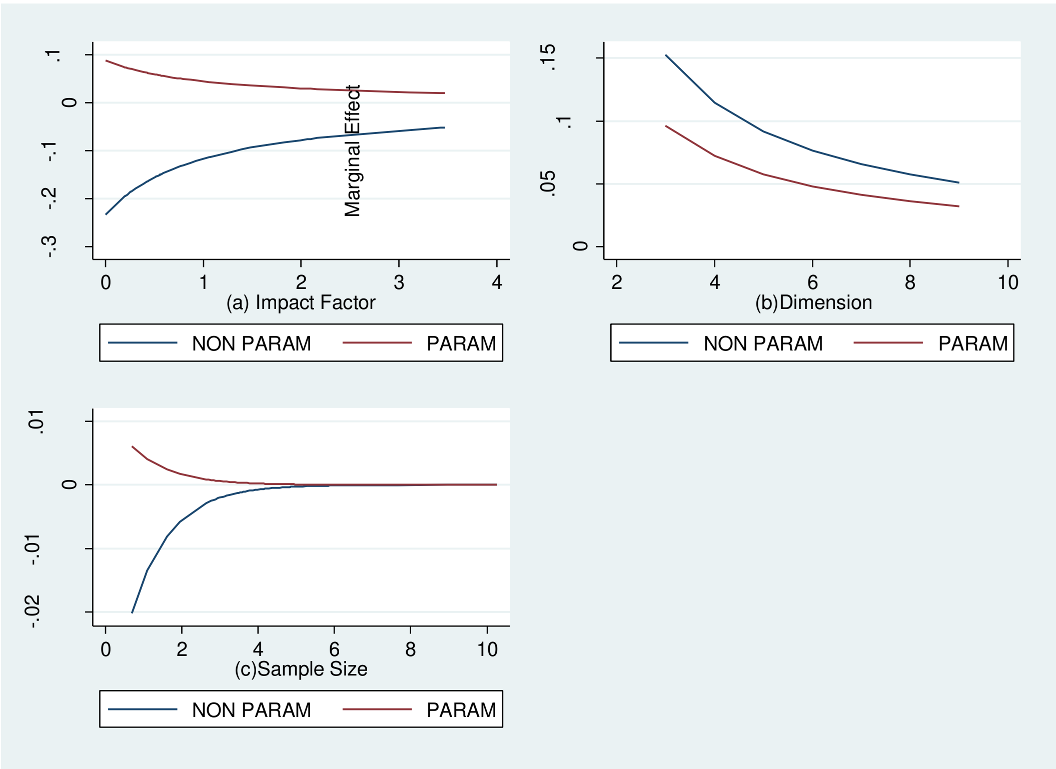
The analysis of the relationship between banking efficiency and the number of observations used in estimating the frontier produces interesting findings. The continuous variable *Sample Size* enters our regressions in logs as we try to control for a potential non-linear effect. It is likely that the impact of sample size diminishes as the observations increase. We also introduce the interaction *Sample Size*PA* in order to verify whether the effect of Sample Size differs between parametric and nonparametric studies. In Model 4, the parameter $\hat{\beta}_{15}$ is negative (-0.04) and highly significant, indicating that nonparametric papers using a large sample of banks report lower levels of efficiency than studies with fewer observations. Interestingly, the coefficient $\hat{\beta}_{16} = 0.05$ is not only positive and significant but also larger than $\hat{\beta}_{15}$, implying that, in parametric studies, the effect exerted by the size of the sample is 0.01: the average level of efficiency increases with the number of observations when estimating banking efficiency using a parametric method. The Sample Size effect does not change when performing a sensitivity analysis of meta-regression results (Table 4). All this also means that the pattern of marginal effect differs between the two approaches: as far as nonparametric studies are concerned, the marginal effect tends to zero from negative values, while in parametric studies it tends to zero from positive values (Figure 3c). Nevertheless, the marginal impact in both cases rapidly tends to zero as sample size increases. With 108 and 63 point-observations (the first quartile of *Sample Size* distribution in parametric and nonparametric studies respectively), the marginal effect is effectively very weak: an increase in the number of observations would determine a very low change in mean efficiency, 0.0001 and -0.0006 respectively (in figure 3c the curve of marginal effects rapidly tends to zero).

Furthermore, we find that the coefficient of the dummy D_{All} is negative, thereby indicating that primary studies focusing on wide and divergent samples of banks are expected to yield, on average, lower level of efficiency than that from papers using homogeneous groups of banks. This is in line with the expectation as heterogeneous samples have high dispersion of data and thus generate (ceteris paribus) lower efficiency than that from studies based on specific and homogenous groups of banks, which are highly clustered around a frontier. Looking at the effect of the choice of the functional form, we find that, on average, the Cobb-Douglas generates higher levels of efficiency than the more flexible functional forms (translog and Fourier). Furthermore, the estimated coefficient of VRS is positive which means that models using VRS hypothesis yields higher efficiency scores than models based on CRS.

With regard the time-effect, we find the average level of estimated efficiency over the years 2000-2004 and 2005-2009 is lower compared with the base years 2010-2014. Estimations related to 2005-2009 period may also be due to the effects on banking performances caused by the crisis originated from the world financial markets. With regard the geographical effect we proceed in two ways. On one hand, the country-effect is meant to impact on the intercepts (Model 3 of Table 2). On the other hand, it might affect the banking regulation slopes (Model 4 of Table 2). We find that the studies on EU members, Eastern Europe, Africa and Oceania yield high level of efficiency, compared to USA (the controlling group). When considering the expanded specification of the MRA (column 4 of Table 2), the efficiency of Latin America, Africa and Asia papers is higher than that observed in the other geographical areas.

A valuable contribution of the paper comes from the use of banking regulation as regressor. In Model 3 the variable Reg has a positive coefficient (0.0112), thereby indicating that the studies for countries with high liberalized credit market yields, on average, higher efficiency scores than the studies focusing on more restricted national banking industries. While Model 3 is in favor of credit market liberalization whatever the country, it is interesting to know if the regulation effect differs at country level. MRA results indicate that some differences exist between the USA (the controlling group) and East Europe, Latin America and Africa. In these countries the role of freedom in banking to explain heterogeneity in efficiency is not only less prominent than that in the USA but it becomes negative. In brief, this MRA provides some insights about regulation over the world: in the USA and EU the high freedom in banking is associated with high values of the efficiency scores from primary-papers. The contrary holds in countries with tighter regulations.

Figure 3 Marginal effects of impact factor, sample size and dimension.



5. Conclusions

This paper collected 1,661 observations of banking efficiency from 120 primary studies published from 2000 to 2014. It used a meta-analysis to evaluate the impacts of a number of related factors on the heterogeneities of efficiency in the primary studies. Our results show that methodological choices cause heterogeneities in banking efficiency. The sensitivity analyses also indicate that the main results are quite robust with respect to different models and subsamples.

First, the descriptive section of our metadata-set highlights the fact that efficiency scores are highly heterogeneous. To be precise, significant differences in means have been found when grouping efficiency on the basis of differing criteria. For instance, cost efficiency is significantly higher than profit and production efficiency. Furthermore, the unconditioned mean of efficiency scores from parametric studies is significantly lower than that from nonparametric studies. This holds true for any frontier type (cost, profit or production). Furthermore, selecting inputs and outputs according to the value added approach yields a higher level of efficiency than the intermediation and the hybrid approaches. Beside differences in means, data also emphasize the existence of substantial differences in the form and shape of efficiency distributions.

Second, it emerges from the meta analysis that some methodological choices can significantly affect banking efficiency. Meta regression results indicate that the studies using parametric methods provide, on average, lower efficiency scores than papers based on nonparametric models. This evidence is confirmed after distinguishing between the primary works based on intermediation and those which use the value added approach or a combination of both. Furthermore, heterogeneity in this area of research significantly depends on how authors select the inputs and outputs of the banking frontier. Other things being equal, papers following the value added approach generate higher levels of efficiency than studies using the intermediation method. Combining these two approaches (within the hybrid approach) yields low levels of efficiency. Importantly, the role of choices relating to the variable approaches is independent of the method (parametric or nonparametric) used to estimate the frontier.

Third, the analysis indicates that the estimated values of banking efficiency depend on other specific factors of primary papers. We find that the average efficiency of published papers is lower than that in unpublished studies, implying that the peer-review process negatively affects the estimates reported in primary papers. With regards to this, there is also a robust nonlinear relationship between efficiency and the journal impact factor. This link is negative in parametric studies, which suggests that efficiency decreases as impact factor increases. The opposite holds for nonparametric studies. These results are more pronounced when the journal impact factor is low. The sign of the effect determined by the sample size differs according to the estimating method: it is negative in nonparametric studies and positive in parametric papers. However, the marginal effect quickly converges to zero in both cases, suggesting that changes in the number of observations have no effect on the average efficiency level for large samples of banks, whatever the method. The number of inputs and outputs included in frontier models of primary studies also affects the results with more inputs and outputs leading to high banking efficiency. In this case too, the marginal effect decreases as dimension increases. A significant role is also exerted by the modeling choices regarding the returns to scale and the functional forms. On one hand, studies assuming variable returns to scale yield higher efficiency levels than studies based on constant returns to scale. On the other hand, the efficiency estimated in frontiers modeled as a Cobb-Douglas is higher than that obtained from more flexible functional forms. Again, the use of panel data does not produce different efficiency scores compared with the use of cross sectional data. Interestingly, our MRA corroborates the view that the specific characteristics of each national banking industry affect the average level of efficiency. In this respect , we find that efficiency of primary papers increases with the level of banking liberalization.

In conclusion, this study organizes the flood of estimates stemming from the recent literature on efficiency in banking. While many individual papers present conflicting arguments concerning the advantages of the various methodologies, we provide clear-cut quantitative effects on bank efficiency caused by alternative methodological choices. Therefore, MA results hopefully give some insights for researchers who are interested in estimating efficiency in banking and testing the sensitivity of their findings to the choice of study design. However, while our main results are robust to different sample of banking observations, the study has some limitations which depend on the data quality. For instance, it would be valuable for academics to know if heterogeneity in banking efficiency might be explained by orientation in technology (input- *versus* output-oriented models). Similarly, data availability of our MRA does not allow the understanding whether efficiency differ according to the bank-type analyzed in the primary papers (i.e., small banks *versus* big banks; commercial banks *versus* mutual-cooperatives; listed *versus* not listed banks). Researchers might address these issues in future work by performing a new MRA. However, this is feasible only if primary papers will provide more detailed information than the one used in this meta-study.

Appendix A

This appendix summarizes the methods applied to estimate the frontier. While the concept of efficiency is subject to different interpretations (Aigner et al. 1977; Battese et al. 2005; Farrell, 1957), there is consensus in considering efficiency to be the degree of proximity of an actual production process to a standard of optimality. Efficiency can be thought of as the ability of a decision unit to minimize the amount of input for the production of a certain output (input-oriented TE) or to maximize the amount of output given a certain amount of input (output-orientated TE), for any level of technology. Furthermore, efficiency may be evaluated and interpreted from different perspectives, depending on whether the focus is on production, profits, costs or revenues. Since efficiency is evaluated in relation to the best-practice, the key concerns in this field of research come from the methods.The proposed classification reports, method by method, the requirements regarding the functional form to be assigned to the frontier, the assumptions regarding the disturbances (existence and composition) and some specificities of the efficiency scores (time-invariant, punctual estimates). A number of advantages/caveats are highlighted for each technique. A common criterion of classification distinguishes between parametric and nonparametric approaches. Parametric methods assign density functions to the stochastic component of the model, while nonparametric methods only define the deterministic part. The SFA, the DFA and the Thick Frontier Approach (TFA) are parametric methods and are all based on a specific functional form of the output-variable (i.e. production, profit, cost or revenue), assign a distribution to the error term and allow to do inference. The DEA and the Free Disposal Hall Approach (FDH) are nonparametric methods. The group name refers to the fact that these methods do not assign a distribution function to the error term. Another criterion is based on how the distance from the frontier should be understood. In this respect, we have stochastic or deterministic methods. The first group admits that a bank may be far from the frontier due to randomness and/or inefficiency. In other words, a stochastic method, such as the SFA, allows the decomposition of the error into two parts, one attributable to inefficiency and the other to random error. On the other hand, when using a deterministic approach, the distance from the frontier is seen as being entirely due to inefficiency. In other words, the determinist approach ignores the existence of pure random disturbance, which may be, for example, due to measurement errors or unforeseen events.

Table A1 A breakdown of some methods used to estimate efficiency

	Nonparametric and determinist approaches		Parametric and stochastic approaches		
	DEA	**FDH**	**SFA**	**DFA**	**TFA**
Functional Form of the Frontier	Not specified	Not specified	To be specified	To be specified	To be specified
Erratic Disturbance	Not allowed	Not allowed	Composite term - inefficiency - random error	Composite term - inefficiency - random error	Composite term - inefficiency - random error
Efficiency	- Time variant - Point estimates	- Time variant - Point estimates	- Time variant - Point estimates	- Time variant - Point estimates	- Time variant - Only general estimate
Advantages	- No constraint to assign a functional form to frontier - No constraint regarding error distribution - Point estimates of each DMU	- No constraint to assign a functional form to frontier - No constraint regarding error distribution - Point estimates of each DMU - No assumption of production set convexity	- Composite error split into a component relating to efficiency and another due to randomness - Point estimates of each DMU	- Composite error split into a component relating to efficiency andanother due to randomness - Point estimates of each DMU	- Composite error split into a component relating to efficiency and another due to randomness
Caveats	- No randomness - No parametric test for inference	- No randomness - No parametric test for inference	- Arbitrary choice of distribution for the error tem - Arbitrary choice of functional form of frontier	- Arbitrary choice of functional form for the frontier - Efficiency is assumed to be time-invariant	Arbitrary choice of functional form for the frontier Arbitrary choice of distribution for the error tem - No point estimates - Arbitrariness in the division of the distribution in quartiles

Legend: DEA = Data Envelopment Analysis; FDH = Free Disposal Hall; SFA: Stochastic Frontier Approach; DFA = Distribution Free Approach; TFA = Thick Frontier Approach.

Appendix B
Table B1 Papers included in the metadata base.

N.	Authors	Year of publication	Journal	Approach to variables	Number of estimations	Average Efficiency	St. Dev.	Min	Max
1	Ab-Rahim, Md-Nor, and Ubaidillah	2012	International Journal of Business and Society	Intermediation	2	0.640	0.094	0.573	0.707
2	Aiello and Bonanno	2013	Economics and Business Letters	Intermediation	2	0.903	0.002	0.902	0.905
3	Akhigbe and McNulty	2003	Journal of Banking and Finance	Hybrid	8	0.760	0.078	0.641	0.855
4	Akhigbe and Stevenson	2010	The Quarterly Review of Economics and Finance	Intermediation	1	0.621	.	0.621	0.621
5	Al Sharkas, Hassan, and Lawrence	2008	Journal of Business Finance & Accounting	Intermediation	4	0.730	0.164	0.525	0.894
6	Altunbas et al.	2000	Journal of Banking and Finance	Intermediation	2	0.943	0.005	0.939	0.946
7	Altunbas et al.	2001	European Economic Review	Intermediation	1	0.794	.	0.794	0.794
8	Andreis and Capraru	2012	Procedia - Social and Behavioral Sciences	Hybrid	3	0.711	0.004	0.707	0.714
9	Ataullah, Cockerill, and Le	2004	Applied Economics	Hybrid	92	0.705	0.165	0.286	0.934
10	Avkairan	2009	Omega	Intermediation	6	0.781	0.046	0.718	0.841
11	Bader et al.	2008	Islamic Economic Studies	Intermediation	72	0.868	0.056	0.739	0.969
12	Barra, Destefanis, and Lubrano Lavadera	2011	Centre for Studies in Economics and Finance - University of Naples	Hybrid	54	0.797	0.086	0.633	0.945
13	Barth et al.	2013	Journal of Banking and Finance	Intermediation	1	0.760	.	0.760	0.760
14	Battaglia et al.	2010	Applied Financial Economics	Intermediation	4	0.776	0.075	0.685	0.868
15	Beccalli, Casu, and Girardone	2006	Journal of Business Finance & Accounting	Intermediation	6	0.825	0.026	0.795	0.866
16	Behr	2010	European Journal of Operational Research	Value-added Intermediation	4	0.797	0.084	0.724	0.891
17	Behr and Tente	2008	Deutsche Bundesbank – Banking and Financial Studies	Intermediation	4	0.599	0.075	0.531	0.673
18	Berger, Hasan, and Zhou	2009	Journal of Banking and Finance	Value-added	2	0.687	0.298	0.476	0.897
19	Berger and Bonaccorsi di Patti	2006	Journal of Banking and Finance	Intermediation	8	0.362	0.212	0.136	0.587
20	Bokpin	2013	Corporate Governance	Intermediation	2	0.465	0.369	0.204	0.725
21	Bonin, Hasan, andWachtel	2005	Journal of Banking and Finance	Value-added	3	0.663	0.189	0.445	0.786
22	Bos et al.	2009	European Journal of Operational Research	Intermediation	10	0.762	0.110	0.610	0.912
23	Bos and Kolari	2005	Journal of Business	Intermediation	8	0.782	0.136	0.607	0.976
24	Canhoto and Dermine	2003	Journal of Banking and Finance	Intermediation	14	0.746	0.096	0.590	0.930
25	Carbo, Gardener, and Williams	2002	The Manchester School	Intermediation	1	0.782	.	0.782	0.782
26	Casu and Girardone	2004	The Service Industries Journal	Intermediation	6	0.753	0.102	0.637	0.874
27	Casu and Girardone	2010	Omega	Intermediation	1	0.765	.	0.765	0.765
28	Casu and Molyneux	2003	Applied Economics	Intermediation	15	0.629	0.033	0.567	0.690
29	Cavallo and Rossi	2002	The European Journal of Finance	Hybrid	4	0.825	0.033	0.788	0.869
30	C. Chen C.	2009	International Monetary Fund	Hybrid	3	0.761	0.032	0.725	0.781

31	K. H. Chen and Yang	2011	Journal of Productivity Analysis	Intermediation	2	0.700	0.083	0.641	0.759
32	T. Chen	2002	The Journal of Operational Research Society	Intermediation	3	0.878	0.083	0.782	0.932
33	Chiu and Y. C. Chen	2009	Economic Modelling	Hybrid	2	0.825	0.162	0.710	0.939
34	Chortareas, Garza Garcia, and Girardone	2011	Review of Development Economics	Intermediation	9	0.657	0.144	0.458	0.836
35	Christopoulos and Tsionas	2001	The Manchester School	Intermediation	4	0.843	0.039	0.792	0.884
36	Cuesta and Orea	2002	Journal of Banking and Finance	Intermediation	2	0.885	0.035	0.860	0.910
37	Daley, Matthews,a nd Zhang	2013	Applied Financial Economics	Intermediation	16	0.768	0.204	0.356	0.961
38	Delis and Tsionas	2009	Journal of Banking and Finance	Hybrid	2	0.874	0.006	0.869	0.878
39	Dietsch and LozanoVivas	2000	Journal of Banking and Finance	Hybrid	12	0.768	0.204	0.356	0.961
40	Drake and Hall	2003	Journal of Banking and Finance	Intermediation	2	0.794	0.098	0.724	0.863
41	Esho	2001	Journal of Banking and Finance	Hybrid	18	0.734	0.213	0.153	0.915
42	Fang, Hasan, and Marton	2011	Bank of Finland	Intermediation	4	0.612	0.090	0.530	0.700
43	Fiordelisi, Marques Ibanez, and Molyneux	2011	Journal of Banking and Finance	Hybrid	3	0.537	0.093	0.445	0.631
44	Fiordelisi and Ricci	2011	The European Journal of Finance	Intermediation	6	0.794	0.129	0.659	0.915
45	Fontani and Vitali	2007	Department of Economics - LUISS Rome	Intermediation	8	0.837	0.092	0.706	0.977
46	Fries and Taci	2005	Journal of Banking and Finance	Intermediation	2	0.658	0.071	0.608	0.708
47	Fuentes and Vergera	2007	Central Bank of Chile	Intermediation	4	0.788	0.192	0.520	0.950
48	Giordano and Lopes	2006	Department of Economics, Mathematics and Statistics - University of Foggia	Hybrid	2	0.941	0.021	0.926	0.955
49	Giordano and Lopes	2012		Intermediation	2	0.889	0.020	0.875	0.903
50	Girardone, Molyneux, and Gardener	2004	Applied Economics	Intermediation	2	0.858	0.001	0.857	0.859
51	Glass et al.	2014	The European Journal of Finance	Value-added	1	0.955	.	0.955	0.955
52	Goddard, Molyneux, and Williams	2014	Journal of Banking and Finance	Intermediation	6	0.793	0.111	0.578	0.870
53	Gordo	2013	Philippine Management Review	Intermediation	10	0.804	0.307	0.032	1.000
54	Guzman and Reverte	2008	Applied Economics	Intermediation	15	0.943	0.023	0.906	0.973
55	Hahn	2007	Empirica	Hybrid	28	0.438	0.153	0.156	0.742
56	Halkos and Salamouris	2004	Management Accounting Research	Valued-added	6	0.930	0.017	0.910	0.950
57	Halkos and Tzeremes	2013	Journal of Banking and Finance	Intermediation	6	0.980	0.013	0.959	0.991
58	Hao, Hunter, and Yang	2001	Journal of Economics and Business	Intermediation	1	0.890	.	0.890	0.890
59	Hasan et al.	2012	PLOS one	Value-added	7	0.946	0.035	0.883	0.985
60	Havránek and Irošvá	2011	Transition Studies Review	Hybrid	48	0.509	0.077	0.391	0.618
61	Havrylchyk	2006	Journal of Banking and Finance	Intermediation	12	0.753	0.125	0.529	0.935
62	Holod and Lewis	2011	Journal of Banking and Finance	Value added Intermediation	69	0.564	0.113	0.356	0.779

63	Huang, Chiang, and K. C. Chen	2011	The Manchester School	Intermediation	30	0.632	0.177	0.401	0.978
64	Huang and Fu	2013	Journal of Productivity Analysis	Intermediation	9	0.698	0.174	0.413	0.871
65	Huang and Wang	2002	The Manchester School	Intermediation	20	0.734	0.113	0.584	0.971
66	Huang and Wang	2003	The Manchester School	Intermediation	10	0.861	0.098	0.686	1.000
67	Huizinga, Nelissen, and Vennet	2001	Tinbergen Institute	Hybrid	2	0.778	0.192	0.642	0.914
68	Isik	2008	Journal of Multinational Financial Management	Intermediation	4	0.795	0.059	0.740	0.860
69	Isik and Hassan	2002	The Financial Review	Intermediation	2	0.866	0.041	0.837	0.895
70	Jiang, Yao, and Zhang	2009	China Economic Review	Hybrid	3	0.722	0.019	0.700	0.734
71	Jimborean, Brack	2010	MPRA	Intermediation	6	0.923	0.042	0.854	0.959
72	Kablan	2010	International Monetary Fund	Value added	1	0.759	.	0.759	0.759
73	Kasman and Yildirim	2006	Applied Economics	Value added	92	0.716	0.085	0.533	0.865
74	Koetter	2006	Journal of Financial Serv Res	Intermediation	6	0.765	0.132	0.643	0.915
75	Koetter and Poghosyan	2009	Journal of Banking and Finance	Intermediation	4	0.828	0.075	0.722	0.896
76	Kohers, Huang, and Kohers	2000	Journal of Financial Economics	Hybrid	6	0.631	0.136	0.449	0.781
77	Kosak and Zoric	2011	Economics of Transition	Intermediation	36	0.863	0.043	0.745	0.951
78	Koutsomanoli-Filippaki, Margaritis, and Staikouras	2009	Journal of Banking and Finance	Value added	1	0.594	.	0.594	0.594
79	Koutsomanoli-Filippaki, Margaritis, and Staikouras	2012	Journal of Productivity Analysis	Intermediation	2	1.025	0.512	0.663	1.387
80	Kraft, Hofler, and Payne	2013	Applied Economics	Intermediation	9	0.674	0.104	0.562	0.872
81	Kumar S.	2013	Economic Change and Restructuring	Intermediation	9	0.882	0.082	0.745	0.960
82	Kumar M. and Arora	2010	Afro-Asian Journal Finance and Accounting	Intermediation	2	0.928	0.001	0.927	0.929
83	Kwan	2006	Journal of Banking and Finance	Intermediation	9	0.305	0.074	0.217	0.417
84	Kyj and Isik	2008	Journal of Economics and Business	Intermediation	14	0.543	0.121	0.320	0.741
85	Liadaki and Gaganis	2010	Omega	Intermediation	12	0.846	0.070	0.760	0.922
86	Lin, Tsao, and Yang	2009	China and World Economy	Intermediation	8	0.279	0.159	0.090	0.477
87	Lozano Vivas et al.	2011	Journal of Productivity Analysis	Value added	33	0.833	0.086	0.705	0.986
88	Luo	2003	Journal of Business Research	Value added	2	0.915	0.049	0.880	0.950
89	Mamatzakis, Staikouras, and Koutsomanoli-Filippaki	2008	International Review of Financial Analysis	Intermediation	46	0.387	0.055	0.306	0.474
90	Matthewes	2010	Cardiff Business School	Intermediation	15	0.756	0.110	0.600	0.927
91	Maudos, Pastor, and Péerez	2002	Applied Financial Economics	Intermediation	60	0.810	0.085	0.665	0.979
92	Maudos et al.	2002	Journal of International Financial Markets	Intermediation	6	0.609	0.254	0.217	0.839
93	Mghaieth and El Mehdi	2014	Ipag Business School	Intermediation	2	0.823	0.002	0.821	0.825
94	Mobarek and Kalonov	2014	Applied Economics	Value added	162	0.679	0.097	0.470	0.950
95	Neal	2004	Australian Economic Papers	Hybrid	15	0.839	0.077	0.712	0.947
96	Papadopouls and Karagiannis	2009	South East European Journal of Economics and Business	Value added	9	0.781	0.007	0.768	0.788
97	Pasiouras, Tanna, and Zopounidis	2009	International Review of Financial Analysis	Hybrid	2	0.824	0.078	0.768	0.879
98	Prior	2003	Journal of Banking and Finance	Value added	9	0.824	0.093	0.662	0.943

99	Ray and Das	2010	European Journal of Operational Research	Intermediation	14	0.721	0.213	0.425	0.970
100	Schure, Wagenvoort, and Obrien	2004	Review of Financial Economics	Value added	1	0.770	.	0.770	0.770
101	Shanmugam and Das	2004	Applied Financial Economics	Intermediation	29	0.531	0.165	0.297	0.756
102	Shen, Liao, and Weyamn-Jones	2009	Journal of Chinese Economic and Business Study	Intermediation	64	0.581	0.255	0.102	0.990
103	Srairi	2010	Journal of Productivity Analysis	Intermediation	36	0.644	0.074	0.513	0.750
104	Staub, da Silva e Souza, and Tabak	2010	European Journal of Operational Research	Hybrid	3	0.583	0.119	0.447	0.669
105	Sturm and Williams	2010	CESifo	Intermediation	8	0.840	0.022	0.800	0.870
106	Sun and Chang	2011	Journal of Banking and Finance	Intermediation	1	0.648	.	0.648	0.648
107	Tecles and Tabak	2010	European Journal of Operational Research	Hybrid Intermediation	32	0.738	0.099	0.509	0.926
108	Thoraneennitiyan and Avkiran	2009	Socio-Economic Planning Sciences	Intermediation	36	0.847	0.099	0.700	0.983
109	Tortosa Ausina et al.	2008	European Journal of Operational Research	Hybrid	1	0.938	.	0.938	0.938
110	Turati	2008		Intermediation	6	0.764	0.024	0.738	0.793
111	Vu and Turnell	2011	Economic Record	Intermediation	6	0.741	0.062	0.693	0.835
112	Weill	2003	Economics of Transition	Intermediation	3	0.660	0.042	0.620	0.704
113	Weill	2004	Journal of Productivity Analysis	Intermediation	15	0.660	0.134	0.402	0.842
114	Williams	2012	Journal of Financial Stability	Hybrid	4	0.628	0.250	0.387	0.903
115	Williams and Gardener	2003	Regional Studies	Hybrid	14	0.920	0.035	0.854	0.958
116	Xiang, Shamsuddin, and Worthngton	2013	Journal of Economics and Finance	Intermediation	3	0.737	0.330	0.360	0.978
117	Yamori, Harimaya, and Kondo	2003	Asia Pacific Financial Markets	Intermediation	6	0.858	0.055	0.799	0.925
118	Yildirim and Philippatos	2007	The European Journal of Finance	Hybrid	52	0.510	0.151	0.274	0.768
119	Yin, Yang, and Mehran	2013	Global Finance Journal	Intermediation	10	0.679	0.105	0.527	0.810
120	Zhang, Wang, and Qu	2012	China Economic Review	Value added Intermediation	2	0.808	0.012	0.799	0.816

Appendix C

This appendix reports the methods used in calculating the differences in average banking efficiency, by estimating method and variable approaches. Compared with the basic model 1 of table 2, the regression to be estimated is augmented by the interacting terms PA*INT and PA*Y and becomes (Equation [4] of Section 3):

$$E_i^* = \beta_0 + \beta_1 S_i^* + \beta_2 PA^* + \beta_3 INT^* + \beta_4 Y^* + \beta_7 (PA * INT)^* + \beta_8 (PA * Y)^* +$$
$$+ \sum_j \beta_j X_j^* + \chi REG_{ct}^* + u_i + e_i$$

By focusing on the dummies PA and INT, this equation allows us to identify six groups, three of which are in the class of parametric methods and three in the class of nonparametric studies. The controlling group is composed of the nonparametric estimations obtained when referring to the hybrid approach, with an expected value of efficiency given by PA=INT=Y=0. The power of this equation lies in the possibility to compare results within and between each class of estimating method. To this end, we calculate the differentials in the efficiency levels for each group compared with the base group. They are:

1. Parametric and Intermediation
$$\Delta Eff\,(PA = 1; INT = 1; Y = 0) = \beta_2 + \beta_3 + \beta_7$$
2. Parametric and Value added
$$\Delta Eff\,(PA = 1; INT = 0; Y = 1) = \beta_2 + \beta_4 + \beta_8$$
3. Parametric and Hybrid
$$\Delta Eff\,(PA = 1; INT = 0; Y = 0) = \beta_2$$
4. Nonparametric and Intermediation
$$\Delta Eff\,(PA = 0; INT = 1; Y = 0) = \beta_3$$
5. Nonparametric and Value added
$$\Delta Eff\,(PA = 0; INT = 0; Y = 1) = \beta_4$$

Some of these are immediately clear. Indeed, it is clear that, compared with hybrid studies, the decision to use the intermediation (value added) approach within the class of nonparametric studies generates a difference in results that is equal to β_3 (β_4). The other cases of interest are the following:

1. The effect of using the intermediation approach instead of the hybrid approach within the parametric studies is $\beta_3 + \beta_7$:
$$\Delta Eff\,(PA = 1; INT = 1 \,\&\, Y = 0) - \Delta Eff\,(PA = 1; INT = 0 \,\&\, Y = 0) = \beta_2 + \beta_3 + \beta_7 - \beta_2$$
$$= \beta_3 + \beta_7$$
2. The effect of using the intermediation approach instead of the value added approach within the parametric studies is $\beta_3 + \beta_7 - \beta_4 - \beta_8$:
$$\Delta Eff\,(PA = 1; INT = 1 \,\&\, Y = 0) - \Delta Eff\,(PA = 1; INT = 0 \,\&\, Y = 1) = \beta_2 + \beta_3 + \beta_7 - \beta_2 - \beta_4 - \beta_8$$
$$= \beta_3 + \beta_7 - \beta_4 - \beta_8$$
3. The effect of using the value added approach instead of the hybrid approach within the parametric studies is $\beta_4 + \beta_8$:
$$\Delta Eff\,(PA = 1; INT = 0 \,\&\, Y = 1) - \Delta Eff\,(PA = 1; INT = 0 \,\&\, Y = 0) = \beta_2 + \beta_4 + \beta_8 - \beta_2$$
$$= \beta_4 + \beta_8$$

4. The effect of using the intermediation approach instead of the value added approach within the nonparametric studies is $\beta_3 - \beta_4$:
$$\Delta Eff\left(PA=0; INT=1 \,\&\, Y=0\right) - \Delta Eff\left(PA=0; INT=0 \,\&\, Y=1\right) = \beta_3 - \beta_4$$

5. The effect of using parametric instead of nonparametric method within the intermediation approach is $\beta_2 + \beta_7$:
$$\Delta Eff\left(PA=1; INT=1 \,\&\, Y=0\right) - \Delta Eff\left(PA=0; INT=1 \,\&\, Y=0\right) = \beta_2 + \beta_7$$

6. The effect of using parametric instead of nonparametric method within the value added approach is $\beta_2 + \beta_8$:
$$\Delta Eff\left(PA=1; INT=0 \,\&\, Y=1\right) - \Delta Eff\left(PA=0; INT=0 \,\&\, Y=1\right) = \beta_2 + \beta_8$$

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