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Aiello, Francesco and Bonanno, Graziella

Department of Economics, Statistics and Finance - University of Calabria I-87036 Arcavacata di Rende (Cosenza) – Italy,
Department of Economics, Statistics and Finance - University of Calabria I-87036 Arcavacata di Rende (Cosenza) – Italy

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Francesco Aiello – Graziella Bonanno

f.aiello@unical.it . graziella.bonanno@unical.it
Department of Economics, Statistics and Finance
University of Calabria
I-87036 Arcavacata di Rende (Cosenza) – Italy

Abstract This study evaluates the cost and the profit efficiency of Italian banking sector over the period 2006-2011. Translog stochastic frontiers are used for this purpose. Following the intermediation approach, efficiency scores are computed from estimating a model with three inputs and three outputs. Results indicate that Italian banks perform well, given that the average levels of cost and profit efficiency are both around 90% and they are quite stable over time. However, there is high heterogeneity in results. Differences have been found when banks are classified by size (efficiency tends to decrease with size), legal type (cooperatives perform better than others) and area (the best performers are in the North East of the country).

JEL codes: G21, C13, D01
Keywords: Banking; Translog Stochastic Frontiers; Cost and Profit Efficiency

1. Introduction

An intense restructuring process of the banking industry has occurred in most countries over the last two decades. This has been aimed at fostering the efficiency of individual banks and competition and financial stability at national level. As far as the case of Italy is concerned, the reform started with the 1990 Amato-Carli Act, the coming into force of EU Directive II and the 1993 Consolidated Act. This was a phase of privatisation which included the elimination of entry barriers and the possibility to open new branches anywhere in the country. The process of institutional reforms has been enriched by other norms, such as the 2002 budget law, the 262/2005 law and the 353/2006 Legislative Decree which aimed at finalising, among other issues, the role of banking foundations in controlling credit institutions. An important force pushing for the restructuring of the sector is the EMU which has encouraged the expansion of banks' activities in foreign markets (on all this see Angelini and Cetorelli 2004; Giannola 2009; Messori *et al.* 2003; Panetta 2003).

All these facts have led to radical changes in the structure of the Italian banking sector. Over-time, there has been: a shift of banking industry from state-owned to private banks; a

marginalisation of banking foundations; a consolidation process, which accelerated in the 2000s, involving the major Italian banks (Banca Intesa, Banca di Roma, Banco Sicily Bank, Unicredit, San Paolo IMI, Capitalia, Monte dei Paschi di Siena, Intesa). The outcome of this process is also documented by the substantial reduction in the number of banks (there were 1037 banks in 1993 and just 706 in 2012) and the increase in bank branches (22133 in 1993 and 32875 in 2012).

Given this circumstance, Italian banks have re-examined their business in several ways regarding their strategies to foster efficiency and face competition better. Thus, it is of great interest to empirically investigate bank performance, given that the industry is now much more market-oriented than in the past. To this end, this paper uses the Stochastic Frontier Approach (SFA) to measure the cost and profit efficiency of almost all Italian banks. In so doing, we follow the specification proposed by Battese and Coelli (1995) and, therefore, we exploit the specificity of the SFA to estimate efficiency scores net of randomness-effect, and are able to get the statistical advantages from estimating the main frontier and the efficiency equation simultaneously.

An aspect of interest in the analysis is related to the period covered, the years between 2006 and 2011. This was a period of instability in financial markets which has not yet been studied in terms of the effects on the efficiency of the Italian banking sector. This article fills this gap by considering a sample of about 700 banks observed annually from 2006 to 2011.

It is also worth noting that the choice of considering both dimension of efficiency overcomes the limits arising from analysing only one of them. Indeed, profit efficiency only gauges performance properly if banks' objectives are restricted to profit maximisation.[1] However, banks tend to minimise costs. Thus, comparing cost and profit helps to understand the type of relationship which occurs when minimising costs or maximising profits. Does one replace the other, or are they complementarily linked? Besides this potential link, it must be said that profit efficiency requires not only technical efficiency and both input and output allocative efficiency (as does the concept of cost efficiency), but also an appropriate scale. In this respect, a bank cannot be on the profit frontier if it is scale inefficient (Berger and Mester, 1997).

Despite the great quantity of literature on bank efficiency - there are exhaustive surveys by Berger and Humphrey (1997) and Fethi and Pasourias, (2010) - few papers have focused on Italy. For instance, Giannola *et al.* (1997) show that small banks had a value of efficiency in 1994 that did not differ from the national level, with a significant contribution by small-banks from North-East of Italy. Large banks registered the highest inefficiency scores. Giannola and Scarfiglieri (1998) argue that cost efficiency and profit efficiency were positively correlated over the period 1993-1996. These years are covered by the study of Girardone *et al.* (2004) which differentiate the analysis by geographical area and bank type, i.e. Ltd, Cooperative Banks (henceforth CBs) and popular banks. They find that overall cost inefficiency decreased over-time and that the best performing group were the CBs followed by the popular banks. At regional level, the highest efficiency scores were recorded by north-western banks. According to Giordano and Lopes (2006), the CBs recorded high cost and low profit efficiency scores in 1993-2003. Instead, popular banks experienced a reduction in both efficiencies. Similar evidence is found in Giordano and Lopes (2012). Fontani and Vitali (2007) focus on the 1994-2004 period and point to the presence of technical progress and scale economies that allowed banking groups to achieve substantial improvements in cost efficiency. Again, Dongili *et al.* (2008) estimate

[1] According to some authors profit efficiency is superior to cost efficiency "for evaluating the overall performance of the firm" (Berger and Humphrey, 1997; Berger and Mester, 1997; Fitzpatrick and McQuinn, 2005). This view is intuitively based on the fact that profit derives from the maximisation of a function which depends on revenues and costs.

bank cost and profit efficiency in the major European countries (France, Germany, Italy, Spain and the UK) for the years 1995-2005. The results show that in each country banks had high cost efficiency and low profit efficiency. Finally, the work by Battaglia *et al.* (2010) explores the case of CBs from 2000 to 2005 and shows that those located in northern Italy achieved higher cost efficiency than those others. However, the opposite holds when considering profit efficiency.

Although the evidence provided by this literature is mixed, three conclusions may be drawn. Firstly, larger banks attain lower efficiency levels. The second result relates to higher levels of cost efficiency for banks in the North of Italy as opposed to those in the South. Thirdly, CBs perform better than other banks in controlling costs.

This study contributes to the debate by updating the analysis and showing that Italian banks performed well over the 2006-2011 period, with profit and cost efficiency at around 90%. However, efficiency was highly heterogeneous. Differences in results emerge when banks are classified by size (efficiency tends to decrease with size), legal type (cooperatives perform better than others) and area (the best performers are in the North East of the country).

The paper is organised as follows. Section 2 presents the method. Section 3 describes the data and section 4 discusses the results. Section 5 concludes.

2. SFA framework and banks' cost and profit frontiers

This section describes the SFA and the frontiers used to measure efficiency. The SFA is a stochastic method because it allows banks to be distant from the frontier also for randomness. In this respect, SFA differs from the DEA, the non-parametric method mostly used in the efficiency literature which supposes that distance from the frontier is explained entirely by inefficiency.[2] Another important feature of SFA is that it assigns a density function to the stochastic component of the model and, thus, permits the make inference. Inference, however, is not specific to SFA, because bootstrapping also makes it possible in a non-parametric framework (see Simar and Wilson 1998; 2000). A further advantage of the SFA is derived from the specification proposed by Battese and Coelli (1995), in which there is also a model for inefficiency to be estimated simultaneously with the main frontier. This specification improves, in terms of consistency, previous modelling where one firstly estimates inefficiency using a frontier and, secondly, uses the estimated value of efficiency as the dependent variable of a subsequent regression (on this "two-step" procedure see Greene (1993)).[3] However, the SFA requires a functional form to be assigned to the frontier and a distribution for the error (see below).

The empirical analysis is carried out by applying SFA to both cost and profit frontier. The following function F_c (.) indicates the minimum cost of producing an output vector y given a price vector w, whereas F_p (.) states the maximum profit obtainable from producing y at input price w.

$$Cost_{it} = F_c(y,w)\exp(v_c)\exp(u_c) \qquad [1]$$

$$Profit_{it} = F_p(y,w)\exp(v_p)\exp(-u_p) \qquad [1']$$

[2] The SFA also appears superior to other parametric methods, such as Thick Frontier Approach, because it provides the scores of inefficiency for any decision making unit.

[3] As shown by Lensink and Meesters (2012) and Wang and Schmidt (2002), the two-step approach suffers from the fact that the inefficiency is assumed to be identically and independently distributed in the main frontier, while it also depends on other variables in the inefficiency equation. In this regards, the specification used in this study also addresses the heterogeneity issue, as in Battaglia *et al*. (2010), Bos *et al*. (2005) and Lensink and Meesters (2012).

As in Berger and Mester (1997), the function [1'] is an alternative profit function since it depends on ***w*** and ***y***, whereas actual profits are related to output-prices. Therefore, the alternative profit function uses the same variables as the cost function, implying that output-prices are free to vary and affect profits (Huizinga *et al.*, 2001). According to Berger and Mester (1997), eq. [1'] is appropriate for measuring profits when there are substantial unmeasured differences in the quality of banking services; outputs are not completely variable; output prices are not accurately measured; output markets are not perfectly competitive. An exhaustive discussion on alternative *versus* traditional profit efficiency is in Vander-Vennet (2002).

By referring to eq. [1], the cost efficiency can be expressed as the ratio between the minimum level of cost of a potentially efficient bank and the cost level actually observed:

$$CE = \frac{F_c(y,w)\exp(v_c)}{F_c(y,w)\exp(v_c)\exp(u_c)} = \exp(-u_c) \qquad [2]$$

while, similarly, profit efficiency is the ratio between the observed banks' profit and the maximum level of profit achievable in the case of full efficiency

$$PE = \frac{F_p(y,w)\exp(v_p)\exp(-u_p)}{F_p(y,w)\exp(v_p)} = \exp(-u_p) \qquad [3]$$

A functional form must be assigned to the frontier, which, in this work, is assumed to be the translogarithmic function. It satisfies the assumptions of non-negativity, concavity and linear homogeneity with respect to input prices (for a detailed discussion, see Kumbhakar and Lovell, 2000). The cost frontier in the log-linear form is:

$$\log Cost = \beta_0 + \sum_j \beta_j \log y_j + \sum_n \gamma_n \log w_n + \frac{1}{2}\left[\sum_j \sum_s \beta_{js} \log y_j \log y_s + \sum_n \sum_q \gamma_{nq} \log w_n \log w_q\right] + \\ + \sum_n \sum_j \alpha_{nj} \log w_n \log y_j + u + v \qquad [4]$$

where *Cost* is a bank's total costs; y_j represents the *j-th* output; w_n is the cost of the *n-th* input; β, γ and α are the parameters to be estimated; u is the inefficiency; v is the random error. The constraint of homogeneity in relation to the input price ($\sum_n \gamma_n = 1$) must be satisfied because of differentiability and the possibility to minimise(maximise) costs(profits). After taking into account this constraint, the estimated model is expressed as follows (w_r is the price of deposits)[4]:

$$\log\left(\frac{Cost}{w_r}\right) = \beta_0 + \sum_j \beta_j \log y_j + \sum_n \gamma_n \log \frac{w_n}{w_r} + \frac{1}{2}\left[\sum_j \sum_s \beta_{js} \log y_j \log y_s + \sum_n \sum_q \gamma_{nq} \log \frac{w_n}{w_r} \log \frac{w_q}{w_r}\right] + \\ + \sum_n \sum_j \alpha_{nj} \log \frac{w_n}{w_r} \log y_j + u + v \qquad [5]$$

With regards the profits, the right-hand side replicates the cost function, while the dependent variable is now given by banks' profit, expressed as $\log\left(\frac{Profit}{w_r}\right)$. A data transformation has been made because profits may be negative. In the same vein of Berger and

[4] Using a transolg function, the linear homogeneity in factor prices also requires (1) standard symmetry ($\beta_{js} = \beta_{sj}$ and $\gamma_{nq} = \gamma_{qn}$) and (2) linear restrictions of the cost (or profit) function ($\sum_n \gamma_{nq} = 0$ and $\sum_n \alpha_{nj} = 0$).

Mester (1997), Bonin *et al.* (2005), Fitzpatrick and McQuinn (2005), Huizinga *et al.* (2001) and Maudos *et al.* (2002) we transform profits by adding the absolute value of minimum profit plus one to actual profits. This ensures that the function $\log(Profit) = \log\left[\pi + \left|\pi^{\min}\right| + 1\right]$ is defined in $[0, +\infty)$.

Another issue to be addressed when using the SFA regards the distribution to be assigned to error. Following some authors (Dongili *et al.*, 2008; Fiordelisi *et al.*, 2010; Turati, 2008), we assumed that the random error (v_{it}) is normally distributed with mean zero and the inefficiency (u_{it}) is distributed as a truncated normal. It is also assumed that v_{it} and u_{it} are independently and identically distributed:

$$v_{it} \sim iidN(0, \sigma_v^2) \quad [6]$$

$$u_{it} \sim N^+(z'\eta, \sigma_u^2) \quad [7]$$

where $z'\eta$ is the linear predictor of the inefficiency equation. The inefficiency component is specified as follows:

$$u_{it} = \sum_{k=1}^{K} \eta_k z_{itk} + e_{it} \quad [8]$$

where z_{itk} represents the *k-th* variable that affects the inefficiency of the *i-th* bank; with $k = 1, ..., K$. t is time and e_{it} the random component. In addition, the inequality $e \geq -z'\eta$ must hold in order to ensure the non-negativity of u.

3. Data and variables

Data on banks are from the *ABI Banking Data* of the Italian Banking Association (ABI), which provides the balance sheets of Italian banks from 1993 to the present. In order to ensure reliability of data, the period under scrutiny covers the period 2006-2011. This is because the implementation of International Accounting Standards (IAS) occurred in 2005 and the individual balance sheets before and after the IAS implementation are not comparable.

A break-down of the sample is presented in table 1. There are 686 banks in 2006, 692 in 2007, 689 in 2008, 686 in 2009, 648 in 2010 and 631 in the final year. The sample is dominated by CBs (in average 63% over time), followed by Ltd (32%) and popular banks (6%). As can be seen, many banks are small and minor (92% of the sample in 2006 and 94% in 2011). In addition, the proportion of banks that have their headquarters in the North is 60% of the sample. This is a much higher value than that for banks that have their registered offices in the South (20%). Table 1 also reports details on banks' size. The average total assets ranges from 2,764 mln euro in 2006 to 3,312 mln euro in 2011. Ltd banks are the category with the largest size (on average 8,879 mln euro in total assets in 2011), followed by popular (7,154 mln) and CBs (approximately 328 mln in 2011). When considering location,[5] the big banks are generally in the north-western of Italy, where the size is, on average, more than 6,3 mln euro in 2011. This value is approximately double that reported by banks in central and north-eastern Italy and nine times higher than the average observed for southern banks (table 1).

[5] As proposed by the Bank of Italy, bank size is defined by considering loans and deposits, the number of employees and of branches, The territorial classification consists of four areas: North-West (Liguria, Lombardy, Piedmont, Aosta Valley), North-East (Emilia Romagna, Friuli Venezia Giulia, Trentino, Veneto); Centre (Lazio, Marche, Tuscany, Umbria), South and Islands (Abruzzo, Basilicata, Calabria, Campania, Molise, Apulia, Sicily and Sardinia).

With regard the variables used in the econometric analysis, it should be noted that there is a debate over whether it is better to use the value added (or production) approach or the intermediation approach (Sealey and Lindley, 1977). These differ mainly in the definition of inputs and outputs to be included in the bank frontier. The added value approach considers loans and deposits as outputs, while labour and physical capital are inputs. Therefore, it considers banks in the same way as it considers manufacturing. In contrast, the intermediation approach identifies the loans as outputs and labour, capital and deposits as inputs. In this case, the bank is seen as a company that collects and manages funds to provide loans to customers. In this paper, variables are used following the intermediation model, which is the appropriate way to measure banks' efficiency according to Berger and Humphrey (1997). Table 2 displays the variables used in estimations.

We estimate a three-inputs, three-outputs model. On the output-side, there is a certain consensus in considering the loans to customers (y_1) as the main banking output. Furthermore, in line with other authors[6], we also introduce commission income (y_2) in reflection of the fact that nowadays banks offer a range of collateral services for which they get gains. The third output is securities (y_3), composed of loans to other banks, equities and bonds (Barra *et al.,* 2011). With regard the inputs, we use labour, capital and deposits. The cost of labour (w_1) is calculated as the ratio between the personnel expenses and the number of employees, capital cost (w_2) is measured as the ratio between the expenses that are not considered in other inputs and the banking product (x_2)[7] and the cost of deposits (w_3) is given by the ratio of interest paid to customers and the value of deposits (x_3).

With regard the determinants of efficiency included in eq. [8], we consider four variables gauging (i) credit quality, (ii) the solvency of banks, (iii) market structure and (iv) market instability at the time of crisis (table 3). Credit quality (z_1) is expressed as the ratio between non-performing loans and total loans.[8] The variable z_2 takes into account riskiness and its effect on efficiency: it is calculated as the ratio between regulatory capital and risk-weighted assets. Thirdly, it is also useful to consider industry concentration as, for instance, in Battaglia *et al.* (2010), Berger and De Young (1997) and Giordano and Lopes (2008). To this end, we use the Herfindahl index (z_3), which is calculated as the sum of squared market shares of each bank in each area. Lastly, the period under scrutiny involves the current crisis and, so, we include the *FTSE* index (z_4) in order to see if there is a relationship between market instability and bank efficiency.[9] Yearly dummy variables are also introduced so as to take into account any other time-effect, and are meant to capture what has happened over the years of the crisis, reflecting

[6] Barra *et al.* (2011), Dongili and Zago (2005); Fiordelisi *et al.* (2010), Giordano and Lopes (2008), Hunter and Timme (1995).

[7] It is worth noting that there are many measurement issues to be addressed in the case of capital. Some studies consider the cost of physical capital, calculated as the ratio between the depreciation and the sum of tangible assets (Fiordelisi *et al.*, 2010). However, this seems to be restrictive for banks which tend to offer online service and, thus, require low levels of physical capital. Another measure of capital is proposed by Barra *et al.* (2011), who calculate the price of capital as the ratio between the sum of administrative expenses, depreciation and other operating costs and the number of branches. Giordano and Lopes (2008) consider the same numerator used in Barra *et al.* (2011), but their denominator is total funds. The capital cost is also calculated as the ratio between regulatory capital and banking product (Fontani and Vitali 2007).

[8] Some authors (Battaglia et al., 2010; Berger and De Young, 1997; Giordano and Lopes, 2008) calculate z1 at individual levels, but this implies that the hypothesis of exogeneity is violated. In this respect, our choice to determine the z_s at territorial level limits the endogeneity bias.

[9] The FTSE used in the paper refers to the Italian banks listed on the Milan Stock Exchange.

phenomena which are different from those gauged by the other z-variables. It must be said that all efficiency-determinants are defined at macro-regional level. While variable z_1 is calculated by using the location of customers (data are from the Bank of Italy), the factors z_2, z_3 and z_4 are determined by aggregating the micro-data of the sample used in this paper. The link between data at bank level and regional level has been made by considering the region where the bank's headquarters are situated. Finally, regressions are augmented by a set of binary variables in order to control for any difference in efficiency caused by legal category, geographical location and bank size. Table 4 presents some descriptive statistics of the variables included in the cost and profit frontiers.

Table 1 Description of the sample.
Number of banks and size* by year.

	2006		2007		2008		2009		2010		2011	
	Banks	Size	Banks	Size	Banks	Size	Banks	Size	Banks	Size	Banks	Size
Area												
North-West	151	6,011	149	6,955	144	8,210	152	7,464	138	5,762	129	6,370
North-East	241	1,636	242	1,884	242	1,877	239	2,045	231	2,883	230	3,020
Centre	151	3,250	150	3,106	154	3,238	150	3,381	144	3,182	139	3,418
South	143	725	151	701	149	712	145	768	135	742	133	736
Legal form												
LTD	218	7,327	218	7,845	222	8,593	233	8,082	207	8,001	193	8,879
CCB	431	241	436	257	428	278	414	301	406	318	404	328
Popular	37	5,276	39	6,368	39	5,506	39	6,001	35	6,689	34	7,154
Size												
Minor	514	277	520	244	521	281	517	296	496	342	489	344
Small	118	2,393	119	2,623	118	2,801	121	2,958	109	2,790	102	3,120
Medium	32	11,100	35	13,100	33	15,900	29	13,800	29	14,200	27	16,000
Large	13	25,000	11	28,900	10	30,600	12	31,200	10	32,700	9	40,000
Major	9	87,800	7	121,000	7	133,000	7	137,000	4	202,000	4	203,000
Total	686	2,764	692	2,983	689	3,253	686	3,268	648	3,177	631	3,312

Note: *average value of total assets, expressed as the ratio between the total assets and the number of banks of each group. Constant values in mln of euro - NIC Index Istat, base year = 1995.
Source: our calculations based on data from ABI.

Table 2 Definition of the variables included in the cost and profit functions

Variables	**Name**	**Description**
y_1	Loans	Loans to customers (Stock variable). It includes current accounts, repurchase agreements, mortgages, credit cards, personal loans and salary-backed loans, transactions relating to financial leasing and factoring, business loans, structured debt securities and other securities
y_2	Commission Income	Revenues arising from non-traditional loans and deposits of banks (Flow variable). It includes incomes from trading of financial instruments and currencies, custody and administration of securities, business consulting, management of insurance products, collection and payment services, collection services.
y_3	Securities	Sum of loans to other banks, equities and bonds (Stock variable)
x_1	Labour	Number of employees
x_2	Capital	Gross Banking Product
x_3	Deposits	Debts to customers
w_1	Labour cost	Ratio between the personnel expenses and the number of employees
w_2	Cost of capital	Ratio between the other expenses (commission expenses, operating costs, depreciation of fixed assets, the administrative costs that do not relate to personnel expenses and the interest expenses that do not relate to those calculated on deposits) and the Gross Banking Product (that is the sum of loans, direct and indirect funding)
w_3	Cost of deposits	Ratio between the interest expenses and the debts to customers
Costs (*y, w*)	Total costs	$w_1x_1 + w_2x_2 + w_3x_3$ = Administrative expenses + Depreciation of fixed assets + Interest expenses + Operating costs + Commission expenses
Profits (*y, w*)	Total profits	$\log(Profit) = \log\left[\pi + \left|\pi^{\min}\right| + 1\right]$

Table 3 Definition of variables included in the inefficiency equation

Variables	Name	Description
z_1	Credit Quality	Ratio between bad loans and total loans for each areas according to the location of customers. Source: Bank of Italy
z_2	Solvency index	Ratio between the regulatory capital and the risk-weighted assets for each areas. It is a proxy of the risk faced by banks and it takes into account the directions in the Basel regulations. Risk-weights consider the operational risk (the risk of loss due to errors in the management of ordinary banking activities), market risk (the risk of loss due to the change in value for financial instruments) and credit risk (risk of loss due to insolvent counterparties)
z_3	Herfindahl index	Sum of squared market shares of each bank (total assets of each bank over the total assets of each area),
z_4	FTSE	Index FTSE measuring the banking performance in Milan Stock Exchange
d2006, d2007, d2008, d2009 d2010	Time	Annual binary variables. 2011 is the controlling group-year
d_ltd, d_pop	Legal form	Dummies for legal form. CCB is the controlling group
d_smallest, d_med, d_large, d_major	Size	Dummies for size. small-banks is the controlling group
d_nw, d_centre, d_south	Geographical location	Dummies for geographical areas. North-East is the controlling group

Table 4 Average values of input and output (2006-2011)
(constant values in mln of euro - NIC Index Istat, base year = 1995)

Variables	Obs.	Mean	S.D.	Min	Max
Cost	3766	161456.60	856024	378.2148	20100000
Π	3766	10226.17	108520	-1040415	4395613
Profit	3766	1050642	108520	1	5436029
y_1 = *loans to customers*	3766	1712072	8435175	1.45	182000000
y_2 = *commission income*	3766	27212.08	133176	0.72	2880022
y_3 = *securities*	3766	716470.30	5922604	206.47	154000000
w_1 = *labour cost*	3758	53.14	20.50	7.12	712.77
w_2 = *cost of capital*	3766	0.0595	1.0283	0.000048	44.81
w_3 = *cost of financial*	3741	0.0135	0.0344	0.000008	1.25

Source: see table 1.

4. Econometric results

4.1 Stochastic frontier estimations

The approach of considering the SFA frontier and the equation of inefficiency in one single model yields a set of estimated parameters which is presented here in two different tables (tables 5 and 6) for ease of exposition.

Table 5 presents the results obtained when estimating the cost and profit frontiers by using the R-project software. The estimated parameters of a translog function are not interpretable in economic terms, but it is still worth noting that, except for $\gamma 2$ and $\gamma 12$, they are always highly significant.[10] One meaningful result regards the value of gamma, which is the ratio between the variance of the inefficiency component and the variance of the composite error. It is close to unity in both the cost and profit frontiers, indicating that almost all of the distance from best practises depends on inefficiency. This evidence is statistically supported by the Likelihood Ratio test, which verifies the correct model specification of a SFA *à la* Battesi and Coelli (1995). The test is based on the null hypothesis that all the parameters in the inefficiency equation [eq. 8] are equal to zero. Phrased differently, if the null hypothesis is accepted, then the OLS estimate will be consistent because the inefficient term u is zero and hence the composite error comprises only randomness. Results indicate that the LR is 805.13 and 4570 in cost and profit frontiers respectively and, therefore, the null hypothesis is rejected at 1% (taking the critical values of the chi-square distribution as tabulated by Kodde and Palm (1986) (table 5).

The estimates retrieved from the inefficiency model are displayed in table 6. Something that is immediately evident is that all variables are significant at least at 5%. With regards to the role of each factor, we find the presence of a positive relationship between bad loans (z_1) and banks inefficiency, whatever the frontier (cost or profit): low credit quality results in high (lower) inefficiency (efficiency). This contrasts with Battaglia *et al.* (2010) who find no significant relationship between cost efficiency and bad loans over the period 2000-2005.[11] The estimated coefficient of solvency index (z_2) is always negative and suggests that banks' cost and profit efficiency increases with capital adequacy: bank performance increases when banking risk is low. This result means that an increase in banks capitalisation to meet operational and market risk induces an improvement in bank efficiency in cost and profit frontiers. The effect of market concentration on efficiency differs according to the frontier. In case of costs, the coefficient is negative and indicates that a higher concentration allows higher cost efficiency levels to be reached.[12] The opposite holds when considering profits. The FTSE index reflects the changes due to the current crisis. The estimated negative relationship between the FTSE and inefficiency means that an increase in the index corresponds to a reduction in inefficiency levels. Looking at the actual dynamics of the FTSE, we see a decrease in financial transactions in 2008, 2010 and

[10] We also implement a LR test to verify the correct functional form of the frontiers. Under the null hypothesis there is the Cobb-Douglas model. We always reject the null hypothesis at 1% in favour of the translog.

[11] In line with the hypothesis of bad management (Berger and De Young, 1997; Williams, 2004), Giordano and Lopes (2006) give a possible explanation for the relationship between credit-quality and inefficiency. Indeed, because of managerial choices, the increased cost efficiency is a result of cost savings in screening and monitoring activities. This, however, may have negative consequences on credit-quality and risk.

[12] Similar results are found in Fontani and Vitali (2007), but contrast with those of Turati (2008), according to which a higher concentration involves lower cost efficiency levels. However, these two papers consider the Herfindahl index calculated at national level, while we refer to territorial markets.

2011. Given the signs of our estimates, it is possible to argue that the annual negative changes in the FTSE in these three years caused an increase in the inefficiency of the Italian banking industry. As regards the annual dummy variables, we find that in 2006, 2007 and 2008 the inefficiency levels were lower than in 2011. The opposite is true for the years 2009 and 2010 when there were lower efficiency scores than in 2011.

The positive coefficients associated with territorial dummies highlight the role of location in efficiency. Other things being equal, banks in north eastern Italy perform better than others, whatever the frontier. Moreover, estimations reveal that banks with their headquarters in the south of Italy perform less well than north eastern institutions, but better than those in the Centre and North West. It is also important to underline that cooperatives banks are the best performing type of bank. Mixed results are found when considering dummies associated with size, where the effect varies according to the frontier. The understanding of size effect on banking efficiency is also discussed in the next paragraph.

Table 5 Cost and profit frontiers of Italian banks.
Translog estimates over the 2006-2011 period

	Cost	**Profit**
β_0	-5.44***	10.18***
β_1	0.73***	0.02
β_2	-0.20***	-0.29***
β_3	0.38***	0.16***
γ_1	1.60***	1.18***
γ_2	0.03	-0.05
β_{11}	0.04***	0.01***
β_{12}	-0.06***	-0.03***
β_{13}	-0.03***	0.05***
β_{22}	0.03***	0.02***
β_{23}	0.02***	-0.07***
β_{33}	0.01***	0.03***
γ_{11}	-0.05***	-0.002
γ_{12}	-0.004	-0.02
γ_{22}	0.05***	0.06***
α_{11}	-0.06***	-0.03***
α_{12}	0.07***	0.08***
α_{13}	-0.02*	-0.06***
α_{21}	0.07***	0.03***
α_{22}	-0.05***	-0.03***
α_{23}	-0.002***	0.01
σ^2	119.43*	260.38***
$\gamma=\frac{\sigma_u^2}{\sigma^2}$	0.9997***	0.9999***
Log-likelihood	363.15	1557.894
LR test	805,13* (34,2)+	4570* (34,2)+

Significance levels: '***' = 0.01; '**' = 0.001; '*' = 0.05; '.' = 0.1; ' ' = 1.
+ LR critical value as tabulate by Kodde and Palm (1986)
Source: see table 1

Table 6 Cost and profit inefficiency equations Italian bank.

Estimates over the 2006-2011 period

	Cost	**Profit**
z_1 = *bad loans*	615.77*	1580.20***
z_2 = *solvency index*	-868.05*	-733.66***
z_3 = *Herfindahl index*	-2875.70*	4728.90***
z_4 = *FTSE*	-0.03*	-0.09***
d2006	-105.64*	-236.19***
d2007	-73.35*	-658.29***
d2008	-859.18*	-4062.70***
d2009	163.84*	-213.31***
d2010	121.89*	-1196.20***
d_ltd	684.34*	3004.90***
d_pop	892.63*	2555.40***
d_minor	-65.13*	16.50***
d_med	-402.49*	760.80***
d_large	-170.87*	1004.60***
d_major	152.38*	1114.10***
d_nw	607.00*	273.02***
d_centre	262.75*	107.54***
d_south	144.99*	157.71***

Significance levels: '***' = 0.01; '**' = 0.001; '*' = 0.05; '.' = 0.1; ' ' = 1.

Source: see table 1.

4.2 Average levels of cost efficiency in Italian banks

Table 7 shows some descriptive statistics for the estimation of cost and profit efficiency scores from 2006 to 2011. The average values of cost and profit efficiency are both slightly higher than 90%. From the cost point of view, Italian banks would have needed only 90% of the inputs used in offering banking services. They earned 90% of their potential profits and, thus, a 10% recovery of profitability would have been possible without increasing inputs. On average, this evidence indicates that Italian banks perform similarly when they control costs or generate profits. We can see from table 8 that this holds even when considering results year-by-year: the average level of efficiency is 91% in both cases in 2006, declines up to 2008 and shows a slight recovery in the two subsequent years. In 2011, cost and profit efficiency scores are around 90%, a lower value than that observed for 2010. While the average values of cost and profit efficiency are comparable, a certain heterogeneity exists between and within groups. The density function of cost efficiency differs from that of profit (figure 1). Profit efficiency is more dispersed than cost efficiency, and the standard deviations are 0.1162 and 0.0825 respectively. Again, the median cost efficiency is 92.4%, while, in the case of profits, it is 94.54%. Finally, for 1% of the

banks, cost efficiency ranges from 4.89% to 50%, while the upper value of profit efficiency is 34.41% for 1% of banks (table 7).

Marked differences in results emerge when disaggregating the analysis by year and bank category (table 8). Whit regards the banks' institutional type, we find that cooperatives perform better than other categories in both frontiers and in every year. On average, over the 2006-2011 period, cooperatives register a cost inefficiency of 3.3% and a profit inefficiency of 4.1%. These are much lower values than those estimated for Ltd, which are about 14% inefficient, whatever the frontier, and popular banks, which have a gap of 17,1% from the cost frontier and almost 13% in the case of profits. Over time, we see a common decline at the beginning of the period, a recovery in 2009 and 2010 and a new loss of efficiency in 2011. These time-changes do not alter the empirical regularity according to which cooperatives gain more in generating profits than in controlling costs (although the gap in efficiency scores is not wide and disappears in 2011). The same applies for popular banks, even though the levels of efficiency are always lower than those registered for cooperatives and the within-group gap between cost and profit efficiency is larger than that revealed for CBs. The picture changes for Ltd, which show a different pattern in efficiency: except for 2010, their cost efficiency is always higher than their profit efficiency. Interestingly, at the end of the period, the distance between profit and cost behaviour increased, as a consequence of the sharp reduction in 2011 profitability.

Other insights derive from classifying banks by size. Three main facts emerge. Firstly, minor banks perform better than others, whatever the frontier: their inefficiency is less than 7% in profitability and 8.5% in managing costs. What we learn from this is that the minor banks, the majority of the Italian banking sector (table 1), make better use of inputs and outputs than any other group. This is always true. The same thing applies for small banks from a profitability point of view, while mixed evidence is found from cost-side (where small banks might reduce inputs by 14,53%, a value close to that (14,16%) observed for large banks and much higher than the cost inefficiency of medium banks (10,22%). Secondly and more in general, we find a sort of size-effect in efficiency. Data clearly indicate that efficiency decreases when size increases. This scale effect is evident in profitability scores recorded in 2009 and 2011, whereas, in the other years, it applies for the first four bank-groups (we find that major banks perform better than large banks in generating profits in 2006, 2007, 2008, 2008 and over the entire 2006-2011 period). A noteworthy fact is that profit efficiency in 2006-2011 is 93.19% for minor banks, 87.29% for small banks, 72.86% for medium banks and 60.01% for large banks. The last group is that of the major banks, which registers a profit efficiency of 63.98%, a higher value than that observed for large banks, but sharply lower than that observed for any other sub-sample. Similarly, a size effect is revealed on the cost side. In this case, with the exception of small banks, the average scores for the six-year period 2006-2001 are 91.56% for minor banks, 89.78% for medium-sized banks, 85.85 for large banks and only 77.60% for major banks. This negative relationship between size and cost efficiency is at work in every year. A final element to be pointed out regards the fact that cost and profit efficiencies record very narrow values for minor and small banks (with cost efficiency slightly higher than profit efficiency). The contrary holds for other groups: medium, large and major banks perform better when controlling costs than when producing profits. The difference in efficiency scores is high at any time and assumes remarkable numbers for 2011 when banks tended to improve their behaviour in managing costs and experienced a drastic worsening in profitability (table 8).

Table 7 Some descriptive statistics of cost and profit efficiency scores (2006-2011)

Cost Efficiency

	Percentiles	Smaller values		
1%	0.5008	0.0490		
5%	0.7830	0.0548		
10%	0.8387	0.0612		
25%	0.8950	0.0672	Obs	3741
50%	0.9245		Mean	0.9021
			Std.	0.08
		Larger values		
75%	0.9413	0.9737		
90%	0.9523	0.9788	Variance	0.0068
95%	0.9566	0.9801	Skewness	-486.57
99%	0.9643	0.9855	Kurtosis	3.595.15

Profit Efficiency

	Percentiles	Smaller values		
1%	0.3441	0.000001		
5%	0.68178	0.0872		
10%	0.8140	0.1142		
25%	0.9112	0.1190	Obs	3741
50%	0.9454		Mean	0.9048
			Std.	0.11
		Larger values		
75%	0.9571	0.9898		
90%	0.9629	0.9905	Variance	0.0135
95%	0.9656	0.9908	Skewness	-3.729.905
99%	0.9713	0.9909	Kurtosis	1.896.607

Source: see table 1

Figure 1 Density of cost and profit efficiency

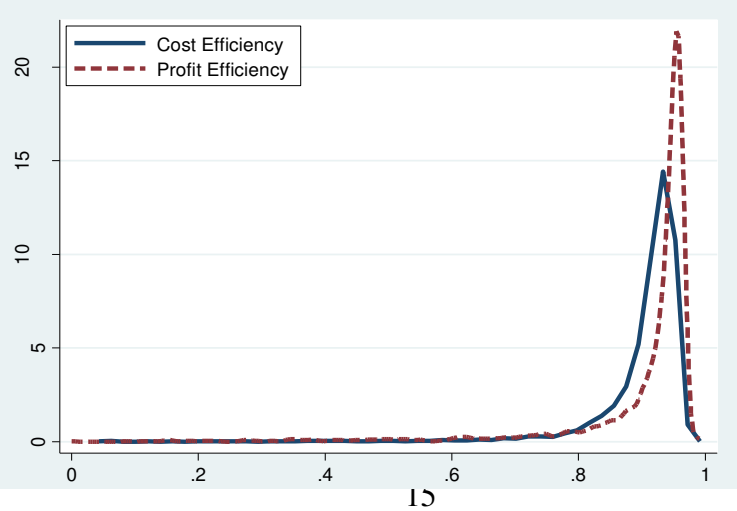

Table 8 Cost and profit efficiency of Italian banks by legal form, size and area (2006-2011)

	2006	2007	2008	2009	2010	2011	2006-2011
Cost Efficiency							
All sample	0.9156	0.8955	0.8766	0.9008	0.906	0.9207	0.9021
Legal form							
Ltd	0.8751	0.8557	0.8203	0.8634	0.8703	0.8866	0.8608
Popular	0.8583	0.8182	0.7799	0.8106	0.8419	0.8782	0.8290
Cooperative Banks	0.9378	0.9203	0.9129	0.9256	0.9263	0.9402	0.9270
Size							
Minor	0.9286	0.9117	0.8996	0.9123	0.9151	0.9278	0.9156
Small	0.8675	0.8438	0.8005	0.8612	0.8748	0.8874	0.8547
Medium	0.9117	0.8806	0.8607	0.9032	0.9092	0.9290	0.8978
Large	0.8753	0.8581	0.7734	0.8779	0.8552	0.9236	0.8584
Major	0.8551	0.7745	0.6759	0.7787	0.7881	0.8586	0.7760
Area							
North West	0.8696	0.8503	0.8315	0.8681	0.8794	0.8857	0.8635
North East	0.9388	0.9138	0.8974	0.9230	0.9394	0.9448	0.9258
Centre	0.9183	0.9054	0.8800	0.8999	0.8855	0.9172	0.9007
South	0.9163	0.8983	0.8816	0.8959	0.8940	0.9174	0.9000
Profit Efficiency							
All sample	0.9191	0.8993	0.8814	0.9102	0.9298	0.8930	0.9048
Legal form							
Ltd	0.8436	0.7962	0.7731	0.8293	0.8685	0.7844	0.8138
Popolar	0.9105	0.8734	0.8345	0.8692	0.9187	0.8658	0.8762
Cooperative Banks	0.9529	0.9497	0.9383	0.9511	0.9570	0.9459	0.9490
Size							
Minor	0.9398	0.9320	0.9154	0.9368	0.9470	0.9232	0.9319
Small	0.8909	0.8565	0.8413	0.8747	0.9108	0.8687	0.8729
Medium	0.7895	0.6892	0.6275	0.7712	0.8302	0.6789	0.7286
Large	0.6783	0.5959	0.5444	0.6525	0.6840	0.4066	0.6001
Major	0.8225	0.7152	0.6719	0.5718	0.7718	0.2391	0.6398
Area							
North West	0.8746	0.8320	0.8093	0.8590	0.8992	0.8334	0.8499
North East	0.9464	0.9298	0.9157	0.9367	0.9505	0.9172	0.9325
Centre	0.8998	0.8865	0.8642	0.9022	0.9084	0.8790	0.8894
South	0.9346	0.9254	0.9104	0.9229	0.9452	0.9237	0.9264

Source: see table 1

5. Concluding remarks

This paper evaluates cost and profit efficiency in the Italian banking sector over the years from 2006 to 2011, a period of structural reforms and increasing competition. By using a stochastic frontier approach on a wide single sample of banks, the study provides evidence on the likely mis-estimation involved when considering exclusively cost or profit efficiency.

When referring to the overall results, no biased image of efficiency appears to occur given that the average levels of cost and profit efficiency are both around 90% and stable over time. The picture changes when the sample of banks is divided into sub-groups. For instance, the groups of medium, large and major banks perform better when controlling costs than when generating profits. In such cases, studies which only focus on the cost frontier will overestimate the capability of the Italian banking industry to be efficient. With regards these three groups of banks, it is worth emphasising that profit efficiency is quite a bit lower than cost efficiency and that they diverge further in 2011. As the profit measure we use admits the existence of market power in setting the prices of output, the evidence signals that Italian medium and large sized banks suffer the increase of competition in national and global markets at the time of the current financial crisis. Two different results have been found for minor-small banks. They not only perform significantly better than medium, large and major-sized banks, whatever the frontier, but their cost and profit efficiency scores are similar in size. Therefore, being small is an advantage in performing well. It also emerges that for all the years included in the analysis, cooperatives banks attained the highest efficiency scores. They even perform better than the Ltd, which are all the banks involved in recent radical changes.

The main conclusion to be drawn from these results is that the Italian large and major-sized banks face the competitive pressures in international financial markets more than the others do and this tends to reduce the opportunity to make profits. Within this scenario, there are some banks, the smallest and those organised as CBs, that perform better than all the others because, evidentially, they still enjoy of a certain degree of monopolistic power in the very restricted local markets where they operate.

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