Assessing Bank Efficiency and Stability*

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Abstract

In this paper I introduce a new banking efficiency indicator that includes efficiency and stability conditions. This indicator relies on the leverage as a proxy of a bank's risk and stability. Banks' leverage played an important role in the last financial crash as well as in the Basel III new regulatory rules. The results of the econometric investigation using a large sample of American commercial banks show that profit efficiency indicators including leverage are better predictors of future profits than current indicators including other measures of bank risk. This is particularly evident for the period during the 2007 - 2009 financial crisis.

JEL classification: C13, C33, E47, G21, G32
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1 Introduction

An interesting aspect of the latest financial crisis is that not only did very efficient banks fail, but that they failed despite them complying with the Basel II rules. This puts into question both the effectiveness of these rules and the efficiency models of banking.

Searching for the roots of the last financial turmoil, Demirguc-Kunt and Huizinga (2010) provided evidence that between 1995 and 2007 there was an expansion of non-lending and non-deposit activities via leverage while the rate of return and risk of banks increased with their fee income share. Similarly, Beltratti and Stulz (2012) documented that the banks that performed poorly during the crisis had extremely high returns and more leverage in 2006; in contrast, the banks that performed better during the crisis had a lower average return and leverage in the same year. On the same line, Berger and Bouwman (2013) provided evidence that capital always increases the probability of survival of small banks and enhances the performance of medium and large banks primarily during banking crises.

These results are due to the fact that banks rationally pursue profits in booms, and accept book losses in busts, as money making opportunities in booms are so attractive. Leverage enhances risk taking and the opportunity to exploit valuable investment opportunities today. On the other hand, highly leveraged banks may be forced to liquidate their portfolios at prices below fundamental values in bad times[1]. Hence, leverage increases the cyclicality of investment and profits and the trade-off between efficiency and stability.

It is noticeable that neither models of banking efficiency nor the Basel II rules deal with leverage and its effect on banking stability and risk in the long run. Even early profit or cost efficiency indicators do not include risk at all. They estimate how close a bank is to producing the maximum possible profit or minimum cost given a particular level of input prices and output prices (and other variables). More recent tests of banking efficiency (e.g., Hughes et al. 1996 and Hughes, Mester and Moon 2001) include measures of risk in the bank efficiency indicators, and they estimate a best-practice risk-return stochastic frontier that gives the highest expected return at any particular risk exposure. Inefficiency is measured by the difference between its potential return and its noise-adjusted expected return, gauged among its peers with the same level of risk. However, the most recent efficiency indicators are still short run in nature and they do not consider the capability of the bank to face adverse conditions in the long run. One implication of this assumption is that a bank with too little expected profit for the amount of risk it is taking is deemed

[1] Despite the fact that banks in the period that run up to the last financial crisis were subject to regulations related to the three Pillars of Basel II (capital requirement, supervisory review and market discipline), regulations on activity were associated with increases in non deposit funding, suggesting that banks could have been circumventing such restrictions on their asset composition by adjusting their funding mix to increase their risk-taking.

inefficient even if the latter is characterized by much better stability conditions than a similar bank on the efficient frontier. Moreover, current tests of efficiency are based on the assumption that any combination of risk and return is equally efficient as long as it lies on the efficient frontier. But, bank managers very often face a trade-off between giving up profit opportunities today to increase their opportunities tomorrow. This trade-off comes from the fact that banks which take on too much risk relative to their resources face a higher probability to be insolvent when adverse effects occur in the future. And the above mentioned empirical evidence suggests that this trade-off may be relevant: being more leveraged and profitable banks before the crisis but more vulnerable to adverse economic conditions. The failure of current models of banking efficiency to take into account the trade-off between efficiency and stability may bring about misleading conclusions on the efficiency conditions of the bank.

This study contributes to the literature on banking efficiency in two ways: Firstly, it builds up a new indicator of profit efficiency which takes into account the trade-off that banks face between efficiency and stability. Secondly, it tests the capability of current tests of banking efficiency as well as one proposed in this paper to predict future profits, both before and after the last financial crisis.

With regard to our suggested efficiency indicator, this relies on the role of leverage as indicator of bank's stability. Specifically, we assume that the level of efficiency of a bank is higher if the bank is characterized by the same risk and return but has a lower leverage than its counterpart. A low leveraged bank may take more advantage of future profits in a boom and it can more easily limit losses if adverse economic conditions occur than a highly leveraged bank. Incorporating leverage into the efficient frontier provides a better understanding of the bank's soundness, since it allows to evaluate whether current expansion of bank's profits occurs at the expense of future additional profits or losses. Note that, leverage not only estimates the impact of external adverse effects on the bank's balance sheet conditions, but it accounts for the likely effects of the bank's failure on the entire economic system (which can make some banks too leveraged to fail). We claim that if the new efficiency indicator including leverage is a better predictor of bank's soundness in a more dynamic contest, this indicator should be a better predictor of future profits than current risk adjusted efficiency indicators, both in a boom and in a bust. The last financial crisis provides a natural experiment to test this assumption. So, using the sample of the US commercial banks included in the Bankscope dataset over the period 2003-2012, we estimate whether more efficient and stable banks at the onset of the crisis were able to withstand better the impact of the crisis. We report strong empirical evidence that highlights the importance of leverage and its imperative inclusion in the estimation of profit efficiency. The superiority of our proposed profit efficiency index, that accounts for both bank's risk and stability conditions, with respect to its predictive power (compared to those currently used in the literature), is supported in all empirical specifications.

The paper includes six sections. Section 2 introduces the key contributions to the literature on banking efficiency and risk on which we base our subsequent analysis. Section 3 presents our proposed efficient indicator as well as the models that we estimate. Section 4 deals with the features of the dataset and Section 5 reports and discusses the econometric results. The final section makes some concluding remarks.

2 Banking efficiency and risk

There is a large literature under the heading "non-structural and structural approaches", which aims at testing efficiency of banks. The non-structural approach compares productivity and performance ratios among banks and considers how these ratios are related to investment strategies and banks' characteristics, such as the quality of bank's governance, its product mix, etc. The structural approach usually relies on the economics of cost minimization or profit maximization, where the performance equation denotes a cost or a profit function. More recently, the optimization problem amounts to managerial utility maximization, where the manager trades off risk and expected return.

As far as the structural performance equation is concerned, this can be fitted to the data as an average relationship which assumes that all banks are equally efficient at minimizing cost or maximizing profit, subject to a random error ε_i, that is assumed to be normally distributed. On the other hand, the structural performance equation can be estimated as a stochastic frontier to capture best-practice and to gauge inefficiency; i.e., the difference between the best-practice performance and achieved performance. In the stochastic frontier, the error term, ε_i, consists of two components: a two-sided random error that represents noise ($v_{\pi i}$) and a one-sided error representing inefficiency ($u_{\pi i}$).

The standard profit function[2] studied in the literature (Berger and Mester, 1997), in log form, is:

$$\ln(\pi + \theta)_i = \ln g(p_i, w_i, z_i, h_i) + v_{\pi i} - u_{\pi i} \quad (1)$$

where π is the variable profits of the bank; θ is a constant added to every bank's profit so that taking the natural log is a positive number; p is the vector of prices of the variable outputs; w is the vector of prices of variable inputs, z is a vector of variables that capture key components of the ith bank's technology (e.g., inputs or outputs, such as physical plant, which cannot be changed quickly), h is a set of environmental or market variables that may affect performance (e.g., market conditions, regulatory restrictions) but are not

[2] In contrast to the cost function, the standard profit function allows for consideration of revenues that can be earned by varying outputs as well as inputs, and some prior evidence (e.g., Berger et al. 1993) suggests that inefficiencies on the output side may be as large or larger than those on the input side. In addition, profit efficiency is based on the more accepted economic goal of profit maximization, which requires that the same amount of managerial attention be paid to raising a marginal dollar of revenue as well as to reducing a marginal dollar of costs.

a choice for firm management, $v_{\pi i}$, represents random error; and $u_{\pi i}$ represents inefficiency that reduces profits.

Profit efficiency is the ratio of the actual profits to the maximum profits that could be earned if the bank was as efficient as the best-practice bank in the sample, net of random error.

The standard profit function assumes that markets for outputs and inputs are perfectly competitive. By contrast, if banks have market power there is an alternative profit function (Berger and Mester, 1997), where banks take as given the quantity of output and the price of inputs (p) and maximize profits by adjusting the price of the output (w) and the quantity of inputs.

Both standard and alternative profit functions or frontiers are measured without considering the banks' capital structure or banks' choice of risk. But, as pointed out by Hughes et al. (1999, 2000), this is a serious omission[3], since banks production technologies embody their ability to diversify and offset a variety of risks, and the production decisions that managers take may mirror their incentives to take on risks as well as to diversify them. Therefore, more recent efficiency models (Hughes et al., 1996, 1999, 2000; Hughes, Mester and Moon, 2001) consider a more general objective function than profit maximization that include measures of risk related to production plans and they estimate a best-practice risk-return frontier and measure inefficiency relative to it. Precisely, they suggest an estimation of a stochastic frontier similar to (1) that gives the highest expected return at any particular risk exposure:

$$E(\pi_i/k_i) = a_0 + a_i\sigma_i + a_2\sigma_i^2 + v_{\pi i} - u_{\pi i}, \quad (2)$$

where k_i denotes equity and $E(\pi_i/k_i)$ expected return on equity; σ_i is the standard error of profit, a measure of risk.

A bank's return inefficiency is the difference between its potential return and its noise-adjusted expected return, gauged among its peers with the same level of return risk[4].

Estimation by Hughes et al. (2000) of the alternative efficiency models for a sample of US commercial banks show that results obtained from the utility maximization model that includes risk differ significantly from the standard profit-maximization model without risk. Similar results are obtained by Koetter (2006) for German universal banks. In addition he finds evidence that low profit efficiency may merely result from alternative yet efficiently chosen risk-return trade-offs.

[3] Hughes (1999) pointed out that this omission can be justified in a one-period model by assuming that production decisions do not influence risk.

[4] Hughes and Mester (2008) pointed out that this measure of inefficiency does not take into account whether bank's managers are taking too much or too little risk relative to the value-maximizing amount.

Subsequent literature investigates the relationship between efficiency and risk and what is the most appropriate indicator of risk. There are ex ante and ex post indicators of risk. The latter include non-performing loans to total loans, loan-loss provisions to total loans, and the ratio of risk-weighted assets to total assets (Casu et al., 2006). Berger and Humphrey (1997) noticed that it is appropriate to include problem loans among the explanatory variables of efficiency if bad loans are caused by "bad luck" events exogenous to the bank, but if they are endogenous to the bank (e.g., due to "bad management"), then they should not be controlled for in the analysis of efficiency. However, bad loans covers only one part of the business (i.e. loans). A wider indicator of risk used in the literature is the variance of profits, evaluated ex ante or ex post. However, the problem with an ex post measure of risk is that they use information from a fixed number of periods in the past, and therefore they assume risk is exogenous to other bank characteristics. On the other hand, many authors (Kim and Santomero, 1988; Rajan 2005; Diamond and Rajan, 2000; Hughes, 1999; Hughes et al., 2001; DeYoung et al., 2001; Freixas and Rochet, 2008; Degryse et al., 2009; Delis et al., 2014) recognize that banks make risk decisions simultaneously with the perception about expected profits and other banks' characteristics, mainly capital and liquidity. Delis et al. (2014) present a model in which profits, risk (the variability of profits) and other banks' characteristics (notably, capital and liquidity) are simultaneously determined. They show that, differently from other risk indicators that remain stable all through the period, the endogenous risk indicator of US banks is stable up to 2001 and accelerates quickly thereafter up to 2007. Following the same line of thought, Chen (2012) pointsout that risk may be considered as undesirable output, or an endogenous variable to be incorporated directly into the production or cost function. He clarifies that risk refers to an ex ante concept and undesirable output refers to an ex post concept. Using the reciprocal capital adequacy ratio as the risk input factor, Chen shows that neglecting the risk input would bring about a distortion of total factor productivity estimation for banks, including a biased estimation of the technological frontier and an overestimation of the degree of scale economy. Similar results are obtained by Altunbas et al. (2000) for Japanese banks. Optimal bank size is considerably smaller when risk and quality factors are taken into account. But these factors do not seem to affect X-inefficiency. However, Altunbas et al. (2000) find that scale inefficiencies dominate X-inefficiencies.

These results suggest that the inclusion of risk into the efficiency measures does affect conclusions on banking efficiency. But empirical evidence on the relationship between efficiency and risk provides contrasting results. Hughes and Moon (1997) and Hughes and Mester (1998) find that inefficient American banks are also more risky; in contrast, Altunbas et al. (2007) provide evidence that inefficient European banks appear to hold more capital and take on less risk. Further, Fiordelisi et al. (2010), using both an ex post and a forward looking measure of risk, do not find a strong relationship between capital and risk for European banks. They find that profit efficiency negatively Granger-causes risk in European banks. These results suggest that American and European banks may respond to different incentives (regulatory hypothesis versus moral hazard hypothesis), or they might differ in the quality of the management. The authors emphasize the importance of attaining long-term efficiency gains to support financial stability objectives.

The last remark addresses the issue of whether current efficiency indicators are suitable to measure banking efficiency also in the long run. Notice that including financial stability issues implies evaluating risk and efficiency in the long run; in turn the latter requires in the efficiency indicator inclusion of forward looking risk indicators. However, neither variance of expected profits nor other forward looking risk indicators used in the literature (expected default, loan loss provision) take into account the trade-off that may exist between a bank's current profits and future profits, due to the business cycle which characterizes the market economies.

3 The model

Leverage allows to expand balance sheet and to increase profits in a boom, but it also increases losses in a bust, forcing banks to liquidate assets below fundamental prices. This is due to the fact that, if banks borrow short term to underwrite securities that finance long term projects, they might not be able to maintain those investments on their books should economic conditions deteriorate. In busts, banks would like to hold on to these undervalued securities but they may be forced to liquidate them by creditors. Thus, leverage promotes a further expansion of balance sheets in boom times, and may lead to liquidations of bank portfolios at prices below fundamental values in bad times.

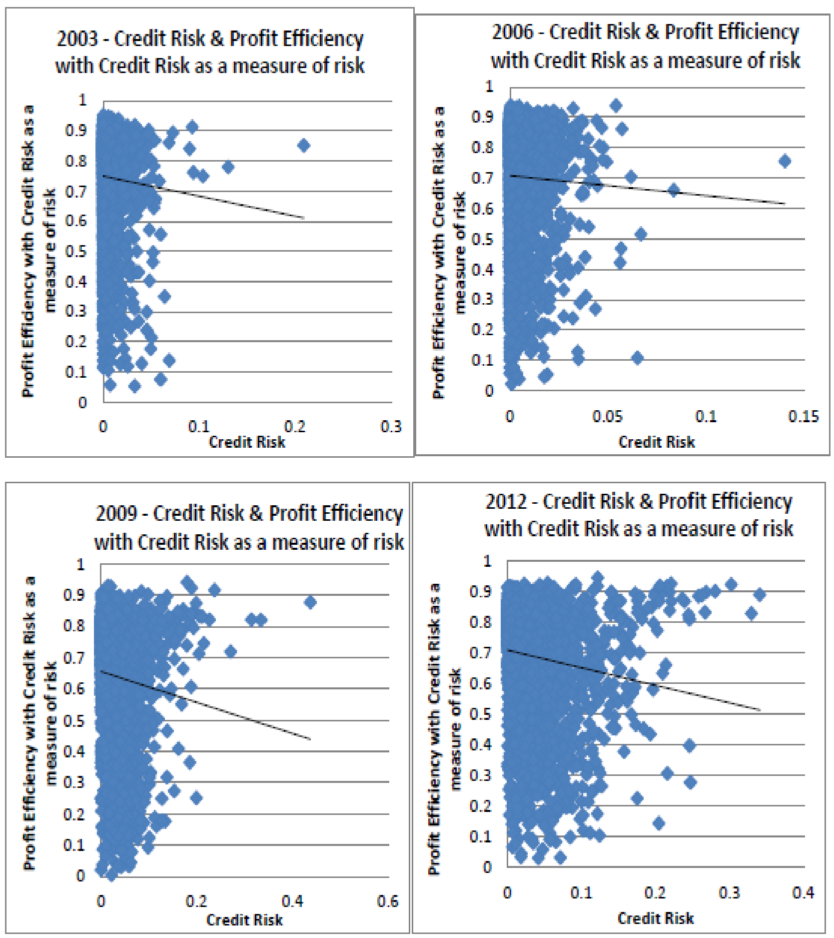
There is a difference between leverage and other indicators of risk. Non-performing loans is an indicator of risk that shows itself only after the crisis hits and loans cannot be repaid, and the variance of expected profits is a short run forward looking indicator of risk. By contrast, leverage is an indicator of risk in the long run, since it considers the trade-off that may exist between profits today and tomorrow, due to the fact that banks which take on too much risk relative to their resources face a higher probability to be insolvent when adverse effects occur in the future. That is, leverage incorporates stability issues which are not considered by other risk indicators, and the profit efficiency indicator including leverage is more related to bank risk in the long run than in the short run.

Other things equal, we would expect that the relationship between leverage (and the other risk indicators) and profit efficiency of the bank is negative.

The figures reported below show some stylized facts of the American commercial banks included in the Bankscope dataset between 2003 and 2012.

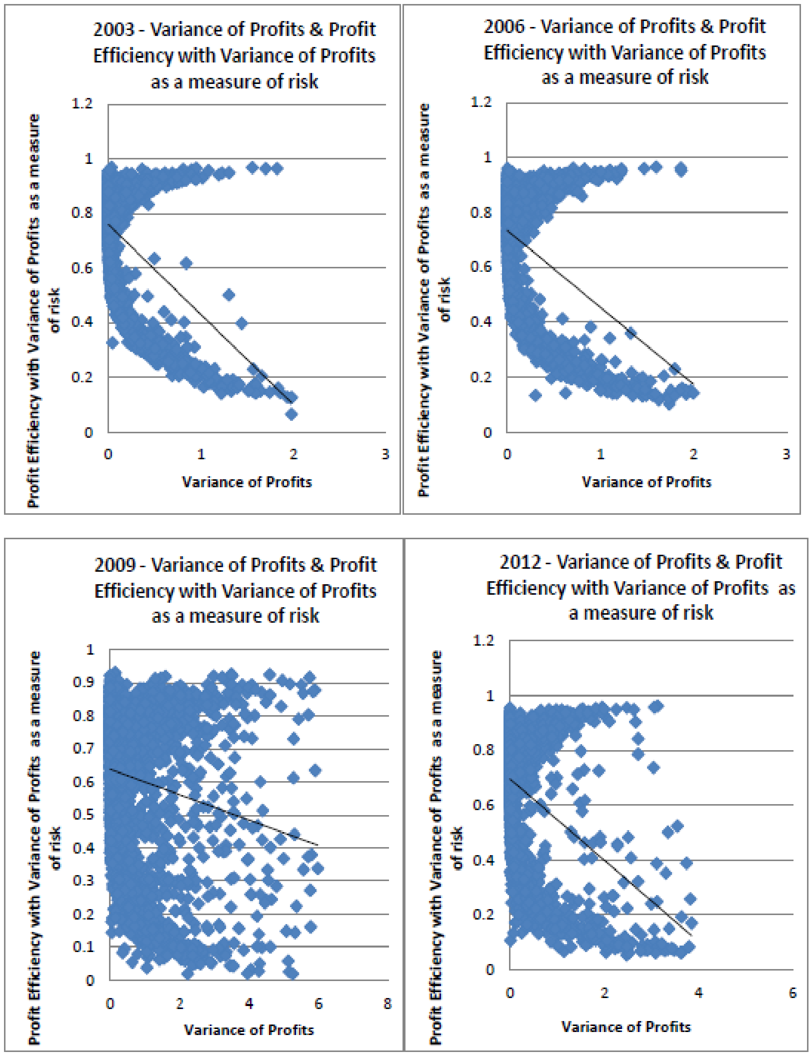
Figure 1(panel‘ A and B) shows profit efficiency and risk for all the banks included in our sample. On average there is a negative relationship between risk and profit efficiency of the banks, both when we measure risk by the *ex-post* and the *ex-ante* risk indicator. If we consider only the banks that are on the efficient frontier, the relationship between the *ex-post* risk indicator and profit efficiency is negative; by contrast, the efficient frontier is positively related to risk when we consider the variance of profit, an *ex-ante* risk indicator.

Figure 1, Panel A



Notes: The figures present the relationship between credit risk and a profit efficiency index, that has been adjusted for credit risk, in four time periods, i.e., 2003, 2006, 2009, 2012.

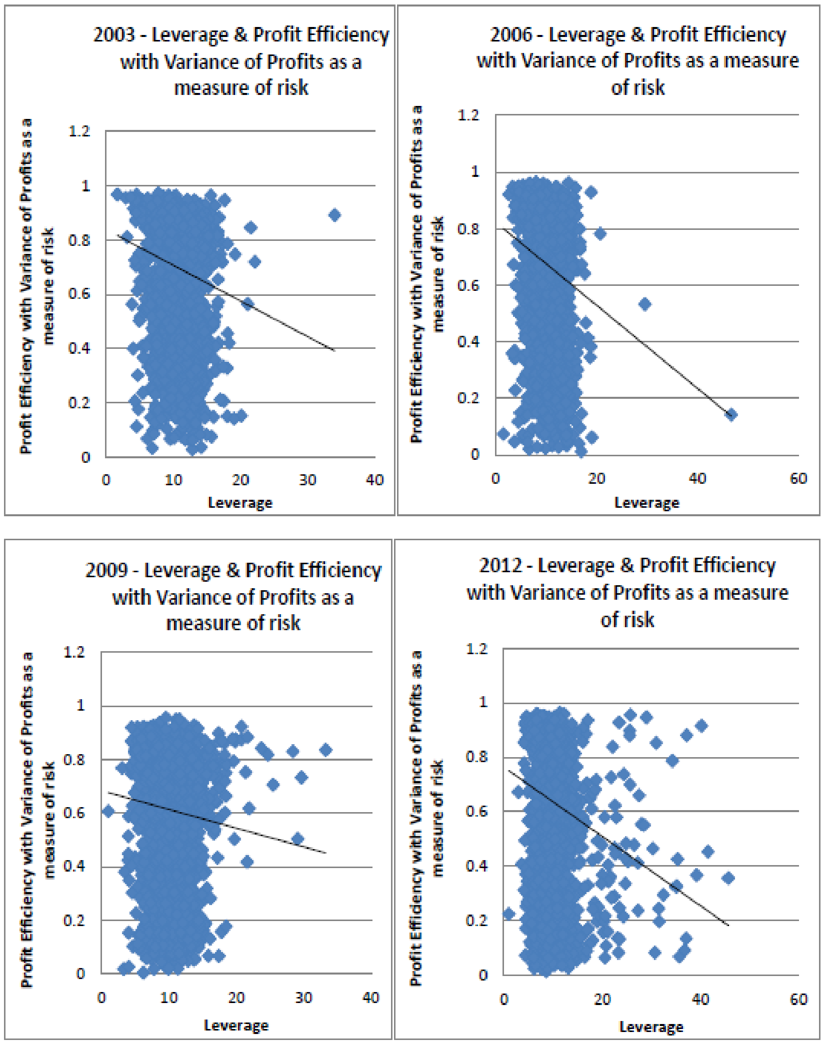
Figure 1, Panel B



Notes: The figures present the relationship between variance of profits and profit efficiency index, that has been adjusted for variance of profits, in four time periods, i.e., 2003, 2006, 2009, 2012.

Further Figure 2 shows that there is on average a negative relationship between profit efficiency and leverage, irrespective of the efficiency indicator we use and whether we are in a boom or bust. More interesting, for the banks on the efficient frontier there is an inverse u-shaped relationship between profit efficiency and leverage, suggesting that banks achieve the maximum value of profit efficiency with intermediate values of leverage.

Figure 2



Notes: This figure presents the relationship between leverage and profit efficiency index, that has been adjusted for variance of profits, in four different time periods, i.e., 2003, 2006, 2009, 2012.

The above empirical evidence suggests that leverage does shape the level of efficiency of the bank, and we include this long run measure of risk into the profit efficiency indicator. Specifically, the profit efficiency indicator (PEI) is the ratio between the bank's expected profit (π_i) and the maximum expected profit (π_j) among the banks with the same level of risk:

$$PEI_i = \frac{\ln(\pi_i)}{\ln^{\max}(\pi_j)}, \tag{3}$$

where (π_i) is determined by the following stochastic frontier model:

$$\ln(Prof_{it}) = a_0 + \sum_{l=1}^{2} a_{ql} \ln q_{it,l} + \sum_{s=1}^{2} a_{ps} \ln p_{it,s} + a_{NPI} \ln NPI_{it}$$
$$+ a_{\sigma 1} \ln(\sigma 1_{it} + 1) + a_{\sigma 2} \ln(\sigma 2_{it}) + u_{it} - v_{it} \quad (4)$$

As dependent variable (i.e., $Prof$) we use total profits before tax (PBT) and, as a robustness check, return on average equity ($ROAE$). In order to tackle the issue of negative profits (losses) we follow the approach proposed by Bos and Koetter (2011) that allows the use of all the available information in the sample. Specifically, we left-censor profit but assign a value of one to those banks with negative profit. In order to include all information available on the censored part of profit we specify an additional independent variable NPI (for Negative Profit Indicator). Consequently, we define profit to be equal to one for positive values of profits, and equal to the absolute value of profit for a loss-incurring bank.

In the estimation of the profit efficiency we make two assumptions. First, efficiency is measured by how close a bank comes to earning maximum profits given its output levels rather than its output prices. That is, banks have some market power. Second, following the intermediation approach (Sealey and Lindley, 1977), we treat deposits as inputs in the production process.

Further, we specify the two mainstream types of outputs as total loans (q_1) and total earning assets (q_2). With regard to inputs we distinguish three types of inputs: (1) the total intermediated funds (F), which consists of savings accounts, current accounts, time deposits, repurchase agreements and alternative funding sources, (2) labor (L), which refers to the manpower involved in the operations of all the credit institutions in the sample and (3) the physical capital depreciation and amortization (K), which consists of fixed assets, including tangible fixed assets (land, buildings, office equipment, etc., less depreciation) and intangible assets (software, under- writing expenses, research expenses, etc.). We measure the price of input (p_1) by using the ratio of interest expenses to total deposits and short term funding. Also we measure the price of input (p_2) by using the ratio of staff expenses to total assets. Lastly we measure the price of input (p_3) by using the ratio of fee and commission expenses added to administration expenses to fixed assets. Notice that linear homogeneity in input prices has to be imposed a priori for the estimation of the profit frontier to develop appropriately. This requires:

$$\sum_{s=1}^{3} a_{ps} = 1 \quad (5)$$

In turn, linear homogeneity restrictions are imposed on all input prices and the dependent variable with respect to one of the input prices. Here we use the price of physical capital depreciation and amortization (p3) as a numeraire. Finally, σ_1 denotes non-performing loans to total loans (an *ex post* indicator of risk) and σ_2 bank's leverage (an *ex ante* indicator of the bank's risk and stability). The other variables have been defined above.

The final specification of our profit stochastic model is a log-linear transformation of a Cobb-Douglas production function.

Since leverage reflects more risk for a bank in the long run than in the short run, we expect the above efficiency indicator to be a better predictor of future profits of the bank than models including *ex post* or short run *ex ante* risk measures in bank efficiency indicator.

In the second stage of the empirical investigation we test this prediction, by estimating the capability of alternative profit efficiency indicators to predict future profits. More precisely, we test the following equation:

$$\begin{aligned} \ln Prof_{it+n} = a_0 + a_1 \ln p_{1,it+n} + a_2 \ln p_{2,it+n} + a_3 \ln q_{1,it+n} + a_4 \ln q_{2,it+n} \\ + a_5 \ln NPI_{it+n} + a_8 Riskadj\_PE_{it} + \varepsilon_{it+n}, \end{aligned} \tag{6}$$

where $Prof$ represents two alternative measures of bank's profitability, i.e., $ROAE$ and PBT. $Riskadj\_PE$ denotes alternative profit risk adjusted efficient indicators. Specifically, we compare the predictive power of the model with profit efficient indicator defined by equation (3) above with alternative econometric models including profit efficient indicators with only ex post or/and short run ex ante risk indicators. We test the predictive power of the alternative profit efficiency indicators in a pre-crisis, during-crisis and post-crisis state of the economy respectively by comparing absolute standard errors and mean standard errors tests of alternative specifications of the equation (6) above.

4 Data

Data used for the estimation of the model consists of a balanced panel of the American commercial banks during the period 2003–2012. Following the majority of empirical studies in banking, the largest part of our bank-level data comes from the Bankscope database of Bureau Van Dijk's company. Any missing information on the variables of interest is filled in from the official websites of the US banks and by the Annual reports of the Board of Governors of the Federal Reserve System. Overall, our sample accounts for a significant market share in terms of assets, loans and deposits. More precisely, the initial sample of the American commercial banks included in the Bankscope dataset consisted of 75,219 observations for 8,886 financial institutions. After building up the balanced panel we ended up with 3,076 financial institutions and 30,760 observations. Bankscope provides company account statements for banks and financial institutions by collecting financial statements with both consolidation and unconsolidation status. We selected the unconsolidated data and excluded the equivalent consolidated data to avoid double counting the same financial institution[5].

As a second step, we take into consideration mergers and acquisitions (M&A). For this purpose we thoroughly went through all M&A activities that took place in the banking sectors so that only the merged entity or the acquiring bank remains in the sample after a take-over[6]. We obtain detailed information on mergers and acquisitions from the Zephyr database of Bureau Van Dijks company. All data are deflated using the GDP deflator (with 2005 as the base year) obtained from the World Bank database and represented in US Dollars[7].

Table 1: Descriptive Statistics of the variables of interest.

Kernel Variable		Mean	St. Dev	Percentiles	
				5th	95th
Profit before tax	PBT	28.054	2.7187	22.7253	33.383
Price of borrowed funds	p1	0.0198	0.0001	0.0197	0.0199
Price of labor	p2	0.0565	0.0001	0.0563	0.0567
Price of physical capital	p3	1.0787	0.0322	1.0156	1.1418
Total loans	q1	1304.419	103.5857	1101.386	1507.5
Total earning assets	q2	712.7214	92.5719	531.2767	894.17
Negative Profit Indicator	NPI	2.2966	0.1566	1.9897	2.6035
Credit Risk	σ1	0.0187	0.0002	0.0184	0.019
Leverage	σ2	10.4844	0.0247	10.4359	10.533
Variance of Profits	VarProf	0.5002	0.0069	0.4867	0.5138
Return on Average Equity	ROAE	8.7782	0.0637	8.6533	8.9031

Notes: This table refers to 30,760 observations and 3,076 US commercial banks between 2003-2012. The table reports descriptive statistics of the kernel variables used in the estimation of the stochastic profit frontier model. All variables are deflated using 2005 as a base year. Kernel variables consist of the dependent variable, i.e. profits before tax (PBT), inputs prices (p), output quantities (q), the negative profit indicator (NPI) and the two risk indicators (σ). We present as well descriptive statistics for two additional variables, i.e., Variance of Profits (VarProf) and Return on Average Equity (ROAE) that we use as an alternative indicator of risk and profitability respectively.

$Table$ 1 presents descriptive statistics of the variables that we use in the estimation of the profit frontier kernel for the US commercial banking sector. Even though we use natural logarithms of variables in the profit kernel components (these represent the

[5] In cases where unconsolidated data were not available, we chose consolidated data instead.

[6] As an intuitive example: assume that bank A and bank B merged in 2006 to create a new entity, bank C, then the two individual banks A and B are each included in the dataset until 2006. From 2006 onwards, these two banks operations are considered to be terminated and the new bank (bank C) is included in the database. In the same spirit, assume that bank A was acquired by bank B in 2006; both banks are included in the database until 2006, with bank A then becoming inactive after 2006 and bank B remaining active after 2006.

[7] In addition to the two considerations above, in our data filtering process we exclude observations of missing, negative or zero values for inputs/outputs and control variables.

intermediation technology) in order to compute the efficiency scores, we show the mean and standard deviations in levels which are more informative.

5 Results

The first question we address in the paper is the impact of leverage (an indicator of a bank's risk and stability) on the bank efficiency indicator.

Results reported in $Table$ 2 show that non-performing loans and leverage have a negative impact on profit efficiency; by contrast the variance of profit is positively correlated to the latter.

Table 2 - Estimation of Profit Efficiency

Panel A: Credit Risk (as a measure of risk) with Leverage

(lnPBTit=a0+a1lnp1,it+a2lnp2,it+a3lnq1,it+a4lnq2,it+a5lnNPI,it+ a6lnCredit_risk,it + a7lnLeverage,it+v,it -u,it)

	2003		2006		2009		2012	
lnPBT	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	5.9638***	0.6029	4.9818***	-0.4916	-0.8147	-1.0578	10.5248***	-1.5442
lnp2	6.0190***	0.2918	4.5353***	-0.3001	7.0403***	-0.4128	6.3710***	-0.2707
lnq1	0.6544***	0.01	0.7203***	-0.0103	0.5545***	-0.0159	0.6494***	-0.0114
lnq2	0.2290***	0.0091	0.1780***	-0.0098	0.2070***	-0.0133	0.2200***	-0.0102
lnNPI	-0.9914***	0.081	-1.3899***	-0.1388	-0.7246***	-0.0151	-0.6211***	-0.0265
lnCR	-3.6450***	0.7874	-5.6479***	-0.9993	-2.4996***	-0.4298	-4.3845***	-0.2975
lnLEV	-0.3291***	0.0301	-0.3895***	-0.0325	-0.2005***	-0.0476	-0.2081***	-0.0352
constant	-1.8917***	0.0738	-1.8312***	-0.0812	-1.8114***	-0.122	-2.3000***	-0.0912
lnsig2v	-2.5479***	0.0539	-2.5196***	-0.058	-1.6148***	-0.0626	-2.1136***	-0.0597
lnsig2u	-2.1517***	0.0694	-1.7263***	-0.0621	-1.1583***	-0.0747	-1.5696***	-0.0696
Observations	3076		3076		3076		3076	

Panel B: Credit Risk & Variance of Profits (as a measures of risk) with Leverage

(lnPBTit=a0+a1lnp1,it+a2lnp2,it+a3lnq1,it+a4lnq2,it+a5lnNPI,it+ a6lnCredit_risk,it + a7lnVariance of Profits,it+ a8lnLeverage,it+v,it -u,it)

	2003		2006		2009		2012	
lnPBT	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	6.0827***	-0.4575	4.9198***	-0.365	-3.2223***	-0.9124	8.5706***	-1.1865
lnp2	5.9485***	-0.2269	4.4153***	-0.2325	7.3357***	-0.3578	6.6676***	-0.2074
lnq1	0.6445***	-0.0072	0.7188***	-0.0074	0.4789***	-0.0137	0.6114***	-0.0081
lnq2	0.2337***	-0.0064	0.1811***	-0.0069	0.2186***	-0.011	0.2404***	-0.0071
lnNPI	-0.9238***	-0.0864	-1.2479***	-0.1265	-0.7745***	-0.0133	-0.6595***	-0.0269
lnCR	-2.2350***	-0.65	-1.5543*	-0.8246	-1.0308***	-0.3771	-1.8146***	-0.2436
lnVarPr	0.0608***	-0.002	0.0627***	-0.002	0.0941***	-0.0043	0.0846***	-0.0027
lnLEV	-0.3389***	-0.0224	-0.3402***	-0.0245	-0.2628***	-0.0401	-0.3107***	-0.0261
constant	-1.5677***	-0.0558	-1.7028***	-0.0615	-1.0663***	-0.1089	-1.7309***	-0.0696
lnsig2v	-3.6402***	-0.0573	-3.5868***	-0.061	-2.2284***	-0.0581	-3.2553***	-0.0605
lnsig2u	-1.6714***	-0.0452	-1.3836***	-0.0444	-0.8791***	-0.0515	-1.1286***	-0.0448
Observations	3076		3076		3076		3076	

Notes: The table reports profit efficiency estimation results (coefficients and standard errors) adjusted for three different indicators of risk (i.e., credit risk, variance of profit and leverage) in four distinct time periods. Specifically, Panel A demonstrates the estimation of a profit efficiency index adjusted for credit risk and leverage whereas Panel B presents estimation results of a profit efficiency index adjusted for credit risk, variance of profit and leverage. The specification of each model is illustrated in the respective panel.

The highest impact on profit efficiency is due to the ex post risk indicator, i.e.; non-performing loans. However, efficiency indicators are affected more by the long run than the short run ex ante risk indicator.

The results in $Table$ 2 indicate that profit efficiency is positively related to the amount of inputs and outputs, suggesting that, *ceteris paribus*, profit efficiency is likely to increase with the size of the bank.

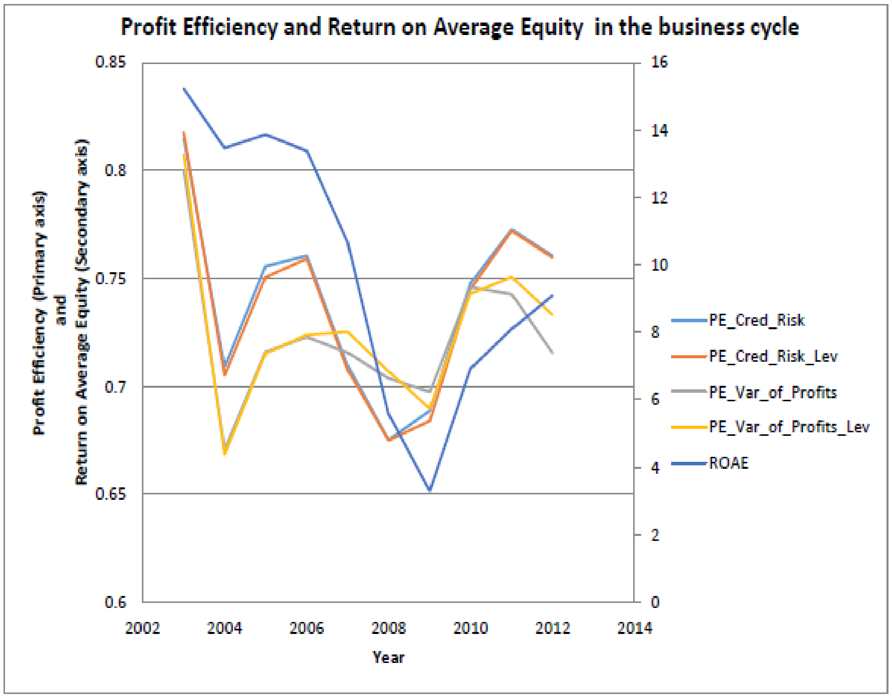
Moreover, through time, profit efficiency is achieved by a different combination of input and output. In the boom period between 2003 and 2006 the impact of the cost of labor and the cost of funding on efficiency decreased as well as the role of other earning assets, but in the same period it increased the impact of loans on profit efficiency ($Table$ 2). By contrast, during the last financial crisis the role of cost of labor increased while those of the cost of funding in determining profit efficiency decreased. The crisis shifted also the role of loans and other assets in determining profit efficiency, by reducing the impact of the former and increasing those of the latter. However, the cost of funding became the dominant factor affecting profit efficiency in the last period of our empirical analysis. In this period the role of output also shifted. From 2009 to 2012 the coefficient of loans increased from 0.48 to 0.61 ($Table$ 2, $Panel\ B$) and also those of other earning assets increased from 0.22 to 0.24($Table$ 2, $Panel\ B$).

Similar qualitative results hold for the impact of the risk indicators. Between 2003 and 2006 the impact of ex ante risk indicators (variance of profit and leverage) on profit efficiency of the American commercial banks increased, while the role of the ex post indicator of risk decreased. By contrast, during the financial crash (from 2006 to 2009) the impact of the two ex ante risk indicators moved in opposite directions: the coefficient of the variance of profit increased and those of the leverage decreased. The ex post indicator of risk continued to loose weight also in this period ($Table$ 2), although it remained the most important determinant of profit efficiency. Similar qualitative results hold in the last period of our investigation. So, a general result of this empirical analysis is both the opposite impact of the two ex ante risk indicators on profit efficiency. Apart from the boom period preceding the 2007 financial crash, the impact of two ex ante risk indicators on profit efficiency moved in opposite directions ($see\ Table$2).

Next we address the issue of how efficient is the efficient indicator defined by equation (3). We compare this indicator with alternative banking efficiency indicators. These indicators are built up assuming alternative measures of risk. The first alternative efficiency indicator includes only the ex post risk indicator (PE_Credit_Risk). In the second alternative efficiency indicator risk is measured by the variance of profit ($PE\_Var\_of\_Profits$), (see Delis et. al., 2014). The third alternative efficient indicator includes both variance of profits and leverage ($PE\_Var\_of\_Profits\_Lev$).

Figure 3 reports the evolution of the weighted average value of the alternative profit efficient indicators for the American commercial banks included in the Bankscope dataset.

Figure 3



Source: Calculations on Bankscope dataset. Notes: The figure illustrates the evolution throughout the sample period (i.e., 2003-2012) of profit efficiency indexes that have been adjusted for different risk exposures, i.e., credit risk, credit risk and leverage, variance of profits, variance of profits and leverage as well as for a measure of profitability, i.e., return on average equity (ROAE).

It is straightforward to see that the efficiency indicator defined in this paper ($i.e.$, $PE\_Credit\_Risk\_Lev$) differs significantly from the alternative indicators of efficiency including the short run *ex ante* risk indicator.

However, all the profit efficiency indicators have a pro-cyclical behavior, and the inclusion of leverage seems to stress this feature[8].

We test efficiency of the alternative profit efficiency indicators by estimating the predictive power of the profits in three years' time. We claim that the profit efficiency indicator (3) is more appropriate to estimate banking efficiency in the long run, and the model including this indicator of efficiency is a better predictor of future profits than the econometric models using alternative profit efficiency indicators.

Table 3 reports the results of the econometric investigation in the case when we measure profit by the return on average equity ($ROAE$). For convenience, we present only the results of the predicted profits in 2006, 2009, 2012 as a function of profit efficiency in-

[8] Geanakoplos (2009), Galo and Thomas (2012), Adrian and Shin (2013) presented models of procyclicity of leverage, and Adrian and Shin (2010) and Jordà et al. (2011), among others, provided empirical evidence supporting this hypothesis.

dicators three years earlier. However, for the other years we get similar qualitative results (the outcomes are available upon request).

Table 3: Predictive Power - Return on Average Equity (ROAE)

Panel A: Pre crisis - 2006 vs. 2003

(lnROAEit+n=a0+a1lnp1,it+n+a2lnp2,it+n+a3lnq1,it+n+a4lnq2,it+n+a5lnNPI,it+n+a6RiskAdj_PE,it+n+ε,it+n)

	Credit Risk		Credit Risk with Leverage		Variance of Profits		Variance of Profits with Leverage	
lnROAE	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	-3.0060***	0.764	-3.2228***	0.7506	-3.0882***	0.7572	-3.3239***	0.7448
lnp2	0.2582	0.4488	0.3982	0.4402	0.2566	0.4448	0.404	0.4365
lnq1	0.1876***	0.0169	0.1879***	0.0168	0.1824***	0.0166	0.1817***	0.0164
lnq2	-0.1272***	0.0153	-0.1268***	0.0152	-0.1225***	0.0151	-0.1213***	0.0149
lnNPI	0		0		0		0	
RiskAdj_PE_2003	1.3258***	0.093	1.4571***	0.0938	1.0004***	0.0641	1.0736***	0.0629
constant	1.0337***	0.0921	0.9289***	0.092	1.3347***	0.0731	1.2783***	0.0718
F(RiskAdj_PE_2003)	203.4		241.34		243.51		291.31	
adjR^2	0.14515498		0.1670129		0.15324719		17507674	
MSE	0.3377879		0.3291508		0.3349737		0.326338	
MAE	0.4053792		0.3981584		0.4054345		0.3979911	
Observations	3076		3076		3076		3076	

Panel B: During crisis - 2009 vs. 2006

(lnROAEit+n=a0+a1lnp1,it+n+a2lnp2,it+n+a3lnq1,it+n+a4lnq2,it+n+a5lnNPI,it+n+a6RiskAdj_PE,it+n+ε,it+n)

	Credit Risk		Credit Risk with Leverage		Variance of Profits		Variance of Profits with Leverage	
lnROAE	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	-9.3578***	1.6025	-9.1623***	1.593	-9.3242***	1.5934	-9.1041***	1.5828
lnp2	1.1733**	0.562	1.1293**	0.5562	1.0780*	0.5612	0.9913*	0.556
lnq1	-0.0781***	0.0255	-0.0808***	0.0251	-0.0773***	0.0253	-0.0805***	0.025
lnq2	0.0532**	0.0217	0.0577***	0.0214	0.0529**	-0.0215	0.0573***	0.0212
lnNPI	-1.4068*	0.7226	-1.4250**	0.7175	-1.3917*	0.7347	-1.4030*	0.7323
RiskAdj_PE_2006	1.5561***	0.1378	1.7202***	0.1354	1.1950***	0.101	1.3197***	0.0995
constant	1.1181***	0.1547	0.9936***	0.1495	1.4180***	0.134	1.3271***	0.1297
F(RiskAdj_PE_2006)	127.59		161.47		140.08		175.95	
adjR^2	0.1174391		0.13858249		0.11566687		0.13480643	
MSE	0.7345245		0.7169276		0.7354325		7195156	
MAE	0.6039618		0.5936171		0.6052779		0.5954717	
Observations	3076		3076		3076		3076	

Panel C: Post crisis - 2012 vs. 2009

(lnROAEit+n=a0+a1lnp1,it+n+a2lnp2,it+n+a3lnq1,it+n+a4lnq2,it+n+a5lnNPI,it+n+a6RiskAdj_PE,it+n+ε,it+n)

	Credit Risk		Credit Risk with Leverage		Variance of Profits		Variance of Profits with Leverage	
lnROAE	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	-6.6444***	2.106	-6.7351***	2.1035	-6.6628***	2.0986	-6.6386***	2.0942
lnp2	0.4627	0.3675	0.4952	0.366	0.4394	0.3685	0.4375	0.3669
lnq1	0.0735***	0.0186	0.0763***	0.0185	0.0669***	0.0182	0.0699***	0.0181
lnq2	-0.0309*	0.0174	-0.0315*	0.0173	-0.0299*	0.0172	-0.0298*	0.0171
lnNPI	-0.8763***	0.229	-0.8553***	0.2259	-0.8780***	0.2204	-0.8522***	0.2158
RiskAdj_PE_2009	1.2960***	0.0848	1.3457***	0.0852	1.1019***	0.0698	1.1464***	0.0693
constant	1.0076***	0.0955	0.9612***	0.096	1.1984***	0.0867	1.1542***	0.0865
F(RiskAdj_PE_2009)	233.64		249.74		249.31		273.94	
adjR^2	0.12156371		0.12986464		0.12799847		0.13960819	
MSE	0.4417555		0.4376582		0.4385766		4328811	
MAE	0.4665605		0.4631282		0.4660154		0.4613357	
Observations	3076		3076		3076		3076	

Note: This table presents results for the ordinary least squares (OLS) regressions where the dependent variable is the banks' profits before tax (PBT) and one of the regressors is the profit efficiency level, in time 't-1', derived by four alternative risk-adjusted profit efficiency indexes ,i.e., a. credit risk, b. credit risk and leverage, c. variance of profits, d. variance of profits and leverage. Panel A, B and C, refers to the 'pre-crisis', 'during crisis' and 'post-crisis' period respectively. The specification of the model for each period is illustrated in the respective panel. The predictive power of the model is captured by the two conventional forecasting measurement errors, i.e., the 'MSE' and 'MAE' , that stand for the 'Mean Square Error' and the 'Mean Absolutely Error' respectively.

Overall adding leverage into the profit efficiency indicator increases the predictive power of the model, whatever the other indicator of risk we use: i.e.; non performing loans or variance of profit.

Moreover and most important, the model including the efficiency indicator presented in this paper has a better predictive power of future profits most of the time. It is a better predictor in the pre-crisis and crisis period but not in the last period of our investigation (2009 versus 2012). In the latter case the best predictor of future profits is the model with profit efficient indicator including the *ex ante* risk indicators (i.e.; variance of profit and leverage) – (*see Table* 3).

As a robustness check, we investigated whether these results hold when we proxy the dependent variable by profit before taxes (PBT).

Table 4: Predictive Power - Profits before Taxes (PBT)

Panel A: Pre crisis - 2006 vs. 2003

(lnPBTit+n=a0+a1lnp1,it+n+a2lnp2,it+n+a3lnq1,it+n+a4lnq2,it+n+a5lnNPI,it+n+a6RiskAdj_PE,it+n+ε,it+n)

	Credit Risk		Credit Risk with Leverage		Variance of Profits		Variance of Profits with Leverage	
lnPBT	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	3.4438***	0.7663	3.2709***	0.7603	3.2709***	0.7603	3.1092***	0.7619
lnp2	4.7710***	0.4838	4.8181***	0.4793	4.8181***	0.4793	4.9306***	0.4808
lnq1	0.7124***	0.0134	0.7029***	0.014	0.7029***	0.014	0.7016***	0.0139
lnq2	0.1654***	0.0135	0.1726***	0.0137	0.1726***	0.0137	0.1737***	0.0137
lnNPI	-1.5621***	0.2725	-1.5526***	0.2644	-1.5526***	0.2644	-1.5260***	0.2394
RiskAdj_PE_2003	1.8840***	0.0781	1.3691***	0.0517	1.3691***	0.0517	1.3107***	0.0506
constant	-4.4470***	0.0713	-3.9750***	0.0551	-3.9750***	0.0551	-3.9365***	0.0544
F(RiskAdj_PE_2003)	581.66		563.34		700.98		669.76	
adjR^2	0.84344271		0.84124576		0.84378806		0.84105141	
MSE	1.301384		0.2004362		0.1981593		0.2016308	
MAE	0.9145676		0.323706		0.3224083		0.3278248	
Observations	3076		3076		3076		3076	

Panel B: During crisis - 2009 vs. 2006

(lnPBTit+n=a0+a1lnp1,it+n+a2lnp2,it+n+a3lnq1,it+n+a4lnq2,it+n+a5lnNPI,it+n+a6RiskAdj_PE,it+n+ε,it+n)

	Credit Risk		Credit Risk with Leverage		Variance of Profits		Variance of Profits with Leverage	
lnPBT	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	-1.7954	1.1663	-1.7644	1.1677	-1.8358	1.181	-1.7974	1.1793
lnp2	6.7512***	0.4316	6.7637***	0.4319	6.6815***	0.4323	6.6632***	0.4327
lnq1	0.4463***	0.0213	0.4443***	0.0211	0.4442***	0.021	0.4417***	0.0208
lnq2	0.2247***	0.0169	0.2270***	0.0168	0.2270***	0.0167	0.2292***	0.0167
lnNPI	-0.7218***	0.0147	-0.7201***	0.0146	-0.7219***	0.0146	-0.7201***	0.0145
RiskAdj_PE_2006	1.4731***	0.0757	1.4712***	0.0745	1.1337***	0.0569	1.1363***	0.0562
constant	-3.3905***	0.1201	-3.3911***	0.1163	-3.1015***	0.1101	-3.1040***	0.1073
F(RiskAdj_PE_2006)	378.75		390.43		397.17		408.67	
adjR^2	0.64240718		0.64375682		64351073		0.64455053	
MSE	0.4487005		0.447007		0.4500176		448705	
MAE	0.4983179		0.4975721		0.4988195		0.4978018	
Observations	3076		3076		3076		3076	

Panel C: Post crisis - 2012 vs. 2009

(lnPBTit+n=a0+a1lnp1,it+n+a2lnp2,it+n+a3lnq1,it+n+a4lnq2,it+n+a5lnNPI,it+n+a6RiskAdj_PE,it+n+ε,it+n)

	Credit Risk		Credit Risk with Leverage		Variance of Profits		Variance of Profits with Leverage	
lnPBT	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
lnp1	5.8554***	1.7875	5.9102***	1.7915	5.7546***	1.7808	5.8678***	1.7853
lnp2	6.6610***	0.2908	6.6782***	0.2913	6.6300***	0.2909	6.6281***	0.2915
lnq1	0.6267***	0.0144	0.6275***	0.0144	0.6171***	0.0143	0.6181***	0.0143
lnq2	0.2434***	0.0131	0.2445***	0.0131	0.2451***	0.013	0.2467***	0.013
lnNPI	-0.8351***	0.0301	-0.8351***	0.03	-0.8275***	0.03	-0.8263***	0.0298
RiskAdj_PE_2009	1.4449***	0.0633	1.4365***	0.0637	1.1928***	0.0508	1.1715***	0.0506
constant	4.2360***	0.0684	-4.2423***	0.0685	-3.9898***	0.062	-3.9898***	0.0619
F(RiskAdj_PE_2009)	521		508.49		551.03		536.98	
adjR^2	0.80404806		0.80357565		0.80403999		0.80333382	
MSE	0.3002209		0.3011089		0.3003506		0.3015103	
MAE	0.3986655		0.3992642		0.4001979		0.4011651	
Observations	3076		3076		3076		3076	

Note: This table presents results for the ordinary least squares (OLS) regressions where the dependent variable is the banks' profits before tax (PBT) and one of the regressors is the profit efficiency level, in time 't-1', derived by four alternative risk-adjusted profit efficiency indexes ,i.e., a. credit risk, b. credit risk and leverage, c. variance of profits, d. variance of profits and leverage. Panel A, B and C, refers to the 'pre-crisis', 'during crisis' and 'post-crisis' period respectively. The specification of the model for each period is illustrated in the respective panel. The predictive power of the model is captured by the two conventional forecasting measurement errors, i.e., the 'MSE' and 'MAE' , that stand for the 'Mean Square Error' and the 'Mean Absolutely Error' respectively.

Results reported in $Table$ 4 suggest that the superiority of the efficiency indicator presented in this paper still holds in the crisis period (2006 versus 2009), but does not extend to the other periods. However, in the latter case alternative models of efficient indicators do not emerge. Indeed, in the pre-crisis period the model including the efficiency indicator with only the variance of profit appears to be the best predictor, and in the post crisis period the model using the efficient indicator only with the *ex post* risk indicator seems to be the best predictor of future profits.

Overall, the results support the view that leverage is an important indicator of bank risk and stability to take account of in estimating banking efficiency.

6 Concluding Remarks

The motivation of this paper stems from the fact that although banking leverage played an important role as a determinant of the last financial crash, current models of banking efficiency do not include this risk indicator. Further note that leverage is a central feature of the Basel III regulatory framework.

In this paper first we present a bank efficiency indicator including leverage as proxy of *ex ante* risk and stability conditions, and then we test the superiority of this indicator by comparing its predictive power of future profits with alternative bank efficient indicators including different measures of risk. Results show that profit efficiency indicators including leverage are better predictors of future profits than those including other indicators of risk. Moreover, the efficient indicator presented in this paper is a better predictor of future profits in a number of cases far higher than any other efficient indicator used currently in the literature. Specifically, it takes into account risk as well as stability conditions of the bank and therefore is the best predictor of future profits in turbulent times. The last results suggest that a natural extension of the paper is to evaluate whether this outcome extends also to predictions of banking failure.

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