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Bank Efficiency during the Current Economic Crisis: An International Comparison

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IES Working Paper: 08/2013

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Bibliographic information:
Babin, A. (2013). "Bank Efficiency during the Current Economic Crisis: An International Comparison" IES Working Paper 08/2013. IES FSV. Charles University.

Bank Efficiency during the Current Economic Crisis: An International Comparison

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July 2013

Abstract:
This paper uses a Latent Class Stochastic Frontier Approach to factor out the heterogeneity in the data and to provide evidence on the existence of different bank technologies in international banking with different response schedules to external shocks and diverse constraints. We use an unbalanced panel of 756 banks from 77 countries during 2005-2010 for this purpose. Using bank level structural variables we determine four different profit and cost banking technologies in the data. Further analysis indicates heterogeneity not only among the level of profit and cost efficiency, but also regarding the response of banks to the crisis. Interestingly, we find that banks from the same class but from different regions had a different efficiency evolution over the period. Moreover, we document the existence of banks that are more predisposed to be efficient in certain regions than in others. Finally,

we document that banks have several potential options for rebalancing the balance sheet for improving the efficiency, albeit some of these strategies have opposite effects on the profit and cost efficiency.

Keywords: efficiency, heterogeneity, crisis, latent classes

JEL: G21, G28

I. INTRODUCTION

There is an increasing interest in the context of the actual crisis for the bank activity studies. This interest stems from several sources. First, banks have been seen as the main originators, drivers and propagators of the crisis (see Stiglitz 2009, Brunnermeier 2009). At the same time, banks were also affected the most during the crisis, registering staggering losses and capital shortfalls (see IMF 2009a, IMF 2009b, IMF 2010, ECB 2010 and ECB 2011). Nevertheless, it seems that the healing process of the banking sectors and the economies across the globe has been uneven. For instance, the US banking systems scaled back their balance sheet and adjusted their activity in a swifter way than their European counterparts. At the same time, the empirical evidence shows that elsewhere in the world, the crisis impact has been either muted, or lagged considerably behind the developments in the developed economies.

The crisis has also prompted regulators and policy makers to set forth several banking reforms which crystalized into Basel III proposal as well as a number of banking structural reforms aimed at countering, to the greatest possible extent, any future recurrence of systemic crises. The implementation of Basel III is estimated to have a negative impact on lending by leading to an increase in lending rates in the long run (Cosimano & Hakura, 2011) while (Šútorová & Teplý, 2013) find a rather limited impact on a sample of European banks. The structural banking reforms, on the other hand, are represented by the Volcker rule in the US, the Liikanen Report proposals in the EU and the Vickers Commission proposals in the UK. All three have in common a separation of commercial banking from securities market activity but differ subtly in several details (Gambacorta & van Rixtel, 2013). If implemented, these packages would reshape considerably the banking business in the near future, and while it is clear that universal banks would have to considerably modify their modus operandi it still remains unlnown how this will affect the economy as a whole and each bank’s profitability, financial strength and efficiency in particular.

In this context it is natural for one to ask how banks from different banking systems compare to one another from a production technology perspective and how, if at all, this technology changed over the 2007-2009 financial and economic crises. To this date there are a very limited number of papers addressing these issues, most of them focusing on the country level analysis, Yildirim

C. , (2002) for Turkish banks, (Sufian, 2009) for Malaysian banks and (Vu & Turnell, 2011) for Australian banks. The limited number of empirical applications in this sense is particularly strange given the rather consistent empirical evidence that bank efficiency scores could be good predictors of imminent problems in the banks' activity, (Berger & DeYoung, 1997), (Berger & Mester, 1997), (Fries & Taci, 2004), etc. On the other hand, the frontier efficiency models, are rather difficult at adapting different technologies, which makes inferences from such applications burdensome and in many cases unreliable. This is particularly attested by the survey of Berger (2007), who indicates that the international bank efficiency comparison literature is riddled by contradictory results across the board.

This is further sustained by the rather new methodological developments in Stochastic Frontier Estimations, which indicate that even for a sample of banks from the same countries, there might be present several different technologies that cannot be accounted by control variables alone, (Orea & Kubhakar, 2004). Moreover, (Greene, 2002) and (Greene, 2005) argues that the standard, a priori, sample split or environmental variables use, solves the inherent heterogeneity in the data only partially. This is further attested in applications using World Health Organization data on the efficiency of health systems of over 100 countries, for which the author proves that the ad hoc split in OECD and non-OECD sample is a poor solution for the heterogeneity in the data. The same is found true for a sample of the US based banks.

We add to the existing literature on international bank efficiency comparisons in several ways. First, we estimate the cost and profit efficiency for a sample of international banks over the most recent crisis period and document the evolution of the cost and profit efficiency over this period. Second, we account for the unobserved heterogeneity in the data using a Latent Class Stochastic Frontier Model estimating a unique benchmark frontier against which we evaluate all banks, while at the same time distinguishing between different banking technologies. Finally, we document the heterogeneous response of banks, both from the profit function and the cost function across different classes, regions and groups.

The rest of the paper is structured as follow. We first provide an exhaustive overview of the related literature. Then, we present our methodological approach for the efficiency estimation. The data and the variables definitions are introduced subsequently in the next section. Then we discuss the main results, by emphasizing the main finding and conclude in the end.

II. LITERATURE REVIEW

This paper relates to two primary streams of literature on bank efficiency. First it belongs to efficiency determinants studies, including the ones elaborating on the efficiency change in time. Second, it relates to the international bank efficiency comparison literature, focusing mainly on the current developments in the industry – particularly discussing the differences in the evolution of bank efficiency over the financial and economic crisis.

The advent of the efficiency literature starts with the elegant proposal of (Aigner, Lovell, & Schmidt, 1977) and (Meeusen & van den Broeck, 1977) to disentangle the inefficiency from the error term from a production or a cost function. The interest for bank efficiency determinants has been growing constantly ever since, as attested by the surveys in (Berger & Humphrey, 1997), (Berger & Mester, 1997), (Berger A. N., 2007) and (Hughes & Mester, 2008). Apart from the empirical curiosity for the differences in efficiency between banks, the literature is still mostly dominated by the debate on the methodological issues, with no real definite conclusiveness arising on the matter.

Country level studies are naturally focused on the US banking system. Several such studies lead the debate on the cost and profit efficiency estimation and their determinants. The size of the bank, the branching, capitalization, the asset structure, the ownership, the quality of assets, profitability and liability structure and the off-balance sheet can be significant determinants of the level of bank efficiency. However the results are mostly mixed across the board. For instance, the size of a bank is found to be significantly negatively related to efficiency in (Berger & Mester, 1997) while in (Mester, 1993) and (Mester, 1996) no statistically significant relationship is attested. Capital is generally found to be inefficiently used by banks in the US, (Hughes & Mester, 1998) although a somewhat more mixed picture emerges from (Mester, 1993) and (Mester, 1996). Other empirical studies provide evidence related to general scale efficiencies emerging from the scale of the banking system in which a bank operates. The main conclusion is that banks operating in larger banking systems, do generally have the possibility to benefit from larger scale economies, (Bossone & Lee, 2004), (Hughes & Mester, 1998) and (Hughes, Mester, & Moon, 2001). Finally the relationship between bank balance sheet structure and the quality of its assets and bank efficiency is also found to be interdependent, (Mester, 1991), (Mester, 1996), (Berger & Mester, 1997) and others. (Berger & de Young, 1997) find that efficiency scores could be good predictors of bank distress as low level of efficiency precede worsening asset quality and bank failure.

The international studies on bank efficiency comparison are numerous by themselves, (Berger A. N., 2007). They are built methodologically on the single country studies, with further extensions and improvements to the methodology to accommodate the heterogeneity in the environmental characteristics of different countries.

The earliest contributions are generally using a single frontier for all the banking systems, (Berg, Førsund, Hjalmarsson, & Suominen, 1993), (Fecher & Pestieau, 1993) and (Pastor, Perez, & Quesada, 1998). Adding environmental variables to the classical frontier estimations was generally been found to improve the estimation and comparability between different country banking systems, (Dietsch & Lozano-Vivas, 2000), (Lozano-Vivas, Pastor, & Hasan, 2001), (Lozano-Vivas, Pastor, & Pastor, 2002) and (Maudos, Pastor, Perez, & Quesada, 2002) for European banks or (Fries & Taci, 2004), (Bonin, Hasan, & Wachtel, 2005), (Yildirim & Philippatos, 2007) and (Rossi, Schwaiger, & Winkler, 2005) for banks from emerging countries or (Stavárek, 2005) and (Stavárek, 2006) for Central and Eastern European Countries. (Bos & Kolari, 2005) provide evidence on the existence of a single profit frontier for European and US banks while no such frontier can be sustained for the cost function.

There is only a limited number of comprehensive international analyses in bank efficiency. (Pasiouras, Tana & Zopounidis, 2009) build an international efficiency frontier for the banking system and measure the impact of different regulatory regimes on the cost and profit efficiency. (Lozano-Vivas & Pasiouras, 2010) is a second attempt to build an international banking efficiency frontier using country specific variables to eliminate heterogeneity and measure the impact of accounting for non-traditional banking outputs on the level of efficiency. The authors conclude that there is a unique international frontier and that at least for the cost efficiency the inclusion of non-traditional banking outputs has a significant effect on the level of efficiency.

However the environmental variables do not necessarily account for all the differences, in which case some of the heterogeneity in the data translates into higher inefficiency levels. To account for any such bias in estimates and to achieve direct comparability among efficiency levels of banks from different countries (Bos & Schmiedel, 2007) propose a meta-frontier methodology and find evidence of a single frontier for banks from EU countries. The methodological advances, however, proved that even for single country bank efficiency analysis, including a set of environmental variables or control variables might not be enough to control for all the heterogeneity in the data. (Greene, 2001) and (Greene, 2002) using random parameters stochastic frontier models, and a latent class model proves that non-observable heterogeneity in the data could have significant effects on the level of bank efficiency. This is further proved for a sample of Spanish banks in (Orea & Kumbhakar, 2004). The authors estimate that, for the Spanish banks solely, there are four different groups of banks with different levels of efficiency. The only application, found for an international sample is represented by (Poghosyan & Kumbhakar, 2010) for a sample of 20 former socialist emerging economies over 1993-2004 period. The authors are able to distinguish three, statistically different group of countries and banking systems from their cost function estimation. As posterior probability determinants, they include primarily macro and financial environment variables.

We add to this last strand of literature by estimating a profit and cost function for a sample of top international banks for the 2005-2010 and comparing bank performance across classes, regions and time.

III. METHODOLOGY

A. Latent Class Stochastic Frontier Specification

To account for the heterogeneity of our dataset and to corroborate our hypothesis of heterogeneity in banking technology we adopt the methodology proposed in (Greene, 2002) and specify a profit and cost function that can adapt multiple latent classes. To limit the proliferation of the coefficients we impose a Cobb-Douglas functional form to both, cost and profit, functions:

$$TC(PRO)_{it} = \alpha + \sum_{m=1}^{4} \beta_m w_{mit} + \sum_{n=1}^{4} \gamma_n y_{nit} + \delta T + v_{it|j} + u_{it|j} \tag{1}$$

where w_{it} are for input prices of the bank *i* at time *t*, *y* is a vector of 4 outputs of a bank *i* at time *t*, *T* is the time trend and v_{it} and u_{it} are the independent components of the error term[1]. The different distributional assumptions of this error terms, allows the modeling of the stochastic frontier. We assume a half-normal distribution for the inefficiency term v_{it} and a normal distribution for the remainder term, u_{it} for each class. The subscript *j* stands for the latent classes in the production and cost functions which have to be determined, and are therefore a priori assumed to take a maximum value of *J*.

To solve the model we have to estimate the likelihood function for each of the banks at each period of time. Following (Greene, 2002) we assume the inefficiency term v_{it}, for each of the latent classes *j*, to be independently and identically distributed over *i* and *t* and express the likelihood function as:

$$LF_{it}(\theta)_j = \frac{\Phi(\frac{\lambda_j \varepsilon_{it|j}}{\sigma_j})}{\Phi(0)} \frac{1}{\sigma_j} \varphi\left(\frac{\varepsilon_{it|j}}{\sigma_j}\right), \varepsilon_{it|j} = TC(PRO)_{it} - x'_{it}\beta_j \tag{2}$$

where Φ and φ are, respectively, the standard normal cumulative and density functions, $\varepsilon_{it|j} = v_{it|k} + u_{it|k}$, $\sigma_j = \sqrt{\sigma_{vk} + \sigma_{uk}}$ and θ is the vector of cost or profit function parameters. The contribution of each bank i in each period t to the conditional likelihood is:

$$LF_{it}(\theta)_j = \prod_{t=1}^{T} LF_{it}(\theta)_j \tag{3}$$

The unconditional probability function of a bank, i, is the weighted sum of conditional likelihood functions. The weight is the posterior probability that a bank, *i*, belongs to a class *J*. This can be expressed as:

$$LF_i(\theta, \rho) = \sum_{j=1}^{J} LF_{ij}(\theta_j) P_{ij}(\rho_j) \tag{4}$$

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[1] The vector of outputs is represented by customer loans, securities portfolio, interbank loans and other assets and the vector of prices is represented by interest expenses on customer deposits, capital expenses, interest expenses on non-depository funding and personnel expenses.

where $P_{ij}(\rho_j)$ is the multinomial Logit parameterization of the prior class probabilities which can be expressed as:

$$P_{ij}(\rho_j) = \frac{\exp(\rho_i'\eta_j)}{\sum_{j=1}^{J}\exp(\rho_i'\eta_j)}, \eta_j = 0 \tag{5}$$

and $\sum P_{ij}=1$ and $0 \leq P_{ij} \geq 1$. In equation 5, η is the vector of bank specific variables that determine the class membership of a bank i and ρ_i is a parameter normalization. This equation also implies that the posterior probability does not depend only on the specific characteristics assigned specifically in the functions, but it can pick up the differences from the cost (profit) function alone. Therefore the estimation of the model does not depend on the availability of additional information regarding the individuals in the sample.

Using the above results, by log-linearizing, we obtain the final log-likelihood function:

$$\log\big(LF(\theta,\rho)\big) = \sum_{i=1}^{N} \log\left(LF_i(\theta,\rho)\right) \tag{6}$$

Which can then be maximized with respect to cost (profit) function parameters and latent class determinants. One remaining issues in this setting is that we have to estimate multiple frontiers, therefore the benchmarking of the cost or profit efficiency becomes problematic as several alternative benchmarks are available. To overcome this, (Greene, 2002) simply proposed weighting the cost (profit) frontiers following the specification:

$$\log(EF_i) = \sum_{j=1}^{J} P(j|i)\log\left(EF_i(j)\right) \tag{7}$$

where $P(j|i)$ is the probability of a bank i to be in a class j and $EFi(j)$ is the efficiency frontier of class j. This set-up allows estimating a general cost (profit) function by taking into consideration all available technologies in the sample. Moreover, this ensures comparability of the efficiency scores among the classes.

The final issue regarding the above model, is the lack of a clear solution for the determination of the number of classes in the sample. In other words, the model does not provide a straight forward way of determining the optimal number of classes. This shortcoming has several inherent risks. First, by specifying a priori too many classes, the model will not be able to estimate the parameters due to over-identification. Second, if we specify too few classes, the estimated efficiencies could be biased downwards. (Greene, 2002), (Orea & Kumbhakar, 2004) and (Greene, 2005) provide some solutions to this problem, in the form of downward testing by using the Akaike and Schwartz's information criterion. Therefore, the best model is the one with the lowest AIC or the highest Schwartz's criterion. An additional check is to compare the level of average efficiency scores predicted by each of the models. The general rule that has to hold, is that models with higher number of classes have to predict higher efficiencies. If this is violated, then the model could be miss-specified. Finally, (Greene, 2002) suggests a likelihood-ratio test, which uses the same downward testing principle as the AIC and BIC criteria.

B. Second Step Regression Analysis

For a better understanding of the evolution of the profit and cost efficiency over the classes, regions and economic development groups, we run and report several second step regressions. As a dependent variable we use the change in cost and profit efficiency. As explanatory variables we use several bank specific, country specific variables and several dummies representing the regions from which banks are and the economic development groups to which the countries banks activate in, belong to[2]. All regressions are run in a panel setting using year and country specific effects. We include these effects to control for any idiosyncratic, country specific and time specific shocks.

The bank specific variables that we use are the changes in the loan-to-deposit ratio which should capture any active readjustment of the balance sheet structure of a bank. Additionally, we control for the adjustments in the funding structure by including the change in deposits-to-total funding ratio. For the asset side readjustment we include the change in liquidity as this might reflect the preference of banks for more flexibility and security at the expense of efficiency, both cost and profit. We control for the economic conditions by including yearly GDP growth rate. Finally, a dummy for FED support is included to control for the effect of the FED's non-standard support programs for banks over the crisis. The data for constructing this dummy is obtained from New

[2] To see the classification of banks by region and economic development consult *Table A. 6* in the appendix.

York Fed report on non-standard measures. The definition of regional and country group dummies is in the appendix. The final model specification takes the following form:

$$\Delta EF_{it|j} = \alpha + \beta_0 \Delta X_{it|j} + \beta_1 FED + \beta_2 GDPG + \beta_3 Crisis + \beta_4 DM + \delta C + \gamma Y + \varepsilon_{it|j} \qquad (8)$$

where $\Delta EF_{it|j}$ is the change in profit of cost efficiency of each bank i from class j, $\Delta X_{it|j}$ is the change in bank specific variables, FED stands for the dummy for the bank and year in which this bank had support from the Federal Reserve, GDPG is the credit growth for each country in the sample, Crisis is a dummy which takes a value of 1 for 2007 and 2008 and a value of 0 otherwise, DM are the region and/or development group dummies, C and Y stand for country fixed effects and year fixed effects, respectively; ε_{it} is the robust error term.

IV. DATA

We use bank level data for a sample of Top 1000 world banks. Some adjustments are required to the original dataset. Therefore, we impose some quality restrictions on the data by limiting the minimum span of available yearly observations to three consecutive years. From an initial 1000 banks sample we end up with 756 banks out of which just 6.35% have a 3 year short span. About 65% of the sample is represented by banks that have complete data for the entire period, 2004-2010. From a geographical perspective, the sample is fairly balanced, the regions being represented proportionately with their economic performance. Thus, there are over 204 European banks, 171 North American banks, 33 banks from Latin America and Caribbean region, 57 banks from Middle East and Africa, and 147 banks from Asia excluding Japan, which is represented by 96 banks. The remaining banks represent the rest of the world (Australia and New Zeeland mainly)[3]. The source of data is Bureau van Djik's BankScope database from which we extract balance sheet and income statement data for all banks.

For the SFA formulation we use (Sealey & Lindley, 1977) intermediation approach and define customer deposits as inputs. Therefore, in our final specification, we have four outputs and four input prices defining the bank cost (profit) frontier. The vector of outputs is represented by: y1 – customer loans, y2 – security portfolio, y3 – interbank loans and y4 – other assets. The vector of input prices is represented by: w1 – interest expenses on customer deposits, w2 – capital

[3] This statistics are for 2008. The number of banks might differ insignificantly by regions year by year as the panel is unbalanced.

expenses defined as other operational expenses over fixed assets, w3 – interest expenses on non-depository funding and finally w4 – personnel expenses defined as personnel expenses over total assets. The dependent variables are the total costs for the cost function and operational profit for the alternative profit function. Since operational profit can take negative values, we normalize it by the minimum figure so that it takes a minimum value of zero. All variables are scaled by total assets to minimize heteroskedasticity in the data. All the price variables and the dependent variables are divided by last price (w4), to impose homogeneity in prices. For a better behaved function we normalize all SFA variables by the geometric mean. Time trend is included to account for the technological change in the function.

In addition to the SFA components, we use a number of variables in order to facilitate the determination of the classes to which a bank is assigned. We experimented with some country level variables at first, *a la* (Poghosyan & Kumbhakar, 2010), but the results and our interest for identifying different business models among banks, fostered the use of bank specific variables in our final specification. For the profit function we use Loans-to-Deposits Ratio which should account for the degree of leverage of a bank and its business model; Customer deposits in Total Funding Ratio which accounts for the funding structure of the bank; and finally NPL ratio which accounts both for the quality of the loan portfolio and the amount of risk to which a bank is exposed. For the cost function, the NPL ratio is dropped from the class membership determinants, due to the rather unstable behavior of the function.

The final formulation of the model takes the Cobb-Douglas form from Equation 1, both for the cost and the alternative profit function. The latent class probabilities are modeled as a function of the three bank specific variables defined above as:

$$P_{ij}(\sigma_j) = \frac{\sigma_{0j} + \sigma_{1j}LDR + \sigma_{2j}DTF + \sigma_{3j}NPL}{\sum_{j=1}^{J}\sigma_{0j} + \sigma_{1j}LDR + \sigma_{2j}DTF + \sigma_{3j}NPL} \qquad (8)^{4}$$

where, LDR is Loans-to-Deposit Ratio, DTF is Customer deposits to Total funding ratio and NPL is the Non-Performing Loan Ratio. These ratios, allow us to distinguish between conservative, traditional, moderately aggressive and aggressive types of banks.

[4] For the cost function the NPL is dropped from the estimation;

The descriptive statistics of all untransformed variables used in the regressions are presented in ***Table A. 1*** in the appendix.

V. RESULTS

A. Model Selection – Number of classes

Prior to the explicit discussion of the results, we have to argument our choice of the model. Particularly, as described in the methodology, we are interested in determining the correct number of latent classes a model has. To do that we follow the top down approach described in (Greene, 2002), (Greene, 2005) and (Orea & Kumbhakar, 2004). We base our decision on the minimization of the Akainke criterion (AIC) and cross-check by investigating the average predicted level of efficiency by each of the models.

For the profit function we started our estimation from a model with 5 latent classes and followed with subsequent estimations of models with fewer classes. According to the AIC criterion, the model with 4 classes is the most optimal (the lowest AIC – 5814.8). According to the average efficiency the model with 5 classes is just a bit less efficient than the 4 class model (75.8% vs. 75.9%). Taking these two criteria together we decided to use the 4 class model in our further discussion.

Table 1 below summarizes the main selection criteria statistics.

Table 1: Model Selection Criteria

Number of Classes	Profit Function		Cost Function	
	AIC	Average Efficiency	AIC	Average Efficiency
5	6154.8	75.8%	Not Converging	
4	**5814.8**	**75.9%**	**5005.3**	**87.5%**
3	6914	75.5%	6297.4	76.9%
2	7751.4	74.1%	6943.6	84.8%
1	9734.7	64.3%	9923	83.9%

Source: Author's computations

For the cost function the same procedure is followed. The estimation starts from a 5 class model. However, in the case of the cost function the 5 class model does not converge, which we take as a sign of over identification (Orea & Kumbhakar, 2004). The model with 4 latent classes proves, once again, to describe best the data, both according to AIC (which takes a 5005.3 value) and the average efficiency which stands at 87.5% and is much higher than the levels predicted by the models with subsequently less latent classes. The only somewhat worrisome sign is the standard error value on the lambda coefficient for the 4th latent class. According to (Greene, 2002) this might be an indication that a model with a lower number of classes could be more optimal. However, in our subsequent search for an optimal level we find both higher AICs and lower predicted cost efficiency averages.

These results indicate that, any of the classical models used in comparing internationally the bank efficiency might suffer from not accounting for the non-observable heterogeneity in the data. In this respect, our results confirm previous findings in the literature such as (Greene, 2002), (Greene, 2005), (Orea & Kumbhakar, 2004) and (Poghosyan & Kumbhakar, 2010), all applying similar types of models for bank efficiency comparisons.

B. Alternative Profit Efficiency

Table A. 2 in the Appendix summarizes the main results for the profit SFA model with 4 latent classes. The latent class determinants are significant in class membership assignment. A quick look over the classes indicates that the 4th class of banks has the highest ratio of customer deposits in total funding. This means that banks in this class have the most traditional business model among the classes. Moreover, approximately 51.5% of the banks belong to the 4th class. The second class of banks stands out as the one with the lowest deposit funding base, that is, its funding structure is primarily based on non-core funding. It also has the lowest NPL ratio, which might hint to a different asset side structure as well (this is also confirmed by the LDR which stands at 188%). The 2nd is also the least represented in the sample, with only about 1.2% of banks. The 1st and 3rd classes have a more moderate funding structure compared to the 4th and 2nd classes, with the 3rd having a moderately aggressive business model and the 1st class having a close to traditional banking business model. ***Table 2*** summarizes the average efficiency scores and the average value of class determinants over the classes.

Table 2: Class Determinants & Average Profit Efficiency

Classes	Loans to Deposits	Deposits to TF	NPLs	Profit Efficiency
1	109.25	74.16	3.45	**87.8%**
2	187.97	49.59	3.00	**58.4%**
3	106.00	73.64	3.90	**65.0%**
4	93.70	80.07	3.54	**76.0%**
Average	**102.52**	**76.49**	**3.58**	**75.9%**

Source: Author's computations

In terms of profit efficiency, the 1st class dominates over the others; while the 2nd class has the lowest levels (see **Table 3**). The banks from the 1st class have on average a profit efficiency of 87.8%, with the 2nd class reaching only 58.4%, the 3rd class with 65% and the last, 4th class, with an average profit efficiency of 76%. Thus, the "moderately aggressive" banks have the highest efficiency while the "aggressive" banks have the lowest efficiency. The NPL is only statistically lower for the 2nd class, while it is equal among all the other classes. At the same time, 4th class of banks has the highest share of customer deposits in total funding, while the second class has the lowest share. Therefore, a lower customer deposit base is also associated with lower profit efficiency which is in line with (Berger & Mester, 1997) finding for the US banks.

Table 3: Profit Efficiency Estimates

Classes	2005	2006	2007	2008	2009	2010	TOTAL
1	89.1%	88.0%	87.3%	87.1%	87.7%	88.1%	**87.8%**
2	49.6%	56.4%	60.9%	63.4%	61.5%	53.1%	**58.4%**
3	62.2%	64.3%	64.4%	67.5%	66.5%	64.5%	**65.0%**
4	79.1%	77.8%	73.2%	74.9%	75.6%	76.1%	**76.0%**
TOTAL	**77.5%**	**77.0%**	**74.2%**	**75.8%**	**76.0%**	**75.4%**	**75.9%**

Source: Author's computations

We are not specifically interested in the magnitude and signs of the frontier variables as they are average densities and do not have a straight forward interpretation. Therefore, we will only discuss the time trend, T, variable which documents, in our case, a rather heterogeneous behavior of bank profits over time. The coefficient on the time trend indicates a constantly increasing operating profit evaluated at sample mean for the 1st class of banks, while the other classes experience decreasing profits. The magnitude of the coefficient indicates that the 2nd class of banks has the most drastic drop in profits among the remaining classes. The squared trend term indicates that the relationship is not linear in any of the four classes. For instance, for the first class the profits were increasing at a decreasing rate, while for the 2nd class the profits were decreasing at a decreasing rate. For the 3rd class of banks the profits were also decreasing at a decreasing rate while for the last, 4th, class, the profits were decreasing at an increasing rate.

The efficiency evolution over time indicates that there is a dip in the level of profit efficiency during the 2007-08 and 2009 years. This result is generally expected, and is confirmed to be statistically significant[5]. However, an investigation over the four latent classes reveals a more nuanced story. Among the four classes of banks, the 1st class has rather stable profit efficiency over time, hovering around 87-88% on average. The 2nd class has a more volatile efficiency. Surprisingly, nevertheless, the efficiency increases over the crisis to an average of 62% from a pre-crisis average of 53%. It stabilizes around 50% in the aftermath. This evolution can be explained by a swift adjustment of the balance sheet. It is associated with a drastic reduction in the average LDR ratio from 225% in 2005 to a 170.4% ratio in 2010. This was happening while on the liability side the DTF ratio was rather constant. It looks like, these banks managed to rebalance their asset structure by reducing the loan portfolios and increasing the holdings of liquid assets (which increased significantly in 2007, 2008 and 2009 compared to the preceding period). This finding could have potentially important implications, as on one hand, the institution that adjusts manages to stabilize its financial position and improve its profit efficiency, while on the other hand, it could create additional pressure on the asset prices through fire sales and could therefore transfer the inefficiency to other banks, that are not undertaking the same balance sheet adjustments[6]. At the same time, the finding is broadly in line with the empirical evidence of the bank deleveraging across the board (Wehinger, 2012) or (ECB, 2013).

Banks from the 4th latent class are on the other end of the spectrum. They had a mild decrease in profits, but experienced a protracted deterioration in profit efficiency. The other classes exhibit

[5] Sample mean statistical comparisons were run for the whole sample comparing the profit efficiency scores year by year. Generally, the result supports the hypothesis that during the crisis, 2007-2009, banks had lower efficiency scores than in the two preceding years, 2005-2006.
6 The positive thing about this is that the sample of banks with such type of behavior is rather small.

moderate flexibility, therefore the efficiency losses were offset relatively quickly. The differences in efficiency levels in the crisis vs. non-crisis period are statistically significant for all classes except the 1st class.[7]

We further extend our analysis by investigating the average efficiency scores over two classifications. First we classify all the countries in groups representing the level of economic development and secondly, we classify countries into regions. Both categories are created using data from Global Market Information Database. ***Table 4*** below summarizes average profit efficiency scores by geographical regions.

Table 4: Profit Efficiency by Regions

World Region	2005	2006	2007	2008	2009	2010	Average
Western Europe	78.3%	76.0%	74.4%	74.9%	76.7%	74.6%	**75.6%**
MEA	74.7%	75.4%	72.9%	77.3%	81.0%	82.6%	**77.4%**
Latin America	66.8%	66.1%	66.5%	72.0%	68.4%	66.3%	**67.9%**
Australia		42.1%	57.4%	59.1%	63.1%	60.1%	**58.5%**
ASIA	80.4%	79.1%	75.5%	78.2%	78.5%	77.8%	**78.2%**
Eastern Europe	78.6%	77.9%	74.3%	75.2%	83.1%	80.9%	**78.3%**
North America	75.7%	77.3%	74.7%	73.8%	69.8%	70.3%	**73.5%**
Average	**77.5%**	**77.0%**	**74.2%**	**75.8%**	**76.0%**	**75.4%**	**75.9%**

Source: Author's computations

The ranking of regions by the average profit efficiency scores is in line with the findings in (Pasiouras, Tanna, & Zopounidis, 2009) and (Lozano-Vivas & Pasiouras, 2010) who rank Latin American, North American and Western European banks among the least efficient. In our sample the Australian banks have the lowest profit efficiency, reaching only about 58.5% on average. On the other hand the North American banks have somewhat higher profit efficiency in our sample, 73.5%, as compared to 64% in (Pasiouras, Tana & Zopounidis, 2009) and 57.6% in (Lozano-Vivas & Pasiouras, 2010). However our sample spans over a somewhat different time span, and, more importantly, we use a latent class model that could envelope much tighter the observations in the sample. Notwithstanding these slight discrepancies, it is surprising that the average predicted profit efficiencies in all these three studies are very close to each other, hovering around 75.5-76.5%. Moreover, the comparable averages for North American and

[7] The mean comparison statistics are available upon request.

Western European banks are in line with the finding of a single profit frontier for American and European banks in (Bos & Kolari, 2005).

Table 5 summarizes the profit efficiency according to the economic development groups over the 2005-2010 period.

Table 5: Profit Efficiency by Economic Development Group of Countries

Groups	2005	2006	2007	2008	2009	2010	Average
Developing	77.7%	77.3%	73.8%	76.7%	79.0%	78.6%	**77.2%**
Advanced	81.4%	77.3%	75.2%	75.8%	78.5%	76.5%	**77.3%**
Major Advanced	75.9%	76.8%	74.3%	75.3%	71.9%	72.0%	**74.3%**
Transition	78.3%	76.0%	73.0%	73.6%	81.8%	80.9%	**77.2%**
Average	**77.5%**	**77.0%**	**74.2%**	**75.8%**	**76.0%**	**75.4%**	**75.9%**

Source: Author's computations

The main conclusion of the comparison is that the average profit efficiency is equal among the groups, less for the advanced major economies which fare somewhat worse than the other groups. (Lozano-Vivas & Pasiouras, 2010) find a somewhat similar picture, albeit for their case the transition economies have lower profit efficiency than advanced and developing economies, and equal to major advanced economies. Since, their sample spans over 1999-2006 while ours starts in 2004 and ends in 2010, we might be capturing a period with improved profit efficiency levels for the banks from the transition economies, which might have caught up with the rest of the banking systems. Certainly, this hypothesis would have to be investigated separately for validation.

For a more suitable presentation of the evolution of the profit efficiency in time and across classes, groups and regions we estimate four separate regressions for each of the classes – using a set of dummy variables to distinguish between regions and also include country specific and bank specific variables to capture the main balance sheet adjustments that drove the changes in efficiency.

Table A. 3 in the appendix summarizes the main findings from regressing equation 8. For the 1st class we find that the change in profit efficiency is negatively associated with all the bank specific variables. This indicates that banks with a decrease in loan-to-deposit ratio have increasing profit efficiency. The same holds true for the deposit-to-total funding ratio and the change in liquidity. While the associations are significant, we cannot claim causation – as the interaction can go both ways. Interestingly, for the 1st class we also find that banks accessing support from FED had on average decreasing profit efficiency. While this is broadly an expected result, it is in contradiction with FED's statements that only pre-qualified, healthy institutions could tap into the prepared funds. The crisis dummy indicates that the efficiency declined in 2007 and 2008 compared to other years. Following through with the analysis we find that banks from Western Europe had declining profit efficiency compared to the other banks, while banks from Eastern Europe and Latin America experienced increasing profit efficiency for banks in this class. Finally, the banks from developing and transition economies had increasing profit efficiency. This last finding supports partially our assertion regarding a possible catch-up process for the banks from transition and developing countries.

The model for the 2nd class provides less informative results. From Model 1 we infer that Western Europe and Eastern Europe had declining profit efficiency, while on the level of economic development groups, the transition economies had a declining profit efficiency and advanced countries had increasing efficiency. This contrasts with the results found for the previous class. Unreported regressions confirm our hypothesis that banks from 2nd class, gained efficiency by adjusting their loan-to-deposit ratio from higher to lower levels. The regression for the 3rd class indicates that banks had somewhat increasing efficiencies during 2007 and 2008. However, for this class we find that banks from Middle East and Africa were mainly gaining efficiency over the period. The economic development group dynamics indicates that banks from advanced countries experienced a decline in profit efficiency while developing countries an increase. The final, 4th class regression points to a positive development for the profit efficiency in Middle East and Africa and Australia, and shows deterioration for Latin American banks. However, both developing and advanced countries experienced declining profit efficiency.

Generally, the results indicate rather heterogeneous outcomes. It looks like the banks from these 4 latent classes that we identified had a different behavior over the period – and subsequently were affected differently by the crisis. An important source of balance sheet rebalancing is the optimization of the loan-to-deposit ratio which emerges negatively associated with the change in profit efficiency, and could therefore represent one of the main tools in managing the revenues.

C. Cost Efficiency

The estimates of the cost function are summarized in ***Table A. 4***. The 4 class latent class SFA cost model indicates the existence of 4 different banking technologies in the data[8]. The class determinants indicate that these technologies are statistically different from one another. A quick analysis of class characteristics indicate that banks with lower loans-to-deposits ratio increase the probability of a bank to be assigned to the first latent class. The funding structure determines the other two classes. Banks with higher customer deposits in total funding are generally assigned to the second or third class. The other influence in class assignment comes from fitting the cost function. The 1st and 4th class, for the cost frontier, are also the smallest groups, with only 4.9% and 8.4% of total banks, respectively. The other banks are split almost equally between the 2nd and 3rd classes, 45.7% and 41% respectively. The averages of class probability determinants and average class cost efficiencies are summarized in ***Table 6***.

Table 6: Class Determinants & Average Cost Efficiency

Classes	Loans to Deposits	Deposits to TF	Cost Efficiency
1	115.14	60.31	**86.9%**
2	96.64	79.06	**80.3%**
3	100.63	78.01	**93.1%**
4	134.13	65.91	**88.9%**
Average	**102.52**	**76.49**	**86.5%**

Source: Author's computations

The efficiency levels are different among the four classes, with the highest level for the 3rd class, 93.1%, the second highest for the 4th class, 89%, for the 1st class, 86.9% and 80.3% for the 2nd latent class. In contrast with the profit efficiency, the more banks relied on alternative (non-core) sources of financing, the more cost efficient they were over the period. It indicates, that generally, the non-core funding is not as cost intensive as the depository funding, which although more stable, also requires more resources to secure it (**Table 7**). This finding is also in line with Berger & Mester's (1997) finding that banks with more non-core funding were on average more cost efficient. On the other hand, our results contrast with those in (Berger & Mester, 1997) when it comes to the level of loans. We find rather mixed results for the latter.

[8] We highlight that the 4 latent classes determined for the cost function are different in content from the 4 classes estimated for the alternative profit function.

Table 7: Cost Efficiency Estimates

Classes	2005	2006	2007	2008	2009	2010	Average
1	86.0%	87.3%	86.6%	87.0%	87.0%	87.2%	**86.9%**
2	80.3%	81.3%	79.3%	80.0%	81.8%	79.2%	**80.3%**
3	93.2%	93.2%	93.0%	93.0%	93.5%	92.9%	**93.1%**
4	88.9%	88.9%	88.2%	88.6%	90.2%	88.7%	**88.9%**
Average	**86.4%**	**87.0%**	**86.0%**	**86.3%**	**87.5%**	**86.1%**	**86.5%**

Source: Author's computations

The coefficient on the trend, T, is positive for all 4 classes indicating an increase in costs across all groups of banks at a decreasing rate. Interestingly, the banks relying more on non-core funding had on average higher cost increases. This is in line with the interbank market freeze during the crisis, when it was prohibitively expensive to refinance the short-term debt, and the banks were experiencing increasing rollover risks. Paradoxically, the banks relying on customer deposits did experience an opposite effect. On the contrary their costs, on average, also increased although central banks from major advanced countries slashed the refinancing interest rates. This finding indicates that there was significant funding fragmentation which was not entirely mitigated by the intervention of the monetary authorities through rate cuts and non-orthodox monetary measures.

The evolution of cost efficiency over time is muted. Unlike, profit efficiency, cost efficiency is rather stable over the period, which indicates that banks are generally more capable of managing the cost side than the revenue side. This is a natural outcome, given that banks' revenue could be influenced by idiosyncratic and unmanageable external shocks. Additionally, the mix of products and their quality cannot be altered fast enough to avoid losses of efficiency. As seen in the previous section, this was only achieved by very few banks. The stability of the cost efficiency is observed over all classes of banks. This also indicates that regardless of the funding structure, banks managed their cost side in a rather smooth way over the cycle.

Additionally, for the cost function we estimate returns to scale as $RTS=1-\sum_j \partial C/\partial \log y_j$. For all classes the returns to scale are estimated to be less than one. This is in line with the existing literature, (Meter & Berger, 1997), (Orea & Kumbhakar, 2004), (Greene, 2003), (Greene, 2004) or (Greene, 2005) and indicates that banks operate at increasing returns to scale.

As for profit efficiency we now compare cost efficiency of banks across regions and economic development groups. **Table 8** below summarizes the differences in cost efficiency among the regions. This picture contrasts sharply with the profit efficiency ranking of regions, but is in broad lines with the findings in (Pasiouras, Tana & Zopounidis, 2009) and (Lozano-Vivas & Pasiouras, 2010). While the mean cost efficiency is around 86%, the most efficient region is North America with an average of 89.7% and the least efficient is Eastern Europe with only 83.2%. The ranking of regions differs slightly from the previous studies, although the patterns are comparable. Western European banks have an average cost efficiency of 85% which is close to that of the banks from Asia and Middle East and Africa. Australian and banks from Latin America register average cost efficiency of 87%. The rather contrasting difference between Western European banks and North American banks indicates, as in (Bos & Kolari, 2005), that banks from these regions operate under different cost frontiers.

Table 8: Cost Efficiency by Regions

World Region	2005	2006	2007	2008	2009	2010	Average
Western Europe	83.3%	85.6%	83.8%	83.9%	86.6%	87.0%	**85.1%**
MEA	87.5%	85.4%	84.8%	86.0%	85.2%	83.5%	**85.3%**
Latin America	86.7%	89.7%	87.4%	86.7%	87.8%	87.8%	**87.6%**
Australia		83.0%	88.4%	88.4%	88.4%	87.3%	**87.7%**
ASIA	84.8%	85.9%	86.0%	86.1%	87.3%	85.0%	**85.9%**
Eastern Europe	85.0%	87.8%	85.0%	83.3%	79.9%	78.9%	**83.2%**
North America	90.4%	89.9%	88.6%	89.6%	91.0%	88.9%	**89.7%**
Average	**86.4%**	**87.0%**	**86.0%**	**86.3%**	**87.5%**	**86.1%**	**86.5%**

Source: Author's computations

The economic development groups display a few rather interesting, albeit, intuitive results as well (see **Table 9** below). Thus, transition economies have the lowest cost efficiency among the groups, with only 83.5% while Major advanced economies have 88.3%. Advanced and developing economies are about the same in terms of cost efficiency, around 85%. This result is broadly in line with the findings in (Lozano-Vivas & Pasiouras, 2010), although obtained with another sample and for another time span.

Table 9: Cost Efficiency by Economic Development Group of Countries

Row Labels	2005	2006	2007	2008	2009	2010	Average
Developing	86.0%	85.8%	85.3%	85.6%	85.8%	84.4%	**85.5%**
Advanced	83.9%	85.7%	84.0%	83.4%	86.0%	86.4%	**84.9%**
Major Advanced	87.6%	88.1%	87.4%	88.4%	90.3%	88.0%	**88.3%**
Transition	85.8%	88.2%	85.4%	83.4%	79.8%	79.0%	**83.5%**
Average	**86.4%**	**87.0%**	**86.0%**	**86.3%**	**87.5%**	**86.1%**	**86.5%**

Source: Author's computations

To grasp in a more granular fashion the main differences among different classes of banks and their behavior during the analyzed period, we estimate equation 8 using, this time, as a dependent variable the change in cost efficiency. The specification, otherwise, remains unchanged from the profit efficiency estimation.

Table A. 5 summarizes the regression results for each of the 4 cost efficiency latent classes. As for the case of the profit efficiency, the results indicate heterogeneous behavior of banks across time, groups and regions. For the 1st class we identify a few significant associations. First, the change in deposits-to-total funding ratio is related positively with cost efficiency changes. That is, for the first class, increases in the ratio are associated with increases in cost efficiency. This generally contrasts with the negative association between the level of efficiency and the deposit-to total funding ratio, (Berger & Mester, 1997). Turning to the region dummies we identify a negative cost efficiency development in Asia and positive in Australia. Developing and advanced groups are mirroring Asia and Australia in the second model, respectively.

The regression results for the 2nd class indicate a positive relationship between cost efficiency change and loans-to-deposits ratio, a negative relationship with the change in liquidity and an increase in cost efficiency over 2007 and 2008 compared to the other periods. Regionally, the evolution of cost efficiency was positive Western Europe, Latin America, Asia and Eastern Europe. We document the same type of evolution across all the development groups without exception. For the 3rd class, the regression indicates that banks which tapped into FED's funds had an increase of cost efficiency during the period. This also overlaps with increasing cost efficiency during 2007 and 2008. Regionally, Western European banks stand out as significantly improving the cost efficiency. On the other hand, within the economic development groups, banks from transition economies had a decline in profit efficiency while advanced countries had an improvement.

This rather segmented picture indicates a rather complex story behind the evolution of banking during 2005-2010 period. It indicates that banks with different characteristics were affected in a different way by the economic and financial shocks of 2007 and 2008. These developments were equally heterogeneous on both sides – cost and revenue. Notwithstanding all the differences, a global efficiency frontier is feasible – under the conditions that the main differences are accounted for – but remains subject to unobserved characteristics which complicate any attempt of generalization.

The current picture of international bank efficiency could however suffer considerable changes under the up-coming structural reforms currently in the pipeline for approval in many jurisdictions. One direct implication of the structural reform agenda will be the disentanglement of the securities business from commercial banking business which will alter the product mix of most of the biggest world banks. This will certainly alter both the revenue side and the cost side of the equation having a direct impact on the scale economies and scale efficiency (Hughes, Mester & Moon, 2001). It could however also affect the cost and profit efficiency of the banks by restraining the sources of diversification of revenues and funding for many banks and by further restricting bank activity along national boundaries (Gambacorta & van Rixtel, 2013).

D. Further research opportunities

While the current analysis provides a raw diagnostic of the international bank efficiency over the 2005-2010 period several extensions could further enhance our understanding of banking activity over the period. One such extension could be built using (Cihak, Demirguc-Kunt, Peria, & Mohseni-Cheraghlou, 2012) the updated international bank supervision database to account for the differences in bank supperviosion across countries, but most importantly to account for the main changes in suppervision during the crisis and quantify their impact on the cost and profit efficiency of the banks. In the same realm we could add an aggregate country variable (liquidity provided by the Central Bank as a fraction of total bank assets) controlling for the bail-out funds commited by the central banks (or the lender of last resort) to measure the impact of these measures on the cost and profit efficiency of banks. Finally, we could extend the analysis beyound the current framework by modifying the sample to include parent banks and subsidiaries operating in different countries as separate entities and control for the environmental and suppervisory differences in an attempt to gauge the possible implementation of the structural reforms currently on the agenda.

VI. CONCLUSIONS

This paper adds to the existing literature on frontier efficiency by providing empirical evidence on the impact of the 2007-2008 financial and economic crises on the profit and cost efficiency of an international sample of banks. It is also among the very few papers applying a Latent Class Stochastic Frontier Analysis to an international comparison study. The model is applied on a set of 756 banks in 77 countries over 2005-2010. The evolution of the efficiency over the period is then analyzed in a second step regression analysis to uncover the main patterns and differences between classes of banks, groups and regions.

We distinguish for each, the profit and cost function, 4 different production (cost) technologies which are statistically meaningful and different among each other, yielding different levels of efficiency. This indicates that while our efficiency estimates are in line with other similar studies, (Pasiouras, Tana & Zopounidis, 2009) or (Lozano-Vivas & Pasiouras, 2010), a more granular analysis depicts a more nuanced picture regarding the international banking industry. The immediate implication emerging from this analysis is that some types of banks are *a priori* more adapted for certain economic conditions than others, and could work equally efficient in any of the countries with the same type of environment.

We also find that banks from different classes have a heterogeneous nature not just from the level of efficiency but also from the evolution of the efficiency over the period. In other words, while during 2007 and 2008 the general trend in profit efficiency was a decreasing one, some groups of banks experienced profit efficiency gains, mostly through a swift balance sheet rebalancing. This also indicates that the more active banks could have achieved that at the expense of more conservative peers. FED's intervention seems to have had a limited positive impact on the funding side while not ameliorating the problems on the revenue. Generally cost efficiency was more stable than profit efficiency. At the same time, similar types of banks responded differently to the crisis depending on the region or country were they activate –

therefore, while structurally the banks from the same class were similar, it looks like there are other factors that drive the response of the banks to external events and that cannot be factored into the model. Such factors could relate to the management team, corporate structure and shareholder control or other corporate governance issues – particularly sensible areas for developing and transition countries.

The results also indicate that banks have several ways of readjusting the balance sheet in order to face the external shocks and to keep the same level or improve the general level of efficiency. They could either operate on through the asset side by rebalancing the liquid and illiquid assets, through the liability side through altering the mix of funding resources or through a combination of both, by scaling back the loan portfolio while increasing the ratio of stable funding. Several of these strategies have opposite effects on the cost and profit efficiency, therefore the use of any of these has to be aligned to the goal of the bank. These strategies could prove particularly crucial should the structural banking reform packages be implemented in the near future.

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Table A. 1: Summary Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Operating Profit	4088	723378.7	2850028	-5.3E+07	3.5E+07
Total Cost	4088	4108426	1.2E+07	10900	1.5E+08
Net Loans	4088	5.1E+07	1.3E+08	1	1.7E+09
Total Securities	4088	3.9E+07	1.5E+08	1	2.4E+09
Loans to Banks	4088	8941703	3.3E+07	1	4.5E+08
Other Assets	4088	3706000	1.7E+07	446	2.7E+08
Personnel Expenses	4088	856276.1	2814366	1	3.5E+07
Total Assets	4088	1.1E+08	3.2E+08	253200	3.8E+09
Other Operating Expenses	4088	877413.9	2609920	3300	4.6E+07
Fixed Assets	4088	876736.4	2444302	1069	3.1E+07
Interest Expenses	4088	3.30%	5.09%	-3.35%	141.24%
Other Interest Expenses	4088	2.90%	2.33%	-1.31%	27.03%
NPL	4088	3.36%	4.01%	0.00%	63.73%
LCD	4088	102.52%	57.35%	0.00%	993.22%
DTF	4088	76.49%	20.18%	0.00%	100.00%
Liquidity	4088	21.83%	24.87%	0.30%	558.97%
GDP Growth (%)	4088	2.92%	4.33%	-17.70%	34.50%
Dummies					
CRISIS	4088	0.3557	0.4788	0	1
FED Support	4088	0.0873	0.2824	0	1
Developing	4088	0.3315	0.4708	0	1
Advanced	4088	0.1690	0.3748	0	1
Major Advanced	4088	0.4477	0.4973	0	1
Transition	4088	0.0519	0.2218	0	1
Western Europe	4088	0.2209	0.4149	0	1
Latin America	4088	0.0384	0.1922	0	1
Australia	4088	0.0064	0.0795	0	1
Eastern Europe	4088	0.0460	0.2095	0	1
North America	4088	0.2405	0.4274	0	1

Note: NPL stands for non-performing loans; LCD stands for loans-to-deposits ratio and DTF stands for deposits to total funding ratio. Crisis is a dummy taking 1 for 2007 and 2008 and 0 otherwise; Fed Support is a dummy taking the value of 1 for the year and the bank which tapped FED's support programs – the data on individual institutions was obtained from the Federal reserve website. Regional and economic categories are defined in **Table …** in the appendix.

Table A. 2: Profit Efficiency Estimation - 4LCM

Variables	1st Class	2nd Class	3rd Class	4th Class
Y1	-.407*** [0.020]	-.470*** [0.105]	-.202*** [0.006]	-.537*** [0.012]
Y2	-.515*** [0.015]	.121*** [0.043]	-.305*** [0.008]	-.393*** [0.009]
Y3	0.006 [0.007]	-0.023 [0.078]	-.036*** [0.005]	.009*** [0.002]
Y4	-0.107 [0.011]	-.336*** [0.092]	-.347*** [0.011]	-.142*** [0.007]
W1	.086*** [0.005]	0.201 [0.182]	.0153*** [0.005]	0.003 [0.002]
W2	.076*** [0.017]	-.349*** [0.100]	.079*** [0.012]	-.047*** [0.017]
W3	-.472*** [0.028]	0.111 [0.192]	-.212*** [0.023]	-.063*** [0.019]
T	.264*** [0.039]	-.803*** [0.179]	-.345*** [0.022]	-.109*** [0.011]
T2	-.051*** [0.006]	.079** [0.034]	.026*** [0.004]	-.004* [0.002]
Sigma	.549*** [0.031]	1.318*** [0.214]	.889*** [0.025]	.642*** [0.002]
Lambda	.740*** [0.175]	2.781 [1.731]	5.273*** [0.593]	3.709*** [0.159]
	Probabilities			
Constant	-0.109 [0.949]	0.229 [1.358]	0.229 [0.836]	Fixed
Loans to Deposits	0.002 [0.003]	0.005 [0.004]	0.001 [0.003]	Fixed
Deposits to Total Financing	-0.010* [0.009]	-.046*** [0.016]	-.017** [0.008]	Fixed
NPL	-0.027 [0.030]	-.294** [0.137]	0.029 [0.022]	Fixed
Posterior Probabilities	25.36%	1.18%	21.90%	51.56%

Source: Author's computations

Table A. 3: Profit Efficiency Change - Groups and Regions

Structure	Profit Efficiency	Class 1	Class 2	Class 3	Class 4
Base	**ΔLCD**	-0.034** [0.015]	0.0431 [0.087]	-0.049* [0.027]	-0.060* [0.033]
	ΔDTF	-0.079** [0.031]	-0.433 [0.420]	-0.126 [0.147]	-0.167 [0.129]
	ΔLiquidity	-0.098** [0.045]	-0.018 [0.101]	-0.070 [0.066]	-0.056 [0.088]
	FED support	-0.988** [0.417]	2.016 [2.419]	0.090 [1.272]	-2.095*** [0.638]
	GDP Growth	0.017 [0.084]	0.543 [0.977]	-0.319 [0.346]	0.096 [0.321]
	CRISIS	-0.972** [0.474]	8.427 [5.828]	4.763* [2.703]	1.765 [2.258]
Model 1	**Western Europe**	-0.312* [0.175]	-20.576*** [2.979]	4.783 [0.827]	0.765 [0.684]
	Latin America	0.779*** [0.273]	1.411 [3.640]	-1.495 [0.833]	-3.848*** [1.392]
	Australia	-	-4.072 [3.456]	0.879 [0.907]	4.993*** [0.932]
	Asia	-0.624 [0.472]	-	-1.174 [2.202]	-0.024 [1.859]
	MEA	0.598 [0.585]	-	5.248*** [0.922]	4.643*** [1.150]
	Eastern Europe	1.898*** [0.123]	-12.910*** [3.367]	-0.201 [0.486]	0.326 [1.885]
Model 2	**Developing**	4.758* [2.873]	1.411 [3.640]	5.248*** [0.922]	-5.331*** [2.014]
	Advanced	-0.624 [0.472]	11.405*** [4.119]	-2.493*** [0.493]	-2.926* [1.675]
	Transition	1.898*** [0.123]	-12.910*** [3.368]	-0.201 [0.486]	0.326 [1.885]
Constant		0.162 [0.290]	-4.754** [3.545]	-1.320 [1.843]	-0.165 [0.539]
Stats	**Number of Groups**	177	23	161	395
	Number of Obs.	765	86	705	1744
	R - squared	15%	25%	8%	7%
	Between	44%	45%	32%	29%
	Within	11%	19%	4%	5%

Note: This table presents the results from the second step regression using as a dependent variable the change in profit efficiency; ΔLCD – stands for the change in loan-to-deposits ratio, ΔDTF – change in the deposit-to-total funding ratio, ΔLiquidity – the change in liquidity; FED support – is a dummy which takes a value of 1for the bank and year in which that bank applied for any of the FED support programs, Crisis is a dummy taking a value of 1 for 2007 and 2008 and 0 otherwise and Western Europe, Latin America, Australia, Asia, MEA and Eastern Europe and North America are the regional dummies as defined in Table A. 6 in the appendix. Developing, Advanced, Transition and Major Advanced are the dummies for the economic development group classification. All the regressions are run with country and time effects to control for any ear specific and country specific shocks. Model 1 includes all the variables under Base and the regional dummies. Model 2 includes all variables under Base and the economic development group dummies.

Table A. 4 : Cost Efficiency Estimation - 4 LCM

	1st Class	2nd Class	3rd Class	4th Class
Constant	14.513*** [0.387]	14.866*** [0.047]	14.381*** [0.076]	13.593 [1488]
Y1	-0.011 [0.012]	.828*** [0.008]	.869*** [0.012]	1.041*** [0.049]
Y2	.125*** [0.018]	.101*** [0.006]	.099*** [0.008]	.464*** [0.034]
Y3	-.164*** [0.044]	.031*** [0.002]	.024*** [0.002]	-.036*** [0.009]
Y4	.478*** [0.043]	-.016*** [0.006]	-.050*** [0.007]	-.348*** [0.026]
W1	.146*** [0.018]	.063*** [0.002]	.064*** [0.002]	1.081*** [0.059]
W2	0.033 [0.037]	-0.022 [0.015]	-.054*** [0.018]	0.053 [0.034]
W3	.582*** [0.050]	.297*** [0.016]	.265*** [0.019]	0.015 [0.069]
T	.572*** [0.159]	.321*** [0.031]	.296*** [0.034]	.421** [0.173]
T2	-.057** [0.023]	-.037*** [0.004]	-.034*** [0.005]	-.055** [0.024]
Sigma	.554*** [0.127]	.529*** [0.007]	.359*** [0.022]	0.696 [9.739]
Lambda	0.818 [0.946]	2.493*** [0.160]	.505** [0.253]	0.008 [2680.14]

Probabilities				
Constant	1.672 [1.263]	0.038 [0.803]	-0.115 [0.892]	Fixed
Loans to Deposits	-.008** [0.004]	-0.003 [0.002]	-0.001 [0.002]	Fixed
Deposits to Total Funding	-0.018 [0.014]	.025*** [0.009]	.023** [0.10]	Fixed
Posterior Probabilities	4.86%	45.69%	41.09%	8.36%

Source: Author's computations

Table A. 5: Cost Efficiency Change - Groups and Regions

Structure	ΔCost Efficiency	Class 1	Class 2	Class 3	Class 4
Base	**ΔLDR**	0.011 [0.019]	0.027* [0.016]	0.009* [0.005]	0.022* [0.012]
	ΔDTF	0.151** [0.069]	0.072 [0.060]	0.013 [0.012]	0.081** [0.032]
	ΔLiquidity	0.026 [0.018]	-0.111*** [0.036]	-0.007 [0.006]	0.004 [0.007]
	FED Support	-0.775 [1.609]	0.418 [0.705]	0.189** [0.086]	0.274 [0.509]
	GDP Growth	-0.107 [0.076]	-0.094 [0.130]	-0.008 [0.038]	0.111 [0.102]
	Crisis	0.096 [1.165]	3.732*** [0.994]	0.554** [0.257]	1.756* [0.922]
Model 1	**Western Europe**	0.578 [0.735]	4.420*** [0.310]	0.314*** [0.091]	0.721*** [0.249]
	Latin America	-	3.624*** [0.468]	-0.117 [0.077]	-0.639* [0.350]
	Australia	1.211** [0.589]	-	-0.034 [0.130]	0.011 [0.317]
	Asia	-4.683*** [1.431]	3.718*** [0.943]	-0.135 [0.251]	0.635** [0.269]
	MEA	1.557 [1.235]	1.034 [0.782]	0.045 [0.094]	-0.030 [0.289]
	Eastern Europe	-0.227 [1.179]	2.076*** [0.179]	0.227 [0.151]	-1.216*** [0.472]
Model 2	**Developing**	-4.683*** [1.431]	6.863*** [0.531]	0.045 [0.094]	-0.030 [0.289]
	Advanced	3.255*** [1.212]	3.918*** [0.717]	1.229*** [0.172]	4.128*** [0.339]

	Transition	-0.227 [1.179]	2.076*** [0.179]	-0.667*** [0.212]	-1.216*** [0.472]
Constant		-0.134 [1.109]	-3.864 [0.576]	-0.584*** [0.142]	-2.233*** [0.507]
Stats	**Number of Groups**	42	348	299	67
	Number of Obs.	172	1515	1324	289
	R - squared	14%	14%	14%	11%
	Between	74%	29%	29%	32%
	Within	25%	11%	11%	7%

Note: This table presents the results from the second step regression using as a dependent variable the change in profit efficiency; ΔLCD – stands for the change in loan-to-deposits ratio, ΔDTF – change in the deposit-to-total funding ratio, ΔLiquidity – the change in liquidity; FED support – is a dummy which takes a value of 1for the bank and year in which that bank applied for any of the FED support programs, Crisis is a dummy taking a value of 1 for 2007 and 2008 and 0 otherwise and Western Europe, Latin America, Australia, Asia, MEA and Eastern Europe and North America are the regional dummies as defined in Table A. 6 in the appendix. Developing, Advanced, Transition and Major Advanced are the dummies for the economic development group classification. All the regressions are run with country and time effects to control for any ear specific and country specific shocks. Model 1 includes all the variables under Base and the regional dummies. Model 2 includes all variables under Base and the economic development group dummies.

Table A. 6: Country Grouping by Economic Development & Geographical Region

Panel A: by Economic Development

Developing			
United Arab Emirates	Angola	Argentina	Bahrain
Bermuda	Brazil	China	Columbia
Costa Rica	Dominican	Egypt	Guatemala
Indonesia	India	Jordan	Kuwait
Lebanon	Morocco	Malta	Mauritius
Mexico	Malaysia	Nigeria	Oman
Panama	Peru	Philippines	Pakistan
Qatar	Saudi Arabia	Togo	Thailand
Turkey	Trinidad & Tobago	Taiwan	Venezuela
South Africa			
Transition			
Azerbaijan	Bulgaria	Belarus	Georgia
Hungary	Kazakhstan	Latvia	Poland
Romania	Russia	Slovenia	Ukraine
Vietnam			
Major Advanced			
Canada	Germany	France	Great Britain
Italy	Japan	USA	
Advanced			
Andorra	Austria	Australia	Belgium
Switzerland	Cyprus	Denmark	Spain
Finland	Greece	Hong Kong	
Ireland	Israel	South Korea	Lichtenstein
Netherlands	Norway	Portugal	Sweden
Singapore			

Panel B: by Geographical Region

Western Europe				
Austria	Belgium	Switzerland	Cyprus	Finland
Germany	Denmark	Spain	Ireland	Netherland
Great Britain	Greece	France	Lichtenstein	Malta
Italy	Norway	Portugal	Sweden	Turkey
Eastern Europe				
Bulgaria	Belarus	Georgia	Hungary	Russia
Latvia	Poland	Romania	Slovenia	Ukraine
Middle East & Africa				
United Arab Emirates	Angola	Bahrain	Egypt	Israel
Morocco	Jordan	Kuwait	Lebanon	Nigeria
Saudi Arabia	Togo	Oman	Qatar	South Africa
Mauritius				
North America				
Canada	USA			
Latin America				
Argentina	Bermuda	Brazil	Columbia	Costa Rica
Trinidad & Tobago	Dominican	Guatemala	Mexico	Peru
Panama	Venezuela			
Asia				
Azerbaijan	China	Hong Kong	Indonesia	
India	Japan	South Korea	Kazakhstan	
Malaysia	Philippines	Pakistan	Singapore	
Thailand	Taiwan	Vietnam		
Australia				
Australia				

Note: The classification was done according to Global Market Information Database.

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