EFFICIENCY DIFFERENCES AMONG BANKS: EXTERNAL, TECHNICAL, INTERNAL, AND MANAGERIAL

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Efficiency Differences Among Banks: External, Technical, Internal, and Managerial.

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Abstract

Using parametric and nonparametric procedures, we identify the apparent source of cost inefficiency in banking. Inefficiencies of 20 to 25% reported in earlier studies are reduced to 1 to 5% when, in addition to commonly specified cost function influences, variables reflecting the external business environment and common industry indicators of "productivity" are added. While these same productivity indicators explain most of the reduction in bank operating cost over time, cost reductions during 1992-2001 were 5 times the reduction from improved efficiency. This helps explain why inefficiency appears stable over time--it is small relative to industry-wide cost changes occuring concurrently. (100 words)

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1. Introduction.

Almost all studies of cost efficiency in banking, whether in the U.S., Europe, or elsewhere, suggest that inefficiency is relatively large and persistent. Averaging the results of 130 studies across five different types of frontier approaches for 21 countries suggests that average cost inefficiency in various nations' banking industries is 20% to 25% (Berger and Humphrey, 1997). That is, the average bank appears to experience total operating plus interest costs that are from 20% to 25% higher than the most cost-efficient bank after controlling for: (a) differences in the value of various types of loans and securities (or deposits) in the balance sheet; (b) differences in average funding, labor, and capital costs among banks; and (c), the technology by which banking inputs are transformed into outputs.

As bank net income is around 17% of total costs (the U.S. average over 1998-2001, with lower percentages for other countries), this suggests that the average bank--not just the most inefficient among them--could more than double their profits and return on assets by restructuring their operations to look like those banks that appear to be most efficient. If true, the incentive to restructure and "look like" the most efficient banks--in a benchmarking or "best practice" context--should be very strong. Yet, the average levels of measured inefficiency do not seem to be consistently falling over time for any of the numerous countries which have been studied. Are measured inefficiencies overstated so actual incentives to improve efficiency are much weaker than they appear? Or, if correctly measured, are they largely beyond the effective control of management? And, if not overstated and not beyond managements= control, what then explains the persistent differences among banks?

It is hard to answer these questions as few studies have had much success in identifying the major sources of the inefficiency being measured. Without knowing the main source(s) of the problem, it is difficult to determine why efficiency is different and appears to be persistent. Unlike banking consultants who have privileged access to detailed cost data and focus on benchmarking efficiency among branches of a single bank (Sherman and Ladino, 1995), existing academic studies are typically concerned with benchmarking efficiency among banks within a single country using only publicly available information. Both approaches are useful to the extent that major sources of efficiency differences can be identified. Our view is that a more informed and comprehensive analysis of identifying the sources of inefficiency is needed. In this regard, we separately identify inefficiency associated with bank funding expenses versus operating costs, which is where we expect to find most of our measured inefficiency. Within the funding and operating cost components, we seek to determine the portions of cost differences among banks attributable to inefficiency from external, technical (cost function), internal, and (residual) managerial sources and thereby assess reasons for its persistence and management's apparent inability to reduce its average incidence over time.

In what follows, we briefly outline the main methods used to determine efficiency in Section 2 and review studies that have attempted to identify sources of inefficiency in banking. Typically, this explanatory analysis has focused on measures derived from banks= balance sheets as opposed to external influences that frame a bank=s economic environment or partial indicators of a bank's internal productivity that are used as benchmarks within the industry. A broader set of influences is developed in this study and consist of: (1) external influences outside of the control of management; (2) technical influences associated with transforming banking inputs into outputs within a cost function framework; (3) influences partly under managerial control and thus are--to differing degrees--internal to the firm; and (4), influences that can not be directly measured with the available data but have been inferred and attributed to unknown managerial policies, organizational structure, or leadership ability.

Our approach to assessing the differing influences on measured cost efficiency is presented in Section 3. To demonstrate the robustness of our results, we apply both a parametric model--Distribution Free Approach (DFA)--and a linear programming model--Data Envelopment Analysis (DEA). Our main parametric efficiency results are reported in Section 4 while those for our nonparametric model are in Section 5. Both are based on semi-annual observations on 46 savings banks plus 31 commercial banks in Spain over 1992-2001, giving a total of 1,540 panel observations. Efficiency estimates are presented separately for funding versus operating costs, grouped according to external, technical, internal, and managerial sources of inefficiency, and distinguished between savings and commercial banks.

Overall, the funding function of a bank is seen to contain few inefficiencies (as expected) while most of the traditionally measured inefficiencies lie within the operating function of a bank. Interest cost efficiency reaches 99.9% with our full model while a 95% level is obtained for operating costs. This is considerably higher than the typical levels attained in more limited studies and suggests that previous studies have understated banking efficiency. As envisioned by the original proponents of the frontier efficiency concept (e.g., Charnes, Cooper, and Rhodes, 1978), we find that previously unexplained (residual) differences in efficiency are dominated by common measures of bank productivity and are not really a "black box" after all. Having reduced measured inefficiency to very low levels, we argue that a portion of the remaining unexplained residual can be attributed to management decisions with a priori inherently uncertain outcomes. Thus a portion of the small amount of remaining inefficiency may best be considered as inherent and irreducible.

In order to compare better the results obtained using these two methodologies, we also present mean efficiency scores for both the DFA and DEA cost frontiers using a bootstrap technique in Section 6 and report the corresponding confidence intervals. A brief summary of the paper and our conclusions are presented in Section 7.

2. Determinants of Inefficiency in Banking.

Two Approaches to Measuring Efficiency. The most common approach to cost efficiency measurement has been to relate total banking costs to the value of various balance sheet components along with funding and labor and capital input prices within a parametric cost function. While the specific form used imposes some structure on the technical relationship between banking inputs and outputs, a more important component is how inefficiency is measured. The composed error Stochastic Frontier Approach (SFA) typically assumes a half-normal distribution for inefficiencies and uses this assumption to separate inefficiencies from normally distributed error in a panel regression.[1] The Distribution Free Approach (DFA)--the model used here--assumes that averaging each bank's residuals across separate yearly cross-section regressions reduces normally distributed error to minimal levels leaving only average inefficiency. Although both models involve strong assumptions, they generate similar levels and rankings of banking inefficiency (Bauer, Berger, Ferrier, and Humphrey, 1998).

A second approach to measuring inefficiency utilizes linear programming, assumes that random error equals zero, and--unlike the cost function parametric approach--places little structure on the specification of the piecewise linear best-practice frontier that results. Of two linear programming models, Data Envelopment Analysis (DEA) is by far the most used and so is

[1]The assumption that most banks are close to the efficient frontier so that inefficient firms are skewed away from the frontier (as in a half-normal distribution of inefficiency) does not appear to be the case in practice (Bauer and Hancock, 1993; Berger, 1993). The distribution of inefficiencies is more like a symmetric normal distribution which would make it difficult to identify separately from normally distributed error.

used here as well.[2] While the parametric models rely on some strong assumptions regarding the form of the distribution of inefficiency or the ability to average random errors to levels close to zero for individual banks over time, the drawback with the DEA model is that the more influences specified as potentially having an effect on explaining inefficiency, the lower will be the measured inefficiency. Importantly, this occurs whether or not the specified variables really are related to inefficiency. Each additional influence (constraint) in the DEA approach reduces the set of banks being compared with the result that measured average inefficiency necessarily declines. With the DFA parametric approach, if a specified influence is truly unimportant, measured inefficiency is unchanged.

Previous Studies Attempting to Determine the Source of Inefficiency. Studies trying to explain differences in inefficiency scores among banks have not had much success. Indeed, the resulting explanatory power of these ancillary regressions is often quite low (e.g., with R^2s < .10). Even so, a few studies have gone beyond the usual set of variables drawn from a bank=s balance sheet and have been more informative. Berger and Mester (1997), for example, have expanded on the usual set of bank size and liability/asset composition variables to include organizational form, governance, market competition, geographical location, and regulatory structure. As well, Dietsch and Lozano-Vivas (2000) have looked deeper still and included variables that reflect how a bank=s economic environment--regional per capita income and population, deposit, and branch densityBcan help explain efficiency differences between two countries. While data availability is a contributing factor here, the basic problem with most efforts to determine the main sources of efficiency differences among banks has been a focus on balance sheet correlates with inefficiency, not on outside environmental factors or even

[2] The other approach is the Free Disposal Hull and will be either congruent with or interior to the DEA frontier. When it is interior, lower estimates of average inefficiency will result (Tulkens, 1993).

partial measures of banking productivity common within the industry (both of which can importantly affect costs among banking firms). In this paper, we continue along the path developed by Berger and Mester and Dietsch and Lozano-Vivas and find that by considering an expanded set of cost influences it is possible to reduce measured (residual) inefficiency down to very low levelsBlevels so low that it is argued that a portion can be considered to be inherent and to a large degree irreducible.

External, Technical, Internal, and Managerial Sources of Inefficiency. Our expanded set of influences on cost efficiency differences among banks concerns external, technical, internal, and managerial sources. External influences on inefficiency represent factors management can do little about at a point in time. Examples include the prevailing level of wages and property/rental costs associated with where a bank is located as well as the current size of the institution. Additional external influences concern the stage of the interest rate cycle (which largely determines the absolute level of deposit and loan rates) and the phase of the business cycle (which is the primary determinant of the strength of loan demand and the supply of deposits, and thus influences the loan-deposit rate spread as well as employment levels of loan officers and tellers).

Technical influences reflect the way in which the cost of producing a given level and composition of banking outputs, such as different types of loans, securities, and/or deposit services, are related to the level of these outputs and the prices of the various funding, labor, and physical (and financial) capital inputs. In short, technical influences are those associated with a cost function and the transformation of banking inputs into outputs.

Internal influences concern cost differences among banks that are partially under the control of banks themselves. This could include the general composition or mix of deposit liabilities (affecting total funding costs) and assets (influencing liability composition via maturity matching). Some institutions will have chosen a liability mix which turns out to be too expensive, given the current stage of the interest rate cycle. Others will have an asset mix that misjudges future loan versus security returns as well as a loan composition that overweights less profitable and higher cost segments. Internal influences on inefficiency also include past managerial decisions on how best to deliver banking services. A large number of ATMs and branches relative to a bank=s deposit base would raise costs and lower net returns while a higher ratio of ATMs to branches, given the deposit base, would do the opposite. Staffing decisions, decisions on how best to meet consumer convenience, and decisions on branch expansion are also internal to the bank and subject to managerial control. They also represent partial measures of banking productivity common within the industry.

Finally, there are organizational differences among banks that can contribute to cost differences. These include differences in organizational structure, in operational policies and procedures, and in the ability of management to lead and motivate employees. These influences are difficult to measure or quantify and can best be determined from in-depth case studies among banks. However, their overall influence may be inferred from the size of the unexplained portion (or residual) of the total difference between a benchmark cost efficiency level for a bank of a given size and location compared to the cost level of an institution of a similar size and location after all the above external, technical, and internal influences on this difference have been accounted for.

3. Specification of Two Efficiency Measurement Models.

Distribution Free Approach (DFA) to Efficiency Measurement. The DFA model of cost frontier measurement uses panel data but does not estimate a panel regression. Instead, for each year of the panel a separate cost function is estimated using cross-section data that relates total banking cost to observed levels of balance sheet variables (loans, securities, deposits) and the average input prices for funding, labor, and physical capital (which sometimes also includes materials and/or financial capitalBequity). The unexplained residuals to each of these cross-section regressions is assumed to contain random measurement error, temporary variations in costs, and persistent but unknown cost differences attributed to inefficiency.

Most efficiency analysis has specified a translog cost equation and estimated it jointly with *n*-1 cost share equations. The log of total (operating plus interest) cost is related to the levels of the logs of banking outputs (Q_i = values of all loans *LOAN* and all securities and other assets *SEC*) controlling for variations in input prices (P_k = prices of funding, labor, physical capital inputs)[3]. The translog specification is:

$$(1)\quad \ln TC = \alpha_0 + \sum \alpha_i \ln Q_i + \tfrac{1}{2} \sum\sum \alpha_{ij} \ln Q_i \ln Q_j + \sum \beta_k \ln P_k + \tfrac{1}{2} \sum\sum \beta_{km} \ln P_k \ln P_m + \sum\sum \gamma_{ik} \ln Q_i \ln P_k + \ln u + \ln v$$

where in the composite error term ln u represents inefficiency and ln v represents random error. The k -1 share equations, with $\ln w$ random error, are:[4]

$$(2)\quad S_k = \beta_k + \sum \beta_{km} \ln P_m + \sum \gamma_{ik} \ln Q_i + \ln w$$

Some studies have used a more flexible function such as the Fourier form which adds sin and cos terms of banking output to the translog specification in (1) giving:[5]

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[3] Appendix Table A1 presents descriptive statistics of all the variables used in our analysis.

[4] Subscripts i, j = 1, 2 are for loans and security "outputs" while subscripts k,m = 1, 2, 3 are for the three input prices.

[5] The term $\ln Q^* = \ln Q(YQ)+ZQ$, where $YQ = 0.8(2\pi)/(\max \ln Q - \min \ln Q)$, $ZQ = 0.2\pi - \min \ln Q(YQ)$, and π = 3.141593..., so that $\ln Q^*$ is essentially expressed in radians. See Mitchell and Onvural (1996) and Berger and Mester (1997). We follow Berger and Mester in our Fourier specification.

$$\begin{aligned}(3)\quad \ln TC = &\text{ Translog Cost Function}\\ &+\sum\left[\omega_{1i}\sin\left(\ln Q_i^*\right)+\omega_{2i}\sin\left(2\ln Q_i^*\right)+\omega_{3i}\sin\left(3\ln Q_i^*\right)\right]\\ &+\sum\left[\omega_{4i}\cos\left(\ln Q_i^*\right)+\omega_{5i}\cos\left(2\ln Q_i^*\right)+\omega_{6i}\cos\left(3\ln Q_i^*\right)\right]\\ &+\omega_7\sin\left(\ln Q_i^*+\ln Q_j^*\right)+\omega_8\cos\left(\ln Q_i^*+\ln Q_j^*\right)\\ &+\omega_9\sin\left(2\ln Q_i^*+\ln Q_j^*\right)+\omega_{10}\cos\left(2\ln Q_i^*+\ln Q_j^*\right)\\ &+\omega_{11}\sin\left(\ln Q_i^*+2\ln Q_j^*\right)+\omega_{12}\cos\left(\ln Q_i^*+2\ln Q_j^*\right)+\ln u+\ln v\end{aligned}$$

with k -1 share equations:

(4) $S_k = \beta_k + \sum \beta_{km} \ln P_m + \sum \gamma_{ik} \ln Q_i + \ln w$.

The DFA concept of efficiency relies on the average value of the unexplained composite residual (ln u + ln v) from a cost function regression which relates total cost to the size, general output composition, and input prices for a set of banking firms over time. The basis for the cost efficiency measure (EFF) is that for each bank over our 10 cross-section estimations, the random error term ln v is assumed to average out to a value close to zero while the mean value of the inefficiency term ln u (represented as ln $\bar{u}$) will reflect the average bank-specific level of cost inefficiency over the period (Berger, 1993).[6] The bank with the lowest average inefficiency term (ln$\bar{u}_{\min}$) is deemed to be the most cost efficient and the efficiency of all the other i banks is determined relative to this standard:

(5) $\text{EFF}_i = \exp\left(\ln \bar{u}_{\min} - \ln \bar{u}_i\right) = \bar{u}_{\min} / \bar{u}_i$

As u_i is multiplicative to TC_i in the un-logged cost equation $TC_i = C(Q,P)u_i$, the ratio $\bar{u}_{\min} / \bar{u}_i$ is an estimate of the ratio of total cost of the most efficient bank, for a given scale of operation and

[6] Using U.S. banking data, DeYoung (1997) devised a test to determine how many years of separate cross-section regressions may be needed to have the random error likely average out close to zero and achieve a stable measure of efficiency. Six years was the result. We have 10 years of data and, instead of positing that measured efficiency should be stable, we interpret our results as an average indicator of efficiency over our period.

input prices, to the total cost of bank i using the same output levels and input prices.[7] For example, if the EFF ratio $\bar{u}_{\min}/\bar{u}_i$ = .80, resources used at the most efficient bank represent only 80% of the level of resources used at the i^{th} bank. This suggests that the i^{th} bank is inefficiently using around (1.00 - .80)/.80 = .20/.80 = 25% of its own resources compared to the most cost efficient bank.[8]

Efficiency with Different Cost Functions and Estimation Procedure. Joint estimation of the translog cost function (1) with its share equations (2) yields a cost efficiency estimate of only .59 for 46 Spanish savings plus 31 commercial banks over 1992-2001.[9] The same result was achieved with the joint estimation of the Fourier cost function (3) with its share equations (4)[10]. An efficiency value of .59 would imply that the average Spanish bank is only around 60% as efficient as the most efficient bank in the data set over this 10 year period. With joint estimation, the average absolute value of the residual across 10 annual cross-section estimations as a

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[7] The ratio $\bar{u}_{\min}/\bar{u}_i = \left(TC_{\min}/C(Q,P)_{\min}\right)/\left(TC_i/C\left(Q,P\right)_i\right)$ and when evaluated at the same output level and input prices, the predicted values of total cost $C(Q,P)_{min}$ and $C(Q,P)_i$ are equal as both are at the same point on the estimated total cost curve, leaving the ratio TC_{min}/TC_i. EFF can vary from zero (where bank i uses multiple times the resources of the most efficient bank) to one (where bank i is just as efficient as the most efficient bank).

[8] The level of inefficiency (INEFF) at the i^{th} bank is INEFF = (1 - EFF)/EFF = (1/EFF) - 1.

[9] Data are observed semi-annually, giving 1,540 panel observations. Our data set includes all savings banks, all but the very smallest commercial banks (which were excluded due mostly missing data), and no cooperative banks (who also had missing data). Even so, the banks we use accounted for 90% of total assets in the Spanish banking system in 2001. Starting at the end of the sample period, data have been backward aggregated to obtain the same number of banks with the same bank code in each year. If two banks had existed but merged before the end of the sample period, they will be aggregated over the period they existed separately and so enter our data set as a single composite bank for the entire period. This permits the use of a balanced panel data set from which to compute the DFA average residual for each bank separately, a process central to this efficiency measure.

[10] We chose not to truncate and arbitrarily improve our efficiency results. Truncation is not normally applied in the DEA approach so, for comparability purposes, it would not be proper to apply it only to the DFA model even though this *ad hoc* adjustment is used in the literature. Similarly, although DEA results can be obtained for each year separately, while DFA efficiency values are an average over 10 years, our reported DEA results are also averaged over the same time period.

percent of the actual level of total cost was 9.4% (so roughly 10% of total cost is unexplained) and the average fit is high at R^2= .987.[11]

The share equations are from $\partial \ln TC/\partial \ln P_k$ and represent the cost share of input k expressed in terms of some of the same parameters as are in the cost function. While joint estimation adds information to the estimation of the parameters, the cross-equation restrictions required to do this will typically reduce the explanatory power of the cost function being estimated. Indeed, when either the translog (1) or Fourier (3) cost functions are estimated without their cost shares, the average fit is marginally improved to R^2= .995 or .996, the average absolute value of the residual as a percent of total cost falls to between 4.7% and 5.7%, andBimportantlyBthe measure of efficiency rises from .59 to .85 (so inefficiency falls from 69% to only 18%). Thus conclusions regarding efficiency can be affected by whether or not the share equation is included in estimation.[12] In the parametric estimations that follow, we shall focus on cost efficiency results derived from the cost function alone without the share equations and, since the translog and the Fourier forms have given almost identical results so far, we shall use only the simpler translog cost model for our parametric efficiency estimates.

Data Envelopment Analysis (DEA) of Efficiency.

The non-parametric DEA model uses linear programming to find the Abest practice≅ bank in the sample ($j = 1,...,J$) that reflects minimum cost in producing the observed output

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[11] This is an average of the R^2 values for the 10 separate yearly cross-section regressions needed to derive he distribution free efficiency result. Both the translog and Fourier models yielded the same average R^2 when rounded off.

[12] It is ironic that joint estimation of the cost function with the share equations, often justified to improve estimation efficiency of the parameters, ends up producing a lower measure of resource cost efficiency. Use of the share equations in joint estimation assumes that there is no allocative inefficiency, a hypothesis we do not wish to maintain.

vector (Q) given input prices (P) and the technology of the cost relationship $C(q, p \mid V,A) = \{(q,p)$ where $q \leq \tau Q, \tau P \leq p, \tau \in \mathbf{R}_+^J, \Sigma^J_{j=1} \tau_j = 1\}$ and satisfies strict availability of outputs and input prices (denoted by A) and exhibits variable returns to scale (denoted by V). Given the technology, where τ denotes a vector of intensity variables from activity analysis, the cost performance of an individual bank j can be evaluated by comparing $j's$ observed vector of input prices p_j , incurred in producing its observed output vector q_j, with input prices on the boundary (or best- practice frontier) of the cost set $C(q,p)$. This radial input cost efficiency (Banker, Charnes, and Cooper, 1984) is empirically calculated with the following linear programming formally expressed as:

$$(6) \quad \min_{\theta,\tau} \ \theta \text{ subject to } \begin{aligned} & q_j \leq \tau Q \\ & \tau P \leq \theta p_j \\ & \tau \in \mathbf{R}_+^J \\ & \textstyle\sum_{j=1}^{J} \tau_j = 1 \end{aligned}$$

As in the parametric model, the vector of two banking outputs in the DEA model includes the total value of loans and securities (including investments and other assets) and the vector of three input prices includes the prices of deposits, labor, and physical capital. On the input side we explore the cost effect of possible inefficiency of input use. Denoting the solution to (6) as θ^*, the minimum (best-practice) cost is given by $p_j^* = \theta^* p_j$, so the relative cost efficiency of bank j is measured by the ratio of best-practice input cost as $\theta^* = p_j^*/p_j$. When $\theta^*=1$, bank j is cost efficient given its output level and input prices (q_j, p_j) and located on the best-practice cost frontier. Alternatively, when $\theta^* < 1$, bank j is cost inefficient as its input expenditures could be reduced proportionately by the scale factor θ^*, while still producing its observed output vector q_j. Thus θ is a direct indicator of the efficiency of input use just as in the DFA model cost efficiency was measured as $EFF_i = \overline{u}_{min} / \overline{u}_i$. Averaging θ over 10 separate annual cross-section computations yields a DEA efficiency score of EFF = .87 which implies that inefficiency is 16%. Using a slightly different DEA specification and focusing on commercial banks, Lozano-Vivas, Pastor, and Pastor (2002) find cost efficiency of .82 for Spain in 1993 while Maudos and Pastor (2003) find cost efficiency of .87 during 1985-1996 for commercial and savings banks together.[13]

4. Parametric Efficiency Results: Sources and Importance.

The goal of cost efficiency analysis should be to identify the important sources that contribute to efficiency differences among banks. Some of these sources will be outside of management=s control while othersBthe ones that we are primarily interested inBcan be influenced by management actions. From a statistical perspective, identifying the sources of inefficiency is equivalent to reducing the average unexplained residual to a level close to zero such that the difference between actual and predicted bank costs is very small. This involves separating influences on efficiency into: (1) influences outside of management control and thus external to the firm; (2) influences associated with the technical process of transforming banking inputs into outputs; (3) influences partly under managerial control and thus internal to the firm; and (4), influences that can not be directly measured but are thought to be related to differences in managerial policies, procedures, and organizational structure. While all earlier studies of bank efficiency have sought to explain observed differences in total costs, greater accuracy should be obtained by separating total cost into funding and operating cost components as well

[13]Both of these studies specify a similar set of banking outputs and inputs. The only differences are that we, like Maudos, et al. (2003), specify deposits as an input (whereas it enters as an output in Lozano-Vivas, et al., 2002) and use the number of employees (rather than employee cost in Lozano-Vivas, et al., 2002). Finally, we use the value of physical and financial capital (rather than just the value of physical capital in Lozano-Vivas, et al., and Maudos, et al.). Apparently, these are not important differences in specification as seen by the similar efficiency values obtained.

as distinguishing between savings and commercial banks.

Interest Cost Efficiency (DFA). Looking at all sources of efficiency, our interest cost (IC) equation is specified as:

(7) $\ln IC = a_0$ + External + Technical + Internal + $\ln u + \ln v$.

External influences on a bank=s interest or funding costs may concern its asset size (Q_{TA}), the three-month market interest rate (*INTRATE*), regional business conditions reflected in the level of regional GDP (*GDPR*) which can affect deposit availability, asset market share (*MKSH*) to reflect the potential degree of market power in the deposit market, and an indicator variable for the region in which the bank is located (*REGION*)[14]. External influences on efficiency in (7) are thus specified as:

(7.1) External = $e_1 \ln Q_{TA} + e_{11} .5 (\ln Q_{TA})^2 + e_2 \ln INTRATE + e_3 \ln GDPR + e_{33} .5 (\ln GDPR)^2$

$+ e_{23} (\ln INTRATE)(\ln GDPR) + e_4 MKSH + e_5 REGION$.

The technical or cost function influences on interest cost follows the translog cost function specification above where the two major banking outputs are loans (*LOAN*) and securities (*SEC*) along with the actual average cost of funding (*PF*):

(7.2) Technical = $a_1 \ln LOAN + a_2 \ln SEC + a_{11} .5 (\ln LOAN)^2 + a_{22} .5 (\ln SEC)^2$

$+ a_{12} (\ln LOAN)(\ln SEC) + b_1 \ln PF + b_{11} .5 (\ln PF)^2 + d_{11} (\ln LOAN)(\ln PF)$

$+ d_{21} (\ln SEC)(\ln PF)$.

Lastly, we specify three measurable potential internal influences on funding costs. A high ratio of ATMs to branch offices (*ATM/BR*) is believed to provide more convenience to depositors and, as a result, may permit a bank to pay a slightly lower deposit rate. In contrast, a high ratio of

[14] The variable *INTRATE* forms the basic market interest rate environment that, through a yield curve, helps to determine funding costs. It is constant for all banks within each six-month period but changes between the two six-month periods in the data that comprise our separate regressions for each year.

loans to assets (*LOAN/TA*) can bring in more revenue per deposited euro and so permit a bank to pay a higher deposit rate. Finally, a high ratio of deposits to assets (*DEP/TA*) can generate a lower average cost of funds for a bank as deposits areBdepending on the interest rate cycleBoften a lower cost source of funds than are other sources of borrowed money. As there seems to be no reason for a possible quadratic relationship here, the specification of Internal influences on interest costs in (6) is quite simple:

(7.3) Internal = i_1 *ATM/BR* + i_2 *LOAN/TA* + i_3 *DEP/TA*.

The contribution of potential External, Technical, and Internal influences in equation (7) on overall efficiency, inefficiency, and the average absolute value of the residual as a percent of actual interest cost, are all shown in Table 1. The usual cost function approach (Technical Influences in the table) yields an efficiency level of EFF = .91 and suggests that Spanish savings and commercial banks have already achieved a high level of interest cost efficiency. Here inefficiency is 10% and only 2.2% of interest cost remains unexplained with the variables specified. This high level of efficiency is due to the fact that the average price of funding (*PF*) Atimes≅ the value of assets needed to be funded (loans plus securities) explains almost all of the variation in interest cost across banking firms. To a lesser degree, the same result occurs looking only at the External Influences which incorporate bank asset size and the three-month market interest rate. External influences by themselves yield an efficiency level of .69, inefficiency of .45, and 10.5% of interest cost remains unexplained.

Combining External and Technical influences, measured efficiency is higher at .922 and the percent of unexplained interest cost across banks is quite small (1.93%). Due to collinearity between the variables in these two sets of influences on efficiency, the incremental improvement over considering just Technical influences aloneBwhere EFF = .91--would be expected to be small. Finally, putting all three sets of influences together, efficiency rises to .989, inefficiency is only .011, and almost all the variation in interest cost among banks is explained (as the average percent that is unexplained falls to a minuscule 0.16%).

So far, efficiency has been measured assuming a common frontier exists between savings and commercial banks. This is valid if there are few differences between the behavior of efficient savings banks and efficient commercial banks. This presumption seems to be met in practice since there is almost no difference in the separate interest cost efficiency of savings banks (at .999) from that found for only commercial banks (at .993).

Table 1: Bank Interest Cost EfficiencyBDFA, 1992-2001

Interest Cost Equation:	EFF	INEFF	% Unexplained
External Influences	.69	.45	10.5%
Technical Influences	.91	.10	2.2%
External+Technical	.922	.085	1.93%
External+Technical+Internal	.989	.011	0.16%
Savings Banks:			
External+Technical+Internal	.999	.001	0.04%
Commercial Banks:			
External+Technical+Internal	.993	.007	0.17%

These results demonstrate that when it comes to efficiency in funding, management is already quite efficient. Overall, the environment a bank is inBin terms of the market interest rate, the value of assets needed to be funded, and the translation of market rates into realized funding costsBalmost completely determines the interest cost efficiency outcome leaving little opportunity for management to improve or worsen the situation by offering more ATMs, changing the mix of loans to securities, or taking advantage of a higher share of deposits in funding.[15] Put differently, variations across banks in managerial policies, procedures,

[15] Indeed, if Internal influences in (7.3) were the only influences considered, efficiency would only be .06 which indicates that the Internal variables selected here explain very little of the variation in interest cost across banks.

organizational structure, or managerial leadership abilitiesBthe non-measurable components that have been cited to explain cost efficiency deviations from 1.00 (no inefficiency)Bplay almost no role here as banks are able to achieve very high levels of measured efficiency without considering these potential but unmeasurable influences.

Operating Cost Efficiency (DFA). Operating cost includes the cost of labor, physical capital, and materials and, as above, is made up of three sets of influences:

(8) $\ln OC = a_0 + \text{External} + \text{Technical} + \text{Internal} + \ln u + \ln v$

External influences on a bank=s operating costs may concern its asset size (Q_{TA}), the average wage in a region the bank is in (*WAGE*) which can affect the average wage a bank pays, an index of property cost in the region (*IPP*) which can affect bank property costs, an indicator of regional business conditions reflected in the level of regional GDP (*GDPR*) which can affect staffing, wage, and property expenses, a measure of asset market share (*MKSH*) to reflect the potential degree of market power in the input market, and an indicator variable for the region in which the bank is located (*REGION*). Thus External influences on operating efficiency in (8) are specified as:

(8.1) $\text{External} = e_1 \ln Q_{TA} + e_{11} .5 (\ln Q_{TA})^2 + e_2 \ln WAGE + e_3 \ln IPP + e_{22} .5 (\ln WAGE)^2$

$+ e_{33} .5 (\ln IPP)^2 + e_{23} (\ln WAGE)(\ln IPP) + e_4 \ln GDPR + e_5 MKSH + e_6 REGION.$

The technical or cost function influences on operating cost follows a translog specification. As above, the two major banking outputs are loans (*LOAN*) and securities (*SEC*). The input prices are different and reflect a bank=s actual average cost of labor (*PL*), the ratio of depreciation to the value of physical capital to reflect capital cost (*PK*), and the opportunity cost of funds spent on materials inputs (*PM*Ba market rate of interest). This specification gives:

(8.2) $\text{Technical} = a_1 \ln LOAN + a_2 \ln SEC + a_{11} .5 (\ln LOAN)^2 + a_{22} .5 (\ln SEC)^2$

$$+ a_{12} (\ln LOAN)(\ln SEC) + b_1 \ln PL + b_2 \ln PK + (1 - b_1 - b_2) \ln PM$$

$$+ b_{11} .5 (\ln PL)^2 + b_{22} .5 (\ln PK)^2 + ((b_{11} + b_{12}) + (b_{12} + b_{22})) .5 (\ln PM)^2$$

$$+ b_{12} (\ln PL)(\ln PK) + (-b_{11} - b_{12}) (\ln PL)(\ln PM) + (-b_{12} - b_{22})(\ln PK)(\ln PM)$$

$$+ d_{11} (\ln LOAN)(\ln PL) + d_{12} (\ln LOAN)(\ln PK) + (-d_{11} - d_{12})(\ln LOAN)(\ln PM)$$

$$+ d_{21} (\ln SEC)(\ln PL) + d_{22} (\ln SEC)(\ln PK) + (-d_{21} - d_{22})(\ln SEC)(\ln PM).$$

Lastly, we have a richer specification of potential internal influences on operating costs than was available for interest expenses. Specifically, internal decisions on the number of ATM and branch offices (*BR*) to provide as well as their mix (*ATM/BR*) affects the level of operating costs. As well, a high ratio of loans to assets (*LOAN/TA*) should lead to greater operating expenses as loans are more costly to produce than holding securities in a bank=s portfolio. Finally, two Internal influences are approximate indicators of banking productivity as a low ratio of labor per branch office (*L/BR*) and a high ratio of deposits per office (*DEP/BR*) directly affect operating costs given the size of a bank. Thus the specification of Internal influences on operating costs in (8) is:

$$(8.3)\ \text{Internal} = i_1 \ln ATM + i_2 \ln BR + i_{11} .5 (\ln ATM)^2 + i_{22} .5 (\ln BR)^2 + i_{12} (\ln ATM)(\ln BR)$$

$$+ i_3\, ATM/BR + i_4\, LOAN/TA + i_5\, L/BR + i_6\, DEP/BR.$$

The contribution of External, Technical, and Internal influences in (8) on overall efficiency, inefficiency, and the average absolute value of the residual as a percent of actual operating cost, are all shown in Table 2 Considering only External influences, efficiency is low at EFF = .52, inefficiency is large at .92, and the average unexplained amount of operating cost is 13.2%. By themselves, either Technical or Internal influences perform better and generate somewhat higher levels of operating cost efficiency even though, for Internal influences, the average amount of unexplained operating cost is somewhat higher.

Table 2: Bank Operating Cost EfficiencyBDFA, 1992-2001

Interest Cost Equation:	EFF	INEFF	% Unexplained
External Influences	.52	.92	13.2%
Technical Influences	.65	.54	12.0%
Internal Influences	.67	.49	15.3%
External+Technical	.72	.39	8.3%
External+Technical+Internal	.89	.12	4.3%
Savings Banks:			
External+Technical+Internal	.94	.06	1.9%
Commercial Banks:			
External+Technical+Internal	.96	.04	1.6%

Putting External and Technical influences together raises efficiency to .72 which is only marginally higher than Internal influences by themselves. Finally, considering all three influences together, EFF = .89, inefficiency is .12, and the average amount of unexplained operating cost drops to only 4.3%. Still further increases in operating cost efficiency are obtained if the assumption of a common efficiency frontier is dropped and savings banks are separated from commercial banks. Here, efficiency is very highBbetween .94 and .96. Correspondingly, inefficiency is quite low and the average amount of unexplained operating cost is in both cases less than 2%.

Our parametric results suggest the following conclusions. First, managerial Acontrol≅ over cost efficiency, as evident from the role played by measurable Internal influences, is only really relevant for operating cost--not interest expense. Second, while the cost efficiency literature typically considers only Technical or cost function influences when determining banking efficiency, it is clear that augmenting this information with External influences--as pioneered by Dietsch and Lozano-Vivas (2000) and Berger and Mester (1997)Byields a more accurate and higher level of measured efficiency.[16] That is, since we wish to determine that portion of

[16] Other studies following this path are Lozano-Vivas, Pastor, and Pastor (2002), and Maudos, Pastor, Pérez, and Quesada (2002).

observed cost differences that management can influence or directly control, it is necessary to first account for the many influences on cost that management essentially can not control and makes up the environment that banks have to operate in. Third, we have demonstrated that much of the previously unexplained differences in bank cost efficiency can be accounted for using measures commonly applied within the banking industry itself to indicate differences in worker and branch operational productivity and differences in how managers wish to deliver services to depositors. As approximate and gross as these productivity indicators are, once they are included in the analysis efficiency levels of .94 to .96 are achieved and the average amount of unexplained operating cost is less than 2%.[17]

Put differently, much of the previously unexplained differences in banking efficiency evidenced in other studies is associated here with partial indicators of banking productivity such as a bank=s intensity of labor usage per branch office (the *L/BR* ratio) and the ability to maximize deposits per branch office (a *DEP/BR* ratio), as well as decisions on how best to deliver services to depositors (the *ATM/BR* ratio). By achieving efficiency levels of over .99 for interest costs and from .94 to .96 for operational expenses, it is clear that the usual assertion that banks only achieve efficiency levels of around .80 (and seemingly misuse 20% to 25% of their resources) importantly understates realized efficiency. As well, most of the previously unexplained differences in efficiency are apparently not due to unmeasured differences in internal bank policies and procedures, organizational form, or leadership abilities as is often asserted. Instead, common measures of banking productivity and service delivery mix can account for much of what was previously unexplained. While some of these productivity differences may be

[17] This is not a surprising result. One of the original purposes of efficiency or frontier analysis was to be able to make efficiency/productivity comparisons using a single overall measure rather than rely on a set of sometimes conflicting partial indicators developed for comparisons within an industry.

inadvertent, it is also the case that some banks will purposely hire more workers per branch office and/or provide what seems to be Atoo many≅ ATMs and standard branch offices as part of their competitive strategy to be more accessible and provide more convenient services. Finally, the remaining amount of unexplained efficiency differences is so low it is possible to argue that it could simply reflect the result of managerial decisions with a priori inherently uncertain outcomes. One example would be guessing Awrong≅ about the future structure of the yield curve of bank funding instruments which affects deposit composition and operating cost. Another is misjudging the likely growth of the local deposit market and providing too many branch offices and/or ATMs, which later may be reduced. Thus a portion of the small amount of remaining inefficiency may best be considered as inherent and irreducible.

5. Nonparametric Efficiency Results: Sources and Importance.

A more complete DEA model is also developed to identify the various sources of efficiency differences among banks. The drawback with the DEA model is that the more influences specified as potentially having an effect on explaining inefficiency, the lower will be the measured inefficiency. The formulation is the same as (6) with the addition of additional constraints $Z_\tau \geq Z_0$ that reflect similar external and internal influences on efficiency as were used above in the parametric interest cost and operating cost models:

$$(9) \quad \min_{\theta,\tau} \theta \text{ subject to } \begin{array}{l} q_j \leq \tau Q \\ \tau P \leq \theta p_j \\ Z_\tau \geq Z_0 \\ \tau \in \mathbf{R}_+^J \\ \sum_{j=1}^{J} \tau_j = 1 \end{array}$$

The results for interest efficiency are shown in Table 3. Using only Technical influences, the level of interest efficiency is EFF = .83 which rises to .92 when External and Technical influences are combined. Adding Internal influences to this model gives EFF = .93. Finally, removing the assumption of a common frontier, interest efficiency at savings banks rises to .97 while that at commercial banks is .92. The small (3%) level of inefficiency for savings banks is similar to that from the full parametric model but inefficiency at commercial banks (9%) is considerably larger.

Table 3: Bank Interest Cost EfficiencyBDEA, 1992-2001

Interest Cost Equation:	EFF	INEFF
Technical Influences	.83	.20
External+Technical	.92	.09
External+Technical+Internal	.93	.08
Savings Banks:		
External+Technical+Internal	.97	.03
Commercial Banks:		
External+Technical+Internal	.92	.09

The contribution of Technical, External and Internal influences on operating efficiency are presented in Table 4. With only technical influences, efficiency is already high at EFF = .95. Adding in External influences raises efficiency to .96 while including all three influences yields an efficiency value of .98. Eliminating the common efficiency frontier results in EFF = .98 for savings banks and EFF = .99 for commercial banks. In both cases, the full operating efficiency model yields residual inefficiency of 2% or less. Overall, the DEA approach to efficiency measurement gives results similar to those found using the parametric DFA approach. Importantly, when both approaches include similar External, Technical, and Internal influences on efficiency measurement, the level of unexplained or residual inefficiency is typically very lowBmuch lower than values commonly reported in this literature.

Table 4: Bank Operating Cost EfficiencyBDEA, 1992-2001

Interest Cost Equation:	EFF	INEFF
Technical Influences	.95	.05
External+Technical	.96	.04
External+Technical+Internal	.98	.02
Savings Banks:		
External+Technical+Internal	.98	.02
Commercial Banks:		
External+Technical+Internal	.99	.01

6. Efficiency Results and Confidence Intervals Using the Bootstrap Technique.

Confidence intervals for DFA and DEA approaches to efficiency measurement can be obtained using a bootstrap procedure involving multiple re-sampling. For the DFA approach, this is much simpler than directly computing confidence intervals applying an asymptotic standard error formula using the estimated regression coefficients and their associated variance covariance matrix across an average of 10 separate yearly estimations. While the DEA approach assumes random error is zero, so our reported values here are presumed to be exact, it is still of interest to see the size of a confidence interval that would apply if the assumption of zero error was not met for this method. Finally, by comparing the bootstrapped confidence intervals for the DFA and DEA approaches, it is possible to determine the degree of overlap in efficiency results for these two methods.[18]

Table 5 presents the bootstrapped mean values and 95% confidence intervals for the DFA and DEA efficiency approaches for most of our earlier results. Means and standard deviations for these efficiency values were estimated from a distribution obtained from repeated sampling (with 10,000 replacements) for a set of nine bank-specific EFF results from both models.[19] Four conclusions stand out. First, the mean efficiency values from the bootstrap

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[18] Efron and Tibshirani (1993) provide a technical discussion of the bootstrap technique.

[19] The DFA total cost result applies to the translog (not the Fourier) function.

procedure are all either identical to or within one percentage point of (after rounding) those reported in Tables 1 to 4 for the same set of nine estimations. Second, the 95% confidence intervals about these mean values are tight and suggest that the mean values have low variance. Third, the confidence intervals are so tight that none of them overlap. This indicates that while some of the mean efficiency values are close together as point estimates, they appear to be significantly different. Finally, as noted earlier, the DEA model produces higher scores for operating cost efficiency (e.g., a 99% efficiency level for savings and commercial banks separately) while the DFA model gives larger scores for interest cost (also at the 99% efficiency level).

Table 5: Bootstrap Results and Confidence Intervals, 1992-2001:
DFA and DEA Total, Interest, and Operating Cost Efficiency

	Mean		Confidence Intervals	
Total Cost:				
Technical Influences	0.855	0.879	[.845,.864]	[.869,.890]
Interest Cost:				
Technical Influences	0.911	0.836	[.908,.916]	[.832,.841]
External+Technical+Internal	0.989	0.935	[.988,.989]	[.929,.940]
Savings Banks:				
External+Technical+Internal	0.999	0.971	[.998,.999]	[.964,.976]
Commercial Banks:				
External+Technical+Internal	0.993	0.927	[.992,.993]	[.914,.944]
Operating Cost:				
Technical Influences	0.653	0.956	[.638,.669]	[.947,.953]
External+Technical+Internal	0.886	0.987	[.878,.893]	[.983,.989]
Savings Banks:				
External+Technical+Internal	0.936	0.986	[.931,.941]	[.981,.989]
Commercial Banks:				
External+Technical+Internal	0.961	0.994	[.956,.965]	[.990,.997]

7. Summary and Conclusions.

A recent survey of efficiency results from 130 studies covering 21 countries= banking sectors suggested that the average bank appears to experience total operating plus interest costs that are from 20% to 25% higher than the most cost-efficient institution (Berger and

Humphrey, 1997). At usual ratios of bank net income to total costs, such levels of inefficiency suggest that the average bank--not just the most inefficient among them--could more than double their profits and return on assets by restructuring their operations to resemble banks that appear to be most efficient. With such a strong incentive to change behavior, it is surprising that these levels of measured inefficiency do not seem to be falling over time.

We specified a fuller set of influences that could explain differences in cost efficiency among banks and, to obtain greater accuracy, total costs were separated into their interest and operating cost components. With this approach, inefficiency levels of only 1% to 2% were obtained compared to the 20% to 25% levels commonly reported in the literature. This occurs for savings and commercial banks in Spain[20] using a parametric approach to efficiency measurement (Distribution Free Approach) as well for savings banks when a non-parametric approach is used (Data Envelopment Analysis).[21]

Our broader set of efficiency influences concerned external influences outside of the control of management, technical influences associated with transforming banking inputs into outputs within a cost function, influences partly under managerial control and thus internal to the firm, and influences that can not be directly measured and so are contained within a residual after all the other measurable influences are accounted for. While the cost efficiency literature typically considers only technical or cost function influences when determining banking efficiency, it is clear that augmenting this information with external influences (c.f., Dietsch and Lozano-Vivas, 2000; Berger and Mester, 1997) yields a more accurate and higher level of measured efficiency. We found that a good portion of the previously unexplained differences in banking cost efficiency evidenced in other studies is actually associated with partial indicators of

[20]Our sample covered 46 savings banks and 31 commercial banks in Spain over 1992-2001.

banking productivity such as a bank=s intensity of labor usage per branch office (the *L/BR* ratio) and the ability to maximize deposits per branch office (a *DEP/BR* ratio), as well as decisions on how best to deliver services to depositors (the *ATM/BR* ratio). By achieving efficiency levels of over .99 for interest costs and from .94 to .96 for operational expenses with a parametric Distribution Free Approach model, it is clear that the usual assertion that banks only achieve efficiency levels of around .80 (and seemingly misuse 20% to 25% of their resources) importantly understates realized efficiency.[22]

Our mean bootstrap efficiency results are virtually identical to those without bootstrapping and appear to have low variance. Examination of confidence intervals, however, suggest that the DFA and DEA efficiency values are significantly different although both methods yield very high efficiency values when the full set of influences (external, technical, and internal) are incorporated in the analysis. Overall, the DFA approach seems to be more Asensitive≅ to the inclusion of internal and external influences in explaining the variation in interest costs among savings and commercial banks while the DEA approach is more Asensitive≅ to these additional influences in explaining variations in operating cost.

These results suggest that most of the previously unexplained differences in efficiency are apparently not due to unmeasured differences in internal bank policies and procedures, organizational form, or leadership abilities as is often asserted. Instead, certain external or environmental influences on efficiency as well as common measures of banking productivity and service delivery mix can account for almost all of what was previously unexplained. Although some of these productivity differences may not be planned, it is also the case that some banks

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[21]The exception was for commercial banks with interest cost efficiency in the DEA model.

[22]With the non-parametric Data Envelopment Analysis model, interest cost efficiency was from .92 to .97 while for operating cost it was .98 to .99.

will purposely hire more workers per branch office and/or provide what seems to be Atoo many≅ ATMs and standard branch offices as part of their competitive strategy to be more accessible and provide more convenient services. The bottom line is that most banks are seen to be quite efficient once the two main approaches to measuring cost efficiency are properly specified and interpreted.

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Appendix

Table A1: Descriptive Statistics

Variable	Mean	Standard Deviation
TC	524,826	1,306,915
LOAN	5,650,417	13,640,000
SEC	2,241,031	6,798,484
PF *(interest rate)*	0.048	0.028
PL *(annual price)*	44.725	44.766
PK	0.135	0.0162
IC	344,020	939,119
Q_{TA} *(ln of value)*	14.82	1.35
INTRATE=PM *(percentage)*	7.107	3.385
GDPR	46,980,000	29,130,000
MKSH *(percentage)*	0.012	0.03
ATM/BR	0.865	0.946
LOAN/TA	0.737	0.097
DEP/TA	0.884	0.075
OC	180,806	379,849
WAGE	1,217	181
IPP *(index number)*	120	36
ATM *(number)*	396	744
BR *(number)*	391	690
L/BR *(number per branch)*	8.14	13.3
DEP/BR *(value per branch)*	33,583	162,821

Note: Values shown are in 1,000 of euros, or ratios of these values, unless otherwise noted.

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