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Efficiency of Financial Institutions: International Survey and Directions for Future Research

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Efficiency of Financial Institutions: International Survey and Directions for Future Research[1]

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Abstract: This paper surveys 130 studies that apply frontier efficiency analysis to financial institutions in 21 countries. The primary goals are to summarize and critically review empirical estimates of financial institution efficiency and to attempt to arrive at a consensus view. We find that the various efficiency methods do not necessarily yield consistent results and suggest some ways that these methods might be improved to bring about findings that are more consistent, accurate, and useful. Secondary goals are to address the implications of efficiency results for financial institutions in the areas of government policy, research, and managerial performance. Areas needing additional research are also outlined.

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1. Introduction

The first task in evaluating the performance of financial institutions is to separate those production units that by some standard perform well from those that perform poorly. This is done by applying nonparametric or parametric frontier analysis to firms within the financial industry or to branches within a financial firm. The information obtained can be used either: (1) to inform government policy by assessing the effects of deregulation, mergers, or market structure on efficiency; (2) to address research issues by describing the efficiency of an industry, ranking its firms, or checking how measured efficiency may be related to the different efficiency techniques employed; or (3) to improve managerial performance by identifying "best practices" and "worst practices" associated with high and low measured efficiency, respectively, and encouraging the former practices while discouraging the latter.

At its heart, frontier analysis is essentially a sophisticated way to "benchmark" the relative performance of production units. Most financial institutions, with varying degrees of success, benchmark themselves and/or use industry consultants to perform this task. The power of frontier analysis is twofold. First, it permits individuals with very little institutional knowledge or experience to select "best practice" firms within the industry (or "best practice" branches within the firm), assign numerical efficiency values, broadly identify areas of input overuse and/or output underproduction, and relate these results to questions of government policy or academic research interest. Second, in the hands of individuals with sufficient institutional background, frontier analysis permits management to objectively identify areas of best practice within complex service operations, a determination not always possible with traditional benchmarking techniques due to a lack of a powerful optimizing methodology such as linear programming.

As practiced by academics, frontier analysis will generally tell informed industry participants little they do not already know in a general, qualitative way. While the qualitative "news" may not be new, the quantification of it is. Frontier analysis provides an overall, objectively determined, numerical efficiency value and ranking of firms (also called X-efficiency in the economics literature) that is not otherwise available. This attribute makes frontier analysis particularly valuable in assessing and informing government policy regarding financial institutions, such as determining the efficiency effects of mergers and acquisitions for possible use in antitrust policy. When frontier analysis is more narrowly focused on proprietary transactions data and detailed input use across branches of a financial institution, a firm's internal performance can often be enhanced beyond that possible with its own benchmarking procedures.

There are now enough frontier efficiency studies of financial institutions to make some tentative comparisons of average efficiency levels both across measurement techniques and across countries, as well as outline the primary results of the many applications of efficiency analysis to policy and research issues. Toward this end, we survey and contrast the results of 130 financial institution efficiency studies. This literature has employed at least five major different efficiency techniques, which have been applied to financial institutions in at least 21 countries. We also cover studies of several different types of depository institutions — commercial banks, savings and loans, and credit unions — as well as firms in the insurance industry. We include this large number of nations and wide array of types of financial institutions because the financial markets of the future are likely to become more globalized, and have more universal-type institutions offering greater selections of financial services within a single institution.

Section 2 critiques the main nonparametric and parametric efficiency estimation methods. A reasonable familiarity with the various frontier measurement techniques is assumed. Readers wishing to be more fully informed regarding these techniques are referred to the numerous comprehensive methodological surveys which exist (Banker, Charnes, Cooper, Swarts, and Thomas, 1989; Bauer, 1990; Seiford and Thrall, 1990; Ali and Seiford, 1993; Greene, 1993; Grosskopf, 1993; Lovell, 1993, and Charnes, Cooper, Lewin, and Seiford, 1994).

In Section 3, the average efficiency and dispersion of efficiency for U.S. commercial banks — the most studied class of financial institutions — is displayed. These data are used to illustrate the differences in efficiency estimates between nonparametric and parametric frontier techniques. As some investigators have already hinted at, the central tendency of the distribution of estimates of average efficiency derived from either type of technique is similar but the degree of dispersion differs. The similarity that exists for average efficiency within an industry across frontier techniques is weaker when rankings of firms by their efficiency value are being compared.

In Section 4, we discuss the similarity of average efficiency estimates across countries and by type of financial institution. We compare the results for 21 nations and four types of financial institutions — banks, S&Ls, credit unions, and insurance firms.

Applications of efficiency analysis are reviewed in Sections 5, 6, and 7, segmented according to the main purpose of the research. Section 5 reviews studies which provide valuable information for government policy, such as the effects of deregulation, financial institution failure, market structure, and mergers. Section 6 reviews studies that are chiefly concerned with research issues, such as the measurement of efficiency, comparisons of efficiency across international borders, issues of corporate control, risk, and the stability over time of firm-level efficiency. Section 7 analyzes studies that are primarily associated with improving managerial performance, most of which measure the relative efficiencies of individual branches within the **same** firm.

We recognize the somewhat artificial nature of this division of issues into government policy, research, and managerial performance. For example, studies which advance the efficiency research agenda will eventually be useful for studying policy, management, or any other efficiency issue.

Finally, Section 8 concludes, assessing the results of applications of efficiency analysis to financial institutions, and suggesting some new directions for future research. Most of the important suggestions concern finding explanations of efficiency that may help inform government policy, identify the economic conditions that create inefficiency, and improve managerial performance.

2. **Nonparametric and Parametric Approaches to Measuring Efficiency**

Our focus in this article is on frontier efficiency, or how close financial institutions are to a “best-practice” frontier. Since engineering information on the technology of financial institutions is not available, studies of frontier efficiency rely on accounting measures of costs, outputs, inputs, revenues, profits, etc. to impute efficiency relative to the best practice within the available sample. There is a virtual consensus in the literature that differences in frontier efficiency among financial institutions exceed inefficiencies attributable to incorrect scale or scope of output.[1] However, there is really no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured.

At least five different types of approaches have been employed in evaluating the efficiency of financial institutions and branches. These methods differ primarily in the assumptions imposed on the data in terms of (a) the functional form of the best-practice frontier (a more restrictive parametric functional form versus a less restrictive nonparametric form), (b) whether or not account is taken of random error that may temporarily give some production units high or low outputs, inputs, costs, or profits, and (c) if there is random error,

[1] See Berger, Hunter, and Timme (1993) for a review of studies of scale and scope efficiencies of financial institutions and how these compare to frontier efficiencies.

the probability distribution assumed for the inefficiencies (e.g., half-normal, truncated normal) used to disentangle the inefficiencies from the random error. Thus, the established approaches to efficiency measurement differ primarily in how much shape is imposed on the frontier and the distributional assumptions imposed on the random error and inefficiency.

Nonparametric Frontiers. Nonparametric approaches, such as much of the work in data envelopment analysis (DEA) and Free Disposal Hull (FDH), put relatively little structure on the specification of the best-practice frontier. DEA is a linear programming technique where the set of best-practice or frontier observations are those for which no other decision making unit or linear combination of units has as much or more of every output (given inputs) or as little or less of every input (given outputs).[2] The DEA frontier is formed as the piecewise linear combinations that connect the set of these best-practice observations, yielding a convex production possibilities set. As such, DEA does not require the explicit specification of the form of the underlying production relationship. The free disposal hull approach (FDH) is a special case of the DEA model where the points on lines connecting the DEA vertices are not included in the frontier. Instead, the FDH production possibilities set is composed only of the DEA vertices and the free disposal hull points interior to these vertices.[3] Because the FDH frontier is either congruent with or interior to the DEA frontier, FDH will typically generate larger estimates of average efficiency than DEA (Tulkens, 1993). Either approach permits efficiency to vary over time and makes no prior assumption regarding the form of the

[2] Developed by Charnes, Cooper, and Rhodes (1978), DEA was originally intended for use in public sector and not-for-profit settings where typical economic behavioral objectives, such as cost minimization or profit maximization, may not apply. Thus, DEA could be used even when conventional cost and profit functions that depend on optimizing reactions to prices could not be justified.

[3] From the perspective of input requirements to produce a given output, DEA presumes that linear substitution is possible between observed input combinations on an isoquant (which is generated from the observations in piecewise linear forms). In contrast, FDH presumes that no substitution is possible so the isoquant looks like a step function formed by the intersection of lines drawn from observed (local) Leontief-type input combinations.

distribution of inefficiencies across observations except that undominated observations are 100% efficient.

However, a key drawback to these nonparametric approaches is that they generally assume that there is no random error. There is assumed to be: (a) no measurement error in constructing the frontier; (b) no luck that temporarily gives a decision making unit better measured performance one year from the next, and (c) no inaccuracies created by accounting rules that would make measured outputs and inputs deviate from economic outputs and inputs. Any of these errors that did appear in an inefficient unit's data may be reflected as a change in its measured efficiency. What may be more problematical is that any of these errors in one of the units on the efficient frontier may alter the measured efficiency of **all** the units that are compared to this unit or linear combinations involving this unit.

Parametric Frontiers. There are three main parametric frontier approaches. The stochastic frontier approach (SFA) - sometimes also referred to as the econometric frontier approach - specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and allows for random error. SFA posits a composed error model where inefficiencies are assumed to follow an asymmetric distribution, usually the half-normal, while random errors follow a symmetric distribution, usually the standard normal. The logic is that the inefficiencies must have a truncated distribution because inefficiencies cannot be negative. Both the inefficiencies and the errors are assumed to be orthogonal to the input, output, or environmental variables specified in the estimating equation. The estimated inefficiency for any firm is taken as the conditional mean or mode of the distribution of the inefficiency term, given the observation of the composed error term.

The half-normal assumption for the distribution of inefficiencies is relatively inflexible and presumes that most firms are clustered near full efficiency. In practice, however, other distributions may be more appropriate (Greene, 1990). Some financial institution studies have found that specifying the more general truncated normal distribution for inefficiency yields minor, but statistically significant, different results from the special case of the half-normal (Berger and DeYoung, 1996). A similar result using life insurance data occurred when a gamma distribution, which is also more flexible than the half-normal, was used (Yuengert, 1993). However, this method of allowing for flexibility in the assumed distribution of inefficiency may make it difficult to separate inefficiency from random error in a composed-error framework, since the truncated normal and gamma distributions may be close to the symmetric normal distribution assumed for the random error.

The distribution-free approach (DFA) also specifies a functional form for the frontier, but separates the inefficiencies from random error in a different way. Unlike SFA, DFA makes no strong assumptions regarding the specific distributions of the inefficiencies or random errors. Instead, DFA assumes that the efficiency of each firm is stable over time, whereas random error tends to average out to zero over time. The estimate of inefficiency for each firm in a panel data set is then determined as the difference between its average residual and the average residual of the firm on the frontier, with some truncation performed to account for the failure of the random error to average out to zero fully.[4] With DFA, inefficiencies can follow almost any distribution, even one that is fairly close to symmetric, as long as the inefficiencies are nonnegative.[5] However, if efficiency is shifting over time due to technical change, regulatory reform, the interest rate cycle, or other influences, then DFA describes the

[4] An alternative way to apply DFA is to use a fixed effects model. In a fixed effects model, a dummy variable is specified for each firm in a panel data set. Differences in the fixed effects estimated across firms represent firm inefficiencies (e.g., Lang and Welzel, 1996). However, Berger (1993) found that the fixed effects were confounded by the differences in scale, which are several thousand times larger in magnitude than differences in efficiency in typical banking data sets.

[5] A plot of an unrestricted distribution of inefficiencies implied by the data in one DFA study determined that the resulting frequency distribution was closer to the shape of a symmetric normal rather than an asymmetric half-normal distribution (Berger, 1993).

average deviation of each firm from the best average-practice frontier, rather than the efficiency at any one point in time.

Lastly, the thick frontier approach (TFA) specifies a functional form and assumes that deviations from predicted performance values within the highest and lowest performance quartiles of observations (stratified by size class) represent random error, while deviations in predicted performance between the highest and lowest quartiles represent inefficiencies. This approach imposes no distributional assumptions on either inefficiency or random error except to assume that inefficiencies differ between the highest and lowest quartiles and that random error exists within these quartiles. TFA itself does not provide exact point estimates of efficiency for individual firms but is intended instead to provide an estimate of the general level of overall efficiency. The TFA reduces the effect of extreme points in the data, as can DFA when the extreme average residuals are truncated.

Is There a "Best" Frontier Method? The lack of agreement among researchers regarding a preferred frontier model at present boils down to a difference of opinion regarding the lesser of evils. The parametric approaches commit the sin of imposing a particular functional form (and associated behavioral assumptions) that presupposes the shape of the frontier. If the functional form is misspecified, measured efficiency may be confounded with the specification errors. Usually a local approximation such as the translog is specified, which has been shown to provide poor approximations for banking data that are not near the mean scale and product mix (see McAllister and McManus, 1993; Mitchell and Onvural, 1996). The translog also forces the frontier average cost curve to have a symmetric U-shape in logs.

The nonparametric studies impose less structure on the frontier but commit the sin of not allowing for random error owing to luck, data problems, or other measurement errors. If random error exists, measured efficiency may be confounded with these random deviations from the true efficiency frontier. As seen below, the conflict between the nonparametric and parametric approaches is important because the two types of methods tend to have different degrees of dispersion and rank the same financial institutions somewhat differently.

It is not possible to determine which of the two major approaches dominates the other since the true level of efficiency is unknown. The solution, in our opinion, lies in adding more flexibility to the parametric approaches and introducing a degree of random error into the nonparametric approaches. By addressing the main limitation of each approach, the efficiency results will presumably yield efficiency estimates which are more consistent across the approaches. These processes have already begun. In the parametric approaches, some studies have experimented with specifying more globally flexible forms. To date, this has focused on specifying a Fourier-flexible functional form which adds Fourier trigonometric terms to a standard translog function (Berger, Cummins, and Weiss, 1996; Berger and DeYoung, 1996; Berger, Leusner, and Mingo, 1996; Berger and Mester, 1997). This greatly increases the flexibility of the frontier by allowing for many inflection points and by including essentially orthogonal trigonometric terms that help fit the frontier to the data wherever it is most needed.[6]

In the nonparametric approaches, two research agendas are being pursued.[7] One is analytical, and seeks to provide a statistical foundation for DEA. The other is empirical, and seeks to develop and implement a stochastic version of DEA. The analytical research has demonstrated that, given certain plausible assumptions concerning the structure of technology and the distribution of the "true" efficiencies, (a) the empirical efficiencies calculated from a DEA model provide consistent estimators for the true efficiencies, (b) the DEA estimators can

[6] The use of the Fourier-flexible form in place of the translog in one case reduced the amount of measured inefficiency by about half—from 10% to 5% of costs—since the more flexible frontier was able to be closer to more of the data (Berger and DeYoung, 1996). Globally flexible functional forms have also been applied to banking data in non-frontier models of scale economies (McAllister and McManus, 1993; Mitchell and Onvural, 1996).

[7] We thank Knox Lovell for his gracious assistance with this and the following paragraph.

be interpreted as maximum likelihood estimators, and (c) the asymptotic empirical distribution recovers the true distribution under the maintained assumptions. This work thus provides a theoretical foundation for statistical hypothesis testing in a DEA environment (see Banker, 1996 for a summary). However, the fundamental problem is one of specifying the distribution of efficiency across observations (Kneip and Simar, 1996; Simar, 1996). Hypothesis testing can be conducted only after the data generating process has been specified, and in a multidimensional nonparametric setting in which the inefficiencies are one-sided, this is a statistically non-trivial matter. Moreover, the sampling distribution of the DEA efficiency estimators remains unknown, and this observation motivates the second line of research.

A resampling technique, such as bootstrapping, is one way of obtaining an empirical approximation to the underlying sampling distribution of DEA efficiency estimates. Once the underlying distribution is approximated, statistical inference can be conducted. This computer-intensive approach to hypothesis testing, however, requires a careful specification of the data generating process (Simar and Wilson, 1995). A different approach is to apply the techniques of chance-constrained programming to the DEA model (Land, Lovell, and Thore, 1993; Olesen and Peterson, 1995). Here inequality constraints describing the structure of the nonparametric DEA technology are converted to "chance constraints" which, due to noise in the data, are allowed to be violated by a certain proportion of the observations. If probability distributions are specified for these violations (the data generating process again), the constraints can be converted into certainty equivalents, and a chance-constrained DEA model emerges as a nonlinear programming problem. Although the chance-constrained DEA model remains deterministic, it incorporates noise in the data (see Grosskopf, 1996, for a survey of both empirical approaches).[8]

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[8] An earlier effort to combine parametric and nonparametric approaches has involved using FDH (or DEA) to first "screen the data" in order to identify the set of efficient observations and then use only these observations in a regression-based estimate of a cost frontier (Thiry

3. **Summary of Efficiency Studies by Measurement Method**

We now turn to the results of studies of financial institution efficiency. Along the way we will take note of how the efficiency estimates vary by the efficiency approach specified (DEA, FDH, SFA, DFA, TFA) and a number of other facts about the method and sample. Table 1 lists the 122 frontier studies we found that apply efficiency analysis to depository financial institutions and notes which of the five frontier methods were used.[9] The 8 studies that apply frontier analysis to insurance firms are shown in another table and are discussed later. Table 1 also shows the country the analysis was applied to, the author(s) of the study, the average yearly efficiency estimates reported, and the type of institution covered. Overall, there were 69 applications of nonparametric techniques and 60 using parametric approaches (some papers used more than one approach).[10] Studies focusing on U.S. financial institutions were the most numerous, accounting for 66 of the 116 single country studies in Table 1.[11]

A frequency distribution of 188 nonparametric and parametric annual average efficiency estimates for U.S. banks from Table 1 (excluding profit efficiency and branch efficiency studies) is shown in Figure 1.[12] The 188 annual estimates exceeds the 50 U.S.

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and Tulkens, 1992; Bauer and Hancock, 1993) or identify these observations with a dummy variable and use all the observations in the regression, circumventing the problem of having too few observations for a large regression (Bardhan, Cooper, Kozmetsky, and Kumbhakar, 1996). This approach is similar to that of the thick frontier approach except that the criterion used to screen the data with is different.

[9] This issue also contains a novel application of DEA efficiency analysis to the performance of mutual funds (Murthi, Choi, and Desai, 1997), but is not listed in our tables.

[10] Of the 69 nonparametric applications, 62 were DEA, 5 were FDH, and 2 were other approaches noted in Table 1. The 60 parametric applications were 24 SFA, 20 DFA, and 16 TFA.

[11] Although we have tried hard to be comprehensive, there are undoubtedly some studies we have missed, and we apologize to the authors of those articles. Some that we know we have missed were not written in English or were in journals to which we did not have access.

[12] Estimates of profit efficiency and branch efficiency are excluded from the display because they are difficult to compare to cost and production efficiencies. Profit efficiency

bank efficiency studies because many of these studies report values for multiple years, techniques, and/or classes of banks, and each is treated as a single observation here.[13] The distribution combines average efficiency estimates of U.S. banks from different time periods, size classes, input-output specifications, and frontier techniques. For DEA-type models, variable returns to scale estimates (if reported) were chosen over efficiency values based on constant returns.

The mean of Figure 1 using both nonparametric and parametric techniques is .79 with median of .83, standard deviation of .13, range of .31 to .97, and interquartile range of .13. The mean of .79 implies an average inefficiency of 27% [(1-.79)/.791.[14] The interval formed by the mean plus and minus one standard deviation would cover efficiency values from .66 to .92, and capture 82 percent of the observations.

The distribution of average efficiency from nonparametric studies of U.S. banks is shown in the dark (bottom) portion of each bar in Figure 1 while the light (top) portion indicates the distribution of the parametric results. These separate results are also summarized in Table 2. As seen, the central tendencies of efficiency using these two broad

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is measured in terms of best-practice profits, which are typically much smaller than the costs, inputs, or output levels used in conventional studies. Branch efficiency is measured relative to the best-practice branch within a firm, which is a very different target than the best firm in a sample.

[13] For example, efficiency estimates obtained by making different assumptions regarding the distribution of inefficiency in SFA composed error models were treated as separate estimates in both Table 1 and Figure 1. This treatment was also applied to efficiency estimates obtained from banks with different organizational forms or separate samples of banks in states with different branching laws. If semi-annual estimates of efficiency were made, these were averaged into annual figures.

[14] Efficiency results are typically reported in either of two ways. The .79 efficiency figure means that if the average firm were producing on the frontier instead of at its current location, then only 79% of the resources currently being used would be necessary to produce the same output (or meet the same objectives). The 27% inefficiency figure means that the average firm requires 27% more resources to produce the same output (or meet the same objectives) as an efficient firm on the frontier (the relationship is .79 = 1/(1 +.27) or .27 = (1-.79)/.79).

classes of frontier techniques give similar ballpark figures near 80%, with the nonparametric techniques generally giving lower efficiency estimates. The mean and median efficiencies for the nonparametric techniques are .72 and .74, respectively; the parametric techniques have a mean of .84 and median of .85. A greater difference between the approaches is that the nonparametric studies suggest a greater dispersion in estimated efficiency ratios. The standard deviation, range, and interquartile range of the nonparametric studies are .17, [.31,. .97], and .24, respectively, which is more dispersed that the .06, [.61, .95], and .07 values, respectively, for the parametric studies.[15] The dispersion shown in Figure 1 and Table 2 suggests that the standard errors associated with individual average efficiency estimates may be relatively large, particularly for the nonparametric estimates. As discussed below, this also appears to be the case so far for those studies that have determined confidence intervals for nonparametric bank efficiency estimates using bootstrapping procedures.

Efficiency Rankings for Nonparametric and Parametric Models. Although there is a good deal of information regarding the average efficiency of depository financial institutions by frontier technique, there is only limited information comparing the efficiency rankings of firms across techniques. Based on the few studies that exist, it appears that the similarity of the central tendency of average efficiency estimates evident in Figure 1 between nonparametric and parametric techniques does not consistently carry over to the rankings of firms within the banking industry. Some studies support a strong relationship between the findings of different techniques, while others find only weak relationships.

Only two studies have compared the efficiency ranking of banking firms between nonparametric and parametric techniques. The Spearman rank correlation coefficient (R_{RANK})

[15] If the extremely low efficiency estimates (.31 to .39 values in Figure 1) from two nonparametric studies are deleted, the mean of the nonparametric studies rises from .72 to .74 and the standard deviation is reduced from .17 to .14, slightly closer to the summary statistics for the parametric studies.

between DEA and SFA technical efficiency rankings in one study of smaller U.S. banks for one year was R_{RANK} = .02 and not significantly different from zero (Ferrier and Lovell, 1990).[16] In another study, using averages over 6 years, R_{RANK} between DEA and SFA varied from .44 to .59 across four size classes of larger U.S. banks (Eisenbeis, Ferrier, and Kwan, 1996). These bank results are weaker than those obtained for efficiency rankings across nonparametric and parametric frontier techniques for Federal Reserve check processing offices with R_{RANK} values on the order of .70 (Bauer and Hancock, 1993) or for insurance firms which yielded R_{RANK} values above .50 (Cummins and Zi, 1995) or above .72 (Fecher, Kessler, Perelman, and Pestieau, 1993). This is one area where further research would prove useful -- determining how the different frontier techniques affect the relative efficiency rankings of individual financial institutions.

There is greater similarity in bank efficiency rankings when, instead of comparing nonparametric with parametric techniques, the comparison is between different techniques within one of these categories. Two parametric techniques - SFA and TFA - were compared when both methods were used to separately identify quartiles of U.S. banks that were, respectively, most or least efficient over a 12 year period. The degree of correspondence was 38% for banks identified by each technique as being in the most efficient quartile (Bauer, Berger, and Humphrey, 1993). A somewhat higher correspondence, at 46%, was found across techniques for banks in the least efficient quartiles. This is compared to an expected 25% correspondence due to chance alone, suggesting a moderate positive relationship between the rankings of the two techniques.

Finally, there are three studies that compared efficiency rankings of banks when

[16] Giokas (1991) compared average efficiency results between DEA and a Cobb-Douglas (frontier) econometric estimation for branches of a single bank, not across banks. Although differences in efficiency results between these two techniques were discussed, no rank correlation was computed between them.

different assumptions were applied within a given efficiency approach. One study found that correlation coefficients for efficiency rankings of U.S. banks using four different radial and nonradial technical efficiency measures with a (variable returns to scale) DEA reference technology were relatively large and ranged from .87 to .99 (Ferrier, Kerstens, and Vanden Eeckaut, 1994). A second study undertook a comparison of radial and nonradial technical efficiency measures using both input-based and output-based FDH reference technology and found a wider range of similarity in efficiency rankings, with correlations ranging between .32 and .96 (DeBorger, Ferrier, and Kerstens, 1995). A third study reported rank correlation values between .86 and .99 for SFA efficiency estimates using assumed half-normal, truncated-normal, and exponential distributions of inefficiency (Maudos, 1996a).[17]

Overall, it seems clear that the estimates of mean or median efficiency for an industry may be a more consistently reliable guide for policy and research purposes than are rankings of firms by their efficiency value, especially between nonparametric and parametric approaches. Because the consistency in rankings of individual firms by their efficiency value can differ across frontier techniques, it follows that statistical results from the numerous ex post analyses correlating firm-level efficiency estimates with various sets of explanatory variables should be viewed with caution. The use of a different method for determining efficiency may affect the qualitative results when searching for explanations of what makes some firms more efficient. Indeed, SFA efficiency values in one study were significantly associated with differences in market and accounting measures of bank risk and seem to strongly affect bank stock returns while DEA efficiency values were much less informative in this regard (Eisenbeis, Ferrier, and Kwan, 1996). This result occurred even though the rankings of banks by their SFA and DEA efficiency values were similar (with rank correlation

[17] Rank correlations of these three sets of estimates with a fixed effects and a random effects model ranged from .56 to .90.

values of .44 to .59). Therefore, policy and research issues that rely upon firm-level efficiency estimates (as opposed to industry-wide averages) may be more convincingly addressed if more than one frontier technique is applied to the same set of data to demonstrate the robustness of the explanatory results obtained.

4. <u>Average Efficiency Across Countries and by Type of Financial Institution</u>

<u>Average Efficiency Estimates Across Countries.</u> Five studies that have compared efficiency levels across countries are noted at the end of Table 1. In one study, a DEA analysis of banks in Norway, Sweden, and Finland was first performed with separate frontiers for each country and then with a "common" frontier. In both the variable and constant returns to scale cases, Sweden was found to be the more efficient of the three (Berg, Forsund, Hjalmarsson, and Suominen, 1993). The robustness of the common frontier results were demonstrated by deleting all banks on the frontier, recomputing efficiency values, and then correlating the new efficiency ranking with the ranking prior to deleting any banks. Even after all the original frontier banks were deleted, the R_{RANK} for the remaining institutions was .96, attesting to the robustness of the original DEA rankings with a common frontier and the conclusion that Swedish banks are more efficient. A follow-up analysis, adding Denmark, found broadly similar results (Bukh, Berg, and Forsund, 1995).[18]

Two other cross-country studies applied DFA and DEA analysis to, respectively, 11 OECD countries and 8 developed countries.[19] In both cases, the cross-country data are

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[18] The same four countries were covered in another study (Bergendahl, 1995) which sought to develop a composite "reference bank" composed of the most efficient parts of the banks in the sample. This generates higher benchmarks than does DEA and indicates what may be possible rather than only what has been achieved by any one bank alone.

[19] A different approach would be to contrast individual banks in all countries with only two other banks—one bank with the lowest and another bank with the highest predicted average cost from a standard non-frontier cost function model (Ruthenberg and Elias, forthcoming). In this analysis the average efficiency was .70 for individual banks in 15 (mostly European) countries.

pooled and used to define a common frontier. In the first study, the average efficiency of financial services (banking and insurance) is determined for 11 OECD countries using national accounts data over 1971-86 (Fecher and Pestieau, 1993). Using a DFA-based fixed effects model, the mean average efficiency value was .82 with a range of .67 (Denmark) to .98 (Japan). Among other results, average efficiency in Sweden (.76) is found to be lower than that for Norway (.90) and the U.S. (.71) had the second lowest efficiency of the 11 countries studied. This result for Sweden is the opposite of that found in the more focused study of Norway, Sweden, and Finland just noted where Swedish banks were the most efficient. In another study, DEA was applied to a cross-section of 427 banks in 8 developed countries (Pastor, Perez, and Quesada, 1994). The mean efficiency value was .86 with a range of .55 (U. K.) to .95 (France). U.S. banks had the second lowest efficiency value (.81) in the cross-section, which is consistent with the finding in the previous study that U.S. banks were relatively inefficient. We note that these cross-country comparisons are difficult to interpret because the regulatory and economic environments faced by financial institutions are likely to differ importantly across nations and because the level and quality of service associated with deposits and loans in different countries may differ in ways that are difficult to measure. Such cross-country differences were not specified when a “common” frontier was being estimated and this may affect the cross-country results. Difficult as they may be to perform and interpret, however, cross-country studies can provide valuable information regarding the competitiveness of banks in different countries, a concern of particular importance in the increasingly harmonized European market for banking services and the perhaps more globalized financial markets of the future.

Figure 2 shows a frequency distribution for the 131 average efficiency values for banks from 14 non-U.S. countries.[20] The comparability of efficiency estimates for specific countries is limited by the fact that each country's efficiency estimate is determined relative only to the frontier for that country. Since frontiers may differ across countries, our comparison here can only illustrate (a) the average dispersion of banks in each country away from that country's own measured best-practice frontier, rather than (b) bank efficiency measured relative to any global best-practice frontier. The advantage of (a) is that banks are measured against a frontier that embodies similar levels of service, regulatory treatment, and economic environment. The advantage of (b) would be that a frontier formed from the complete data set across nations would allow for a better comparison across nations, since the banks in each country would be compared against the same standard. Since frontiers likely differ across countries, efficiency measured relative to single-nation frontiers will be overstated relative to what would be measured with a common or global frontier, so (a) will likely show greater overall efficiency than would (b).

With these caveats in mind, the mean annual average efficiency value in Figure 2 is .75, with median of .81, standard deviation of .13, range of .24 to .98, and interquartile range of .15. An interval formed by the mean plus and minus one standard deviation would cover efficiency values from .62 to .88, covering 84 percent of the observations in Figure 2. The mean average efficiency derived from nonparametric (.75) and parametric (.76) models is very similar but the standard deviation of the nonparametric model results (.14) is slightly larger than that for parametric models (.12).

Strictly speaking, the results of Figures 1 and 2 are comparable only if all or most of the separate country frontiers would lie close to the same global frontier. We expect this to be an unlikely event and so we cannot draw the conclusion from these figures that U.S. banks

[20] Efficiency comparisons among S&Ls or branches of a single bank, the only information available for 6 other countries (Belgium, Canada, Cyprus, Greece, Saudi Arabia, and the U.K.), is discussed below.

are more efficient than banks in other countries. Indeed, the opposite result was found in two of the multiple country studies noted above (where U.S. banks were among the least efficient). Clearly, this is an area where more work is needed, especially the proper specification of country-specific environmental influences that will justify using a common frontier for cross-country comparisons of efficiency.

Average Efficiency of Thrift Institutions. The 14 studies that have focused on savings and loan associations (S&Ls) and credit unions cover the U. S., U. K., Spain, and Sweden. These are listed in Table 1. The mean average efficiency level for U.S. S&Ls is .83, which is higher, but close to, the value reported for U.S. banks (.79) in Figure 1. The average efficiency for credit unions, at .88, is higher still. The average efficiency of Spanish savings banks, at .80, is higher than the mean for banks in other countries in Figure 2 (.75).[21] Similar to the international case above, it is difficult to compare results across industries because no common frontier has been established. Nonetheless, a tentative conclusion is that there is no significant evidence to suggest that there is much of a difference among the average efficiencies of these types of depository financial institutions — banks, S&Ls, and credit unions. A more definitive result will have to await further study.

Average Efficiency of Insurance Firms. The average efficiency for different types of insurance firms is shown in Table 3. The mean average annual efficiency for the U.S. insurance firms shown is .79 with a standard deviation of .15 (profit efficiency excluded). As a central tendency, U.S. insurance firms seem to have an average efficiency close to that for U.S. banks (Figure 1). The insurance studies are notable in another respect: rankings of firms by their efficiency level between nonparametric and parametric techniques yielded (as noted earlier) R_{RANK} values above .50 (Cummins and Zi, 1995) or above .72 (Fecher, Kessler,

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[21] The remaining S&L studies for Sweden and the U.K. are branch analyses, which are discussed below.

Perelman, and Pestieau, 1993), showing greater consistency in firm rankings than similar evidence for banks. Cummins and Zi (1995) found even higher correlations for rankings of firms by different nonparametric (DEA and FDH) or different parametric (EFA and DFA) techniques. Thus, consistent with the bank results, there is greater similarity in firm level efficiency estimates among techniques within the nonparametric or parametric category than there is among techniques between these categories.

A different issue was addressed by Yuengert (1993). This concerned the problem of disentangling the effects of scale inefficiencies from frontier inefficiencies in the presence of heteroskedasticity. The problem arises in cross-section data on U.S. insurance firms and banks where there is a greater dispersion of average costs for smaller firms than for larger ones, but the envelope of lowest-cost firms across all size classes is relatively flat.[22] In such a situation, the average of firm average costs for smaller institutions will tend to be higher for smaller institutions than for larger ones. One interpretation is that there are economies of scale and that the greater dispersion in costs for smaller firms is due to heteroskedasticity in the random error. An alternative interpretation is that there are no scale economies, but rather a greater dispersion in efficiency levels for smaller firms than larger ones (reflecting "heteroskedasticity" of efficiency across firms). Standard composed error models cannot distinguish between these cases or determine which interpretation is more correct.

Yuengert's "solution" to this problem is to permit both the random error term and the inefficiency term to be heteroskedastic and let the data determine the outcome. While this is a useful idea from a theoretical perspective, and could work in very large data sets, it may not be a practical solution when data sets are relatively small as they typically are for most countries. That is, it is very difficult to estimate two types of heteroskedasticity from a single

[22] This result can be seen in scatter diagrams in Yuengert (1993) for insurance firms and Humphrey (1987) for banks.

composed error under the best of situations, but it is likely to be even more difficult when data are relatively limited. In practice, it may be best to note the potential for confounding scale with efficiency effects and attempt to judge the potential bias by comparing scale estimates obtained in non-frontier models with frontier scale estimates. If these two sets of scale estimates are very similar, then the bias from “efficiency heteroskedasticity” is likely small, and the measured differences in frontier efficiency across size classes of firms may be relatively accurately estimated. Fortunately, most estimates of average and frontier scale economies in banking are fairly similar, suggesting that this problem of confounding scale economies and inefficiencies due to heteroskedasticity is not substantial.

5. Informing Government Policy Toward Financial Institutions

In order to summarize the main findings of efficiency studies of financial institutions, the studies listed in Table 1 have been rearranged into three broad categories based upon whether a study’s **primary** contribution was to inform government policy, to address general research issues, or to improve managerial performance. These studies are shown in Table 4. While many studies have contributed directly to more than one area, and most can be viewed as contributing indirectly to policy makers, researchers, and managers, each study is listed only once.[23] The discussion of informing government policy toward depository financial institutions is divided into four subcategories: (1) deregulation and financial disruption, (2) institution failure, risk, problem loans, and management quality, (3) market structure and concentration, and (4) the effects of mergers and acquisitions.

Deregulation, Financial Disruption. Deregulation is typically undertaken to improve the performance of the industry being deregulated. If efficiency is raised, the improvement in resource allocation will benefit society and may lead to price reductions and/or service

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[23] For example, Giokas (1991) is listed under “Address Research Issues” because it compares efficiency measurement techniques, but it could have easily been listed under “Improving Managerial Performance” because it estimates the efficiency of individual bank branches.

expansion for consumers if competition is sufficient. However, in many cases deregulation is initiated less by a desire to benefit consumers than by a need to improve the competitive viability of the industry. One such example was the removal of interest rate ceilings on deposits paid by U.S. banks in the 1980s, which permitted banks to compete better with money market mutual funds in acquiring funds. Another example is the harmonization and unification of banking markets in Europe — removing restrictions that have limited the ability of banks in one country from aggressively entering markets in other countries.

Given that a primary goal of deregulation has been to improve efficiency, the results have been mixed. Norwegian banks experienced improved efficiency and productivity after deregulation (Berg, Forsund, and Jansen, 1992) as did Turkish institutions in a more liberalized banking environment (Zaim, 1995). In contrast, banking efficiency in the U.S. was relatively unchanged by the deregulation of the early 1980s (Bauer, Berger, and Humphrey, 1993; Elyasiani and Mehdian, 1995). Although measured bank productivity fell (Humphrey, 1993; Humphrey and Pulley, 1997), this was largely because interest rate deregulation induced a competitive scramble to pay higher interest rates on consumer deposits without a corresponding reduction in either banking services or an immediate and fully offsetting increase in deposit fees. Thus productivity benefits which otherwise would have been captured by banks was instead passed onto consumers. Spain experienced deregulation results similar to the U.S. (Grifell-Tatje and Lovell, forthcoming; Lozano, 1995a). Lastly, the bursting of the speculative bubble in Japan seemed to have little effect overall on the efficiency of Japanese banks (Fukuyama, 1995), although the bad loans it created clearly had a significant adverse effect on the financial conditions of Japanese banks.

Depending on industry conditions prior to deregulation — such as existing excess loan demand in Norway, a desire to rapidly expand market share in Spain, or competition to pay higher deposit interest rates in the U.S. — the consequences of deregulation may differ across countries. Indeed, in some cases, deregulation appears to have led to a reduction in measured productivity rather than an improvement. The implication for government policy is that the conventional wisdom which holds that deregulation always improves efficiency and productivity may be incorrect. Industry conditions prior to deregulation and other incentives may intervene. Measurement over longer time periods may eventually show a net improvement in both efficiency and productivity but this has not yet been demonstrated.

Institution Failure, Risk, Problem Loans, and Management Quality. A key role of a country's financial institution regulators is to limit systemic risk — the risk that the problems of a few institutions spread to many other institutions that are otherwise solvent and liquid. This protects the money supply and the payment system from being severely disrupted and involves the management of bank failures. Most bank failures are directly related to having a large number of problem loans, a low capital position, a weak or negative cash flow, and poor management quality. It might be expected that institutions would display low efficiency prior to failure and that management quality would be positively related to efficiency. Both of these priors are supported in studies that have looked at these issues.

Banks and S&Ls with low efficiency failed at greater rates than institutions with higher efficiency levels (Berger and Humphrey, 1992a; Cebenoyan, Cooperman, and Register, 1993; Hermalin and Wallace, 1994) and this relationship was evident a number of years ahead of eventual failure (Barr, Seiford, and Siems, 1994). Management quality, as measured by regulatory agency assessments, is positively related to cost efficiency (DeYoung, 1997c) which, in turn, Granger-causes reductions in problem loans (past due and nonaccrual, Berger and DeYoung, 1996). As a result, efficiency measures have been shown to improve the predictive accuracy of failure prediction models and thus may represent a useful addition to current modeling efforts by regulatory agencies (as shown by Barr, Seiford, and Siems, 1994, for banks and Kramer, 1997, for insurance firms).[24]

Problem loans have been included as explanatory variables in some efficiency studies (e.g., Hughes and Mester, 1993; Mester, 1996, 1997) with the result that slight measured scale diseconomies for larger institutions are altered to economies and efficiency is increased. Whether or not it is appropriate to control for problem loans depends on which is the dominating explanation for the observed negative relationship between measured efficiency and problem loans. If problem loans are generally caused by “bad luck” events exogenous to the bank, such as regional downturns, then measured cost efficiency may be artificially low because of the expenses associated with dealing with these loans (e.g., extra monitoring, negotiating workout arrangements, etc.). Alternatively, problem loans may be related to measured efficiency because “bad management” is poor at controlling both costs and risks. If “bad luck” dominates, then problem loans are mostly exogenous and should be controlled for in efficiency models. If “bad management” dominates, then problems loans are essentially endogenous to financial institution efficiency and should not be controlled for in the analysis of efficiency. To this point, the evidence is mixed, yielding some support for both hypotheses (Berger and DeYoung, 1996). A potential solution to this problem is to control for the problem loan ratio for the state or region of the bank, which should primarily reflect the “bad luck” facing the bank, rather than its own “bad management” (see Berger and Mester 1997).

Market Structure and Concentration. An important area of government policy concerns antitrust issues. Many studies of financial institutions and other firms have found a positive statistical relationship between market concentration and profitability. This may be due to market-power explanations in which firms in concentrated markets exercise market power in pricing and earn supernormal profits. Alternatively, the efficient-structure paradigm links

[24] This result is not surprising since it has been shown that information contained in an efficiency measure closely corresponds to that contained in standard financial ratios (Elyasiani, Mehdian, and Rezvanian, 1994).

concentration to high profitability through efficiency (Demsetz, 1973). Under efficient-structure, relatively efficient firms compete more aggressively for and gain dominant market shares and also have high profits because of their low costs of production. These different explanations of differences in profitability across firms — market power versus efficiency — have directly opposing implications for antitrust policy. If high profits are created by market power, then antitrust actions are likely to be socially beneficial, moving prices toward competitive levels and allocating resources more effectively. However, if high efficiency is the explanation for high profits, then breaking up efficient firms that have gained large market shares or disallowing efficient firms to acquire other firms is likely to raise costs and may lead to prices less favorable to consumers. Regulatory agencies have typically followed the market-power paradigm in their antitrust policies.

The evidence comparing market power and efficiency effects is limited, but it suggests that cost efficiency is somewhat more important than market power in explaining profitability. However, as measured by R^2's, neither efficiency nor market power explains much of the observed variance of profitability (Berger, 1995; Maudos, 1996b).

Although concentration is not significantly positively related to profitability after controlling for efficiency, higher concentration is significantly associated with lower deposit interest rates and higher loan rates even after accounting for efficiency differences (Berger and Hannan, 1997). One explanation seems to be that financial institutions with more market power charge higher prices but, instead of enjoying higher than average profits, experience reduced cost efficiency as managers pursue other goals and a “quiet life” (in Hicks’ words).[25] The extra costs from “quiet life” inefficiency have been estimated to several times larger than the traditional welfare triangle costs from the exercise of market power (Berger and Hannan,

[25] Some support is found in Devaney and Weber (1995) who determined that rural U.S. banking markets that experience a decrease in concentration appear to have greater efficiency and productivity growth.

1995).

Unfortunately, most of the research on this topic has been on the U.S. banking industry, where the structure of the industry is quite different from the rest of the world. In the U.S., many financial products such as retail deposits and small business loans are essentially only competed for on a local basis so prices can differ significantly among these markets. Most of the studies have focused on the relationship between local market concentration and measures of bank performance. Although some financial products, such as large certificates of deposit and large wholesale loans are competed for on a nationwide basis, the U.S. national market is extremely unconcentrated by world standards. For example, it would take over 2,000 banking organizations to account for 90% of deposits in the U.S., while in most other developed countries 90% of deposits would be accounted for by fewer than 10 organizations. It would be of research and policy importance to discover whether the relationships among efficiency, concentration, prices, and profitability found in local U.S. markets obtain in other nations, where banking markets are typically more national in scope and are generally much more highly concentrated.

An alternative approach to examining market structure questions is to rely on direct estimates of the degree of oligopolistic output interdependence among suppliers of financial services. Adopting this approach, a frontier conjectural variations model has been estimated for Norwegian banks (Berg and Kim, 1994). From the view of efficiency analysis, the innovation is that market structure effects are directly accounted for when estimating scale economies and frontier efficiency. This is done by specifying that each firm's cost is a function of its own output as well as the output level of other firms in the same market. While the average of firm frontier cost efficiency estimates is only little affected by including or excluding conjectural variation effects, the scale economy measure moves from indicating constant costs in a standard cost frontier framework to indicating decreasing costs when conjectural variations are added. In a profit function context, however, adding conjectural variations significantly improves measured profit efficiency, suggesting that this aspect of market behavior is likely an important factor in efficiency measurement (Berg and Kim, 1996).

Mergers and Acquisitions. Relative to historical trends, banking industries in a number of countries have been subject to an increased number of mergers and acquisitions. In the U. S., much of the activity has been spawned by liberalizations of state rules regarding bank and bank holding company expansion both within and between states. In the early 1980s, there was almost no interstate banking activity, but by the end of 1994, 28 percent of U.S. banking assets were controlled by out-of-state banking organizations, primarily through regional compacts among nearby states (Berger, Kashyap, and Scalise, 1995).

The conventional wisdom among bank consultants and the popular press is that mergers can be and have been successful in improving cost ratios and cost efficiency, at least for a number of firms. However, academic studies usually find no such improvement **on average.** This holds whether simple accounting ratios are compared pre- and post-merger, holding industry effects constant, or in more sophisticated econometric analyses using frontier cost functions (Berg, 1992; Berger and Humphrey, 1992b; Rhoades, 1993; Peristiani 1996; DeYoung, 1997b).

Although many individual mergers have been quite successful in improving cost performance, many others have worsened their cost ratios or cost efficiency, so that on average there is no significant improvement. This would suggest that government merger policy should not as a rule be influenced by claims of expected cost efficiency benefits from mergers. However, an exception could occur if there existed a reliable precondition that could be used to identify mergers that are very likely to improve cost efficiency. Two plausible preconditions were found, upon testing, to provide little in the way of significant additional information. First, it was expected that a successful merger might be one with a high degree of local market overlap between merging institutions because of the greater potential for eliminating duplicate expenditures on branches and back-office operations. Second, it was thought that mergers would be more successful when the acquiring firm is more cost efficient than the firm being acquired, because the superior management team would gain control and use its (apparently) demonstrated ability to improve the less efficient firm. Upon investigation, neither of these expectations were realized (Berger and Humphrey, 1992b).

The effects of mergers on profit efficiency have been less intensively investigated. However, initial results suggest that profit efficiency improves significantly from mergers of large banks (Akhavein, Berger, and Humphrey, 1997). The different results experienced for cost and profit efficiency appear to occur because measured cost efficiency changes do not take into account the effects of the changes in output that occur after the merger. Merging banks tend to shift their output mixes away from securities toward loans, which raises profit efficiency because issuing loans creates more value (and usually more risk) than purchasing securities. This shift in mix may occur because merging banks are better able to diversify these risks than the previous management, allowing a higher loan/asset ratio to be held with same amount of capital (see also Benston, Hunter, and Wall, 1995; Hughes, Lang, Mester, and Moon, 1996). Further investigation of the profit efficiency versus cost efficiency effects of mergers represents an area for fruitful additional research.

6. <u>Address Research Issues Related to Financial Institutions</u>

Much of the work in efficiency analysis has been focused on methodology and measurement issues. Research issues include the study of: (1) the similarity of efficiency results derived from different frontier models, (2) the sensitivity of efficiency results when different output measures are applied, (3) the association between efficiency and firm organizational structure, (4) different ways to measure efficiency, (5) the effects of incorporating opportunity cost and product diversification in the analysis, (6) the consistency between cost, profit, or production efficiency measures, and (7) the variability of efficiency estimates over time. The general level of efficiency, along with broad comparisons of efficiency levels across different frontier techniques and countries, has been discussed above. The survey that follows will thus focus on the remaining research issues noted in Table 4.

Confidence Intervals and Comparing Different Efficiency Techniques or Assumptions. The effect that different frontier approaches can have on estimates of industry average and individual firm efficiency estimates has been noted above.[26] In almost all of these analyses, conclusions have been drawn from only point estimates of efficiency. Thus it is of interest to derive confidence intervals for efficiency estimates in order to determine if the efficiency comparisons being made are meaningful in a statistical sense. Fortunately, bootstrapping methods have become more widely known and available (Efron and Tibshirani, 1993; Hall, Hardle, and Simar, 1993; Mooney and Duval, 1993; Atkinson and Wilson, 1995). Thus new research in the efficiency area should try to make it a practice to provide confidence intervals for the efficiency estimates they generate. Somewhat similar information may be obtained through sensitivity analysis to examine the robustness of efficiency estimates (Brockett, Rousseau, and Wang, 1995; Thompson, Dharmapala, Diaz, Gonzalez-Lima, and Thrall, forthcoming).

When confidence intervals of efficiency estimates have been provided, these intervals appear to be quite large (Simar, 1992; Ferrier and Hirschberg, 1994; Mester, 1996, 1997).[27] When confidence intervals are large, comparisons of efficiency among firms in an industry, or branches within a firm, may be more meaningful when groups of observations, rather than

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[26] Additional studies, not mentioned earlier, have examined the stability of efficiency estimates from an SFA model when different efficiency distributions are specified (Altunbas and Molyneux, n.d.) or when different functional forms are specified (Zhu, Ellinger, and Shumway, forthcoming).

[27] Confidence intervals are computed for year-to-year changes in efficiency in Wheelock and Wilson (1994).

individual values, are being compared. Thus the common practice of regressing point estimates of firm efficiency, or rankings of firms by their efficiency value, on sets of explanatory variables might be improved upon or augmented with a subset analysis. This would involve an additional examination of the data where only subsets of firms with relatively high and relatively low efficiency values are used in a regression (with the middle group of firms excluded) to explore the robustness of the posited relationships. This could also be used to determine if the correspondence of firm-level efficiency estimates among different frontier methods could be improved if only the most important subsets of observations, rather than all the observations, were used. [28]

Comparing Different Output Measures. There are two main approaches to the choice of how to measure the flow of services provided by financial institutions. Under the "production" approach, financial institutions are thought of as primarily producing services for account holders. The financial institutions perform transactions and process documents for customers, such as loan applications, credit reports, checks or other payment instruments, and insurance policy or claim forms. Under this approach, output is best measured by the number and type of transactions or documents processed over a given time period (e.g., Kuussaari and Vesala, 1995). Unfortunately, such detailed transaction flow data is typically proprietary and not generally available. As a result, data on the stock of the number of deposit or loan accounts serviced or the number of insurance policies outstanding are sometimes used instead (e.g., Ferrier and Lovell, 1990; Ferrier, Grosskopf, Hayes, and Yaisawarng, 1993). Under the alternative "intermediation" approach, financial institutions are thought of as primarily intermediating funds between savers and investors. With this approach, since service flow data are not usually available, the flows are typically assumed

[28] One study where this was done suggested that the improvement may be slight (Bauer, Berger, and Humphrey, 1993). Even so, it may be useful to see if this result holds up in additional analyses.

to be proportional to the stock of financial value in the accounts, such as the numbers of dollars of loans, deposits, or insurance in force (e.g., Berger and Humphrey, 1991).

These approaches also have implications for which inputs or costs should be included in the analysis. Under the production approach, only physical inputs such as labor and capital and their costs should be included, since only physical inputs are needed to perform transactions and process financial documents. Under the intermediation approach, the input of funds and their interest cost should also be included in the analysis, since funds are the main "raw material" which is transformed in the financial intermediation process.

Neither of these two approaches is perfect because neither fully captures the dual roles of financial institutions as (i) providing transactions/document processing services and (ii) being financial intermediaries that transfer funds from savers to investors. While it would probably be best to employ both approaches to determine whether the results were qualitatively affected by the choice of output metric, sufficient data to implement such a research design are not usually available. Nevertheless, each of the approaches has some advantages. The production approach may be somewhat better for evaluating the efficiencies of branches of financial institutions, because branches primarily process customer documents for the institution as a whole and branch managers typically have little influence over bank funding and investment decisions. The intermediation approach may be more appropriate for evaluating entire financial institutions because this approach is inclusive of interest expenses, which (depending on the phase of the interest rate cycle) often accounts for one-half to two-thirds of total costs. As well, the intermediation approach may be superior for evaluating the importance of frontier efficiency to the profitability of the financial institution, since minimization of total costs, not just production costs, is needed to maximize profits.

One study compared the production and intermediation approaches by applying both to the same data set of bank branches using the same functional form, finding correlations above .40 between the frontier efficiency rankings of the two approaches (Berger, Leusner, and Mingo, 1996). Other studies have also compared efficiency results obtained with outputs measured by numbers of accounts versus the financial values in these accounts. In one case, little difference was found in the distribution of efficiency estimates when these two stock indicators of financial firm output were used (Berg, Forsund, and Jansen, 1991) while in another case, a similar distribution was found but mean efficiency was higher when financial values were specified (Kuussaari, 1993). Although the efficiency estimates had a similar distribution, the rankings of firms within these distributions differed. In Berg, Forsund, and Jansen (1991), the average R_{RANK} for the two comparisons made was .64 while R_{RANK} was .32 in Kuussaari (1993). Overall, it appears that inferences regarding efficiency may be importantly affected by how output is measured, a result which is usually less dependent upon investigator choice than availability of data.

Despite the many other differences in assumptions involved in measuring efficiency, there is reasonable agreement about the specification of most of the important inputs and outputs for financial institutions. The asset, user cost, and value-added methods of assigning financial goods to input and output categories all agree that loans and other major assets of financial institutions should count as outputs. However, there is a longstanding controversy whether deposits should count as inputs or outputs. Deposits have input characteristics because they are paid for in part by interest payments and the funds raised provide the institution with the raw material of investible funds. However, deposits also have output characteristics because they are associated with a substantial amount of liquidity, safekeeping, and payments services provided to depositors.

Some studies resolve this issue with a dual approach that captures **both** the input and output characteristics of deposits. The interest paid on deposits is counted as part of costs and the rate paid is included as an input price, both consistent with the input of the raw material of investible funds. These same studies specify the quantities of deposits as outputs because these quantities are assumed to be proportionate to the output of depositor services provided (Berger and Humphrey, 1991; Bauer, Berger, and Humphrey, 1993).

Other efficiency studies have first treated deposits as an input and then as an output. These investigations find that efficiency is somewhat higher when deposits are specified as an output. In a DEA model, the R_{RANK} between these two specifications averaged .77 (Favero and Papi, 1995), while in a DFA model R_{RANK} = .16 (Hunter and Timme, 1995). Since the treatment of deposits in efficiency models can affect the efficiency estimates, this aspect of model specification may be of some importance to the outcome.

Organizational Form and Corporate Control Issues. Financial institutions are organized in a number of different ways. Relying on agency theory, some studies have investigated whether organizational form is associated with differences in frontier efficiency. Firms owned by stockholders might be expected to face stronger incentives to control costs and/or enhance profits compared to mutual organizations where depositors or policyholders own the firm. The evidence is mixed. One study found that stock S&Ls were less efficient than mutual S&Ls (Mester, 1993) while another found that efficiency was not significantly related to this difference in ownership (Cebenoyan, Cooperman, Register, and Hudgins, 1993). This issue might be somewhat confounded by the fact that so many S&Ls have switched status, possibly creating a sample selection bias if either inefficient or efficient firms switched at a greater pace. Study of frontier efficiency in the U.S. life insurance industry (Garner and Grace, 1993) and in the U.S. property-liability insurance industry (Berger, Cummins, and Weiss, 1996) found no significant differences between stocks and mutuals in cost efficiency, but stock firms providing property-liability insurance were sometimes statistically significantly more profit efficient than mutuals, all else held equal.

In the banking industry, the primary organizational trade off for large organizations is between a multibank holding company (MBHC) arrangement, where a commonly-owned group of banks have separate charters and financial books, versus an extensive branch banking arrangement where banks have been merged under a single charter within a larger branching network with a consolidated operation. This will likely be an important issue over the next several years in the U. S., as the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 allows interstate branch banking for the first time in many decades. The results of one study suggest that branch banking may lead to greater efficiency than keeping banks separate within a MBHC (Grabowski, Rangan, and Rezvanian, 1993).[29]

A related issue concerns possible efficiency differences associated with foreign versus domestic ownership. Four studies have found that foreign-owned banks in the U.S. were significantly less efficient than U.S.-owned banks (Chang, Hasan, and Hunter, 1993; DeYoung and Nolle, 1996; Mahajan, Rangan, and Zardkoohi, 1996; Hasan and Hunter, forthcoming]. In contrast, foreign owned banks in India were found to be somewhat more efficient than privately owned domestic banks but government owned banks were more efficient than both (Bhattacharya, Lovell, and Sahay, 1997). It has been suggested that foreign-owned banks in the U.S. have in effect traded current profits for rapid expansion of market share. The rapid growth was made possible by relying on purchased funds, which are more expensive than core deposits raised through a network of branches, which takes time to establish.

The evidence is also quite limited on the links between other aspects of corporate governance and frontier efficiency. When the CEO is also the chairman of the board, efficiency has been measured to be lower in one study, and this effect is not offset by having

[29] However, no significant differences in efficiency were found between banks located in branching versus non-branching (unit banking) states in the U.S. (Rangan, Grabowski, Aly, and Pasurka, 1988; Aly, Grabowski, Pasurka, and Rangan, 1990). This result is essentially a weaker test of the branching/separate bank relationship since the separate bank arrangement was important in states that restricted branching while both branching and separate bank arrangements existed in states that permitted branching.

a higher proportion of outside directors on the board (Pi and Timme, 1993). In another study, minority ownership was investigated, but no significant differences were found (Elyasiani and Mehdian, 1992). A different ownership issue concerns possible efficiency differences among banks depending upon holding company status. One study found that being in a holding company seemed to confer some cost advantages compared to remaining independent (Newman and Shrieves, 1993), but another study found no difference between one-bank and multibank holding company affiliation (Elyasiani and Mehdian, 1990b). All of these issues will require substantially more future research to resolve.

Methodology Issues. Since our focus in this article is on the application of frontier efficiency techniques to financial institutions, the methodology studies noted here are mostly limited to those in which there has been an application of new methodology to financial institutions. There have been a number of attempts to improve both nonparametric and parametric frontier models and estimation in this field. Improvements and/or alternatives to the standard DEA nonparametric approach concern the development and application of FDH (Fried, Lovell, and Vanden Eeckaut, 1993; Tulkens, 1993; Fried and Lovell, 1994), the polyhedral cone-ratio DEA model (Charnes, Cooper, Huang, and Sun, 1990; Brockett, Charnes, Cooper, Huang, and Sun, 1997), and the assurance region DEA model (Thompson, Brinkmann, Dharmapala, Gonzalez-Lima, and Thrall, 1997; Taylor, Thompson, Thrall, and Dharmapala, 1997). In addition, the nonparametric Malmquist Index approach to efficiency measurement has been generalized (Grifell-Tatje and Lovell, 1994), goal programming is being applied (Cooper, Lelas, and Sueyoshi, 1997), and the sensitivity of DEA and FDH efficiency models to different radial and non-radial measurement techniques is being tested (Ferrier, Kerstens, and Vanden Eeckaut, 1994; Pastor, 1995; DeBorger, Ferrier, and Kerstens, 1995). The general conclusion of this work is that the standard DEA model, along with the radial measurement of efficiency, may not be as well-suited to distinguishing efficient from inefficient observations as the newer approaches cited here.

From another perspective, two recent additions to the DEA literature promise to extend the analysis in important new directions. First, it has been suggested (Bergendahl, 1995) that perhaps the DEA frontier should be composed of the most efficient **parts** of banks within the sample — forming a composite or representative firm, rather than being composed of separate and individual firms as is now the case. A "composite frontier" would serve to indicate the efficiency that had been achieved within the sample, although not necessarily all at a single institution. Such a frontier accurately represents what is possible and does not confound efficient results in one specified area of interest with inefficient results from other areas.[30]

A second analysis (Lovell and Pastor, 1997) implements a statistical test of the effect of sequentially reducing the number of constraints in a DEA model. The goal is to provide a method whereby the constraints in the DEA model can be collapsed down to only those that are important to the results obtained. With this approach, extraneous constraints can be discarded and attention focused on only influential constraints. This work, as well as that on cone-ratio and assurance region DEA models which both specify additional **a priori** information, also address the problem where individual bank observations may be 100% efficient by default (due to non-comparability among observations when "too many" constraints are specified). The DEA assurance region model, for example, has consistently reduced the number of bank "self-identified" observations (Taylor, Thompson, Thrall, and Dharmapala, 1997; Thompson, Brinkmann, Dharmapala, Gonzalez-Lima, and Thrall, 1997; Thompson, Dharmapala, Humphrey, Taylor, and Thrall, 1996). These techniques should go a long way toward ensuring that extraneous constraints do not "contaminate" the DEA results

[30]This "composite frontier" is theoretically similar to the "true" best-practice frontier discussed elsewhere, which would be made up only of branches (and other financial institution units) that are fully efficient (Berger, Leusner, and Mingo, 1996). Both concepts seek to set higher standards for the frontier than any firm in the sample has achieved by looking at the best-practice segments of firms.

and thus may generate more consistent efficiency estimates across different studies.[31]

Similar efforts to improve the standard parametric SFA frontier model include the development of two alternatives — the thick frontier approach TFA (Berger and Humphrey, 1991), and distribution-free approach DFA (Berger, 1993), the latter being a modification of earlier work by Schmidt and Sickles (1984). More general parametric estimation procedures have also been attempted. This work has focused on replacing the translog functional form with the more flexible Fourier form (e.g., Berger and Mester, 1997), the use of random coefficient estimation which also provides greater flexibility (Akhavein, Swamy, and Taubman, 1997), and correcting for situations where the regressors and error are correlated (Adams, Berger, and Sickles, 1996). In general, greater flexibility has resulted in higher estimates of efficiency. At present, the choice between the various parametric models and estimation procedures is based primarily on ease of use and/or the apparent reasonableness of underlying assumptions, rather than on any strong theoretical foundation.

To date, parametric efficiency analysis has essentially assigned all deviations from an estimated efficient frontier to a dependent variable such as total costs or profits. Importantly, the resulting inefficiency value can be made more informative by additionally decomposing it into its technical and allocative components. Further information is obtained when inefficiency can be directly related to specific inputs. This has been done by Kumbhakar (1988) and Chaffai (1997).

Opportunity Cost, Output Diversification. Nonparametric and parametric studies can

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[31] In some cases, the choice of which constraints to discard may be fairly straightforward, such as when some of the constraints essentially contain the same economic information. An example is a DEA model that specifies as bank inputs transactions deposits, nontransactions deposits, total noninterest expenses, and total interest expenses (e.g., Miller and Noulas, 1996, and other papers referenced there). The goal of trying to capture the effects of funding mix (transactions versus nontransactions deposits) along with the interest rates paid (interest versus noninterest expenses), while laudable, may be problematic since in cross-section data nontransactions deposits are virtually the sole source of interest expenses while transactions deposits make up the largest segment of noninterest expenses.

underestimate efficiency when important cost influences have not been included in the analysis. Two such influences routinely neglected in earlier studies have been the opportunity cost of equity and the expenses undertaken to reduce risk. An expected result would be that including these additional costs may improve efficiency estimates as the cost or profit function would fit the data more closely and less specification error might be counted as inefficiency. Studies incorporating these factors include Dietsch (1994), Clark (1996), Mester (1996, 1997), Berger and Mester (1997). Clark (1996) and Berger and Mester (1997) compared efficiency estimates that did and did not account for the effects of equity capital and Clark found that accounting for equity raised measured cost efficiency, and Berger and Mester found that it raised estimated profit efficiency substantially. As noted above, there also can be a problem with controlling for problem loans or other variables that may be endogenous to the decisions of the firm being studied.

Extending efficiency analysis in a different direction, some research has been done on the effects on efficiency from output diversification and product diversity. The "optimal scope economies" concept based on the profit function rather than the cost function includes all the revenue effects of output choices as well the cost effects of input choices (Berger, Hancock, and Humphrey, 1993). On the cost side, a measure of diversification more general than the traditional scope concept was applied to U.S. banks (Ferrier, Grosskopf, Hayes, and Yaisawarng, 1993). It was found that greater diversification tended to reduce cost efficiency. Similarly, "universal" banks in Europe (who provide a broader mix of services) were found to experience lower cost efficiency than more specialized banks (Chaffai and Dietsch, 1995). A seemingly contrary result was found in an analysis of the effects of shifting from making bank loans to providing a broader mix of services by expanding fee-based services, since the shift was associated with higher (not lower) banking efficiency (DeYoung, 1994).

Profit and Revenue Efficiency. Most of the parametric models applied to financial institutions have focused on cost efficiency while nonparametric models have concentrated on the relationship between inputs and outputs directly. An area only recently attracting interest has been the estimation of profit and revenue efficiency. The techniques are essentially the same but the data are different. Profit efficiency is concerned with both cost and revenue efficiency but only under certain conditions would it be likely that the former will equal the sum of the latter. This is because cost (revenue) efficiency presumes that the observed level of output (input use) is already profit maximizing, which may or may not be the case in practice. In addition, there may be differences in the quality of some financial services that are not captured in the output measures. This may make high-quality producers appear to be cost inefficient because of the extra expenses associated with producing the higher quality output. Such a problem may be ameliorated by the use of a profit function or profit programming orientation because high quality should be rewarded in the marketplace by extra revenues that offset the extra expenses.[32]

A number of the studies cited in Table 1 measure profit efficiency. The mean profit efficiency from studies of U.S. depository institutions is .64, so these firms were earning about 64% of their potential profits on average (Berger, Hancock, and Humphrey, 1993; DeYoung and Nolle, 1996; Miller and Noulas, 1996; Akhavein, Berger, and Humphrey, 1997; Akhavein, Swamy, and Taubman, 1997; Berger and Mester, 1997; Humphrey and Pulley, 1997; Hasan and Hunter, forthcoming). Similarly, a study of Spanish depositories found average profit efficiency of .72 (Lozano, 1995b).[33] Much lower profit efficiency was found

[32] The alternative of directly specifying service-level or quality constraints or variables directly in a cost model is usually not possible due to limited and proprietary data.

[33] Profits (and productivity) in the Spanish banking industry have been decomposed into a productivity effect (technical change and operating efficiency), an activity effect (product mix and scale), and a price effect (Grifell-Tatje and Lovell, 1996, 1997). Less comprehensively, profits in the U.S. banking industry have been split into an endogenous or management determined component and an exogenous or external “business conditions” component (Humphrey and Pulley, 1997).

for large merging U.S. banking organizations using the DFA method, .24 before merger, .34 after merger (Akhavein, Berger, and Humphrey, 1997). This contrasts with a DEA study of large U.S. banks which found profit efficiency of .97, with 42% of the firms being 100% technically efficient (Miller and Noulas, 1996). A profit efficiency study of U.S. banks using random coefficients found the average efficiency to be highly dependent upon the choice of subsample (Akhavein, Swamy, and Taubman, 1997).

A study of insurance companies found average profit efficiencies on the order of about 60% efficient (Berger, Cummins, and Weiss, 1996). When profit efficiency and cost efficiency results are made comparable by expressing the quantities of inefficiency in terms of a common denominator, cost inefficiency was found to be larger than profit inefficiency, suggesting that cost inefficiency may be overstated because of differences in service quality or other variables not accounted for in the analysis.[34]

Some of these studies employ an alternative profit function in which the firm maximizes profits given output quantities, rather than taking output prices as exogenous (Berger, Cummins and Weiss, 1996; Humphrey and Pulley, 1997; Akhavein, Berger, and Humphrey, 1997; Berger and Mester, 1997; Hasan and Hunter, forthcoming). In most cases, the alternative profit function provides qualitatively similar results to the standard profit function. The alternative profit function may be useful when one or more of the assumptions underlying the standard cost and profit efficiency models are violated by the data (e.g., competitive imperfections, unmeasured differences in product quality).[35]

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[34] In another study of banks, the reverse was found: expressed as a percent of total assets, profit inefficiency was over 10% of asset value while cost inefficiency was between 1% and 3% of asset value (Ellinger, Zhu, Shumway, and Neff, forthcoming). The cost result is possible, since total costs as a percent of assets averages around 7% for banks. However, since profits as a percent of assets are usually only around 1%, it is hard to believe that average inefficiency is 10 times the level of profits.

[35] See Berger and Mester (1997) for further discussion.

Revenue efficiency is essentiality the mirror image of cost inefficiency, incorporating errors in the choice of output mix, having too little output, etc. Although few revenue frontier analyses have been undertaken, revenue efficiency estimates (as measured by an output distance function) appear to be similar to those for cost efficiency (English, Grosskopf, Hayes, and Yaisawarng, 1993).[36]

Stability over Time. A final research issue concerns the stability of efficiency over time. This refers both to average efficiency levels for an industry and for rankings of firms by their efficiency level. This is an important issue for the DFA frontier model since the efficiency measure here is based on the assumption that firm efficiency is stable over time and that random error, when averaged, will be close to zero. Several studies have found that efficiency is reasonably persistent over time: two studies computed a series of correlations among firms ranked by their estimated SFA and DEA efficiency level over time (Kwan and Eisenbeis, 1994; Eisenbeis, Ferrier, and Kwan, 1996); another looked for consistency in groups of high and low cost firms over a number of years (Berger and Humphrey, 1991); and yet another examined the stability of frontier banks over time (Berg, 1992).

Another study tried to determine for DFA the number of years that may be needed to strike a balance between the benefits and costs of the extra information from adding another year of data. The benefits come from having another residual to help average the random error toward zero to get more precise estimates of the inefficiency term, whereas the costs come from the increasing likelihood that the efficiency in the extra year has drifted further

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[36] Revenue efficiency is expressed as a percent of revenue and, since revenues are typically only a bit larger than costs, revenue efficiency estimates are essentially comparable to those for cost efficiency. An ad hoc revenue frontier approach—essentially a one-year DFA model—found a similar result (Elyasiani and Mehdian, 1990b). Berger, Humphrey, and Pulley (1997) specified an alternative revenue function, similar to the alternative profit function and found no evidence of revenue economies of scope, suggesting that customers do not value 'one-stop banking' or that banks do not have sufficient market power to extract the value that consumers do place on this convenience.

away from its level at point being measured. The study found that the benefits and costs balance out at about 6 years for U.S. banking data (DeYoung, 1997a).

However, the apparent persistence of relative efficiencies across firms over time does not necessarily carry over to changes in the overall level or distribution of efficiency. Advances and declines in year-to-year efficiency affect banks over time (Bauer, Berger, Ferrier, and Humphrey, 1995). Finally, although numerous studies have commented on how efficiency seems to differ or not differ across size classes of banks (e.g., Ray and Mukherjee, 1994), our view is that these simple contrasts remain unreliable until the issue discussed above of possibly confounding scale economies with inefficiency due to heteroskedasticity in the data is more completely resolved.

7. Improving Managerial Performance at Financial Institutions

In principle, virtually **any** efficiency study of financial institutions can be used as a tool by managers to improve performance, as long at there is information in the study on the characteristics or identities of the relatively efficient and inefficient institutions. Management practices or characteristics that are found to be relatively common among financial institutions on or near the efficient frontier may be identified as "best practices," which should be adopted if possible. Managers can also adjust their policies and procedures to avoid "worst practices" that are relatively common among institutions that are far from the efficient frontier. In addition, owners and managers of financial institutions may pay particular attention to the relationship between measured frontier efficiency and organizational form, which may suggest managerial arrangements which are more conducive to high performance.

Many frontier efficiency studies perform ex post analyses to identify the most important determinants of firm efficiency. However, to date, the results of these analyses have not been very informative because of a lack of detailed data. Exceptions have been studies that compared and contrasted the performance of individual credit unions (Fried, Lovell, and Vanden Eeckaut, 1993; Fried and Lovell, 1994). The incorporation of price and service variety components into the output of credit unions resulted in more accurate benchmarking of these firms and yielded higher average efficiency values being measured, because certain "high cost" credit unions were found to incur higher costs in order to improve the services they provided. This can be important for mutual and cooperative types of organizations in which the customers are the owners. The customer/owner may prefer an increase in costs which would lower conventionally-measured efficiency if the higher costs were in the form of higher interest paid or additional services provided.

Perhaps the best potential use of frontier efficiency methods in improving managerial performance, largely due to the availability of detailed proprietary data, comes from efficiency analysis of the branches of an individual financial institution. A financial institution may use frontier efficiency rankings, along with its own internal measures of performance, to determine where problems lay and help solve them. In the hands of a researcher who has a good institutional understanding of a given industry, frontier analysis can assist management to determine objectively those procedures or branches that may be classified as best practice and worst practice within a firm. The best and worse practices that are discovered can be used to rewrite the policies and procedures book for the branches. In addition, management may use frontier efficiency rankings to determine which branches are in most need of reform, local management replacement, or closure. The measurement and use of frontier efficiency for these purposes may work particularly well in analyzing branches which effectively have the same production function and produce a similar output mix but may differ importantly in productivity and efficiency. While many firms have their own internal benchmarking procedures, they often are composed of relatively simple comparisons or rankings of offices according to a small (but sometimes, an overly large) set of partial performance ratios (Colwell and Davis, 1992; Sherman and Ladino, 1995; Lovell and Pastor, 1997). Although informative, such comparisons are not as broadly-based as frontier analysis and typically lack a powerful and comprehensive optimizing methodology. As well, the use of simple ratios typically does not account for differences in output mix and input prices faced by the different branches.

However, frontier analysis may not always indicate the remedy for inefficient observations. Internal audits or intensive reviews of procedures are often also needed to uncover the source and nature of the operating and other changes that will likely improve efficiency at less efficient branches.

As shown in Table 4, there have been a number of frontier analyses focusing on branch performance within a single banking firm. Only one of these studies used parametric methods, applying DFA (Berger, Leusner, and Mingo, 1996), while all the other studies have relied on nonparametric approaches, DEA or FDH. As proprietary data is often available for these studies, many inputs and outputs can be expressed in physical flow terms (e.g., hours worked by type of labor, numbers of transactions processed) and more accurate measures of stock inputs may be specified (e.g., square footage of office space used). This has been the case for the branch operations of a large Canadian bank (Schaffnit, Rosen, Paradi, 1997) which permits a detailed and comprehensive efficiency analysis. Regional or seasonal influences, differences in market location or operating environments, office size, or even management style and organization may also be considered (Parkan, 1987; Oral and Yolalan, 1990; Tulkens and Malnero, 1994; Athanassopoulos, 1995, 1997; Sherman and Ladino, 1995; Zenios, Zenios, Agathocleous, and Soteriou, 1996; Drake and Howcroft, forthcoming). Less comprehensive studies have to rely on more indirect indicators such as the stock of accounts serviced or the values within various accounts, with little or no information on important customer characteristics or other environmental influences that can importantly affect the outcome.

When detailed transactions and service data are available, it often is grouped into a smaller set of similar categories to be made operational, such as aggregating 60 banking operations into only eight service areas (Tulkens, 1993) or constructing a weighted measure of 4 service categories from 17 of the most common services offered at the branch level (Sherman and Gold, 1985). One reason for partially aggregating the data is that it reduces the number of constraints that have to be specified, and so reduces the number of observations that are determined to be 100% efficient by virtue of having no other observations with which to be compared (self-identifiers). A more appropriate way to do this is through a statistical test which can discriminate between informative and extraneous constraints (Lovell and Pastor, 1997) or applying a cone-ratio or assurance region DEA model (Schaffnit, Rosen, and Paradi, 1997).

The one parametric study finds frontier efficiency of about .90 to .95 for total branching costs (including interest expenses) or about .75 to .80 of branch operating costs, consistent with studies of financial institutions generally. In contrast, the nonparametric frontier analyses of branches tend to find a relatively large proportion of branches to be 100% efficient. This may occur in some cases because the number of inputs and outputs is large relative to the number of observations available, making it difficult to find other branches or linear combination of branches that dominate in every input and output.

8. Conclusions and Directions for Future Research

We have outlined the results of 130 studies of financial institution efficiency covering 21 countries that apply five different frontier approaches. The efficiency estimates from nonparametric (DEA and FDH) studies are similar to those from parametric frontier models (SFA, DFA, and TFA), but the nonparametric methods generally yield slightly lower mean efficiency estimates and seem to have greater dispersion than the results of the parametric models. Overall, depository financial institutions (banks, S&Ls, credit unions) in these studies experience an average efficiency of around 77% (median 82%). The similarity in average efficiency values for firms across different frontier models, however, does not strongly carry over to rankings of individual firms by their efficiency values across models. This suggests that estimates of mean efficiency for an industry may be a more reliable guide for policy and research purposes than are the estimated efficiency rankings of firms, and that analyses of the causes or correlates of efficiency should be viewed with caution. The standard deviation of the efficiency estimates, at 13 percentage points, is relatively large. This suggests, and some initial studies confirm, that the confidence intervals surrounding individual firm or branch efficiency estimates may be substantial.

Applications of Efficiency Analysis. In terms of applications, research on financial institution efficiency has largely focused on using institution efficiency estimates: (1) to inform government policy (e.g., by assessing the effects of deregulation, mergers, and market structure on industry efficiency); (2) to address research issues (e.g., by determining how efficiency varies with different frontier approaches, output definitions, and time periods); and (3) to improve managerial performance (e.g., by identifying best-practice and worst-practice branches within a single firm).

Results from these applications suggest the following sets of conclusions. First, the government policy-efficiency literature finds that deregulation of financial institutions can either improve or worsen efficiency, depending upon industry conditions prior to deregulation. In a number of countries, deregulation has led to rapid branch expansion, excessive asset growth, a run-up in bank failures, and reduced efficiency. Although one goal of deregulation has been to improve efficiency, other incentives may intervene.

A similar result applies to mergers and acquisitions: some consolidations improve cost efficiency, whereas others worsen the performance of the combined institution relative to the separate institutions. On average, there appears to be no significant cost improvement.

However, profit efficiency may improve with mergers and acquisitions due to altering output mix toward more profitable products (e.g., from securities to loans), rather than improved cost efficiency.

The application of frontier efficiency analysis to the market-power versus efficient-structure debate about the determinants of profitability also yields mixed results. Cost efficiency is found to be more important than market concentration in explaining financial institution profitability, but both influences together only weakly explain performance variation. Market power does seem to affect the prices of some types of local deposits and loans, but has little apparent effect on profits. One reason may be that the managers of financial institutions with market power appear to take some of the benefits of charging higher prices as a “quiet life” in which they pursue goals other than maximizing efficiency.

The research-efficiency literature on financial institutions generally finds that efficiency rankings differ depending on which frontier approach is used (as noted above) and by how financial institution output is measured — as a transaction-based flow, a stock of numbers of accounts, or a stock of value in these accounts. Once a frontier approach is adopted and an output specification is selected, however, efflciency estimates are fairly stable from year to year, showing persistence. The limited evidence also suggests that the confidence intervals around efficiency estimates may be quite large.

Much of this literature is also concerned with the determinants of efficiency. Firm efficiency appears to be greater for some forms of corporate organization or control than others. However, most of these effects are slight and may not always be economically important, even if they are statistically significant.

There are a number of important methodological developments under way that may help resolve some of the conflicts among methods, make efficiency estimation more accurate, and help find the determinants of efficiency. For the nonparametric techniques, these developments include non-radial measures, the use of “composite” frontiers which embody the best parts of different financial institutions, the use of output distance functions, measurement of confidence intervals, optimization of the number of constraints, finding a statistical basis for the nonstochastic approaches, and resampling to take account of some of the random error in the data. For the parametric techniques, the new developments include the specification of more globally flexible functional forms, the use of less restrictive assumptions on the distributions of inefficiencies, the allowance for heteroskedasticity in the distributions of both inefficiencies and random errors, the measurement of confidence intervals, random coefficient estimation, allowance for correlations between regressors and inefficiencies, measurement of the effects of output mix and diversification, and the development of profit efficiency.

The management performance-efficiency literature on financial institutions is perhaps the least developed of the three types of applications. Some of this research has focused on alternative goals for managers, particularly when the firm is organized on a mutual or cooperative basis, rather than as a value-maximizing enterprise. The burgeoning literature on bank branch efficiency offers an opportunity for researchers to provide managers with information that may help to identify troubled branches and to help rewrite operational policies and procedures books based upon practices that are common among branches with the highest or lowest measured efficiency. Unfortunately, few of these studies have noted in any detail the specific changes implemented to improve performance at inefficient branches.

Directions for Future Research. Finally, it is important to point out shortcomings in existing research that should be addressed, suggest ways in which the existing research may be refocused to fill gaps in the literature, and outline potential areas for future research. Existing research has shown us that financial institutions are less than fully efficient and have quantified the apparent extent of this deficiency. However, little has been offered in terms of the significance of the measured efficiency differences, in determining the specific causes of these differences, and in explaining why they seem to persist in market-based economies.

One problem of frontier analysis is that although the central tendency of average efficiency values for financial institutions is generally similar across frontier techniques, rankings of firms by their measured efficiencies can differ. Since rankings differ depending on the frontier technique used, the common practice of regressing firm efficiency values (or ranks) on other variables of interest may lead to misleading results. If these ex post regressions are to be informative, they should be demonstrated to be robust to efficiency estimates from more than just one class of frontier technique.

There are also shortcomings in applying both nonparametric and parametric frontier methods. The parametric approaches impose functional forms that restrict the shape of the frontier, and the nonparametric approaches do not allow for random error that may affect measured performance. Attempts to remedy these situations by specifying more globally flexible functional forms in the parametric approaches and trying to implement stochastic versions of the nonparametric approaches should continue. By generalizing both types of approaches, the data will presumably have a better chance to yield results that are more accurate and more consistent across approaches.

Other shortcomings in the two types of approaches are clear as well. For example, the choice among the various parametric models is typically based more on ease of use and/or the apparent reasonableness of the assumptions that underlie the different approaches than on any strong theoretical or empirical foundation. This gap in the literature is being filled for nonparametric models with an attempt to demonstrate that a stronger theoretical foundation exists for FDH than for DEA and that both approaches have a valid statistical foundation. Even so, nonparametric models are often specified in such a manner that many observations turn out to be 100% efficient, and this has been particularly so in the case of bank branches.

Financial institutions or branches may be found to be fully efficient either because there truly are no other units that dominate them (even when a small set of important core variables/constraints are specified). Alternatively, these units may be found to be efficient because too many constraints have been specified, leading to excessive numbers of self-identifiers -- units which neither dominated any other unit nor were dominated by any other unit or combination of units in every dimension. While this problem is well-known, there have been few attempts to solve it. The statistical test applied by Lovell and Pastor (1997) to identify extraneous constraints, however, may finally address this issue.

In addition, efficiency studies should try to provide confidence intervals for the estimates they generate, as some very recent studies have done. These intervals, when they have been provided, appear to be large relative to the range of efficiency estimates provided. As a result, comparisons of efficiency estimates across observations may be more meaningful if groups of observations, rather than individual observations, were being compared. Attributes associated with the group of observations with relatively high efficiency values can be contrasted with attributes associated with the group with relatively low values (with the middle group excluded entirely). In this context, it would be interesting to see if the imperfect correspondence found for firm-level efficiency estimates among different frontier methods is markedly improved if groups of observations, rather than individual observations, were used.

An area of research also deserving additional attention concerns efficiency comparisons among countries. With so few cross-country comparative efficiency studies to draw upon, the results obtained so far should be taken with caution unless the robustness of an intercountry comparison is demonstrated by finding the same result using different frontier techniques on the same data set. As well, most financial institution efficiency studies have been applied to the U.S. banking industry, which has distinct local markets for many products and is quite unconcentrated by world standards. It is important for research and policy purposes to see if the U.S. results carry over into other nations with banking markets that are more national in scope with much higher levels of concentration.

Finally, there is a considerable lack of information on what the main determinants of efficiency are both across firms within the financial industry and across branches within a single firm. Almost all of the studies which estimate efficiency and then regress it on sets of explanatory variables have been unable to explain more than just a small portion of its total variation. While some differences have been found, little published information exists regarding those influences that are under direct management control, such as the choice of funding sources, wholesale versus retail orientation, etc. In sum, while there have been improvements made in applying efficiency analysis to financial institutions, there are many areas which deserve further research.

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Table 1: Studies of the Efficiency of Depository Financial Institutions.

Country:	Method:	Author (Date):	Average Annual Efficiency Estimate	Institution Type
Belgium	FDH	Tulkens (1993)	.97 .93	Branch
Belgium	FDH	Tulkens and Malnero (1994)	.93	Branch
Canada	DEA	Parkan (1987)	.98	Branch
Canada	DEA	Schaffnit, Rosen, and Paradi (1997)	.87	Branch
Cyprus	DEA	Zenios, Zenios, Agathocleous, and Soteriou (1996)	.89 .92 .88	Branch
Denmark	DEA	Bukh (1994)	.80 .85	Bank
Finland	DEA	Kuussaari (1993)	.80 .86	Bank
Finland	DEA	Kuussaari and Vesala (1995)	.86	Bank
France	DFA	Chaffai and Dietsch (1995)	.24 .33	Bank
France	DFA	Dietsch (1994)	.72 .71 .68 .71 .69	Bank
Germany	SFA	Altunbas and Molyneux (n.d.)	.81 .77 .77	Bank
Germany	TFA	Lang and Welzel (1995)	.93	Bank
Germany	DFA	Lang and Welzel (1996)	.54 .61	Bank
Greece	DEA,	Giokas (1991)	.87	Branch
	& SFA		.72	Branch
Greece	DEA	Vassiloglou and Giokas (1990)	.91	Branch
India	DEA	Bhattacharya, Lovell, and Sahay (1997)	.86 .75 .79	Bank
Italy	DEA	Favero and Papi (1995)	.88 .91 .79 .84	Bank
Italy	DEA	Ferrier and Hirschberg (1994)	.98	Bank
Italy	DEA,	Resti (1995)	.74 .76 .74 .75 .73	Bank
	& SFA		.69 .70 .70 .70 .70	Bank
Japan	DEA	Fukuyama (1993)	.86	Bank
Japan	DEA	Fukuyama (1995)	.46 .46 .44	Bank
Mexico	DEA	Taylor, Thompson, Thrall, and Dharmapala (1997)	.75 .72 .69	Bank
Norway	DEA	Berg (1992)	.62 .51 .57 .47 .49 .68 .57	Bank
Norway	DEA	Berg, Forsund, and Jansen (1991)	.81	Bank
Norway	DEA	Berg, Forsund, and Jansen (1992)	n.a.	Bank
Norway	TFA	Berg and Kim (1994)	.81 .81	Bank
Norway	TFA	Berg and Kim (1996)	.89 .74	Bank
Saudi Arabia	DEA	Al-Faraj, Alidi, and Bu-Bshait (1993)	.87	Branch
Spain	DEA	Grifell-Tatje and Lovell (1994)	n.a.	S&L
Spain	DEA	Grifell-Tatje and Lovell (1996)	n.a.	Bank,S&L,π
Spain	DEA	Grifell-Tatje and Lovell (1997)	.81 .85 .85 .84 .83 .84 .83 .87	Bank
			.84 .85 .84 .83 .80 .82 .81 .77	S&L
Spain	DEA	Grifell-Tatje and Lovell (forthcoming)	.76 .75 .75 .80 .78 .80	S&L
Spain	DEA	Lovell and Pastor (1997)	.92 .90	Branch
Spain	TFA	Lozano (1995a)	.90 .88 .89 .88 .87 .87 .87	Bank
Spain	TFA	Lozano (1995b)	.68 .67 .66 .73 .78 .81	S&L, π
Spain	DEA	Pastor (1995)	.87 .80	Branch

Table 1: (continued)

Spain	DEA	Perez and Quesada (1994)	.83	Bank
Spain	SFA	Maudos (1996a)	.81 .83 .82 .81 .81 .81 .81 .79 .80	
			.82 .83 .82 .80 .82 .82 .81 .80 .81	
			.85 .87 .85 .81 .84 .85 .84 .82 .82	Bank
Spain	SFA	Maudos (1996b)	.82 .83 .83	Bank
Sweden	DEA	Hartman and Storbeck (1995)	.85 .78	S&L
Switzerland	DEA	Sheldon and Haegler (1993)	.56	Bank
Tunisia	SFA	Chaffai (1993)	.66 .65 .65 .64 .63 .63	
			.62 .62 .62 .61 .61 .61	Bank
Tunisia	SFA	Chaffai (1997)	n.a.	Bank
Turkey	DEA	Oral and Yolalan (1990)	.87 .53	Branch
Turkey	DEA	Zaim (1995)	.83 .94	Bank
U.K.	DEA	Athanassopoulos (1995)	.85	Branch
U.K.	DEA	Athanassopoulos (1997)	.90	Branch
U.K.	DEA	Drake and Howcroft (forthcoming)	.93 .97	Branch
U.K.	DEA	Drake and Weyman-Jones (1992)	.98	S&L
U.K.	DEA	Field (1990)	.93	S&L
U.S.	DFA	Adams, Berger, and Sickles (1996)	.64 .61 .69 .64 .70 .77	Bank
U.S.	DFA	Akhavein, Berger, and Humphrey (1997)	.24 .34	Bank, π
U.S.	DFA	Akhavein, Swamy, and Taubman (1997)	.99 .44	Bank, π
U.S.	DEA	Aly, Grabowski, Pasurka, and Rangan (1990)	.75 .81	Bank
U.S.	DEA	Barr, Seiford, and Siems (1994)	.81 .83	Bank
U.S.	SFA,	Bauer, Berger, and Humphrey (1993)	.87 .86 .86 .87 .86 .88	
			.89 .87 .87 .87 .85 .85	Bank
	DFA,		.86 .85 .86 .86 .85 .86	
			.87 .86 .86 .86 .85 .85	Bank
	& TFA		.86 .90 .81 .80 .84 .84	
			.86 .83 .81 .82 .83 .79	Bank
U.S.	DEA	Bauer, Berger, Ferrier, and Humphrey (1995)	.73 .71 .71 .73 .75 .76	
			.74 .73 .73 .70 .67 .67	Bank
U.S.	DFA	Berger (1993)	.85 .84 .75	Bank
U.S.	DFA	Berger (1995)	n.a.	Bank
U.S.	SFA	Berger and DeYoung (1996)	.92 .94 .95 .91 .93 .91	
			.91 .91 .93 .95	Bank
U.S.	DFA	Berger, Hancock, and Humphrey (1993)	.52 .65 .66	Bank, π
U.S.	DFA	Berger and Hannan (1997)	n.a.	Bank
U.S.	TFA	Berger and Humphrey (1991)	.81 .84	Bank
U.S.	TFA	Berger and Humphrey (1992a)	.85 .81 .71 .80 .84 .80	Bank
U.S.	DFA	Berger and Humphrey (1992b)	n.a.	Bank
U.S.	DFA	Berger, Leusner, and Mingo (1996)	.94 .79	Branch
U.S.	DFA	Berger and Mester (1997)	.87	Bank
			.55 .46	Bank, π
U.S.	SFA	Cebenoyan, Cooperman, and Register (1993)	.77 .83	S&L
U.S.	SFA	Cebenoyan, Cooperman, Register, and Hudgins (1993)	.87 .86	S&L
U.S.	SFA	Chang, Hasan, and Hunter (1993)	.81	Bank
U.S.	DEA	Charnes, Cooper, Huang, and Sun (1990)	n.a.	Bank
U.S.	TFA	Clark (1996)	.73 .90	Bank
U.S.	FDH	DeBorger, Ferrier, and Kerstens (1995)	.94 .88 .89 .80 .95 .88 .89	
			.80 .97 .95 .89 .89 .77	Bank
U.S.	DEA	Devaney and Weber (1995)	.75 .75 .71	Bank
U.S.	TFA	DeYoung (1994)	n.a.	Bank
U.S.	DFA	DeYoung (1997a)	.80	Bank

Table 1: (continued)

U.S.	TFA	DeYoung (1997b)	.82	Bank
U.S.	TFA	DeYoung (1997c)	.84 .89	Bank
U.S.	DFA	DeYoung and Nolle (1996)	.56 .73	Bank, π
U.S.	DEA,	Eisenbeis, Ferrier, and Kwan (1996)	.72 .73 .73 .78	
	& SFA		.84 .87 .89 .93	Bank
U.S.	SFA	Ellinger, Zhu, Shumway, and Neff (forthcoming)	n.a.	Bank
U.S.	DEA	Elyasiani and Mehdian (1990a)	.90 .78	Bank
U.S.	SFA	Elyasiani and Mehdian (1990b)	.88	Bank
U.S.	DEA	Elyasiani and Mehdian (1992)	.89	Bank
U.S.	DEA	Elyasiani and Mehdian (1995)	.97 .95 .95 .96	Bank
U.S.	DEA	Elyasiani, Mehdian, and Rezvanian (1994)	.86 .83	Bank
U.S.	DEA	English, Grosskopf, Hayes, and Yaisawarng (1993)	.75 .76	Bank
U.S.	DEA	Ferrier, Grosskopf, Hayes, and Yaisawarng (1993)	.69 .60	Bank
U.S.	DEA	Ferrier, Kerstens, and Vanden Eeckaut (1994)	.37 .33	Bank
U.S.	DEA,	Ferrier and Lovell (1990)	.83	Bank
	& SFA		.79	Bank
U.S.	IN[1]	Fixler and Zieschang (1993)	n.a.	Bank
U.S.	FDH	Fried and Lovell (1994)	.93	CU
U.S.	FDH	Fried, Lovell, Vanden Eechaut (1993)	.83	CU
U.S.	DEA	Grabowski, Rangan, and Rezvanian (1993)	.72	Bank
U.S.	SFA,	Hasan and Hunter (forthcoming)	.82 .79	Bank
	& TFA		.64 .70	Bank, π
U.S.	DEA	Hermalin and Wallace (1994)	.75 .73	S&L
U.S.	TFA	Humphrey and Pulley (1997)	.81 .82 .85	Bank, π
U.S.	DFA	Hunter and Timme (1995)	.84 .77 .78	Bank
U.S.	SFA	Kaparakis, Miller, and Noulas (1994)	.90	Bank
U.S.	SFA	Kwan and Eisenbeis (1994)	.88 .85 .84 .84 .88 .88	Bank
U.S.	TFA	Mahajan, Rangan, and Zardkoohi (1996)	.77 .88	Bank
U.S.	SFA	Mester (1993)	.92 .87	S&L
U.S.	SFA	Mester (1996)	.86	Bank
U.S.	SFA	Mester (1997)	.93 .92 .85 .87 .89 .88 .86 .85	Bank
U.S.	DEA	Miller and Noulas (1996)	.97	Bank, π
U.S.	DFA	Newman and Shrieves (1993)	n.a.	Bank
U.S.	DFA	Peristiani (1997)	.79 .79 .77 .81 .81 .77	Bank
U.S.	SFA	Pi and Timme (1993)	.87	Bank
U.S.	DEA	Rangan, Grabowski, Aly, and Pasurka (1988)	.70	Bank
U.S.	DEA	Ray and Mukherjee (1994)	.88	Bank
U.S.	DEA	Sherman and Gold (1985)	.96	Branch
U.S.	DEA	Sherman and Ladino (1995)	.80	Branch
U.S.	DEA	Thompson, Brinkmann, Dharmapala, Gonzalez-Lima, and Thrall (1997)	.81 .69 .59 .59 .54 .62	Bank
U.S.	DEA	Thompson, Dharmapala, Humphrey, Taylor, and Thrall (1996)	.53 .51 .45 .39 .35 .31 .46 .44 .53	Bank
U.S.	DEA	Wheelock and Wilson (1994)	.84 .77 .69 .59 .59 .46 .51 .42	Bank
U.S.	SFA	Zhu, Ellinger, and Shumway (forthcoming)	.88 .86 .82	Bank

Table 1: (continued)

Multiple Type Countries:	Method:	Author (Date):	Average Annual Efficiency Estimate	Institution
Norway	DEA	Berg, Forsund, Hjalmarsson, and Suominen (1993)	.57	Bank
Sweden			.78	Bank
Finland			.53	Bank
Norway	MOS[1]	Bergendahl (1995)	.09-1.00; Average = .51	Bank
Sweden			.05-1.00; Average = .64	Bank
Finland				
Denmark				
Norway	DEA	Bukh, Berg, and Forsund (1995)	.54	Bank
Sweden			.85	Bank
Finland			.52	Bank
Denmark			.78	Bank
11 OECD countries	DFA	Fecher and Pestieau (1993)	.71-.98; Average = .82	Financial Services
8 developed countries	DEA	Pastor, Perez, and Quesada (1994)	.55-.95; Average = .86	Bank
15 developed countries	TFA	Ruthenberg and Elias (1996)	.55-.94; Average = .70	Bank

Notes: n.a. indicates either not reported, not comparable, or duplicates earlier estimates.

π indicates a profit efficiency measure. The profit efficiency ratios employ a substantially different denominator (maximum or optimal profits), and therefore are not comparable to the other ratios.

In order to make the reported efficiencies as comparable as possible, we try to report only technical efficiency ratios, and exclude scale, scope, and allocative inefficiencies, which are not measured in most studies. In some cases, these other types of inefficiencies could not be separated out. For example, some of the profit efficiency ratios incorporate scale and scope inefficiencies which create deviations from the optimal output point.

[1] IN refers to a nonparametric index number approach. MOS is a mixed optimal strategy where the most efficient "parts" of different banks are combined and used as a frontier, in contrast to DEA and FDH where all parts of an individual bank defines the frontier.

Key:			
	Nonparametric	DEA	Data Envelopment Analysis
		FDH	Free Disposal Hull
		IN	Index Numbers
		MOS	Mixed Optimal Strategy
	Parametric:	SFA	Stochastic Frontier Approach (composed error)
		DFA	Distribution Free Approach (different composed error)
		TFA	Thick Frontier Approach

Table 2: Average Efficiency of U.S. Banks by Frontier Technique.

Nonparametric Techniques: DEA and FDH[1] (78 observations)			Parametric Techniques: SFA, DFA, and TFA (110 observations)		
Mean	=	.72	Mean	=	.84
Median	=	.74	Median	=	.85
Standard Deviation	=	.17	Standard Deviation	=	.06
Interquartile Range	=	.24	Interquartile Range	=	.07
Range	=	.31 to .97	Range	=	.61 to .95

[1] Two nonparametric studies (noted as IN and MOS in Table 1) have not been included.

Table 3: Studies of the Efficiency of Insurance Firms.

Country:	Method:	Author (Date):	Average Annual Efficiency Estimate (Institution Type)
France	DEA, & SFA	Fecher, Kessler, Perelman, and Pestieau (1993)	.50 .33 (Life & Non-Life) .41 .24 (Life & Non-Life)
Italy	DEA	Cummins, Turchetti, and Weiss (1995)	.71 .71 .72 .76 .72 .78 .77 .74 (Life & Non-Life)
U.S.	SFA	Cummins and Weiss (1993)	.90 .79 .88 (Property Liability)
U.S.	DFA	Gardner and Grace (1993)	.42 (Life)
U.S.	SFA, & TFA	Yuengert (1993)	.75 (Life) .63 (Life)
U.S.	DFA	Berger, Cummins, and Weiss (1996)	.74 .70 (Property Liability) .63 .51 .68 .58 (Property Liability, π)
U.S.	DEA	Cummins, Weiss, and Zi (1995)	.88 .88 .85 .86 .86 .85 .85 .85 .85 .85 (Prop. Liab.) .90 .91 .88 .88 .88 .87 .87 .89 .88 .87 (Prop. Liab.)
U.S.	SFA, & DFA, & DEA, & FDH	Cummins and Zi (1995)	.58 .63 .61 .61 .63 (Life) .47 (Life) .56 .58 .56 .61 .60 (Life) .98 .98 .98 .98 .98 (Life)

Table 4: Applications of Efficiency Analysis of Financial Institutions.

Application:	Country:	Method:	Authors:
Inform Government Policy:			
Deregulation, financial disruption	Norway	DEA	Berg, Forsund, and Jansen (1992)
	U.S.	DEA	Elyasiani and Mehdian (1995)
	Japan	DEA	Fukuyama (1995)
	Spain	TFA	Lozano (1995a)
	Turkey	DEA	Zaim (1995)
	U.S.	TFA	Humphrey and Pulley (1997)
	Spain	DEA	Grifell-Tatje and Lovell (forthcoming)
Institution failure, risk, problem loans, and management quality	U.S.	TFA	Berger and Humphrey (1992a)
	U.S.	SFA	Cebenoyan, Cooperman, and Register (1993)
	U.S.	DEA	Barr, Seiford, and Siems (1994)
	U.S.	DEA	Elyasiani, Mehdian, and Rezvanian (1994)
	U.S.	DEA	Hermalin and Wallace (1994)
	U.S.	SFA	Berger and DeYoung (1996)
	U.S.	SFA	Mester (1996)
	U.S.	SFA	Mester (1997)
	U.S.	TFA	DeYoung (1997c)
Market structure and Concentration	Norway	TFA	Berg and Kim (1994)
	U.S.	DFA	Berger (1995)
	U.S.	DEA	Devaney and Weber (1995)
	Norway	TFA	Berg and Kim (1996)
	Spain	SFA	Maudos (1996b)
	U.S.	DFA	Berger and Hannan (1997)
Mergers	Norway	DEA	Berg (1992)
	U.S.	DFA	Berger and Humphrey (1992b)
	U.S.	IN	Fixler and Zieschang (1993)
	U.S.	DFA	Akhavein, Berger, and Humphrey (1997)
	U.S.	TFA	DeYoung (1997b)
	U.S.	DFA	Peristiani (1997)
Address Research Issues:			
Confidence intervals	Italy	DEA	Ferrier and Hirschberg (1994)
	U.S.	DEA	Wheelock and Wilson (1994)
Comparing different efficiency techniques or assumptions	U.S.	DEA,SFA	Ferrier and Lovell (1990)
	Greece	DEA,SFA	Giokas (1991)
	U.S.	SFA,DFA,TFA	Bauer, Berger, and Humphrey (1993)
	U.S.	DEA,SFA	Eisenbeis, Ferrier, and Kwan (1996)
	Spain	SFA	Maudos (1996a)
	Germany	SFA	Altunbas and Molyneux (n.d.)
	U.S.	SFA	Zhu, Ellinger, and Shumway (forthcoming)
Comparing different output measures	Norway	DEA	Berg, Forsund, and Jansen (1991)
	Finland	DEA	Kuussaari (1993)
	Italy	DEA	Favero and Papi (1995)
	U.S.	DFA	Hunter and Timme (1995)
	Finland	DEA	Kuussaari and Vesala (1995)

Table 4: (continued)

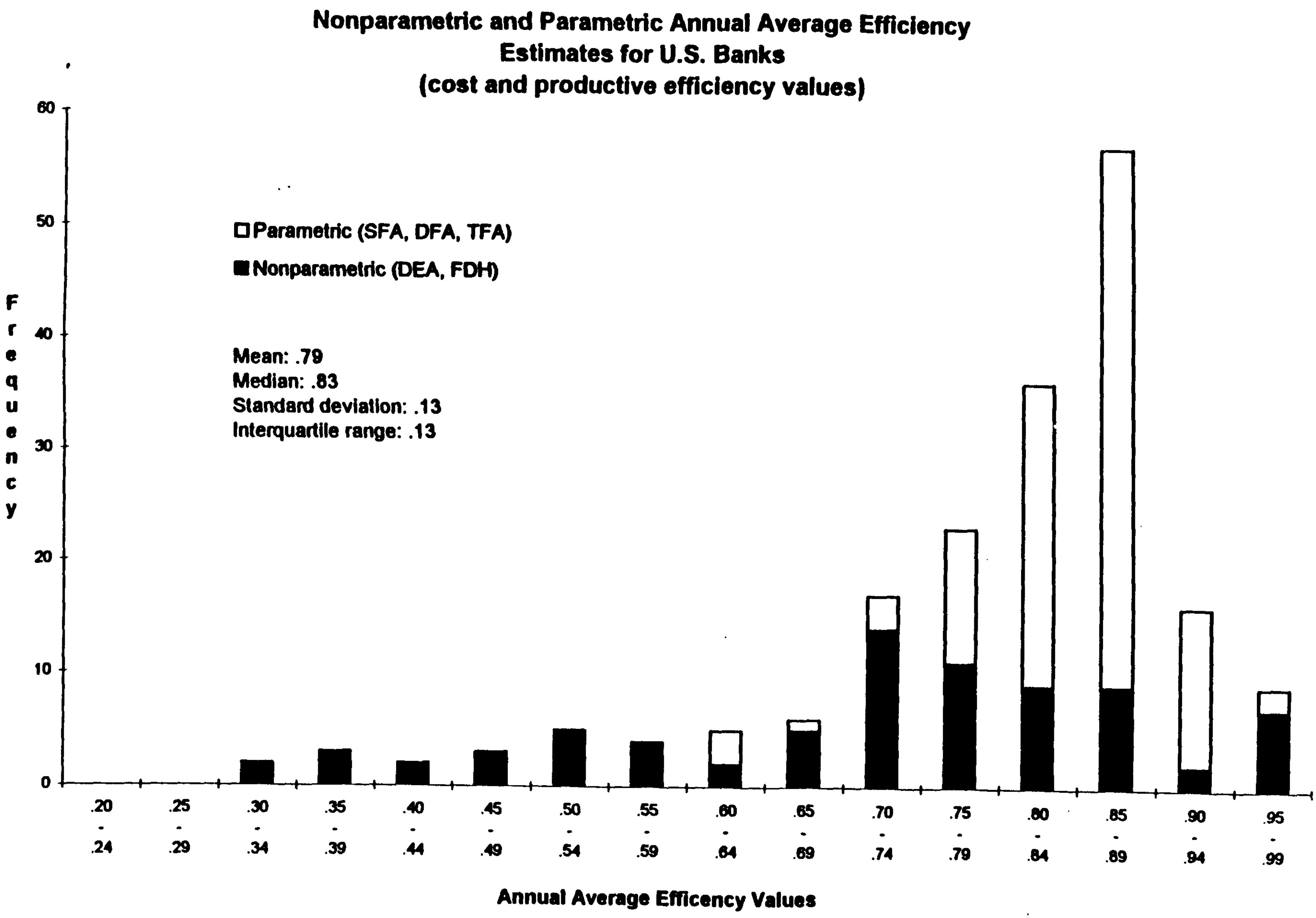
Organizational form, corporate control issues	U.S.	DEA	Rangan, Grabowski, Aly, and Pasurka (1988)
	U.S.	DEA	Aly, Grabowski, Pasurka, and Rangan (1990)
	U.S.	DEA	Elyasiani and Mehdian (1992)
	U.S.	SFA	Cebenoyan, Cooperman, Register, and Hudgins (1993)
	U.S.	SFA	Chang, Hasan, and Hunter (1993)
	U.S.	DEA	Grabowski, Rangan, and Rezvanian (1993)
	U.S.	SFA	Mester (1993)
	U.S.	DFA	Newman and Shrieves (1993)
	U.S.	SFA	Pi and Timme (1993)
	U.S.	DFA	DeYoung and Nolle (1996)
	U.S.	TFA	Mahajan, Rangan, and Zardkoohi (1996)
	India	DEA	Bhattacharya, Lovell, and Sahay (1997)
	U.S.	SFA,TFA	Hasan and Hunter (forthcoming)
General level of efficiency	U.S.	DEA	Elyasiani and Mehdian (1990a)
	U.K.	DEA	Field (1990)
	U.K.	DEA	Drake and Weyman-Jones (1992)
	Tunisia	SFA	Chaffai (1993)
	Japan	DEA	Fukuyama (1993)
	Switzerland	DEA	Sheldon and Haegler (1993)
	Denmark	DEA	Bukh (1994)
	U.S.	SFA	Kaparakis, Miller, and Noulas (1994)
	Spain	DEA	Perez and Quesada (1994)
	Germany	TFA	Lang and Welzel (1995)
	Italy	DEA,SFA	Resti (1995)
	Germany	DFA	Lang and Welzel (1996)
	U.S.	DEA	Miller and Noulas (1996)
Intercountry comparisons	Norway Sweden Finland	DEA	Berg, Forsund, Hjalmarsson, and Suominen (1993)
	11 OECD countries	SFA	Fecher and Pestieau (1993)
	8 developed countries	DEA	Pastor, Perez, and Quesada (1994)
	Norway Sweden Finland Denmark	DEA	Bukh, Berg, and Forsund (1995)
	15 developed countries	TFA	Ruthenberg and Elias (1996)
Methodology issues	U.S.	DEA	Charnes, Cooper, Huang, and Sun (1990)
	U.S.	TFA	Berger and Humphrey (1991)
	U.S.	DFA	Berger (1993)
	Belgium	FDH	Tulkens (1993)
	U.S.	DEA	Ferrier, Kerstens, and Vanden Eeckaut (1994)
	Spain	DEA	Grifell-Tatje and Lovell (1994)
	Norway Sweden Finland Denmark	MOS[1]	Bergendahl (1995)
	U.S.	DFA	Adams, Berger, and Sickles (1996)
	U.S.	DFA	Akhavein, Swamy, and Taubman (1997)

Table 4: (continued)

	U.S.	FDH	DeBorger, Ferrier, and Kerstens (1995)
	Spain	DEA	Pastor (1995)
	U.S.	DEA	Thompson, Dharmapala, Humphrey, Taylor, and Thrall (1996
	U.S.	DFA	Berger and Mester (1997)
	Tunisia	SFA	Chaffai (1997)
	U.S.	DFA	DeYoung (1997a)
	Spain	DEA	Grifell-Tatje and Lovell (1997)
	Spain	DEA	Lovell and Pastor (1997)
	Mexico	DEA	Taylor, Thompson, Thrall, and Dharmapala (1997)
	U.S.	DEA	Thompson, Brinkmann, Dharmapala, Gonzalez-Lima, and Thrall (1997)
Opportunity cost, output diversification	U.S.	DEA	Ferrier, Grosskopf, Hayes, and Yaisawarng (1993)
	U.S.	TFA	DeYoung (1994)
	France	DFA	Dietsch (1994)
	France	DFA	Chaffai and Dietsch (1995)
	U.S.	TFA	Clark (1996)
Profit, revenue	U.S.	SFA	Elyasiani and Mehdian (1990b)
	U.S.	DFA	Berger, Hancock, and Humphrey (1993)
	U.S.	DEA	English, Grosskopf, Hayes, and Yaisawarng (1993)
	Spain	TFA	Lozano (1995b)
	Spain	DEA	Grifell-Tatje and Lovell (1996)
	U.S.	SFA	Ellinger, Zhu, Shumway, and Neff (forthcoming)
Stability over time, institution size	U.S.	SFA	Kwan and Eisenbeis (1994)
	U.S.	DEA	Ray and Mukherjee (1994)
	U.S.	DEA	Bauer, Berger, Ferrier, and Humphrey (1995)
Improve Managerial Performance:			
Credit Unions	U.S.	FDH	Fried, Lovell, Vanden Eechaut (1993)
	U.S.	FDH	Fried and Lovell (1994)
Bank Branch	U.S.	DEA	Sherman and Gold (1985)
	Canada	DEA	Parkan (1987)
	Turkey	DEA	Oral and Yolalan (1990)
	Greece	DEA	Vassiloglou and Giokas (1990)
	Saudi Arabia	DEA	Al-Faraj, Alidi, and Bu-Bshait (1993)
	Belgium	FDH	Tulkens and Malnero (1994)
	U.K.	DEA	Athanassopoulos (1995)
	U.S.	DEA	Sherman and Ladino (1995)
	U.S.	DFA	Berger, Leusner, and Mingo (1996)
	Cyprus	DEA	Zenios, Zenios, Agathocleous, and Soteriou (1996)
	U.K.	DEA	Athanassopoulos (1997)
	Canada	DEA	Schaffnit, Rosen, and Paradi (1997)
	U.K.	DEA	Drake and Howcroft (forthcoming)
S&L Branch	Sweden	DEA	Hartman and Storbeck (1995)

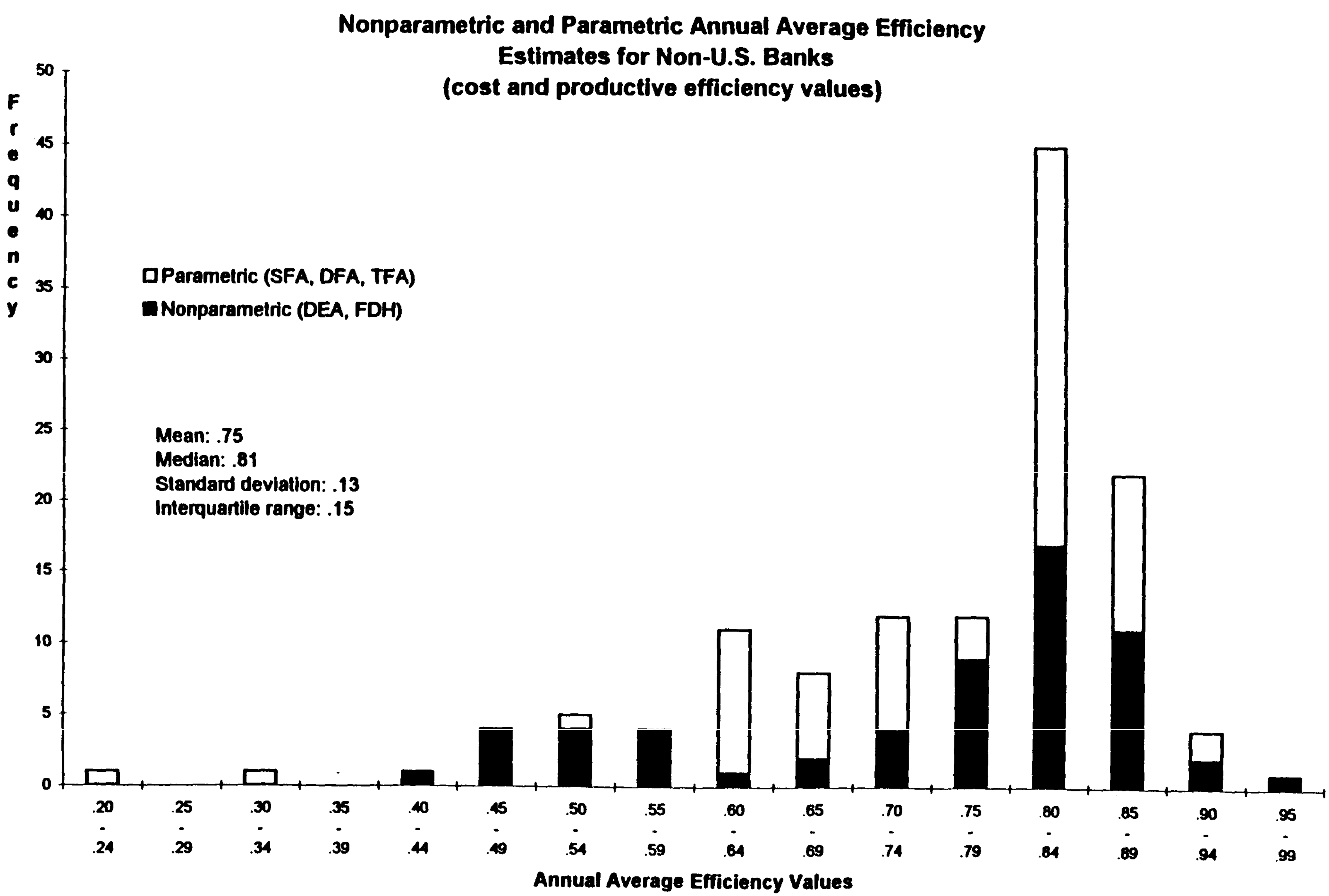
[1] See notes to Table 1.

Figure 1



Nonparametric and Parametric Annual Average Efficiency
Estimates for U.S. Banks
(cost and productive efficiency values)
Parametric (SFA, DFA, TFA)
Nonparametric (DEA, FDH)
Mean: .79
Median: .83
Standard deviation: .13
Interquartile range: .13
Frequency
0
10
20
30
40
50
60
.20 - .24
.25 - .29
.30 - .34
.35 - .39
.40 - .44
.45 - .49
.50 - .54
.55 - .59
.60 - .64
.65 - .69
.70 - .74
.75 - .79
.80 - .84
.85 - .89
.90 - .94
.95 - .99
Annual Average Efficicency Values

Figure 2


Nonparametric and Parametric Annual Average Efficiency
Estimates for Non-U.S. Banks
(cost and productive efficiency values)
Frequency
50
45
40
35
30
25
20
15
10
5
0
Parametric (SFA, DFA, TFA)
Nonparametric (DEA, FDH)
Mean: .75
Median: .81
Standard deviation: .13
Interquartile range: .15
.20 - .24
.25 - .29
.30 - .34
.35 - .39
.40 - .44
.45 - .49
.50 - .54
.55 - .59
.60 - .64
.65 - .69
.70 - .74
.75 - .79
.80 - .84
.85 - .89
.90 - .94
.95 - .99
Annual Average Efficiency Values