THE USE OF DEA TO ASSESS THE FINANCIAL EFFICIENCY OF LARGE U.S. BANKS

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Data envelopment analysis (DEA) was used to analyze the input/output efficiency of large U.S. banks in 1987 and 1992. The former was the year that banks belatedly began to acknowledge financially the increasingly severe problems from their loans to less-developed countries, especially in Latin America. For 1987 it was found that the DEA identified efficient ("best practice") banks were in fact financial "bad practice" banks. DEA efficient banks were less profitable in all dimensions than the identified inefficient banks. Loans to foreign borrowers had become such a pervasive output that they became identified as a positive, necessary component of input/output efficiency. By 1992, DEA identified "best practice" banks were financial "good practice" banks as well. DEA efficient banks were then more profitable in all dimensions than the identified inefficient banks.

INTRODUCTION

Since 1980, U.S. banks have been subjected to various events that have significantly changed the nature of the industry and its competitive environment. *Legislative* and *regulatory* changes have eased regulation and intensified the degree and scope of competition among banks and between banks and nonbank financial institutions. A major example is The Depository Institutions Deregulation and Monetary Control Act of 1980. *Institutional* changes, primarily in the growth of substitutes for banking services, have placed additional competitive burdens on banks. One such an example is direct corporate borrowing from the commercial paper market. Increased *globalization* of commerce and financial markets has provided greater opportunities for banks, but at the cost of a more competitive and risky environment. The tremendous increase in loans to less-developed countries (LDCs) during the 1970s and early 1980s proved to be costly examples of this risk.

In addition, Park (1994) identified corollary macro- as well as local/regional *economic* events that frequently had unfortunate consequences for banks, especially those with marginal management, small capital and deteriorating earnings and asset quality. These events included a worldwide recession and collapse of the domestic real estate market.

Park also found that *bank management* contributed to increased bank risk during the 1980s. As bank earnings declined, some managers adopted risky strategies with high variance outcomes.[1] These actions, especially in banks that lacked cost controls and made poor investment decisions, had adverse results that contributed to the large degree of inefficiency attributed to the banking industry.

The importance of *management* to bank success is also detailed in Graham and Horner's (1988) Comptroller of the Currency study. Their study of failed, rehabilitated, and sound banks focused on the relative importance of *economic conditions* and *internal management*. They found that internal factors greatly influenced the degree to which adverse external conditions harmed banks. The ultimate determinants of a bank's success or failure were found to be its management and its board of directors. Management shortcomings and inadequate board supervision were the critical causes of bank failure. These weaknesses resulted in poor asset quality and eventual erosion of bank capital. On the other hand, banks that remained healthy had strong, established internal policies, systems and controls that ameliorated the impact of depressed economic conditions.[2]

They found that the shortcomings of failed banks included several relevant to the measurement of finan-

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cial efficiency, such as: (1) overly liberal loan policies and practices; (2) inadequate credit standards and control of problem loans; (3) excessive emphasis on asset/loan growth; (4) inadequate asset/liability management; (5) inadequate knowledge of risk/return issues in a competitive environment; (6) excessive use of large, volatile deposits; (7) inadequate liquid assets; and (8) inadequate bank capital.

The Economist (1990) summarized the net financial implications of the events described above for major banks in 1987. The importance of "efficiency" in bank performance was also noted:

> The decade [1980s] that ... just passed did not add up to the best of times for America's commercial banks. *Efficiency* (emphasis added) and profitability, not size, became the holy grail; but for many banks it remained elusive. Annual net income ... was barely higher at the end of the 1980s than it was at the beginning ... Return on equity ... fell from ... 1980 to ... 1988 ..., having hit a horrible low of 2% in 1987.

Much of what made 1987 a terrible year for large U.S. banks was the belated acknowledgment on their financial statements of the increasingly severe problems from their loans to LDCs, especially in Latin America. This resulted in huge increases in provisions for loan losses, which, of course, played a major role in the poor financial performance noted above.

The fact that "efficiency ... remained elusive" during the 1980s must certainly have had important implications for bank profitability performance. It is this question of bank efficiency, and its implications and trend that motivated this study.[3] Operationally, the *purposes* of this paper are: (1) to determine the relative financial efficiency of large U.S. banks in each of the years 1987 and 1992; (2) to summarize, assess, and compare the financial input/output characteristics of the identified "inefficient" banks in each year and across years; and (3) to determine, assess, and compare the financial performance of the identified "efficient" and "inefficient" banks in each year and across years.

As discussed below, this notion of "financial efficiency" adapts input/output measures derived from production theory for use in a data envelopment model to identify "efficient" and "inefficient" U.S. banks.

BANK EFFICIENCY

As reviewed in Evanoff and Israilevich (1991), previous studies of production efficiency in the firm have identified input and output inefficiency, each of which has two subclasses.[4] While the empirical model used in this study does not directly decompose inefficiency in the same way, these inefficiency constructs are important nonetheless. In some cases this study's empirical findings may be related, by deduction, to these earlier constructs.

The first basic type of inefficiency is *output inefficiency*, which includes two suboptimal uses of outputs with respect to achieving the lowest per unit cost of production. *Scale* inefficiency exists where changes in output levels generate either increasing or decreasing—rather than proportional (constant)—returns to scale. Management may not be able to correct this inefficiency unless market demand is sufficient over the relevant range of output. *Scope* inefficiency exists where the cost savings offered by jointness in overall or product specific production are not realized. This occurs if one service is produced where jointly producing two or more services would lower per unit costs for each. Management may not be able to correct this inefficiency if the joint production of particular services is constrained by regulation.

The second basic type of inefficiency is *input inefficiency*, which includes two suboptimal uses of inputs. *Allocative* inefficiency reflects suboptimal proportions of factor inputs. Management cannot correct this inefficiency to the extent that it is due to regulation, such as the need to substitute service for interest payments on demand deposits. *Pure technical* inefficiency reflects excess input levels for a given level of output. This inefficiency may be sustainable if competitive forces are weak, which is increasingly less the case. This inefficiency is unique in that it is caused by and correctable by management.

Evanoff and Israilevich (1991) also reported that pure technical inefficiency is the largest source of inefficiency, representing some 20-30% of costs. This inefficiency is larger than those due to regulatory constraints and other inefficiencies, including technology. Scale inefficiencies are estimated at 10-20% of costs, while allocative inefficiencies represent only some 5% of costs. In sum, while bank management cannot correct all sources of inefficiency, there is still much they can do to reduce aspects of it.

Thus, in today's competitive markets it is important to understand how the efficiency of large U.S. banks was affected in 1987 from the various events discussed above, and how it trended from then to the present time (1992). It is doubtlessly important for banks to understand and improve their financial efficiency if they are to be effective competitors in the world market for banking services.

INPUT/OUTPUT VARIABLES

Criteria adapted from Hancock's (1986) methodology for defining "user costs" were used to classify financial variables as inputs or outputs. These criteria provided guidance to selection of the financial variables and to their classification as either inputs or outputs. This was an important contribution because, as reported earlier by Clark (1984), there has been a lack of consensus in the literature concerning how to define financial inputs/outputs.

Hancock utilized conventional cost function variables such as "labor," "materials" and "real physical capital," as reflected on bank financial statements. It is noted that financial firms hold inventories of financial assets, liabilities, and capital during each discrete time period. The "user cost" of each financial variable is defined as the net price of holding one dollar unit per period. User costs are derived using intertemporal production models. *Negative* user costs (positive "returns") identify *output* variables, and *positive* user costs (negative "returns") identify *input* variables.

The expected normative sign for a variable's user cost was used in the current study to classify financial variables as inputs or outputs. The input/output variables so selected are defined from their call report origins and presented in Appendix A. Thus, these input/output variables reflect bank specific versions of conventional cost variables. Appendix A also presents performance variables used to characterize the banks identified as "efficient" or "inefficient."

The input/output variables selected are consistent with the "intermediation" approach to defining the bank production process. As reviewed in Mester (1987), the bank production process involves the borrowing of funds and their subsequent lending—"financial intermediation." Bank outputs are measured by the dollar value of the various earning assets, while borrowed funds, capital and labor are considered inputs in the production of assets. As noted in Ferrier and Lovell (1990), this approach (as contrasted to the alternative "production" method), focuses on the overall bank "costs" for purposes of analyzing their economic viability. This approach is most consistent with the motivation for this study (discussed above).

METHODOLOGY AND MODEL USED

Data Envelopment Analysis (DEA) was selected to test the efficiency of the sample banks. DEA has previously been used primarily to analyze the relative efficiency of public sector organizations, such as schools, hospitals, prisons and military operations, but more recently it has been applied to questions of efficiency in banking.[5]

The theory, development and applications of DEA, as well as its strengths and weaknesses, have been detailed elsewhere and are beyond the empirical scope of this paper.[6] Nonetheless, some review of this technique facilitates a clearer understanding and interpretation of the results obtained here.

In a pioneering paper, Farrell (1957) demonstrated that overall unit efficiency can decomposed into "allocative efficiency" and "technical efficiency." According to Elysiani and Mehdian (1990), conventional production functions are appropriate for measuring economies of scale and scope, but not for measuring Farrell-type "efficiency" because, as noted below, they generate "average" rather than "frontier" production functions. These functions confound the effects of scale economies and Farrell efficiency. Further, conventional production functions measure efficiency parametrically (stochastic or deterministic), where the form of the production function is assumed known or is estimated. The advantages are that hypotheses can be tested with statistical rigor and that inputs/outputs follow known functional forms.

However, there are cases, such as in service organizations, where the form of the production function is not known or perhaps where it is not even appropriate to think in terms of a production function. In these cases, it may be appropriate to use DEA because it is a flexible, nonparametric technique that makes no assumptions about the form of the production function. Instead, it estimates an empirical "best practice production frontier" from the observed inputs/outputs of individual units. This frontier replicates behavior of individual units rather than that of the average sample estimate of conventional production functions. The DEA "best practice frontier" is necessarily piecewise linear and approximates the "true" production function. DEA is so-named because it is the data from the best practice banks that comprise the production frontier and thereby "envelop" the data from the remaining sample banks.

Farrell's (1957) approach was generalized by Charnes, Cooper and Rhodes (1978, 1979, 1981) to multiple outputs and reformulated as a mathematical programming problem, thus leading to the efficiency measurement technique known as "DEA."[7] Their work had roots both in economics and engineering because they desired to distinguish inefficiencies due to production technology from those due to *managerial decision making*. Charnes, et al. (1978) introduced an empirically determined "best practice" production frontier based on the multiple input/output data of individual (not aggregated) "decision making units" (DMUs), such as an individual banking entity.

DEA may be described as a mathematical programming approach to the analysis of observational data that generates empirically defined efficient production frontiers. A DMU is "efficient" when comparisons with other units indicate no inefficiency in the utilization of inputs/outputs, as measured by its position relative to the efficient production frontier. More precisely, DEA is an extended nonlinear formulation of an ordinary fractional programming problem, in which equivalences are made to ordinary linear programming models for computations. Since its origins, the term DEA now represents various models that actually encompass several alternative approaches to measuring efficiency.[8]

The DEA analysis was performed using the Integrated Data Envelopment System (IDEAS), which includes several variations of the basic DEA model.[9] Each of these optional models has an implicit evaluation system that identifies which of n decision-making units

(DMUs), in this case banks, determine an envelopment surface ("efficient frontier") when considering *m* inputs and *s* outputs. The DMUs that lie on this surface are deemed "efficient," and those that do not are "inefficient."

The IDEAS model selected for application in this study may be characterized as: (1) specifying variable returns to scale (VRS), rather than constant returns to scale (CRS); (2) nonoriented, rather than input or output oriented; and (3) units invariant, rather than "standard." The discussion of these choices follows.

A *VRS* envelopment surface was selected because each sample bank has total assets consistent with Shaffer and David's (1991) findings of increasing returns to scale for banks of this size (discussed below).[10]

A *nonoriented* ("base") model was selected rather than an oriented model, where either input or output variables are given priority.[11] With input oriented models, the proportional movement from the observed point to the envelopment surface is first achieved in input space, thereby seeking a projected point that first maximizes proportional input reduction. With output oriented models, the proportional movement to the envelopment surface is first achieved in output space, thereby seeking a projected point that first maximizes proportional output augmentation.

On the other hand, the nonoriented model has an overall focus, in which neither input excess nor output slack is given priority. This model captures inefficiency entirely, but does not describe it only in terms of proportional changes in inputs/outputs. This overall focus is appropriate for complex systems like banks, where efficiency is affected by interactive and simultaneous input/output decisions.

In an *units-invariant* model, unlike the "standard" model, the marginal values of inputs/outputs are not constrained to be equal.[12] It assumes that the marginal values of nonzero output slack and excess input variables differ, where the value of each output slack or input excess is measured with respect to its level. This model distinguishes the relative value of inputs/outputs for each DMU, as well as across DMUs.

It is for these reasons that the units-invariant model is appropriate for banks. Each bank is to some extent unique, which impacts the way its inputs/outputs are managed. Differences in input/output management reflects such factors as its technology base, managerial competence and decision choices, labor force, organizational structure, competition, services provided, customer demand, etc.

The *distance* measure *delta* was used as the defining criterion for determining whether a bank was "efficient" or "inefficient." In the nonoriented model, delta is the measure that is "optimized" to minimize total input/output "waste" for each bank. Delta represents the weighted aggregation of the differences between observed and projected input/output points on the envelopment surface. If the delta measure is zero, the bank is deemed "efficient," and its observed and projected points are the same. If the delta measure is greater than zero, the bank is "inefficient," and its observed and projected points differ.

The delta total discrepancy between observed and projected input/output points can be due to the need for proportional input reduction, proportional output augmentation, residual nonproportional input reduction, and residual nonproportional output augmentation. Of this discrepancy, the *theta* score indicates the portion that can be eliminated by proportional input reduction, and the *phi* score reveals that which can be eliminated by proportional output augmentation. If the theta and/or phi scores equal one for a given inefficient bank, then the discrepancies in input and/or output efficiency are due solely to residual, nonproportional factors. This would indicate that this bank could not have become input and/or output efficient simply by making proportional changes in these variables. These issues are treated further in the discussion of the results.

SAMPLE CONSTRUCTION

The data for the study are from the Federal Reserve's (1987, 1992) *Report of Condition and Income for Commercial Banks,* specifically the Federal Financial Institutions Examination Council (FFIEC) Form 031 reports of condition as of December 31, 1987 and 1992, and the reports of income for these years. Form 031 is required of all banks that the Federal Reserve has *approved* to operate both foreign and domestic offices.

The banks preliminarily selected for this study were required to have at least a minimum level of foreign activity. To ensure this, each bank selected satisfied the following criteria: (1) domestic office assets less than or equal to 90% of total assets, (2) foreign office loans equal to or greater than 10% of total loans, and/or (3) foreign office deposits greater than or equal to 10% of total deposits. This screen identified a 1987 preliminary sample of 62 banks from a universe of 256; it also produced a 1992 preliminary sample of 53 banks from a field of 218.

The banks in these preliminary samples ranged in total asset size from $45.8 million to $163.8 billion. The sample banks are much larger than those generally used to estimate the size range at which economies of scale are exhausted. Fortunately, Shaffer and David (1991) estimated cost functions for the 100 largest banks. They found the efficient scale for these very large banks to be well into the multibillion-dollar range of total assets, rather than the typical estimate for small banks of somewhere below $100 million in total assets.

Shaffer and David used hedonic cost functions to allow adjustment for the fact that banks differ from one another in a variety of ways, especially among the very large, more complex banking organizations. They augmented the scale variable with "hedonic' variables that reflect qualitative differences among banks. These hedonic variables represented: (1) funding/strategy/deposit mix/average deposit size, (2) off balance sheet activities, (3) asset quality, (4) regulatory environment, and (5) target clientele/asset mix/average loan size. The hedonic terms were estimated individually as well as all simultaneously. Individual and total estimates of these terms found that scale economies persisted out to total-asset sizes ranging from $19.4 billion to $37.2 billion.

The ratio of commercial and industrial (business) loans to total loans, representing the target clientele, etc., was found to have the largest positive impact on scale economies. It was the use of this ratio that extended variable returns to scale to maximum total assets of $37.2 billion. This business loan variable most closely corresponds to the input/output variables used in the DEA analysis, where both foreign and domestic loans are included as output variables.

Thus, it is assumed that variable returns to scale exist to total assets of $37.2 billion. As a result, six to eight banks in each preliminary sample were omitted from the analysis because they were larger than this amount. The *final* 1987 sample thus contains 54 banks, and the 1992 sample includes 47 banks.

The year 1987 was selected for study because, as discussed above, this was the first year in which the unfolding "bad" loans to Latin America began to be acknowledged on bank financial statements for the serious problem they were. The year 1992 was selected as the latest year with available data when the study began. It thus serves as the "current situation" for purposes of making individual year and comparative aggregate analyses of bank efficiency and performance.

RESULTS

The DEA analysis of the 1987 sample of 54 banks identified 17 (31.5%) inefficient banks. Twelve (25.5%) inefficient banks were identified in the 1992 sample of 47 banks. These results are reasonable empirically, given that Berger and Humphrey (1990) found some 25% of insured banks to be inefficient. The inefficient banks in each year of the current study are listed in Table 1.

The means of the delta measures of DEA efficiency for the 1987 and 1992 inefficient banks were found to be 5.06 (less two outliers) and 8.13 (less two outliers), respectively. As discussed above, it was also found that the percentage of inefficient banks declined from 31.5% in 1987 to 25.5% in 1992. This was a positive signal. Further, the theta and phi scores were both found equal to one, which indicated no potential gains in efficiency could have come from proportional input reduction and proportional output augmentation, respectively. To increase efficiency, changes should have been made in specific input/output levels.

A frequency distribution (Table 2) of the 1987 *excess input* variable observations reveals 49 such observations, representing only 18.1% of the 270 sample input observations. Of these 49 observations, over 85% represent inefficiencies measured in terms of excessive cash, labor expenses, and real capital. Thus, the 1987 inefficient banks should have more closely monitored and controlled the amounts devoted to these variables as a means of increasing relative efficiency.

A distribution of the *deficit output* variable observations (also Table 2) reveals 30 such observations, representing only 13.9% of the 216 sample output observations. Of these observations, 80.0% represent inefficiencies measured in terms of loans to foreign borrowers and noninterest-bearing deposits. Thus, in the "bad banking" year of 1987, the DEA "best practice" model indicated that inefficient banks should have increased their foreign loans to increase their relative efficiency. This apparent contradiction is discussed further and explained below.

It was also found that 62.0% of the inefficient variable observations represent excess inputs, while the remaining 38.0% represent deficit outputs (Table 2). Thus, it appears that the majority of inefficient observations (the inputs) were related to pure technical inefficiency, rather than scope and scale inefficiency (the outputs). As reviewed above by Evanoff and Israilevich (1991), pure technical inefficiency is the largest source of inefficiency, but it is nonetheless correctable by management.

A frequency distribution (Table 3) of the 1992 *excess input* variable observations reveals 37 such observations, representing only 15.7% of the 235 sample input observations. Of these 37 observations, over 78% represent inefficiencies measured in terms of excessive cash, real capital, and materials expense. Thus, the 1992 inefficient banks should have more closely monitored and controlled the amounts devoted to these variables as a means of increasing relative efficiency.

A distribution of the *deficit output* variable observations (also Table 3) reveals 23 such observations, representing only 12.2% of the 188 sample output observations. Of these 23 observations, nearly 70% represent inefficiencies measured in terms of loans to foreign borrowers and total investments. Thus, in 1992, the "best practice" DEA model indicated that inefficient banks should have increased their foreign loans to increase relative efficiency. This was the same as the 1987 finding, but 1992 appeared to be a more "normal" year (discussed further below).

It was also found that 67.1% of the inefficient variable observations represent excess inputs, while the remaining 32.9% represent deficit output (Table 3). As in 1987, the majority of inefficient observations (the inputs) appear related to pure technical inefficiency.

Tables 2 and 3 indicate some input/output similarities for inefficient banks in both years. Cash and real capital are ranked among the three most frequently observed excess *input* variables in both years. Overall, cash ranked as the most frequently observed excess input variable. An encouraging sign was the significant decline in rank (from first to fourth) of labor expense as an observed excess input variable over the period. On the other side, loans to foreign borrowers ranked first by far as the most frequently observed deficit *output* variable in both years. As discussed below, this rank had very different financial implications.

In addition to these findings, the percentage of observed inefficient *input* variables was very similar in both years (18.1% and 15.7%). Further, the percentage of observed inefficient *output* variables was even more similar in both years (13.9% and 12.2%). Finally, the percentages of inefficient *input* variable observations to total inefficient input/output variable observations were almost identical in both years (62.0% and 61.7%). Thus, these findings indicated general stability in the proportions of inefficient input/output variable observations over this period.

Next, the profitability performance of efficient and inefficient banks in 1987 and 1992 (Table 4) is reviewed and assessed. These findings added to the apparent contradiction in the 1987 DEA findings that inefficient banks should have increased their foreign loans, given the huge losses on bank loans to LDCs.

In 1987, *inefficient* had higher "returns" (i.e., accounting profitability) than efficient banks on all measures: consolidated net income to consolidated total assets, consolidated net income to total equity capital, foreign net income to consolidated total assets, foreign net income to foreign total assets, domestic net income to consolidated total assets, and domestic net income to domestic total assets. Their returns on overall and domestic activities were positive, but they were negative on foreign activities.

On the other hand, *efficient* banks had positive returns on domestic activities, but negative returns on overall and foreign activities. Thus, while DEA efficient banks had a positive focus on foreign loans, their returns on foreign activities were negative. Further, the returns on the 1987 foreign activities of both efficient and inefficient banks were negative, although less so for inefficient banks. These negative returns on foreign activities are expected given the events of 1987. However, the higher returns of inefficient banks on foreign activities appears to contradict the positive focus on foreign loans of DEA identified efficient banks.

The 1992 profitability performance of efficient and inefficient banks suggested a return to more "normal" times. *Efficient* banks had higher returns on all measures than inefficient banks. Further, all of the returns were positive, and those on foreign activities were higher than on domestic activities.

On the other hand, *inefficient* banks had negative returns on their overall and domestic activities, but positive returns on foreign activities. Thus, both efficient and inefficient banks had positive returns on foreign activities, although they were higher for efficient banks. The fact that efficient banks had higher returns than inefficient banks on all measures was a complete reversal from 1987.

The reason for this apparent contradiction in the positive focus on foreign loans in the 1987 DEA identified inefficient banks, given the LDC "loan crisis" and the higher returns of identified inefficient banks, lies in the methodology. As discussed above, DEA estimates an empirical "best practice" production frontier from the *observed* inputs/outputs of individual DMUs, i.e., banks. Based on this empirical determination, the inputs/outputs of efficient banks lie on this frontier, which "envelops" the inputs/outputs of inefficient banks.

In 1987, these large banks began to "pay" for their large involvement in loans to LDCs. Nonetheless, because of their large, widespread use (something akin to a "herd" instinct), the empirically-based DEA recognized this overriding focus as "best practice." This is clearly seen because all inefficient banks were identified as deficient in foreign loan outputs. Nonetheless, they were consistently more profitable than identified efficient banks, including foreign activities. Thus, the 1987 DEA identified "best practice" banks were also financial "bad practice" banks.

In 1992, banking appeared to be more "normal" in that DEA identified "best practice" banks were also financial "good practice" banks. Identified efficient banks were consistently more profitable than identified inefficient banks, including foreign activities. Interestingly, inefficient banks were again identified as deficient in foreign loan outputs. Thus, the findings indicated that the LDC "loan crisis" was over and foreign loans were again profitable.

CONCLUSIONS

To conclude this study of the DEA input/output efficiency of large U.S. banks, it was found that the 1987 banks identified as efficient ("best practice") banks were in fact "bad practice" banks in terms of financial performance. It appears that something akin to a "herd instinct" led banks to make excessive loans to LDCs, especially in Latin America. These foreign loans became so pervasive that DEA identified them as a positive, necessary focus of bank efficiency. As a result, inefficient banks were identified as deficient in foreign loan outputs. However, their foreign activities were more profitable (actually less unprofitable) than efficient banks. Further, inefficient banks were more profitable than efficient banks in all measures, overall, foreign and domestic.

By 1992, the LDC loan crisis had passed and DEA identified "best practice" banks were also financial "good practice" banks. Banking appeared to be more rational and "normal" than in 1987. Identified efficient banks were more profitable in all measures (overall, foreign and domestic) than inefficient banks. And, again, inefficient banks were identified as deficient in foreign loan outputs, but in this case their foreign activities were profitable.

ENDNOTES

[1] The adoption of these strategies could have been due to errors in management judgment and/or incentives for increased risk-taking motivated by shareholder limited liability and deposit insurance. In other cases, managers faced with increased competition and deteriorating earnings took additional risks in hope fortuitous events would improve earnings and save their jobs.

[2] Banks with boards of directors and management that were deficient in knowledge, information or attentiveness were typically characterized as having inadequate: (1) loan policies; (2) controls over staff; (3) systems of problem loan identification: (4) control over decisions of a dominant person; (5) asset/liability management policies; (6) understanding of risk/return issues in a deregulated environment; and (7) policies, systems and controls to guide decision making. Banks with boards and management that were overly aggressive or growth-minded were found to have: (1) too liberal lending policies and practices with respect to repayment terms, collections or credit standards; (2) excessive loan growth relative to management and financial resources; (3) excessive reliance on large, volatile CDS; and (4) inadequate liquid assets. Banks that lacked strong CEOs with experience, capability and integrity were found to have: (1) excessive exceptions from appropriate credit standards with respect to financial information, collateral documentation, overlending, collateral-based lending, cash flow analysis, and concentration of credit; and (2) incidences of insider abuse and fraud.

[3] Net loan and lease charge-offs losses increased each year beginning in 1979 for *all* insured commercial banks. The 1991 net charge-offs were nearly thirteen times those in 1979. Thus, the 1980s were challenging years for banks in general.

[4] For reviews of the literature on bank costs and outputs, see Clark (1984), Mester (1987), and Gilbert (1984).

[5] Selections from applications of DEA to banking include, Aly, Grabowski, Pasurka and Rangan (1990); Elyasiani and Mehdian (1990); Evanhoff and Israilevich (1991); Charnes, Cooper, Huang and Sun (1990); Parkan (1987); Rangan, Grabowski, Aly and Pasurka (1988); Sherman and Gold (1985); Yue (1992); and Ferrier and Lovell (1990). Mester (1987) discusses its disadvantages in this regard.

[6] See Ganley and Cubbin (1992) for an extensive DEA bibliography and thorough introduction, including the mathematics, detailed applications with interpretation of results, and appraisals of the technique. Also, see Norman and Stoker (1991) for a thorough treatment and application of DEA, and Seiford and Thrall (1990) for developments in DEA. Further, see Charnes, Cooper, Lewin and Seiford (1994) for an extensive bibliography and treatment of DEA, as well as the treatment of DEA and its applications in Lovell and Schmidt, eds. (1993).

[7] These models were developed further in such papers as Charnes, Cooper and Schinnar (1982); Fare, Grosskopf and Lovell (1983, 1985); Banker (1984); Banker, Charnes and Cooper (1984); and Banker and Thrall (1989).

[8] The use of DEA should not be interpreted to imply that it is without shortcomings. As discussed in Ganley and Cubbin (1992), and elsewhere, these include: (1) no allowance for noise in the data; (2) no inclusion of variable selection criteria; (3) limited to static, one-period evaluation (panel data provide continuum of static results); and (4) unit efficiency scores follow an upward trend as the number of variables increase.

[9] The technical discussion in IDEAS is supplemented in Scheraga (1995), which includes related references to working papers by A. Ali and by Ali and others. These ideas are also treated usefully in Ali and Seiford (1993) and Lovell (1993).

[10] The VRS model was first presented in Charnes, Cooper, Golany, Seiford and Stutz (1985).

[11] Nonoriented and oriented models are discussed in Ali and Seiford (1993).

[12] The units-invariant model derives from the extended additive model in Charnes, Cooper, Rousseau and Semple (1987).

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APPENDIX A
Variable Definitions

A. Input Variables

Cash

This item is RCFD 0010 ("Cash and balances due from depository institutions").

Labor Expense

This item is RIAD 4135 ("Salaries and employee benefits").

Real Capital

This item is the total of RCFD 2145 ("Premises and fixed assets (including capitalized leases)") and RCFD 2150 ("Other real estate owned").

Materials Expense

This item is RIAD 4092 ("Other noninterest expense").

Total Borrowed Funds

This item is the total of RCFD 6636 ("Deposits - interest-bearing"), RCFD 2800 ("Federal funds purchased and securities under agreements to repurchase in domestic offices of the bank"), RCFD 2850 ("Other borrowed money"), RCFD 2910 ("Mortgage indebtedness and obligations under capitalized leases"), RCFD 3200 ("Notes and debentures subordinated to deposits"), and RCON 2840 ("Demand notes issued to the U.S. Treasury").

B. Output Variables

Loans to Foreign Borrowers

This item is the total of RCFD 1516 ("Loans to other banks in foreign countries"), RCFD 1764 ("Commercial and industrial loans to non-U.S. addressees"), RCFD 1757 ("Acceptances of foreign banks"), RCFD 2081 ("Loans to foreign governments and official institutions"), and RCFD 2183 ("Lease financing receivables (net of unearned income) of non-U.S. addressees").

Loans to Domestic Borrowers

This item is RCFD 2122 ("Total loans and leases, net of unearned income") less "Loans to Foreign Borrowers" (defined immediately above).

Total Investments

This item is the total of RCFD 0390 ("Total investment securities"), RCFD 2146 ("Assets held in trading accounts"), RCFD 1350 ("Federal funds sold & securities purchased under agreements to resell") and RCFD 2130 ("Investments in unconsolidated subsidiaries and associated companies").

Noninterest-bearing Deposits

This item is RCFD 6631 ("Deposits - noninterest bearing").

C. Performance Variables

Return on assets for the consolidated bank (NI_C/TA_C)

NI_C (RIAD 4340, "Net income") is divided by TA_C (RCFD 2170, "Total assets")

Return on capital for the consolidated bank (NI_C/TEC_C)

NI_C (RIAD 4340, "Net income") is divided by TEC_C (RCFD 3210, "Total equity capital")

Total equity capital ratio for the consolidated bank (TEC_C/TA_C)

TEC_C (RCFD 3210, "Total equity capital") is divided by TA_C (RCFD 2170, "Total assets")

Mean and standard deviation for TA_C (RCFD 2170, "Total assets")

Return on total assets for foreign operations (NI_F/TA_C)

NI_F (RIAD 4341, "Net income attributable to international business") is divided by TA_C (RCFD 2170, "Total assets")

Return on total assets for domestic operations (NI_D/TA_C)

NI_C (RIAD 4340, "Net income") less NI_F (RIAD 4341 ("Net income attributable to international business") is divided by TA_C (RCFD 2170, "Total assets")

Return on foreign assets for foreign operations (NI_F/TA_F)

NI_F (RIAD 4341 ("Net income attributable to international business") is divided by TA_F (RCFN 2170, "Total assets" for foreign offices)

Return on domestic assets for domestic operations (NI_D/TA_D)

NI_C (RIAD 4340, "Net income") less NI_F (RIAD 4341 ("Net income attributable to international business") is divided by TA_D (RCON 2170, "Total assets" for domestic offices)

Table 1
Inefficient Banks: 1987 and 1992 Samples

1987 (n=17)

Bank Leumi Trust Company of New York
Industrial Bank of Japan Trust Company
Israel Discount Bank of New York
Sumitomo Bank of California
Bank Audi USA
Chinese American Bank
Union Chelsea National Bank
Fidelity Bank NA
American Security Bank NA
Riggs National Bank of Washington
Northern Trust Bank of Florida NA
Pacific National Bank
Manufacturers National Bank
Old Kent Bank & Trust Company
California Commerce Bank
Bank of Hawaii
Rainier National Bank

1992 (n=12)

Bank Leumi Trust Company of New York
Sanwa Bank of California
Boston Safe Deposit & Trust Company
UMB Bank & Trust Company
LBS Bank, New York
Northern Trust Company
Bankers Trust, Delaware
Bank Audi USA
Chinese American Bank
Century Bank
Riggs National Bank of Washington
Banco Central Hispano-USA

Table 2
Analysis of Inefficient Input/Output Variable Observations
Seventeen Inefficient Banks, 1987
(31.5% of Total Sample, n=54)

Excess Input Variable Observations

	n	%
Cash*	14	28.6
Labor Expense*	15	30.6
Real Capital*	13	26.5
Materials Expense	5	10.2
Total Borrowed Funds	2	4.1
Total	49	100.0

Deficit Output Variable Observations

	n	%
Loans to Foreign Borrowers**	16	53.3
Loans to Domestic Borrowers	2	6.7
Total Investments	4	13.3
Noninterest-bearing Deposits**	8	26.7
Total	30	100.0

Input Variable Observations: Efficient vs. Inefficient

	n	%
Efficient	221	81.9
Inefficient	49	18.1
Total (54x5)	270	100.0

Output Variable Observation: Efficient vs. Inefficient

	n	%
Efficient	186	86.1
Inefficient	30	13.9
Total (54x4)	216	100.0

Inefficient Variable Observations: Input vs. Output

	n	%
Input	49	62.0
Output	30	38.0
Total	79	100.0

Notes:

* Sum to 85.7% of the number of excess *input* observations
** Sum to 80.0% of the number of deficit *output* observations

Table 3
Analysis of Inefficient Input/Output Variable Observations
Twelve Inefficient Banks, 1992
(25.5% of Total Sample, n=47)

Excess Input Variable Observations

	n	%
Cash*	11	29.7
Labor Expense	6	16.2
Real Capital*	10	27.0
Materials Expense*	8	21.6
Total Borrowed Funds	2	5.4
Total	37	100.0

Deficit Output Variable Observations

	n	%
Loans to Foreign Borrowers**	10	43.5
Loans to Domestic Borrowers	3	13.0
Total Investments	6	26.1
Noninterest-bearing Deposits**	4	17.4
Total	23	100.0

Input Variable Observations: Efficient vs. Inefficient

	n	%
Efficient	198	84.3
Inefficient	37	15.7
Total (47x5)	235	100.0

Output Variable Observations: Efficient vs. Inefficient

	n	%
Efficient	165	87.8
Inefficient	23	12.2
Total (47x4)	188	100.0

Inefficient Variable Observations: Input vs. Output

	n	%
Input	37	61.7
Output	23	38.3
Total	60	100.0

Notes:

* Sum to 78.3% of the number of excess *input* observations
** Sum to 69.6% of the number of deficit *output* observations

Table 4
Mean Variable Performance: Efficient vs. Inefficient Banks
1987 and 1992 Samples

Variable	Efficient Banks *1987 (n=37)*	Inefficient Banks *1987 (n=17)*
NI_C/TA_C	- 0.42% (L)	0.27% (H)
NI_C/TEC_C	-13.61% (L)	4.45% (H)
NI_F/TA_C	- 0.70% (L)	- 0.32% (H)
NI_D/TA_C	0.27% (L)	0.60% (H)
NI_F/TA_F	- 3.82% (L)	- 2.16% (H)
NI_D/TA_D	0.29% (L)	0.76% (H)
	1992 (n=35)	*1992 (n=12)*
NI_C/TA_C	0.51% (H)	- 0.38% (L)
NI_C/TEC_C	6.26% (H)	- 7.38% (L)
NI_F/TA_C	0.40% (H)	0.21% (L)
NI_D/TA_C	0.11% (H)	- 0.59% (L)
NI_F/TA_F	1.53% (H)	0.81% (L)
NI_D/TA_D	0.10% (H)	- 0.66% (L)

Notes:

Variables defined in Appendix A
H = highest variable value: efficient vs. inefficient banks, same year
L = lowest variable value: efficient vs. inefficient banks, same year