Thomas F. Siems
Senior Economist
Federal Reserve Bank of Dallas

Quantifying Management's Role in Bank Survival

Banking literature often cites mismanagement as the most important cause of bank failures. Pantalone and Platt (1987) state that "it is the management of the bank that determines success or failure. Most often, banks fail because they have chosen paths that are excessively risky for the returns that they receive and because these paths make them particularly vulnerable to adverse economic conditions." Seballos and Thomson (1990) recently wrote that "the ultimate determinant of whether or not a bank fails is the ability of its management to operate the institution efficiently and to evaluate and manage risk." Additionally, in a study by the Office of the Comptroller of the Currency to uncover specific reasons for bank failures, Graham and Horner (1988) concluded that "the difference between the failed banks and those that remained healthy or recovered from problems was the caliber of management."

No specific quantitative measure currently exists to assess the quality of bank management. Rather, generally bank examiners regularly visit banks and conduct on-site examinations to assess them. From these examinations, examiners give banks a *CAMEL* rating, which is an overall evaluation of a bank's health and is an acronym based on the following five factors:

> **C**apital adequacy,
> **A**sset quality,
> **M**anagement quality,
> **E**arnings ability, and
> **L**iquidity.

Examiners score each of these factors as a single number from one to five, with one being the strongest rating, and develop an overall CAMEL rating from one to five from the factor scores. The use of CAMEL factors in evaluating a bank's health has become widespread because of both its simplicity and use by regulators.

Financial data and relationships are the principal ingredients for scoring capital, asset quality, earnings, and liquidity. Assessing management quality, however, is considered qualitative and therefore requires professional judgment of a bank's compliance with policies and procedures, aptitude for risk-taking, development of strategic plans, and the degree of involvement by the bank's officers and directors in the decisionmaking process.

In this article, I present a new model to quantitatively measure bank management quality. This model considers the essential intermediation functions of a bank and uses multiple inputs and outputs to compute a scalar measure of efficiency. I compute the efficiency metric, a proxy for management quality, using a linear programming technique known as *data envelopment analysis* (DEA). DEA has been used successfully to provide a new definition of efficiency in many applications, including schools (Bessent and others 1982), courts (Lewin, Morey, and Cook 1982), strip mines (Byrnes, Färe, and Grosskopf 1984), and health care (Nunamaker 1985 and Sherman 1984).

I built the efficiency model presented in this article on the notion of using the metric as a variable in a bank-failure prediction equation. Given that we wish to differentiate banks that fail from those that survive, I include in the model variables that I believe capture the importance of

I wish to thank Robert T. Clair, Gerald P. O'Driscoll, and Kevin J. Yeats for helpful comments and suggestions. Any remaining errors are solely my responsibility.

management in a bank's survival, that is, the necessary input allocation and product mix decisions needed to acquire deposits and subsequently make loans and investments. While this metric, which is based strictly on publicly available financial information, may not replace an examiner's assessment of management completed during an on-site examination, it can assist examiners as an early warning tool.[1]

While others may disagree with my choice of input and output variables for this model, the empirical results support the argument that management quality is very important to a bank's survival.[2]

The importance of management

An institution's management quality is important to its long-term survival. Cates (1985) states, "[B]ank failure, which affects only a handful of banks, is caused by mismanagement; mismanagement, furthermore, of the basic, old-fashioned risks of banking like lending, liquidity, and control." Bank managers make the decisions and fashion the plans that define the direction for the institution. Management determines allocation of the bank's resources, establishes the internal controls and procedures, organizes strategic plans, and responds to changes in the external environment.

Because banks operate in a competitive, uncertain, changing environment, bank managers must learn to deal with and manage the inherent risks. As Kaufman (1986) states, "[T]o survive in a risky world, banking firms must cope with risk and manage it."

[1] *Siems (1991) found the management quality metric to be a highly significant variable in both one-year-ahead (twelve-month to eighteen-month) and two-year-ahead (twenty-four-month to thirty-month) bank-failure prediction models. Furthermore, the predictive accuracy of these models significantly improved with the inclusion of this variable.*

[2] *The objective is not so much the theoretical development of a model to prove efficiency but rather the construction of a measure to help distinguish banks that survive from those that fail. The model developed herein is a useful proxy for management quality because the variables focus on bank management's basic allocation, control, and product mix decisions.*

Measuring bank management quality

To proxy bank management quality, I present a model to measure the efficiency by which management can transform inputs into outputs. I built the model on the notion of using the measure to help discriminate banks that survive from those that fail. Hence, the model includes variables that are most descriptive of management's decisionmaking role in a bank's intermediation process.

Because of the multitude of functions performed and decisions made by management, a descriptive model of bank management quality must contain several inputs and outputs. Single ratios, such as total operating income divided by total operating expense, suffer from several limitations. For example, while such ratios may provide an overall measure of operational efficiency, they fail to indicate the resource allocation and product decisions made by management because the numerator and denominator are aggregate measures.

Moreover, when several nonaggregated single input–output ratios are used to assess the myriad of decisions made by management, the ratios collectively present a morass of numbers that give no clear evidence of the efficiency of a bank. One ratio may show that the bank is highly efficient, while another displays a highly inefficient operation. Sexton (1986) argues that such ambiguity makes ratio analysis ineffective in measuring true efficiency.

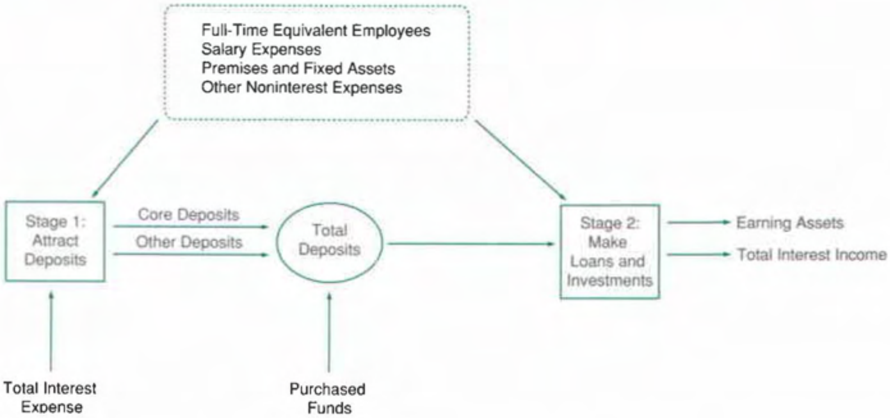
Clearly, a model that captures bank management's allocation and control decisions is needed. Such a model requires the identification of several inputs and outputs. What are the allocation and control decisions that managers make to operate a bank?

Essential functions in banking

The banking industry has changed over the years, but the functions of operating as a financial intermediary have remained basically unchanged. For the model presented herein, commercial banks are represented in a two-stage process in which they first acquire deposits and then bundle together these monies to make loans and investments.

In a manner similar to that of Berg, Forsund,

Figure 1
Commercial Bank Decisionmaking Model: Two-Stage Representation



and Jansen (1989), the model interprets deposits as intermediary outputs, which is also consistent with the view advocated by Kolari and Zardkoohi (1987). This two-stage representation aids in interpretation because deposits are produced in the first stage and used as inputs to the production of loans and investments in the second stage.

A new model to measure bank management quality

I have identified a subset of inputs (resources) and outputs (products and services) that I believe model the quality of commercial bank management from a failure-prediction perspective. That is, the model includes certain inputs and outputs that I feel are critically important to the management of a bank.[3]

Considering again the two main functions of a bank—acquiring deposits and making loans and investments—I developed a two-stage model that employs multiple inputs and outputs to assess management efficiency. As Figure 1 shows, both stages utilize four inputs that primarily represent operating expenses. These four inputs are the number of full-time equivalent employees, salary expenses, value of premises and fixed assets, and other noninterest expenses as reported on a bank's Consolidated Report of Condition and Income to its primary regulator. The operation of all bank activities involves labor, materials, machines, and buildings, and management certainly has a great deal of discretion concerning the allocation of these resources.

Management determines the number of employees needed to perform desired functions at a desired level of service. They establish salary levels, and they determine the types of facilities to build, where to build them, and how to furnish and operate them.[4] Management also decides (possibly as a result of previous decisions) what other noninterest expenses to incur, such as legal

[3] *The number of DEA efficiency models applied to banking are relatively few and recent. In general, researchers have developed models to measure either the relative efficiency of bank branches or the overall efficiency of the banking industry. Charnes and others (1990), Berg, Forsund, and Jansen (1989), Rangan and others (1988), Parkan (1987), and Sherman and Gold (1985) provide five different DEA models applied to banking. Another useful reference concerning efficiency in banking is Evanoff and Israilevich (1991), in which they discuss the concept of efficiency and define the means to measure it. Their article also includes a review of relevant literature regarding inefficiency in the banking industry.*

[4] *Some of these input factors, such as salary expenses, are largely determined by market forces; however, bank management ultimately makes decisions regarding the overall level of salaries, which can influence past-due collections, loan portfolio quality decisions, etc.*

assistance and administrative expenditures related to maintaining and liquidating foreclosed real estate and other assets.

Another input associated with acquiring deposits in stage one is total interest expense. Management establishes the types of deposits they wish to attract and the interest rate levels offered to depositors. While interest rates are largely influenced by market forces and monetary policy, management makes decisions regarding the composition of deposits, which directly influences total interest expenditures.

Purchased funds, the final input in the model, represents funds needed in addition to all other deposits to adequately service the bank's investments and provide needed liquidity.[5] High purchased funds signal that management has not attracted enough stable or core deposits for the volume of loans it is currently servicing. When this happens, the bank must buy funds and subject itself to increased liquidity risk.[6]

Humphrey (1991) argues that the user costs of demand deposits, small time and savings deposits, and purchased funds must be included as appropriate inputs along with labor and physical capital. He states that operating costs are less than one-third of total banking costs at typical banks and therefore do not give an overall picture of productivity in banking. Other models that show purchased funds as an appropriate banking input include Rangan and others (1988) and Triplett (1991).

The obvious output from the first stage of the model is total deposits. For a bank, deposits can be considered as either an input or an output. In this model, core deposits are interpreted as an intermediary output. These are relatively stable deposits obtained by the bank. Finally, the second stage has two outputs: earning assets, which include all interest-earning assets, and total interest income.

The outputs in this new model also appear to be a direct result of management's decisions. Core deposits represent stable funds desired by the organization for lending and investment purposes. Earning assets and total interest income result from management's decisions regarding where to invest funds. Management makes decisions concerning the relative riskiness of each asset in which it invests.

The most efficient banks allocate resources and control internal processes by effectively managing the number of employees, salary expenses, facilities, other noninterest expenses, total interest expenses, and purchased funds while working to maximize core deposits, earning assets, and total interest income. To do this, efficient bank managers establish controls and procedures that keep operating expenses relatively low while still attracting an adequate volume of core deposits (so that purchased funds remain low).

Prudent managers also devise loan policies that discriminate creditworthy borrowers from those in danger of default to increase the value of earning assets and operating income. By evaluating the riskiness of potential loans, management is better able to choose which loans to make. Failed banks historically exhibited more lending problems (that is, mismanagement of the loan portfolio) than other operating inefficiencies. Graham and Horner (1988) found that 86 percent of the failed banks they studied had inappropriate lending policies, including liberal repayment terms, collection practices, or credit standards.

Overall, bank managers must integrate policies and techniques for managing the money position, providing liquidity, lending profitably, and investing rationally in a practical asset/liability management framework. The most efficient banks do this by controlling operating expenses, managing interest rate sensitivity, utilizing risk management techniques, and strategically planning for the bank and its markets for the future.

Quantifying bank management quality

Data envelopment analysis computes a bank's efficiency in transforming inputs into outputs, relative to its peers. First developed by

[5] *Purchased funds include federal funds purchased and securities sold under agreements to repurchase, demand notes issued to the U.S. Treasury, other borrowed money, time certificates of deposit of $100,000 or more, and open-account time deposits of $100,000 or more.*

[6] *In addition, Gunther (1989) states that "a high reliance on purchased or wholesale funds, such as large certificates of deposit, federal funds purchased, and securities sold under agreement to repurchase, is often associated with high asset growth and aggressive lending strategies."*

Charnes, Cooper, and Rhodes (1978), who built on the concept of technical efficiency by Farrell (1957), DEA provides a new definition of efficiency. DEA is a linear programming technique that converts multiple inputs and outputs into a scalar measure of efficiency.[7] This conversion is accomplished by comparing the mix and volume of services provided and the resources used by each bank compared with all other banks. Each bank is evaluated against a hypothetical bank with an identical output mix that is constructed as a combination of efficient banks.

DEA identifies the most efficient banks in a population and provides a measure of inefficiency for all others. The most efficient banks are rated a score of one, while the less efficient institutions score between zero and one. DEA does not give a measure of optimal efficiency; it will only differentiate the least efficient banks from the set of all banks (even where all banks might be inefficient). Thus, the efficient institutions calculated using DEA establish the *best practice* frontier.

DEA was designed specifically to measure relative efficiency using multiple inputs and outputs with no *a priori* information regarding which inputs and outputs are most important in determining an efficiency score. The relative efficiency of a bank is defined as the ratio of its total weighted output to its total weighted input. Mathematically, this is represented as

$$EFFICIENCY_k = \frac{\sum_{r=1}^{s} u_{rk} OUTPUT_{rk}}{\sum_{i=1}^{m} v_{ik} INPUT_{ik}},$$

where u_{rk} is the unit weight placed on output r and v_{ik} is the unit weight placed on input i by the kth bank in a population of banks. Using this notation, there are s output variables and m input variables used to calculate efficiency.

Now, how should the weights (the u's and v's) be selected? DEA selects the weights that maximize each bank's efficiency score as long as no weight is negative and the weights are universal (that is, any bank should be able to use the same set of weights to evaluate its own efficiency ratio, and the resulting ratio must not exceed one). That is, for each bank, DEA will maximize the ratio of its own weighted output to its own weighted input. In general, banks will have higher weights on those inputs that it uses least and those outputs that it produces most.[8]

Graphical representation of DEA

In this section, I illustrate graphically a small problem. Visualizing the concepts underlying DEA will assist with its interpretation for larger and more complex problems.

Consider five banks, each using one input to produce two outputs. Table 1 shows the levels of the input required to produce the outputs for each bank. Single input–output analyses can be used to characterize each bank using the single input ($INPUT_1$) and the two outputs ($OUTPUT_1$ and $OUTPUT_2$).[9] In fact, by normalizing each output relative to the level of input required to produce it, each bank can be graphically represented in a two-dimensional space, as Figure 2 shows. In this figure, each bank is represented by a point whose coordinates are simply the normalized output levels shown in Table 1.

Any bank located both above and to the right of another bank is clearly more efficient, because it is producing higher levels of both

[7] See Seiford (1990) for an extensive bibliography of DEA-related publications.

[8] The DEA model for a specific bank can be formulated as a linear fractional problem, which can be easily solved if it is transformed into an equivalent linear program in which the bank's input and output weights are the decision variables. A complete DEA solution requires that one such linear program be solved for each bank. See Barr and Siems (1991a) for technical details regarding the mathematical formulation of DEA.

[9] While ratios can provide useful information about efficiency, they fail to accommodate multiple inputs and outputs when accurate objective weights for the inputs and outputs are not known. In this example, if $OUTPUT_2/INPUT_1$ was the only ratio used to measure efficiency, bank A would be rated as the least efficient and bank C as the most efficient. If management decided to measure efficiency by using a weight of 0.8 for $OUTPUT_1/INPUT_1$ and 0.2 for $OUTPUT_2/INPUT_1$, then bank A would be rated as the most efficient and bank C as the second least efficient. Clearly, with more inputs and outputs the task of measuring efficiency in this manner becomes even more complex and subjective.

Table 1
Sample Data for DEA Example

Bank	$INPUT_1$	$OUTPUT_1$	$OUTPUT_2$	$OUTPUT_1/INPUT_1$	$OUTPUT_2/INPUT_1$
A	5	25	10	5	2
B	6	24	24	4	4
C	8	16	40	2	5
D	4	16	12	4	3
E	7	7	21	1	3

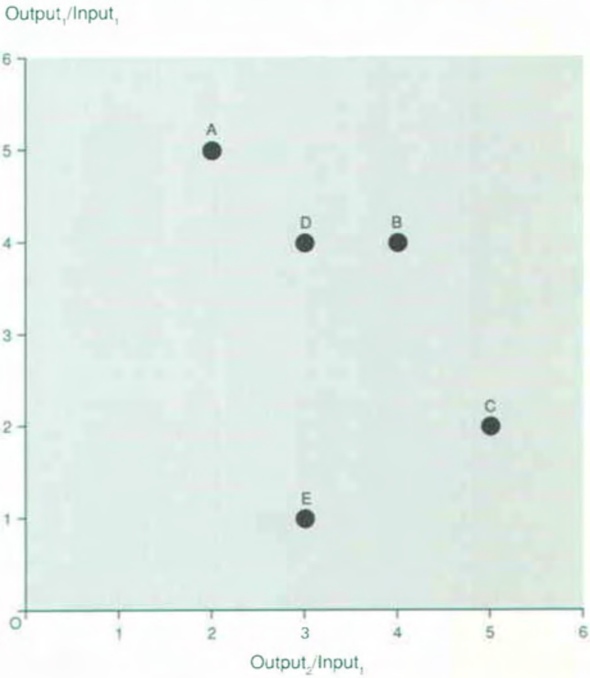
outputs while using the same level of input. Figure 3 shows that banks A, B, and C define the efficient frontier (represented by the thick, black line) as a piecewise linear curve. These banks have the property that no other bank is superior on both dimensions.

Every bank is in one of three places: on the efficient frontier, on one of the extensions from the frontier to one of the axes, or somewhere between the origin and the frontier. A bank on an extension is called a *weakly efficient* bank. That is, the bank will have an efficiency score of one, but it is not technically on the efficient frontier because another bank is superior on at least one dimension. Banks that are inside the piecewise linear curve that forms the efficient frontier (including the extensions) are *enveloped*; hence this analytical technique is called *data envelopment analysis*.

Each bank gets an efficiency score in terms of its position relative to the frontier.[10] Banks on the frontier are the *best practice* firms, which use current technologies and methods in the banking industry most efficiently and therefore have efficiency scores of one. Each enveloped bank is compared with a hypothetical comparison bank, which is a theoretical point on the frontier having the same output mix as the bank under evaluation. The efficiency score for each enveloped bank is simply the ratio of the actual output levels from the bank to the theoretical levels of its hypothetical comparison bank.

Figure 4 shows how the efficiency scores are computed for each bank. Each bank that forms the frontier (for example, banks A, B, and C) has

Figure 2
Normalized Output Levels for Five Banks



[10] Efficiency, *as used here, refers to a bank's ability to transform a set of inputs into a set of outputs. This ability differs from models designed to measure profit maximization. A bank might be able to increase profits by changing its product mix, but this change may not necessarily make the bank more efficient given the inputs and outputs selected for this model.*

Figure 3
DEA Efficient Frontier

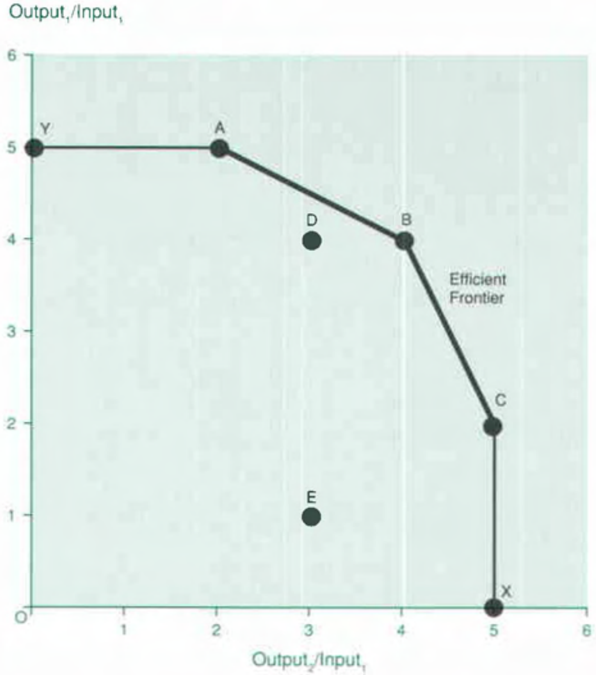
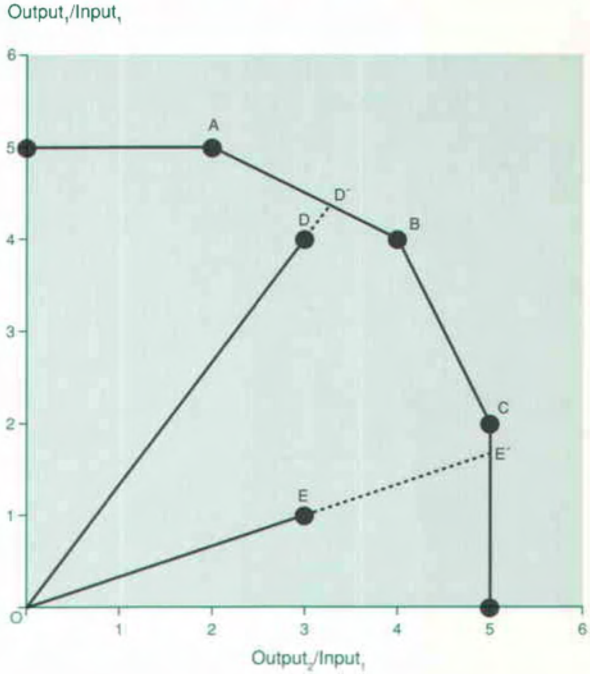


Figure 4
Efficiency Scores for Banks D and E



an efficiency score of one. The efficiency score for bank D is 0.92, a number between zero and one that is the ratio of the distance of line segment OD (5.00) to line segment OD′ (5.45).[11] Because D′ (the hypothetical comparison bank for bank D) is on line segment AB, banks A and B form the efficiency reference set for bank D. Clearly, only efficient banks can compose the efficiency reference set for an inefficient bank.

Similarly, the efficiency score for bank E is 0.60 and is computed by taking the ratio of OE to OE′. Obviously, bank E is the most inefficient of the five banks. Epstein and Henderson (1989) point out that "the concepts of data envelopment, efficient frontier, efficiency score, efficiency reference set, and hypothetical comparison unit are easily extended to higher dimensions and are thus applicable in a multiple-input, multiple-output context."

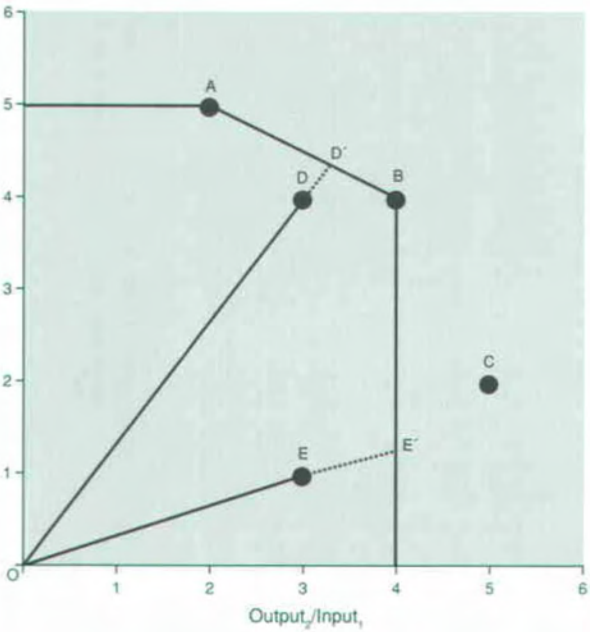
Some limitations of DEA

Several assumptions are made in evaluating banks in this manner. First, hypothetical banks, like point D′ in Figure 4, are assumed to be feasible. In other words, any point along the piecewise linear curve is assumed feasible even though there may not be a bank at that particular point on the frontier. Sexton (1986) argues that "this assumption is questionable when there are only a small number of production technologies from which to choose and where such weighted averages have no counterpart in reality." In other words, it may not be reasonable to assume that bank D could change its input or output mix to move to point D′ on the frontier. It may be easier for bank D to move toward point B, because this is a known feasible point on the frontier. The most optimal path for an inefficient institution to become efficient is an area for future research.

Second, in Figure 3 the efficient frontier was extended vertically from point C to point X and horizontally from point A to point Y. Other

[11] *See Barr and Siems (1991a) for mathematical computations to calculate individual efficiency scores using the DEA linear programming formulation.*

Figure 5
Efficient Frontier Change from
Dropping Bank C from the Population



methods of forming the outer edges of the frontier could result in much different efficiency scores for banks near the outer areas.[12] Additionally, using a ray out of the origin to measure efficiency is just one way to compute efficiency.[13]

Third, the efficiency scores for each bank are computed relative to all other banks under evaluation. Changes in the number of banks in the population and changes in the set of input and output variables in the model can cause the efficient frontier to change. For example, as Figure 5 shows, if bank C were dropped from the set of banks, only banks A and B would form the efficient frontier. Furthermore, bank E's efficiency score would improve from 0.60 to 0.75 because the efficient frontier (and its extension to the horizontal axis) is closer to bank E with the removal of bank C. Similar comments apply if new banks are added to the analysis; if new banks become part of the frontier, existing banks may have their efficiency scores altered.

The value of DEA to banking

Bank managers and regulators can use DEA in several important ways. First, the DEA efficiency scores can identify the banks that need the most attention. The least efficient banks can be analyzed on-site more thoroughly to identify specific problems.

Second, for all banks with less-than-perfect efficiency scores, a subset of efficient banks—the *efficiency reference set*—exists. From this information, managers and regulators can formulate strategies to improve the less-than-efficient banks. The DEA results allow an analyst to build a theoretical or hypothetical bank that uses fewer inputs than the inefficient bank but produces the same outputs, thereby increasing the bank's efficiency.

Third, DEA can help identify efficient banks that are managed differently from most other banks because they use an unconventional mixture of inputs or produce a different mixture of outputs. Additional in-depth analyses of these banks may help identify some underlying managerial techniques that could improve the performance of other banks.

Management quality in surviving and failed banks

To test the usefulness of DEA in measuring management quality, I compared average DEA scores for failed banks with scores for those that survived. Surviving banks are those institutions in operation from 1984 through 1989. Failed banks are those institutions declared insolvent by a regulatory agency sometime between 1986 and 1988.

The sample population had 611 survivors

---

[12] Banks near the outer edges emphasize certain inputs and outputs to a greater degree than others. Because of distortions that this emphasis can create in computing efficiency scores, a minimum level of a given input or output may need to be specified before including a bank in the population.

[13] I have presented here the original approach in measuring overall efficiency (see Charnes, Cooper, and Rhodes 1978). Seiford and Thrall (1990) describe many recent developments in DEA, contrasting the original model with newer proposed DEA models.

Table 2
Average DEA Scores for Survivors and Failure Groups

Date	SURV	88:2	88:1	87:2	87:1	86:2	86:1
December 1984	.82	.74	.80	.77	.76	.75	.74
June 1985	.83	.72	.77	.76	.72	.72	.68
December 1985	.83	.74	.78	.75	.72	.72	.68
June 1986	.82	.72	.73	.69	.67	.65	
December 1986	.84	.72	.73	.70	.64		
June 1987	.81	.66	.67	.63			

NOTE: SURV = Survivors
88:2 = Banks failing between July 1, 1988, and December 31, 1988
88:1 = Banks failing between January 1, 1988, and June 30, 1988
87:2 = Banks failing between July 1, 1987, and December 31, 1987
87:1 = Banks failing between January 1, 1987, and June 30, 1987
86:2 = Banks failing between July 1, 1986, and December 31, 1986
86:1 = Banks failing between January 1, 1986, and June 30, 1986

SOURCE OF PRIMARY DATA: Consolidated Report of Condition and Income statements.

and 319 failures, with total assets between $20 million and $300 million, and each bank was at least three years old.[14] I randomly selected the 611 surviving institutions from the total population of more than 12,000 national commercial banks, and the failed institutions were also national banks. To analyze the management quality metric, I divided the banks into the following seven groups:

SURV = Survivors
88:2 = Banks failing between July 1, 1988, and December 31, 1988
88:1 = Banks failing between January 1, 1988, and June 30, 1988
87:2 = Banks failing between July 1, 1987, and December 31, 1987
87:1 = Banks failing between January 1, 1987, and June 30, 1987
86:2 = Banks failing between July 1, 1986, and December 31, 1986
86:1 = Banks failing between January 1, 1986, and June 30, 1986

Using a DEA computer code described and documented in Kennington (1980) and Ali and others (1981), I computed results to evaluate the relative efficiency of all banks in the sample. The matrix in Table 2 shows the average DEA scores for each group for each six-month period from December 1984 to June 1987.

One can draw two general conclusions from this analysis. First, the closer a bank is to its failure date, the lower its DEA score is, on average. For example, the average DEA score for 88:1 banks relative to all other banks in the sample at the end of 1984 was 0.80. As the group's failure date approaches (moving down the column), the average DEA score generally declines. In June 1985, the group's average DEA score was 0.77. By the end of 1985, the average score had risen slightly to 0.78, but it quickly fell to 0.73 by June 1986.

The general degradation in the 88:1 average DEA scores continues as time progresses. By June 1987, only six to twelve months before failure, the group's average DEA score was 0.67. Over these two and one-half years (from December 1984 to

[14] The age and size limitations will allow for an analysis of a key segment of the banking industry that has the greatest need of problem identification. Most mid-sized banks (those with $20 million to $300 million in total assets) operate according to the financial intermediary model presented in this article and are roughly 71 percent of all banks operating in the United States.

Figure 6
Average DEA Scores for Survivors and First-Half 1988 Failures

SOURCE OF PRIMARY DATA: Consolidated Report of Condition and Income statements.

June 1987), this group's average DEA score declined by 0.13, while the average score of the survivors declined by less than 0.01. Figure 6 displays the average DEA scores for the survivors and the 88:1 failure group from December 1984 to June 1987.

A similar deterioration in average DEA scores occurs for all the failure groups. Only a few anomalies exist when the average DEA score rises instead of falls for each successive period closer to a group's failure date. In all cases, however, there is a statistically significant drop in average DEA scores from the first date analyzed (December 1984) until the group's actual failure.

Second, the average DEA score for the survivors is higher than that for the failed groups. In Table 2, examine the row that corresponds to June 1986. The average DEA score for the survivors was 0.82. For the failure groups, the scores generally decline as the individual groups' failure dates get nearer (reading left to right across the row). The average score for the group failing in the second half of 1988 was 0.72. For banks failing in the first half of 1988, the DEA score was slightly higher at 0.73, but for failures occurring in the second half of 1987 the average score was lower at 0.69. Moving left to right across the row, the average DEA scores continue to decline.

To further examine the significance of this result, I performed *t* tests for statistical differences in the mean scores of the failure groups as compared with those of the survivors. Table 3 shows the *t* values for the average DEA scores of the failed bank groups compared with those of the survivors for each six-month period. All the comparisons are significant at the 0.01 level for the December 1984 data except for banks failing in the first half of 1988. Here, the *t* value is 1.72, which corresponds to a significance level of roughly 0.10.

The results in Table 3 show that the average DEA scores for failed banks are significantly different from the scores of surviving banks at the 0.01 level for every six-month period up to two and one-half years before the bank's failure. As a group's actual failure date nears, the differences in means generally become more significant.

Conclusion

In this article, I have shown that the quality of bank management can be quantified just like capital, asset quality, liquidity, and earnings. I computed this new management quality metric by using data envelopment analysis to proxy the multiple-input, multiple-output transformational efficiency of a bank.

The important contribution from this analysis is that by utilizing DEA with the six inputs and three outputs identified herein, the surviving and failing groups can be statistically differentiated on the basis of the resulting efficiency scores. Long before failure occurs, there appear to be significant statistical differences between the quality of management for banks that fail and those that survive. This result, that management is important to the success or failure of a bank, is intuitively appealing and validated statistically in this study. Banks whose managers poorly allocate resources and disregard the needs of their customers and markets have a greater chance of failing.[15]

[15] *Evanoff and Israilevich (1991) state that "firms whose management does an inadequate job of utilizing factor inputs may soon find it difficult to survive in the more competitive market."*

Table 3
t Ratios for Survivors Versus Failure Groups

Date	88:2	88:1	87:2	87:1	86:2	86:1
December 1984	7.10	1.72	3.47	4.70	5.48	5.74
June 1985	10.57	3.95	6.35	6.81	7.57	6.85
December 1985	10.04	4.34	6.33	8.19	8.13	6.99
June 1986	9.12	6.91	9.58	9.58	10.91	
December 1986	10.62	8.62	8.69	12.63		
June 1987	17.25	8.51	8.51			

NOTE: 88:2 = Banks failing between July 1, 1988, and December 31, 1988
88:1 = Banks failing between January 1, 1988, and June 30, 1988
87:2 = Banks failing between July 1, 1987, and December 31, 1987
87:1 = Banks failing between January 1, 1987, and June 30, 1987
86:2 = Banks failing between July 1, 1986, and December 31, 1986
86:1 = Banks failing between January 1, 1986, and June 30, 1986

SOURCE OF PRIMARY DATA: Consolidated Report of Condition and Income statements.

The multiple-input, multiple-output efficiency measure, or management quality metric, developed in this article is easier to understand and analyze than single input–output ratios. DEA is superior to single ratio analysis because the model allows one to compute efficiency by examining management's role in making resource allocation and product decisions. Because bank managers make a plethora of decisions, a multiple-input, multiple-output model is more suitable and understandable than the morass of numbers presented in single input–output ratios, in which one ratio may show a highly efficient bank and another may show an inefficient operation.

I modeled management quality in a two-stage representation, in which deposits were produced in the first stage and subsequently used in the second stage to make loans and investments. The selection of variables for the model is of critical importance, and the resulting efficiency measure is highly sensitive to the variables selected. While economists, bankers, and policymakers will certainly argue over the appropriate variables for an efficiency model, the variables identified here differentiate effectively between surviving and failed banks.

There are many potential applications for this new model. The bank management quality metric could be used as a variable in an early warning model (see Barr and Siems 1991b). Regulators could use the metric to identify the most inefficient banks that require the greatest attention. For these institutions, regulators could use the results of DEA to construct a hypothetical efficient bank to help the institution focus on problem areas, such as overutilized inputs.

References

Ali, I., A. Bessent, W. Bessent, and J. Kennington (1981), "Data Envelopment Analysis of the Efficiency to Decision-Making Units with the DEA3 Code (Version 3.0)," Research Report CCS 410 (Austin, Texas: University of Texas, Center for Cybernetic Studies, July).

Barr, R. S., and T. F. Siems (1991a), "A New Paradigm for Assessing the Management Quality of Banking Institutions," Federal Reserve Bank of Dallas Research Paper, forthcoming.

———, and ——— (1991b), "Predicting Bank Failure Using DEA to Quantify Management Quality," Federal Reserve Bank of Dallas Research Paper, forthcoming.

Berg, S. A., F. R. Forsund, and E. S. Jansen (1989), "Bank Output Measurement and the Construction of Best Practice Frontiers," Research Report, Bank of Norway, July.

Bessent, A., W. Bessent, J. Kennington, and B. Reagan (1982), "An Application of Mathematical Programming to Assess Productivity in the Houston Independent School District," *Management Science* 28 (12): 1355–67.

Byrnes, P., R. Färe, and S. Grosskopf (1984), "Measuring Productive Efficiency: An Application to Illinois Strip Mines," *Management Science* 30 (6): 671–81.

Cates, D. C. (1985), "Bank Risk and Predicting Bank Failure," *Issues in Bank Regulation* 9 (2): 16–20.

Charnes, A., W. W. Cooper, Z. M. Huang, and D. B. Sun (1990), "Polyhedral Cone-Ratio DEA Models with an Illustrative Application to Large Commercial Banks," *Journal of Econometrics* 46 (1/2, October/November): 73–91.

———, ———, and E. Rhodes (1978), "Measuring the Efficiency of Decision-Making Units," *European Journal of Operational Research* 2 (6): 429–44.

Epstein, M. K., and J. C. Henderson (1989), "Data Envelopment Analysis for Managerial Control and Diagnosis," *Decision Sciences* 20 (1): 90–119.

Evanoff, D. D., and P. R. Israilevich (1991), "Productive Efficiency in Banking," Federal Reserve Bank of Chicago *Economic Perspectives* 15 (4): 11–32.

Farrell, M. J. (1957), "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society*, Series A, 253–81.

Graham, F. C., and J. E. Horner (1988), "Bank Failure: An Evaluation of Factors Contributing to the Failure of National Banks," *Issues in Bank Regulation* 12 (2): 8–12.

Gunther, J. W. (1989), "Texas Banking Conditions: Managerial Versus Economic Factors," Federal Reserve Bank of Dallas *Financial Industry Studies*, October.

Humphrey, D. B. (1991), "Flow Versus Stock Indicators of Banking Output: Effects on Productivity and Scale Economy Measurement," paper presented at the Western Economic Association meetings in Seattle, Washington, June 29–July 3.

Kaufman, G. G. (1986), "Banking Risk in Historical Perspective," Federal Reserve Bank of Chicago *Bank Structure and Competition*, May, 231–49.

Kennington, J. (1980), "A Primal Simplex Code for Computing the Efficiency of Decision-Making Units," Technical Report OREM 80001 (Dallas: Southern Methodist University, Department of Operations Research).

Kolari, J., and A. Zardkoohi (1987), *Bank Costs, Structure, and Performance* (Lexington, Mass.: D. C. Heath and Company).

Lewin, A. Y., R. C. Morey, and T. J. Cook (1982), "Evaluating the Administrative Efficiency of

Courts," *Omega: International Journal of Management Science* 10 (4): 401–11.

Nunamaker, T. R. (1985), "Using Data Envelopment Analysis to Measure the Efficiency of Non-Profit Organizations: A Critical Evaluation," *Managerial and Decision Economics* 6 (1): 50–58.

Pantalone, C. C., and M. B. Platt (1987), "Predicting Commercial Bank Failure Since Deregulation," Federal Reserve Bank of Boston *New England Economic Review*, July/August, 37–47.

Parkan, C. (1987), "Measuring the Efficiency of Service Operations: An Application to Bank Branches," *Engineering Costs and Production Economics* 12, 237–42.

Rangan, N., R. Grabowski, H. Y. Aly, and C. Pasurka (1988), "The Technical Efficiency of U.S. Banks," *Economics Letters* 28, 169–75.

Seballos, L. D., and J. B. Thomson (1990), "Underlying Causes of Commercial Bank Failures in the 1980s," Federal Reserve Bank of Cleveland *Economic Commentary*, September.

Seiford, L. M. (1990), "A Bibliography of Data Envelopment Analysis (1978–1990)," Version 5.0, Technical Report (Amherst, Mass.: University of Massachusetts, Department of Industrial Engineering, April).

———, and R. M. Thrall (1990), "Recent Developments in DEA: The Mathematical Programming Approach to Frontier Analysis," *Journal of Econometrics* 46 (1/2, October/November): 7–38.

Sexton, T. R. (1986), "The Methodology of Data Envelopment Analysis," in *Measuring Efficiency: An Assessment of Data Envelopment Analysis*, ed. R. H. Silkman (San Francisco: Jossey–Bass).

Sherman, H. D. (1984), "Improving the Productivity of Service Businesses," *Sloan Management Review*, Spring, 11–23.

———, and F. Gold (1985), "Bank Branch Operating Efficiency: Evaluation with Data Envelopment Analysis," *Journal of Banking and Finance* 9 (2): 297–315.

Siems, T. F. (1991), "An Envelopment-Analysis Approach to Measuring Management Quality and Predicting Failure of Banks," Ph.D. dissertation, Southern Methodist University.

Triplett, J. E. (1991), "Measuring the Output of Banks: What Do Banks Do?" paper presented at the Western Economic Association meetings in Seattle, Washington, June 29–July 3.