

Operating Efficiency of the Federal Deposit Insurance Corporation Member Banks

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Abstract

This work develops a Data Envelopment Analysis (DEA) of the aggregate of the member banks of the Federal Deposit Insurance Corporation. It was found that operating efficiency has been somewhat variable over the recent 25 years, but without any discernible trend. The nature of returns to scale is established through variations on the basic DEA model. It is concluded that there have been increasing returns to scale over most of this time period, but at a decreasing rate that has finally settled at constant returns to scale over the final years.

I. Introduction

A mechanism for comparing annual levels in operating efficiency of United States banks is developed here. The study group is all the member banks of the Federal Deposit Insurance Corporation (FDIC), and the years of the study are 1980 – 2004. The analysis will be used to show that there has not been a consistent trend in annual aggregate operating efficiency. Using the FDIC member banks for the analysis is important because they include the largest institutions in the country. The efficiency patterns of this group will typify those of the entire industry. The efficiency results that are obtained will subsequently be used to determine the nature of returns to scale over the years for the banking industry.

Annual operating efficiency will be calculated with the special- purpose linear programming technique called Data Envelopment Analysis (DEA). This method has been widely used in financial environments and elsewhere as a means of comparing operating efficiency of competing organizational entities at a given moment in time. It is not known to have been used heretofore to track efficiency of a single organizational entity over an extended time period. It will be done here by treating each year's operating performance as a competing entity among all years of the study. In order to have equitable annual comparisons, all yearly performance measures will be discounted using the CPI measure All Urban Consumers, All Items, 1982-84 = 100.

II. Efficiency studies with Data Envelopment Analysis

Several recent studies have illustrated the value of DEA in measuring and comparing organizational efficiency among banks. These include Ferrier and Lovell (1990), Rangan et al (1988) and Sherman and Gold (1985). Kraft and Tirtigolu (1998) used DEA to establish an efficient frontier of efficiency, using the Croatian banking system as their example. Athanassopoulos and Giokas (2000) used DEA to compare several banking institutions in Greece. Banker and Thrall (1992) estimated returns to scale using DEA, and Banker (1984) used DEA to establish a best or most productive scale size for an organization.

Barr, Seiford and Siems (1994) used DEA to predict the occurrence of bank failures. Berg, Forsund and Jansen (1991) applied DEA to a study of comparative organizational efficiency of the Norwegian banks. Favore and Pappi (1995) did a similar study comparing Italian banks to each other. Also, Oral and Yolalan (1990) did an empirical DEA comparative study that incorporated operating efficiency and profitability of different bank branches. Berger and Humphrey (1991) examined the inefficiencies among competing banks that are revealed by DEA. Shaffnit, Rosen and Parodi (1997) used DEA to identify best banking practices among bank branches. Zenios, Zenios, Agathocleous and Soteriou (1999) also used DEA to find the characteristics of efficient bank branch operations.

The familiar log-linear efficiency models are compared to the newer DEA models in the review by Berger and Humphrey (1997). An important advantage of the DEA approach is that it permits including as many output variables in the model as desired, whereas the log-linear models have just a single output variable.

Data Envelopment Analysis was first presented by Charnes, Cooper and Rhodes (1978). After the method was so widely embraced, Charnes and Cooper worked with Lewin and Seiford on a monograph that carefully shows the DEA mathematical theory and assorted applications (1994). Charnes, Cooper and Rhodes (1981) also did the pioneering application of DEA. Yet another related work was by Banker, Charnes and Cooper (1984), which also used DEA to identify sources of organizational inefficiency. Another useful primer on DEA and development of the efficient frontier was done by Seiford and Thrall (1990). Seiford (1994) followed this with a bibliography on DEA models. He later did another DEA review (1996).

III. The Data Envelopment Analysis Mathematical Model

In data envelopment analysis, several different organizational entities are compared for the purpose of identifying the relatively efficient units and those that are less so. The several organizational units are known as decision-making units (DMUs). Relative efficiency is determined through looking at the level of consumption of a set of inputs and also the attainment level from a set of outputs for each DMU. Roughly said, if an entity has large outputs and/or small inputs compared to other entities, it will be relatively efficient. For each DMU an efficiency value E ($0 < E < 1$) will be calculated. A subset of all the DMUs will have $E = 1$. These are the efficient DMUs. The other DMUs will be relatively inefficient and have E values smaller than 1.

The parameters and variables of DEA are

n = number of DMUs under comparison

E_i = efficiency of DMU $_i$

u_{ij} = input level of DMU $_i$ for input measure j

v_{ij} = output level of DMU $_i$ for output measure j

w_i = percentage weight of DMU $_i$ in the weighted average composite DMU

DEA seeks to construct a weighted average of the several DMUs being compared. The required weighted average is one that has the greatest efficiency. This embraces two things. First, the weighted average will have outputs that are at least as great as those of any individual DMU. Second, the weighted average will use input levels that are at most only E_i percent as large as those of any DMU $_i$. It may turn out that the entire weighted average composite is formed from just one most efficient DMU, or perhaps the efficient composite is formed from a larger subset or the entirety of all DMUs.

The formal DEA model for DMU_i is:

$$\text{Minimize: } z = E_i \quad (\text{Ia})$$

Subject to:

$$\sum_{i=1}^n w_i = 1 \quad (\text{Ib})$$

$$\sum_{i=1}^n v_{ij} w_i > v_{ij} \quad \text{all outputs } j \quad (\text{Ic})$$

$$\sum_{i=1}^n u_{ij} w_i < u_{ij} E_i \quad \text{all inputs } j \quad (\text{Id})$$

all $w_i, E_i > 0$

The objective function in (Ia) serves to determine the relative efficiency level E_i for DMU_i. Constraint (Ib) forces the relative weights in the composite DMU to sum to one. This causes the individual weights to be percentages of the total composite entity. The constraints of (Ic) force the several outputs of the composite to be at least as large as the corresponding outputs from any individual DMU, which clearly is needed for an efficient entity. Finally, constraints (Id) require that the several inputs of the weighted average composite DMU be no greater than $E_i\%$ of those of any DMU_i. As always in a linear programming formulation, the variables are also required to be nonnegative.

IV. The Member Banks of the Federal Deposit Insurance Corporation

The FDIC provides deposit insurance to most of the nation's banks, including all of the major institutions. All banks with a national charter are required to belong to the system. The vitality of the banking system is a critically important national concern. The FDIC provides depositor protection by insuring the deposit liabilities of the member banks. The FDIC continually monitors bank performance through examinations and data submission. The collected data from these sources are aggregated and made available to the public through the FDIC web site (www2.fdic.gov/SDI/SOB). Essential operating statistics for the member institutions are collected annually. These include loan and lease volume, deposits, cash and receivables, value of premises and equipment, and aggregate equity capital, along with other related categories. This is the source that was used for the variables being used here.

There are four input variables in this study. They are the number of participating institutions at the start of the year, the real value of cash plus receivables at the beginning of the year, the real value of bank premises and equipment at the beginning of the year and the real value of total equity capital at the beginning of the year. The real values were derived from the nominal values by dividing the nominal value by the value of the Consumer Price Index- All Urban Consumers, 1983-84 = 100. Real values are needed because the annual data values must be comparable in an efficiency comparison for the various years.

The number of institutions is an interesting variable because of the number of mergers and consolidations over the years. These open the possibility of increasing the

industry's level of efficiency. In fact, in 1980 there were 14,434 member institutions, and that number steadily declined to 7630 in 2004.

The other three input variables are included because they are necessary components of a banking operation. Cash and receivables are needed in the anticipation that loans can be granted during the year. Premises and equipment are necessary for customer contact and for processing ongoing operations. Equity capital is a limitation because of prudence and also regulations which do not permit excessive financial leverage. The national average has been approximately that the loan-to-capital ratio has not exceeded 150%.

There are four output variables incorporated into the efficiency comparison: real annual pre-tax operating income, annual change in real net loans plus leases, annual change in real total deposits and the annual change in the book value of investment securities. These four output measures are useful because they all indicate the state of the financial health of the industry.

The decision making units (DMUs) in this study are the annual values for the several input and output variables described above. The years used were 1980 to 2004, being 25 in all. Another DMU was introduced to circumvent a common problem in DEA. It is that the output of the linear programming model for any particular DMU will show a single DMU or a subset of all the DMUs as the efficient set. Then the comparable linear programming model is to be run for other DMUs as well. It is very possible that the efficient sets of DMUs from these successive models will not be identical. That is, individual DMUs are being compared for relative efficiency based upon differing standards of comparison. This problem is avoided by introducing IDEAL, a new DMU. IDEAL is formed by assigning to it the minimum values of all the input variables and the maximum values of all the output variables. IDEAL thus will have the greatest outputs and use the smallest inputs. It will automatically be the efficient DMU that will be used as the standard of comparison for each individual DMU. IDEAL will be the sole DMU in the optimal subset because it is weakly Pareto optimal. That is, in order for some other DMU to be taken as optimal, it would have to have some combination of inputs and outputs that are no worse than that obtained by IDEAL. This actually is possible, because the optimal linear programming solution might well have alternative optimal solutions, one of which is to have IDEAL as the sole optimal DMU, and other equally optimal solutions containing subsets of the remaining population DMUs. Because of this real possibility, IDEAL cannot generally be strongly Pareto optimal.

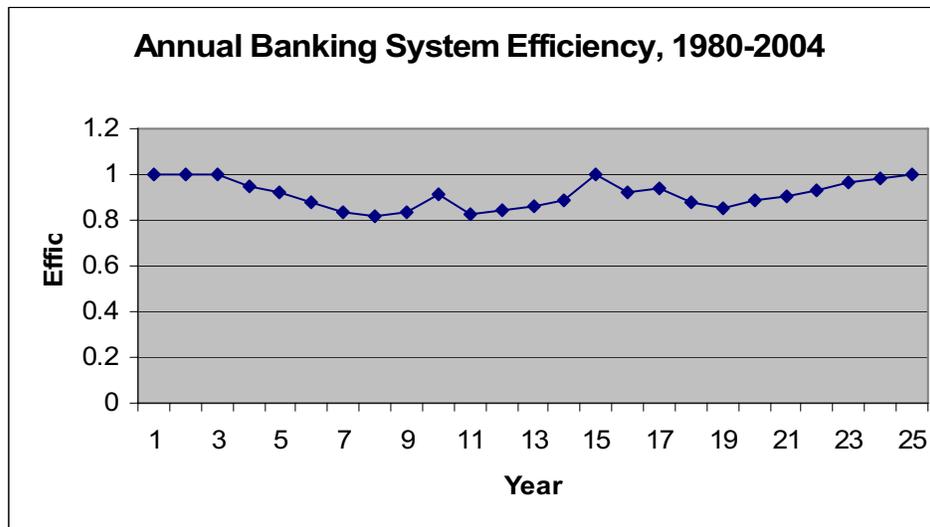
The linear programming DEA model of (Ia) – (Id) was developed with the FDIC data. It required creating a separate mathematical model for each year of the study, so 25 different linear programming models were prepared and solved. For the purpose of showing the model, the one for 1985 is presented in listing 1, and its optimal solution is given in listing 2. Note that there are 27 variables in the model. These are w_{1980} , w_{1981} , ..., w_{2004} , w_{IDEAL} and E_i . These variables are the weights to be assigned to the optimal subset of DMUs among the 25 years, and they must sum to 1. IDEAL was created so that it will be the only optimal DMU. This is necessary to avoid a potential problem of having each year's efficiency being compared against optimal subsets that are not the same as the optimal subsets of other years. The optimal solution for 1985 had the efficiency $E_{85} = .8775454$ and $w_{IDEAL} = 1.000$, as expected. Therefore, 1985 was a year where aggregate bank operating efficiency was only 87% of what it was in the best years.

The 25 DEA models were optimally solved and the pure technical efficiency values are found in the E1 column of Table 1. They are also shown graphically in Figure

1. The years of 100% efficiency are 1980, 1981, 1982, 1994 and 2004. All other years had inferior real operating performance because of combinations of excessive use of real inputs and/or substandard real outputs. There are not enough observations available to do a reliable time series study of the nature of the efficiency values over time. Even so, observation of Table 1 and Figure 1 likely would not provide support for the idea that there is a decided trend in aggregate industry efficiency. The question of a relationship between the level of efficiency and the strength of the economy is interesting, but formal conclusions would be difficult to state because of the virtual impossibility of having sufficient data for a time series analysis.

An interesting observation is to be made concerning the pure technical efficiency results and the number of member institutions. The number of insured institutions decreased virtually monotonically over time. However, the calculated efficiency values have seemingly varied without a clear trend. This leaves a first impression that enhanced efficiency might not follow from consolidation. Consolidation does open the possibility that efficiency improvement might result from economies of scale because the surviving entities are bigger. The next section examines the nature of economies of scale over the study period.

Figure 1: Annual FDIC Aggregate Member Bank Efficiency



V. Returns to Scale in the Banking Industry

Linear programming model (Ia) – (Id) yields efficiency values E_i that are known as pure technical efficiency. The efficiency level is obtained through requiring the left side of constraint (Ia) to sum to one. The effect of this is to produce a convex frontier for the efficiency weights, which admits the possibility of variable returns to scale (Aly, Grabowski, et al., 1990). If constraint (Ib) is removed, the solution to the problem gives an efficiency score that is called technical efficiency. The solution of this formulation assumes the presence of constant returns to scale. If the problem is solved with the right-hand-side of (Ib) set as < 1 then the solution that emerges allows only nonincreasing returns to scale.

For convenience, designate the solution of the problem version with (Ib) set as $= 1$ as E_1 , the version with (Ib) set at < 1 as E_2 and the version with (Ib) removed as E_3 . Form the ratio $S = E_3/E_1$. If $S = 1$ then there are constant returns to scale. When S is not equal to 1 there is scale inefficiency and returns to scale are either increasing or decreasing. If S is not equal to 1 and $E_1 = E_2$ then there are decreasing returns to scale.

Also, if S is not equal to 1 and $E1$ is not equal to $E2$ then there are increasing returns to scale.

Table 1 contains the numerical results obtained from solving all three versions of the efficiency problem for all 25 years. It is interesting that the $E2$ and $E3$ values were identical in every year. The efficient frontiers for both versions are nonconvex. Note that the ratio $S = E3/E1$ is generally less than 1. At the same time, the $E1$ and $E2$ values are almost always unequal. So the results for the years 1980 – 2001 are portrayed as having increasing returns to scale. This conclusion becomes gradually weaker in the later years because the S ratio approaches 1 starting in 1992. Finally, in years 2002 – 2004 there is no further evidence of increasing returns to scale, since the S ratio is either equal to 1 or nearly so.

Table 1: Annual Operating Efficiency

VARIABLES:					
CASE	Year	E1	E2	E3	S=E3/E1
1	1980	1.00000	.2982	.2982	.2982
2	1981	1.00000	.2795	.2995	.2795
3	1982	1.00000	.2512	.2512	.2512
4	1983	0.974800	.5614	.5614	.5737
5	1984	0.922300	.6101	.6101	.6624
6	1985	0.877500	.4096	.4096	.4667
7	1986	0.832700	.4210	.4210	.5090
8	1987	0.819300	.1638	.1638	.1999
9	1988	0.838800	.3010	.3010	.3588
10	1989	0.910600	.2033	.2033	.2232
11	1990	0.823800	.1792	.1792	.2164
12	1991	0.845100	.4762	.4762	.5634
13	1992	0.856600	.4641	.4641	.5421
14	1993	0.889100	.4477	.4477	.5035
15	1994	1.00000	.5749	.5749	.5749
16	1995	0.922200	.5665	.5665	.6142
17	1996	0.939100	.5980	.5980	.6367
18	1997	0.882100	.6174	.6174	.6999
19	1998	0.853600	.6187	.6187	.7248
20	1999	0.885400	.7401	.7401	.8358
21	2000	0.905300	.7350	.7350	.8118
22	2001	0.934300	.7064	.7064	.7560
23	2002	0.961500	.9615	.9615	1.0000
24	2003	0.985000	.9824	.9824	.9973
25	2004	1.00000	1.0000	1.0000	1.0000

This closer look at returns to scale has shown that the initial impression that economies are not realized as mergers and consolidations continue is not justified. The industry has continued to benefit from increasing returns to scale, so the incentive for consolidations exists. Because the results from the most recent years indicate that the

incentive has diminished, it will be interesting to note whether or not the pace of consolidation continues.

VI. Conclusion

An efficiency study of the aggregate performance of the member banks of the FDIC system has been carried out here. It was found that pure technical efficiency for the industry has fluctuated nonmonotonically over the years of the study (1980 – 2004). Further analysis has shown that real returns to scale have been generally increasing, but at a decreasing rate. In the most recent years the level of returns to scale has flattened out to being constant. The industry appears to be attaining an optimal level of pure technical efficiency, so it remains a matter of great interest to see if there will continue to be interest more real growth and consolidation.

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Listing 1: The Linear Programming DEA Formulation for 1985

MIN E85
 SUBJECT TO

2) $W04 + W03 + W02 + W01 + W00 + W99 + W98 + W97 + W96 + W95 + W94 + W93 + W92 + W91 + W90 + W89 + W88 + W87 + W86 + W85 + W84 + W83 + W82 + W81 + W80 + WIDEAL = 1$

3) $- 14496 E85 + 7769 W04 + 7887 W03 + 8080 W02 + 8315 W01 + 8581 W00 + 8774 W99 + 9143 W98 + 9530 W97 + 9942 W96 + 10452 W95 + 10960 W94 + 11466 W93 + 11927 W92 + 12347 W91 + 12715 W90 + 13137 W89 + 13723 W88 + 14210 W87 + 14417 W86 + 14496 W85 + 14469 W84 + 14451 W83 + 14414 W82 + 14434 W81 + 14364 W80 + 7769 WIDEAL \leq 0$

4) $- 3115632 E85 + 2105638 W04 + 2133667 W03 + 2204067 W02 + 2148261 W01 + 2199613 W00 + 2188362 W99 + 2212763 W98 + 2141412 W97 + 2011298 W96 + 2048217 W95 + 1889001 W94 + 2124569 W93 + 2238341 W92 + 2433174 W91 + 2824471 W90 + 3005603 W89 + 3154390 W88 + 3461046 W87 + 3166258 W86 + 3115632 W85 + 3432228 W84 + 3463378 W83 + 3601870 W82 + 4028021 W81 + 4222672 W80 + 1889001 WIDEAL \leq 0$

5) $- 377902 E85 + 459427 W04 + 453135 W03 + 440447 W02 + 432772 W01 + 440148 W00 + 442636 W99 + 437487 W98 + 418581 W97 + 411794 W96 + 403048 W95 + 397582 W94 + 384273 W93 + 378493 W92 + 383622 W91 + 393548 W90 + 388809 W89 + 386582 W88 + 395690 W87 + 389265 W86$

+ 377902 W85 + 369924 W84 + 367520 W83 + 352020 W82 + 334191 W81
+ 324228 W80 + 324228 WIDEAL <= 0

6) - 1483072 E85 + 3760487 W04 + 3598935 W03 + 3352322 W02
+ 3079883 W01 + 2879291 W00 + 2835773 W99 + 26046430 W98 + 2391611 W97
+ 2293769 W96 + 21058320 W95 + 20518420 W94 + 18774240 W93
+ 1701168 W92 + 1672656 W91 + 1651795 W90 + 1661415 W89 + 1590237 W88
+ 1661894 W87 + 1571726 W86 + 1483072 W85 + 1411014 W84 + 1335056 W83
+ 1301463 W82 + 1305752 W81 + 1339407 W80 + 1301463 WIDEAL <= 0

7) 793723 W04 + 791623 W03 + 707516 W02 + 600173 W01 + 644448 W00
+ 663502 W99 + 553768 W98 + 555606 W97 + 505409 W96 + 487559 W95
+ 456325 W94 + 399706 W93 + 299735 W92 + 165504 W91 + 172664 W90
+ 193581 W89 + 284937 W88 + 57919 W87 + 168406 W86 + 202723 W85
+ 193879 W84 + 189718 W83 + 199430 W82 + 222596 W81 + 236711 W80
+ 793723 WIDEAL >= 202723

8) 1925302 W04 + 975779 W03 + 1149799 W02 - 260083 W01
+ 1194688 W00 + 1084875 W99 + 1315040 W98 + 613455 W97 + 843837 W96
+ 1172507 W95 + 1048638 W94 + 417179 W93 - 571951 W92 - 1053529 W91
- 444671 W90 + 224858 W89 + 277359 W88 - 99485 W87 + 822352 W86
+ 600979 W85 + 1273525 W84 + 515279 W83 + 227498 W82 + 108873 W81
- 672274 W80 + 1925302 WIDEAL >= 600979

9) 2275699 W04 + 1262414 W03 + 1351217 W02 + 446411 W01
+ 1276039 W00 + 410329 W99 + 1266443 W98 + 941874 W97 + 510929 W96
+ 470300 W95 + 334570 W94 - 173974 W93 - 498136 W92 - 543374 W91
- 275870 W90 - 3202 W89 - 2929 W88 - 276513 W87 + 1150272 W86

+ 793326 W85 + 392479 W84 + 823492 W83 + 197183 W82 - 496917 W81
- 796151 W80 + 2275699 WIDEAL >= 793326

10) 297340 W04 + 494910 W03 + 799047 W02 + 354895 W01 - 15848 W00
+ 270274 W99 + 579184 W98 + 329356 W97 - 217766 W96 - 232791 W95
- 236912 W94 + 281195 W93 + 432943 W92 + 450213 W91 + 120879 W90
- 25660 W89 - 52933 W88 + 159798 W87 + 340242 W86 + 373025 W85
- 549310 W84 + 460238 W83 + 66670 W82 - 211798 W81 + 31765 W80
+ 799047 WIDEAL >= 373025

END

Listing 2: The Solution of the 1985 Efficiency Formulation

OBJECTIVE FUNCTION VALUE

.87754540

VARIABLE	VALUE	REDUCED COST
E85	.877545	.000000
W04	.000000	1.658061
W03	.000000	1.549131
W02	.000000	1.382845
W01	.000000	1.199146
W00	.000000	1.063892
W99	.000000	1.034549
W98	.000000	16.684940
W97	.000000	.735061
W96	.000000	.669088
W95	.000000	13.321580
W94	.000000	12.957540
W93	.000000	11.781480
W92	.000000	.269512
W91	.000000	.250287
W90	.000000	.236221
W89	.000000	.242707
W88	.000000	.194713
W87	.000000	.243030
W86	.000000	.182232
W85	.000000	.122455
W84	.000000	.073868
W83	.000000	.022651
W82	.000000	.000000
W81	.000000	.002892
W80	.000000	.025585
WIDEAL	1.000000	.000000
ROW	SLACK OR SURPLUS	DUAL PRICES
2)	.000000	-.877545
3)	4951.898000	.000000
4)	845107.500000	.000000
5)	7398.159000	.000000
6)	.000000	.000001
7)	591000.000000	.000000
8)	1324323.000000	.000000
9)	1482373.000000	.000000
10)	426022.000000	.000000
NO. ITERATIONS=	4	