Measuring Inefficiencies of Individual Agricultural Banks

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Introduction

In a presentation at the 1992 NC-207 regional committee meeting in Minneapolis, Ellinger and Neff examined issues and approaches of efficiency analysis of commercial banks. Ten major issues in estimating bank efficiencies were discussed. These included:

1. Bank data sources
2. Bank cost definition
3. Bank output definition
4. Empirical technique
5. Functional form
6. Bank entity to evaluate
7. Time period used
8. Economies of scale/scope issues
9. Incorporation of risk
10. Incorporation of environmental variables into cost equations

This presentation, and a subsequent *Agricultural Finance Review* article, examined issues 2., 3., and 4. -- bank cost and output definition and empirical technique -- using a sample of 500 agricultural banks and quarterly call report data from March 1987 - December 1990. To examine bank cost and output definition, four cost functions were estimated, each with alternative input and output specifications. The alternative output specifications compared the value-added and intermediation approaches while the alternative input specifications measured the effect of including interest expense as a bank cost. Efficiency analyses of the sample banks were conducted using two empirical techniques and the four alternative models. These techniques were the stochastic parametric and the nonparametric cost frontiers. Summary statistics, histograms and correlation analyses were used to compare efficiency results among the eight models.

The results of this analysis indicated that nonparametric models resulted in larger and more disperse measures of bank inefficiency than the stochastic cost frontier. Inefficiency estimates were 50-87 percent inefficient on average for the nonparametric models and 3-28 percent inefficient on average for the stochastic models. Given that all of the sample banks had been operating for at least a three year period and many of the estimated inefficiency ratios were over 100 percent for the sample banks, it seems unlikely that these banks could have survived at such high cost levels relative to other banks. The nonparametric technique does not allow for random disturbances away from the efficient cost frontier, and hence a portion of the measured inefficiency could have been caused by such occurrences.

In terms of bank cost definition, the inclusion of interest expenses was more desirable. Because noninterest costs can differ substantially based upon the types of funds use, the exclusion of interest costs may rank banks which use funding sources with higher operating costs (e.g., transactions deposits) as less efficient than banks using funding sources with relatively lower operating costs (e.g., federal funds purchased).

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When alternative bank output definitions were compared, the value-added approach (which includes demand, savings and time deposits as outputs) was the preferred approach. Deposits are responsible for a high proportion of value-added by commercial banks and a considerable amount of labor, physical capital and interest expense inputs are employed in producing these services.

Given these earlier results, this analysis employs a translog functional form to estimate a stochastic cost frontier for a much larger sample of U.S. banks (7,140). The value-added approach to output definition is used and bank interest expenses are included as an input. This study focuses on evaluating bank inefficiency results from a given model and method rather than comparing inefficiency results between alternative models and methods. Summary statistics; histograms; graphical examinations of average inefficiency ratios by bank size, Federal Reserve Bank region, agricultural loan-to-deposit ratio and holding company affiliation; and a regression analysis which correlates inefficiency estimates with bank environmental variables are employed to examine inefficiency estimates.

Methods

Bank inefficiency is estimated using the translog cost function system originated by Christensen and Greene and adapted to commercial bank data by Ferrier and Lovell. This specification incorporates both technical and allocative inefficiencies. The translog cost function system is composed of a cost function and input share equations:

Cost function: (1)

$$\ln(w'x)_s = [\alpha_0 + \sum_{i=1}^{m} \alpha_i \ln y_{is} + \sum_{i=1}^{n} \beta_i \ln w_{is} + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \alpha_{ij} \ln y_{js} \ln y_{js} + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln w_{is} \ln w_{js} + \sum_{i=1}^{m}\sum_{j=1}^{n} \delta_{ij} \ln y_{is} \ln w_{js} + T_s + A_s + V_s$$

Input share equations: (2)

$$\left(\frac{w_j x_j}{w'x}\right)_s = [\beta_j + \sum_{k=1}^{n} \beta_{jk} \ln w_{ks} + \sum_{i=1}^{m} \delta_{ij} \ln y_{is}] + b_j + u_{js}, \quad j=1,\ldots,n$$

where, $w'x = \sum_{i=1}^{n} (w_i \times x_i)$, s=1,...,S, indexes banks, j=1,...,n, indexes inputs, x is the vector of inputs, w is a vector of input prices, y is a vector of outputs, T is the technical inefficiency, A is the allocative inefficiency and u and v are statistical noise. It is assumed that T is distributed half-normally and u and v are distributed normally. Furthermore, $B_{js}=b_j+u_{js}$ and $B_{js}\sim N(b_j, \sigma_{B_j}^2)$.

The decomposition of error terms, technical inefficiency and allocative inefficiency can be achieved through methods outlined by Schmidt. He suggests that the decompositions should have two characteristics. These include:

1. $A \geq 0$, with $A = 0$ if and only if all elements of B are zero;

2. A and $|b_s + u_s|$ are positively correlated, and A and the variances of the composed errors $(b_s + u_s)$ are correlated.

In this study, allocative inefficiencies are estimated as:

$$A = FB \otimes B = (F_{11}B_1^2 + F_{22}B_2^2 + .. + F_{nn}B_n^2)$$

where n is the number of inputs, F is 1xn vector with $F_{jj} > 0$. F_{jj} represents the relative effect of allocative inefficiencies from input j on the increasing production cost. The allocative inefficiencies defined in this way reflect the weighted average effect of allocative distortion on each of the share equations. The F_{jj} are estimated with the cost system.

This specification of the linkage of allocative inefficiencies between cost function and share equations not only meets the two requirements recommended by Schmidt, but also provides information on the level of allocative inefficiency for each firm. The estimation of technical inefficiencies in this analysis is similar to the mode of the conditional distribution derived by Jondrow, Lovell, Materov and Schmidt.

Data

The selection of sample banks was based on two criteria:

1. At least 50 percent of the deposits of branches are not located in a metropolitan service area (MSA), or

2. The bank has an agricultural loan ratio of 25 percent or higher.

Criteria #1 selects rural (nonMSA) banks. Criteria #2 allows banks to be selected in MSAs if their agricultural loan ratio is greater than 25 percent. These criteria resulted in a sample of 7,140 banks. Four-quarter averages from 1990 are used for the explanatory input, output, price and cost data.

The translog cost function includes six outputs and four inputs:

Outputs	Inputs
Transaction deposits	Number of employees
Nontransaction deposits	Occupancy expenses
Nonagricultural real estate loans	Other operating expenses
Nonagricultural nonreal estate loans	Interest expense on deposits
Agricultural real estate and nonreal estate loans	
Other bank output	

This model, with imposed homogeneity and symmetry restrictions, consists of four share equations and the translog cost function. To avoid singularity, the last share equation is omitted. Maximum likelihood is used to jointly estimate the cost function and share equations.

Tables 1 and 2 provide summary statistics and the bank size distribution of the sample banks. Approximately seven percent of the sample consists of very small banks (total assets < $10 million) and two percent are large banks (total assets ≥ $250 million) (the average size of the banks is $59,762,600 total assets). The average number of bank employees is 33 and the average annual salary per employee is $27,367. The mean agricultural loan ratio is 26 percent, indicating that 26 percent of the loans made by the sample banks on average is for agricultural purposes or secured by agricultural assets. On average, the banks have about 2.2 branches, a market share of 20 percent and a 9.3 percent rate-of-return on equity capital.

Results

Table 3 presents summary statistics of technical, allocative and overall inefficiency estimates by bank asset size class and for the total sample. On average, the banks exhibited four percent technical inefficiency, two percent allocative inefficiency and six percent total inefficiency. The average total inefficiency of the sample is slightly higher than Ellinger and Neff find using a similar model (approximately 3.3 percent). It is substantially lower, however, than Ferrier and Lovell's estimate of eight percent technical, 17 percent allocative and 26 percent total cost inefficiency for a sample of 575 banks who participated in the Federal Reserve System's Functional Cost Analysis (FCA) program in 1984. One explanation for the difference between the results of Ferrier and Lovell and this study may be due to the data employed (FCA versus Call Report). The outputs used in the Ferrier and Lovell study consist of the number of deposits and loans, rather than their values. In addition, Ferrier and Lovell estimate an average allocative inefficiency level for the total sample, rather than individual estimates for each bank.

Figure 1 provides a histogram of total inefficiency measures for the sample banks. Nearly 6,400 of the 7,140 banks have total inefficiency estimates between zero and ten percent. About 600 banks have total inefficiency between ten and 15 percent and fewer numbers of banks have inefficiency ratios in higher categories. These results are consistent with Ellinger and Neff, who find similarly narrow inefficiency distributions for agricultural banks using the stochastic parametric method.

Technical, allocative and total inefficiency measures decrease somewhat as bank size increases (Table 3). The largest difference is between the smallest size category of banks and the rest of the size classes. Small banks are approximately two percent, one percent and three percent more technically, allocatively and totally inefficient, respectively, on average than larger banks. This results is in contrast to Ferrier and Lovell, who find no apparent relationship between cost inefficiency and bank size using bank deposit size classes.

Figures 2-4 present average technical, allocative and total inefficiency of the agricultural sample banks by Federal Reserve District. The largest average technical inefficiency was 6.6 percent for the San Francisco District banks. The New York District banks also had a relatively large average inefficiency estimate of 5.4 percent. These areas are dominated by branches of large banks located in major metropolitan areas (Los Angeles, San Francisco, New York City, etc.). The competitive forces of these branches may result in higher inefficiencies for other banks. The average allocative inefficiency by Federal Reserve District is fairly uniform at about two percent except for Philadelphia District banks, who have an average allocative inefficiency of 3.0 percent. The average total inefficiency is highest for the San Francisco District banks, at 8.5 percent cost inefficient. The Dallas District exhibited the lowest average cost inefficiency (5.2 percent).

Figure 5 presents average total inefficiency estimates by bank agricultural loan ratio (ALR). Over a wide range of ALRs, the average total inefficiency is fairly constant at approximately six percent. This is nearly the same as the average total inefficiency of the full sample of 7,140 agricultural banks. However, average total inefficiency increases for banks with ALRs of greater than 70 percent with average measures of 7.1, 8.3 and 20.8 percent for banks in the 70-80, 80-90

Table 1. Summary Statistics of Sample Banks (7,140 Observations)

Variable	Minimum	Maximum	Average	Standard Deviation
Y1-Transactions deposits ($000)	0.1000	1,084,966	12,724	29,350
Y2-Nontransaction deposits ($000)	0.1000	2,690,038	39,828	82,359
Y3-Nonagricultural real estate loans ($000)	0.1000	1,608,725	14,691	40,970
Y4-Nonagricultural nonreal estate loans ($000)	0.1000	270,222	4,652	7,117
Y5-Agricultural real estate and nonreal estate loans ($000)	0.1000	1,404,112	13,606	47,255
Y6-Other bank output ($000)	0.1000	74,209	220	1,382
X1-Number of employees	0.5000	3,631	33	81
X2-Expenses of fixed assets & premises ($000)	0.1000	258,616	3,329	7,480
X3-Other noninterest oper. expenses ($000)	0.1000	26,996	233	653
X4-Interest expense on deposits ($000)	0.1000	121,092	686	2,297
P1-Average salary ($000)	0.0000	101.0000	27.3673	6.4575
P2-(X2/total deposits)	0.0000	0.5020	0.0613	0.0093
P3-(X3/total deposits)	0.0000	0.0359	0.0045	0.0024
P4-(X4/total deposits)	0.0000	0.3336	0.0128	0.0076
Agricultural loan ratio	0.0000	0.9514	0.2599	0.2322
Loan to deposit ratio	0.0061	4.7314	0.5703	0.1694
Number of branches	1	302	2.24	5.50
Real estate to total loans ratio	0.0000	1.0015	0.4444	0.1806
Market share	0.0003	1.0000	0.1979	0.1875
ROA	-0.0790	0.0681	0.0086	0.0078
ROE	-8.7941	22.3648	0.0927	0.3613

Table 2. **Bank Size Distribution of Sample**

Asset Size Class	Number of Banks	Percent of Sample
Assets < $10M	491	6.9%
$10M ≤ Assets < $25M	2,029	28.4%
$25M ≤ Assets < $50M	2,093	29.3%
$50M ≤ Assets < $100M	1,577	22.1%
$100M ≤ Assets < $250M	807	11.3%
$250M ≤ Assets	143	2.0%
Total Sample	7,140	100.0%

and ≥90 ALR categories, respectively. These results, however, are being influenced by two things. First, there were only five banks with ALR ≥ 90 percent. Hence, the average inefficiency measure may be being influenced by one or two particularly inefficient banks. Secondly, bank size is inversely related to the ALR. Smaller banks (particularly those with assets of less than $10 million), previously shown (Table 3) to be more inefficient, may be dominating the larger ALR categories.

Table 3. **Technical, Allocative and Overall Efficiency by Bank Size**

Asset Size Class	Obs.	Efficiency	Minimum	Maximum	Mean	Standard Deviation
Assets < $10M	491	Technical	0.000	1.040	0.060	0.081
		Allocative	0.002	1.125	0.033	0.101
		Overall	0.002	1.125	0.093	0.125
$10M ≤ Assets < $25M	2,029	Technical	0.000	0.479	0.044	0.040
		Allocative	0.002	0.189	0.020	0.009
		Overall	0.002	0.493	0.064	0.041
$25M ≤ Assets < $50M	2,093	Technical	0.000	0.647	0.038	0.030
		Allocative	0.004	0.224	0.020	0.008
		Overall	0.005	0.663	0.058	0.031
$50M ≤ Assets < $100M	1,577	Technical	0.000	0.270	0.039	0.027
		Allocative	0.003	0.366	0.020	0.011
		Overall	0.005	0.366	0.059	0.030
$100M ≤ Assets < $250M	807	Technical	0.000	0.237	0.036	0.029
		Allocative	0.005	0.198	0.020	0.008
		Overall	0.006	0.273	0.056	0.031
$250M ≤ Assets	143	Technical	0.000	0.348	0.035	0.052
		Allocative	0.005	0.669	0.024	0.055
		Overall	0.007	0.818	0.059	0.085
Total Sample	7,140	Technical	0.000	1.040	0.041	0.039
		Allocative	0.002	1.125	0.021	0.029
		Overall	0.002	1.125	0.062	0.049

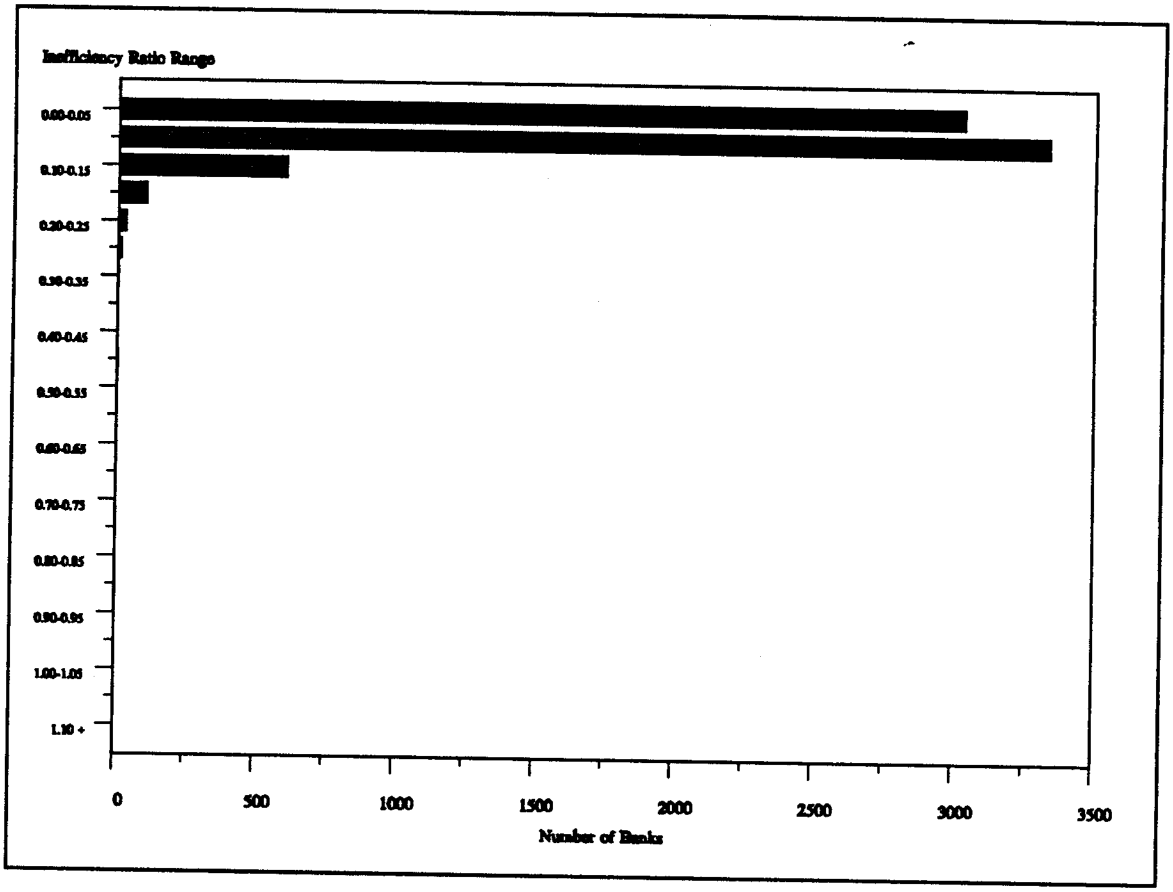

Figure 1. Distribution of Total Inefficiency Estimates for 7,140 Banks

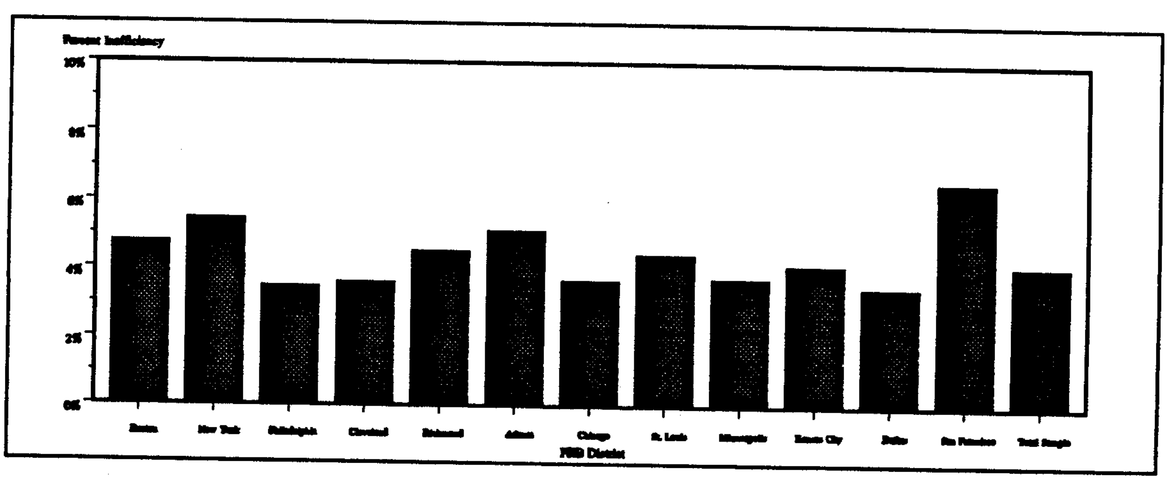

Figure 2. Average Technical Inefficiency by Federal Reserve Bank District

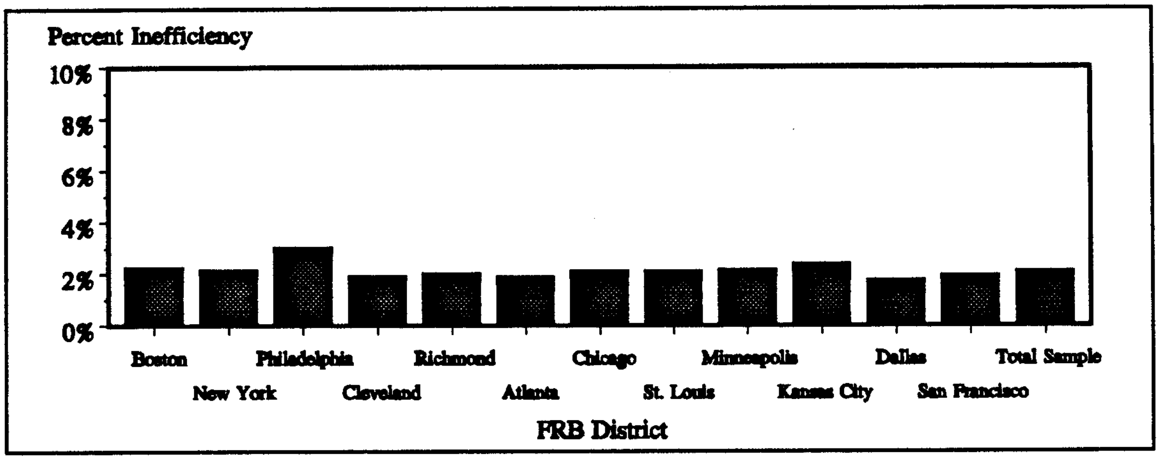

Figure 3. **Average Allocative Inefficiency by Federal Reserve Bank District**

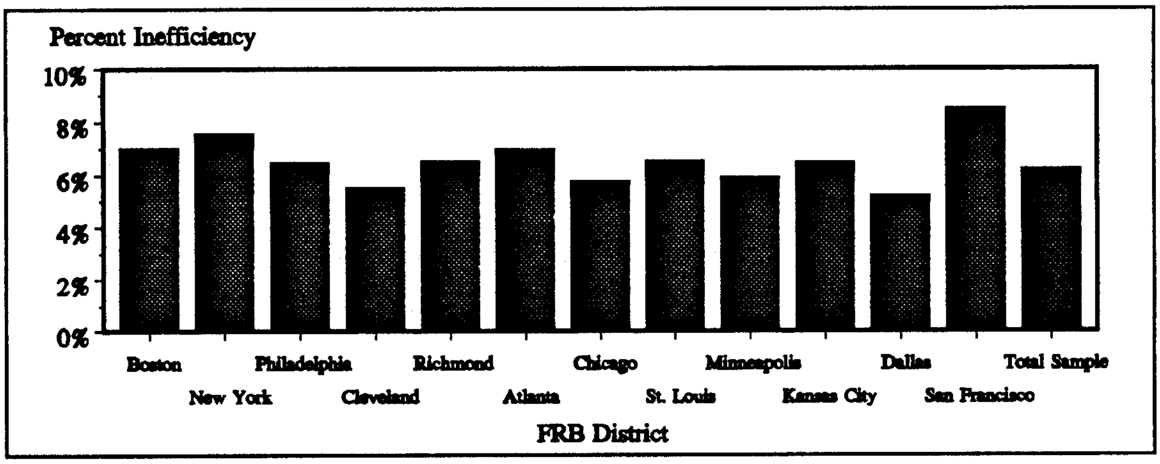

Figure 4. **Average Total Inefficiency by Federal Reserve Bank District**

To examine this issue in more detail, average total inefficiency by ALR is presented in Figure 6 for only those banks in the $10 million - $25 million total assets size category. Average inefficiency is greater both for banks with very low and very high ALRs. Banks with ALRs of approximately 20 to 70 percent are less cost inefficient than other banks. Hence, the inclusion of agricultural loans in a bank's total loan portfolio may provide some efficiency improvement, provided the ALR does not rise above 70 percent. The limited results of this analysis, however, do not provide strong evidence in support of this argument and further research is clearly necessary to isolate the effect of the agricultural to nonagricultural loan portfolio mix on total bank cost inefficiency.

Figures 7-9 examine bank inefficiency by bank holding company affiliation and size class. In Figure 7, banks that are affiliated with a single- or no-bank holding company (5,499 banks) are more technically and slightly more allocatively inefficient, on average, than those banks that are affiliated with a multi-bank holding company (1,641 banks). Again, the effect of bank size on inefficiency may be influencing the results, since banks which are affiliated with multi-bank holding companies are larger, with average assets of approximately $89 million versus $51 million for single- or no-bank holding company banks.

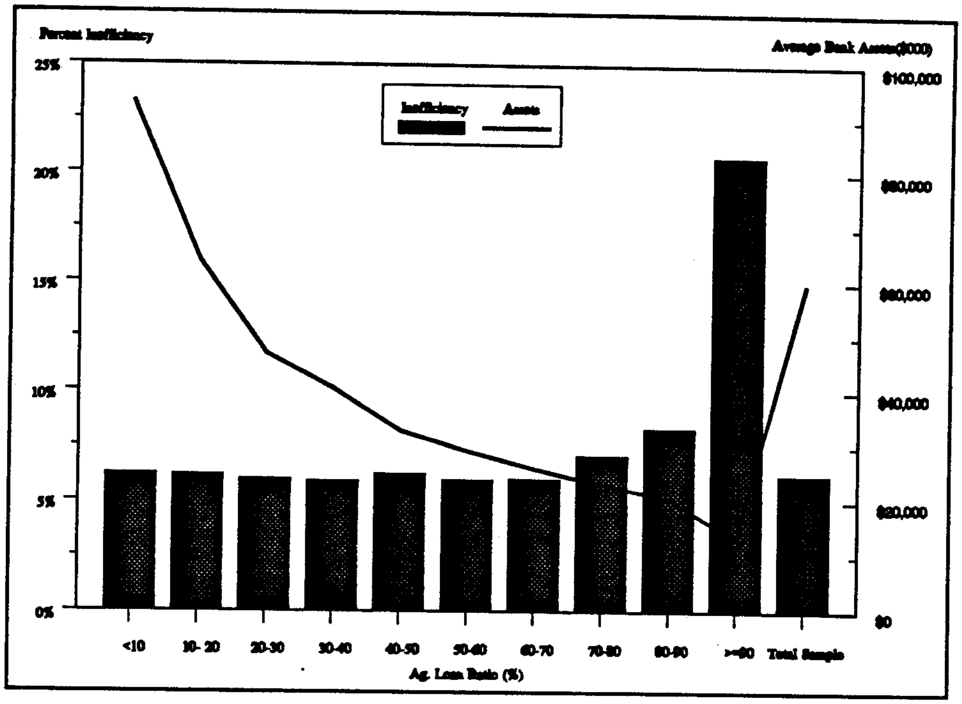

Figure 5. Average Total Inefficiency and Average Bank Assets by Agricultural Loan Ratio

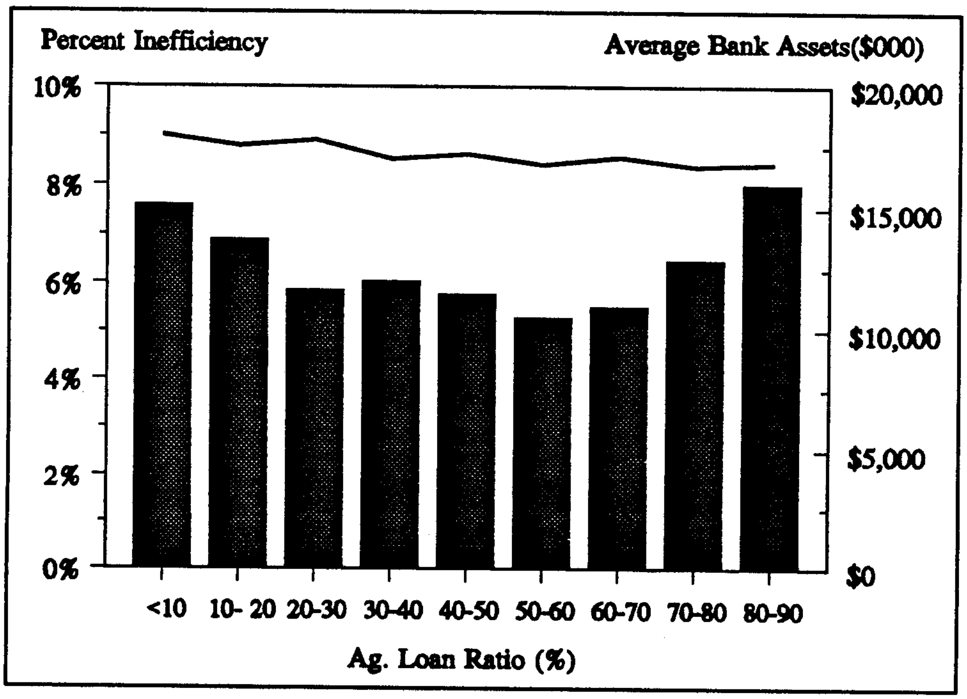

Figure 6. Average Total Inefficiency and Average Total Assets by Agricultural Loan Ratio $\$10M \leq Assets < \$25M$

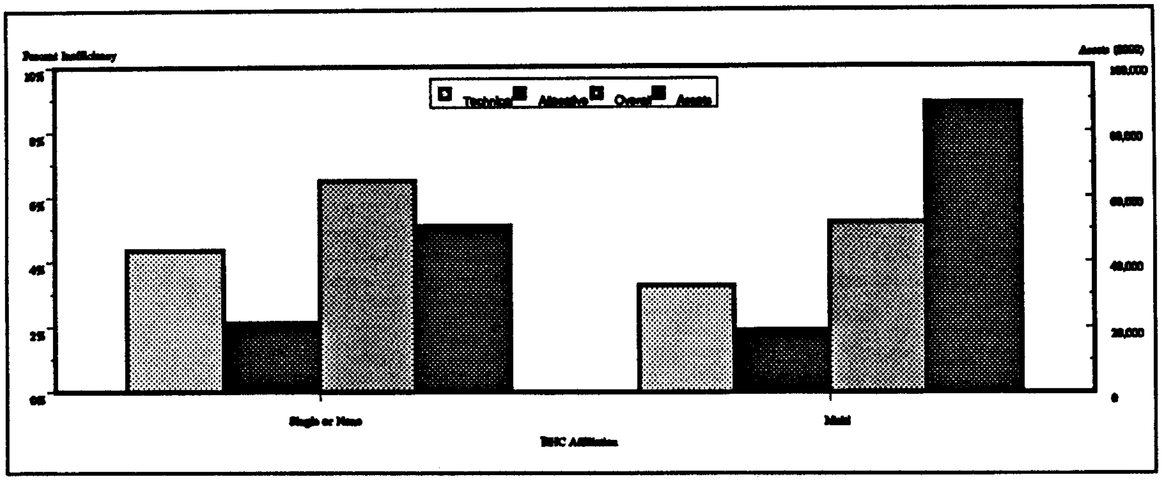

Figure 7. Average Total Inefficiency and Average Assets by BHC Affiliation

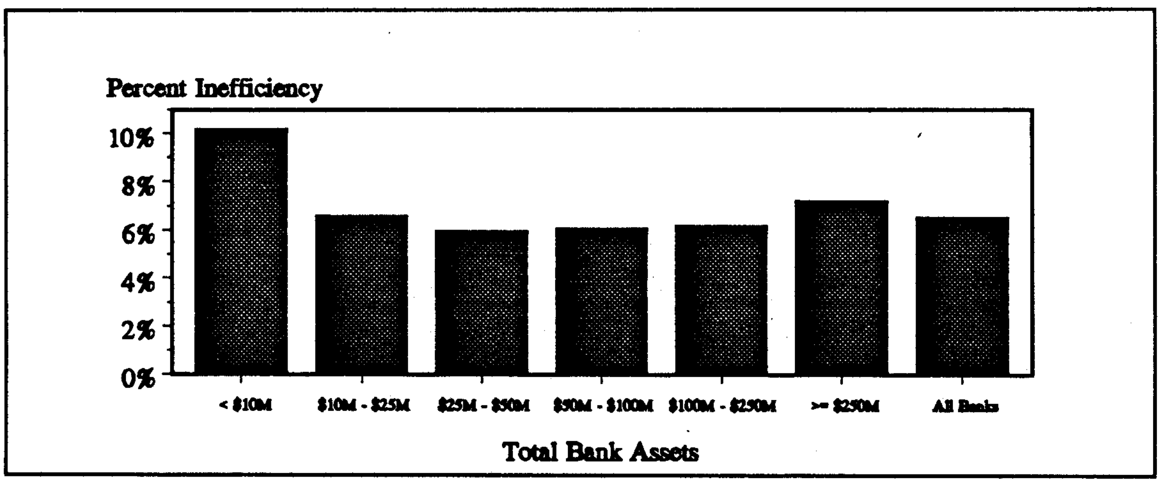

Figure 8. Average Total Inefficiency by Bank Size Class
Single- or No-BHC Banks

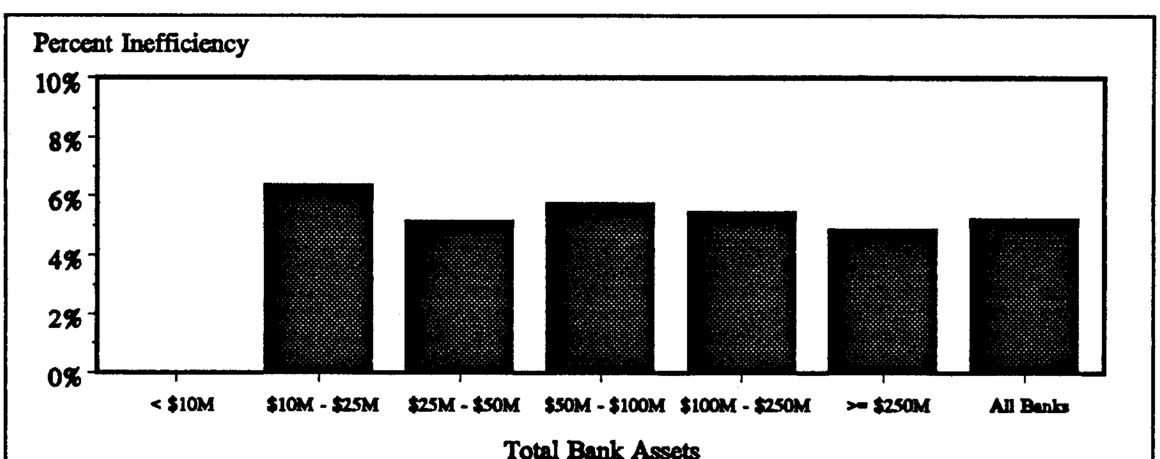

Figure 9. Average Total Inefficiency by Bank Size Class -- Multi-BHC Banks

When average total inefficiency is examined by bank size class for the single- or no-bank holding company banks (Figure 8), small banks have approximately 10 percent total inefficiency. Larger banks are about six percent inefficient, or about the same as the sample average. Banks that are affiliated with a multi-bank holding company (Figure 9) exhibit similar average total inefficiency measures across the $10 million - $250 million size classes. There are no multi-bank holding company banks with assets less than $10 million. However, large banks, those with total assets of greater than $250 million, are somewhat less inefficient, on average, (about five percent) if they are affiliated with a multi-bank holding company than if they are not (Figure 8, about seven percent).

In order to isolate the influences of bank size and holding company affiliation on bank inefficiency, the results of a regression which correlates bank total inefficiency with these variables and several bank environmental variables are presented in Table 4. Bank size (measured as the natural log of assets) is inversely related to inefficiency, which confirms results from the various graphical presentations discussed previously. Affiliation with a multi-bank holding company also decreases inefficiency, supporting the results in Figure 7.

Table 4. Regression Results of Total Inefficiency as a Function of Bank Environmental Characteristics

Variable	Parameter Estimate	P-value
Intercept	0.1324	0.0001
Log Assets	-0.0070	0.0001
Holding Company Affiliation	-0.0104	0.0001
Loans-to-Deposits Ratio	0.0180	0.0001
Real Estate-to-Total Loan Ratio	-0.0074	0.0283
Market Share	-0.0079	0.0131
F Value	51.812	0.0001
Adjusted R-square	0.0344	

Holding a greater proportion of real estate in a bank's loan portfolio also decreases total cost inefficiency. These types of loans typically require less annual servicing than operating and/or shorter-term loans, thus decreasing cost inefficiency (or increasing cost efficiency). Banks which have a relatively greater market share also are less inefficient on average. Lastly, a larger loan-to-deposit ratio increases bank cost inefficiency. Banks with a greater than average loan-to-deposit ratio may be experiencing larger cost inefficiencies because of the greater servicing requirements associated with loans versus deposits.

Summary and Conclusions

This analysis estimates technical, allocative and total cost inefficiency for a sample of 7,140 U.S. agricultural or rural banks using 1990 quarterly Call Report data. A stochastic parametric translog cost frontier with input share equations incorporating six outputs and four inputs is employed to obtain individual estimates of bank inefficiency.

On average, total bank inefficiency is approximately six percent. Approximately two-thirds of the total inefficiency is caused by technical reasons and one-third is associated with allocative inefficiencies. Average inefficiency is the highest for small banks, those with total assets less than $10 million. Inefficiency is relatively constant across other bank size categories, except for extremely large banks (total assets ≥ $250 million). Here, bank inefficiency decreases if the bank is affiliated with a multi-bank holding company but increases if it is not.

Inefficiency is examined by FRB District, but no clear differences are present in the results. Total cost inefficiency is higher for banks with low (less than 20 percent) and high (greater than 70 percent) agricultural loan ratios when banks in the $10 million - $25 million total asset category are examined. This result provides evidence that banks with agricultural loan ratios in the 20 - 70 percent range tend to have lower cost inefficiency, but more research is needed before this hypothesis can be supported with a high degree of certainty.

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