AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# An Analysis of the Cost of Efficiency in the Farm Credit System for Direct Lending Associations

**Ming-Che Chien and David J. Leatham**

**Proceedings of a Seminar sponsored by**
**North Central Regional Project NC-207**
**"Regulatory, Efficiency and Management Issues Affecting Rural Financial Markets"**
**Federal Reserve Bank of Chicago**
**Chicago, Illinois**
**October 4-5, 1993**

Department of Agricultural, Resource and Managerial Economics
College of Agricultural and Life Sciences
Cornell University, Ithaca, New York 14853

December 1993

*Copyright 1992 by author. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.*

# AN ANALYSIS OF THE COST EFFICIENCY IN THE FARM CREDIT SYSTEM FOR DIRECT LENDING ASSOCIATIONS

Ming-Che Chien and David J. Leatham[1]

The cooperative Farm Credit System (FCS) in the United States is a network of borrower-owned lending institutions. Its primary economic and political function is to provide reliable, low-cost credit to its owner-borrowers (Collender, Nehring, and Somwaru). For the last few years, the FCS has been undergoing substantial structural changes. Two important factors in these changes are the passage of the Agricultural Credit Act of 1987 (ACA87) and the increasing competition from the commercial banking industry.

The ACA87 contains an extensive set of provisions. Among these, the call for several mergers, with financial incentives involving the repayment of any government federal aid provided, has significant impacts on the organizational structure of the FCS. For example, the Federal Land Bank (FLB) and Federal Intermediate Credit Bank (FICB) in each district, except the FLB of Jackson in receivership, have merged to form the Farm Credit Bank (FCB). Also, 10 of the 12 district Banks for Cooperatives (BCs) voted to merge into the Central Bank for Cooperatives (CoBank). Furthermore, Production Credit Associations (PCAs) and Federal Land Bank Associations (FLBAs) in several districts have merged voluntarily to form Agricultural Credit Associations (ACAs). As direct-lending authority was granted to certain FLBAs, these FLBAs became Federal Land Credit Associations (FLCAs). The organizational changes in the FCS institutions from January 1, 1988 to January 1, 1993 are presented in Table 1.

The increasing competition from the commercial bank industry is shown by the increased outstanding agricultural loans by the commercial banks, both in loan volume and in percentage of market share. As shown in Table 2, total loan volume for the FCS has decreased from about $61.6 million (33.8 percent of total loans) in 1981 to about $35.2 million (25.2 percent of total loans) in 1992. However, total outstanding agricultural loans for the commercial banks have increased from about $38.8 million (21.3 percent of total loans) to about $52.1 million (37.3 percent of total loans) during the same period. The increase in competition puts FCS institutions in a situation where their success depends on their ability to adapt and operate more efficiently in the new environment.

In the past few years, many studies have concentrated on analyzing commercial bank productive efficiency (Evanoff and Israilevich; Ferrier and Lovell; Bauer, Berger, and Humphrey; Berger and Humphrey; Berger, Hancock, and Humphrey). However, comparatively few studies have focused on the efficiency analysis of FCS institutions (Collender; Collender, Nehring, and Somwaru). Furthermore, most studies in bank efficiency used data on a single cross-section of firms, and the separation of technical inefficiency from random noise required strong assumptions about their distributions. Schmidt (1986) advocated the use of panel data to remedy certain serious problems of efficiency analyses, including the one mentioned above.

Productive efficiency literature commonly uses the single equation approach. This method assumes no persistent allocative inefficiency exists. A cost or production function is estimated and the inefficiency is obtained. Alternatively, a system of equations consisting of the cost or production function with the share equations or equations representing the first order conditions for cost minimization can be estimated. This approach is argued to be more appropriate for the internal consistency of the model and to increase the efficiency of the parameter estimates. However, the model will be more complicated and the estimation is intensive, especially for the MLE estimation.

---

[1] Ming-Che Chien is a graduate assistant in the Department of Agricultural Economics, Texas A&M University. David J. Leatham is an associate professor in the Department of Agricultural Economics, Texas A&M University.

**Table 1. Numbers for Each Farm Credit Institution, 1988Q1 - 1992Q4.**

| | FLB | FICB | BC | PCA | FLBA | FCB | ACA | FLCA | SC | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1988Q1 | 12 | 12 | 13 | 150 | 230 | 12 | - | - | 4 | 433 |
| 1988Q2 | 12 | 12 | 13 | 148 | 229 | 12 | - | - | 4 | 430 |
| 1988Q3 | 1 | 1 | 13 | 143 | 224 | 11 | - | - | 4 | 397 |
| 1988Q4 | 1 | 1 | 13 | 142 | 224 | 11 | - | - | 6 | 398 |
| 1989Q1 | 1 | 1 | 3 | 101 | 148 | 11 | 34 | 4 | 6 | 309 |
| 1989Q2 | 1 | 1 | 3 | 96 | 143 | 11 | 39 | 2 | 6 | 302 |
| 1989Q3 | 1 | 1 | 3 | 95 | 142 | 11 | 40 | 2 | 6 | 301 |
| 1989Q4 | 1 | 1 | 3 | 95 | 148 | 11 | 39 | 2 | 6 | 306 |
| 1990Q1 | 1 | 1 | 3 | 94 | 146 | 11 | 40 | 2 | 6 | 304 |
| 1990Q2 | 1 | 1 | 3 | 93 | 145 | 11 | 40 | 3 | 6 | 303 |
| 1990Q3 | 1 | 1 | 3 | 112 | 144 | 11 | 40 | 4 | 6 | 322 |
| 1990Q4 | 1 | 1 | 3 | 112 | 141 | 11 | 40 | 7 | 6 | 322 |
| 1991Q1 | 1 | 1 | 3 | 117 | 121 | 11 | 44 | 18 | 5 | 321 |
| 1991Q2 | 1 | 1 | 3 | 91 | 96 | 11 | 66 | 19 | 5 | 293 |
| 1991Q3 | 1 | 1 | 3 | 87 | 90 | 11 | 70 | 22 | 5 | 290 |
| 1991Q4 | 1 | 1 | 3 | 87 | 87 | 11 | 70 | 25 | 5 | 290 |
| 1992Q1 | 1 | 1 | 3 | 82 | 84 | 10 | 70 | 24 | 5 | 280 |
| 1992Q2 | 1 | 1 | 3 | 75 | 84 | 10 | 70 | 24 | 5 | 273 |
| 1992Q3 | 1 | 1 | 3 | 73 | 80 | 10 | 70 | 26 | 5 | 269 |
| 1992Q4 | 1 | 1 | 3 | 72 | 78 | 10 | 70 | 27 | 4 | 266 |

*Source:* FCS Call Reports, 1988Q1-1992Q4, Farm Credit Administration

Note: FLB-Federal Land Bank, FICB-Federal Intermediate Credit Bank, BC-Bank for Cooperatives, PCA-Production Credit Association, FLBA-Federal Land Bank Association, FCB-Farm Credit Banks, ACA-Agricultural Credit Association, FLCA-Federal Land Credit Association, and SC-Service Corporation.

The objective of this study is to estimate and compare the cost efficiency for the Farm Credit System direct lending institutions using a stochastic frontier approach in the context of the panel data analysis. The maximum likelihood estimation technique (MLE) of the single equation approach is used to obtain the efficiency measurements for each institution. Specific objectives are: 1) Use the MLE of the single equation approach to estimate the cost efficiencies for the FCS direct lending institutions, 2) Compare and contrast efficiencies among districts where institutions are highly, moderately, and not yet consolidated and among different types of institutions.

In the next section, the theoretical background of the measurement of cost efficiency will be presented. The estimation procedures for the cost efficiencies of the FCS direct lending associations for the single equation approach in the context of the cost frontier model are detailed

Table 2. Total Farm Debt, Excluding Households, December 31, 1981-92

| Year | Debt Owed to Reporting Institutions | | | | | Individuals and Others | Total Debt |
|---|---|---|---|---|---|---|---|
| | Farm Credit System | Commercial Banks | Farmers Home Administration | Life Insurance Companies | Total | | |
| | *Million Dollars* | | | | | | |
| 1981 | 61,566 | 38,799 | 20,802 | 12,150 | 133,317 | 49,064 | 182,381 |
| 1982 | 64,219 | 41,890 | 21,275 | 11,829 | 139,213 | 49,592 | 188,805 |
| 1983 | 63,708 | 45,422 | 21,427 | 11,666 | 142,223 | 48,840 | 191,064 |
| 1984 | 64,686 | 47,245 | 23,262 | 11,889 | 147,082 | 46,690 | 193,782 |
| 1985 | 56,168 | 44,470 | 24,534 | 11,270 | 136,442 | 41,150 | 177,592 |
| 1986 | 45,906 | 41,620 | 24,137 | 10,374 | 122,037 | 34,923 | 156,960 |
| 1987 | 40,026 | 41,130 | 23,552 | 9,352 | 114,060 | 30,338 | 144,399 |
| 1988 | 37,138 | 42,706 | 21,852 | 9,018 | 110,714 | 28,654 | 139,368 |
| 1989 | 36,164 | 44,794 | 18,973 | 9,051 | 108,982 | 28,202 | 137,185 |
| 1990 | 34,954 | 47,432 | 16,954 | 9,641 | 108,981 | 27,801 | 136,782 |
| 1991 | 35,356 | 50,169 | 15,212 | 9,495 | 110,232 | 28,522 | 138,754 |
| 1992 | 35,234 | 52,132 | 13,594 | 9,467 | 110,427 | 29,236 | 139,663 |
| | *Percentage Distribution of Total Debt* | | | | | | |
| 1981 | 33.8 | 21.3 | 11.4 | 6.7 | 73.1 | 26.9 | 100.00 |
| 1982 | 34.0 | 22.2 | 11.3 | 6.3 | 73.3 | 26.3 | 100.00 |
| 1983 | 33.3 | 23.8 | 11.2 | 6.1 | 74.4 | 25.6 | 100.00 |
| 1984 | 33.4 | 24.4 | 12.0 | 6.1 | 75.9 | 24.1 | 100.00 |
| 1985 | 31.6 | 25.0 | 13.8 | 6.3 | 76.8 | 23.2 | 100.00 |
| 1986 | 29.2 | 26.5 | 15.4 | 6.6 | 77.8 | 22.2 | 100.00 |
| 1987 | 27.7 | 28.5 | 16.3 | 6.5 | 79.0 | 21.0 | 100.00 |
| 1988 | 26.6 | 30.6 | 15.7 | 6.5 | 79.4 | 20.6 | 100.00 |
| 1989 | 26.4 | 32.7 | 13.8 | 6.6 | 79.4 | 20.6 | 100.00 |
| 1990 | 25.6 | 34.7 | 12.4 | 7.0 | 79.7 | 20.3 | 100.00 |
| 1991 | 25.5 | 36.2 | 11.0 | 6.8 | 79.4 | 20.6 | 100.00 |
| 1992 | 25.2 | 37.3 | 9.7 | 6.8 | 79.1 | 20.9 | 100.00 |

*Source:* Agricultural Income and Finance, Situation and Outlook Report, Economic Research Service, U.S. Department of Agriculture, Feb. 1993.

in the following section. The data needed in this study obtained from the FCA call reports are also discussed, followed by the section of results from empirical estimation of the efficiency measurements for each institution. The concluding section summarizes the major findings and results of this study. Efficiency differences between jointly and nonjointly managed institutions, currently active and dechartered institutions, and acquired and acquiring institutions also will be examined.

## The Measurement of Cost Efficiency

The economic theory of the firm assumes production takes place in an environment in which managers attempt to maximize profits by operating in the most efficient manner possible. The possibility that producers might operate inefficiently is typically ignored in modern neoclassical production theory. Early efforts in the investigation of efficiency and its measurement were made by Koopmans (1951, 1957) and Debreu. Koopmans defines a feasible input-output vector to be technically efficient if it is technologically impossible to increase any output and/or to reduce any input without simultaneously reducing at least one other output and/or increasing at least one other input.

While Koopmans offered a definition and characterization of technical efficiency, it was Debreu who first provided a measure or an index of the degree of technical efficiency with his "coefficient of resource utilization." This coefficient is computed as one minus the maximum equiproprotionate reduction in all inputs consistent with continued production of existing outputs, and from it Debreu obtained measures of the magnitude and the cost of technical inefficiency. Farrell (1957) first obtained a partial decomposition of private efficiency into technical and allocative components. Farrell also proposed indexes of technical, allocative, and overall private efficiency, the first being a direct descendent of Debreu's coefficient of resource utilization.

After Farrell's efficiency measures were developed, which were defined over a fairly restrictive technology, subsequent studies have extended or generalized the measures to cover a wide range of technologies (Färe; Färe and Lovell; Färe, Lovell, and Zieschang; Färe and Grosskopf). In this study, we consider the radial, input-induced measures of efficiency like those originally introduced by Farrell. The input-induced measures quantify the efficiency of an input vector in the production of a specified vector of outputs. Because only proportional contractions of the observed input vector are considered in the search for an efficient input vector, they are said to be radial.

The input vector x is called technically efficient for y if and only if $x \in \text{Eff } L(y)$. A technically efficient input vector $x \in \text{Eff } L(y)$ is called allocatively efficient for (y, w) if and only if $w^T x = C(y, w)$. Thus, a firm whose input vector is technically efficient for y and allocatively efficient for (y, w) minimizes the cost of producing its output, and is called cost efficient for (y, w). Note, however, there is no guarantee that the correct output mix is being chosen, given output prices. As a result, efficiency measurement with respect to the input correspondence L(y) is most reasonable in cases in which the output vector y is exogenous to the production unit.

Given these definitions of productive efficiency, the problem is to devise a framework for measuring each type of efficiency. Following Farrell, the technical efficiency (TE) of input vector $x \in L(y)$ is given by

$$TE(x; y) \equiv \min \{\lambda: \lambda x \in L(y), \lambda \geq 0\}. \tag{1}$$

The cost efficiency (CE) of input vector $x \in L(y)$ is given by

$$CE(x; y, w) \equiv C(y, w)/w^T x \tag{2}$$

and the allocative efficiency (AE) of input vector $x \in L(y)$ is given by

$$AE(x; y, w) = CE(x; y, w)/TE(x; y). \tag{3}$$

The notions of cost, technical, and allocative input inefficiencies are illustrated in Figure 1. Assume that a firm uses two inputs, available at fixed prices, $x_1$ and $x_2$ to produce a single output, y. Let QQ' be the isoquant depicting various efficient combinations of two inputs which can be used to produce a specific level of output, $y_0$. The isoquant further to the right (left) corresponds to higher (lower) levels of output. For a given set of input prices, the isocost line, WW', represents the various combinations of inputs which generate the same level of expenditures. Isocost lines further to the right (left) correspond to higher (lower) level of expenditures on inputs.

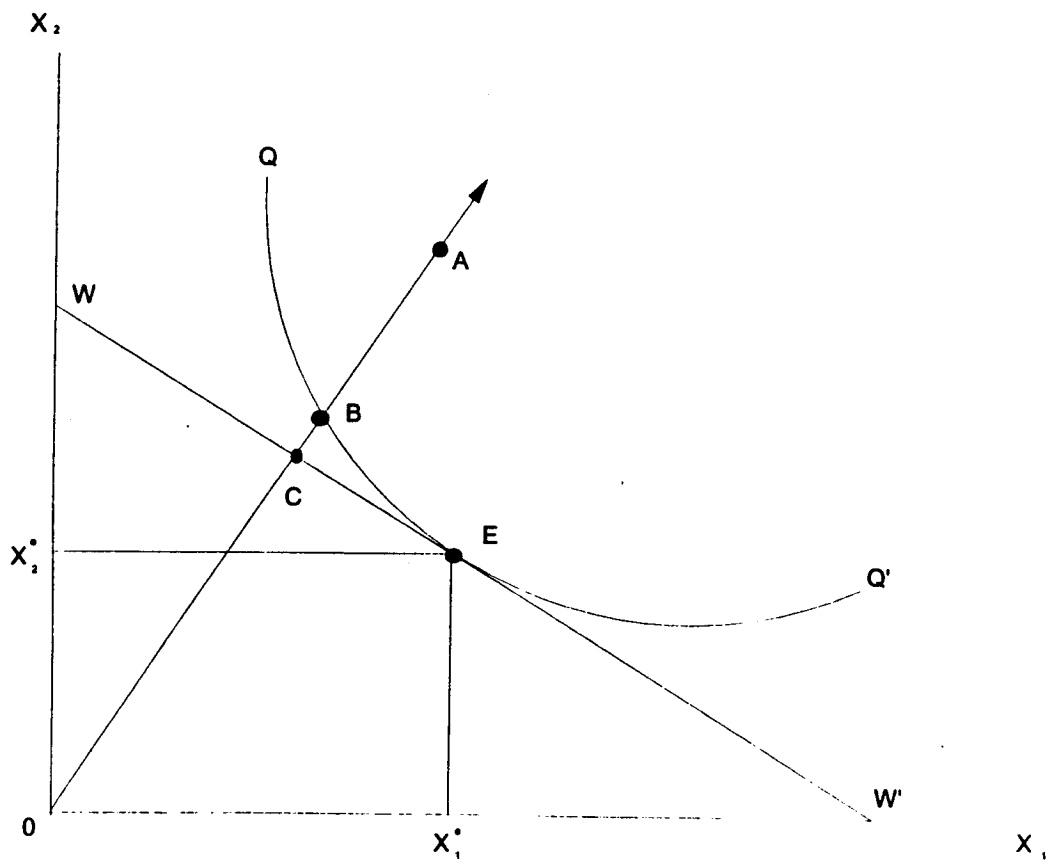


Figure 1. Farrell Efficiency Measurement Using the Input Correspondence

For a firm to produce $y_0$ at minimum cost, the optimal input combination is at point E. That is, given factor prices, output $y_0$ can be optimally produced by employing $x_1^*$ units of inputs $x_1$ and $x_2^*$ units of input $x_2$. Any other combination of the inputs along the WW' isocost line would generate less output for the same cost. Alternatively, the production of $y_0$ using any combination of inputs except for that corresponding to point E would cost more. Therefore, at Point E, input efficiency exists. Suppose that the observed input usage of a firm to produce $y_0$ is at point A. Clearly, the firm is inefficient because it operates above the isoquant for its observed level of output. The firm could contract its input usage along the ray OA to the point B and still produce $y_0$ units of output. Point B represents the minimum input vector that retains the input mix and output level associated with the firm at point A. Thus, the firm could contract its input vector by a factor OB/OA and suffer

no loss of output while realizing a cost savings. The measure OB/OA, which gives the fraction of observed level of output, provides an index of technical efficiency as:

$$TE(x, y) = OB/OA. \tag{1'}$$

Technical efficiency ranges from 0 to 1. A firm observed operating on the isoquant would have a technical efficiency score of 1. Values less than 1 reflect technical inefficiency.

For this sample example, we also can depict allocative inefficiency resulting from producing at point A. Scaling its inputs back to point B would make the observed firm technically efficient, but its costs would still be above the cost minimizing level given by the optimal input mix at point E. Point C represents a level of costs equal to that of the efficient production process at point E because it is on line WW'. Point B corresponds to an output level equal to $y_0$ because it is on isoquant QQ'. Therefore, the distance CB corresponds to additional production expenses resulting from the suboptimal allocation of inputs. That is, allocative inefficiency exists because we are not on the isocost line, WW'. Formally, OC/OB is a measure of allocative efficiency as:

$$AE(x, y, w) = OC/OB. \tag{3'}$$

OC/OB shows the fraction by which the firm could reduce input usage and, thus, cost to achieve minimum cost. Allocative efficiency also ranges from 0 to 1. A firm observed operating at point of tangency between the isoquant and the isocost curve would have an allocative efficiency score of 1. Values less than 1 reflect allocative inefficiency. Also note that the greater the curvature of the isoquant is (i.e., the less substitutable inputs are), the greater the gap between point B and C would be, and hence the more costly would be any given deviation from the optimal input mix.

Given that the isocost line depicts total expenditures used in production, distance CA is a less than optimal usage of all inputs and corresponds to additional production expenses. Therefore, cost input efficiency is measured as OC/OA. It is the ratio of the minimum possible cost and the observed cost of producing a given level of output and is the product of the two subcomponents, technical and allocative efficiency:

$$CE(x, y, w) = OC/OA = OB/OA \bullet OC/OB. \tag{2'}$$

## Estimation Procedures and Data

Based on economic theory, the cost function or the production function uniquely defines the technology. Thus, either the cost function or the production function can be incorporated into the productive efficiency analysis and is normally called the cost frontier and production frontier approach, respectively. However, as pointed out by Kumbhakar (1989), estimation of the production function directly poses two possible problems. First, estimation of the production function directly is appropriate only when inputs can be treated as exogenous. Thus, input demand functions are assumed to be independent to the technical inefficiency of the firm. If outputs are exogenous and inputs are endogenous, direct estimation of the production function using output as the dependent variable is inappropriate. Second, direct estimation of the production function considers only technical inefficiency. Inferences about the overall economic efficiency can not be made unless allocative efficiency is considered.

One of the major advantages of the cost function approach is consistent estimates of the parameters can be obtained if output is exogenous, which is one of the basic behavioral assumptions behind cost minimization. As mentioned before, only the single cost function approach will be considered in this study. Single equation approach has been used by Murray and White; Gilligan and Smirlock; Kim; Goldstein, McNulty, and Verbrugge; Shaffer and David; Goldberg, Hanweck, Keenan, and Young; Ellinger and Neff; and Mester. The cost function used in this study

is the translog cost function that can be viewed as a local, second-order approximation to an arbitrary cost function and has been used extensively in the literature.

We will start the specification of the translog cost function as follows by suppressing the firm and time subscripts:

$$\ln TC^Z = \alpha_0^Z + \sum_{i=1}^{n} \alpha_i^Z \ln w_i^Z + \sum_{k=1}^{m} \beta_k^Z \ln y_k^Z + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij}^Z \ln w_i^Z \ln w_j^Z$$
$$+ \frac{1}{2}\sum_{k=1}^{m}\sum_{l=1}^{m} \delta_{kl}^Z \ln y_k^Z \ln y_l^Z + \sum_{i=1}^{n}\sum_{k=1}^{m} \theta_{ik}^Z \ln w_i^Z \ln y_k^Z + \varepsilon^Z, \tag{4}$$

where, $\alpha$'s, $\beta$'s, $\gamma$'s, $\delta$'s, and $\theta$'s are parameters to be estimated with $\gamma_{ij} = \gamma_{ji}$ and $\delta_{kl} = \delta_{lk}$, the TC is the total production costs, the $w_i$'s are the n input prices, and $y_k$'s are the m outputs, and Z is the type of association representing PCA, ACA, and FLCA. The restrictions of the linear homogeneity in factor prices for the cost function are imposed as:

$$\Sigma\, \alpha_i = 1,\ \ \Sigma\, \gamma_{ij} = 0, \text{ and } \Sigma\, \theta_{ik} = 0. \tag{5}$$

Following Aigner, Lovell, and Schmidt; and Meeusen and van den Broeck, the error term, $\varepsilon_{ft}$, is composed of two different types of disturbances:

$$\varepsilon_{ft} = u_f + v_{ft} \tag{6}$$

where $u_f$ is one-sided distributed, $u_f \geq 0$, which represents inefficiency and $v_{ft}$ is a stochastic variable that represents uncontrolled random shocks in the production process.

The MLE will be used to estimate equation (4) to obtain the cost frontier and the associated inefficiency measurement for each institution. To estimate equation (4) by the MLE technique, we need to derive the probability density function (pdf) of the composed error term, $\varepsilon_{ft} = u_f + v_{ft}$, first. The distributional assumptions on the composed error are: $u_f$ is i.i.d. one-sided distributed with half-normal density function

$$h(u) = \frac{2}{\sqrt{2\pi}\,\sigma_u} \exp\{-\frac{u^2}{2\sigma_u^2}\},\ u \geq 0; \tag{7}$$

$v_{ft}$ is i.i.d. with mean zero and variance $\sigma_v^2$, $u_f$ and $v_{ft}$ are independent.

Let g(v) be the density function of $v_{ft}$. Following Pitt and Lee; and Maddala (p.195), the joint pdf $f(\varepsilon_{ft})$ of $\varepsilon_{ft}$ can be defined as follows:

$$f(\varepsilon_{ft}) = \frac{2}{\sigma}\, \phi(\frac{\varepsilon_{ft}}{\sigma})\, [\, 1 - \Phi(\frac{\varepsilon_{ft}\lambda}{\sigma})\, ], \tag{8}$$

where, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \sigma_u / \sigma_v$, and $\phi(\bullet)$ and $\Phi(\bullet)$ are the density function and distribution function of the standard normal, respectively. Then the log-likelihood function for the pooled data is

$$\ln L = \frac{FT}{2} \ln \frac{2}{\pi} - FT \ln \sigma - \frac{1}{2\sigma^2} \sum_{f=1}^{F}\sum_{t=1}^{T} \varepsilon_{ft}^2 + \sum_{f=1}^{F}\sum_{t=1}^{T} \ln [\, \Phi(\frac{\varepsilon_{ft}\lambda}{\sigma})\, ]. \tag{9}$$

The above model can be estimated by the maximum likelihood techniques. After the model is estimated, the efficiency measurement for each institution can be obtained from the conditional mean or mode of $u_f$ given $\varepsilon_{ft}$. Jondrow, Lovell, Materov, and Schmidt have shown that the distribution of $u_f$ conditional on $\varepsilon_{ft}$ is a normal distribution truncated at zero. The mean or mode of $u_f$ given $\varepsilon_{ft}$ is then expressed as follows, respectively:

$$E\ (\ u_i|\varepsilon_{it}\ ) = (\frac{\sigma_u\sigma_v}{\sigma})[\ \frac{\phi(\frac{\varepsilon\lambda}{\sigma})}{\Phi(\frac{\varepsilon\lambda}{\sigma})} + \frac{\varepsilon\lambda}{\sigma}\ ], \tag{10}$$

$$M(\ u_i|\varepsilon_{it}\ ) = \frac{\sigma_u^2}{\sigma_v^2}\ \varepsilon_{it},\ \text{if}\ \varepsilon_{it} \geq 0;\ \text{otherwise zero.} \tag{11}$$

Given the availability of panel data, Kumbhakar has shown that the mean or mode of $u_i|\varepsilon_{it}$, a point estimator of $u_i$, is unbiased and consistent as $t \rightarrow \infty$. In this study, we choose the conditional mean of $u_i$ given $\varepsilon_{it}$ as the inefficiency estimate for each FCS institution by evaluating equation (10) at the estimates of $\sigma_u^2$ and $\sigma_v^2$.

The Data

Data needed in estimating the cost function and, thus, the cost efficiency include total costs, outputs, and input prices for each institution at each time period. In bank efficiency analysis, two approaches exist for defining inputs, outputs, and costs. The production approach views banks as production units. Loans and deposits are treated as outputs using labor, capital, and other inputs to produce them. Operating cost is the only cost considered. Intermediation approach, on the other hand, views banks as the institutions that intermediate funds into loans. It views the dollar volume of loan and deposits as the outputs, while the costs included are operating costs and interest costs. For cooperative FCS institution, the intermediation approach seems to be more appropriate than the production approach because one of the major functions of the FCS institutions is to channel lower cost of credit to members of the association.

Following Collender, outputs considered in this study are accrual and nonaccrual loans. Inputs include labor, physical capital, other operating expenses, and interest costs of borrowed funds. The price of labor is approximated by dividing total labor expenses (salary and benefit expense, director expense) by total liabilities for each institution. The price of physical capital is approximated by dividing occupancy and equipment expenses by the average book value of fixed assets. The price of other operating expenses is approximated by dividing total other operating expenses by the total liabilities. The price of interest expenses is approximated by dividing interest expenses by total liabilities. These data are obtained from the FCA call reports by each institution. To account for the seasonality characteristic of agricultural loans, especially those short-term operating loans, quarterly data with time series running from 1988Q1 through 1992Q4 are used in this study. The end-user computer package, TSP, is used to perform the MLE.

## Empirical Results

Parameter and Efficiency Estimates

The MLE parameter estimates for PCA, ACA, and FLCA are presented in Table 3. As shown, more than half of the parameter estimates for the PCA are significant at one percent level, while slightly less than half of the MLE estimates for the ACA are significant at one percent level. Most parameter estimates for the FLCA are surprisingly not significant at five percent level. Because of its lengthy report, the efficiency estimate for each association and its associated ranking will not be presented here but are available from the authors. However, some general findings are summarized as follows. First, the efficiency measurement for individual PCA ranges widely from 0.5807 of one PCA to 0.9714 of another PCA both in the Texas District. The PCA with the 0.5807 efficiency measurement is the least efficient because it is now in liquidation. Second, the efficiency measurement for each ACA also ranges widely, from 0.6432 of one ACA in the St. Paul District to 0.9934 of an ACA in the Baltimore District. The ACA with the efficiency measurement of 0.6432 is not currently active. The efficiency measurement for each FLCA ranges from 0.8065 for a FLCA in

**Table 3. MLE Parameter Estimates of the Translog Cost Function**

| | PCA | | ACA | | FLCA | |
|---|---|---|---|---|---|---|
| Variable | Parameter Estimater | Standard Error | Parameter Estimate | Standard Error | Parameter Estimate | Standard Error |
| LY1 | 0.4011 | 0.0685* | 0.6527 | 0.1282* | -0.2967 | 0.5755 |
| LY2 | 0.2187 | 0.0350* | 0.2790 | 0.0681* | 0.2639 | 0.1868 |
| LW1 | -0.5106 | 0.1642* | -1.7201 | 0.1658* | 1.5854 | 1.2591 |
| LW2 | 0.5576 | 0.0625 | -0.5417 | 0.1316* | 0.3029 | 0.3943 |
| LW3 | 0.2396 | 0.1632 | 0.2259 | 0.1847 | -0.9023 | 1.3118 |
| LW4 | 0.3947 | 0.2647 | -0.5245 | 0.4127 | 1.0745 | 0.9413 |
| LY1W1 | 0.0744 | 0.0101* | 0.0179 | 0.0156 | -0.0692 | 0.0937 |
| LY1W2 | -0.0134 | 0.0036* | -0.0207 | 0.0122*** | -0.0146 | 0.0334 |
| LY1W3 | 0.0173 | 0.0074* | -0.0100 | 0.0135 | -0.0260 | 0.1224 |
| LY1W4 | 0.0129 | 0.0144 | -0.0349 | 0.0235 | 0.0538 | 0.0622 |
| LY2W1 | -0.0442 | 0.0055* | 0.0094 | 0.0093 | 0.0005 | 0.0247 |
| LY2W2 | -0.0004 | 0.0016 | 0.0049 | 0.0055 | 0.0041 | 0.0079 |
| LY2W3 | -0.0033 | 0.0041 | 0.0061 | 0.0054 | -0.0107 | 0.0309 |
| LY2W4 | 0.0128 | 0.0067*** | 0.0348 | 0.0114* | 0.0067 | 0.0246 |
| LY1Y1 | 0.1329 | 0.0030* | 0.0184 | 0.0149 | 0.0906 | 0.0903 |
| LY1Y2 | -0.0522 | 0.0017* | -0.0064 | 0.0055 | -0.0263 | 0.0129** |
| LY2Y2 | 0.0267 | 0.0012* | 0.0085 | 0.0014* | 0.0038 | 0.0102 |
| LW1W1 | -0.0562 | 0.0273** | -0.0576 | 0.0294*** | 0.1212 | 0.2206 |
| LW1W2 | 0.0016 | 0.0106 | -0.0987 | 0.0168* | 0.0230 | 0.0549 |
| LW1W3 | 0.0599 | 0.0171* | 0.0038 | 0.0271 | -0.0294 | 0.2274 |
| LW1W4 | -0.0385 | 0.0292 | -0.2340 | 0.0367* | 0.0080 | 0.1764 |
| LW2W2 | -0.0056 | 0.0035 | -0.0017 | 0.0157 | 0.0041 | 0.0232 |
| LW2W3 | -0.0044 | 0.0080 | 0.0064 | 0.0153 | -0.0036 | 0.0743 |
| LW2W4 | -0.0079 | 0.0133 | -0.0518 | 0.0253** | 0.0087 | 0.0532 |
| LW3W3 | 0.0626 | 0.0123* | 0.0321 | 0.0269 | -0.1291 | 0.2618 |
| LW3W4 | -0.1028 | 0.0352* | -0.0448 | 0.0368 | -0.0705 | 0.1850 |
| LW4W4 | 0.1974 | 0.0541* | 0.0889 | 0.0827 | 0.3034 | 0.1347** |
| $1/\sigma$ | 7.1273 | 0.2082* | 11.3642 | 0.2488* | 8.7960 | 1.0716* |
| $\lambda$ | 1.9588 | 0.2064* | 5.0205 | 0.7292* | 1.8347 | 0.7476* |
| Constant | 0.8696 | 0.6771 | -6.8608 | 1.1405* | 9.5693 | 3.8077* |
| $\sigma_v^2$ | | 0.0041 | | 0.0003 | | 0.0030 |
| $\sigma_u^2$ | | 0.0156 | | 0.0074 | | 0.0100 |
| Log of Likelihood Function | | 1621.95 | | 1273.92 | | 220.76 |

* Statistically significant at one percent level, ** Statistically significant at five percent level, *** Statistically significant at 10 percent level.

the St. Paul District to 0.9741 for a FLCA in the St. Louis District. Both of them are currently located in the Agribank District, a result of the mergers of St. Paul and St. Louis Districts in 1992.

Efficiency Comparisons

While the efficiency estimate of each association above helps us understand the efficiency performance of each firm relative to those of the others, it also provides us a basis to conduct several efficiency comparisons of interest. In this section, the efficiency differences among types of associations, among districts, and between associations with different characteristics are compared and contrasted using the efficiency estimates of the MLE.

*Efficiency Differences Among Types of Associations*

The PCAs are authorized to make short term loans directly to association members, while those FLBAs authorized to make the long term loans directly to members of the associations will become the FLCAs. The ACAs are the combined services of the PCAs and the FLCAs in which both long and short term loans are made directly to members of the associations. It may be of interest to see if efficiency differences exist between or among PCA, ACA, and FLCA.

Table 4 presents the average cost efficiency estimates of the MLE by each farm credit district and type of association. As shown, the total average efficiency estimates of the ACA are higher than those of the PCA and FLCA using either all sample associations or currently active associations. The all sample associations include all chartered or dechartered associations during 1988Q1 to 1992Q4, while the currently active associations are those currently chartered associations only. By examining average cost efficiency estimates for each district, we found that only ACA efficiency estimates for St. Paul and Spokane and Western districts are lower than those of PCA or FLCA using all sample associations and currently active associations, respectively. Both total and district average efficiency estimates of the MLE suggest that FLCA is more efficient than PCA using all samples or currently active associations.

*Efficiency Differences Among Districts*

While the restructuring of the farm credit associations is still under way, each farm credit district has been experiencing different impact and structural change. As of January 1, 1993, PCAs are active in the Omaha, Wichita, and Texas districts only, while ACAs are active in the Springfield, Baltimore, Columbia, Louisville, and Spokane districts only. Loans made by the above districts are highly specialized through single type of association. Two districts, Western and Agribank districts, are diversified in loan services in which the PCAs, ACAs, and FLCAs are all active in both districts. Thus, in terms of channelling loans to members of the associations, three groups are categorized: districts with PCAs only, districts with ACAs only, and districts with PCAs, ACAs, and FLCAs. In this section, the district efficiency differences within and between groups will be compared and contrasted first.

As shown in the lower panel of Table 4, for districts that channel loans to members directly through PCAs only, MLE efficiency estimates show little difference in the cost efficiency for all four districts, with Texas being the least efficient. For districts that channel loans through ACAs only, Springfield and Baltimore are most efficient, followed by Columbia, Louisville, and Spokane districts. For districts with all types of associations being active, PCAs in the Western district are found to be more efficient than Agribank district. ACAs in the Agribank district are found to be more efficient than those of Western, while results of the FLCA show little difference between these two districts.

**Table 4. Average Cost Efficiency Estimates for Each Farm Credit District**

| District | PCA | ACA | FLCA |
|---|---|---|---|
| All Sample Associations: | | | |
| Springfield | 0.9110 | 0.9601 | - |
| Baltimore | 0.9124 | 0.9567 | - |
| Columbia | 0.8272 | 0.9449 | - |
| Louisville | 0.9122 | 0.9396 | 0.9340 |
| Jackson | 0.9202 | - | - |
| St. Louis | 0.8732 | - | 0.9158 |
| St. Paul | 0.8803 | 0.8762 | 0.8823 |
| Omaha | 0.9231 | - | - |
| Wichita | 0.9177 | - | - |
| Texas | 0.9133 | - | - |
| Western | 0.9144 | 0.8923 | 0.9383 |
| Spokane | 0.8103 | 0.7659 | - |
| Agribank | 0.8922 | 0.9433 | 0.9398 |
| Total Average | 0.8950 | 0.9345 | 0.9267 |
| Currently Active Associations Only: | | | |
| Springfield | - | 0.9604 (N=11) | - |
| Baltimore | - | 0.9522 (N=16) | - |
| Columbia | - | 0.9450 (N=19) | - |
| Louisville | - | 0.9390 (N=5) | - |
| Jackson | 0.9202 (N=2) | - | - |
| St. Louis | - | - | - |
| St. Paul | - | - | - |
| Omaha | 0.9231 (N=1) | - | - |
| Wichita | 0.9200 (N=11) | - | - |
| Texas | 0.9112 (N=16) | - | - |
| Western | 0.9122 (N=13) | 0.8904 (N=4) | 0.9382 (N=9) |
| Spokane | - | 0.7659 (N=1) | - |
| Agribank | 0.8902 (N=20) | 0.9433 (N=10) | 0.9399 (N=18) |
| Total Average | 0.9082 (N=63) | 0.9431 (N=66) | 0.9393 (N=27) |

Comparing efficiency estimates between groups of districts, in general, we find that PCAs in those districts with multi-loan-channels such as Western and Agribank districts are less efficient than those districts with single-loan-channel such as Wichita, Texas, Omaha, and Jackson districts. ACAs in those districts with single loan channel are also found to be more efficient than those with

several loan channels, with a few exceptions. Results above suggest that districts specializing in loan services are more efficient than districts with diversified loan services.

Second, the degree of the consolidation between associations is different in each district. For example, PCAs in the Omaha and Jackson districts have been highly consolidated into one and two associations, respectively. PCAs in the Wichita, Western, Texas, and Agribank districts are moderately or less consolidated in which numbers of PCAs are 11, 13, 16, and 20, respectively. Districts with highly consolidated ACAs include Spokane, Western, and Louisville with one, four, and five ACAs, respectively. Districts with moderately or less consolidated ACAs are Agribank, Springfield, Baltimore, and Columbia districts with 10, 11, 16, and 19 ACAs, respectively. Western district FLCAs are moderately consolidated in which nine are active currently, while Agribank district has 18 FLCAs and is considered less consolidated. The efficiency difference between districts with different degrees of consolidation is examined next.

As shown in the lower panel of Table 4, in general, districts with highly consolidated PCAs such as Omaha and Jackson are more efficient than districts with moderately or less consolidated PCAs. Districts with highly consolidated ACAs are less efficient than moderately or less consolidated districts. With FLCAs being moderately consolidated, cost efficiency of the Western district is found to be little different from the Agribank district with less consolidated FLCAs.

*Efficiency Differences Between Associations with Different Characteristics*

Other than the efficiency differences among types of associations and among districts, comparisons of efficiencies for associations with different management characteristics also may be of interest. For example, it may be interesting to see if associations currently active are more efficient than associations already dechartered. We should expect that associations currently active are more efficient than those already dechartered. Several associations are authorized by the FCA to be jointly managed such that they are at the same office and building and share the incurred operating costs. It may be of interest to see if the associations with joint management status are more efficient then those without nonjoint management. Last, the mergers between or among farm credit associations have been ongoing for years, it is of major concern to association managers and policy makers to see if mergers between or among associations have resulted in efficiency gains. Thus, the efficiency differences between acquired and acquiring associations also will be examined in this section.

As shown in Table 5, as expected, currently active PCAs, ACAs, and FLCAs are found to be more efficient than those already dechartered. However, jointly managed PCAs and FLCAs are not found to be more efficient than nonjointly managed PCAs and FLCAs. The efficiency gains or losses of mergers are not obvious. As shown, the cost efficiencies of the acquired and acquiring PCAs are not much different with the acquired PCAs slightly higher than that of the acquiring PCAs. The cost efficiency of the acquired and acquiring ACAs also show little difference with acquiring ACAs slightly higher than acquired PCAs.

## Conclusions

The cooperative FCS has been undergoing substantial structural changes for years. The Agricultural Credit Act of 1987 and the increasing competition from the commercial banks are the major contributions to these changes. As a result, the FCS institutions are in a situation where their success depends on their ability to adapt and operate more efficiently in the new environment. In this study, the cost efficiency of each FCS direct lending institution is estimated using the single equation stochastic cost frontier approach. Efficiency differences among types of associations, among districts, and between associations with different characteristics are compared and contrasted.

**Table 5. Efficiency Comparisons Between Associations with Different Characteristics**

| | Number of Observations | Average Efficiency |
|---|---|---|
| PCA: | | |
| All Sample Associations | 210 | 0.8950 |
| Currently Active Associations | 63 | 0.9082 |
| Dechartered Associations | 147 | 0.8884 |
| Jointly Managed Associations | 37 | 0.9009 |
| NonJointly Managed Associations | 33 | 0.9164 |
| Acquired Associations | 23 | 0.9171 |
| Acquiring Associations | 14 | 0.9162 |
| ACA: | | |
| All Sample Associations | 90 | 0.9345 |
| Currently Active Associations | 66 | 0.9431 |
| Dechartered Associations | 24 | 0.9044 |
| Jointly Managed Associations | - | - |
| Nonjointly Managed Associations | - | - |
| Acquired Associations | 5 | 0.9711 |
| Acquiring Associations | 2 | 0.9781 |
| FLCA: | | |
| All Sample Associations | 47 | 0.9267 |
| Currently Active Associations | 27 | 0.9393 |
| Dechartered Associations | 20 | 0.9096 |
| Jointly Managed Associations | 22 | 0.9399 |
| Nonjointly Managed Associations | 5 | 0.9635 |
| Acquired Associations | - | - |
| Acquiring Associations | - | - |

Results show that, first, the efficiency estimates for PCAs and ACAs range widely. The least efficient PCA is only 58.07 percent efficiency of the efficiency of the best practice firm, while the least efficient ACA is only 64.32 percent efficiency of the efficiency of the best practice firm. Second, comparisons among different types of associations show that ACA providing both long- and short-term loan services are, in general, more efficient than PCA and FLCA providing only short- and long-term loan service, respectively. The result above suggests that associations providing a complete and coordinated set of short- and long-term credit services to members may be the direction for the future restructuring. On average, FLCA is found to be more efficient than PCA. Third, cost efficiencies are not much different for districts channelling loans to members directly through PCAs only. Springfield and Baltimore districts are the most efficient for districts channelling loans through ACAs only. For districts with all types of associations active, PCAs in the Western district are found to be more efficient than those in the Agribank district, while ACAs in the Agribank district are found to be more efficient than those of Western district.

Fourth, districts specializing in loan services are found to be more efficient than districts with diversified loan services. Districts with highly consolidated PCAs are more efficient than districts with moderately or less consolidated PCAs. This result supports the recent movement of most or all of PCAs in several districts being restructured into a single district-wide PCA. However, districts with highly consolidated ACAs are not found to be more efficient than moderately or less consolidated districts. The unexpected result above suggests that the operations of the newly created ACAs may not have adjusted to be as effective as those of PCAs whose operations have been in existence since the establishment of the FCS. Last, efficiency comparisons between different characteristics show that, as expected, currently active associations are more efficient than those already dechartered associations. Jointly managed PCAs and FLCAs are not found to be more efficient than those of nonjointly managed. The impact of association mergers on efficiency show undetermined results in which acquired PCAs are slightly more efficient than acquiring PCAs, while acquiring ACAs are slightly more efficient than acquired ACAs.

## References


Aigner, D.J., C.A.K. Lovell, and P. Schmidt. "Formulation and Estimation of Stochastic Frontier Production Function Models." *Journal of Econometrics* 6(1977):21-37.

Bauer, P.W., A.N. Berger, and D.B. Humphrey. *Inefficiency and Productivity Growth in Banking: A Comparison of Stochastic Econometric and Thick Frontier Methods.* Working paper 9117, Federal Reserve Bank of Cleveland, 1991.

Berger, A.N., D. Hancock, and D.B. Humphrey. "Bank Efficiency Derived from the Profit Function." *Journal of Banking and Finance* 17(1993):317-47.

Berger, A.N. and D.B. Humphrey. "The Dominance of Inefficiencies over Scale and Product Mix Economies in Banking." *Journal of Monetary Economics* 28(1991):117-48.

Collender, R.N. "Production Economies and Inefficiencies in the Farm Credit System." Paper presented at the AAEA annual meetings in Baltimore, MD, August 8-12, 1991.

Collender, R.N., R. Nehring, and A. Somwaru. *Profit Efficiency of Farm Credit System Associations.* U.S. Dept. of Agriculture, ERS, Nov. 1991.

Debreu, G. "The Coefficient of Resource Utilization." *Econometrica* 19(1951):273-92.

Ellinger P.N. and D.L. Neff "Issues and Approaches in Efficiency Analysis of Agricultural Banks." *Agricultural Finance Review* 53(1993):82-99.

Evanoff, D.D. and P.R. Israilevich. "Deregulation, Cost Economies and Allocative Efficiency of Large Commercial Banks." *Issues in Financial Regulation* Federal Reserve Bank of Chicago Working paper 90-19, 1990.

Färe, R. "Efficiency and Production Function." *Zeitschrift für Nationalökonomie* 35(1975):317-24.

Färe, R. and C.A.K. Lovell. "Measuring the Technical Efficiency of Production." *Journal of Economic Theory* 19(1978):150-62.

Färe, R., C.A.K. Lovell, and Zieschang, K. "Measuring the Technical Efficiency of Multiple Output Production Technologies." *Quantitative Studies on Production and Prices*, W. Eichhorn, R. Henn, K. Neumann, and R.W. Shephard, eds. Würzburg and Vienna: Physica-Verlag, 1983.

Färe, R. and Grosskopf, S. "Measuring Output Efficiency." *European Journal of Operational Research* 13(1983):173-79.

Farrell, M.J. "The Measurement of Productive Efficiency." *Journal of the Royal Statistical Society* Series A., General, 120(1957):253-81.

Ferrier, G.D. and C.A.K. Lovell. "Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence." *Journal of Econometrics* 46(1990):229-45.

Gilligan, M.W. and M.L. Smirlock. "An Empirical Study of Joint Production and Scale Economies in Commercial Banking." *Journal of Banking and Finance* 8(1984):67-77.

Goldberg, L.G., G.A. Hanweck, M. Keenan, and A. Young. "Economies of Scale and Scope in the Securities Industry." *Journal of Banking and Finance* 15(1991):91-107.

Goldstein, S.J., J.E. McNulty, and J.A. Verbrugge. "Scale Economies in the Savings and Loan Industry before Deregulation." *Journal of Economics and Business* 39(1987):199-207.

Jondrow, J., C.A.K. Lovell, I.S. Materov, and P. Schmidt. "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model." *Journal of Econometrics* 19(1982):233-38.

Kim, H.Y. "Economies of Scale and Economies of Scope in Multiproduct Financial Institutions: Further Evidence from Credit Union." *Journal of Money, Credit, and Banking* Vol. 18, No.2 (1986):220-26.

Koopmans, T.C. "An Analysis of Production as an Efficient Combination of Activities." *Activity Analysis of Production and Allocation*, T.C. Koopmans, ed., Cowles Commission for Research in Economics. Monograph No. 13, New York: John Wiley and Sons, Inc., 1951.

_____. *Three Essays on the State of Economic Science.* New York: McGraw Hill Book Co., 1957.

Kumbhakar, S.C. "Production Frontiers and Panel Data: An Application to U.S. Class 1 Railroads." *Journal of Business & Statistics* Vol. 5, No.2 (1987):249-55.

Maddala, G.S. *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge University Press, 1983.

Meeusen, W. and J. van den Broeck. "Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error." *International Economics Review* 18(1977):435-44.

Mester, L.J. "Efficiency in the Savings and Loan Industry." *Journal of Banking and Finance* 17(1993):267-86.

Murray, J.D. and R.W. White. "Economies of Scale and Economies of Scope in Multiproduct Financial Institutions: A Study of British Columbia Credit Unions." *The Journal of Finance* Vol 38, No. 3 (1983):887-902.

Pitt, M.M. and L.F. Lee. "The Measurement and Sources of Technical Inefficiency in the Indonesian Weaving Industry." *Journal of Development Economics* 9(1981):43-64.

Schmidt, P. "Frontier Production Functions." *Econometric Reviews* Vol. 4, No.2, (1986):289-328.

Shaffer, S. and E. David. "Economies of Superscale in Commercial Banking." *Applied Economics* 23(1991):283-93.