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Providing supervised agricultural credit on subsidized terms has been one program frequently used by governments to improve the efficiency of the farm sector or a targeted subset of farmers. While program objectives and farm eligibility requirements differ, most programs operate on the premise that greater availability of credit and management advice will improve farm productivity and income. The Farmers Home Administration (FmHA) is a program of this nature which has been operating since 1946.

The basic eligibility requirement for receiving a farm loan from FmHA is that borrowers are unable to obtain credit from commercial sources on satisfactory terms. Assuming lenders use economically rational criteria in dispensing credit, this infers that the FmHA borrowers would likely be those having inadequate repayment capacity, weak financial structure, inadequate collateral, or other related deficiencies. One factor which is likely to be associated with these criteria is the overall efficiency of the operation. For example, an inefficient operation leads to low repayment capacity, through time to weak financial structure and inadequate collateral as debts accumulate and capital investment slows. This implies that one appropriate measure for evaluating the effectiveness of the FmHA program is to examine the efficiency of FmHA borrowers.

The major objective of this study is to measure the overall efficiency of FmHA borrowers who operate cash grain farms and compare their efficiency to a peer group of farmers in an area of southern Illinois. Rejection of the null

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hypothesis that overall efficiency of FmHA borrowers is equal to the peer group of farmers implies that the credit market was able to distinguish between efficient and inefficient farms.

A considerable body of literature concerning FmHA exists but most describes FmHA programs and characteristics of borrowers rather than directly focusing on the overall efficiency of farms financed with FmHA credit. David and Meyer discuss difficulties of measuring the impact of agricultural credit programs on resource allocation and farm efficiency. However, they indicate, "efficiency gap models are appealing, and future analysis might be extended to estimate loan impact on farm production or income." A recent study of this nature by Taylor, Drummond and Gomes estimated a full frontier production function to calculate technical and allocative efficiency of two samples of farms in an area of Brazil. One sample consists of participants of a credit program while the other sample was composed of nonparticipants. Their empirical results indicated that credit programs had no effect on technical efficiency of participants; however, a negative effect on allocative efficiency of the borrowers was found.

In addition to measuring the overall efficiency of a sample of FmHA borrowers compared to a sample of other farmers who are not likely to be receiving FmHA credit, we investigated the relationship between overall efficiency of FmHA borrowers and selected borrower, farm, and financial characteristics.

Measuring Overall Efficiency

Farrell was the first researcher who proposed a definitional and computational framework for measuring efficiency. He decomposed efficiency into two components, technical and allocative efficiency. Technical efficiency is defined as the ability of a producing agent to employ the "best practice in an industry" such that not more than the necessary amount of a given set of inputs is used in producing a level of output. Allocative efficiency is defined as the choice of the optimum combination of inputs consistent with relative factor prices.

Since Farrell, a body of literature has been developed to propose approaches in calculating efficiency through frontier models. The models resulting from these studies include nonparametric frontier models (Farrell; Fare et al. 1985), parametric frontier models (Aigner and Chu; Timmer), the deterministic statistical frontier models and stochastic frontier models (Aigner et al, Meensen and van den Broeck).

Among these models nonparametric models are of interest, because these models do not impose any functional form on data, they avoid statistical restrictions arising from multicolinearity and, as pointed out by Fare and Grosskopf, these models allow one to relax the assumption of the production technology being a continuously twice differentiable production function. However, since this approach is not statistical, no possibility exists to test for statistical significance.

Source of Data and Model

We consider two groups of cash grain farmers located in 14 counties of southern Illinois: FmHA borrowers and a peer group of cash grain farmers. The data on FmHA borrowers were collected from files at FmHA offices. The data consist of information on 98 cash grain farms in 1984. The peer group of farmers was selected randomly from the Illinois Farm Business Farm Management Service (FBFMS). They were located in the same counties as the FmHA borrowers.

The variables used in this study to estimate the frontier are denoted and defined as follows: a) Total value of output (Y) includes the sale of crops plus the value of crops used on the farm plus or minus changes in inventory. b)

Land (L) includes the number of crop acres cultivated by the farmer. It excludes pasture, woods, waste and other non-cropped land. c) Labor (N) measures the total number of months of labor available on the farm. The variable includes hired and as well as family labor. d) Equipment input (K) measures the total annual machinery and equipment cost incurred in the process of production. It includes depreciation, machinery hired, fuel, oil, and repairs. e) Chemical inputs (C) includes the dollar value of the fertilizer, pesticides, spray material and other chemical inputs used in the production process. f) Seeds (S) is designed to measure the dollar value of seed used in production. Hence the data set can be summarized as follows:

$$X = \begin{bmatrix} N_1 & K_1 & C_1 & S_1 & L_1 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ N_n & K_n & C_n & S_n & L_n \end{bmatrix} \qquad Y = \begin{bmatrix} y_1 \\ \cdot \\ \cdot \\ \cdot \\ y_n \end{bmatrix}$$

We pool the sample of FmHA borrowers and the peer group of farms in 1984, and calculate an overall efficiency index for each individual farm defined as

$$OAE = y_j/y_j*$$

where y_j is observed gross income of farm j and y_j* is optimal value of gross income of farm j given all observations on gross income and inputs. More specifically, y_j* is the solution of the following linear program:

$$\text{Max } y_j* = Y'z$$

$$\text{s.t.}$$

$$X'z \leqq xj$$

$$z \geq 0$$

where X is input matrix, z is a vector of intensity parameters and x_j is column j of matrix X' indicating the input set utilized by farm j.

The programming solution determines the maximum gross income obtainable from the inputs used by the jth farm based on a subset (5 or less) of the most efficient farms included in the data set. If no other farm or combination of farms is as efficient as the jth farm then the maximum value of gross income equals the actual value of gross income and overall efficiency index is one for the jth farm.

Besides capturing differences in efficiency due to technology, managerial ability and scale of inputs, the efficiency index also reflects differences due to location factors such as weather and soil productivity. By designing the sample to include an equal number of peer farms as FmHA farms from each county and by removing obvious outliers, it was assumed that any differences in efficiency between the FmHA group and the peer group was due to technical, managerial or scale efficiency and not due to locational factors.

After calculating the overall efficiency index for 196 farmers, we test the hypothesis that the overall efficiency of FmHA borrowers is no different compared to that of the peer group of farms in 1984. Next we examine the relationship between the overall efficiency index of FmHA borrowers and selected operator, farm and financial characteristics.

The Overall Efficiency of FmHA Borrowers Compared to a Peer Group of Farmers

The entire group of FmHA borrowers and peer farmers produced output which was on average 57 percent of their potential output in 1984. As a group the FmHA borrowers' average efficiency was 53.5 percent and the peer group of farmers averaged 61.2 percent of the potential, Table 1. Potential output, actual output and output lost are also shown for the two groups of farmers.

To determine whether the data presents sufficient evidence to indicate a difference in the indices of efficiency between the two groups we apply two tests. One tests for differences between means and the other tests for differences between medians.[1] The result of both tests indicated significant differences between the two groups at the 1 percent significant level. Based on the above two tests we can conclude that the data provides evidence to indicate that in 1984 the means and medians of overall efficiency indices of the two populations--FmHA borrowers and the peer group of farmers--are not the same and the overall efficiency index for FmHA borrowers is shifted to the left of the relative frequency of distribution for the peer group of farmers. This indicates that farmers who obtained credit in 1984 from FmHA were on average less efficient than the peer group of farmers.

The Relationship Between the Overall Efficiency Index and Selected Characteristics of FmHA Borrowers

A second the objective of the study was to examine the association between the overall efficiency index and farm and operator characteristics. For this

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[1]Differences between means:

$$H_o : \mu_1 = \mu_2$$

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$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_1}\right)^{\frac{1}{2}}}$$

Differences between medians:

$$H_o : M_1 = M_2$$

$$H_1 : M_1 = M_2$$

$$Z = \frac{U - (n_1 n_1/2)}{\frac{n_1\ n_2(n_1 + n_2 + 1)^{\frac{1}{2}}}{12}}$$

$$\text{such that } U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - T_1$$

where T_1 = sum rank of the peer group's efficiency index part of the study we calculated a production frontier based entirely on FmHA borrowers. This frontier function, composed entirely of FmHA borrowers, lies below that derived from the pooled sample. Correlation coefficients between selected characteristics and the efficiency index for the sample of FmHA borrowers are shown in Table 2. In addition, the average value of each characteristic for three categories of FmHA borrowers grouped by their overall efficiency index is also shown in Table 2. Several observations can be made.

1. The highest correlation is between net return and the efficiency index. Average net farm returns range from a negative amount in the low efficiency group to $34,200 in the most efficient group. The reverse side of this positive correlation is the high negative correlation of the ratio of expenses to value of output with the efficiency index.

   Assuming a 5 percent debt amortization requirement, we estimate that the net cash flow of the efficient-operators was enough to service average debt of $278,000 and still leave about $20,000 for family living. However, for either of the other two efficiency groups, if one assumes a modest $12,000 is required for family living, there would be inadequate cash to retire debt.

2. The correlation coefficient indicates larger farms tend to be more efficient than smaller farms. This observation holds whether size of business is measured by total assets, equity, value of output or acres of cropland. While it is noted that lower ratios of the value of output to interest expense are associated with low efficiency and higher ratios with high efficiency, we believe this association is more related to scale than to the effects of finance charges.

3. While their is no correlation between the farmer's debt/asset ratio and the efficiency index, one observes that the debt/asset ratio is higher for farmers in the lowest and highest efficiency groups and lowest for those in the middle efficiency group. Though the differences in the average debt/asset ratio between efficiency groups are not large, the observed results conform to our understanding of the effects of leverage. High debt/asset ratios are beneficial (high net income) when the efficiency of the firm is good and act as a deterrent (in this case, negative net return) when high leverage is associated with firms having poor efficiency.

   Additional but related evidence (not shown in table 2) that credit plays a different role among efficient and inefficient farmers is the correlation between the amount of total debt outstanding with net income within each efficiency group. Among farms in the most efficient group, increased amounts of total debt was not significantly associated with net income. However, among inefficient FmHA borrowers, larger amounts of total debt had a negative correlation coefficient (-.46) with net income and this association was significant at the 2 percent level of probability.

   Further indication that the firm's financial structure interacts with efficiency and contributes to varying degrees of financial stress is the ratio of owned to total acres. Though not statistically significant, the group of farms with the lowest efficiency, on average owned relatively more of the land they operated than did farms with higher efficiency.

4. Finally, it is noted that the number of years of education of the operator had a positive correlation with the efficiency index. However, it was only significant at the 10 percent level of probability.

Conclusion

The conclusion we draw from this study is that farmers who obtained credit from the FmHA in 1984 were on average less efficient than a peer group of farms. However, we note that the peer group are members of the Illinois FBFMS, a group who are generally regarded as performing at least at average productivity levels. Nevertheless, based on this comparison, our evidence indicates that on the whole farm lenders distinguished between borrowers in a way which resulted in FmHA providing credit and associated services to a group of farm borrowers it was designed to serve.

However, the study also indicates that in 1984 FmHA provided credit to a number of efficient farms as well as to some inefficient farms. This suggests that FmHA needs to reevaluate loan eligibility requirements in order to reduce the number of borrowers at either end of the efficiency spectrum. This should be beneficial as it appears that some of the efficient units were eligible to receive credit from commercial sources while some of those having low efficiency have a low probability of becoming commercially viable without an unusually large commitment of public resources.

A feature which may modify this conclusion is that FmHA policies in the early 1980's were relaxed so as to accomodate a larger number of financially stressed farmers. This probably contributed to the wide range in efficiency and profitability levels observed among FmHA borrowers. Currently, policies require borrowers to meet more stringent cash flow requirements and permit loan liquidation which had previously been temporarily prohibited. With firmer criteria in effect, it is likely that an analysis of FmHA borrowers in 1986 would contain relatively fewer borrowers at the lower end of the efficiency spectrum.

The last part of the paper indicates that efficiency and net farm income are strongly correlated. We also found positive correlation between overall efficiency and various measures of size of business. Finally we observed that farms with low efficiency and having high debt/asset ratios were under more financial stress than those of higher efficiency.

We believe this approach is a potentially useful way to examine credit programs and borrowers. We plan to extend this analysis by examining efficiency as related to scale and by examining whether participation in the FmHA program through time changes the overall efficiency of FmHA borrowers relative to the peer group.

Table 1. Average Potential Output, Actual Output and the Overall EFficiency Index for FmHA Borrowers and the Peer Group of Farmers, 1984.

Item	Pool Sample	FmHA	Peer Group of Farmers
Number of Observations	196	98	98
Potential Output	$162,286	$147,308	$177,265
(Standard Deviation)	(85,527)	(77,971)	(90,401)
Actual Output	94,814	80,197	109,431
(Standard Deviation)	(65,799)	(56,932)	(70,928)
Output Lost	67,472	67,111	67,834
(Standard Deviation)	(49,516)	(47,239)	(51,934)
Efficiency Index	.573	.535	.612
(Standard Deviation)	(.219)	(.222)	(.210)

Table 2. Selected Characteristics of FmHA Borrowers Grouped by the Farms' Overall Efficiency Index and the Correlation Between Characteristics and Farm Efficiency

	Farm Efficiency Index Group			All FmHA Borrowers	
Item or Characteristic	Less than 40%	40% to 59.9%	60% and over	All Efficiency Levels	Correlation Coefficient Between Efficiency Index and Characteristic
Number of Farms	26	34	38	98	N.A.
Average Efficiency (%)	30	49	81	56	N.A.
Total Assets ($000)	250	335	485	371	.28**
Total Debts ($000)	143	174	278	206	.24*
Net Worth ($000)	107	161	207	165	.21*
Debt/Asset (%)	66	53	64	61	-.00
FmHA Debt Outstanding ($000)	44	37	96	62	.26*
Value of Output ($00)	316	726	1203	802	.66**
Expenses ($00)	452	634	861	673	.39**
Net Return ($00)	-136	92	342	129	.71**
Nonfarm Income ($00)	- 97	92	82	90	-.09
Acres of Cropland	356	525	637	524	.31**
Acres Owned/Total Acres (%)	45	32	35	36	-.12
Expenses/Value of Output (%)	1.44	.84	.74	.96	-.63**
Value of Output/Interest Expense	5.7	8.6	12.0	9.2	.25*
Years of Education	11.5	11.6	12.1	11.7	.18

*Significant at 5 percent level of probability.
**Significant at 1 percent level of probability.

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