Characteristics of Highly Efficient Farms

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Abstract

A sample of Kansas farms was used to examine the relationship between overall efficiency and farm characteristics. Overall efficiency was significantly related to operator age, farm size, and farm type. Approximately 26.7% of the farms were in the top one-third overall efficiency category for more than half of the sample period.

Introduction

Production costs and profitability vary considerably among farms and ranches. The profitability of farms has been examined thoroughly in past research (Fox, Bergen, and Dickson). Numerous studies have focused on the magnitude, determinants, and causal relationships of cost control and profitability. However, few studies have examined the persistency of performance over time.

Langemeier, Haley, and DeLano examined the consistency of wheat enterprise performance for Kansas farms. From 19% to 26% of the farms, depending on the category and region of the state, were in the top one-third cost and profit categories for 4 or more of the 6 year sample period. Research that examines a longer period of time, and the relationship between consistent performance and farm characteristics is needed.

The objective of this paper is to examine the relationship between overall efficiency and farm characteristics such as operator age, farm size, and farm type for a sample of Kansas farms. The paper will also examine how many years each farm was in the top one-third and bottom one-third overall efficiency categories and the relationship between persistence in overall efficiency and farm characteristics.

Conceptual Framework

Data envelope analysis (DEA) and stochastic frontier methods can be used to estimate relative efficiency (Coelli, Rao, and Battese). Stochastic frontier methods effectively account for noise and can be used to conduct hypotheses tests. DEA does not require the specification of a functional form for the production and cost functions, and can more effectively account for multiple outputs.

The DEA approach developed by Fare, Grosskopf, and Lovell and implemented by Chavas and Aliber was used in this study. Technical, allocative, scale, and overall efficiencies can be derived with this approach. Technical efficiency measures whether a farm is producing on the production frontier. Allocative efficiency measures whether a farm is using the cost-minimizing input mix for a given output, and scale efficiency measures whether a farm is producing at the most efficient size. Overall efficiency is the product of technical, allocative, and scale efficiencies. The discussion below provides a summary of how each efficiency measure was computed.

Technical efficiency under variable returns to scale (VRS) was computed by solving the following linear program for each observation or farm:

$$\text{Min } 1_j \tag{1}$$

subject to:

$$Xz \# 1_j x_j$$

$$y№z > y_j$$

$$z_1 + z_2 + ... + z_n = 1$$

$$z_j \, 0 \, U^+$$

where 1_j , a scaling variable used to adjust an input bundle to efficient scale for a fixed output level, represents technical efficiency for the jth wheat producer; X is a matrix of input levels for each farm; x_j is the jth producer's input levels; z represents a column vector of variable weights; y is a column vector of fixed output levels; and y_j is output for the jth wheat producer.

Allocative efficiency (AE_j) indices were computed using the following equation:

$$AE_j = (CM_j^{\,v})/(C_j \;\; TE_j) \tag{2}$$

where C_j is the actual cost of production for the jth producer, and CM_j^v is minimum cost to produce y_j

under VRS. CM_j^v was derived by solving the following linear program for each farm:

$$\text{Min } CM_j^v = w_j' \theta_j \qquad (3)$$

subject to:

$$Xz \leq \theta_j$$

$$y'z > y_j$$

$$z_1 + z_2 + ... + z_n = 1$$

$$z_j \in \Re^+$$

where w_j is a column vector of input prices paid by the j[th] producer, and θ_j is a cost-minimizing input bundle for the j[th] producer. The VRS were imposed by constraining the sum of z's (z-sum) to equal 1.

Scale efficiency (SE_j) measures were calculated by minimizing total cost under CRS and scaling the result using minimum cost under VRS:

$$SE_j = CM_j^c / CM_j^v \qquad (4)$$

Minimum cost under CRS (CM_j^c) was obtained using model (3) with the z-sum unconstrained.

Overall efficiency (OE_j) was derived from TE, AE, and SE:

$$OE_j = TE_j \times AE_j \times SE_j \qquad (5)$$

To determine the relationship between overall efficiency and farm characteristics, each efficiency measure (technical, allocative, scale, and overall efficiency) was first computed using average input, output, and cost information for 24 years, 1973 to 1996. The relationship between overall efficiency and farm characteristics was then explored using Tobit analysis. Farm characteristics used in the analysis included operator age, farm size, and farm type. Mixed enterprise farms were used as the default farm type.

To examine the persistency of overall efficiency, each efficiency measure was computed for each year in the sample period. Farms were then separated into top one-third, middle one-third, and bottom one-third overall efficiency categories. The number of years each farm was in the top one-third and bottom one-third overall efficiency categories were used as persistence measures. Tobit analysis was used to examine the relationship between persistence and operator age, farm size, and farm type.

Judge et al. suggest using the likelihood ratio test statistic as a summary and goodness of fit measure for qualitative and limited dependent variable models. Thus, the likelihood ratio test statistic was reported for each Tobit regression.

Kansas Farm Management Data

Data for 195 farms in the Kansas Farm Management Associations with continuous data from 1973 to 1996 were used in this study. These 195 farms represented approximately 7.1% of the total farms enrolled in the Kansas Farm Management Associations in 1996.

Data from the Kansas Farm Management Associations were well suited for examining relative overall efficiency. Income and expense information was available for each farm. Income was expressed on an accrual basis and could be separated into seven categories: grain income (corn, sorghum, wheat, and other small grains), hay and forage income, cash crop income (soybeans and sunflowers), beef income (income from cow/calf, backgrounding, and finishing operations), dairy income, swine income, and other income (income not included in the other six categories). Livestock income was reported on a value-added basis.

Three expense categories were used: labor, purchased inputs, and capital expenses. Labor included hired and unpaid operator labor. Purchased inputs included fuel, utilities, seed, crop insurance, fertilizer, lime, herbicide, insecticide, feed, services, and marketing expenses. Capital included repairs, machine hire, conservation, interest, rent, taxes, general farm insurance, and depreciation. Interest charges on land were computed using the rent to value ratio for dryland, irrigated land, and pasture in Kansas and individual farm land values. Interest charges on intermediate assets were computed using asset values and interest rates. Following the procedures of the Kansas Farm Management Associations, a flat labor charge per operator ($22,500 in 1996) and a management charge of 5% of gross farm income were used to compute unpaid operator labor and management charges.

Table 1 presents the averages and standard deviations of selected production and financial characteristics for the sample of farms. All financial variables are converted to 1996 dollars using the implicit price deflator for personal consumption expenditures (U.S. Department of Commerce). Average gross farm income was $244,570. Of this amount, $149,609 was derived from crops and $94,962 was derived from livestock. Farm types were computed by examining the percent of income derived from various sources. For a farm to be a particular type, over 50% of gross farm income had to be derived from one source. Crop production was the most common farm type followed by mixed enterprise farms (farms that did not derive over 50% of their income from crops, beef, dairy, or swine).

Results

Overall Efficiency

The distribution of the four efficiency measures computed using average input, output, and cost information is presented in Table 3. Overall efficiency averaged 0.565. Thus, on average, cost could have been reduced by 43.5% if all of the farms were producing on the cost frontier at the constant returns to scale level. Approximately 11.3% of the farms had an overall efficiency index above 0.80 and 2 of the farms were overall efficient. Farms with an overall efficiency index less than 1 could have been technically, allocatively, and/or scale inefficient.

Table 4 presents the regression results examining the relationship between efficiency, and age of operator, farm size, and farm type. All of the regression variables except the swine farm type were significant for at least one of the efficiency measures.

Age of operator was negatively related to overall efficiency suggesting that older operators were less overall efficient than younger operators. Farm size (gross farm income) was positively related to overall efficiency. Beef farms were less overall efficient, and crop and dairy farm were more overall efficient than the mixed enterprise farm type.

Persistence of Overall Efficiency

The persistence of overall efficiency is presented in Table 4. Approximately 27.2% of the farms were in the bottom one-third overall efficiency category for 13 or more of the 24 years. Approximately 11.8% of the farms were in this category for 20 or more years. Approximately 12.8% of the farms were not in the bottom one-third overall efficiency category for any of the 24 years.

Approximately 26.7% of the farms were in the top one-third overall efficiency category for 13 or more of the 24 years. Approximately 12.3% of the farms were in this category for 20 or more years and 5 farms were in this category for each of the 24 years. On the low end of the distribution, 32 of the 195 farms were not in the top one-third overall efficiency category for any of the 24 years.

The results in Table 4 suggest that it is possible, even given the wide fluctuations in weather over time, for farms to be consistently good performers. It is also important to note that some farms have a difficult time staying out of the bottom one-third overall efficiency category. These farms are consistently poor performers.

Table 5 presents the Tobit regressions examining the relationship between persistence in overall efficiency, and age of operator, farm size, and farm type. Gross farm income was positively related to the number of years in which a farm was in the top one-third overall efficiency category and negatively related to the number of years a farm was in the bottom one-third overall efficiency category. Beef farms tended to be poor performers while crop and dairy farms tended to be good performers.

Conclusions and Implications

This study examined the overall efficiency and persistence of overall efficiency for a sample of Kansas farms. Overall efficiency was significantly related to operator age, farm size, and farm type. Younger operators, larger farms, and crop and dairy farms tended to be relatively more overall efficient.

Approximately one-fourth of the farms were in the top one-third overall efficient category for 13 or more of the 24 years. Another one-fourth of the farms were in the bottom one-third overall efficiency category for 13 or more of the 24 years. Thus, there does seem to be a quite a bit of persistence in cost efficiency rankings over time. This result strengthens the results of studies that use only a few years when conducting efficiency analyses.

Table 1. Summary Statistics for a Sample of Kansas Farms.

Variable	Unit	Average	Standard Deviation
Income Measures			
Crop Income	$	149,609	112,390
Livestock Income	$	94,962	109,366
Gross Farm Income	$	244,570	156,779
Cost Measures			
Labor	$	41,461	25,402
Purchased Inputs	$	91,444	73,150
Capital	$	120,800	71,716
Total Expenses	$	253,705	160,247
Farm Characteristics			
Age of Operator	No.	52.33	7.33
Beef Farms	%	12.31	32.94
Dairy Farms	%	4.10	19.89
Swine Farms	%	4.10	19.89
Crop Farms	%	64.10	48.09
Mixed Enterprise Farms	%	15.38	36.17

Notes: Data constructed from 1973-1996 continuous data records maintained by sample farms participating in the Kansas Farm Management Associations program. All financial variables are converted to 1996 dollars.

Table 2. Efficiency Measures for a Sample of Kansas Farms.

Variable	Efficiency Measures			
	Technical	Allocative	Scale	Overall
Summary Statistics				
Average	0.733	0.910	0.847	0.565
Standard Deviation	0.173	0.084	0.142	0.178
Distribution of Farms				
Less than 0.30	0	0	1	6
0.30 to 0.40	3	0	0	33
0.40 to 0.50	13	0	4	38
0.50 to 0.60	35	1	5	47
0.60 to 0.70	40	2	25	25
0.70 to 0.80	33	23	27	24
0.80 to 0.90	29	40	35	14
0.90 to 1.00	17	119	96	6
1.00	25	10	2	2

Table 3. Tobit Regression Analysis of Relationships Between Efficiency and Farm Characteristics.

Variable	Efficiency Measures			
	Technical	Allocative	Scale	Overall
Intercept	0.880042***	0.967351***	0.573651***	0.527845***
	(0.097618)	(0.055279)	(0.057986)	(0.083083)
Age of Operator	-0.003301**	0.000271	-0.001304	-0.003381***
	(0.001503)	(0.000851)	(0.000891)	(0.001278)
Gross Farm Income	-6.482 E-07***	-4.834 E-07***	1.857 E-06***	5.470 E-07***
	(2.258 E-07)	(1.285 E-07)	(1.340 E-07)	(1.917 E-07)
Gross Farm Income Squared	6.156 E-13**	5.181 E-13***	-1.764 E-12***	-5.702 E-13**
	(2.700 E-13)	(1.550 E-13)	(1.600 E-13)	(2.290 E-13)
Beef	-0.025291	-0.012667	-0.079464***	-0.080242**
	(0.039861)	(0.022818)	(0.023895)	(0.034261)
Dairy	0.602435***	0.072952**	0.032569	0.402654***
	(0.088472)	(0.034473)	(0.035350)	(0.050557)
Swine	0.045612	-0.035615	-0.037053	-0.022226
	(0.057759)	(0.032994)	(0.034660)	(0.049695)
Crop	0.191656***	0.008784	0.073100***	0.192634***
	(0.029745)	(0.016974)	(0.017803)	(0.025514)
Likelihood Ratio Test Statistic	112.26***	23.30***	194.64***	143.20***

Notes: Numbers in parentheses are standard errors. Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Persistence of Overall Efficiency.

	Number of Farms in Overall Efficiency Category	
Number of Years	Bottom One-Third	Top One-Third
0	25	32
1	21	22
2	14	12
3	9	6
4	14	11
5	13	13
6	13	8
7	6	6
8	4	11
9	10	6
10	4	6
11	5	5
12	4	5
13	5	5
14	5	2
15	1	4
16	4	1
17	5	6
18	2	5
19	8	5
20	8	5
21	7	6
22	2	6
23	4	2
24	2	5

Table 5. Tobit Regression Analysis of Relationship Between Persistence in Overall Efficiency and Farm Characteristics.

	Overall Efficiency Category	
Variable	Bottom One-Third	Top One-Third
Intercept	11.69590***	2.59273
	(3.71955)	(4.60599)
Age of Operator	0.10619*	-0.10852
	(0.05725)	(0.07101)
Gross Farm Income	-3.110 E-05***	2.643 E-05**
	(8.607 E-06)	(1.100 E-05)
Gross Farm Income Squared	3.515 E-11***	-2.742 E-11**
	(1.030 E-11)	(1.260 E-11)
Beef	5.91038***	-4.02233*
	(1.52400)	(2.08456)
Dairy	-17.68009***	19.39090***
	(3.26096)	(2.80652)
Swine	0.39869	0.44275
	(2.20086)	(2.79670)
Crop	-8.08979***	9.06965***
	(1.13513)	(1.43852)
Likelihood Ratio Test Statistic	150.10***	147.86***

Notes: Numbers in parentheses are standard errors. Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% levels, respectively.

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