Journal of Agricultural and Applied Economics, 29,1(July 1997):175–184

A Nonparametric Analysis of Efficiency for a Sample of Kansas Beef Cow Farms

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ABSTRACT

Competitive pressures in the cow-calf sector increased in 1995 because of a decline of 27% in calf prices. Technical, allocative, and scale efficiency measures were used to examine the competitiveness of a sample of Kansas beef cow farms. On average, the farms were 78% technically efficient, 81% allocatively efficient, and 95% scale efficient. Enterprise profitability was correlated positively with the efficiency measures. Inefficiency was related to herd size and degree of specialization. Producers should focus on using capital, feed, and labor more efficiently rather than increasing their size. Increased concentration of the cow-calf sector will not result in large cost savings given the current technology.

Key Words: beef cow, industry structure, nonparametric efficiency.

The industrialization of agricultural production has had a large impact on many agricultural sectors, as confirmed by recent published research. Drabenstott documented the significant changes that have occurred in the broiler, egg, turkey, and processed vegetable and fresh vegetable sectors. Rhodes reported that the hog sector is moving rapidly toward industrialized production. In their recent study of the industrialization of the beef sector, Feuz and Ward found that concentration in the cattle sector varies by stage of production. The cattle sector is industrialized at the finishing level, with the 25 largest firms marketing 31.2% of the fed cattle; however, the cattle sector is much less concentrated at the cow-calf level, with the largest 25 firms holding less than 1% of beef cow inventories (Feuz and Ward). According to the *1992 Census of Agriculture* (U.S. Department of Commerce), from 1974 to 1992, the size of beef cow herds changed by less than 1%, from 40.3 cows to 40.5 cows.

Although the size of the average beef cow herd has not changed dramatically, profitability remains widely variable among producers. Langemeier, McGrann, and Parker, using a sample of U.S. beef cow herds, observed that the difference in profitability between the top quartile and bottom quartile of producers is over $285 per cow. Whether these differences in profitability are due to economies of scale or to production inefficiency within the industry is not clear. Factors that may explain this difference in profitability include input usage, sale weights, death loss, and marketing and financing differences.

The drop in calf prices of 27% from January 1995 to January 1996, combined with the

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The authors would like to acknowledge the helpful comments of two anonymous journal reviewers. This is contribution no. 96-513-J of the Kansas Agricultural Experiment Station.

intense competition for the consumer's meat dollar, will make survival for high-cost producers increasingly difficult. Johnson et al. suggest that beef producers need to reduce cost to compete with poultry and pork producers. They note that two factors, production efficiency and consolidation, will be important to increasing the competitiveness of the beef sector.

The objective of this study is to examine the efficiency of beef cow production for a sample of Kansas farms. Little published research has examined the efficiency and optimal size of beef cow farms. Nonparametric methods, based on linear programming, are used in this analysis to measure efficiency. Efficiency is measured in terms of scale, allocative, and pure technical efficiency, with each farm's performance being compared to the production or cost frontier. The relationship between efficiency and profitability and the impact of farm characteristics and cost factors on efficiency also are examined.

Nonparametric Production Efficiency

Historically, production efficiency has been measured using parametric and nonparametric approaches. The parametric approach assumes a functional form and then measures the distance of observations from that estimated functional form. The parametric approach began with the use of Cobb-Douglas technology and has evolved into the use of flexible functional forms. Bauer presents an excellent treatment of the parametric approach to efficiency analysis.

An alternative method used to measure efficiency is the nonparametric approach proposed by Färe, Grosskopf, and Lovell. One of the advantages of the nonparametric approach is that it does not impose parametric restrictions on the underlying technology (Chavas and Aliber). The approach proposed by Färe, Grosskopf, and Lovell allows for the measurement of overall, allocative, pure technical, and scale efficiency.

Other studies have addressed economic efficiency in agriculture. Chavas and Aliber evaluated the efficiency of crop and livestock production in Wisconsin. They found significant linkages between financial structure of farms and their economic efficiency. Garcia, Sonka, and Yoo examined the efficiency of Illinois grain farms and found that the economic efficiency of larger farms is similar to that of moderate-sized farms. Hall and Leveen studied the efficiency of crop and vegetable farms in California. Their results indicated that a major portion of cost savings could be achieved by modest-sized farms. In his analysis of the efficiency of large-scale dairies in California, Matulich reported that almost 80% of dairy herd costs were found to be invariant to herd size. Sexton, Wilson, and Wann examined the efficiency of cotton ginning and found that capital inputs were overutilized.

Many types of nonparametric analysis are found in the literature. Some methods assume cost-minimizing behavior, whereas others assume profit-, output-, or revenue-maximizing behavior. In their study of farmers' optimizing behavior, Featherstone, Moghnieh, and Goodwin observed that behavior aligned more closely with the cost-minimization hypothesis than with the profit-maximization hypothesis. They found that the ex post optimizing behavior of 13 out of 289 farms was consistent with the profit-maximization hypothesis, whereas that of 151 farms was consistent with the cost-minimization hypothesis. Based on the work of Featherstone, Moghnieh, and Goodwin, the cost-minimization hypothesis is assumed for the current study.

Overall efficiency represents the minimum cost of producing the level of output for the ith farm (y_i), given input prices for the ith farm (w_i), and constant returns-to-scale technology (T_c). Overall efficiency is determined for each farm by the following equation:

$$(1) \qquad \rho_i = C_i(w, y, T_c)/w_i'x_i.$$

The denominator $w_i'x_i$ is the cost the ith farm incurs to produce y_i. The numerator, which is the minimum cost of producing the ith farm's output, given prices and constant returns-to-scale technology, can be determined by the following linear program:

(2) $C_i(w, y, T_c) = \text{Min } w_i'x_i$

subject to:

$$x_{11}z_1 + x_{12}z_2 + \ldots + x_{1k}z_k \leq x_{1i}$$
$$x_{21}z_1 + x_{22}z_2 + \ldots + x_{2k}z_k \leq x_{2i}$$
$$\cdots\cdots$$
$$\cdots\cdots$$
$$x_{n1}z_1 + x_{n2}z_2 + \ldots + x_{nk}z_k \leq x_{ni}$$
$$y_1z_1 + y_2z_2 + \ldots + y_kz_k - y_i \geq 0,$$

where $z_k \in \Re^+$ and measures the intensity of use of the kth farm's technology. The subscript k represents the number of farms, i denotes the farm of interest, and n is the number of inputs. The intensity variables construct the frontier technology set by choosing the best technology or combination of technologies from those observed in the sample of all farms that produce at least the output for the ith farm. The solution of the above linear programming problem can be divided by actual cost to determine overall efficiency for the ith farm.

Overall efficiency is the product of pure technical, allocative, and scale efficiency measures. Pure technical efficiency (technical efficiency) is a measure of the distance a farm is off the production function under variable returns to scale. Technical efficiency can be determined by using either an input or output orientation. The input orientation measures the proportional decrease in input variables necessary to produce the same output bundle. The output orientation measures the proportional increase in output that could be produced given the input used. Under constant returns to scale, the measure of input efficiency will be the inverse of the measure of output efficiency (Färe and Lovell). Either a primal or dual method can be used to determine efficiency measures. The primal approach is sometimes referred to as data envelopment analysis (DEA). Cloutier and Rowley used DEA to measure technical efficiency with an input orientation. Technical efficiency using an input orientation and the dual approach, λ_i, is determined by solving the following linear programming problem for each farm:

(3) $\text{Min } \lambda_i$

subject to:

$$x_{11}z_1 + x_{12}z_2 + \ldots + x_{1k}z_k \leq \lambda x_{1i}$$
$$x_{21}z_1 + x_{22}z_2 + \ldots + x_{2k}z_k \leq \lambda x_{2i}$$
$$\cdots\cdots$$
$$\cdots\cdots$$
$$x_{n1}z_1 + x_{n2}z_2 + \ldots + x_{nk}z_k \leq \lambda x_{ni}$$
$$y_1z_1 + y_2z_2 + \ldots + y_kz_k - y_i \geq 0$$
$$z_1 + z_2 + \ldots + z_k = 1.$$

The last equation in (3), which restricts the intensity vector to sum to one, allows the technology to consist of variable returns to scale instead of constant returns to scale. The farm is technically efficient if $\lambda_i = 1$, and technically inefficient if $\lambda_i < 1$.

Allocative efficiency, sometimes referred to as pricing efficiency, examines whether a farm is using the optimal input mix. Allocative efficiency (γ_i) can be determined by dividing the minimum cost under variable returns-to-scale technology by the actual cost adjusted for technical efficiency (λ_i):

(4) $\gamma_i = C_i(w, y, T_v)/w_i'\lambda_i x_i.$

The minimum cost under variable returns-to-scale technology can be found by solving the following linear programming problem for each farm:

(5) $C_i(w, y, T_v) = \text{Min } w_i'x_i$

subject to:

$$x_{11}z_1 + x_{12}z_2 + \ldots + x_{1k}z_k \leq x_{1i}$$
$$x_{21}z_1 + x_{22}z_2 + \ldots + x_{2k}z_k \leq x_{2i}$$
$$\cdots\cdots$$
$$\cdots\cdots$$
$$x_{n1}z_1 + x_{n2}z_2 + \ldots + x_{nk}z_k \leq x_{ni}$$
$$y_1z_1 + y_2z_2 + \ldots + y_kz_k - y_i \geq 0$$
$$z_1 + z_2 + \ldots + z_k = 1.$$

Allocative efficiency is determined by dividing the minimum cost from the above linear programming problem by actual cost multiplied by pure technical efficiency.

The final measure of efficiency is referred to as scale efficiency, which measures whether the farm is at the most efficient size. Scale efficiency (Θ_i) is determined by

$$(6) \qquad \Theta_i = C_i(w, y, T_c)/C_i(w, y, T_v).$$

Scale efficiency is calculated by dividing the minimum cost from model (2) by the minimum cost from model (5). Overall efficiency is the product of scale, allocative, and pure technical efficiencies. This relationship can be shown by using equations (4) and (6) and the measure of pure technical efficiency [model (3)]:

$$(7) \qquad \rho_i = \frac{C_i(w, y, T_c)}{w_i' x_i} = \Theta_i \times \gamma_i \times \lambda_i.$$

Finally, to determine whether each farm is under constant, increasing, or decreasing returns to scale, the following linear programming problem can be solved:

$$(8) \qquad C_i(w, y, T^*) = \text{Min } w_i' x_i$$

subject to:

$$x_{11}z_1 + x_{12}z_2 + \ldots + x_{1k}z_k \leq x_{1i}$$
$$x_{21}z_1 + x_{22}z_2 + \ldots + x_{2k}z_k \leq x_{2i}$$
$$\cdots\cdots$$
$$\cdots\cdots$$
$$x_{n1}z_1 + x_{n2}z_2 + \ldots + x_{nk}z_k \leq x_{ni}$$
$$y_1z_1 + y_2z_2 + \ldots + y_kz_k - y_i \geq 0$$
$$z_1 + z_2 + \ldots + z_k \leq 1.$$

The sum of the intensity variables is restricted so that it is less than 1, indicating the case of nondecreasing returns to scale. If $\Theta_i \neq 1$, and $C_i(w, y, T_c) = C_i(w, y, T^*)$, the farm is operating in a region of increasing returns to scale (decreasing average cost curve). Conversely, if $\Theta_i \neq 1$, and $C_i(w, y, T_c) \neq C_i(w, y, T^*)$, the farm is operating in a region of decreasing returns to scale (increasing average cost curve).

Data and Methods

The nonparametric methodology was applied to 195 farms in the Kansas Farm Management Association program that kept beef cow enterprise records during 1992. Enterprise data were constructed by area field personnel and staff in consultation with producers to ensure accuracy and completeness. Six inputs were used: feed, labor (paid and unpaid), capital, utilities and fuel, veterinary expenses, and miscellaneous costs. Capital costs included interest, repairs, depreciation, and machinery hired. Accrual gross income, measured on a value-added basis, was used to measure output. Any purchased cattle were subtracted from the accrual gross income variable. Farm-level prices were not collected. Following Chavas and Aliber, we assume the law of one price, i.e., that all producers faced the same relative input prices during 1992.

The total output and input variables per farm are used in the nonparametric models. The mean and standard deviation of the input and output variables on a per cow basis are presented in table 1. Feed and capital costs are the largest costs incurred on these beef cow farms. The net income per cow was −$60, indicating that these farms were not covering all of their costs. However, comparing the net income per cow with the "fixed" capital costs reveals that these farms were covering all variable costs, on average. Figure 1 shows the distribution of net income per cow. Approximately 16% (17%) of the farms had a net income per cow that was more than one standard deviation lower (higher) than the mean.

Four linear programs were solved for each of the 195 farms [models (2), (3), (5), and (8)]. Based on these results, measures of overall, allocative, pure technical, and scale efficiencies for each of the farms were calculated. In addition, we determined whether each farm was operating at constant, increasing, or decreasing returns to scale.

Tobit models were used to examine the relationship between the efficiency measures and farm characteristics. The efficiency measures were converted to inefficiency measures by subtracting each efficiency measure from 1.

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

Variable	Unit	Mean	Std. Dev.
Number of Farms	No.	195	
Number of Cows per Farm	No.	97	72
Age of Operator	Years	47	13
Gross Income per Cow	$	470	100
Feed Costs per Cow	$	261	79
Labor Costs per Cow	$	82	49
Utilities and Fuel per Cow	$	19	11
Veterinary Expenses per Cow	$	13	10
Capital Costs per Cow	$	138	46
Miscellaneous Costs per Cow	$	18	25
Net Income per Cow	$	−60	121
Gross Farm Income	$	157,007	123,864
Net Farm Income	$	44,653	46,496
Percentage of Income from Beef Cows	%	35	25
Assets	$	513,089	416,009
Percentage of Land Owned	%	36	28
Leverage	%	32	26

Note: Data constructed from 1992 beef cow enterprise records maintained by sample farms participating in the Kansas Farm Management Association program.

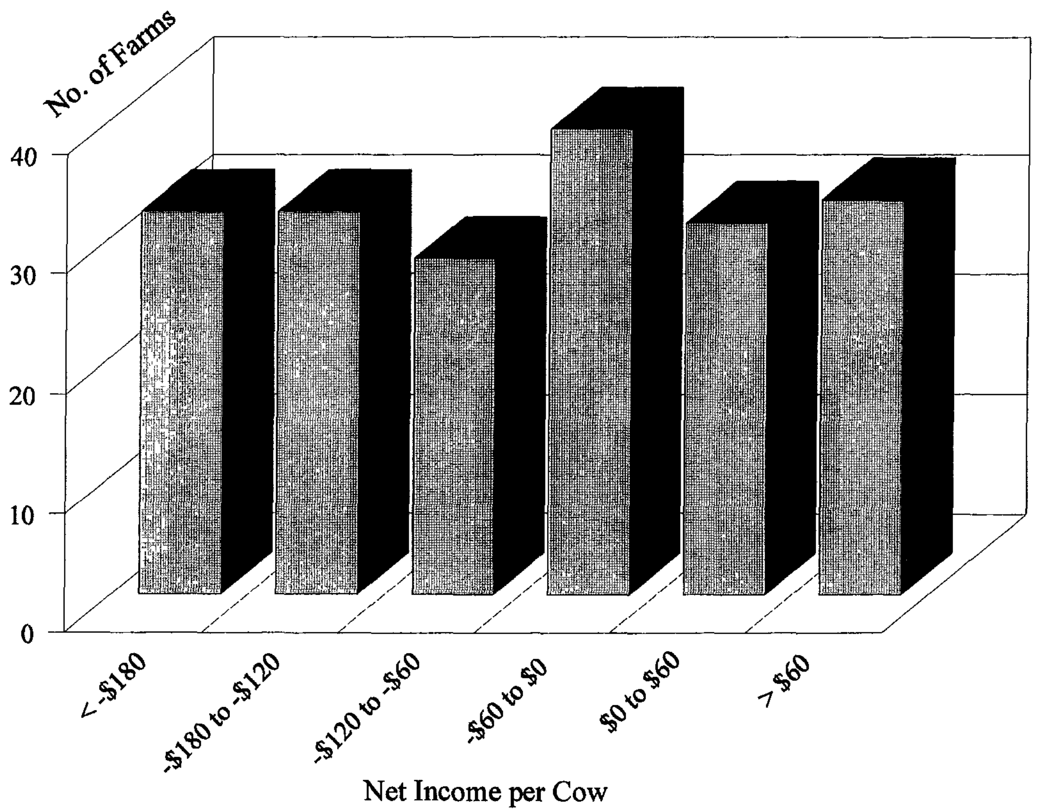

Figure 1. Distribution of net income per cow

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

	Technical	Allocative	Scale	Overall
Summary Statistics:				
Mean	0.78	0.81	0.95	0.60
Standard Deviation	0.17	0.11	0.08	0.14
Minimum	0.37	0.47	0.53	0.31
Maximum	1.00	1.00	1.00	1.00
Distribution of Farms:				
Less than 0.40	1	0	0	6
0.40 to 0.50	5	3	0	49
0.50 to 0.60	27	8	2	54
0.60 to 0.70	38	19	4	43
0.70 to 0.80	34	44	7	22
0.80 to 0.90	30	79	18	13
0.90 to 1.00	11	36	163	7
1.00	49	6	1	1

Formally, the tobit model was estimated as follows:

$$(9)\qquad IE_t = \sum_{t=1}^{n} \beta_t x_t + e_t \quad \text{if} \sum_{t=1}^{n} \beta_t x_t + e_t > 0,$$
$$= 0 \qquad \text{otherwise,}$$

where IE_t is the measure of inefficiency for each farm, x_i is an explanatory variable for the ith farm, β_i is an estimated parameter, and e_i is the normally distributed error term. The explanatory variables included the age of the operator, the number of beef cows on the farm, tenancy position, leverage, and the percentage of gross farm income from beef cow production. The tenancy position was measured by the percentage of land owned. Means and standard deviations of the explanatory variables also are found in table 1.

The relationship between profitability and efficiency was determined using correlation analysis. In addition, tobit models were estimated to examine the relative importance of each cost factor on a per cow basis measured in logarithms in explaining logged efficiency.

Efficiency Results

Overall efficiency varied across farms from 0.31 to 1 (table 2). The average overall efficiency for the beef cow herds was 0.60, indicating that, on average, the farms were inefficient. If all farms had been producing on the minimum cost frontier at constant returns to scale, the same level of output could have been produced with 40% less cost. Roughly 75% of the farms were between 50% and 80% efficient. Overall efficiency is the product of technical efficiency, allocative efficiency, and scale efficiency, and thus could be due to any of these three measures.

Technical efficiency ranged from 0.37 to 1, with an average measure of 0.78 (table 2). Thus, the output of the farms potentially could be increased by roughly 22% if each farm were purely technically efficient (i.e., if each farm operated on the production frontier). Forty-nine out of the 195 farms were technically efficient.

Allocative efficiency ranged from 0.47 to 1, with an average measure of 0.81 and a standard deviation of 0.11 (table 2). Allocative efficiencies were higher than technical efficiencies; over 60% of the farms had allocative efficiency measures greater than 80%, whereas only 48% of the farms had technical efficiency measures that were greater than 80%. Technical and allocative efficiency can be represented graphically, as shown in figure 2. The line represents the minimum cost frontier, and the stars represent the average cost per unit of output for individual farms. The difference between the average cost per farm and the cost frontier represents technical and allocative inefficiencies. The minimum average cost frontier was determined by dividing $C_t(w, y, T_v)$ in equation (5) by y_t, which is measured in total revenue. The minimum average cost occurred at a revenue of $22,743, or roughly 48 cows, using the average gross farm income per cow of $470. The minimum average cost was $14,836, or $306.60 per cow. The cost frontier drops very steeply until reaching the minimum average cost, and then flattens out. The beef cow average cost curve in figure 2 was consistent with the "L" shape found in many other studies (Hallam).

Scale efficiency ranged from 0.53 to 1, and averaged 0.95. Roughly 84% of the farms were over 90% scale efficient. Graphically,

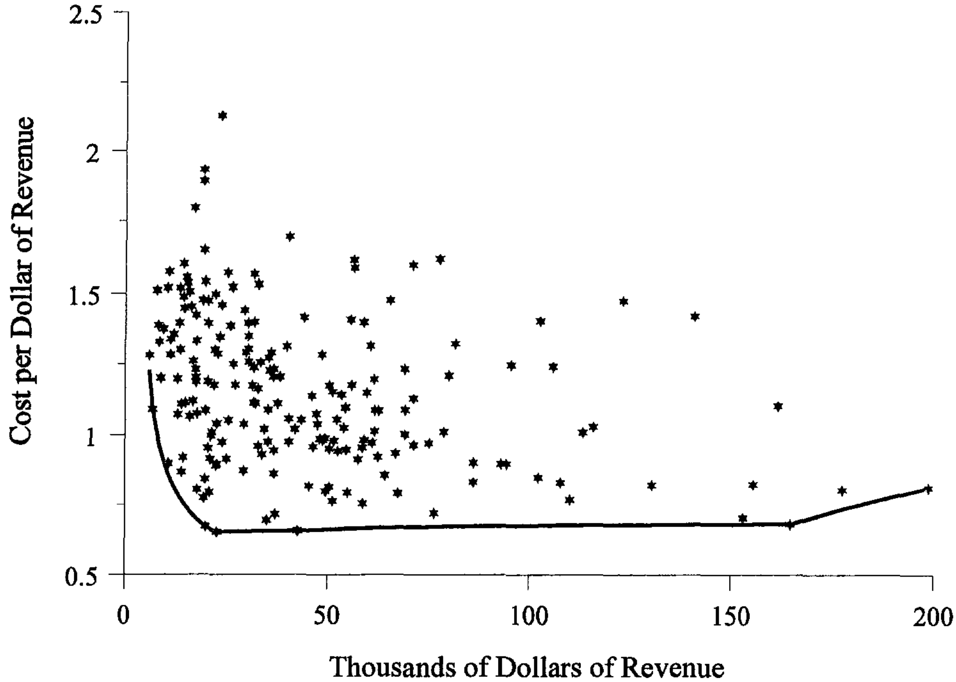

Figure 2. Kansas beef cow average cost

scale inefficiency represents the distance between a horizontal line at the minimum cost and the cost frontier depicted in figure 2. Given the flatness of the average cost curve, scale efficiency was expected to be relatively high. The results generally indicate that a greater proportion of overall inefficiency was due to farms producing above the cost frontier than to farms being of an inefficient scale. The individual analyses of the farms showed that 62 farms were operating in the region of increasing returns to scale, one farm was producing at constant returns to scale, and 132 farms were operating in the region of decreasing returns to scale.

To identify the sources of inefficiencies, tobit models regressing one minus the efficiency indices on a set of farm characteristics were used. The explanatory variables used in the model were age of operator, leverage position, number of beef cows in the herd, the percentage of income from beef cow production, and percentage of land owned.

Tobit results are presented in table 3. Size (number of beef cows), age of operator, and the degree of specialization (percentage of income from beef cows) were significant variables (at the 10% level) associated with technical inefficiency. Older farmers were technically more inefficient than younger farmers. This could be due to younger farmers adopting more efficient production methods. Specialization increased technical inefficiency, perhaps indicating that significant economies of scope may be present in beef production. That is, farms that were more diversified were more efficient than farms that were more specialized. These scope economies likely arise from the fact that most beef cow herds in Kansas are secondary enterprises which utilize excess forages and other resources that have thin markets. Larger beef cow herds were more technically efficient than smaller beef cow herds. Given the scale results, large, less technically efficient farms are able to compete with the highly efficient smaller farms.

Allocative inefficiency was not associated with any of the independent variables. Scale inefficiency was associated with size and specialization. The large farms were more scale efficient, and more specialized farms also tended to be more scale efficient.

Table 3. Relationships Among Inefficiency and Farm Characteristics

Independent Variable	Technical	Allocative	Scale	Overall
Intercept	0.0411	0.2452***	0.1008***	0.3734***
	(0.0820)	(0.0427)	(0.0290)	(0.0534)
Age of Operator	0.0026*	−0.0006	−0.0001	0.0015
	(0.0015)	(0.0008)	(0.0005)	(0.0010)
Number of Beef Cows	−0.0004*	−0.0000	−0.0002***	−0.0005***
	(0.0002)	(0.0001)	(0.0001)	(0.0002)
Percentage of Income from Beef Cows	0.1693**	−0.0296	−0.0527**	0.0457
	(0.0697)	(0.0366)	(0.0249)	(0.0457)
Leverage	0.0688	−0.0549	−0.0304	−0.0153
	(0.0658)	(0.0342)	(0.0233)	(0.0428)
Percentage of Acres Owned	−0.0497	0.0105	0.0183	−0.0218
	(0.0642)	(0.0331)	(0.0225)	(0.0413)
Likelihood Ratio Test	11.64***	4.38	22.57***	63.41***
McFadden's R^2	.175	.016	.050	.062

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

Overall inefficiency was associated most highly with farm size. Large farms were more efficient than smaller farms. Although specialization was significant in explaining technical and scale efficiencies, the effects were offsetting, leaving no relationship between specialization and overall efficiencies.

The leverage variable was not statistically significant in any of the tobit models. It was included to estimate the effects of financing decisions on productive performance. If capital markets are perfect, investment and financing decisions are independent. Given the lack of statistical significance of leverage in each of the models, our results are consistent with the perfect capital markets hypothesis. Our results conflict with those of Chavas and Aliber, who found a significant relationship between leverage and efficiency.

The tenure variable also was not significant in any of the tobit models. Our results suggest that a significant relationship does not exist between tenure and efficiency for this sample of farms.

Efficiency and Profitability

The importance of efficiency measures in explaining profitability can be examined by using correlation coefficients. Net income per cow was correlated positively with overall (0.95), pure technical (0.70), allocative (0.37), and scale efficiency (0.18). All of the above correlation coefficients are significant at the 1% level. Pure technical efficiency was relatively more important in explaining profitability than either allocative or scale efficiency. Simple regressions indicated that a 0.10 increase in pure technical efficiency increases net income per cow by $51. A 0.10 increase in allocative and scale efficiencies increases net income per cow by $40 and $27, respectively. A 0.10 increase in overall efficiency increases net income per cow by $81. Thus, efficiency measures are important in explaining profitability differences. Given these results, producers who are experiencing low or negative levels of profitability need to concentrate more on reducing input use per unit of output rather than adjusting the size of their cow herd.

The importance of each of the inputs in explaining efficiency is reported in table 4. The log of input costs on a per cow basis was regressed using tobit analysis on the log of the efficiency factors. Significant factors associated with technical efficiency include feed, labor, utilities and fuel, veterinary services, and

Table 4. Relationships Among Efficiency and Inputs Used

Independent Variable	Technical	Allocative	Scale	Overall
Intercept	2.682***	0.363*	0.257*	2.482***
	(0.406)	(0.203)	(0.151)	(0.294)
Feed	−0.319***	0.005	0.005	−0.223***
	(0.058)	(0.029)	(0.022)	(0.042)
Labor	−0.076**	−0.100***	−0.012	−0.159***
	(0.034)	(0.017)	(0.012)	(0.024)
Capital	−0.055	−0.126***	−0.057**	−0.232***
	(0.063)	(0.033)	(0.025)	(0.048)
Utilities	−0.102***	0.099***	−0.017	0.001
	(0.033)	(0.017)	(0.013)	(0.025)
Veterinary	−0.069***	0.052***	0.008	0.014
	(0.024)	(0.012)	(0.009)	(0.017)
Miscellaneous	−0.051***	0.016*	0.011	−0.010
	(0.018)	(0.009)	(0.007)	(0.014)
Likelihood Ratio Test	81.45***	66.48***	13.59**	105.44***
McFadden's R^2	.551	.289	.037	.963

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

miscellaneous costs. Because these variables are in log form, the relative importance of the independent variables in explaining efficiency can be determined directly from the tobit coefficients. Using McDonald and Moffitt's results, $\partial \ln(Y)/\partial \ln(x_i)$ is proportional to β_i. Thus, the most important factor affecting technical efficiency was feed cost.

Significant factors related to allocative efficiency include labor, capital, utilities and fuel, veterinary services, and miscellaneous. Allocative efficiency measures a movement along the isoquant. Results indicate that veterinary services and utilities tended to be underutilized, whereas labor and capital tended to be overutilized. Thus, allocative efficiency can be improved by using less labor and capital, or more utilities and fuel and veterinary services.

The only significant factor explaining scale efficiency was capital. Farms with lower capital costs per cow were more scale efficient.

Overall efficiency was explained by feed, labor, and capital costs. These three cost categories represent roughly 91% of all costs. Capital and feed costs are relatively more important than labor. Thus, to increase overall efficiency, producers should concentrate on feed and capital costs.

Concluding Remarks

The beef sector is under pressure to cut production costs. This pressure is due to the recent decline in cattle prices and the intense competition the sector is facing from the poultry and hog sectors. A major factor affecting the future structure of the cow-calf industry will be the relative efficiency of different producers. Producers who are inefficient will face pressures to reduce costs or to exit the industry. Whether or not the sector becomes more concentrated will depend upon whether inefficiency is due to economies of scale or production inefficiency.

This study used nonparametric production analysis to examine the efficiency of a sample of Kansas beef cow herds. Technical, allocative, and scale efficiencies for each of the 195 cow herds were examined. Technical inefficiency was higher than either allocative or scale inefficiency. On average, the farms were 78% technically efficient, 81% allocatively efficient, and

95% scale efficient. A majority of the farms (68%) exhibited decreasing returns to scale.

Farm characteristics such as age, tenancy, size, specialization, and leverage were regressed on each of the efficiency measures. The coefficients on the size of the cow herd and the percentage of income from beef cow production were significant in the technical and scale efficiencies analyses. Technical and scale efficiencies increased with herd size. Technical efficiency decreased as the farms became more specialized, suggesting that economies of scope may be important. Conversely, scale efficiency increased with specialization. In addition, we found that leverage and tenure did not significantly affect efficiency. Enterprise profitability was correlated positively with technical, allocative, scale, and overall efficiencies. Feed, labor, and capital costs were relatively more important in explaining overall efficiency than utilities and fuel, veterinary expenses, and miscellaneous costs. Feed costs were particularly important in explaining technical efficiency.

Most economies of scale are exhausted at a beef cow herd of only 48 cows, which is the average number of beef cows per farm in Kansas (U.S. Department of Commerce). Substantial economies of scale exist up to a herd size of 48 cows. The cost frontier is relatively flat for herd sizes greater than 48 cows. Because allocative and technical inefficiencies were more problematic for the sample of beef cow farms than scale inefficiency, producers should focus on using their inputs more efficiently rather than increasing their size. Cost differences are wider among producers of the same size than they are among producers of different sizes. Thus, these results suggest that significant concentration of the cow-calf industry will not occur, given the current technology.

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