"An Efficiency Analysis of Cattle Backgrounding in Kansas"

By

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Abstract:

Efficiency measures can be used to generate inferences about the future direction of the industry and determine factors that may influence the structure. This study evaluated relative efficiencies of Kansas backgrounding operations. Farms that engaged in the backgrounding of cattle were very inefficient. Significant improvement is needed in technology adoption and input usage.

Introduction

The livestock sector comprises approximately 40% of agriculture's contribution to Kansas' gross state product. Within the livestock sector, cattle account for over 80% of the value of all livestock production in Kansas. Consequently, fluctuating livestock profitability has a large effect on total income in the state's agricultural sector (Featherstone et al., 1996). Since cattle provide the bulk of the livestock industry's revenue, the profitability of the cattle industry has a far greater effect on aggregate returns for Kansas agriculture than returns earned by any other livestock enterprise.

Recently, great importance has been placed on the economic efficiency of agricultural production because of its role in explaining profitability differences. With the increase in industrialization in many sectors of agriculture, particularly the beef sector, individuals from all facets of the economy (i.e. consumers, producers, politicians, taxpayers, etc.) are asking what the future of agriculture will hold.

Little published research has been conducted on efficiency issues related to cattle. Most recently, Featherstone et al. (1997) published an article on the efficiency of the cow-calf industry. This is one of the first articles to look at the effect of efficiency and optimal herd size of beef cows. Their objective was to examine the efficiency of beef cow production for a sample of Kansas farms. Featherstone et al. (1997) found that if overall efficiency increased by 10% for a cow-calf herd, net income per cow increased $81. They also concluded that producers who are experiencing low levels of profitability need to concentrate on reducing input use per unit of output rather than adjusting herd size. It has been found that a major structural change, like in the feedlot sector, is not likely within the in the cow-calf sector. This is because there are no major cost and profitability differences among producers of different size. However, little research has addressed these issues for backgrounding operations. We have seen dramatic structural change in the feedlot sector and little change is likely to occur in the cow-calf sector. They question is what is going to happen to the structure of the backgrounding sector, which is the intermediary stage of production for the cattle market?

This study evaluated the relative efficiency of Kansas backgrounding operations. Specifically, technical, allocative, scale, economic, and overall efficiency for a sample of backgrounding operations will be examined. In addition, farm characteristics associated with efficiency measures were identified. Farm characteristics included: age of operator, operation size, percent of income from backgrounding, total gross farm income and total farm assets. Efficiency measures can be used to generate inferences about the future direction of the industry and determine the factors that may influence the structure of the firms in that industry (Hallam, 1989).

As the structure of the beef industry continues to change, it will become increasing more important to understand the efficiency, cost, and profitability relationships that exist in the backgrounding sector. This research will use a well-established technique (Chavas and Aliber, 1993; Rowland, 1996; Featherstone, 1997;) for evaluating efficiency for an industry that has not received much attention in literature. From this we can draw conclusions on whether it is likely that backgrounding operations in Kansas will follow the trend of feeders and begin to consolidate into large enterprises; remain relatively unchanged in size and number; or merge into existing feedlots and/or cow-calf operations.

Methods

Production efficiency in agriculture has typically focused on technical, allocative, and scale efficiency (Lau and Yotopolous, 1971; Hall and Leeven, 1978; Sidhu and Baanante, 1979; Kalirajan, 1981; Garcia et al., 1982.). The majority of these studies attempt to identify the factors influencing the efficient allocation of limited resources in agriculture. Efficiency measures have historically been quantified using parametric and nonparametric approaches. The parametric approach specifies a form of production, profit and/or cost function and fits it to the observed data by minimizing the residual distances from the estimated function (Forsund et al., 1980; Kalirajan, 1981; Garcia et al., 1982; Bauer,1990).

Several recent articles have employed the nonparametric approach to estimate efficiency in agriculture. This technique is not designed to explain actual farm behavior, but to illustrate the relationship between production costs and certain characteristics of the farm (Hall and Leeven, 1978). One main drawback of this approach is the lack of statistical inference associated with the estimates of the efficiency indexes (Chavas and Aliber, 1993). A nonparametric approach was used to measure backgrounding efficiency relative to the industry's cost and production possibility frontier. Specifically, overall efficiency, technical efficiency, allocative efficiency, and scale efficiency were measured.

Technical efficiency addresses the question of whether a firm uses the best available technology in it production process. It is considered a measure of the distance a farm is off the production function under variable returns to scale (Featherstone et al., 1997). It can be defined as the minimal proportion by which a vector of inputs ***x*** can be re-scaled while still producing outputs ***y*** (Chavas and Aliber, 1993). Technical efficiency, $8_{i,}$ can be calculated by solving the following linear program:

$$\text{Min } 8_i \quad \text{subject to:} \qquad (1)$$

$$x_{n1}z_1 + x_{n2}z_2 + \ldots x_{nk}z_k \# 8x_{ni}$$

$$y_1z_1 + y_2z_2 + \ldots y_kz_k - y_i \$ 0$$

$$z_1 + z_2 + \ldots\ldots + z_k = 1.$$

The last equation of the program restricts the intensity vector to sum to one which allows for the technology to consist of variable returns to scale. The farm is technically efficient if $8_i = 1$, and technically inefficiency if $8_i < 1$.

Allocative efficiency can be related to the ability of the firm to choose it inputs in a cost minimizing way. It reflects whether a technically efficient firm produces at the lowest possible cost (Chavas and Aliber, 1993). Allocative efficiency ($(_i$) can be determined by dividing the minimum cost under variable returns to scale technology by the actual cost adjusted for technical efficiency (8_i). This can be represented by:

$$(_i = C_i(w, y, T_v) / w_i{'}8_i\, x_{i.} \qquad (2)$$

The minimum cost under variable returns to scale technology can be found by solving the following linear program:

$$C_i(w, y, T_v) = \text{Min } w_i{'}x_i \quad \textit{subject to:} \qquad (3)$$

$$x_{n1}z_1 + x_{n2}z_2 + \ldots x_{nk}z_k \; \# \; x_{ni}$$

$$y_1z_1 + y_2z_2 + \ldots y_kz_k - y_i \; \$ \; 0$$

$$z_1 + z_2 + \ldots + z_k = 1.$$

Scale economies help assess the efficiency of farm size. It is calculated by :

$$1_i = C_i(w, y, T_c)/C_i(w, y, T_v). \qquad (4)$$

The numerator is found from the linear program in equation (3) without the last constraint and the denominator can be found using the linear program from equation (3).

Overall efficiency represents the minimum cost of producing the level of output for the i^{th} farm (y_i), given input prices for the i^{th} farm (w_i), and constant returns to scale technology (T_c) (Featherstone et al., 1997). Overall efficiency is the product of technical efficiency, allocative efficiency and scale efficiency and can be defined as:

$$D_i = C_i(w, y, T_c) / w_i{'}x_i. \qquad (5)$$

The cost of the i^{th} firm to produce y_i is represented by the denominator; whereas, the numerator represents the minimum cost of producing the i^{th} farm's output, given prices and constant returns to scale technology. The numerator can be determined using the linear program from equation (3) without the last constraint.

Results

Data was obtained from the Kansas Farm Management Association for backgrounding operations that reported data for 1995, 1996, and 1997. Enterprise data was converted into six input categories: utilities and fuel, capital, feed, veterinary, and miscellaneous. Output was measured in pounds of beef produced. Table 1 reports the summary statistics for the sample of Kansas backgrounding operations. On average, gross income was $55.80/cwt and total costs were $81.50/cwt. Feed expenses were the most expensive cost component, accounting for 53.1% of the total costs followed by capital expenses at 24%. Feed costs include all cash and opportunity costs (i.e. charged a market value for any feed grown and used on the operation.) Capital costs included: interest expense, interest charge, depreciation, machine hire and repair, and any automobile expenses. The interest charge represents an opportunity cost of owned capital, and those operations that own most of their capital resources will have a high interest charge. The average operation size was 381 head, with an average of 288 pounds produced per head. Average operator age was 51 years.

Table 2 reports average efficiency measures and distribution for the sample of Kansas backgrounding operations. Efficiency measures are relative and are based on a comparison to the most efficient operator in the sample. Overall efficiency ranged from 0.11 to 1.0 with an average of 0.39. This means that the same level of output could be produced at 61% less cost if the operation was technically, allocatively, and scale efficient. 83% of the farms were below 50% efficient. Overall efficiency is a function of technical, allocative, and scale efficiency and determines the minimum cost of producing a given output level under constant returns to scale technology. At constant returns to scale there is no cost advantages to becoming larger or smaller. Average overall efficiency was 39%. This would be the point be the optimal point of production, where costs are minimized. This indicates that on average backgrounding operations were very inefficient.

Technical efficiency ranged from 0.23 to 1.0 with an average of 0.72. Technical efficiency (TE) measures whether or not a producer is using the most up-to-date technologies. A technically inefficient farm (TE measure of less than 1) cannot produce as much output with the same levels of input as a technically efficient farm. Consequently, average output of Kansas backgrounding operations could have increased 29% if the latest technology was being implemented.

Allocative efficiency ranged from 0.35 to 1.0 with an average of 0.69. Allocative efficiency (AE) measures whether a farm is using the cost-minimizing input mix for a given level of output. This means that given the level of inputs used, backgrounding operations could have on average produced 31% more output or used 31% less input to obtain the same level of output. Scale efficiency ranged from 0.10 to 1.00 with an average of 0.83. Scale efficiency (SE) measures whether a farm is producing at the most efficient size. Costs could be reduced 17% if farms were operating at the most efficient size. 86% of all farms were above 80% scale efficient.

Table 3 reports the average farm characteristics of backgrounding operations based on their level of efficiency. Low efficiency producers (bottom one-third of the sample) had an average gross farm income of $203,230 with 20% of income from backgrounding operation and total farm assets of $958,384. The average operator age was 48 and the average herd size was 262. Farms in the medium efficiency category (middle one-third of the sample) had an average gross farm income of $228,472 with 26% of income from backgrounding and total farm assets of $1,048,922. The average operator age was 50 and the average herd size was 372. For farms in the high efficiency category (top one-third of the sample), average gross farm income was $233,424 with 39% of their income from backgrounding and total farm assets of $1,193,527. This would indicate that average overall efficiency for this sample increased as average total farm assets, average number of head, and specialization increased. In this sample, age of operator did not appear to change between efficiency groups.

Table 4 reports average efficiencies based on size, farm type, and operator age. The average size for a small operation was 120 head, 272 for a medium operation, and 788 for a large operation. Large operations had the highest average TE measure with 79%. Small and medium operations had TE measures of 68% and 67% respectively. Small operations had the highest level of allocative efficiency with 76%, followed by large at 68% and medium at 61%. Medium size operations had the highest scale efficiency with 94%, followed by large and small with 84% and 72% respectively. Large size operations had the highest measure of overall efficiency with 45%, followed by medium and small with 38% and 35% respectively.

When looking at the farm characteristics of each efficiency category, operator age did not change significantly. However, when you examine efficiency measures for farms broken down by age groups of operators, the farms with operators in the 40-65 age group had the highest level of OE and AE measures (41% and 70%) and were tied for the highest PTE (72%). This indicates that in this sample this age group most efficiently used inputs and adopts technology. Operators in the 65 and over group had the highest level of scale efficiency (89%), but had the lowest level of overall efficiency (33%). This would indicate that they need to focus on technology adoption and input usage as the main sources of their inefficiencies.

Another way to examine efficiencies is by farm type. Farm types in this data set were determined by the percentage of total farm labor dedicated to different enterprises. Farms that only engaged in backgrounding operations had the highest level of OE (50%), AE (73%) and PTE (84%). Cash-crop/cowherd was close with an OE of 49%. Cash-Crop/backgrounding and cash-crop/beef farms that backgrounded cattle had the highest level of scale efficiency (89%), followed closely by cash-crop/sow-litter (88%). Cash-crop/irrigated and cash-crop/non-irrigated farms had the lowest levels of OE with 33% and 37% respectively. Cash-crop/ irrigated farms also had the lowest AE (56%) and tied for the lowest PTE (57%). Cash-crop/beef farms while having the highest level of scale efficiency had the lowest level of overall efficiency.

Conclusions and Implications

Given the average levels of technical, allocative, and overall efficiency found in this study, significant room for improvement exists in technology adoption and input usage. Overall, farms that engaged in the backgrounding of cattle were very inefficient. This is evident by the fact that on average backgrounding enterprises lost $25.70/cwt. There is room for size adjustment for some farms but this is not the driving force behind the inefficiencies in the backgrounding sector. Backgrounding operations in the future will have to adopt technology more aggressively. In addition, more efforts will need to be made for using the cost minimizing bundle of inputs. Both of these implications will allow the same level of output to be produced more inexpensively or output to be increased without increasing costs. This will be essential for the backgrounding farm to become more competitive and begin to make profits in the future. As the structure of the beef industry continues to change, it will become increasingly more important to understand the efficiency, cost, and profitability relationships that exist in the backgrounding/finishing sector. In order for the backgrounding as a whole and for individual operators to continue to be competitive, it is necessary to understand where sources of inefficiencies exist so that appropriate adjustments can be made. This information will be invaluable to an industry with an uncertain future.

Table 1. Summary Statistics of a Sample of Kansas Backgrounding Operations

Variable	Unit	Mean	STD
Number of Farms	No.	123	
Number of Head/farm	No	389	373
Age of Operator	Years	50	11
Gross Income/cwt	$	55.80	22.74
Total Costs/cwt	$	81.50	22.58
Feed Costs/cwt	$	43.28	16.73
Labor Costs/cwt	$	8.22	5.54
Utility Costs/cwt	$	2.22	1.54
Veterinary Costs/cwt	$	4.59	5.46
Capital Costs/cwt	$	19.68	9.53

Table 2. Efficiency Measures for a Sample of Kansas Backgrounding Operations.

	PTE	***AE***	***Scale***	***OE***
Mean	.72	.69	.83	.39
Standard Deviation	.22	.15	.15	.13
Minimum	.23	.35	.10	.11
Maximum	1	1	1	1
Distribution of Farms:				
< .40	10	2	4	69
.40 - .50	11	14	2	33
.50 - .60	23	24	2	11
.60 - .70	18	21	5	8
.70 - .80	14	34	14	0
.80 - .90	15	19	55	1
.90 - 1.00	8	4	40	0
1.00	24	5	1	1

Table 3 . Low, Medium, and High Efficiency Categories

Variable	Low Eff.	Med. Eff.	High Eff.
Efficiency Measures	***Mean (STD)***	***Mean (STD)***	***Mean (STD)***
Overall Efficiency	.27 (.06)	.38 (.02)	.53 (.12)
Scale Efficiency	.69 (.02)	.87 (.02)	.94 (.03)
Technical Efficiency	.47 (.09)	.71 (.08)	.96 (.06)
Allocative Efficiency	.51 (.07)	.69 (.04)	.85 (.07)
Farm Characteristics			
Total Farm Assets ($'s)	958,384	1,048,922	1,193,527
Gross Farm Income ($'s)	203,230	228,472	233,424
Operator Age (years)	48 (12)	50 (10)	49 (10)
Number of Head	262 (233)	372 (306)	533 (488)
% of Income from	20 (21)	26 (20)	39 (28)

Table 4. Efficiency Measures by Farm Size, Age of Operator, and Farm Type

Farm Size	PTE	AE	Scale	OE
Small (ave. 120 hd/farm; n=41)	.68	.76	.72	.35
Medium (ave. 272 hd/farm; n=41)	.67	.61	.94	.38
Large (ave. 788 hd/farm; n=41)	.79	.68	.84	.45
Age of Operator	**PTE**	**AE**	**Scale**	**OE**
<40 years (ave. 34.30; n=20)	.72	.65	.77	.34
40-65 years (ave. 50.46; n=106)	.72	.70	.84	.41
> 65 years (ave. 69.27; n=11)	.65	.61	.89	.33
Farm Type	**PTE**	**AE**	**Scale**	**OE**
Cash Crop - dryland (n=48)	.70	.71	.80	.37
Cash Crop - irrigated (n=3)	.57	.56	.75	.23
Backgrounding (n=11)	.84	.73	.82	.50
Cash Crop - Cow Herd (n=6)	.87	.69	.82	.49
Cash Crop - Sow and Litter (n=4)	.57	.75	.88	.37
Cow Herd - Backgrounding (n=4)	.62	.69	.75	.29
Cash Crop - Backgrounding (n=36)	.74	.65	.89	.42
Cash Crop - Beef (n=11)	.62	.63	.89	.33

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