Measuring the Productivity of Cattle Finishing

Michael R. Langemeier
and
Rodney D. Jones

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Michael R. Langemeier is an Associate Professor and Rodney D. Jones is an Assistant Professor of Agricultural Economics at Kansas State University, Manhattan, Kansas.

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Abstract

This study examines the productivity of steer placements from 1980 to 1994 for two feedlots in western Kansas. Regression analysis is used to examine the trend in feed conversions and to examine the growth in output. Growth in output is decomposed into changes in productivity and changes in input use.

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Introduction

The competitive position of the beef industry depends on the relative efficiency and productivity of beef production. Johnson et al. and Schroeder, Mintert, and Brester indicate that beef producers need to reduce costs and increase productivity to compete with the pork and poultry sectors. Increases in productivity or technological change can lead to a reduction in average production costs resulting in a more competitive industry.

An analysis of technological change needs to take into account output growth, which is a function of technological change, changes in input use, and changes in technical efficiency. If changes in input use or technical efficiency are ignored, inaccurate conclusions with respect to technological change or productivity growth will result.

The objective of this paper is to examine technological change for steers placed from 1980 to 1994 in two western Kansas feedlots. Trends in feed conversion are examined using regression analysis. A fixed effects production function is used to decompose output growth into technological change, changes in technical efficiency, and input use changes.

Empirical Models

Trends in feed conversion are examined using ordinary least squares regression. Feed conversion is the dependent variable. Independent variables include a time trend, dummy variables for February through December placements, and dummy variables for major weather shocks. The dummy variables for February through December placements capture the impact of seasonality on feed conversions (Albright et al.). The standard deviation of feed conversion is used to create dummy variables to account for adverse weather conditions. Any period that exhibits a feed conversion that is two standard deviations from the mean for that period of time is identified as a weather shock.

Separate models are run for 600 to 700 pound placements, 700 to 800 pound placements, and 800 to 900 pound placements. These separate regressions are used to capture differences in feed conversion trends that may exist between placement weight categories. For example, early in the study period, steers in the 600 to 700 pound were primarily light yearlings. Later in the period this placement group may have included weaned calves or steers backgrounded for less than 60 days.

Technological change is also examined. Technological change can be examined using nonparametric and parametric approaches (Grosskopf). One of the primary advantages associated with the nonparametric approach is that a functional form assumption does not have to be made. The parametric approach allows for the inclusion of variables such as firm effects or other variables that may shift the frontier.

The parametric approach to productivity measurement is used in this paper. This approach allows for the inclusion of seasonality and weather dummy variables. Firm effects or the influence of different management between the feedlots are modeled using the fixed effects production function (Fecher and Pestieau; Ahmad and Bravo-Ureta). Time invariant and time variant models are specified for each placement weight category.

The fixed effects model with time invariant technical efficiency can be written as follows:

$$(1) \qquad \ln Y_{it} = \alpha + \Sigma_k \beta_k \ln X_{kit} + \Sigma_j \Phi_j Z_{jit} + \delta T + \Sigma_i \gamma_i D_i + v_{it}$$

where Y is output, X_k is the k^{th} input, Z_j is the j^{th} seasonality or weather variable, and D_i is a dummy variable for the i^{th} firm. Technical efficiency for each firm is calculated using the following equation:

$$(2) \qquad TE_i = \{\exp(\gamma_i)\}/\max\{\exp(\gamma_i)\}$$

The fixed effects model with time variant technical efficiency can be written as follows:

$$(3) \qquad \ln Y_{it} = \alpha + \Sigma_k \beta_k \ln X_{kit} + \Sigma_j \Phi_j Z_{jit} + \delta T + \Sigma_i \{\gamma_i + \rho_i T\}D_i + v_{it}$$

The ρ_i coefficient is a firm-specific slope parameter with respect to time. This coefficient allows for time variant technical efficiency.

Time variant efficiency can be estimated in two steps (Cornwell, Schmidt, and Sickles; Fecher and Pestieau; Ahmad and Bravo-Ureta). The first step is to estimate equation (3) without the γ_i and ρ_i parameters. The second step regresses the residuals from this regression on D_i and D_iT. This regression can be specified as follows:

$$(4) \qquad \__{it} = \eta + \gamma_i D_i + \rho_i D_i T$$

The predicted values from equation (4), r, are then used to compute technical efficiency for each firm and time period. Specifically, time variant technical efficiency is computed as follows:

(5) $TE_{it} = \{\exp(r_{it})\}/\max\{\exp(r_{it})\}$

Equation (4) can be used to test whether technical efficiency is time variant or time invariant. An insignificant F value for the regression in equation (4) would indicate that technical efficiency is time invariant. If this was the case, equations (1) and (2) would be used. A significant F value, on the other hand, would indicate that technical efficiency is time variant and thus equations (3), (4), and (5) would be used to measure productivity growth.

Output growth for the fixed effects model is decomposed into technological change, technical efficiency change, and input change. The coefficient on the time trend is used as an estimate of technological change. The change in technical efficiency is computed by subtracting the natural log of technical change in time period *t-1* from the natural log of technical efficiency in time period *t*. Change in inputs are computed using input information for successive periods and the regression coefficient for each input. If technical efficiency is time invariant, technical efficiency does not vary over time and output growth is decomposed into technological change and input change.

Data

Feedlot closeout data were collected from two large feedlots in western Kansas. Data from over 10,000 individual pens of steers were used to compute monthly output and input information. Gain per head was used as the output measure. Inputs included feed, interest, and other expenses. Pounds of feed fed (on an as-fed basis) was used as the feed input. Implicit quantities for interest and other expenses were computed using costs per head and price indices. An interest rate index was used for interest and a labor price index was used for other expenses. Output and input data were separated into three placement weight categories: 600 to 700 pounds, 700 to 800 pounds, and 800 to 900 pounds.

Table 1 presents summary statistics for output, inputs, and feed conversion for each placement weight category. Due to seasonal placement patterns, data for some placement weight, month, and feedlot combinations was not available. The number of observations available by placement weight category was 336 for the 600 to 700 pound placements, 348 for the 700 to 800 pound placements, and 328 for the 800 to 900 pound placements. A complete data set would have contained 360 observations or data for 180 months for each feedlot.

Two adverse weather periods were identified. The first period was the January 1980 to March 1980 placement period. The second period was the September 1992 to December 1992 placement period. Monthly average feed conversions during these two periods were more than two standard deviations above the average for these months across the 15 year period. Thus, dummy variables for these two periods were used in the empirical models.

Results

Table 2 presents the results of the feed conversion regression for each steer placement weight. Confirming previous findings, feed conversions follow a pronounced seasonal pattern for each placement weight category (Albright et al.). In addition, feed conversions during the two adverse weather periods were substantially above average for each placement weight. Feed conversions for feedlot 2 were significantly lower than those for feedlot 1. This result could have been due to the type of cattle fed in each feedlot. The time trend variable was significant at the 1% level in each of the regressions. On an annual basis, feed conversion decreased (improved) by 0.42%, 0.48%, and 0.44% per year for the 600 to 700, 700 to 800, and 800 to 900 pound placement categories, respectively.

The results of efforts to test for technological change are presented in Table 3. The time invariant F statistic was insignificant for each of the placement weight categories suggesting that technical efficiency is time invariant or does not vary over time. Equations (1) and (2) were thus used to estimate the fixed effects production function and to compute technical efficiency for each feedlot. Table 3 presents the results of estimating equation (1). Using equation (2), feedlot 1 was technically efficient (index of 1.000) in the production of 600 to 700 pound and 700 to 800 pound placements. Feedlot 2 was technically efficient (index of 1.000) in the production of 800 to 900 pound placements. Inefficiency was a minor problem and ranged from 0.9817 for 800 to 900 pound placements produced in feedlot 1 to 0.9971 for 600 to 700 pound placements produced in feedlot 2.

Output for each placement weight category exhibited a pronounced seasonal trend. Output during the January 1980 to March 1982 period was significantly lower for the 700 to 800 and 800 to 900 pound placements. For the September 1992 to December 1992 period, output was significantly lower for each of the placement weight categories. The parameter on the time variable is significant at the 1% level for each placement weight category. Technological change on an annual basis averaged 0.58% for 600 to 700 pound placements, 0.45% for 700 to 800 pound placements, and 0.30% for 800 to 900 pound placements. Thus, the rate of technological change for the lighter placement weight category was almost double that of the heaviest placement weight category.

Information on output growth and technological change can be used to examine changes in input use over the study period. Output growth ranged from 0.14% per year for 600 to 700 pound placements to 0.43% per year for 800 to 900 pound placements. Output growth for the 700 to 800 pound placement category averaged 0.18%. These output growth rates were consistent with increases in sale weights that occurred over time. The output growth rates for the 600 to 700 and 700 to 800 pound placement weight categories were lower than the rate of technological change. Thus, input use declined over time for these two placement weight categories. To achieve the output growth rate of 0.43%, input use for 800 to 900 pound placements had to increase over time.

Summary and Implications

This paper examined trends in feed conversions and technological change for cattle finished from 1980 to 1994 in two western Kansas feedlots. Annual average declines in feed conversions for the three placement weight categories ranged from 0.42% to 0.48%. Technological change on an annual basis was 0.58% for 600 to 700 pound steer placements, 0.45% for 700 to 800 pound steer placements, and 0.30% for 800 to 900 pound steer placements.

Technological change in cattle finishing was considerably lower than that experienced by all of U.S. agriculture over a similar time period. Technological change for U.S. agriculture averaged 2.37% over the 1980 to 1993 period (USDA). Slow technological change in cattle finishing may have contributed to the deterioration in the competitive position of the beef industry during the 1980's and early 1990's. To address this issue, future research could compare the rates of technological change found in the cattle industry to those experienced in the pork and/or poultry industries over the same time period.

Table 1. Summary Statistics for Output, Inputs, and Feed Conversion.

Variable	Unit of Measure	Mean	Standard Deviation
600-700 Pound Placements			
Gain	Lb./Head	455.75	49.69
Feed	Lb./Head	3737.80	385.96
Interest	$/Head	31.42	5.69
Other Expense	$/Head	57.48	16.51
Feed Conversion	Index	8.23	0.70
700-800 Pound Placements			
Gain	Lb./Head	413.17	43.94
Feed	Lb./Head	3490.90	373.49
Interest	$/Head	29.54	5.46
Other Expense	$/Head	52.72	15.26
Feed Conversion	Index	8.48	0.75
800-900 Pound Placements			
Gain	Lb./Head	382.07	49.76
Feed	Lb./Head	3326.90	435.83
Interest	$/Head	28.67	5.61
Other Expense	$/Head	49.75	14.72
Feed Conversion	Index	8.75	0.82

Table 2. Regression Analysis Examining the Relationship Between Feed Conversion, Seasonality, and Technological Change.

Independent Variable	Placement Weight 600 - 700 lb.	700 - 800 lb.	800 - 900 lb.
Intercept	8.3445*** (0.1152)	8.9192*** (0.1027)	9.3658*** (0.1255)
Time	-0.0029*** (0.0006)	-0.0034*** (0.0005)	-0.0032*** (0.0006)
February	-0.1485 0.1389	-0.3789*** (0.1248)	-0.2860* (0.1523)
March	-0.2398* (0.1389)	-0.4621*** (0.1248)	-0.5833*** (0.1554)
April	-0.0727 (0.1394)	-0.4520*** (0.1252)	-0.5926*** (0.1502)
May	-0.0417 (0.1381)	-0.3636*** (0.1252)	-0.5407*** (0.1503)
June	-0.0482 (0.1394)	-0.3605*** (0.1252)	-0.5395*** (0.1503)
July	0.2574* (0.1369)	-0.2917** (0.1241)	-0.5153*** (0.1515)
August	0.4841*** (0.1369)	-0.0027 (0.1231)	-0.2781* (0.1503)
September	0.7130*** (0.1375)	0.3579*** (0.1236)	-0.0427 (0.1485)
October	0.8132*** (0.1364)	0.6033*** (0.1236)	0.3195** (0.1485)
November	0.6646*** (0.1387)	0.6103*** (0.1236)	0.5552*** (0.1485)
December	0.3836*** (0.1388)	0.3760*** (0.1236)	0.3679*** (0.1561)
1/80 to 3/80	0.9690*** (0.3059)	1.1239*** (0.2820)	1.2617*** (0.3265)
9/92 to 12/92	1.5766*** (0.1909)	2.0317*** (0.1755)	2.3396*** (0.2159)
Feedlot 2	-0.2680*** (0.0560)	-0.3408*** (0.0508)	-0.4251*** (0.0607)
Adjusted R^2	0.4730	0.6032	0.5609

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

Table 3. Regression Analysis Examining the Relationship Between Output, Inputs, Seasonality, and Technological Change.

Independent Variable	Placement Weight 600 - 700 lb.	700 - 800 lb.	800 - 900 lb.
Intercept	0.39791 (0.37140)	1.02290*** (0.31000)	-0.69702** (0.30620)
Feed	0.66385*** (0.05059)	0.54944*** (0.04375)	0.74986*** (0.04662)
Interest	0.00999 (0.02970)	0.08503*** (0.02657)	0.07046** (0.03324)
Other Expense	0.05177*** (0.01486)	0.05331*** (0.01150)	0.07416*** (0.01350)
Time	0.00048*** (0.00010)	0.00037*** (0.00007)	0.00025*** (0.00009)
February	0.01872 (0.01468)	0.04272*** (0.01177)	0.02516 (0.01582)
March	0.02963** (0.01470)	0.05839*** (0.01178)	0.05900*** (0.01609)
April	0.02122 (0.01490)	0.06294*** (0.01188)	0.06276*** (0.01554)
May	0.00184 (0.01470)	0.04519*** (0.01192)	0.04996*** (0.01561)
June	-0.00005 (0.01484)	0.04156*** (0.01204)	0.04923*** (0.01573)
July	-0.04078*** (0.01458)	0.02807** (0.01189)	0.04120*** (0.01590)
August	-0.06260*** (0.01459)	0.00286 (0.01182)	0.01836 (0.01579)
September	-0.08527*** (0.01481)	-0.03737*** (0.01184)	-0.00627 (0.01549)
October	-0.09330*** (0.01461)	-0.05595*** (0.01191)	-0.04004*** (0.01550)
November	-0.07357*** (0.01480)	-0.05733*** (0.01179)	-0.05890*** (0.01549)
December	-0.04519*** (0.01469)	-0.04159*** (0.01166)	-0.03978** (0.01613)

Table 3. (Continued)

Independent Variable	Placement Weight		
	600 - 700 lb.	700 - 800 lb.	800 - 900 lb.
1/80 to 3/80	-0.04116 (0.03384)	-0.07131*** (0.02751)	-0.06886* (0.03510)
9/92 to 12/92	-0.16106*** (0.02021)	-0.20982*** (0.01657)	-0.22732*** (0.02233)
Feedlot 2	-0.00288 (0.00695)	-0.00617 (0.00603)	0.01852** (0.00758)
Adjusted R^2	0.7449	0.8246	0.8198
Time Invariant F	0.531	0.640	0.237

Notes: Numbers in parentheses are standard errors. Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% level, respectively. The critical F for time invariant technical efficiency is 2.60.

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