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**SCALE ECONOMIES AND ECONOMIC PERFORMANCE
IN SOUTHEASTERN U.S. COW-CALF PRODUCTION**

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Abstract

The objective of this study is to assess the scale and technical efficiencies and other economic performance measures of southeastern U.S. cow-calf farms. We describe and compare cow-calf operations by size and farm resource region and measure their relative competitiveness. We estimate an input distance function using stochastic production frontier techniques (SPF).

1. Introduction

U.S. livestock farms are important contributors to American agricultural production. The largest livestock industry in the U.S. is the beef industry. Today, U.S. cattle production is more specialized than ever with concentration in feedlot cattle and cow-calf operations. Feedlot cattle production is concentrated in the High Plains states (Wyoming, South Dakota, Nebraska, Colorado, Kansas, New Mexico, Oklahoma and Texas) and also in states such as Iowa and California (U.S. Environmental Protection Agency). Cow-calf operations are located in all 50 states, but are most concentrated in Tennessee, Missouri, Kentucky, Montana, South Dakota, North Dakota, Oklahoma, Kansas and Nebraska (U.S. Environmental Protection Agency).

Most livestock production takes place on a large number of small farms. According to the 2007 U.S. Census of Agriculture Report, farms with fewer than 100 beef cows accounted for 90.4 percent of total U.S. farms with beef cows. Additionally, farms with fewer than 50 beef cows accounted for 79.4 percent of total U.S. farms with beef cows (NASS, 2007 Census of Agriculture).

Beef cow-calf operations are generally operated on land that is not suitable for crop production and their production potential depends on range or pasture forage conditions

(McBride and Mathews, 2011). U.S. beef cattle production includes three major stages: cow-calf, stocker, and finishing stages. Every U.S. state has the cow-calf segment of beef cow production, with a wide range of herd sizes (Gillespie et al., 2000). The stocker (backgrounding) phase gives flexibility to cow-calf producers for growing their calves to heavier weights. Beef animals in the feedlot finishing stage of the industry are fed forage and grain. They combine forage and grain until the calves gain enough weight to be slaughtered.

According to McBride and Mathews (2011), the Southeast region has proportionately more cow-calf farms than the other regions, but the lowest production value per farm. The reason for this distinction is that most southeastern farms have smaller beef cow herd sizes compared with other regions. Pasture acreage used and stocking rates differ significantly by region. More than 90 percent of farms use private pasture land for grazing beef cattle. The Southeast has the lowest stocking rates, averaging three acres per beef cow (McBride and Mathews, 2011).

The Southeastern U.S. beef cow-calf region includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. According to the 2007 U.S. Census of Agriculture Report, the southeastern states grazed over 7.8 million beef cows, almost 23.8 percent of the U.S. total beef cow herd (Table 1). As shown by the 2007 U.S. Census of Agriculture Report, 235,291 of 764,984 U.S. beef cow farms, or approximately 30.7 percent, are located in the Southeast (Table 1). Moreover, the Southeast has more farms with cow herd sizes of < 20, 20 to 49 or 50 to 99 compared with the West, the North Central, or the Northern Plains regions.

Table 1. The Southeast region beef cow-calf farms by size and number of beef cows, 2007

Item	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Farms	21,415	25,361	16,694	17,721	38,298	12,569	15,910	14,895	8,177	42,344	21,907
Number	691,911	947,765	942,419	554,099	1,166,385	510,837	521,517	373,024	230,419	1,179,102	695,061
Farms & number of head with cow herd size of:											
< 20	12,213	11,899	10,725	10,363	19,863	6,232	8,017	9,205	4,226	22,986	11,990
	103,866	107,566	75,991	86,534	179,498	54,079	74,384	75,773	36,825	213,288	105,764
20 to 49	5,689	8,087	3,148	4,545	12,237	3,536	5,141	3,973	2,783	13,281	6,276
	170,954	245,505	93,192	135,821	371,213	107,154	154,410	116,801	84,623	396,953	188,883
50 to 99	2,148	3,398	1,264	1,733	4,244	1,469	1,812	1,169	906	4,283	2,328
	141,578	223,886	84,203	114,991	279,007	97,974	118,838	75,840	57,333	284,873	153,668
100 to 199	910	1,404	697	716	1,457	713	676	394	213	1,449	922
	118,668	180,919	92,529	93,447	187,723	93,139	85,644	50,918	27,054	183,038	120,870
200 to 499	403	493	549	311	458	338	226	131	63	316	357
	110,340	134,537	160,647	84,461	120,692	98,634	61,883	35,915	17,533	81,459	100,130
≥ 500	52	80	311	53	39	67	38	23	6	29	34
	33,543	55,352	435,857	38,845	28,252	59,857	26,358	17,777	7,051	19,491	25,746

Source: USDA, NASS, 2007 Census of Agriculture.

The Southeast is well suited to producing beef cattle because of extended grazing periods for beef cow-calf production. This extended grazing period gives southeastern cow-calf producers the opportunity to keep calves on the pasture for an additional 2-3 months to put weight on calves after weaning. In addition, the extended grazing period decreases cow-calf producers' dependence on concentrated feedstuffs, adding value to calves with less expensive inputs compared to other regions. In some beef cattle production regions or states, it is not possible to graze year-round, thus such regions depend on the use of conserved or stockpiled forages during a few months of the year.

There has been little research on the scale economies in southeastern beef production from the perspective of the whole farm or the farm household. Similarly, there has been little research on the technical and scale efficiencies of beef cow-calf production systems from the perspective of the whole farm or the farm household. The primary goal of this study is to measure the technical and scale efficiencies at the whole farm level for cow-

calf operations in the Southeastern U.S. In addition, we examine the link between cow-calf farm efficiency and output diversification (off-farm income).

2. Literature

Over the past few decades, major structural and technological changes have taken place in the U.S. agricultural sector. In particular, the increased tendency to move toward larger farms has been the concern of survivability of small farms in a competitive market. Studies have examined the economic performance of U.S. Corn Belt farms (Morrison-Paul et al., 2004; Morrison-Paul and Nehring, 2005) and explored the potential competitiveness of small versus large farms. Overall, large farms have been shown to have cost advantages over small farms. These studies have estimated output and input distance functions using stochastic frontier techniques.

A few studies have examined European beef cattle farm technical efficiency and profitability (Iraizoz et al., 2005; Trestini, 2006). Samarajeewa et al., (2012) estimated economic performance of cow-calf operations in Alberta, Canada. Little research has estimated economic performance measures and technical efficiencies of U.S. cow-calf farms. Studies have estimated the technical, allocative and scale efficiencies of cow-calf farms using nonparametric linear programming-based or data envelopment analysis and parametric approaches (Featherstone et al., 1997; Rakipova, Gillespie and Franke, 2003; Nehring et al., 2009). Larger beef cow farms were more technically efficient than smaller beef cow farms and herd sizes of farms up to 48 beef cows exhibited substantial economies of scale (Featherstone et al., 1997). Rakipova, Gillespie and Franke (2003) focused on the discussion of technical efficiency and the effect of cow-calf farms' characteristics, management, and production practices on technical efficiency. Use of an input distance function allowed Nehring et al. (2009) to relate multiple outputs to

multiple inputs in a single equation to measure technical and scale efficiencies. Small cow-calf farms could be competitive as long as producers had substantial off-farm income.

The present study attempts to quantify economic performance of the southeastern cow-calf farms. We focus on input and output jointness and their complementarities, including scope economies and input substitutability or complementarity.

3. Data Sources and Methods

This study uses the USDA's 2008 Agricultural Resource Management Survey (ARMS) data. The ARMS data is an exclusive, detailed annual survey conducted by the USDA Economic Research Service (ERS) and the USDA-National Agricultural Statistics Service (NASS). The 2008 ARMS's beef cow-calf costs and returns cross-section survey collected detailed information on farm size measures, production costs, business arrangements, production facilities and practices, and farm operator and financial characteristics of beef cow-calf production on farms in 22 states. The survey data include only beef cow-calf operations with 20 or more cows at any time during 2008.

We use an input distance function (IDF) analysis to determine the economic performance of cow-calf farms from a whole-farm production perspective, exploring the importance of output diversification economies in Southeastern U.S. cow-calf production. To estimate this function econometrically, we apply the stochastic production frontier. We specify the input distance function as $D^I(X, Q, R)$, where X denotes a vector of inputs, Q denotes to a vector of outputs, and R refers to a vector of enterprise efficiency determinants. For the whole farm IDF analysis, two outputs are developed from the

ARMS data: Q_{GROSS} = gross value of farm production, and $Q_{OFFFARM}$ = total principal operator household off-farm income.

Inputs are: X_{LND} = quality-adjusted land price; X_{CAP} = total fixed expenses (including insurance expenses, interest expenses, and rental and lease payment expenses) and capital expenditures (including total principal operator capital expenditures, non-cash expenses for paid labor, and depreciation expenses); X_{OPER} = total operating expenses (including fuel and oil expenses, machine hire and custom work expenses, purchased feed expenses, fertilizer and chemicals expenses, maintenance and repair expenses, seed and plant expenses, utility expenses, purchased livestock expenses, other livestock related expenses, and other variable expenses); and X_{LABOR} = total labor expenses. We also developed the farm-specific technical efficiency variables (R) from the ARMS data. Farm- and farmer characteristics include: debt-asset ratio, farm resource regions, farm gross sales, cattle breeding stock, stocker, spouse off-farm hours, operator off-farm hours, operator's education level, and age.

The whole farm IDF can be approximated by a translog functional form for empirical implementation in order to limit a priori restrictions on the relationship among inputs. To capture the relationship between inputs and outputs, the IDF requires homogeneity in input levels (Färe and Primont, 1995) and symmetry restrictions. After normalization (Lovell et al., 1994), this function results in:

$$\ln \frac{D_i^I(X, Q, R)}{X_{1,i}} = \alpha_0 + \sum_m \ln X_{mi}^* + \frac{1}{2} \sum_m \sum_n \alpha_{mn} \ln X_{mi}^* \ln X_{ni}^* + \sum_k \beta_k \ln Q_{ki} \\ + \frac{1}{2} \sum_k \sum_l \beta_{kl} \ln Q_{ki} \ln Q_{li} + \sum_q \delta_q R_{qit} + \frac{1}{2} \sum_q \sum_r \gamma_{qr} \ln R_{qi} \ln R_{ri} + \sum_k \sum_m \theta_{km} \ln Q_{ki} \ln X_{mi}^*$$

$$+ \sum_q \sum_m \varphi_{qm} \ln R_{qi} \ln X_{mi}^* + \sum_k \sum_q \tau_{kq} \ln Q_{ki} \ln R_{qi} + v_i = TL(X^*, Q, R) + v_i \quad (1)$$

(1) can be written as

$$- \ln X_{1,i} = TL(X^*, Q, R) + v_i - \ln D_i^l(X, Q, R) = TL(X^*, Q, R) + v_i - u_i \quad (2)$$

where i denotes farms; k, l the outputs; m, n the inputs; and q, r the farm characteristic variables. X_1 is land, specified as a normalization factor in inputs. $\ln D_i^l(X, Q, R)$ is the distance from the frontier and it characterizes the technical inefficiency (TI) error, $-u_i$. TI is a function of farm- and farmer-specific characteristics. Technical efficiency (TE) can be obtained as the expectation of the term $-u_i$ conditional on the composed error term $\varepsilon_i = v_i - u_i$ (Jondrow et al., 1982). TE can be measured as:

$$TE = \exp^{-u_i} \quad (3)$$

We use single-step maximum likelihood (ML) methods (Battese and Coelli, 1995) to estimate (2) as an error components model. More precisely, the parameters of the IDF and the TI are estimated jointly using stochastic production frontier techniques. The random error component v_{it} is independently and identically distributed, $N(0, \sigma_v^2)$. The one-sided error component of $u_i \geq 0$ is a random variable independently distributed with truncation at zero of $N(m_i, \sigma_u^2)$ distribution, where $m_i = \sum_n F_n \tau$, F_n is a vector of whole-farm efficiency determinants, and τ are unknown estimable parameters. The ARMS contains expansion factors or “weight” that can be used to expand the data to a population estimate. These weights are used in the analysis and robust standard errors are estimated in STATA to correct for heteroskedasticity.

4. Stochastic Production Frontier Results

The ML parameter estimates for the IDF model are presented in Table 2. The inputs have mixed signs. Total operating expenses (X_{OPER}) have the expected sign but total

capital expenditure (X_{CAP}) and total labor expenses (X_{LABOR}) have unexpected signs. All input variables are significant expect for total capital expenditure. Output variables, gross value of farm production (Q_{GROSS}) and total principal operator household off-farm income ($Q_{OFFFARM}$), are significant. We find that total capital expenditure and total operating expenses, and total operating expenses and total labor expenses have complementary effects on southeastern U.S. cow-calf farm production. Total capital and total labor expenses are, however, substitutes.

Table 2. Maximum-likelihood estimates for the IDF

Variables	Coeff.	t-test	Variables	Coeff.	t-test
constant	12.121 ^{**}	5.97	Inefficiency model		
lab_d	3.994 ^{**}	2.14	constant	-4.234 ^{***}	-3.02
off_d	-1.228	-1.55	Very large Farms	4.215 ^{***}	3.83
X_{CAP}	0.298	1.06	Age	0.002	0.11
X_{OPER}	-0.674 [*]	-1.91	College Degree	0.058	0.08
X_{LABOR}	0.711 ^{**}	2.40	Breeder	-0.313	-0.48
X_{CAP_SQ}	-0.087 ^{***}	-3.61	Stocker	1.025	1.48
X_{OPER_SQ}	-0.136 ^{***}	-4.68	Eastern Upland	-0.184	-0.41
X_{LABOR_SQ}	-0.149 ^{***}	-3.86	Fruitful Rim	-26.380 ^{***}	-5.58
X_{CAP_OPER}	0.117 [*]	1.79	Mississippi Portal	-0.168	-0.24
X_{CAP_LABOR}	-0.049	-0.82	Spouse Off-farm Hours	0.000	0.41
X_{OPER_LABOR}	0.272 ^{***}	4.73	Operator Off-farm Hours	0.001 ^{**}	2.40
Q_{GROSS}	-0.545 [*]	-1.76	Debt-Asset Ratio	-2.030 [*]	-1.75
$Q_{OFFFARM}$	-0.303 ^{***}	-1.62			
Q_{GROSS_SQ}	0.093 ^{***}	3.44			
$Q_{OFFFARM_SQ}$	0.027 [*]	1.61			
$Q_{GROSS_OFFFARM}$	0.008	0.55			
$X_{CAP_Q_{GROSS}}$	-0.035	-1.39			
$X_{CAP_Q_{OFFFARM}}$	-0.012 [*]	-1.88			
$X_{OPER_Q_{GROSS}}$	0.050 [*]	1.66			
$X_{OPER_Q_{OFFFARM}}$	-0.002	-0.25			
$X_{LABOR_Q_{GROSS}}$	-0.119 ^{***}	-4.85			
$X_{LABOR_Q_{OFFFARM}}$	0.006	0.62			
Metro_ Q_{GROSS}	0.011	0.29			
Metro_ $Q_{OFFFARM}$	0.063 [*]	1.81			
Metro_ X_{CAP}	0.076	1.42			
Metro_ X_{OPER}	-0.072	-1.10			
Metro_ X_{LABOR}	0.026	0.41			
Metro04	-0.790	-1.31			

Notes: ^{*} 10% level of significance, ^{**} 5% level of significance, ^{***} 1% level of significance.

All of the coefficients of outputs are statistically significant, but they have unexpected signs. The results of the heteroskedasticity inefficiency error terms or inefficiency effects show that breeder, debt-asset ratio and farm resource region dummies such as Eastern Uplands, Fruitful Rim, and Mississippi Portal decrease the variance of inefficiency or enhance technical efficiency of Southeastern U.S. farms. Only the debt-asset ratio was statistically significant. The results of the region dummies show that Fruitful Rim farms were more technical efficiency than Southern Seaboard farms.

The distribution of the estimated input-oriented technical efficiency scores is presented in Table 3. The results show an average efficiency of 0.86. This implies a technical inefficiency level that is 14% on average, or that the average southeastern cow-calf farm could reduce about 14% in inputs to produce the same output as an efficient southeastern farm on the frontier. The table also shows that approximately 80% of the farmers achieved technical efficiency levels of 80% or higher.

Table 3. Distribution of the technical efficiency (TE)

Range of TE	Freq.	% of farms in TE interval
0.00-0.00	43	6.58
TE ≤ 0.40	21	3.22
0.40 < TE ≤ 0.50	12	1.84
0.50 < TE ≤ 0.60	6	0.92
0.60 < TE ≤ 0.70	14	2.14
0.70 < TE ≤ 0.80	35	5.36
0.80 < TE ≤ 0.90	198	30.32
0.90 < TE ≤ 1.00	324	49.62
Mean TE	610	0.86
Std. Dev.		0.15

The productivity impacts or marginal productive contributions (MPCs) of inputs and outputs have correct signs, negative for inputs and positive for outputs, as shown in Table

4. All of the measures are significant except for total capital expenditure. We also find decreasing returns to scale for the southeastern cow-calf operations.

Table 4. MPCs for inputs and outputs, and return to scale (RTS)

MPCs	Coeff.	t-test	MPCs	Coeff.	t-test
X _{LND}	-0.219***	-5.92	Q _{GROSS}	1.568***	4.61
X _{CAP}	-0.047	1.73	Q _{OFFFARM}	0.363*	1.73
X _{OPER}	-0.268***	-5.78			
X _{LABOR}	-0.466***	-10.99			
			RTS	1.931***	4.39

Notes: *, **, *** Significances at the 10%, 5% and 1% levels, respectively.

5. Conclusions

This paper measures economic performance of Southeastern U.S. region cow-calf farms, focusing on technical efficiency, scale economies, and output or input substitution or complementary effects. This study employed the 2008 ARMS cow-calf version cross-sectional survey data for the analysis of the southeastern cow-calf operations.

The results show that total operating expenses and total labor expenses were significant inputs for the cow-calf farmer operations. We also found complementary effects between inputs including: total capital expenditure and total operating expenses, and total operating expenses and total labor expenses on cow-calf production. There was a substitution effect between total capital expenditure and total labor expenses. The measures of marginal productive contributions had correct signs for inputs and outputs, and they were significant except for total capital expenditure. The results also show that there is a room to decrease input use to produce output at the production frontier level.

References

- Battese, G.E. and T.J. Coelli (1995). "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data." *Empirical Economics*, 20, 325-332.
- Färe, R., and D. Primont (1995). *Multi-Output Production and Duality: Theory and Applications*. Kluwer Academic Publishers: Boston.
- Featherstone, A. M., M.R. Langemeier and M. Ismet (1997). "A Nonparametric Analysis of Efficiency for a Sample of Kansas Beef Cow Farms." *Journal of Agricultural and Applied Economics*, 29, 175-84.
- Gillespie, J., C. Davis, A. Basarir and A. Schupp (2000). "A Comparative Analysis of The Evolution of the Three Major U.S. Meat Industries. With Implications for the Future Direction of the U.S. Beef Industry." Louisiana State University Agricultural Center Research and Extension. Bulletin No. 877.
- Iraizoz, B., I. Bardaji and M. Rapun (2005). "The Spanish Beef Sector in the 1990s: Impact of the BSE Crisis on Efficiency and Profitability." *Applied Economics*, 37, 473-484.
- Jondrow, J., C.A.K. Lovell, I. Materov, P. Schmidt (1982). "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Model." *Journal of Econometrics* 19, 223-238.
- Lovel, C.A.K., S. Richardson, P. Travers and L.L. Wood (1994). "Resources and Functionings: A New View of Inequality in Australia," in *Models and Measurement of Welfare and Inequality* (W. Eichhorn, ed.), Berlin: Springer-Verlag Press.
- McBride, W. D., and K. Mathews (2011). "The Diverse Structure and Organization of U.S. Beef Cow-Calf Farms." *Economic Information Bulletin No. 73*. U.S. Department of Agriculture, Economic Research Service.
- Morrison-Paul, C. J., R. Nehring, D. Banker and A. Somwaru (2004). "Scale Economies and Efficiency in U.S. Agriculture: Are Traditional Farms History?" *Journal of Productivity Analysis*, 22, 185-205.
- Morrison-Paul, C. J., and R. Nehring (2005). "Production Diversification, Production Systems, and Economic Performance in U.S. Agricultural Production." *Journal of Econometrics* 126, 525-548.
- Nehring, R., D. Peel and D. Nulph (2009). "Cow-Calf Farm Management: Farm Survey Evidence from 2007." Southern Association of Agricultural Economists Annual Conference, January 31-February 3, 2009, Atlanta, Georgia.
- Rakipova, A. N., J. Gillespie and D. E. Franke (2003). "Determinants of Technical Efficiency in Louisiana Beef Cattle Production." 2003 *Journal of the ASFMRA*, July 31, 2003.
- Samarajeewa, S., G. Hailu, S. R. Jeffrey and M. Bredahl (2012). "Analysis of Production Efficiency of Beef Cow/calf Farms in Alberta." *Applied Economics*, 44, 313-322.
- Trestini, S. (2006). "Technical Efficiency of Italian Beef Cattle Production under a Heteroscedastic Non-neutral Production Frontier Approach." The 10th Joint Conference on Food, Agricultural and the Environment, 26-30 August 2006 Duluth, Minnesota, USA.
- U.S. Department of Agriculture, National Agricultural Statistics Service (USDA, NASS), 2007, *Census of Agriculture*. <http://www.agcensus.usda.gov/Publications/2007/index.php>
- U.S. Environmental Protection Agency. Beef Production/Ag101/Agriculture/US EPA. <http://www.epa.gov/agriculture/ag101/printbeef.html>