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Abstract

A Stochastic Production Frontier (SPF) model is estimated for U.S. dairy farms to examine the productivity of organic and non-organic dairy farms by system and size. For both systems, size is the major determinant of competitiveness based on various measures of productivity and returns to scale.

Introduction

Over the past 20 years, organic milk production has continued to expand so that it now claims a consequential share of U.S. milk production. Estimates from the 2005, 2010 and 2016 U.S. Agricultural Resource Management Surveys (ARMS), dairy versions, show that organic milk production represented 0.7%, 4.1%, and close to 5% of total U.S. milk production in those years, respectively. Production expansion has occurred alongside increased demand for certified organic milk. Certified organic dairy farming has evolved such that it differs dramatically by size and region (McBride and Greene 2009). Using ARMS data, we explore the extent of U.S. organic milk production in 2016; estimate returns to scale (RTS) and technical efficiency (TE) associated with organic versus non-organic production by size and system; and compare financial performance of organic with non-organic farms by size and level of management.

Since we are estimating economic performance measures by system, we use a stochastic production frontier (SPF) approach following Morrison-Paul et al. (2004a,b) to analyze performance by group. We find that large farms economically outperform smaller farms in both organic and non-organic categories. We highlight financial, economic, and technical differences across organic compared to non-organic groupings by size, providing additional perspective to the McBride and Greene (2009) results.

Background

Using the 2010 ARMS survey, Nehring et al. estimated that organic milk production represented close to 5 percent of milk sales. In terms of inventory shares for total cows, estimates of the 2016 Organic Production Survey by the U.S. Census of Agriculture indicate that 3.0% of the U.S. dairy cow inventory was under organic production compared with 2.2 percent in the 2008 survey. Expansion has occurred alongside increases in organic milk demand. This segment of the dairy industry has expanded greatly since the early 2000s, but less favorable economic conditions for organic dairying may have sprung up recently. Feedstuffs reports that the United States has lost nearly a quarter of its dairy farms since 2010 (Feedstuffs 2018). And, according to a recent USDA *Organic Dairy Market News* report, following years when U.S. dairy farmers could not supply enough organic milk to meet consumer demand, a surplus of 50 million gallons of organic milk was expected for 2017. According to Hoards Dairyman (2017), this suggests some organic milk may likely be sold on the conventional market.

Shifts in organic production systems and price premiums may further impact the market. Since 2010, USDA’s new pasture rules for all organic dairies have aimed at enforcing pasture grazing during the entire grazing season. Organic dairy farming has evolved such that it differs dramatically by size and region. Though at least one analysis has examined the economics of organic versus conventional dairy production using 2010 ARMS data (Nehring et al. 2017), we are aware of none that have analyzed 2016 data. Doing this is particularly important since economic changes have occurred in this market since 2010.

Data and Methods

This study uses data from the 2016 ARMS Phase III, dairy version, conducted by USDA agencies National Agricultural Statistics Service and Economic Research Service. For 2016, this dataset provides 1,422 usable responses, including 420 organic dairies. We filtered on dairies with more than 40 cows for the SPF estimate to eliminate outliers. The ARMS collects information on farm size and type, production practices, income and expenses, and farm and household characteristics. The ARMS is a design-based survey that uses stratified sampling, so weights or expansion factors are included for each observation to extend results to the dairy farm population of the largest dairy states in the U.S. The sample selects farms from States representing 90 percent of production.

Assessing Technical and Scale Efficiency

A parametric input distance function approach is used to estimate the production technology of U.S. dairy farms. The input distance function is denoted as $D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})$, with $\boldsymbol{X}$ referring to inputs, $\boldsymbol{Y}$ to outputs, and $\boldsymbol{R}$ to other farm efficiency determinants. Two outputs are included in our model for dairy farms: Y_{CROP} = value of crop production and Y_{LIVE} = value of livestock production. Inputs include: X_{LAB} = labor, X_{CAP} = capital, X_{MISC} = miscellaneous including fuel, fertilizer, and feed, and X_{OLND} = land. Estimation of $D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})$ requires the imposition of linear homogeneity in input levels (Färe and Primont), accomplished through normalization (Lovell et al.): $\mathrm{D}^{\mathrm{I}}(\boldsymbol{X},\boldsymbol{Y}, \boldsymbol{R})/X_1 = \mathrm{D}^{\mathrm{I}}(\boldsymbol{X}/X_1,\boldsymbol{Y}, \boldsymbol{R}) = \mathrm{D}^{\mathrm{I}}(\boldsymbol{X^*},\boldsymbol{Y}, \boldsymbol{R})$.[1] Approximation using a translog functional form results in the following specification:

(1a) $\ln D^I_{it}/X_{1,it} = \alpha_0 + \Sigma_m \alpha_m \ln X^*_{mit} + .5\, \Sigma_m \Sigma_n \alpha_{mn} \ln X^*_{mit} \ln X^*_{nit} + \Sigma_k \beta_k \ln Y_{kit}$

$+ .5\, \Sigma_k \Sigma_l \beta_{kl} \ln Y_{kit} \ln Y_{lit} + \Sigma_q \phi_q R_{qit} + .5\, \Sigma_q \Sigma_r \phi_{qr} R_{qit} R_{rit} + \Sigma_k \Sigma_m \gamma_{km} \ln Y_{kit} \ln X^*_{mit}$

$+ \Sigma_q \Sigma_m \gamma_{qm} \ln R_{qit} \ln X^*_{mit} + \Sigma_k \Sigma_q \gamma_{kq} \ln Y_{kit} \ln R_{qit} + v_{it} = TL(\boldsymbol{X^*}, \boldsymbol{Y}, \boldsymbol{R}) + v_{it}$, or

(1b) $-\ln X_{1,it} = TL(\boldsymbol{X^*}, \boldsymbol{Y}, \boldsymbol{R}) + v_{it} - \ln D^I_{it} = TL(\boldsymbol{X^*}, \boldsymbol{Y}, \boldsymbol{R}) + v_{it} - u_{it}$,

where *i* denotes farm; *t* the time period; *k,l* the outputs; *m,n* the inputs; and *q,r* the ***R*** variables. In our analysis, X_1 is land, so the function is specified on a per-acre basis. Structural ***R*** variables include soil texture (TEXT), water-holding capacity of the soil (WATHCA), whether the farm is close to an urban area (URBAN), and whether the operator or spouse work off-farm (SPLABOR, OPLABOR).

The technical inefficiency error $-u_{it}$ (distributed as half-normal) is the distance from the frontier, $-\ln D^I_{it}$. Maximum likelihood methods are used to estimate (1b) as an error components model (Battese and Coelli). The one-sided error term u_{it} is a nonnegative random variable independently distributed with truncation at zero of the $N(m_{it},\sigma_u^2)$ distribution, where $m_{it}=\boldsymbol{R}_{it}\delta$, $\boldsymbol{R}_{it}$ is a vector of farm efficiency determinants (assumed here to be the factors in the ***R*** vector), and δ is a vector of estimable parameters. The random error component v_{it} is assumed to be independently and identically distributed, $N(0,\sigma_v^2)$. We estimate a household model using stochastic production frontier (SPF) techniques.

The marginal productive contributions (MPC) of outputs and inputs are estimated by the first order elasticities, $MPC_m = -\varepsilon_{DI,Ym} = -\partial \ln D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})/\partial \ln Y_m = \varepsilon_{X1,Ym}$ and $MPC_k = -\varepsilon_{DI,X^*m} = -\partial \ln$

$D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})/\partial \ln X^*_k = \varepsilon_{X1,X^*k}$. The increase in overall input use when output expands is represented by MPC_m, and is expected to be positive, such as an output elasticity or marginal cost measure. The shadow value of the k^{th} input relative to X_1 is represented by MPC_k (Fare and Primont) and, like the slope of an isoquant, is expected to negative. The MPCs of structural factors are measured through elasticities $MPC_{Rq} = -\varepsilon_{DI,Rq} = -\partial \ln D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})/\partial R_q = \varepsilon_{X1,Rq}$.

The total contribution of the M outputs Y_m, or the scale elasticity $SE = -\varepsilon_{DI,Y} = -\Sigma_m \partial \ln D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})/\partial \ln Y_m = \varepsilon_{X1,Y}$ provide a measure of scale economies (SE). Increasing returns to scale are found if $SE<1$. We estimate technical efficiency (TE) “scores” as $TE = \exp(-u_{it})$.

Operator or spousal off-farm labor may impact the productivity of inputs. We use instrumental variables to predict operator and spousal off-farm labor. For operator off-farm hours, we use value of crop inventory, operator education, household assets and acres cultivated. For spouse off-farm hours, we use value of crop inventory, operator education, and household assets. The predicted values of these two variables are included in the inefficiency effects.

We use results of the SPF to examine productivity measures of eight categories of dairy farm size / production system.

We account for differences in land characteristics by starting with state-level quality-adjusted values for the U.S. as estimated in Ball et al. (2008), and multiply these by pasture and non-pasture acres to construct a stock of land by farm. A service flow is computed based on a service life of 20 years and interest rate of 6%, as discussed by Nehring et al. (2006). Ignoring land heterogeneity, urbanization effects, and climatic information would result in biased efficiency estimates (Ball et al. 2008; Nehring et al. 2006).

For many dairy operations, off-farm labor is a major source of income. As such, off-farm work by either the operator or spouse may influence the impact of his or her labor on output and the use of hired labor, as well as the efficiency with which inputs are used. Nehring et al. (2009) found that off farm operator labor lowered TE while off farm spousal labor increased TE. Hence, we constructed predicted values for operator and spousal off-farm labor given instruments available in the data set. For operator off-farm hours, we use value of crop inventory, operator education, household assets and acres cultivated. For spouse off-farm hours, we use value of crop inventory, operator education, and household assets. We include the predicated values of these two variables in the inefficiency effects.

The parametric stochastic production frontier approach, introduced by Aigner, Lovell, and Schmidt and Meeusen and van den Broeck, was modified by Battese and Coelli to specify stochastic frontiers for TE effects and simultaneously estimate all parameters involved. However, in this paper we estimate drivers for technical efficiency derived from the Coelli inefficiency effects—a negative (positive) sign implies a positive (negative) impact on technical efficiency.

Technical efficiency "scores" are estimated as $TE = exp(-u_{it})$. Impacts of inefficiency effects on TE can be measured by the corresponding δ coefficient in the inefficiency specification for -u_{it}. Inefficiency effects are assumed to be independently distributed and u_{it} arises by truncation (at zero) of the exponential distribution with mean μ_{it}, and variance σ^2.

Farm Categories for Comparison

We compare results from nine combinations of organic status and farm size in this study. Farms are first divided by organic status, with those farms selling organic milk or transitioning to organic being classified as organic; otherwise they are classified as conventional. Organic farms are broken into the following size categories: <75 cows, 75-199 cows, and ≥200 cows. Given the wide range in the farm size for conventional farms, these categories are broken into the more size categories for conventional: < 75 cows, 75–199 cows, 200-499 cows, 500-999 cows, 1,000-2,499 cows, and ≥2,500 cows. These size categories allow for comparisons of financial, productivity, and environmental measures by organic status and farm size.

Results

Stochastic Frontier Results

Table 1 shows stochastic frontier estimates. Of the 32 model coefficients, 27 are significant at the 10% level or better. Input elasticities are of the expected signs and are significant. The summation of the input elasticities indicates RTS of 0.69, or increasing RTS. The Coelli results are model-based, as we filtered on dairy farms with more than 40 cows. Hence, the results in terms of significance of estimated parameters are appropriate to represent the underlying sample of dairy farms but not necessarily for the population of dairy farms that this sample represents. The model based technical efficiency estimate is 0.80 at the mean. We have confidence that the group sorts presented in Table 3 satisfactorily identify performance measures by farm by group, given that most of the coefficients in the Table 1 estimates are significant.

Among the TE drivers shown in Table 1, pasture-based operation, operator labor hours, spouse labor hours, organic status, and use of artificial insemination are statistically significant.

Comparisons by Size Category

Table 2 presents farm characteristics and economic measures by organic status and size. The category representing the largest number of farms is the non-organic category with <75 cows; the smallest category is that of organic farms with ≥200 cows. The non-organic farms with ≥2500 cows produced the most milk, while Organic farms with 75-199 cows produced the least. Pasture use decreased for both organic and non-organic farms as farm size increased; the highest usage was 0.77 acres/cow for Organic <75 Cows and the least was for Non-organic ≥2,500 Cows, at 0.02 acres/cow. Milk per cow generally increased with size for both organic and non-organic farms; organic farms produced less milk per cow than non-organic farms.

Purchased feed costs per cow were lowest for smaller-scale operations, likely because of increased pasture and homegrown feed use. Variable cost per hundredweight of milk produced was highest for small organic farms, decreasing with size within that system. Variable costs per hundredweight of milk produced also declined with size for non-organic farms. Net return on assets was highest for larger-scale organic and non-organic farms. Larger-scale operations showed higher debt relative to assets; they were more highly leveraged. Returns to scale increased with size for both organic and non-organic farms, showing evidence of economies of size in U.S. milk production. Technical efficiency increased with farm size for both organic and non-organic farms.

Conclusions

Preliminary results show significant differences in net return on assets, TE, and scale efficiency measures by organic status. However, size continues to be the dominant determinant of profitability and efficiency. Preliminary results indicate medium and large-sized organic operations (more than fifty percent of all organic production) are competitive with medium to large-sized conventional operations of up to 2,500 cows.

Given the rapid expansion of both demand and supply of organic milk, it is of importance to determine the relative profitability of conventional versus organic milk production. A number of typically smaller-scale non-organic dairy farmers are considering the costly transition to organic production.

References

Ball VE, Lindamood WA, Nehring R, Mesonada CSJ (2008) Capital as a factor of production in OECD agriculture: Measurement and data. Applied Economics 40:1253-77.

Banerjee S, Martin SW, Roberts RK, Larson JA, Hogan RJ, Johnson JL, Paxton KW, Reeves JM (2010) Adoption of conservation-tillage practices and herbicide-resistant seed in cotton production. AgBioForum 12:1-21.

Butler LJ (2002) The economics of organic milk production in California: A comparison with intensive costs. American Journal of Alternative Agriculture 17:83-91.

Coelli T, Perelman S (2000) Technical efficiency of European railways: A distance function approach. Applied Economics 32:1967-1976.

Cohen S, Xanthopoulos J, Jones G (1988) An evaluation of available statistical software procedures appropriate for the regression analysis of complex survey data. Journal of Official Statistics 4:17-34.

Dalton TJ, Bragg LA, Kersbergen R, Parsons R, Rogers G, Kauppila D, Wang Q (2005) Costs and Returns to Organic Dairy Farming in Maine and Vermont for 2004. Dept. of Resource Economics and Policy Staff Paper 555, University of Maine.

Dimitri C, Greene C (2002) Recent Growth Patterns in the U.S. Organic Foods Market. Agriculture Information Bulletin 777, Economic Research Service, USDA.

Dorfman J, Koop G (2005) Current developments in productivity and efficiency measurement. Journal of Econometrics 126:233-240.

Dubman RW (2000) Variance Estimation with USDA's Farm Costs and Returns Surveys and Agricultural Resource Management Study Surveys. Washington DC: U.S. Department of Agriculture, Economic Research Service Staff Paper AGES 00-01.

Fare R, Primont D (1995) Multi-output Production and Duality: Theory and Applications. Boston: Kluwer Academic Publishers.

Feedstuffs, " Drowning in milk: Dairy industry must ajdust," Welshans,Krissa, Bloomington, Minnesota, April 2, 2018.

Fleming E, Lien G (2009) Synergies, scope economies, and scale diseconomies on farms in Norway. Food Economics – Acta Agriculturae Scandinavica, Section C 6(1):21-31.

Hanson J, Dismukes R, Chambers W, Greene C, Kremen A (2004) Risk and risk management in organic agriculture: Views of organic farmers. Renewable Agriculture and Food Systems 19(4):218-227.

Hoards Dairyman, “The Organic Milk Market is Overflowing,” Bauer, Abby, Ft Atkinson, Wisconsin, May 15, 2017.

Kott PS (2005) Using the Delete-a-Group Jackknife Variance Estimator in NASS Surveys. Washington DC: U.S. Department of Agriculture, National Agricultural Statistics Service Research Report RD-98-01.

Lovell CAK, Richardson S, Travers P, Wood LL (1994) Resources and functionings: A new view of inequality in Australia. In Eichhorn W (ed) Models and Measurement of Welfare and Inequality. Berlin: Springer-Verlag Press.

Martin A (2007) Organic milk supply expected to surge as farmers pursue a payoff. New York Times, Business Section, April 20:3,5.

Mayen CD, Balagtas JV, Alexander CE (2010) Technology adoption and technical efficiency: Organic and conventional dairy farms in the United States. American Journal of Agricultural Economics 92(1):181-195.

Mayen CD, Balagtas JV, Alexander CE (2009) Vertical economies of scope in dairy farming. Journal of Agricultural and Food Industrial Organization 7(1):1-15.

McBride WD, Greene C (2009) Costs of organic milk production on U.S. dairy farms. Review of Agricultural Economics 31(4):793-813.

Morrison-Paul C, Nehring R, Banker D, Somwaru A (2004a) Are traditional farms history? Journal of Productivity Analysis 22:185-205.

Morrison-Paul C, Nehring R, Banker D (2004b) Productivity, economies, and efficiency in U.S. agriculture: A look at contracts. American Journal of Agricultural Economics 86:1308-1314.

Morrison-Paul C, Nehring R (2005) Product diversification, production systems, and economic performance in U.S. agricultural production. Journal of Econometrics 126:525-548.

Mosheim R, Lovell K (2009) Scale economies and inefficiency of U.S. dairy farms. American Journal of Agricultural Economics 91:777-794.

Nehring, Richard F., Richard Barton, and Hallahan, “The Economics and Productivity of US dairy farms that use crossbred vs non-crossbred breeding technology (production systems.” Agricultural Finance Review Volume 77 No 2. (2017):275;294.

Nehring R, Barnard C, Banker D, Breneman V (2006) Urban influence on costs of production in the Corn Belt. American Journal of Agricultural Economics 88(4):930-946.

Nehring R, Gillespie J, Sandretto C, Hallahan C (2009) Small U.S. dairy farms: Can they compete? Agricultural Economics 40:817-825.

Neuman W (2010) New pasture rules issued for organic dairy producers. New York Times, Business Section. February 13.

PRISM Group. (2008), Gridded climate data time series for the Conterminous United States, 1895-2008. Oregon State University. http://prism.oregonstate.edu

Reksen O, Tverdal A, Ropstad E (2005) A comparative study of reproductive performance in organic and intensive dairy husbandry. Journal of Dairy Science 88(7):2462-2475.

Rodriguez-Alvarez A, del Rosal I, Banos-Pino J (2007) The cost of strikes in the Spanish mining sector: Modelling an undesirable input with a distance function. Journal of Productivity Analysis 27:73-83.

Rosati A, Aumaitre A (2004) Organic dairy farming in Europe? Livestock Production Science 90:42-51.

St. Piere, N.R. , B. Cobanov, and G Schnitkey “Economic Loss from Heat Stress by U.S. Livestock Industries.” Journal of Dairy Science. 86(2003)(E Suppl.):E52-E77.

Tauer LW, Mishra AK (2006) Dairy farm cost efficiency. Journal of Dairy Science 89:4937-4943.

Yalcin, S., S. Ozkan, L. Turkmut, and P. B. Siegel. “Responses to heat stress in commercial and local broiler stock.” Broiler Poultry Science. 42(2001):149-162.

Zwald AG, Ruegg PL, Kaneene JB, Warnick LD, Wells SJ, Fossler C, Halbert LW (2004) Management practices and reported antimicrobial usage on intensive and organic dairy farms. Journal of Dairy Science 87:191-201.

Table 1. Input Distance Function Parameter Estimates, 2016 Dairy.

Variable	Parameter t-test Pooled
α_0	0.128 (8.83)***
α_{XLAB}	-0.322 (-42.35)***
α_{XFEED}	-0.395 (-7.22)***
α_{XCAP}	-0.100 (-6.24)***
β_{YCROP}	-0.011 (-0.392)
β_{YLIVE}	-0.751 (-3.59)***
$\beta_{YCROP,YCROP}$	0.004 (1.65)*
$\beta_{YLIVE,YLIVE}$	-0.051 (-2.86)***
$\beta_{YCROP,YLIVE}$	0.001 (1.30)
$\gamma_{YLIVE,TEXT}$	0.007 (72.11)***
$\gamma_{YLIVE,WATHCA}$	0.056 (7.09)***
$\gamma_{YCrop,Urban}$	-0.003 (-2.77)**
$\alpha_{XLAB,XLAB}$	0.001 (9.65)***
$\alpha_{XFEED,XFEED}$	-0.004 (-6.40)***
$\alpha_{XCAP,XCAP}$	-0.001 (-0.68)
$\alpha_{XLAB,XFEED}$	0.031 (2.02)*
$\alpha_{XLAB,XCAP}$	0.022 (2.57)**
$\alpha_{XFEED,XCAP}$	-0.575 (-0.97)
δ_{INEFF}	-0.042 (-3.04)***
$\delta_{PastureDum}$	0.394 (2.13)*
$\delta_{Oplabor}$	0.393 (2.17)**
$\delta_{Splabor}$	-0.149 (-2.56)**
$\delta_{DumDairy}$	-0.508 (-1.53)
$\delta_{Organic}$	0.241 (2.44)**
δ_{AI}	-0.329 (-1.83)*
δ_U^2	0.111 (2.59)**
γ	0.529 (1.19)
Eff	0.800 ***
RTS	0.690***

Notes: ***significance at the 1% level (t=2.977), **significance at the 5% level (t=2.145), and *significance at the 10% level (t=1.761). Source: ARMS, USDA (2016). The t-statistics are based on 1,532 observations for the pooled sample, using weighting techniques described in in Dubman's CV15 program. Finally note that significance levels for the marginal contributions and RTS are derived by dividing constructed means/CV's in SAS.

Table 2: MPC's for Outputs and Inputs (t-statistics in Parentheses)

MPC_{YCROP}	***0.001***	*(0.01)*	MPC_{XLAB}	***-0.520***	*(-3.71)****
MPC_{YLIVE}	***0.690***	*(4.14)****	MPC_{XFEED}	***-0.080***	*(-2.67)***
RTS	***0.691***	*(4.06)****	MPC_{XCAP}	***-0.270***	*(-3.86)****
			MPC_{XLAND}	***-0.150***	*(-2.96)***

Notes: ***significance at the 1% level (t=2.977), **significance at the 5% level (t=2.145), * significance at the 10% level t =1.761). Source: USDA ARMS (2010-2016). The t-statistics are based on 10,033 observations using weighting techniques described in Dubman's CV15 program.

Table 3. Characteristics of Farms Including Technical Efficiency and Returns to Scale, by Organic Status and Size, 2016 ARMS Dairy Survey. (* indicates estimate is statistically significantly different from Organic Herds with ≥200 Cows)

Item	Group						
	Organic <75 Cows	Organic 75≤ Cows<200	Organic ≥200 Cows	Non-organic <75 Cows	Non-organic 75≤ Cows <200	Non-organic 200≤ Cows <500	Non-organic 500≤ Cows <1,000
No. Obs.	263	98	33	216	339	198	126
No. Farms	3,466	906	322	15,660	8,356	3,117	1,544
% Value of Production	2.00	1.52	2.70	8.15	11.29	11.90	13.03
Cows per Farm	44	113	514	51*	123*	316	716
Pasture Acres per Cow	0.82	0.64	0.53	0.30	0.15	0.13	0.05*
Milk per Cow, lbs/yr	13,045*	13,976*	16,280	17,565	19,803*	21,779*	23,131*
Cost Pur Feed / Cow	589*	673	776	495	558	679	935
Labor per Cow $	2,417.72*	1,172.45*	878.21	1,861.44	1,194.75	868.04	732.68
Variable Cost per cwt Milk	28.79*	19.09	15.95	18.35	13.61	11.35	11.39
Net Ret on Assets	0.054*	0.092*	0.119	* 0.024	0.031	0.050	0.046
Household Returns	0.048*	0.086*	0.150	* 0.022	0.032	0.054	0.050
Milk Price per cwt	16.66*	17.13*	22.11	9.46*	8.72	9.83	8.40
Debt-Asset Ratio	0.142	0.198	0.244	0.123*	0.167	0.223	0.289
Land price, $/acre	4,685.78*	3,368.24*	4,003.35	4,561.32	3,956.79	3,932.42	5,027.78
ThiMean Index	595.751	517.457	493.543	706.231*	906.102*	1,051.580*	1,113.899*
Household Well-being	3.376*	3.687	3.863	2.896*	3.282*	3.509	3.515
Have Parlor	0.28*	0.71	0.90	0.26*	0.75*	0.94	0.96
Use AI	0.67	0.82	0.80	0.76	0.84	0.81	0.86
Individual Records	0.58	0.67	0.84	0.53	0.69	0.79	0.89
Robotics	0.01	0.01	0.03	0.01	0.02	0.03	0.05
Total Exp/Cwt Cents	27.57	28.64	27.82	18.55*	18.50*	18.46*	17.93*
Total Feed Cost per Cow	1,219	1,347	1,627	1,141*	1,202	1,423	1,863
Technical Efficiency	0.679*	0.679*	0.719	0.802*	0.810*	0.819*	0.911*
RTS	0.58*	0.67*	0.80	0.60*	0.71*	0.79	0.84*