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Abstract – **Technical and scale efficiencies are estimated for organic and non-organic dairy farms in the United States using an input distance function approach. A multinomial logit analysis is used to categorize the farms by technology. Large conventional farms outperformed smaller farms in most technology / organic / non-organic categories. There was high variability in net returns among the organics so that they did not differ significantly from the large conventional farms. The largest conventional non-organic operations and conventional organic operations tended to have the higher technical efficiencies.**

Keywords – **organic dairy production, input distance function, technical efficiency**

I. INTRODUCTION

Over the past decade, organic milk production has increased considerably, emerging as an enterprise option for farmers throughout the United States. Though organic milk production continues to represent a small portion of the total U.S. milk produced, it is becoming more widespread as organic milk demand continues to increase. In an April 20, 2007, *New York Times* article, Martin [1] reported that Organic Valley, which sells dairy products in Wisconsin, would be adding 269 organic dairy farmers in 2007, to total 972 farms. Meanwhile, the largest U.S. company dealing in organic dairy products, Horizon Organic, added 350 farms with 230 more in transition [1].

As the market for organic milk expands, more farmers are considering making the transition from conventional to organic milk production. Using data from USDA's Agricultural Resource Management Survey (ARMS), this paper explores the extent of U.S. organic milk production in 2005, estimates the net returns and technical efficiency (TE) associated with organic versus non-organic production, and compares the financial performance of organic versus non-organic producers.

I. BACKGROUND

Certified organic milk production in the United States must be consistent with USDA guidelines. As discussed by Dimitri and Greene [2], the animals cannot be provided antibiotics or growth hormones, but do receive preventive veterinary care. They must have access to pasture, though the extent of pasture access is unspecified. All feed must be organically grown. To convert from conventional to organic, cows must be fed a diet of 80 percent or more organic feed for 9 months, followed by 100 percent organic feed for 3 months. The alternative is to graze land under a certified organic plan [2].

Organic milk is available not only in outlets that specialize in organic and natural foods, but also increasingly in traditional grocery stores. Organic milk consumers generally prefer organic over conventional milk for perceived health, environmental, animal welfare, or other reasons. Dhar and Foltz [3] found that consumers benefited from having a variety of choices in the market – conventional, rBST-free, and organic milk – and consumers were willing to pay significantly more for rBST-free and organic milk. Kiesel and Villas-Boas [4] found the USDA organic seal to increase consumer likelihood of purchasing organic milk and to substitute organic for rBGH-free labeled milk.

A number of studies have examined organic milk production. De Boer [5] found eutrophication potential to be lower with organic than conventional milk production. Zwald et al. [6] showed selected organic dairy farmers in the traditional U.S. milk production region to be smaller, more likely to use purchased feeds, total mixed rations, and tie-stall barns, and less likely to seek help from veterinarians or use antibiotics than conventional dairy farmers. Reksen, Tverdal, and Ropstad [7] found lower reproductive efficiency under organic production, but greater roughage to milk conversion efficiency. Differences in technology usage among organic versus conventional producers leads to different risks, whether from inability to use risk-reducing inputs or to procure a suitable volume of organic inputs, instability of organic product prices, or policy changes [8]

A. Previous Economic Studies

Though previous studies have examined the economics of organic milk production outside the United States [9], only two economic analyses of organic dairy farming in the United States were identified. Butler [10] compared net returns associated with organic and non-organic milk production in California. He found higher feed, herd replacement, interest, depreciation, tax, and insurance expenses with organic production, and total production costs that were 20 percent higher than with non-organic production. Though the organic milk price was higher than that for non-organic-produced milk, average net farm income was lower for organic. The Butler study was conducted in 1999, early in the upturn in organic milk production; of 10 California organic dairies, six were included in the study. Though this represented a high percentage of dairies, it represents a small number for statistical purposes, opening the door for further analysis since the industry has expanded substantially since that study.

Dalton et al. [11] examined net returns associated with organic dairies in Vermont and Maine in 2004. Using a sample of 30 dairies with average herd size 48 cows and rolling herd average 14,060 lbs/cow/year, net farm income for organic dairy production was estimated at $105.04 per cow. However, when unpaid labor and management were included, net farm income was a negative $380.30 per cow. Return on assets averaged a negative 2.85 percent. Both Butler [10] and Dalton et al. [11] show higher revenue per cow with organic dairy production, but no economic profit.

Rosati and Aumaitre [12] examined organic milk production in Europe. They report that, while organic milk production accounts for a small proportion of total milk production, growth in organic farming is strong. They argue that organic production gross margins and farm incomes are higher in organic dairy systems than non-organic dairy farming systems. But this assessment is predicated on higher prices and lower input costs for organic dairies.

II. DATA AND METHODS

This study uses data from the 2005 Agricultural Resource Management Survey (ARMS) Phase III dairy version, conducted by the U.S. Department of Agriculture's National Agricultural Statistics Service and Economic Research Service. This dataset provides 1,814 usable responses from 24 states, including 348 organic dairies. The survey collected information on farm size, type and structure; income and expenses; production practices; and farm and household characteristics, resulting in a rich database for economic analysis of the dairy sector. Because this design-based survey uses stratified sampling, the dataset contains weights for each observation that can be used to extend the results to the U.S. dairy farm population.

The dataset includes twenty-four primary dairy-producing states: Arizona, California, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kentucky, Maine, Michigan, Minnesota, Missouri, New Mexico, Ohio, Oregon, New York, Pennsylvania, Texas, Tennessee, Vermont, Virginia, Washington, and Wisconsin. Many dairy farmers in these states have found opportunities to develop organic dairies.

A. Model to Assess Technical and Scale Efficiency

An input distance function approach is used to estimate performance measures, including returns to scale (RTS), and technical efficiency (TE). For the input distance function analyses, three outputs developed from the ARMS data for dairy farms are: Y_{CROP}= value of crop production, $Y_{LIVESTL}$= value of livestock production, and $Y_{OFF\text{-}FARM}$= off-farm income. Inputs are: X_L= labor, X_K= capital, X_{FEED}= feed and miscellaneous including fertilizer and fuel, and X_{OLND}=quality adjusted land.

To account for differences in land characteristics, the quality-adjusted values computed in Ball et al. [13] are multiplied by the pasture acres and non pasture acres to construct a stock of land by farm. That is, the estimated state level quality adjusted price for each observation is multiplied by the actual acres of pasture and non-pasture and a service flow is computed based on a service life of 20 years and an interest rate of 6 percent [14]. Ignoring the heterogeneity of land would result in biased efficiency estimates [13].

B. The Parametric Approach

Estimating $D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})$ requires imposing linear homogeneity in input levels [15], which is accomplished through normalization [16]; $D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})/X_1 = D^I(\boldsymbol{X}/X_1,\boldsymbol{Y},\boldsymbol{R}) = D^I(\boldsymbol{X}^*,\boldsymbol{Y},\boldsymbol{R})$.[1] Approximating this function by a translog functional form to limit *a priori* restrictions on the relationships among its arguments results in:

(1a) $\ln D^I_{it}/X_{1,it} = \alpha_0 + \Sigma_m \alpha_m \ln X^*_{mit} + .5\, \Sigma_m \Sigma_n \alpha_{mn} \ln X^*_{mit} \ln X^*_{nit} + \Sigma_k \beta_k \ln Y_{kit} + .5\, \Sigma_k \Sigma_l \beta_{kl} \ln Y_{kit} \ln Y_{lit} + \Sigma_q \phi_q R_{qit} + .5\, \Sigma_q \Sigma_r \phi_{qr} R_{qit} R_{rit} + \Sigma_k \Sigma_m \gamma_{km} \ln$

1. By definition, linear homogeneity implies that $D^I(\omega\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R}) = \omega D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})$ for any $\omega>0$; so if ω is set arbitrarily at $1/X_1$, $D^I(\boldsymbol{X},\boldsymbol{Y},\boldsymbol{R})/X_1 = D^I(\boldsymbol{X}/X_1,\boldsymbol{Y},\boldsymbol{R})$.

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 $\boldsymbol{R}$ variables. The variable X_1 is specified as land, so the function is specified on a per-acre basis, consistent with much of the literature on farm production in terms of yields.

In addition, the distance from the frontier, -ln D^I_{it} is explicitly characterized as the technical inefficiency error -u_{it}. As in Battese and Coelli [17],[2] we use maximum likelihood (ML) methods to estimate (1b) as an error components model. The one-sided error term u_{it} is a nonnegative random variable independently distributed with truncation at zero of the N(m_{it},σ_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 $\boldsymbol{R}$ 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,σ_v^2). Both a household model and a farm model are estimated (the farm model omits the off-farm income output and the farm efficiency determinants $\boldsymbol{R}$).

This function is estimated using stochastic production frontier (SPF) techniques. Technical efficiency is characterized assuming a radial contraction of inputs to the frontier (constant input composition). The econometric model includes two error terms, a random (white noise) error term, v_{it}, assumed to be normally distributed, and a one-sided error term, u_{it}, assumed to be distributed as a half normal, to represent the distance from the frontier.

The productivity impacts (marginal productive contributions, MPC) of outputs or inputs can be estimated from this model by the first order elasticities, MPC_m = -$\varepsilon_{DI,Ym}$ = $-\partial$ln D^I($\boldsymbol{X}$,$\boldsymbol{Y}$,$\boldsymbol{R}$)/∂ln Y_m = $\varepsilon_{X1,Ym}$ and MPC_k = -$\varepsilon_{DI,X*m}$ = -∂ln D^I($\boldsymbol{X}$,$\boldsymbol{Y}$,$\boldsymbol{R}$)/∂ln X^*_k = $\varepsilon_{X1,X*k}$. MPC_m indicates the increase in overall input use when output expands (and so should be positive, like a marginal cost or output elasticity measure), and MPC_k indicates the shadow value [15] of the k^{th} input relative to X_1 (and so should be negative, like the slope of an isoquant). Similarly, the marginal productive contributions of structural factors (TEXTURE, WATER, POPACC, and the time shifters) can be measured through the elasticities, MPC_{Rq} = -$\varepsilon_{DI,Rq}$ = -∂ln D^I($\boldsymbol{X}$,$\boldsymbol{Y}$,$\boldsymbol{R}$)/∂R_q = $\varepsilon_{X1,Rq}$ (if $\varepsilon_{X1,Rq}$ <0, an increased R_q implies that less input is required to produce a given output, which implies enhanced productivity, and vice versa).[3]

Scale economies (SE) are calculated as the combined contribution of the M outputs Y_m, or the scale elasticity SE = -$\varepsilon_{DI,Y}$ = -$\Sigma_m\partial$ln D^I($\boldsymbol{X}$,$\boldsymbol{Y}$,$\boldsymbol{R}$)/∂ln Y_m = $\varepsilon_{X1,Y}$. That is, the sum of the input elasticities, Σ_m ∂ln X_1/∂ln Y_m, indicates the overall input-output relationship and thus returns to scale. The extent of scale economies is thus implied by the short-fall of SE from 1; if SE<1, inputs do not increase proportionately with output levels, implying increasing returns to scale.

In addition to the more common estimation of the productive effects of outputs and inputs, the direct marginal productive impacts or contributions of structural/policy factors (such as BST, age, or stocking rate) are measured on overall scale economies and technical efficiency.

Finally, technical efficiency (TE) "scores" are estimated as TE = exp(-u_{it}.). The impact of changes in R_q on technical efficiency can also be measured by the corresponding δ coefficient in the inefficiency specification for -u_{it}.

C. Technologies for Comparison

The nonparametric methods are used to estimate technical efficiency (TE) associated with dairies that fall into 10 combinations of size, organic, non-organic, forage reliant, semi-forage reliant, and conventional production, the specific combinations are discussed later. For purposes of the present study, forage reliant production is generally "low-technology" production, referring primarily to extensive pasture use and generally lower use of production-enhancing technologies. These are generally lower-cost, lower-output, smaller farms. At the other end of the spectrum is what has in some circles been referred to as "industrial production," intensive production with no access to pasture and expanded use of production-enhancing technologies. These would be the higher-cost, higher-output, generally larger farms. "Semi-forage reliant" refers

2.Tim Coelli's FRONTIER package was used for the SPF estimation, and computed the measures and t-statistics for measures using PC-TSP.

3. Note that a standard "productivity" or "technical change" measure, usually defined as the elasticity with respect to time, or the time trend of the input-output relationship, is not targeted here. Elasticities with respect to the time dummies provide indications of production frontier shifts for each time period, but for short time series other external factors such as weather often confound estimation of a real technical change trend.

to technology and management that utilizes pasture but not as the major forage source, and some use of production-enhancing technologies. The primary characteristic of concern among the three categories is extent of pasture use, but the employment of complementary and substitute technology is also of importance.

To systematically categorize the farms into the conventional, semi-forage reliant, and forage reliant categories, a multinomial logit model is used, as reported in detail in Gillespie et al. [18] Briefly, the dependent variable includes three categories describing the extent of pasture use, where conventional production uses no pasture, semi-forage reliant production relies on pasture for 1 to 49 percent of forage needs during the grazing season, and forage reliant production relies on pasture for 50 percent or more of the forage needs during the grazing season. Farmers were asked two consecutive questions in the ARMS that allow for this categorization.

Independent variables in the multinomial logit analysis include eight regions of the U.S., land value/acre, farm acres, number of cows, percentage of income from milk, the number of beef cattle, off-farm work, debt-asset ratio, age, college degree, an instrumental variable for number of times per day the cows were milked, and an instrumental variable for pasture acres per cow. The instrumental variable for number of times per day the cows were milked was estimated using a probit model, while the instrumental variable for pasture acres per cow was estimated using a tobit model. The multinomial logit model resulted in a correct prediction of 68.3 percent.

Estimation of the multinomial logit model results in predicted probabilities of each farm falling into each of the three categories. The category with the highest predicted probability for each observation was the category in which the farm was placed. Farms were further divided into organic and non-organic, based upon whether the respondent indicated the farm was selling organic milk. Given the wide range in the size distribution of conventional non-organic farms, this category was further broken into four size categories for the conventional farms, 1 to 99 cows, 100 to 500 cows, 501 to 1000 cows, and more than 1000 cows; and two size categories for the conventional organic farms, 1 to 99 cows and >99 cows. The final resulting 10 categories provided technology/management practice groups that could be compared on the basis of technical efficiency, and other productivity measures.

IV. STOCHASTIC FRONTIER RESULTS

More that one-half of the estimated coefficients from the input distance fit are significant, including the own price on labor, feed, and capital, and the cross price effects of crops and livestock. All of the measures of outputs and inputs have the expected signs, positive for outputs and negative for inputs, as shown in Table 1--see Morrison-Paul et al. [19]

Table 1. MPCs for outputs and inputs (t-stats in parenthesis).

MPC_{YCROP}	0.120	(1.79)*
$MPC_{YLIVESTK}$	0.450	(5.15)***
$MPC_{YOFF\text{-}FARM}$	0.020	(0.90)
MPC_{XL}	-0.400	(-2.30)**
MPC_{XFEED}	-0.350	(-2.25)**
MPC_{XK}	-0.120	(-1.82)*
MPC_{XQLND}	-0.130	(-2.94)***

Notes: *** Significance at the 1% level (t=2.576). ** Significance at the 5% level (t=1.96). * Significance at the 10% level t =1.645). Source: USDA 2005 Agricultural Resource Management Survey. The t-statistics are based on 1,804 observations using weighting techniques described in Dubman's CV15 program.

V. MULTINOMIAL LOGIT RESULTS

The majority of surveyed farms fell into either the semi-forage reliant (647) or conventional (985) technologies (Table 2). Table 3 shows results of the multinomial logit analysis. Pasture acres per cow was greater for the forage reliant organic farms (1.82) than any of the other categories except for the semi-forage reliant organic farms (1.45), likely due to the limitations of inputs that can be applied to organic pasture. Of the organic conventionals, milk produced per cow was lower for the small farms with <100 cows (12,453 lb/cow/yr) than for the large farms with ≥100 cows (16,528 lb/cow/yr). Multinomial logit results suggest that region influenced choice of forage system, as did predicted pasture acres per cow and whether animals are milked 3 times per day.

In terms of economic measures, forage reliant non-organic, semi-forage reliant, small conventional organic, and the conventional non-organics with fewer than 1,000 cows had lower net returns than the conventional non-organics with ≥1,000 cows. The semi-forage reliant organic and small conventional organic farmers had lower net returns on assets than the conventional non-organics with ≥1,000 cows, as did several of the smaller non-organics. Net returns per cow and per hundredweight of milk produced were generally sensitive primarily to size. Though the organic forage reliant and semi-forage reliant operations did not have significantly different net returns than any of the other categories, their means were numerically lower, in the range of other categories that were dominated by the large conventional farms. This suggests

Table 2. Cost and Production Means and Statistics by Forage Intensity and Herd Size, 2005

Item	Forage Reliant Non-Organic	Forage Reliant Organic	Semi-forage Reliant Non-Organic	Semi-forage Reliant Organic	Conventional organic cows<=100	Conventional organic cows>100	Conventional 0 to 99 cows	Conventional 100 to 500 cows	Conventional 501 to 1000 cows	Conventional > 1000 cows
Number of Observations	79	93	550	97	120	39	154	375	158	139
Percent of farms	6.8	0.4	47.0	0.4	0.6	0.2	22.1	17.4	2.9	2.2
Percent of value of prod.	2.2	0.1	21.3	0.2	0.2	0.3	7.1	22.1	14.5	32.0
Dairy Cows per Farm	65.6 $^{\text{CEFHIJ}}$	53.5 $^{\text{FHIJ}}$	82.3$^{\text{AEFGHIJ}}$	78.0$^{\text{FHIJ}}$	53.8 $^{\text{ACFHIJ}}$	338.2$^{\text{ABCDEGHIJ}}$	57.9$^{\text{CFHIJ}}$	203.7$^{\text{ABCDEGIJ}}$	670.9$^{\text{ABCDEFGHJ}}$	1,985.1$^{\text{ABCDEFGHI}}$
Milk per Cow (lbs. annually)	16,524 $^{\text{EHIJ}}$	12,455	17,248 $^{\text{EHIJ}}$	14,736$^{\text{I}}$	12,453$^{\text{ACFGHIJ}}$	16,528 $^{\text{EHIJ}}$	17,005$^{\text{EHIJ}}$	19,411$^{\text{ACEFGI}}$	20,924 $^{\text{ACDEFGH}}$	20,180$^{\text{ACEFG}}$
Net Return on Assets (%)	4.7 $^{\text{J}}$	3.7	4.1$^{\text{J}}$	3.9$^{\text{J}}$	4.1$^{\text{HJ}}$	8.0	4.8 $^{\text{J}}$	4.8$^{\text{J}}$	5.0$^{\text{J}}$	12.2$^{\text{ACDEGHI}}$
Net profits per cow ($)	-1,195 $^{\text{FHIJ}}$	-1,225	-969 $^{\text{FGHIJ}}$	-917	-1,056$^{\text{FHIJ}}$	-126$^{\text{ACEGJ}}$	-1,327$^{\text{CFHIJ}}$	-326$^{\text{ACEGIJ}}$	97$^{\text{ACEGHJ}}$	662$^{\text{ACEFGHI}}$
Net profits per cwt milk ($)	-7.44$^{\text{FHIJ}}$	-10.12	-5.69 $^{\text{EFGHIJ}}$	-6.38	-8.79$^{\text{CFHIJ}}$	-0.77$^{\text{ACEGJ}}$	-7.91$^{\text{CFHIJ}}$	-1.70$^{\text{ACEGIJ}}$	0.47$^{\text{ACEGHJ}}$	3.30$^{\text{ACEFGHI}}$
Returns to scale	0.59 $^{\text{EFGHIJJ}}$	0.55	0.58 $^{\text{FHIJ}}$	0.57 $^{\text{AFHIF}}$	0.57$^{\text{AFHIJ}}$	0.71 $^{\text{ACDEGIJ}}$	0.57 $^{\text{AFHIJ}}$	0.69$^{\text{ACDEGIJ}}$	0.87 $^{\text{ABCDEFHJ}}$	0.96 $^{\text{ACDEGGHI}}$
Efficiency score	0.85 $^{\text{I}}$	0.89	0.86$^{\text{FIJ}}$	0.87	0.86$^{\text{I}}$	0.88 $^{\text{CGI}}$	0.86 $^{\text{FIJ}}$	0.87$^{\text{I}}$	0.91 $^{\text{ACEFGH}}$	0.89 $^{\text{CG}}$
FORAGE INTENSITY										
Dairy pasture acres/cow	0.82 $^{\text{BEFGHIJ}}$	1.82$^{\text{ACEFGHIJ}}$	0.72$^{\text{BEFGHIJ}}$	1.45$^{\text{EFGHIJ}}$	0.08$^{\text{ABCDFGHIJ}}$	0.02 $^{\text{ABCDEIJ}}$	0.02$^{\text{ABCDEHIJ}}$	0.00$^{\text{ABCDEGIJ}}$	0.00$^{\text{ABCDEFGHJ}}$	0.00$^{\text{ABCDEFGHI}}$
Manure N per ac. harvested (lbs.)	67 $^{\text{EFGIJ}}$	49 $^{\text{J}}$	65 $^{\text{EFGIJ}}$	56 $^{\text{FIJ}}$	51 $^{\text{ACFHIJ}}$	138 $^{\text{ACDEGHJ}}$	46 $^{\text{ACFHIJ}}$	69 $^{\text{EFGIJ}}$	140 $^{\text{ACDEGHJ}}$	321 $^{\text{ABCDEFGHI}}$
Manure P per ac. harvested (lbs.)	26 $^{\text{EFGIJ}}$	19 $^{\text{J}}$	26 $^{\text{EFGIJ}}$	22 $^{\text{FIJ}}$	20 $^{\text{ACFHIJ}}$	54 $^{\text{ACDEGHJ}}$	18 $^{\text{ACFHIJ}}$	27 $^{\text{EFGIJ}}$	55 $^{\text{ACDEGHJ}}$	126 $^{\text{ABCDEFGHI}}$

Source: Authors' analysis of USDA 2005 Agricultural Resource Management Survey. The t-statistics are based on 1,804 observations using weighting techniques described in Dubman. A through J indicate significant differences in means across columns with A = forage reliant non-organic, B = forage reliant organic, C = semi-forage reliant non-organic, D = semi-forage reliant organic, E = conventional organic <=100 cows, F = conventional organic >100 cows, G = conventional 0 to 99, H = conventional 100 to 500cows, I = conventional 501 to 1000 cows, J= conventional >1000 cows.

Table 3. Multinomial Logit Results for Choice of Grazing Technology

Variable	Forage Reliant vs. Semi-Forage Reliant		Conventional vs. Semi-Forage Reliant		Conventional vs. Forage Reliant	
	Beta	t-stat	Beta	t-stat	Beta	t-stat
Constant	-0.2293	-0.1647	1.1378	0.9502	-1.3671	-0.8713
Lake States	1.3315*	1.6898	-0.6056	-0.6869	1.9371**	3.3454
Corn Belt	1.0045	1.2762	-0.2194	-0.2679	1.2239**	5.3299
Appalachia	0.2161	0.3575	-0.1448	-0.2099	0.3610	0.9360
Southeast	-1.6191	-1.0425	-1.8898	-0.1742	0.2707	0.0255
Southern Plains	2.9567	0.7846	2.4410**	2.5059	0.5156	0.1657
Mountain West	2.3613**	2.2278	0.1710	0.1713	2.1903**	2.9932
Pacific	0.9789	1.1180	1.3883**	2.0775	-0.4094	-0.5901
No. Acres	0.0005	1.2389	-0.0002	-0.2085	0.0007	1.2791
No. Cows	0.0001	0.2011	-0.0047	-1.3969	0.0048	1.3370
No. Beef Cattle	0.0000	0.0475	-0.0023	-1.5480	0.0023	1.3908
Producer Age	0.0177	1.5676	0.0041	0.3002	0.0137	0.8903
% Income Milk	-0.0039	-0.3390	0.0027	1.1284	-0.0066	-0.5535
Debt-Asset Ratio	1.3932	1.0543	-0.4930	-0.4080	1.8862	1.4923
Land Price / Acre	0.0000	0.4146	-0.0001	-1.2157	0.0000	1.3236
Pr-Pasture/Cow	-5.4861**	-3.4971	-1.6398**	-3.9426	-3.8462**	-2.8105
Pr-Milk 3 Times/Day	0.8348	0.9273	-4.0461*	-1.9032	4.8809**	2.5485

Percent Correctly Predicted: 68.3%.
N=1804.

substantial variation in net returns within the two pasture-based organic categories. Note also the higher technical efficiency scores of the conventional 501-1000-cow non-organic farms relative to many of the other categories.

Of considerable interest are two environmental measures – manure nitrogen pounds per harvested acre on the farm, and manure phosphorus pounds per harvested acre. Nutrient density per acre from manure appears to be greatly influenced by farm size, with the largest two conventional size categories producing the greatest densities per acre. Small (<100 cows) conventional categories, both organic and non-organic, are estimated to have produced lower nutrient densities per acre than the larger conventionals and the forage reliant and semi-forage reliant non-organics.

Charts 1-3 provide insight into the percentages of producers within different categories realizing positive household net returns per acre, including land (Economic); positive enterprise net returns per cow (Net Cow); positive whole-farm net returns per acre, excluding land (Operating); and household net worth exceeding $1.2 million (Net Worth). In some cases, categories are broken into high technical efficiency (HT) and low technical efficiency (LT); these categories indicate farms that have technical efficiency measures greater or less than the median within the respective categories. Chart 1 shows the largest conventional farms having the highest percentages of positive net returns by all measures, followed by the 500-1,000 cow category. The large organics with >100 cows and the 100-500 cow conventional have roughly similar percentages of positive net returns. The small organics and conventionals have relatively low percentages realizing positive net returns by all measures. Chart 2 further shows the greater economic viability of a higher percentage of farms among the 500-1,000 cow conventional farms (and hence the ≥1,000 cow conventionals) relative to the forage and semi-forage farms, both organic and non-organic. Chart 3 builds on the results of Chart 2, showing the differences in net returns among the semi-forage non-organics by region. Though relatively higher percentages of the Northeastern, Southeastern, and Western semi-forage non-organics had positive net returns by most measures, none were competitive with the 500-1,000 cow conventionals and, hence, the ≥1,000 cow conventionals.

VI. CONCLUSIONS

A number of factors included in the multinomial logit model allowed us to sort farms into three general dairy farm technologies. Further sorting those categories into organic and non-organic farms allows for comparisons of economic viability and environmental impact of organic and non-organic farms. The overall conclusion is that, in terms of economic viability, size of operation matters. The large conventional farms economically outperformed smaller farms in most technology / organic / non-organic categories. There appears to be relatively high variability in net returns among the organics, causing some of these categories to not differ significantly from the large categories. This would be expected as producers adopt the new technology, some more successfully than others. In addition, it is likely that organic operations would have higher variability of net returns than non-organics since some risk-reducing inputs are not used. The largest conventional non-organics and the conventional organics tended to have among the higher technical efficiencies in the group.

From an environmental perspective, large numbers of cows generally mean more manure per acre, thus more nitrogen, phosphorus, and other nutrients per acre. Differences were not seen, however, between organics and non-organics within the same size category and technology category. This does not consider, however, the fact that commercial fertilizers are not used on organic farms, so our measure provides only a partial look of the environmental picture.

VII. REFERENCES

1. Martin A. Organic milk supply expected to surge as farmers pursue a payoff. New York Times, Business Section, April 20, 2007: 3, 5.
2. Dimitri C., Greene C (2002) Recent growth patterns in the U.S. organic foods market. Agriculture Information Bulletin 777, Economic Research Service, U.S. Department of Agriculture, September 2002.
3. Dahr T, Foltz J (2003). Market structure and consumer valuation in the rBST-free and organic milk markets. Food System Research Group Working Paper Series FSWP2003-2, University of Wisconsin, Madison.
4. Kiesel K, Villas-Boas S (2007). Got organic milk? Consumer valuations of milk labels after the implementation of the USDA organic seal. Journal of Agricultural and Food Industrial Organization 5:1-38.
5. De Boer I (2003). Environmental impact assessment of conventional and organic milk production. Livestock Production Science 80:69-77.
6. Zwald A, Ruegg P, Kaneene J, Warnick L, Wells S, Fossler C, Halbert L (2004). "Management practices and reported antimicrobial usage on conventional and organic dairy farms. Journal of Dairy Science 87:191-201
7. Reksen O, Tverdal A, Ropstad E (2005). A comparative study of reproductive performance in

organic and conventional dairy husbandry. Journal of Dairy Science 88:2462-75.
8. 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 19:218-227.
9. Morisset M., Gilbert D (2000). Organic milk: What are the costs? Bulletin of the International Dairy Federation: 25-30.
10. Butler L (2002). The economics of organic milk production in California: A comparison with conventional costs. American Journal of Alternative Agriculture 17: 83-91.
11. Dalton T, Bragg L, Kersbergen R, Parsons R, Rogers G, Kauppila D, Wang Q (2005). Costs and returns to organic dairy farming in Maine and Vermont for 2004. Department of Resource Economics and Policy Staff Paper #555, University of Maine.
12. Rosati A, Aumaitre A (2004). Organic dairy farming in Europe? Livestock Production Science. 90:42-51.
13. Ball V, Lindamood W, Nehring R, Mesonada C (2008). Capital as a factor of production in OECD agriculture: Measurement and data. Applied Economics. 40:1253-1277.
14. Nehring R, Barnard C, Banker D Breneman V (2006). Urban influence on costs of production in the Corn Belt. American Journal of Agricultural Economics 88:930-946.
15. Fare R, Primont D (1995). Multi-output production and duality: Theory and applications. Boston: Kluwer Academic Publishers.
16. Lovell C, Richardson S, Travers P, Wood L (1994). Resources and functionings: A new view of inequality in Australia. In W. Eichhorn, ed., Models and measurement of welfare and inequality. Berlin: Springer-Verlag Press.
17. Battese G, Coelli T (1992). Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. Journal of Productivity Analysis 3:153-69.
18. Gillespie J, Nehring R, Hallahan C, Sandretto C (2007). Dairy resource management: A focus on conventional and pasture-based systems. Paper presented at the annual meetings of the Northeastern Agricultural and Resource Economics Association, Rehoboth Beach, DE.
19. Morrison-Paul C, Nehring R, Banker D, Somwaru A (2004). Are traditional farms history? Journal of Productivity Analysis 22:185-205.

Chart 1: Dairy enterprise returns and whole farm (household and farm) returns and household wealth levels show that some farms are competitive in all classes

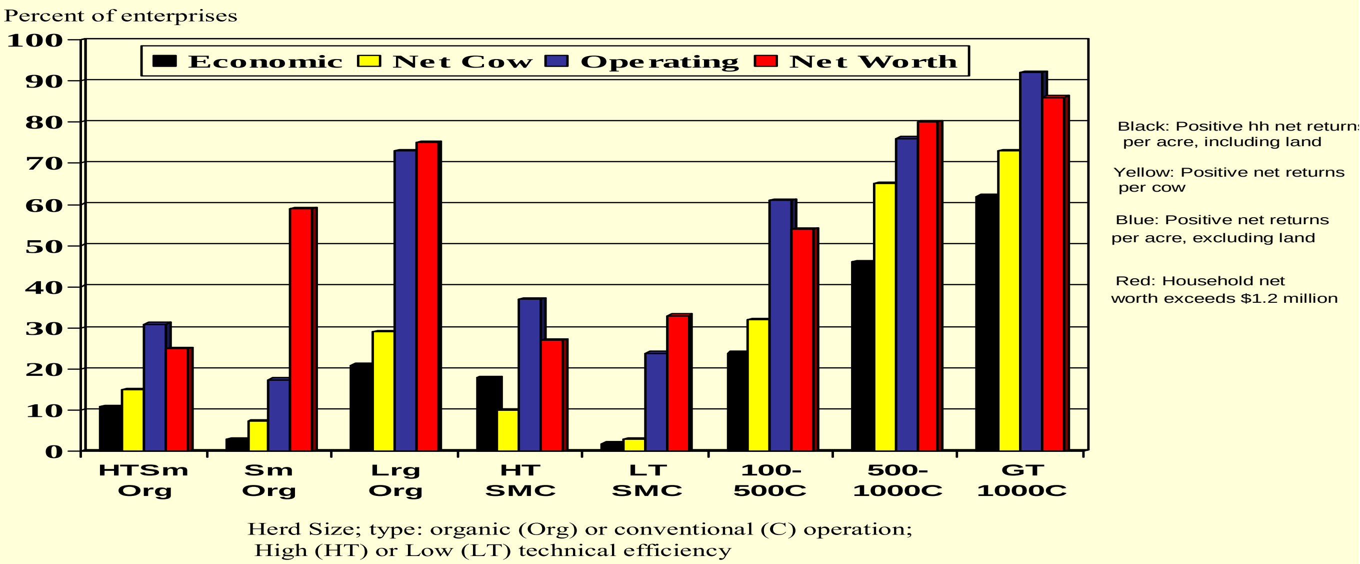


Chart 2: A comparison of economic indicators shows that forage or semi-forage dairy enterprises are generally less competitive than large conventional dairy enterprises

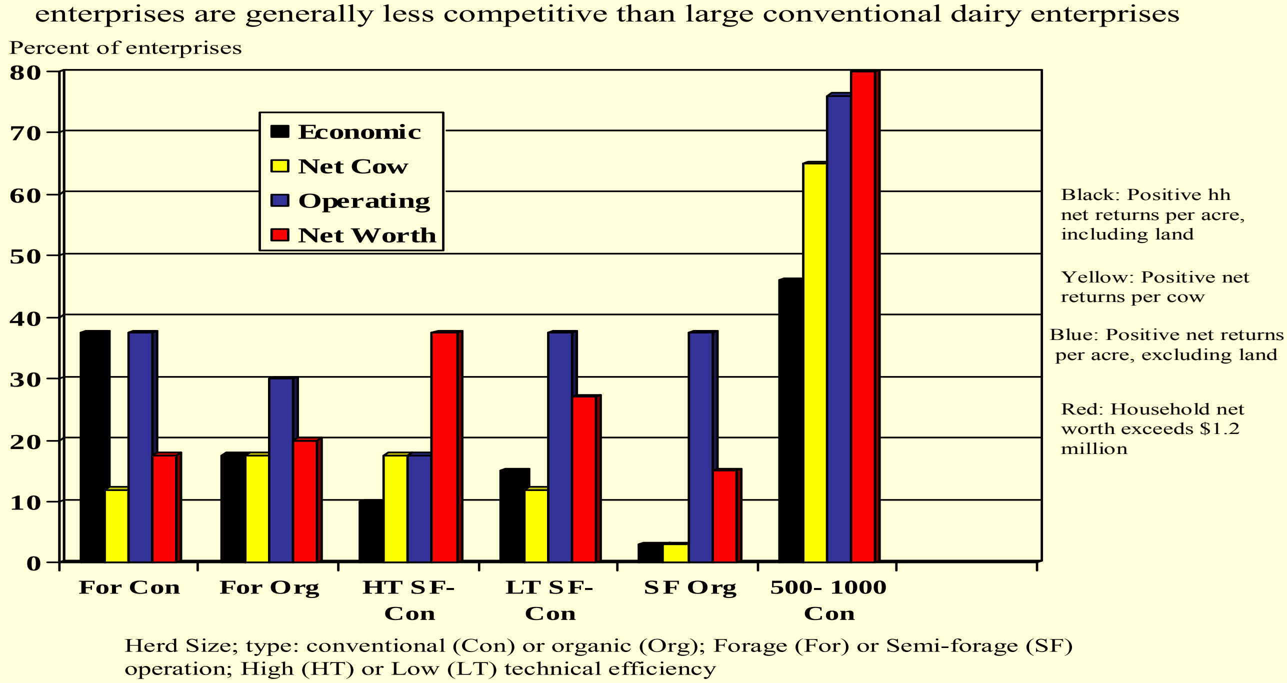
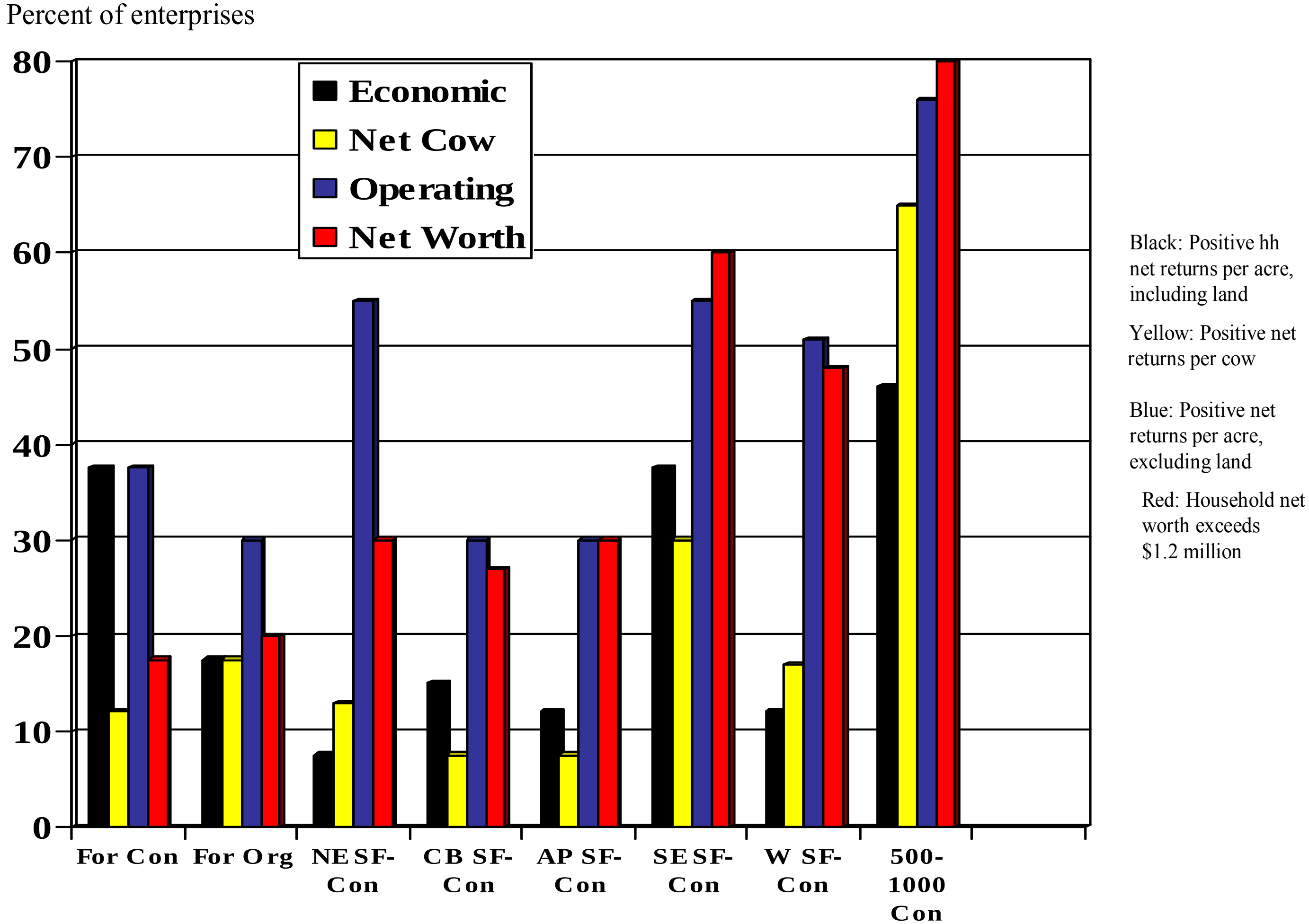


Chart 3: Southeast and Western Semi-forage dairies are particularly competitive



Herd Size; type: conventional (Con) or organic (Org); Forage (For) or Semi-forage (SF) operation; region: Northeast (NE), Corn Belt (CB), Appalachia (AP), Southeast (SE), or West (W)