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THE CAUSES OF ECONOMIC INEFFICIENCIES IN NEW YORK DAIRY FARMS

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Abstract

Technical and overall cost efficiencies are measured for 125 New York dairy farms. Explanatory models of efficiencies are estimated to determine how farms can increase their efficiencies. Changes in efficiencies are explained by changes in both assets and prices. Efficiency levels are explained by farm and operator characteristics.

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In a competitive environment the success and survival of an individual firm is dependent on economic efficiency in that firm's production process. Efficient use of resources in a production process also benefits society. Given this importance it is not surprising that extensive efforts have been made defining and measuring various types of firm efficiencies. More surprisingly, however, is that little effort has gone into determining why some firms are more efficient than others. This is essential to determine how firms may be made more efficient in their use of resources.

The purpose of this paper is to estimate the technical and overall cost efficiencies of 125 New York dairy farms annually from 1981 through 1987. The efficiencies of these farms are then explained by characteristics of the farms. Annual changes in efficiencies are partially explained by changes in investment and prices. The annual relative static measures of efficiency are partially explained by farm and operator characteristics.

Measuring Efficiencies of New York Dairy Farms

Färe's non-parametric technical efficiency measure allowing for variable returns to scale was used to determine the farms' technical efficiencies. (Fare and Grosskopf, p.597) This efficiency measure is the value of the objective function in the following linear program.

$$\begin{aligned} &\text{Min } \lambda \\ &\text{s.t. } zU \geq u_a \\ &\quad\quad zX \leq \lambda x_a \\ &\quad\quad \sum_{i=1}^{s} z_i = 1 \\ &\quad\quad z \in \Re_+^s \end{aligned}$$

In the linear program, s is the number of firms, m is the number of outputs, n is the number of inputs, U is an sxm matrix of the firms' outputs, X is an sxn matrix of the firms' inputs, u_a is a 1xm vector of firm a's outputs, and x_a is a 1xn vector of firm a's inputs.

The 125 dairy farms comprising the data consistently participated in the New York Dairy Farm Business Summary Program for the seven years 1981 through 1987 (Smith, et al.). The quality of these data are considered quite high, but they are not necessarily representative of all New York dairy farms. In fact, they are perceived to be better than average farms. The efficiency measurement procedure used computes efficiency relative to the entire group of farms. Specifically, the linear programming approach determines if any farm or linear combination of farms is more efficient than the specific farm being tested. The efficiency of each farm was computed for each of the seven years. This requires running 125 linear programs for each year.

Milk is the principle output of the farms and was defined as the single output. Miscellaneous receipts were converted into milk equivalent units by dividing by the annual price received for milk on that farm.

Since the level of aggregation affects the resulting efficiencies (Thomas and Tauer), two technical efficiency measures were estimated, one using eight inputs and one using two inputs. The eight inputs include hired labor, family labor, livestock expense, crop expense, machinery expense, real estate expense, debt capital, and equity capital. These were linearly aggregated from more detailed expense categories. The two inputs were simply variable and fixed expenses.

Summaries of the efficiency measures as well as an overall cost efficiency measure are presented in Tables 1-3. Overall cost efficiency was estimated using the common procedure of comparing actual costs to minimum costs. (Färe, Grosskopf, and Lovell, p. 75)

Technical efficiencies measured over the seven years using eight inputs had means near 96 percent with minimum observed efficiencies around 70 percent. Efficiencies measured using only two inputs had means near 80 percent with observed minimums in the range of 55 to 60 percent. The number of inefficient farms in the eight-input case ranged from 44 to 58 over the seven years, as opposed to 111 to 115 inefficient farms in the two-input case. Mean overall cost efficiencies ranged from 66 to 77 percent with observed minimums ranging from 40 to 50 percent. Since only one farm produced at the minimum cost per unit of output, 124 farms were found to be overall cost inefficient.

The explanatory models of efficiencies that follow rely on the variability of efficiencies between firms and over time. When eight inputs were used to measure firms' technical efficiencies, the resulting efficiencies were quite high. In fact, for most years nearly half of the firms were found to be 100 percent efficient. This low variability consequently weakens later analyses that use this eight-input efficiency measure. Much more variability is present, however, in the two-input technical efficiency and overall cost efficiency measures.

Table 1. Summary statistics of eight-input technical efficiencies for 125 New York DFBS farms, 1981-87

Year		1981	1982	1983
Mean		96.98	96.21	95.92
Min Efficiency		73.77	71.05	74.80
Max Efficiency		100.00	100.00	100.00
Number Inefficient		44	49	55
	1984	1985	1986	1987
Mean	95.92	96.13	96.28	96.29
Min Efficiency	70.78	66.98	67.59	75.55
Max Efficiency	100.00	100.00	100.00	100.00
Number Inefficient	46	58	54	49

Table 2. Summary statistics of two-input technical efficiencies for 125 New York DFBS farms, 1981-87

Year		1981	1982	1983
Mean		79.83	79.93	78.51
Min Efficiency		59.76	56.73	56.91
Max Efficiency		100.00	100.00	100.00
Number Inefficient		114	111	115
	1984	1985	1986	1987
Mean	83.30	81.02	80.90	78.45
Min Efficiency	55.60	54.29	58.90	55.89
Max Efficiency	100.00	100.00	100.00	100.00
Number Inefficient	112	113	112	115

Table 3. Summary statistics of overall cost efficiencies for 125 New York DFBS farms, 1981-87

Year		1981	1982	1983
Mean		71.77	70.88	66.06
Min Efficiency		47.96	43.08	41.93
Max Efficiency		100.00	100.00	100.00
Number Inefficient		124	124	124
	1984	1985	1986	1987
Mean	77.27	75.95	73.92	71.56
Min Efficiency	49.77	40.70	44.81	44.78
Max Efficiency	100.00	100.00	100.00	100.00
Number Inefficient	124	124	124	124

Explaining Efficiencies of New York Dairy Farms

If technology is embodied in the assets of a farm, one would expect purchasing new assets to cause a farm's technical efficiency to decline the year the new assets are purchased, while the operator accustoms himself to using the new technology. In subsequent years, the farm's technical efficiency should be restored gradually as the farmer learns to use the new technology. Since Thomas and Tauer have shown that technical efficiencies measured from inputs that are linearly aggregated are actually combined technical and allocative efficiencies, one would expect factors causing changes in allocative efficiency to affect the three computed efficiency measures. Perhaps the most significant cause of a change in allocative efficiency is a change in price. A change in output or input prices may cause a farmer to be initially inefficient as he searches for the new optimal input mix. A dynamic first-difference model which explains the change in efficiency as a function of changes in assets and changes in prices was estimated for the eight-input and two-input measures of technical efficiency and the overall cost efficiency.

Ideally, the change in efficiency should be modelled as a function of changes in specific farm input and output prices and the change in specific farm assets. Data limitations on individual input prices and specific assets restricted the models to include only the change in the price of milk for a farm squared (ΔMPSQ) and the change in total farm assets lagged one and two years (ΔASSET(-1) and ΔASSET(-2)). Milk price is squared to allow either a price increase or decrease to decrease efficiency symmetrically. Percentage changes in assets rather than absolute changes are used to account for size. The model specification is linear in the variables.

Given that contemporaneous correlation exists in the errors between years and that a relatively large sample is used, seemingly unrelated regression (SUR) estimators should be more efficient than OLS estimators for each of the seven years. (Judge, et. al.) Therefore, SUR estimators were used.

The SUR models estimated for the change in overall cost efficiency are presented in Table 4. The OLS model for 1987 is included as well for illustrating differences between the estimation procedures. The model coefficients for the change in the two-input technical efficiency were similar. In the case of the eight-input technical efficiency, however, the models were substantially weaker, due to the large number of efficient farms. A limited dependent variable model might be appropriate for the eight-input data.

The overall explanatory power of the models is low. However, many of the parameters are statistically significant and signed consistently with expectations. Purchasing assets appears to result

Table 4. First-difference dynamic models of a change in the overall cost efficiency for 125 New York DFBS farms, 1983-87

Year:	1983	1984	1985	1986	1987	1987
Method:	SUR	SUR	SUR	SUR	SUR	OLS
Variable	Parameter (t-ratio)	Parameter (t-ratio)	Parameter (t-ratio)	Parameter (t-ratio)	Parameter (t-ratio)	Parameter (t-ratio)
INTERCEPT	-4.8476 (-6.09)	11.4952 (19.29)	-1.2538 (-2.01)	-1.8352 (-2.91)	-1.4860 (-2.53)	-1.1922 (-1.97)
ΔASSET(-1)	-8.6144 (-0.74)	-16.0931 (-1.92)	-22.3608 (-2.93)	-19.2039 (-3.07)	-16.8192 (-2.23)	-19.1013 (-2.40)
ΔASSET(-2)	-1.6847 (-0.28)	1.1447 (0.28)	9.8390 (2.09)	-4.9121 (-1.14)	1.2747 (0.35)	0.9561 (0.26)
ΔMPSQ	-0.2252 (-0.21)	-2.0703 (-0.69)	0.9758 (1.81)	1.3960 (1.70)	-1.5474 (-1.22)	-2.4784 (-1.83)
R-Squared					0.1250	0.0742

* The R-squared reported under the SUR model in 1987 is the SUR system weighted R-squared for all years.

in decreased measured efficiency the year following the purchase. For example, in accordance with the linear specification a one percent increase in assets resulted in an 8.61 percent decrease in efficiency in 1983. However, the second year there appears to be no significant positive or negative effect, perhaps indicating that farmers re-establish their efficiency at different rates after an asset purchase. It was initially hypothesized that a change in the milk price, regardless of whether it is an increase or decrease, would decrease efficiency. However, the parameter estimates for ΔMPSQ and their lack of significance fail to confirm this.[1] The intercept is typically significant but varies in sign. It may reflect either a positive or negative trend in efficiency during the year, perhaps caused by changes in government policies or input prices.

Factors expected to influence a farm's general or static level of efficiency over the entire period are characteristics of the farm and operator that remain stable or slowly change, such as region within the state, age of the operator, education of the operator, type of milking system, type of barn, size of farm, type of dairy production records, type of business records, and type of business ownership. Moreover, price levels that are consistently different among farms may affect a farm's efficiency.

More specifically, the eight-input and two-input technical efficiencies and overall cost efficiencies are modelled as linear

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1 The models were also estimated with the change in milk price rather than the change in milk price squared. The parameter estimates for the change in milk price were all negative and statistically significant. A plausible explanation is that an increase in the price of milk affords farmers the opportunity to become less efficient in the short run.

functions of the following variables. A dummy variable is included for farm participation in the Dairy Herd Improvement (DHI) association, which maintains dairy production records for farm decision use. Milking system types are incorporated through the dummy variables, pipeline (PIPE) and parlor (PARLOR). Because the type of milking system highly correlates with the type of barn, barn type was not included. Sole proprietorships (PROPR), as opposed to multiple ownership operations, are indicated through a dummy variable. Business record keeping systems, both accountbooks (ACCTBK) and computerized systems (COMP), are accounted for as dummy variables. The age (AGE) and education (EDUC) of the primary farm operator are included. Five dummy variables incorporate the regional location of the farm within New York state--southwestern (SW), northwestern (NW), central (CENT), northern (NORTH), and the Catskill region (CATSK). Different soil, climate, and infrastructure are available in these different regions. Average herd numbers (COWNO) are included as a proxy for farm size. Finally, the price of milk (PMILK) is included.

As was the case with the dynamic models, the estimation method used was Zellner's seemingly unrelated regression (SUR) method. Table 5 presents the annual static models. Also, OLS estimates for 1987 are again provided for the purpose of illustrating the differences that exist in the two estimation methods.

The explanatory power of the models is not particularly strong, as indicated by the low r-squared values. The models for the eight-input technical efficiencies again proved to be the weakest. Nonetheless, the explanatory power of the models is comparable to similar efficiency studies. (Tauer and Belbase, Kalirajan and Shand)

Table 5. Static models of the overall cost efficiencies for 125 New York DFBS farms, 1983-87

Year:	1983	1984	1985
Method:	SUR	SUR	SUR
Variable	Parameter (t-ratio)	Parameter (t-ratio)	Parameter (t-ratio)
INTERCEPT	97.2246 (7.44)	130.5895 (9.31)	119.4357 (9.47)
DHI	0.9242 (0.50)	0.7901 (0.41)	0.7276 (0.39)
PIPE	4.2725 (2.11)	3.9077 (1.80)	2.0264 (0.87)
PARLOR	5.7243 (2.43)	5.5288 (2.22)	2.4007 (0.92)
PROPR	-0.3414 (-0.24)	0.9135 (0.61)	-1.1626 (-0.74)
ACCTBK	1.3017 (0.74)	1.9881 (1.14)	1.1805 (0.63)
COMP	0.6935 (0.40)	2.3010 (1.34)	2.0362 (1.08)
AGE	-0.1006 (-1.85)	-0.1288 (-2.12)	-0.2436 (-3.72)
EDUC	0.5233 (2.38)	0.6379 (2.39)	0.2687 (0.95)
SW	4.9719 (1.70)	5.3147 (1.68)	3.1755 (0.95)
NW	7.1015 (2.53)	7.3947 (2.40)	5.6143 (1.72)
CENT	2.8935 (1.09)	3.4153 (1.18)	2.8439 (0.93)
NORTH	3.6344 (1.31)	6.0305 (2.00)	4.9779 (1.56)
CATSK	1.4925 (0.65)	1.8149 (0.72)	0.1234 (0.05)
COWNO	0.0317 (2.89)	0.0319 (2.99)	0.0404 (3.84)
PMILK	-3.3284 (-3.92)	-5.1805 (-5.54)	-3.5178 (-4.13)

Table 5 (cont.). Static models of the overall cost efficiencies for 125 New York DFBS farms, 1983-87

Year:	1986	1987	1987
Method:	SUR	SUR	OLS
Variable	Parameter (t-ratio)	Parameter (t-ratio)	Parameter (t-ratio)
INTERCEPT	132.2242	115.7439	121.1104
	(10.49)	(10.09)	(7.54)
DHI	-0.0849	0.8172	4.5745
	(-0.05)	(0.51)	(2.08)
PIPE	2.7096	4.8214	3.6891
	(1.19)	(2.22)	(1.33)
PARLOR	4.4630	6.4132	6.4764
	(1.73)	(2.61)	(2.13)
PROPR	-0.4898	1.6981	1.9506
	(-0.33)	(1.25)	(1.16)
ACCTBK	0.4821	-0.1347	0.1352
	(0.26)	(-0.07)	(0.05)
COMP	2.2911	1.5867	1.8688
	(1.25)	(0.91)	(0.75)
AGE	-0.1657	-0.1190	-0.1482
	(-2.77)	(-2.13)	(-1.93)
EDUC	-0.0260	0.2257	0.3472
	(-0.09)	(0.91)	(1.01)
SW	1.4469	-0.6302	-0.5535
	(0.46)	(-0.22)	(-0.19)
NW	3.6245	6.5270	6.6551
	(1.18)	(2.35)	(2.33)
CENT	-1.6358	0.7003	1.2720
	(-0.56)	(0.27)	(0.47)
NORTH	4.5344	4.8464	4.0726
	(1.48)	(1.77)	(1.44)
CATSK	-0.7879	0.2816	0.9278
	(-0.31)	(0.12)	(0.40)
COWNO	0.0335	0.0221	0.0150
	(3.85)	(3.27)	(2.09)
PMILK	-4.6472	-4.1433	-4.7751
	(-5.28)	(-5.09)	(-4.14)
R-squared*		0.2892	0.4349

* The R-squared reported under the SUR model in 1987 is the SUR system weighted R-squared for all years.

Several sets of variables are generally statistically significant and consistently signed in the models. Operator age is shown to be negatively related to efficiency, perhaps contrary to researchers' typical beliefs that experience with age increases efficiency. About half of the regional dummy variables are statistically significant. The parameters indicate that farmers in northwestern and northern New York are more efficient than farmers in other regions of the state. As might be expected, the average herd size is positively related to efficiency. Finally, milk price is found to be negatively related to efficiency, as was the case in the dynamic explanatory models.

Summary and Conclusions

Efficiencies of 125 New York dairy farms were estimated annually from 1981 to 1987. These efficiencies were used in dynamic and static explanatory models of efficiency. Results found that a change in assets decreased efficiency in the following year. This lends credance to the dynamic adjustment cost models based upon asset changes (Howard and Shumway). Milk price changes were not found to symmetrically decrease efficiencies, but rather milk price changes were statistically significant and negatively related to the change in efficiency. The level of efficiency about which yearly fluctuations occur was explained primarily by the age of the operator, the regional location of the farm within New York state, the average herd size of the farm, and the price of milk.

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