where σ_{11} is variance of $Gini_{v,s}$ and $\sigma_{\overline{NFI}}$ is variance of $\overline{NFI}_s$.

Independence of Managerial Practices and Expected Financial Performance

Because managerial practices in general have been found important to the success of the farming operation (Sonka, Hornbaker, and Hudson, 1989), this study identifies those practices that are relevant to commercial dairy farming, using what is commonly referred to in the literature as the *F*-test of independence (Fuller and others, 1986, p. 44). To accomplish this, net farm incomes and per-unit returns of commercial dairy farms in milk-producing States are first sorted, then two groups of farms are identified based on whether their net farm incomes and per-unit returns exceeded the thresholds marking the incomes and returns of the top 20 percent of the population. The design of hypotheses tested is illustrated by accepting or rejecting the null hypothesis, H_0, of independence between a farm's undertaking of a certain management practice and its financial success. Success is defined here as being in the top 20 percent of the net farm income and the per-unit returns distributions.

Results

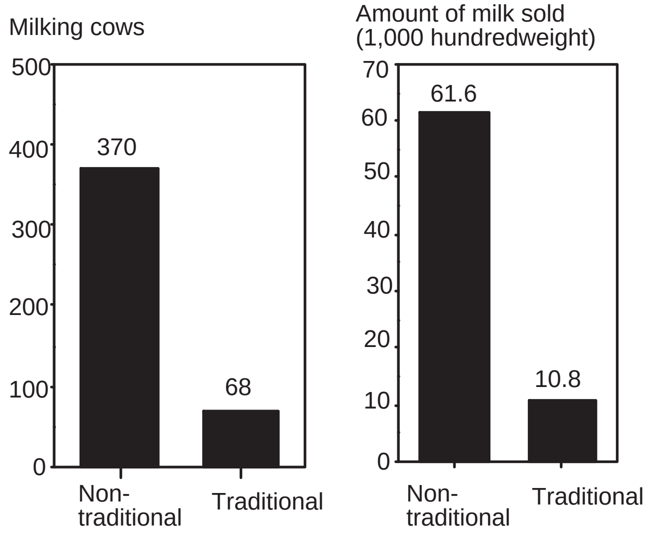
Figures 5-10 provide a pictorial representation of the differences among dairy farms in terms of size, labor availability, balance sheet, and farm profitability based on the location of the dairy operation. The following is a summary of these differences:

- Commercial dairy farms in non-traditional milk-producing States are at least five times (both in terms of cow inventory and in amount of milk sold) larger, with nearly two-thirds operating with herds of 150 milk cows or more (figs. 5 and 6).

- Commercial dairy farms in non-traditional areas use twice as much labor, 2,732 hours per quarter year, compared with 1,234 hours for commercial dairies in the traditional milking areas, with a portion of the labor hours in both milking areas used to produce other commodities beside milk. On a per-hundredweight-of-milk-sold basis (cwt), this amounts to 0.04 and 0.11 hours per cwt, respectively. Unlike dairies in traditional milk producing-areas, which tend to rely more on the operator as the main source of working labor, dairies in non-traditional milk-producing areas tend to rely on full-time paid labor for more than half of their total labor requirement (fig. 7).

Figure 5

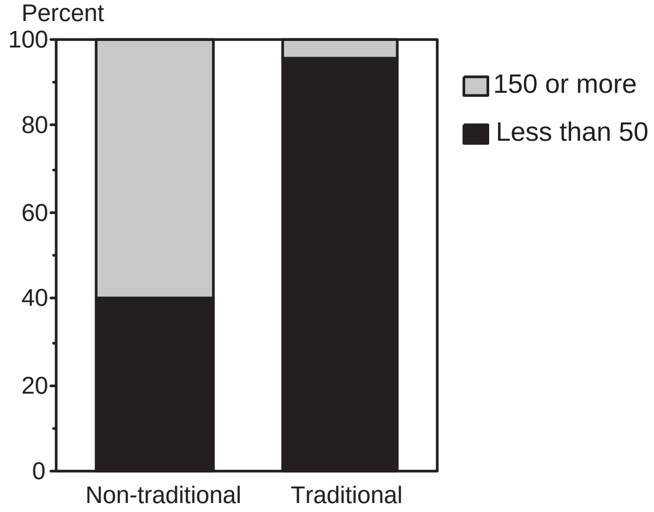
Average size of commercial dairy farms, in selected milk-producing States, 1993



Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Figure 6

Distribution of commercial dairy farms, in selected milk-producing States, by number of milking cows, 1993



Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

- Farm assets of commercial dairies in non-traditional areas are twice as great as the assets of dairies in the traditional milk-producing areas (fig. 8). The value of farm equipment in traditional milk-producing States is almost identical to that of non-traditional milk-producing States indicating that commercial dairies in traditional milk-producing areas have a larger per- cow machinery investment, given that they are one-fifth as large. This observation, however, must be interpreted in the context that a portion of the value of the farm equipment in both groups of milk-producing States is used in the production of other commodities besides milk. Dairy farms in the traditional milk-producing States tend to rely more on forage and grass production for herds' daily intake, which explains the higher level of per-cow investment in farm equipment due to higher per-cow machinery requirements. In terms of indebtedness, non-traditional commercial dairies owe almost four times more than their counterparts in the traditional milk-producing areas, with non-real estate liabilities compromising the majority of the debt load. Although more indebted on a per-farm basis, commercial dairy farms in the non-traditional milk-producing States tend to have less farm business debt on a per-hundredweight-of-milk- sold basis, at $6.98 per cwt compared with $11.04 per cwt for those in the traditional milk-producing States.

- Figure 9 shows that a commercial dairy farm, particularly if located in a non-traditional milk-producing State, tends to exhibit declining debt-to-asset (*DA*) ratios and, correspondingly, tends to exhibit increasing equity value, as the farm operator gets older. The fact that farmers 60 years or older have much lower *DA* than operators under 40 (0.15 and 0.42, respectively, for dairies in non-traditional areas, and 0.14 and 0.19, respectively, for operators in traditional milk-producing States) is consistent with the notion that the farm business follows a life cycle that corresponds to the life cycle of the operator (Boehlje, 1973; Sexton and Duffus, 1977; Backhouse and others, 1988).[8] The higher levels of *DA* of younger operators are compatible with their higher needs for expansion capital in the early stage of their life cycle. In contrast, lower *DA* levels by older operators indicate that their farm businesses have reached the stage in which operators are ready to begin the process of retirement or of intergenerational transfer of wealth.

- Figure 10 shows striking regional differences in the farm financial performance (measured here in terms of

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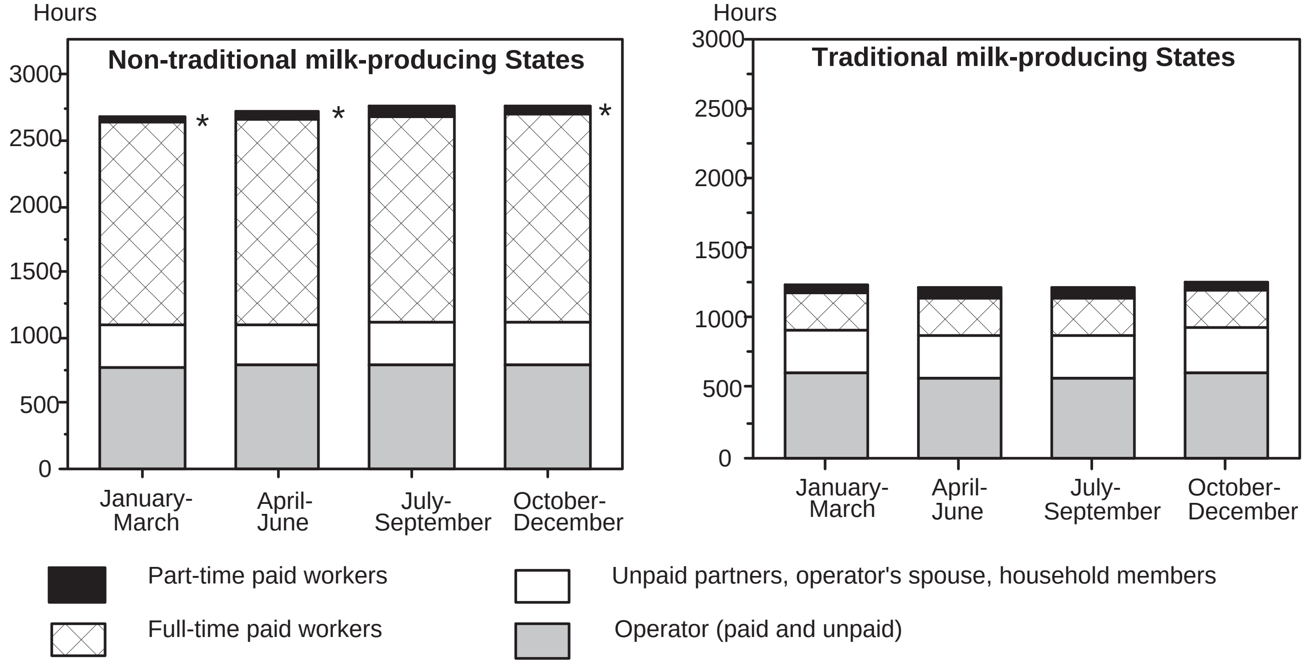
[8] As in Sexton and Duffus, the term "life cycle" used here is not intended to signify a movement of a specific group of operators over time but rather as a reference of a cross-section of farmers at a certain point in time.

Figure 7

Commercial dairy farms' quarterly distribution of labor, 1993



* Coefficient of variation ranges between 25 and 45 percent.

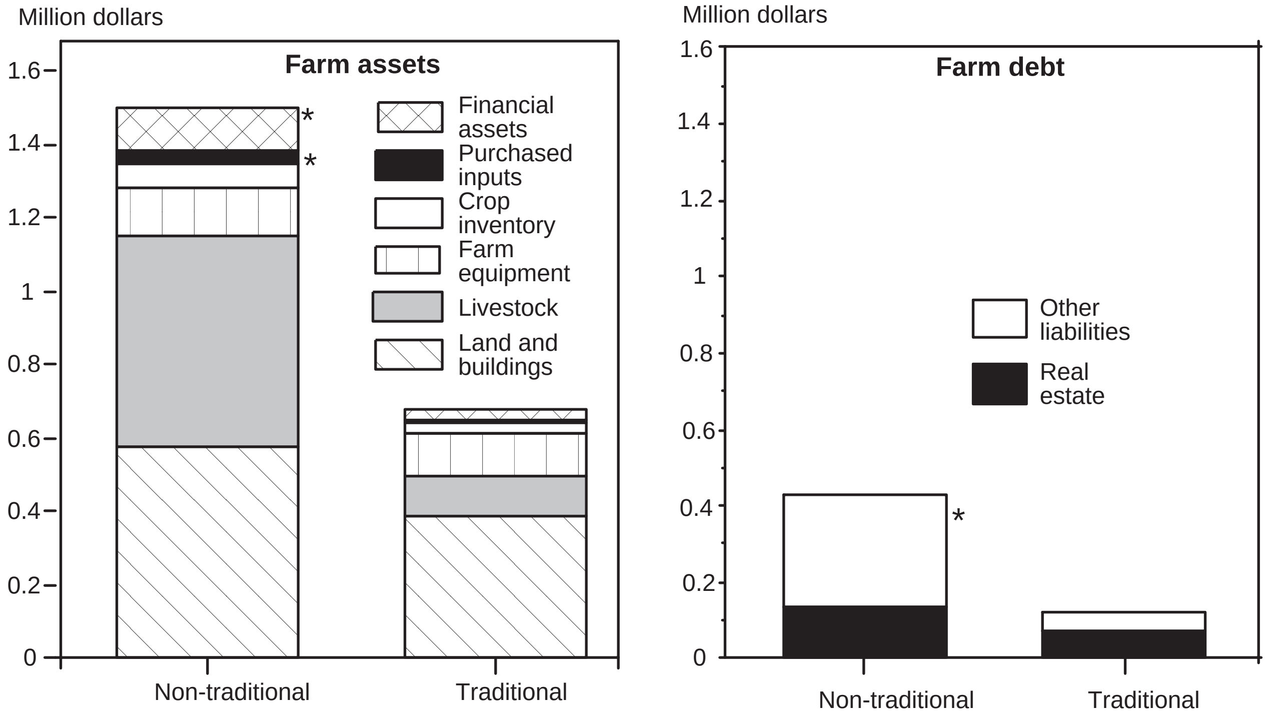
Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

the profitability of the farm business) of commercial dairies. Consistent with the scale of their operation, commercial dairies in the non-traditional milk-producing States have income on a cash basis (net cash income) or on an accrual basis (net farm income) that is five times larger than the income of dairies in the traditional milk-producing States.[9]

The figures discussed above reveal that farms in non-traditional milk-producing States are, on average, larger, more in debt, wealthier, and more likely to financially outperform farms in the traditional milk-producing States. While this information in and by itself is useful, it falls short in revealing whether farms are homogeneous in terms of their financial position or resource base. To remedy this, the farms are distributed by farm debt, farm assets, farm equity, farm income (both net cash and net farm), net returns (gross returns less cash expenses and capital replacement) per hundredweight of milk sold, cow inventory, and milk sales (table 1). The upper 10 percent of commercial dairies in the non-traditional and the traditional milk-producing States have debt levels exceeding $763,978 and $256,699, respectively, illustrating a significant spread in debt levels. Regardless of where the dairy operation is located (whether in the traditional or non-traditional milk-producing States), debt of the top 10 percent of dairy farms is almost 90 times larger than the debt of the lowest 10 percent of farms.[10] The largest 10 percent of commercial dairies in the non-traditional milk-producing States have farm sizes over 40 times larger than farms in the lower 10 percent of the distribution. In contrast, dairy farms in the traditional milk-producing States exhibit less size-related variation since the top 10 percent of the farms are only 4 times larger than farms in the bottom 10 percent. Income, whether per farm on a cash or accrual basis or per enterprise on a per-unit-of-output basis, appears to

Figure 8

Commercial dairy farm operator's balance sheet in selected milk-producing States, 1993



* Coefficient of variation ranges between 25 and 45 percent.

Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

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[9] Because net farm and net cash income measures are absolute amounts and are size-driven, any comparison across farm businesses based solely on these measures must be interpreted with caution.

[10] Comparing the value of a particular measure that corresponds to the 90th percentile of the population to that of the value at the 10th percentile yields a measure of inequality known in the literature as the decile ratio (Bronfenbrenner, 1977, p. 402).

exhibit tremendous variation both within and across the two groups of milk-producing States.

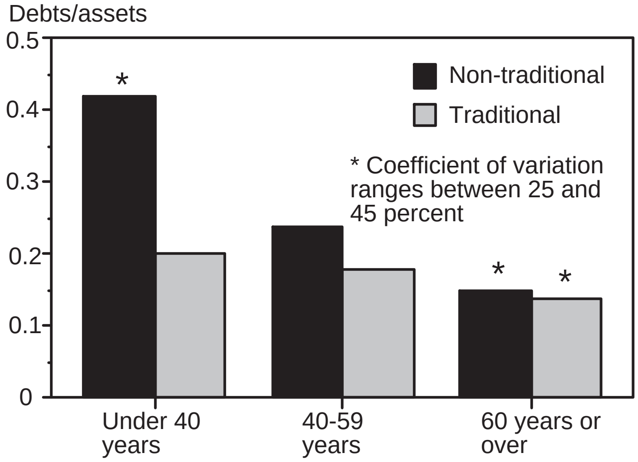
Figures 11-13 present Lorenz curves that provide a graphical description of the distributions of commercial dairy farms in the non-traditional and in the traditional milk-producing States, and of all dairy farms (i.e., regardless of their economic size) in all the FCRS sampled States, by the various measures discussed above. Figure 11 illustrates that the distribution of debt capital for commercial dairies in the non-traditional milk-producing States was by far the most concentrated. For example, the figure shows that the upper 10 percent of farms in the non-traditional milk-producing States owed over 60 percent of all debt, compared with about 40 percent by the top 10 percent of dairies in the traditional milk-producing States. The Lorenz curves of farm assets and farm equity in figure 11, as well as those for net cash and net farm income (fig. 12), and milking cows and milk sales (fig. 13), reveal that the dairy industry in the non-traditional milk-producing States, in comparison with that in the traditional milk-producing States, and in comparison with that in all FCRS-sampled milk-producing States, is more concentrated.

The decile ratios and the Lorenz curves point to commercial dairy farms in the non-traditional milk-producing States having less evenly distributed measures. The Gini coefficients shown in table 2 support these findings. The implication of the distinctively larger Gini coefficients is that the resource base and financial positions of these dairies tend to exhibit tremendous diversity, which in turn, suggests potential complications in the design and implementation of public policies, especially policies aimed at supporting income levels.

Table 3 shows the definitions and the corresponding means of the variables used in two separate regressions based on *NFI* and *NRU* as the dependent variable. Means of continuous and dummy variables are compared across the two groups of milk-producing States and are tested for significant differences, using a 90-percent confidence interval (appendix). In terms of continuous farm characteristics variables, mean rented acres per total operated acres, mean size of largest tractor on farm, and mean debt-to-asset ratios are all significantly different between the non-traditional and the traditional milk-producing States. For the continuous variables that describe enterprise characteristics, only the means for the number of milk cows, for purchased feed per cow, and for the cost of land, buildings and equipment per cow (i.e., investment per cow) are significantly different between the two groups of States. The means of the dummy variables that describe the type of business organization and the type of production practices used in the operation are significantly different between the two groups of milk-

Figure 9

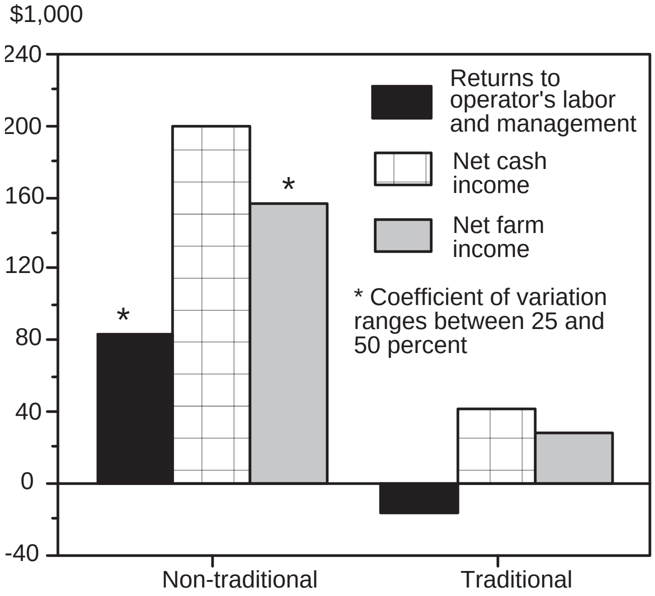
Commercial dairy farm's debt-asset ratios, in selected milk-producing States, by operator's age, 1993



Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Figure 10

Returns to operator's labor and management, net cash income, and net farm income of commercial dairy farms, in selected milk-producing States, 1993



Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Table 1–Distribution of commercial dairy farms, 1993

Proportion of farms below or at specified levels	Non-traditional milk-producing States	Traditional milk-producing States	Proportion of farms below or at specified level	Non-traditional milk-producing States	Traditional milk-producing States
	Dollars per farm			*Dollars per farm*	
Farm debt			**Net farm income**		
10 percent	8,686	2,949	10 percent	-27,353	-7,851
20 percent	25,923	13,540	20 percent	-1,277[4]	2,407
30 percent	67,108	35,130	30 percent	886	8,689
50 percent	123,027	75,206	50 percent	40,506	22,762
70 percent	284,616	137,763	70 percent	128,750	38,904
80 percent	413,166	184,596	80 percent	227,208	48,461
90 percent	763,978	256,699	90 percent	358,853	60,761
	Dollars per farm	*Dollars /cwt*			
Farm assets			**Net returns per unit**		
10 percent	309,070	243,315	10 percent	-5.97[5]	-6.68
20 percent	340,085[1]	363,125	20 percent	-1.78[5]	-4.01
30 percent	418,367	413,141	30 percent	-0.79	-2.34
50 percent	765,832	569,812	50 percent	-0.35	-0.54
70 percent	1,301,828	733,954	70 percent	1.62	0.99
80 percent	2,082,828	881,258	80 percent	2.89	2.17
90 percent	3,418,750	1,182,635	90 percent	3.75[5]	3.57
	Dollars per farm	*Cows per farm*			
Farm equity			**Number of cows**		
10 percent	162,713	166,978	10 percent	22	33
20 percent	259,027[2]	269,353	20 percent	72	40
30 percent	308,250	322,285	30 percent	113	43
50 percent	521,991	448,904	50 percent	186	56
70 percent	992,151	632,607	70 percent	303	70
80 percent	1,520,180	700,666	80 percent	497	83
90 percent	2,476,921	1,065,980	90 percent	900	121
	Dollars per farm	*Dollars per farm*			
Net cash income			**Milk sales**		
10 percent	-10,129[3]	1,118	10 percent	55,227	62,513
20 percent	-2,094	12,525	20 percent	135,900	70,623
30 percent	20,612	20,776	30 percent	195,029	86,817
50 percent	58,320	31,243	50 percent	348,607	106,918
70 percent	159,321	47,731	70 percent	608,395	146,082
80 percent	268,099	58,101	80 percent	861,000	167,570
90 percent	564,182	78,604	90 percent	1,802,093	240,084

[1] This value is the average of the nearest asset values surrounding the 20th percentile as no single value exists at the lower quintile of the distribution.

[2] This value is the average of the nearest equity values surrounding the 20th percentile as no single value exists at the lower quintile of the distribution.

[3] This value is the average of the nearest net cash income values surrounding the 10th percentile as no single value exists at the lower decile of the distribution.

[4] This value is the average of the nearest net farm income values surrounding the 20th percentile as no single value exists at the lower quintile of the distribution.

[5] These values are the averages of the nearest net returns per unit surrounding the corresponding percentiles as no single values exist at the 10th, 20th, and 90th percentiles.

Source: USDA, Economic Research Service.

producing States. Production practices involving a capital purchase (e.g., herringbone, parallel, polygon, or carousel milking parlor), or a production recordkeeping system such as membership in a Dairy Herd Improvement Association (DHIA), are used in this study as proxies for the adoption of what is known in the literature (Zepeda, 1990), respectively, as capital- and management-intensive technologies.[11]

Weighted least squares estimates of factors hypothesized to affect commercial dairy farms' financial performance for the *NFI* and *NRU* models are shown in tables 4 and 5, respectively. The appropriateness of splitting the data between the two groups of milk-producing States was tested (Pindyck and Rubinfeld, 1981, p. 120). Based on computed F-statistics resulting from pooled regressions (appendix), the null hypothesis of equality of sets of coefficients across milk-producing States (1.93 and 3.11 in tables 4 and 5, respectively) for the two models was rejected based on a 99-percent confidence interval. The rejection of this hypothesis implies that in 1993, the determinants of financial performance for commercial dairy farms differed across the two groups of milk-producing States. The remaining F-statistics in tables 4 and 5 (9.80 and 5.32, 19.65 and 16.37, respectively) indicate that the explanatory variables considered in the analysis, as a group, were influential in explaining financial performance in commercial dairy production.

The R^2 of 0.54 in table 4 indicates that the explanatory variables used in the weighted least squares explained 54 percent of the variation in the net farm income of commercial dairy farms in the non-traditional milk-producing States. This is in contrast to the R^2 of 0.30 in the traditional milk-producing States, which indicates a much lower percentage of explained variation, 30 percent. Significantly higher levels of R^2 are found with the net returns per unit model, 0.76 for the non-traditional milk-producing States' regression, and 0.50 for the traditional milk-producing States' regression (table 5). Despite the fact that these levels of explained variation depicted in both tables are fairly typical when analyses are based on cross-sectional data, higher levels might have been reached if weather- and market-related data, such as milk price, among others, were available.

Table 2–Gini coefficients of farm debt, assets, equity, income, cow inventory, and milk sales for commercial dairy farms in selected milk-producing States, 1993

Item	Non-traditional States	Traditional States
	Ratio	
Farm debt	0.756	0.57
Farm assets	0.568	0.343
Farm equity	0.625[1]	0.383[1]
Net cash income	0.802[1]	0.545[1]
Net farm income	0.887[1]	0.736[1]
Cow inventory	0.608	0.305
Milk sales	0.628	0.343

[1] The Gini coefficients reported here are based on the formulation of the adjusted Gini coefficient that corrects for the presence of negative values.
Source: USDA, Economic Research Service.

To demonstrate, prolonged drought in the West caused premium-quality alfalfa in 1993 to be scarce, and the damage from the 1993 excessive rains in some of the Lake States reduced the availability of premium-quality alfalfa (U.S. Department of Agriculture, 1993a, p. viii; U.S. Department of Agriculture, 1993b, p. 6), thus causing milk production costs of affected producers to be higher. An example of the need to incorporate market-related data when examining financial performance in dairy production stems from the fact that the price farmers receive for milk directly affects their profit margins. To a large extent, classified pricing of Federal and State milk orders and the proportion of milk used as fluid in various States contribute to inter-state variation in the prices received for milk delivered to plants (U.S. Congress, 1986). This, in turn, provides the basis for the milk price to be a source of variation in the profitability of dairy farms.[12]

Regression results from studies by Lins, Ellinger, and Lattz (1987) and Lazarus, Streeter, and Jofre-Giraudo (1990) find a negative and significant relationship between farm profitability and debt-to-asset ratio.

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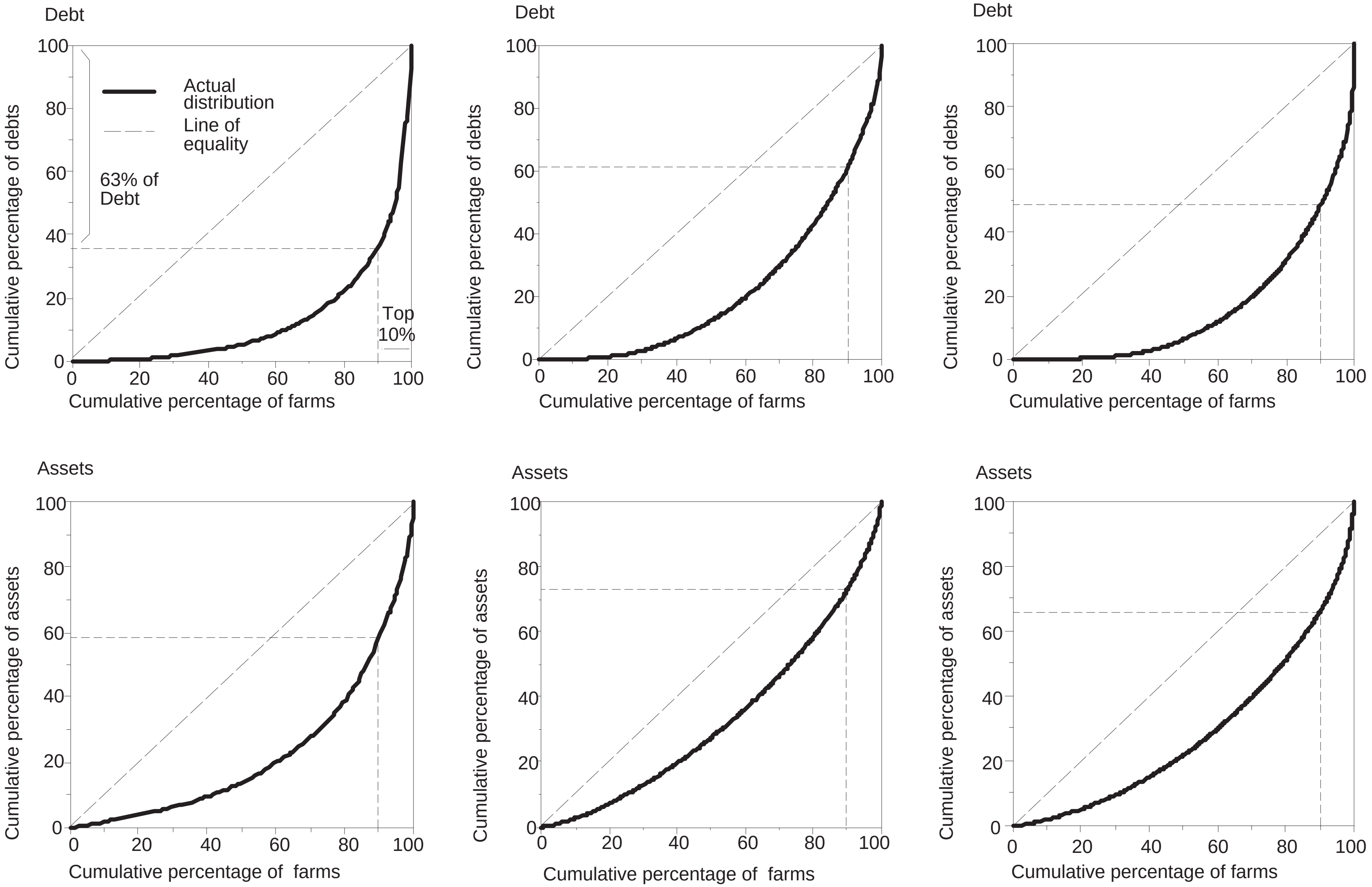
[11] The term "capital-intensive technology," as in Zepeda, 1991, refers to a technology for which the largest single cost share for its implementation is capital cost. A management-intense technology is defined similarly.

[12] The FCRS does not collect information on commodity prices. Instead, price information needed in the computation of gross value of production is based on annual State level information from the U.S. Department of Agriculture's Agricultural Prices. Contrary to expectation, regressions performed with the State milk price as one of the explanatory variables did not reveal a strong correlation between this variable and farms' profitability, a result which may have been caused by the lack of strong variation in milk price in 1993 in the selected milk-producing States.

Figure 11

Lorenz curves of farm debt, assets, and equity: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993



Non-traditional

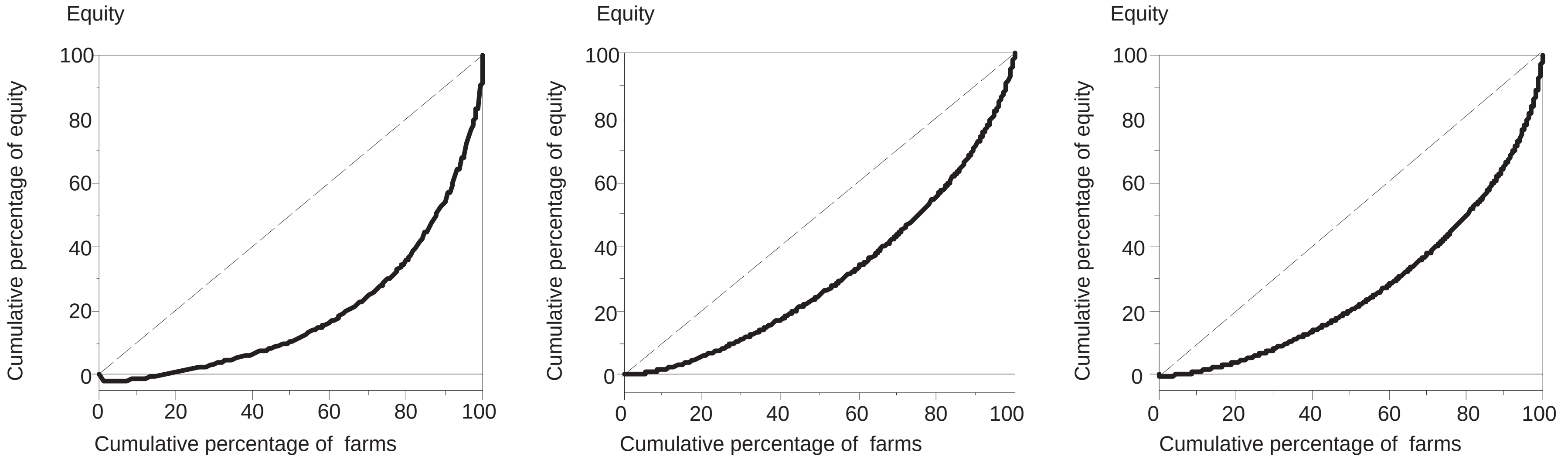
Traditional

All FCRS sampled States

continued--

Figure 11

Lorenz curves of farm debt, assets, and equity: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993--continued

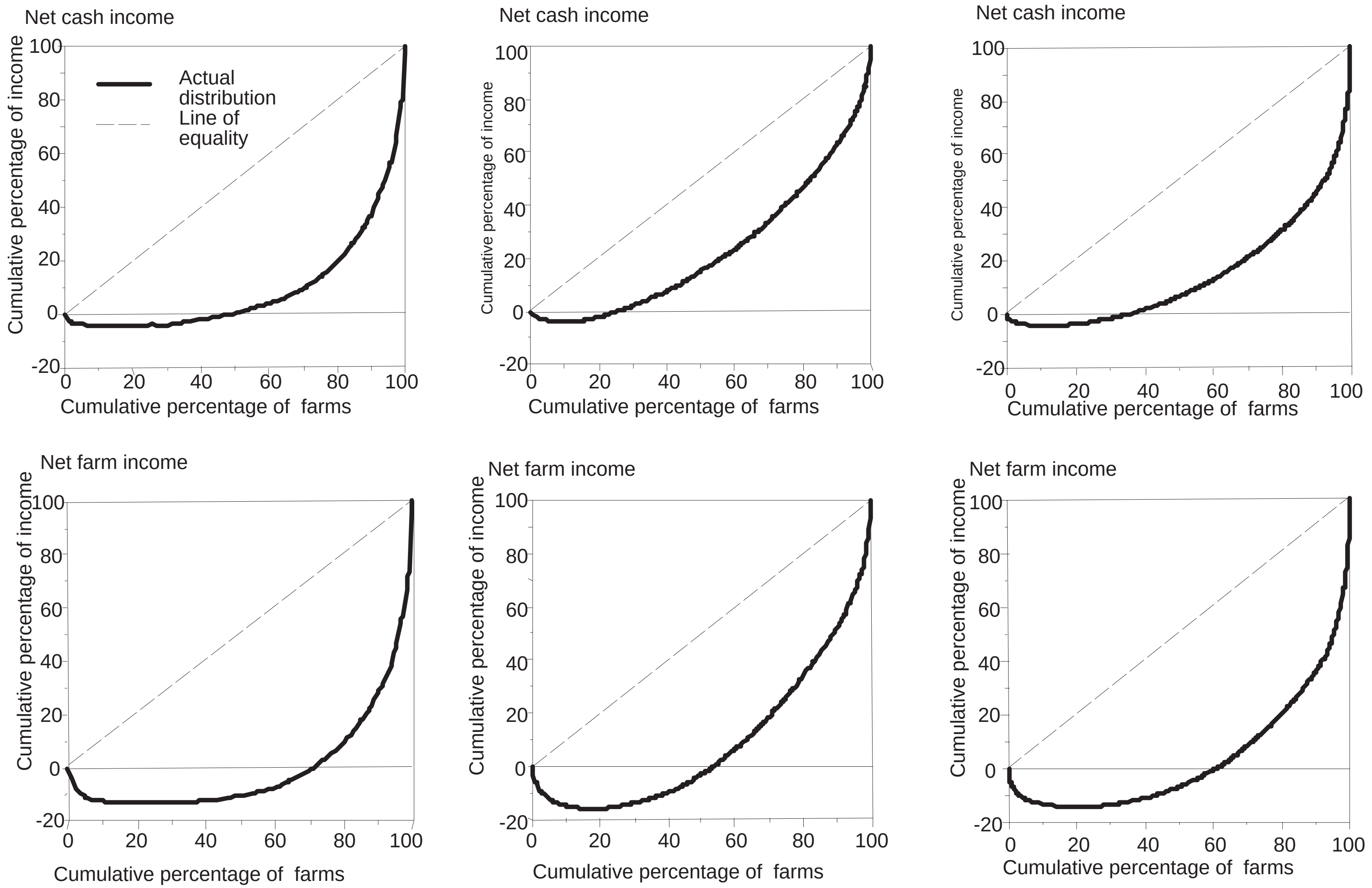


Non-traditional **Traditional** **All FCRS sampled States**

Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Figure 12

Lorenz curves of net cash and net farm income: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993



Non-traditional

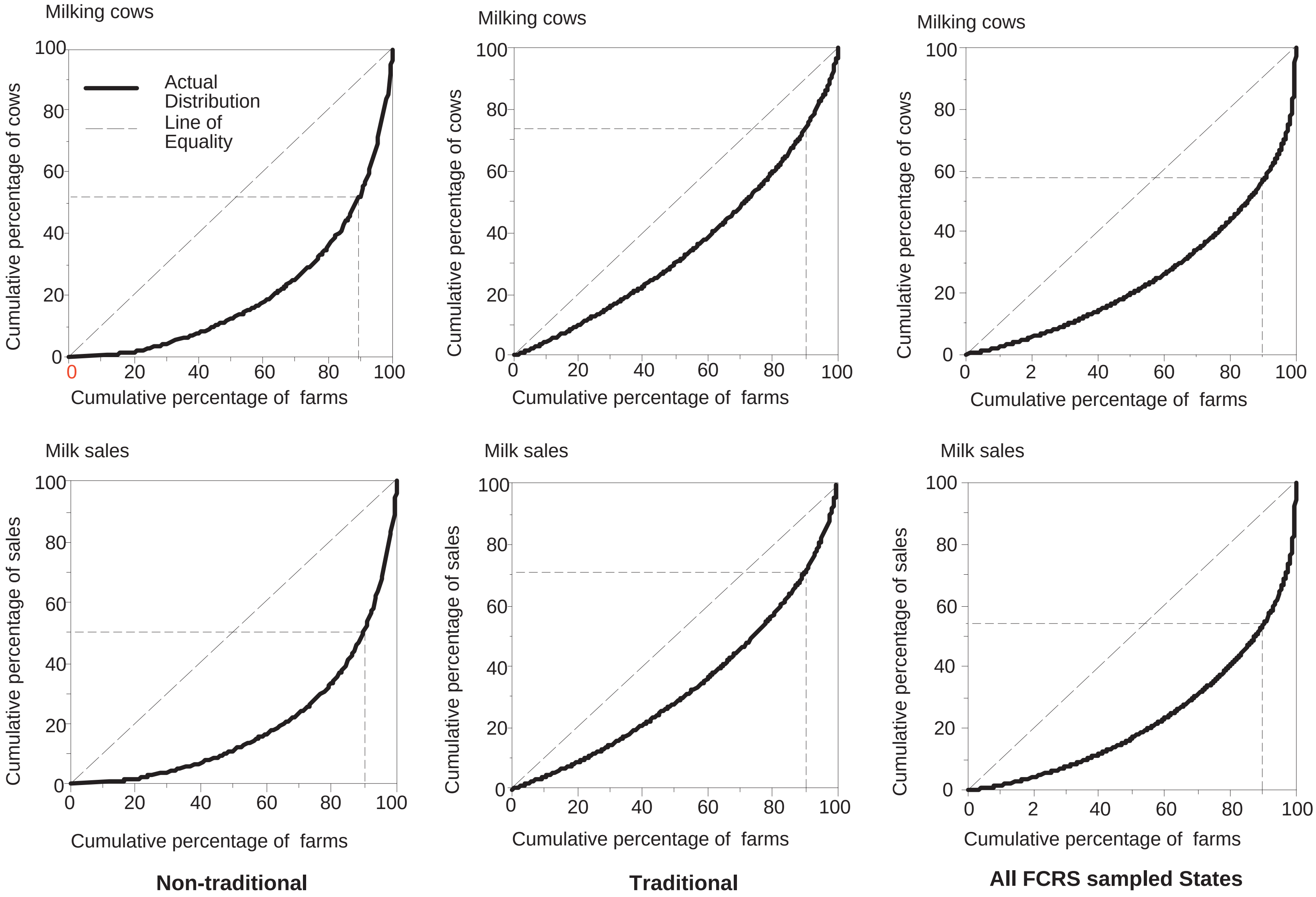
Traditional

All FCRS sampled States

Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Figure 13

Lorenz curves of milking cows and milk sales: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993



Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Table 3–Definitions and means of variables used in weighted least squares

			Means[1]	
Variables	Definition	Unit	Non-traditional milk-producing States	Traditional milk-producing States
Farm characteristics:				
RAC	Rented acres per total operated acres	Percent	51.53[2]	32.46
MACH	Size of largest tractor on farm	Horsepower	88[2]	106
DA	Debt-asset ratio	Percent	25.28[2]	20.11
Enterprise characteristics:				
COWS	Milk cows	Number	370[2]	68
PEF	Milk sold per cow	Hundredweight	164	156
FCT	Forage expense per cow	Dollars	492	537
PCT	Purchased feed per cow	Dollars	686[2]	564
LCT	Hired labor per cow	Dollars	97	81
BCT	Land, buildings, and equipment per cow	Dollars	2,628[2]	5,267
Operator characteristic:				
AGE	Age of farm operator	Years	47	48
Additional attributes:				
TYPE	Type of business organization 1= multi-owner business 0= sole proprietorship		0.40[2]	0.20
PRACTICE[3]	Advanced milking parlors *(AMP)*		0.35[2]	0.07
	Production record-keeping system *(PRS)* [4]		0.14[2]	0.53
	Combination of *AMP* and *PRS (AMP-PRS)*		0.42[2]	0.09
Performance measure:				
NFI	Net farm income	Dollars	156,147[2]	28,446
NRU	Net returns per unit of milk sold	Dollars/hundredweight	(0.03)	-1.29
Sample			150	353
Population			6,737	57,375

[1] Estimates that are underlined have coefficients of variation (CV's) ranging from 25 to 30, and those in parentheses have CV's exceeding 100 percent.

[2] Difference of mean in the Non-traditional milk-producing States category relative to the mean in the traditional milk-producing States category is significant at α =0.10 or better.

[3] *PRACTICE* denotes a grouping of dummy variables in which the category reflecting no use of either AMP or PRS equals zero and the remaining categories are ones. The types of milking parlors reflected by AMP include herringbone, side opening, polygon, and carousel.

[4] An example of this is membership in the Dairy Herd Improvement Association (DHIA).

Source: USDA, Economic Research Service, 1993, Farm Costs and Returns Survey (Dairy Version).

Table 4–Weighted least squares estimates of dairy farm profitability (NFI) model, for selected milk-producing States, 1993

	Net farm income (*NFI*)				
	Non-traditional States (NT)		Traditional States (T)		Ho: $\beta_{NT} = \beta_T$
Variables[1]	β_{NT}	t-statistic[2]	β_T	t-statistic[2]	t-statistic[3]
INTERCEPT	136,823.67	0.62	-4,936.33	0.19	-0.65
RAC	110.89	0.10	-430.65[c]	3.24	-0.48
MACH	-1110.09	1.35	25.36	0.21	1.40
DA	-6,308.43[a]	1.88	-216.68	0.99	1.85[a]
COWS	705.97[b]	2.26	767.08[c]	3.53	0.16
COWSSQ	-0.02	0.82	-1.55[c]	3.75	-3.64[c]
PEF	552.88	0.36	329.62[c]	3.55	-0.15
FCT	-85.61	0.51	-3.77	0.35	0.49
PCT	22.35	0.24	-12.78[c]	2.58	-0.38
LCT	-628.01	1.62	12.78	0.25	1.67[a]
BCT	-8.51	0.79	-2.33[a]	1.75	0.56
AGE	275.32	0.08	-550.85[b]	2.32	-0.24
TYPE	85.74	0.00	9,910.46	1.09	0.16
AMP	-359.51	0.01	-1,687.26	0.15	-0.02
PRS	26,530.58	0.35	-658.77	0.11	-0.36
AMP-PRS	62,214.47	0.85	24,736.45[b]	2.09	-0.52
R^2 (adjusted)	0.5393 (0.4878)		0.2988 (0.2676)		
F-statistic$_{(d,f)}$	9.80$_{(15, 135)}$[c,4]		5.32$_{(15, 321)}$[c,4]		1.93$_{(16, 456)}$[c,5]
Sample	150		353		503
Population	6,737		57,375		64,112

[a,b,c] denote two-tailed statistical significance at 0.10, 0.05, and 0.01 levels, respectively.

[1] Except for *COWSSQ*, variables are defined in table 3. *COWSSQ* is the squared terms for *COWS*, respectively.

[2] Reported t-statistics are absolute values.

[3] Each t-statistic in this column tests the hypothesis that a specific estimated parameter in the profitability model of non-traditional milk-producing States (that is, FL, CA, WA, TX, AZ) is equal to its corresponding counterpart in the profitability model of traditional milk-producing States (that is, MN, MI, WI, PA, NY, VT). A negative superscripted t-statistic indicates that the corresponding β_T is statistically smaller than its β_{NT} counterpart. A positive superscripted t-statistic indicates the opposite (i.e., $\beta_T > \beta_{NT}$).

[4] This statistic tests whether all regression coefficients, except the intercept, are zero.

[5] This statistic tests whether the set of coefficients in the non-traditional milk-producing States' profitability model are all equal to the set of coefficients in the traditional milk-producing States' profitability model.

Source: USDA, Economic Research Service.

Table 5–Weighted least squares estimates of the dairy enterprise's per-unit returns (NRU) model, for selected milk-producing States, 1993

	Net returns per unit (*NRU*)				
	Non-traditional States(NT)		Traditional States (T)		Ho: $\beta_{NT} = \beta_T$
Variables[1]	β_{NT}	t-statistic[2]	β_T	t-statistic[2]	t-statistic[3]
INTERCEPT	2.0372	1.29	-1.7268	0.64	-1.20
RAC	-0.0036	0.80	0.0011	0.08	0.34
MACH	-0.0010	0.41	-0.0121	0.88	-0.78
DA	-0.0119	1.43	-0.0318^{a}	1.78	-1.01
COWS	0.0002	0.45	-0.0072	0.54	-0.55
COWSSQ	-2.00E-08	0.38	6.00E-06	0.51	0.51
PEF	0.0453^{c}	4.46	0.0864^{c}	6.09	2.35^{b}
FCT	-0.0084^{c}	7.82	-0.0076^{c}	7.38	0.52
PCT	-0.0052^{c}	7.18	-0.0096^{c}	7.85	-3.14^{c}
LCT	-0.0037^{b}	2.37	0.0007	0.13	0.83
BCT	-0.0003^{c}	3.33	-0.0002	1.51	0.44
AGE	0.0105	0.64	-0.0054	0.24	-0.57
TYPE	0.1558	0.37	-0.2868	0.43	-0.56
AMP	-1.2335^{b}	2.58	0.8165	1.04	2.23^{b}
PRS	-0.2602	0.49	0.4368	0.70	0.85
AMP-PRS	-0.3122	0.70	0.4605	0.59	0.85
R^2 (adjusted)	0.7576 (0.7305)		0.4995 (0.4772)		
F-statistic$_{(d,f)}$	$19.65_{(15,\ 135)}^{c,4}$		$16.37_{(15,\ 321)}^{c,4}$		$3.11_{(16,\ 456)}^{c,5}$
Sample	150		353		503
Population	6,737		57,375		64,112

[a,b,c] denote two-tailed statistical significance at 0.10, 0.05, and 0.01 levels, respectively.

[1] Except for *COWSSQ*, variables are defined in table 3. *COWSSQ* is the squared terms for *COWS*, respectively.

[2] Reported t-statistics are absolute values.

[3] Each t-statistic in this column tests the hypothesis that a specific estimated parameter in the per-unit returns model of non-traditional milk-producing States (that is, FL, CA, WA, TX, AZ) is equal to its corresponding counterpart in the per-unit returns model of traditional milk-producing States (that is, MN, MI, WI, PA, NY, VT). A negative superscripted t-statistic indicates that the corresponding β_T is statistically smaller than its β_{NT} counterpart. A positive superscripted t-statistic indicates the opposite (i.e., $\beta_T > \beta_{NT}$).

[4] This statistic tests whether all regression coefficients, except the intercept, are zero.

[5] This statistic tests whether the set of coefficients in the non-traditional milk-producing States' per-unit returns model are all equal to the set of coefficients in the traditional milk-producing States' per-unit returns model.

Source: USDA, Economic Research Service.

Estimation of the net farm income model in the non-traditional milk-producing States yields similar results, where a significant and negatively signed coefficient of debt-to-asset ratio (*DA*) is also found. This implies that for every 1-percentage point increase in *DA*, mean net farm income decreases by around $6,300. The positive and significant coefficient of *COWS* shows that each additional cow brings in an additional $706 in net income.

For the net farm income model in the traditional milk-producing States, regression results show that a 1-percent increase in the percentage of rented land relative to total operated acres (*RAC*) lowers the profitability of a commercial dairy by $431.[13] Also, a 1-percentage point increase in the debt-to-asset ratio lowers profitability by $217, however, the decline in profitability is not statistically significant. Based on the significance and the signs of the *COW* and *COWSSQ*'s estimated parameters while holding all else constant, net farm income of an average farm in the traditional milk-producing States appears to increase at a decreasing rate.[14]

Improving levels of milk production per cow, as indicated by the sign and magnitude on the estimated coefficient of *PEF*, is shown to strongly affect the financial performance of commercial dairy farms in the traditional milk-producing areas. This result is in accordance with findings by Carley and Fletcher (1986) and by Haden and Johnson (1989). In terms of the other remaining enterprise-specific variables, the coefficients of *PCT* and *BCT* are negative and significant, suggesting that, all else equal, net-farm incomes of commercial dairies in the traditional milk-producing States are inversely related to per-cow expenditures on purchased feed as well as per-cow investment in land, buildings, and equipment. The fact that the coefficient of *LCT* is significant is not surprising since commercial dairies in the traditional milk-producing States tend to rely on operator and family labor for over 70 percent of all of their labor needs (fig. 7). The coefficient of *AGE* is significant and negatively signed, implying that commercial dairy farms operated by older farmers tend to earn less income than dairy farms operated by younger farmers. This finding is in line with Tauer's (1995) who found efficiency to initially increase with age then to decrease as the operator became much older. Adelaja and Rose (1988), who found negative correlation between age and farm viability, attribute young farmers' higher farm earnings to the fact that they are more likely to adopt cost-saving technologies due to the flexibility they exhibit in making production decisions.

Of the dummy variables considered (that is, *TYPE*, *AMP*, *PRS*, *AMP-PRS*), only the coefficient of *AMP-PRS* is shown to be significant. This result is consistent with the notion that technology, at least in the early stages of its implementation, works at increasing farm income. Specifically, the results here show that commercial dairy farms in the traditional milk-producing States are likely to earn, on average, about $25,000 more in net-farm income if their production practices involve the use of an advanced milking parlor in conjunction with the services of a Dairy Herd Improvement Association.

The significantly higher levels of net farm incomes associated with the adoption of combined capital- and management-intensive technologies by dairy farms in the traditional milk-producing States make it surprising that these technologies are used by only 9 percent of the farms (see table 3). Researchers have often pointed to the size of the operation, credit constraints that can be proxied by debt-to-asset ratio, human capital, and risk preferences of the operator that can be proxied by age, among other things, as important factors in explaining the likelihood of technological adoption (Feder, Just, and Zilberman, 1985). A binary variable, with values of one denoting the adoption of these combined technologies and with values of zero denoting no adoption, was created and then used in a simple logistic regression to analyze how these factors affect the adoption decision (see appendix). Results of the regressions pointed to the importance of size in explaining the probability of adoption in both groups of

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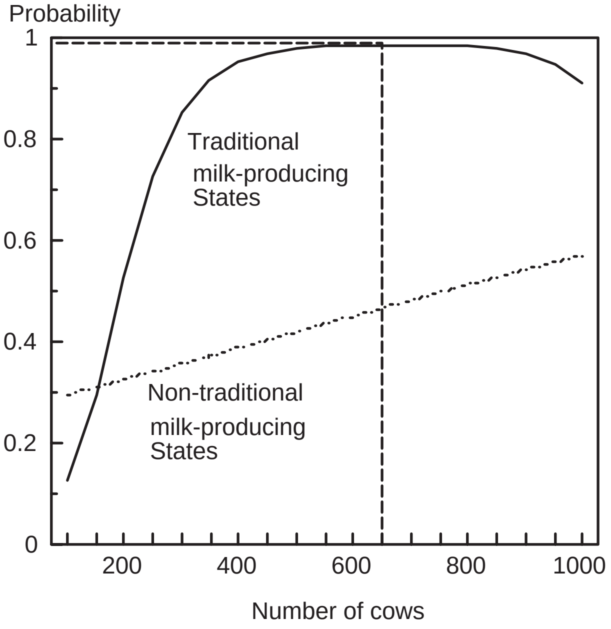
[13] As one reviewer notes, if net farm income decreases by $431 due to a 1-percentage point increase in rented acres, that may be interpreted as indicating that the rent paid by a dairy operator in the traditional milk-producing States exceeds the amount that should be paid as land rent (i.e., the economic return that accrues or should accrue to land for its use in production), which may also imply that the rental market in these milk-producing areas is inefficient.

[14] The reader should note that what appears as a concave relationship between herd size and net farm income is suspect, as the significant effect of *COWSSQ* shown here is primarily due to the presence of an extreme point in the data where a large dairy operation is shown to have huge losses, this is despite the operation's high residual returns from milk production. Regression with this observation excluded yielded relatively identical parameter estimates as in the original regression, with the exception that the coefficients of both *COW* and *COWSSQ* are now positive, although statistically insignificant.

milk-producing States.[15] Figure 14 shows that for dairies in the traditional milk-producing States, the probability of adopting a combination of capital- and management-intensive technologies tends to be highest at a size of operation equivalent to 650 milking cows (see appendix, equation 16). The fact that the average size of the dairy operation is only 68 cows may thus, in itself, explain the lower rate of adoption. This is consistent with the view by Feder, Just, and Zilberman (1985) that smaller farms tend to be less inclined to adopt technologies with large fixed costs, as in the case of *AMP-PRS* technology. As one reviewer has noted, many dairy farms in the traditional milk-producing States are family farms and are quite satisfied with the size of their operations (60-100 cows). Many of these smaller family farms, based on the availability of family labor and the management skills of their experienced operators, are able to produce milk as efficiently as larger operations with expensive milking parlors. The importance of management ability to the profitability of the farm business is also noted by Hoffman who found, based on farm records, that well-managed farms are able to compete in per-unit profitability with farms many times larger.

Figure 14

Probability of adopting capital- and management-intensive technologies (AMP-PRS), by size of farm, 1993



Source: USDA, Economic Research Service, Farm Costs and Returns Survey, 1993.

Table 5 presents results from estimating a model based on net returns per hundredweight of milk. Findings that pertain to commercial dairy farms in the non-traditional milk-producing States are summarized as follows:

- Size of the operation, as indicated by the insignificant coefficients of *COWS* and *COWSSQ*, appears irrelevant in determining the dairy enterprise's unit returns.
- The significant and positive sign of *PEF*'s coefficient shows that each additional hundredweight increase in the cows' productivity is associated with a nearly 5-cent increase in per unit-net returns.
- Each additional dollar of per-cow expenditures on forage, purchased feed, hired labor, and land, buildings, and equipment, as indicated by the coefficients of *FCT*, *PCT*, *LCT*, and *BCT*, respectively, causes per-unit net returns to decrease.
- As indicated by the significant coefficient on *AMP*, and because of higher replacement costs, farms with advanced milking parlors have lower per-unit net returns than their counterparts with conventional milking parlors.

Results pertaining to the estimation of net returns per hundredweight of milk sold for commercial dairy operations in the traditional milk-producing States are summarized as follows:

- A 1-percentage point increase in debt-to-asset ratio lowers per-unit returns by 3 cents.
- An increase in cow production increases per-unit returns by nearly 9 cents.
- Of the types of expenditures considered, only the marginal increases in the cost of forage and purchasing feed significantly lower the per-unit net returns.[16]

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[15] The estimation of the logistic regressions yielded the following:
Non-traditional milk-producing States:
$\ln P_i / (1-P_i) = 1.45 - (0.09)*A + (9.5E-4)*A^2 + (0.001)*\underline{S} - (1.5E-7)*S^2 - (0.01)*DA + (2.5*E-4)*DA^2$, McFadden's $R^2 = 0.078$.
Traditional milk-producing States:
$\ln P_i / (1-P_i) = -7.31 + (0.14)*A - (0.001)*A^2 + (0.03)*\underline{S} - (2.0E-5)*\underline{S^2} - (0.03)*DA + (2.9*E-4)*DA^2$, McFadden's $R^2 = 0.193$, where ln is natural logarithm, P_i is the probability of adopting *AMP-PRS* technology, and where *A*, *S*, and *DA* are age, number of milking cows, and debt-to-asset ratio, respectively. Underlining of the variables denotes significance of the corresponding coefficients at 0.05 level.

[16] It is likely that the insignificance of the BCT variable is caused by the presence in the data of some large operations—mainly new

The last columns of numbers in tables 4 and 5 denote the *t*-tests of the difference in coefficients across the two groups of milk-producing States for the net farm income and the net returns per unit of output models, respectively. The tests, which use a multiplicative dummy variables approach (appendix), identify *DA*, *COWSSQ*, and *LCT* in the net farm income model as having significantly different coefficients across the two groups of milk-producing States.[17] This is indicated by *t*-statistics of 1.85, -3.64, and 1.67, respectively (table 4). The implication of this is that, with the exception of indebtedness and size of operation, and cost of hired labor, the determinants of farm profitability across the traditional and non-traditional milk-producing States appear the same. Using the multiplicative dummy variables approach on the per-unit returns model reveals cow productivity, cost of purchased feed, and level of adoption of advanced milking parlors as the only factors with significantly different regression coefficients across the two groups of milk-producing States.

The results described in the previous sections are used here to assess how variability in financial performance is affected by each of the explanatory variables used in the weighted least squares procedures (tables 4 and 5). Such assessment is accomplished by first apportioning the variations in *NFI* and *NRU* to the contribution of each of the explanatory variables, and second, by using the method of coefficients of separate determination where the sum of these coefficients for a particular regression model equals the goodness of fit measure, commonly referred to as R^2 (Burt and Finley, 1968; Langemeier, Schroeder, and Mintert, 1992).

Table 6 reports the extent to which each explanatory variable alone, relative to other variables, contributes to the explained variation in net farm income and in per-unit returns. When considering only the effect of the variances of the explanatory variables (that is, when the covariance effects are suppressed) on the total variation in net farm income, the size of the operation as measured by the number of cows appears to dominate. Specifically, the variability in farm size alone (as measured by *COWS* and *COWSSQ*) accounts for 86 percent of the explained variation in net farm income when milk is produced in the non-traditional milk-producing States. When milk is produced in the traditional milk-producing States, the variation in size accounts for 89 percent of net farm income's explained variation.[18] Except for variations in debt-to-asset ratios in the non-traditional milk-producing States, and in the percentage of rented acreage and in cow productivity in the traditional milk-producing States, variations in all other variables exert little influence on *NFI*'s explained variation.

Table 6–Decomposition of variance of net farm income and net returns per unit of milk sold, by selected milk-producing States, 1993[1]

	Net farm income		Net returns per unit	
Variables	Non-traditional States	Traditional States	Non-traditional States	Traditional States
		Percent		
RAC	0.01	3.56	0.17	0.00
MACH	1.09	0.02	0.02	0.88
DA	10.08	0.36	0.73	1.51
COWS	81.47	34.45	0.12	0.58
COWSSQ	4.52	54.97	0.05	0.18
PEF	0.16	2.86	21.36	37.75
FCT	0.23	0.02	44.83	18.72
PCT	0.02	0.34	23.11	37.53
LCT	1.84	0.05	1.32	0.02
BCT	0.19	1.22	5.09	2.33
AGE	0.00	0.80	0.10	0.02
TYPE	0.00	0.34	0.05	0.05
AMP	0.00	0.00	2.79	0.16
PRS	0.03	0.00	0.06	0.19
AMP-PRS	0.37	1.01	0.19	0.07
Total	100	100	100	100

[1] This variance decomposition suppresses the effects of the covariances.
Source: USDA, Economic Research Service.

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ones with newer facilities and equipments—that are highly efficient in the production of milk, which in turns, lessens BCT`s negative cost effect on per-unit net returns. Unlike in the 1993 FCRS where information on the age of capital structure and equipments were not collected, such data were available in the dairy version of the 1989 FCRS. These data show that larger dairy operations (with at least twice the average size of 68 cows as reported in table 3) in the traditional milk-producing areas do tend to produce milk with significantly newer facilities and equipment than smaller operations.

[17] A positive t-statistic larger than a critical value indicates that the coefficient of the estimated model in the traditional milk-producing States is significantly larger than its counterpart in the non-traditional. A negative t-statistic has the opposite meaning.

[18] In the absence of the extreme observation discussed in footnote 14, the variation in size (COWS and COWSSQ) accounts for 20 percent of the explained variation in net farm income in the traditional milk-producing States.

Variation in the per-cow cost of land, buildings, and equipment contributes nearly 5 percent to the explained variation of per-unit returns in the non-traditional States, and its contribution to the total variance effect is exceeded only by those from productivity per cow (*PEF*), forage production costs (*FCT*), and purchased feed costs (*PCT*). In fact, variations from these three variables alone contribute more than 90 percent of total variance effect in this group of milk-producing States, with variation in the forage production costs accounting for nearly half of the total. In comparison, 94 percent of the explained variation in the per-unit returns in the traditional milk-producing areas comes from these same variables, although the importance of the forage production costs in explaining the variation in *NRU* is now second to that of the two variables denoting productivity per cow and purchased feed costs.

Table 7–Coefficients of separate determination for factors affecting the net farm income and the net returns per unit for commercial dairy farms, for selected milk-producing States, 1993

	Net farm income		Net returns per unit	
Variables	Non-traditional States	Traditional States	Non-traditional States	Traditional States
RAC	-0.000208	0.014319	0.008765	0.000154
MACH	-0.003318	0.001887	-0.002335	0.004341
DA	0.005421	0.001439	-0.002316	0.002162
COWS	0.636998	0.030167	0.006544	-0.001064
COWSSQ	-0.115633	0.184782	-0.000513	0.001019
PEF	0.002405	0.027655	-0.075598	0.192358
FCT	0.000029	0.000584	0.398334	0.094327
PCT	-0.002457	0.001005	0.269526	0.185205
LCT	-0.001466	0.003248	-0.010539	0.000653
BCT	0.008004	0.007171	0.121897	0.012558
AGE	-0.000345	-0.000216	0.000424	-0.000199
TYPE	0.000009	0.008660	-0.004126	-0.000163
AMP	0.000043	-0.000273	0.057292	-0.000764
PRS	-0.000901	0.000011	0.000253	0.002952
AMP-PRS	0.010742	0.018405	-0.009974	0.000828
Total	0.539323	0.298845	0.757636	0.499473
Unexplained variation	0.460677	0.701155	0.242364	0.500527

Source: USDA, Economic Research Service.

Table 7 shows the results pertaining to the coefficients of separate determination for factors affecting both the net farm income and the per-unit returns for commercial dairy farms. Size of the operation, as indicated by the variable *COWS*, is the most important variable in explaining the variability in net farm income of commercial dairy operations in the non-traditional milk-producing States. This is based on a value of coefficient of separate determination of 0.637, which is the highest of all variables. For commercial dairy operations in the traditional milk-producing States, the variation in *NFI* tends to be explained the most by the size of the operation and by cow productivity.

In terms of explaining the variation in per-unit returns in the non-traditional milk-producing areas, the magnitudes of the coefficient of separate determinations point to the importance of forage consumption per cow (0.398), per-cow cost of purchased feed (0.269), and per-cow land, buildings, and equipment cost (0.122). The coefficients of separate determination of the variables *PEF*, *FCT*, and *PCF* (at 0.192, 0.094, and 0.185, respectively) show that the per-cow productivity of the dairy operation, and the per-cow costs of forage and of purchased feed exert a measurable influence on the variability of per-unit returns in the traditional milk-producing States.

In an attempt to explain variations in the financial performance of the dairy industry in the traditional and non-traditional milk-producing States, linear regression models are estimated using States' mean net-farm income and mean per-unit returns as dependent variables, and Gini ratios of certain financial and resource base variates as explanatory variables. When mean net-farm income is the dependent variable, the coefficients of determination (R^2) range from 0.602 to 0.826 (table 8), denoting that over 50 percent of the variation in States' expected net-farm income from dairy production is explained by the concentration in any of the financial and resource variates used in the analysis. Most dramatic is the result pertaining to the concentration in debt capital and its effect on States' mean net farm income. The significant and positive coefficient of $Gini_{debt\ capital}$ indicates that a 1-percent increase in concentration in States' debt capital increases States' mean net-farm income by around $16,000.[19] In comparison, the significant and positive coefficients of $Gini_{cow\ inventory}$ and of $Gini_{milk\ sales}$ indicate that a 1-percent increase in concentration in dairy production increases profitability by over $8,000.

When mean per-unit returns is the dependent variable, results in table 8 show that only around one-third of its variation is explained by the concentration in debt, assets, or equity, and variation is explained to a lesser extent (nearly one-fifth) by the concentration in cow inventory or in milk sales. In fact, increased concentration in States' dairy production is found not significant in terms of impacting States' per-unit returns.

For the group of commercial dairy farms in the non-traditional milk-producing States, and based on potential (or expected) net-farm income (see equation 4 and results in table 4), the results of tests of

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[19] Gini ratios for debt capital, farm assets, equity, cow inventory, and milk sales for the States considered in the analysis can be obtained from the authors upon request.

Table 8–Regression coefficients: State income (net farm and net returns per unit of output) and selected explanatory variables, 1993

	Regression variates				
Variable included	(1)	(2)	(3)	(4)	(5)
Net farm income					
Intercept	$-907,955^{c}$	$-332,941^{c}$	$-414,368^{c}$	$-235,553^{b}$	$-271,941^{b}$
$Gini_{debt\ capital}$	$16,142^{c}$				
$Gini_{assets}$		$10,415^{c}$			
$Gini_{equity}$			$11,353^{c}$		
$Gini_{cow\ inventory}$				$8,440^{c}$	
$Gini_{milk\ sales}$					$8,758^{c}$
R^2	0.673	0.749	0.826	0.607	0.602
R^2 (adjusted)	0.636	0.721	0.806	0.564	0.558
F-Statistic$_{(d,f)}$	$18.45_{(1,10)}^{c}$	$26.86_{(1,10)}^{c}$	$42.63_{(1,\ 10)}^{c}$	$13.91_{(1,10)}^{c}$	$13.61_{(1,10)}^{c}$
Net returns per unit of output					
Intercept	-6.95^{b}	-3.33^{b}	-3.74^{b}	-2.35^{a}	-2.53^{a}
$Gini_{debt\ capital}$	0.10^{a}				
$Gini_{assets}$		0.07^{b}			
$Gini_{equity}$			0.07^{b}		
$Gini_{cow\ inventory}$				0.05	
$Gini_{milk\ sales}$					0.052
R^2	0.349	0.401	0.414	0.237	0.229
R^2 (adjusted)	0.277	0.335	0.349	0.153	0.144
F-Statistic$_{(d,f)}$	$4.83_{(1,\ 10)}^{a}$	$6.03_{(1,\ 10)}^{b}$	$6.35_{(1,\ 10)}^{b}$	$2.8_{(1,\ 10)}$	$2.68_{(1,\ 10)}$
Sample[2]	11	11	11	11	11

^{a,b,c} denote statistical significance at 0.10, 0.05, and 0.01 levels, respectively.
[1] All explanatory variables are expressed as percentages.
[2] The elements of the sample are the States in the traditional (MN, MI, WI, PA, NY, VT) and the non-traditional (FL, CA, WA, TX, AZ) milk-producing areas.
Source: USDA, Economic Research Service.

independence in table 9 provide strong evidence that a farm's use of automatic takeoffs on milking units and of artificial insemination is associated with the farm's financial success, where success is defined as being in the top 20 percent of the income distribution. The practice of using automatic takeoffs on milking units and of milking cows three times per day by commercial dairy farms in the traditional milk-producing States is found to be strongly related to their financial success.

Based on expected per-unit returns, which are not size-driven like net farm income, none of the management practices considered is strongly related to the financial success of dairies in the non-traditional milk-producing States (table 9). This finding points to the likelihood that better-than-average management in controlling costs and/or size economies, rather than just management practices that involve the use of advanced technology makes certain dairies in the non-traditional milk-producing States climb to the top 20 percent. In contrast, the identification of a commercial dairy farm in the traditional milk-producing States as one of the top 20 percent is shown to be strongly related to its use of artificial insemination.

Conclusions

Findings from this study point to significant differences in the resource base, in the structure of profitability, and in management practices between commercial dairy farms in the non-traditional and traditional milk-producing States. Concentration measures such as decile ratios, Lorenz curves, and Gini coefficients show that debt capital, farm assets, equity, income, herd inventory, and milk sales are more concentrated in non-traditional milk-producing States than in traditional milk-producing States.

For commercial dairy operations in the non-traditional milk-producing States, performing weighted least squares regression on a net farm income model identified debt-to-asset ratio and farm size, as measured by the number of milking cows, as important determinants of farm profitability. For dairy farms in the traditional milk-producing States, the results pointed to use of rented acres, herd size, productivity per cow, per-cow purchased feed and land, buildings, and equipment costs, age of the operator, and level of adoption of capital- and management-intensive technologies as important determinants of farm financial performance. Higher levels of profitability will be reaped by dairy farms in the traditional milk-producing States if efforts to increase efficiency in milk production are emphasized, along with increased emphasis at controlling per-cow investment and cost of purchased feed. Significant improvements in profitability will result from adopting a technology that combines better recordkeeping with advanced milking parlors.

For commercial dairies in the non-traditional milk-producing States, regression results based on a per-unit returns model revealed the importance of cow productivity in increasing profitability. Dairy farm management in these States that lowers per-cow expenditures on items such as forage production, purchased feed, hired labor, and per-cow investment will significantly improve the financial performance of these farming operations. Per-unit returns of dairies with advanced milking parlors are found lower, because of higher replacement costs, than the returns of dairies with traditional milking parlors. For the group of

Table 9–Results of test of independence of expected income (net farm and net returns per unit of output) of top 20 percent of commercial dairy operations and management practices, for selected milk-producing States, 1993

	F-statistic	
Test of independence	Non-traditional[1] States	Traditional[2] States
Net farm income		
Computerized milking system	1.03	0.03
Use of automatic takeoffs on milking units	4.43[b]	13.94[c]
Use of artificial insemination	3.77[b]	0.16
Dairy cows milked three times per day	0.14	3.23[a]
Net returns per unit		
Computerized milking system	1.19	2.27
Use of automatic takeoffs on milking units	0.32	1.37E-07
Use of artificial insemination	1.83	10.81[c]
Dairy cows milked three times per day	0.22	0.03

[a,b,c] denote statistical significance at 0.10, 0.05, and 0.01 levels, respectively.

[1] Relevant numerator and denominator degrees of freedom are 1 and 135, respectively.

[2] Relevant numerator and denominator degrees of freedom are 1 and 321, respectively.

Source: USDA, Economic Research Service.