Determinants of Financial Performance of Commercial Dairy Farms. By Hisham S. El-Osta and James D. Johnson. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1859.

Abstract

Data from the 1993 Farm Costs and Returns Survey were used in a multi-variate analysis framework to determine factors associated with the financial performance of commercial dairy farm operations. Statistical equivalency tests revealed regional differences in the way extensive indebtedness, size of operation, and labor cost affect net farm incomes. Regional differences were also found in terms of how milk production per cow, per-unit cost of purchased feed, and level of adoption of capital intensive technologies affect per-unit returns. Examination of the variation in the net farm income of commercial dairy farms using the method of coefficients of separate determination identified the size of the operation, regardless of the location of the farm business, as the factor contributing the most to the variability in net farm income. On a per-unit-of-returns basis, factors found most important in explaining the variation in net returns per hundredweight of milk sold were cow's productivity, and per-cow forage production and purchased feed costs.

Keywords: Financial performance, net farm income, technological adoption, Lorenz curve, Gini coefficient.

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Contents

Summary

Data from the 1993 Farm Costs and Returns Survey (FCRS) were used to determine the factors that contribute to the financial performance of commercial dairy operations in the traditional milk-producing States (MN, MI, WI, PA, NY, VT) and the non-traditional milk-producing States (FL, CA, WA, TX, AZ). As in the case of net farm income, the size of operation as measured by the number of milking cows in the non-traditional milk-producing States was at least five times larger than in traditional milk-producing States. Because of their large scale of operation, commercial dairy farms in non-traditional milk-producing States tended to use twice as much labor and own twice as much farm assets. Use of concentration measures such as the Gini coefficient and Lorenz curves demonstrated that milking cow inventory, milk sales, debt capital, farm assets, farm equity, and income (both net cash and net farm) were more concentrated in the non-traditional milk-producing States than they were in the traditional milk-producing States. Concentration in debt capital, farm assets, dairy production, each tended to play a significant role in the explanation of interstate variation in financial performance.

Regression results based on a net farm income model indicated the importance of farm size, regardless of the location of the dairy farm business, in explaining farm financial performance. For commercial dairy farms in the traditional milk-producing States, a milking practice that involved a combination of advanced milking parlors and a membership in a production record keeping system tended to have a positive and significant effect on farm financial performance. Profitability in milk production in the non-traditional milk-producing States depends significantly on the level of indebtedness, as results pointed to a potential reduction in income of nearly $6,310 for every 1-percent increase in debt-to-assets ratio. For commercial dairies in the traditional milk-producing States, increases in the proportion of rented acreage, and per-cow costs of purchased feed and of land, buildings, and equipment were significant in their ability to lower the net farm income of commercial dairies in the traditional milk-producing States. Age of the operator and profitability tended to be negatively correlated.

For commercial farms in the non-traditional milk-producing States, regression results based on a per-unit returns model revealed the importance of controlling the per-unit costs of forage production, purchased feed, labor, and of land, buildings, and equipment. For the traditional milk-producing areas, factors such as purchased feed and forage production costs per cow were all negatively correlated with farm profitability. Regardless of the location of the commercial dairy operation, increases in per-cow milk production tended to significantly increase per-unit returns.

Results of tests of independence of potential or expected net farm income and management practices identified the top 20 percent of performing commercial dairy farms in the non-traditional milk-producing States as those using automatic takeoffs on milking units and artificial insemination in their dairy production. For commercial dairy operations in the traditional milk-producing States, top-performing dairy operations were identified as those using automatic takeoffs on milking units and those that milked their cow herds three times a day. Conducting similar tests on a expected per-unit-of-returns basis identified the top 20 percent of performing commercial dairy farms as those using artificial insemination and automatic takeoffs on milking units, but only if the farm was located in the traditional milk-producing States.

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Determinants of Financial Performance of Commercial Dairy Farms

Hisham S. El-Osta and James D. Johnson

Introduction

The Federal dairy policy under the 1996 farm bill calls for replacing government purchases of dairy products in the year 2000 with a recourse loan program. The farm bill, which repeals the provision for a minimum support level for milk also rescinds provisions for assessments and for increasing and decreasing support levels based on the estimated level of government purchases. These changes, in effect, will eliminate the role the government has played for many decades in supporting milk prices. The likelihood of increased volatility in milk prices resulting from a market-oriented dairy policy will adversely affect the financial position of many dairy farms, and may even force some to exit the industry. Particularly vulnerable are the marginal operations with low production efficiency, and those that are highly leveraged. To minimize the potential of this adverse effect, the Federal Government is stepping up use of the Dairy Export Incentive Program while many State governments are allowing for the establishment of multi-state dairy compacts designed to establish a minimum milk price.

The financial position of dairy farms hinges on many factors in addition to the price of milk, a factor no dairy producer can control. Large dairy operations that are utilizing the latest in technological innovation with high rates of production, and small and mid-sized dairies that are well managed and with low levels of indebtedness are likely to continue to operate profitably, even when dairy farming becomes increasingly dependent on the free market. Other factors that influence profitability in dairy production are cost of inputs and efficient conversion of labor, feed, and capital resources into milk (Conlin), all of which tend to fall under the control of the individual producer.

To the extent that many dairy operations will have to adjust to the new economic environment set forth by the new farm bill if they are to survive, the focus of this report is to provide information that might prove useful to dairy farmers and policymakers alike during the course of the adjustment. Specifically, the report will first provide insight to the regional differences that characterize the dairy industry in terms of size, labor availability, balance sheet, and farm profitability. In pursuing this objective, the report will highlight the regional differences by providing a pictorial representation of the means of these variates, by producing tabulations that show how dairy farms are distributed across the ranges of some of these variates, by plotting corresponding Lorenz curves, and by presenting estimates of Gini coefficients, which are helpful in describing concentration magnitudes. In providing measurements of the degree of concentration in the resource base and financial position of dairy farms, the study in effect will be providing insight regarding the extent of heterogeneity that might exist among farms in terms of their income-generating capabilities, thus remedying the lack of work in this area. In doing so, the report will have contributed to the literature by extending the public knowledge base about the dairy industry.

This public knowledge base will be enhanced even more as the report attempts to achieve its main objective, which is to assess factors hypothesized to affect the profitability of commercial dairy farms.[1] This objective is achieved by using weighted multiple linear regression where measures of profitability are regressed against *k* independent variables that describe

[1]ERS generally defines a commercial farm as any farming operation with total annual sales of $50,000 or more (Hoppe and others, 1996). In the context of this report, a commercial dairy farm is defined as any farming operation with annual milk sales of $50,000 or more. The dairy enterprise in a commercial dairy farm defined in this manner is characterized as being dominant since data from the 1993 Farm Costs and Returns Survey show that nearly 80 percent of all farm sales tend to be generated from the sale of milk. Also note that excluded from the analysis are commercial dairy farms organized as nonfamily corporations or cooperatives.

the characteristics of the farm, the enterprise, and the operator. Once the functional relationships between profitability measures and the *k* independent variables are estimated, hypotheses tests concerning estimated parameters are utilized to isolate the variables deemed important to the profitability of the dairy farm. Having fitted these regressions and having obtained the prediction equations based on the estimated parameters, these prediction equations allow for the imputation of farms' potential or expected financial performance in the absence of any statistical noise.

Two subsidiary issues are also investigated: (1) The question of how much variation in profitability is explained by the *k* independent variables, and (2) how much variation in States' financial performance is explained by the level of concentration of capital in farming and in the resource base, namely, debt capital, farm assets, farm equity, and cow inventory and its proxy milk sales. These issues will be investigated using the concepts of the coefficients of separate determination, and the coefficient of determination, respectively.

The third and final objective is to determine, based on expected financial performance, which management practices are employed by the top 20 percent of commercial dairy operations. Such determination is carried using a statistical test commonly known as the *F*-test of independence.

The report, which builds on the work by Haden and Johnson (1989), and Kauffman and Tauer (1986), among others uses standard econometric methods to identify important factors in financial performance of dairy farm businesses. However, unlike in Haden and Johnson and in Kauffman and Tauer, where data from individual milk-producing States were used (Tennessee and New York, respectively), the report uses representative and probability-based data collected by the Economic Research Service (ERS) from multiple milk-producing States.

Data Source and Delineation of Milk-Producing Areas

The report draws on data from the Dairy Cost of Production version (COP) of the 1993 Farm Costs and Returns Survey (FCRS). The FCRS, which has a complex stratified, multiframe design, is a national annual survey of farms conducted by ERS and the National Agricultural Statistics Service (NASS). Because of survey costs, ERS and NASS collect detailed surveys on a specific commodity only once every 4 years. The FCRS fully integrates information about the production practices and inputs used in the farm's dominant dairy enterprise with structural information about the farm's financial position, organization, and performance and demographic attributes of the operator.

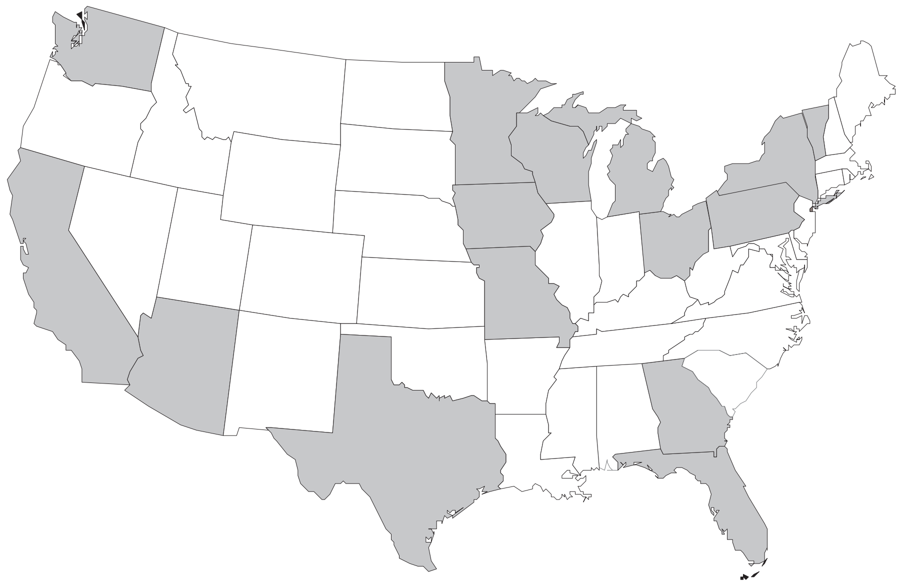
ERS uses four general approaches to estimate commodity production costs: direct and indirect costing, valuing of input quantities, and allocation of whole-farm costs (Short and McBride, 1996). Direct costing involves summarizing survey responses to questions about the total amount paid for selected inputs and is especially suited for estimating variable cost components. Indirect costing involves the combination of survey information and engineering formulas and is used in estimating machinery, building, and equipment replacement costs; fuel, lubrication, and electricity costs; and repair costs. Valuing quantities of inputs requires survey data of the physical quantities of inputs used in production (e.g., quantities of homegrown feed, hours of unpaid labor, etc.). Allocating whole-farm expenses occurs for inputs that are not specifically associated with production of a certain commodity such as general farm overhead, interest, property taxes, and insurance. For dairy farmers, expenses incurred by the farm business for these items are allocated to the milk enterprise based on the share of total value of farm production attributed to milk sales.

Figure 1 highlights the 1993 FCRS sample coverage of milk production. Figures 2 and 3 show the ranking of sampled milk-producing States based on changes in milk production (1977-93) and in number of milk cows (1978-92). By comparing the ranking of each sampled milk-producing area in both figures, evidence emerges that, with the exception of Pennsylvania, the traditional milk-producing States of the Northeast and Lake States are becoming stagnant in increases in milk output and number of milking cows.

Fallert and Blayney (1990) and Perez (1994) point to factors that may have contributed to shifts in milk production from traditional milk-producing States to those of the Southeast, Southern Plains, Pacific, and, to some extent, Mountain States, namely: (1) rapid

Figure 1

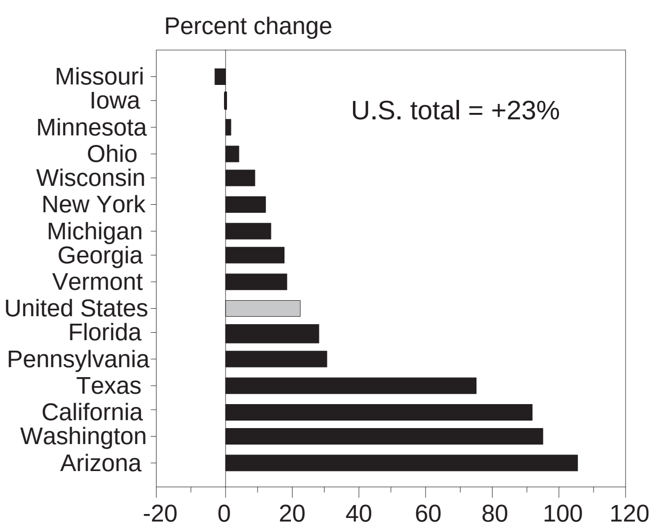
1993 Farm Costs and Returns Survey's sampling coverage of milk production



Producers in the States shaded were surveyed about production practices and costs of production.
Source: USDA, Economic Research Service.

Figure 2

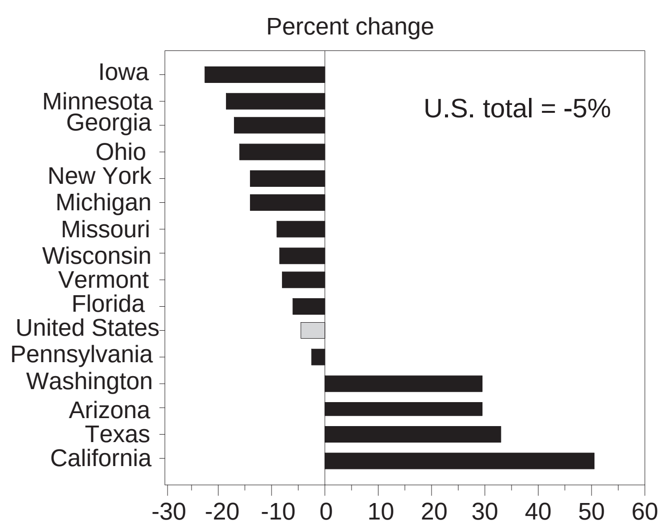
Percentage change in milk production in 1977-93 in areas sampled by the 1993 Farm Costs and Returns Survey



Source: Perez, Agnes. 1994. Changing Structure of U.S. *Dairy Farms. AER-690. U.S. Department of Agriculture,* Economic Research Service.

Figure 3

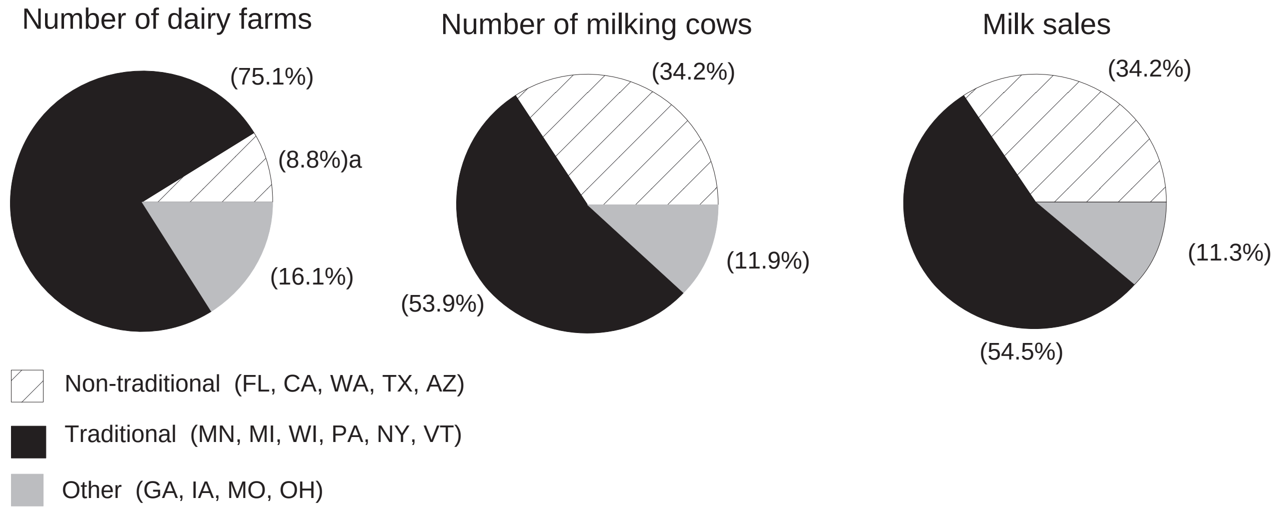
Percentage change in number of milk cows, 1978-92, in areas sampled by the 1993 Farm Costs and Returns Survey



Based on dairy farms with sales of $10,000 or more by Standard Industrial Code (SIC) 024, U.S. Department of Commerce, Census of Agriculture, 1982 and 1992 issues.
Source: USDA, Economic Research Service.

Figure 4

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



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

population growth, particularly in the West and Southwest, with its accompanying demand for locally produced milk; and (2) the milder climate in much of the West and Southwest, which is more conducive to the production of high-quality irrigated forage and where there is less need for expensive housing facilities or heated or insulated barns. Weersink and Tauer (1991) found that dairy operations in the Western and Southern States have become larger because of the exploitation of size economies.

In the context of FCRS-sampled milk-producing States, the importance of Florida, California, Washington, Texas, and Arizona as a leading group of non-traditional milk-producing States is emphasized in figure 4. For example, while commercial dairy farms in these five milk-producing States constituted only about 9 percent of all the commercial dairy farms, their milk cow inventories and milk sales stood at about one-third of all cows and all milk sold. This was in stark contrast to the six sampled traditional milk-producing States (Minnesota, Michigan, Wisconsin, Pennsylvania, New York, and Vermont). Together, these States accounted for about 75 percent of all commercial dairy farms, yet their cow inventory and milk sales stood at about 55 percent.[2] Figure 4 also shows that while Georgia, Iowa, Missouri, and Ohio accounted for 16 percent of the total number of commercial dairy farms, as a group they provided only 11 percent of all milk sold, thereby diminishing their importance relative to that of the other two groups of milk-producing States.

Based on the 1993 FCRS, 76,401 commercial dairies together sold 1 billion hundredweight of milk produced by about 7 million cows. For this report, we examined the levels of concentration in the financial and the resource base and the determinants of financial performance of commercial dairy farms for a sample of 503 commercial dairy farms from the traditional and the non-traditional milk-producing States. This sample, when expanded using the survey expansion factor, represents a population of 65,112 dairy farms, with the majority (almost 90 percent) located in the traditional milk-producing States.[3]

[2]The division between traditional and non-traditional milk-producing States is intended to separate those States dominated by traditional-style farms from those dominated by farms that are large, specialize in dairy production, rely more on purchased inputs, and have industrial-style division of labor. To this extent, as one reviewer remarked, a better delineation of these States would have excluded Texas from the group of non-traditional milk-producing States since the factors that characterize its dairy production are common to those in both organizational types. Similarly, although Florida is organizationally similar to the Western States, it could be excluded because of the unique features that characterize its production methods. Both Texas and Florida are kept in the analysis to save on degrees of freedom.

[3]Each observation in the FCRS, which is a multiframe stratified survey, represents a number of similar farms, the particular number being the survey expansion factor. Each expansion factor, which is the inverse of the probability of the particular farm being selected, is used to expand the FCRS sample to represent the population of all farms.

Methodology

Highlighting Differences Among Dairy Farms by Location

In accordance with the first objective of the study, a highlight of the differences that might exist among dairy farms in the traditional and non-traditional milk-producing States is provided by charting the means of certain variables such as those pertaining to the size of the operation, availability of labor hours, and farm financial performance. While reporting per-farm averages is revealing, using per-farm averages as the basis of discerning which group of farms fares better can be misleading (Backhouse and others, 1988). For example, a higher industry average could be attained if in a given year the equity position of the top 5 percent of farm businesses improved dramatically, while that of others remained unchanged. This would lead falsely to the impression that the equity position of all farms had improved. This report averts the potential for this type of misinterpretation by providing evidence regarding how uniformly each of the variates considered in the analysis is distributed. This is done by first producing tabulations that show how farms are distributed across the ranges of relevant measures. Specifically, this approach starts by first sorting the farms by a variate (e.g., farm debt, farm assets, farm equity, net cash income, etc.), and then by reporting the levels of the variate held by each decile of farms. The larger the spread between the levels of the variate held by the upper decile relative to that held by the lower decile, the larger is the level of concentration, which also implies that farms, in terms of the chosen variate, are dissimilar.

Another method of examining concentration is that of the Lorenz curve where the cumulative percentage of a relevant measure is plotted against the cumulative percentage of farms. Using farm assets as an example, if all dairy farms are equal owners of farm wealth so that each 1 percent of the farms own 1 percent of the wealth, then the Lorenz curve is diagonal, also known as the "egalitarian line." If the upper 1 percent of farms own more than 1 percent of all assets, then the Lorenz curve lies below the diagonal, and will lie even farther away the higher is their proportion of owned wealth. The usefulness of the Lorenz curve becomes limited in cases where a variate contains negative observations. Using equity as an example, the presence of negative values makes the Lorenz curve unsuitable for the measurement of the proportion of equity that is owned by the lower or upper deciles of the population. However, the Lorenz curve of such variate remains useful since it allows for a visual interpretation of the extent of the dissimilarity that may exist across the two groups of milk-producing States.

The third and final method used to assess concentration is that of the adjusted Gini coefficient originally developed by Chen, Tsaur, and Rhai (1982) and further developed by Berrebi and Silber (1985). As Lerman and Yitzhaki note (1985), the benefit of using the adjusted Gini is that it allows for the measurement of concentration regardless of whether the observations constituting a particular distribution are all positive. For the sake of demonstration, let Y_j denote the j^{th} farm's net farm income where $Y_1 \# \ldots \# Y_n$ with some $Y_j < 0$, and let m be the size of the subset of farms whose combined income is zero with $Y_1 \# \ldots \# Y_m$.[4] The adjusted Gini is computed as:

$$G^*(Y) = \frac{(2/n)\sum_{j=1}^{n} j y_i - \frac{n+1}{n}}{\left[1 + (2/n)\sum_{j=1}^{m} j y_i\right] + (1/n)\sum_{j=1}^{m} y_i \left[\frac{\sum_{j=1}^{m} y_j}{y_{m+1}} - (1+2m)\right]}, \quad (1)$$

where

$$y_j = Y_j / n\overline{Y} \quad (2)$$

and

$$\overline{Y} = \sum_{j=1}^{n} Y_j / n > 0. \quad (3)$$

In equation 1, y_j is the income share of the j^{th} farm. This formulation of the Gini normalizes the distribution of Y in such a manner that the upper bound on the Gini coefficient, due to the presence of negative values, does not exceed unity. The Gini coefficient is related to the Lorenz curve in that it is defined as the ratio of the area between the actual distribution depicted by the Lorenz

[4]For computational purposes, m is determined where the sum of the first m farms is negative and the sum of the first m+1 farms is positive.

curve and the line of equality to the area of the triangle under the line of equality (Bronfenbrenner, 1977, p. 401). When all observations are positive, the Gini ratio lies between zero, indicating complete equality, and 1, signifying maximum concentration.

Examining the Determinants of Financial Performance

The primary financial performance measure used here is net farm income (*NFI*). *NFI* is defined as total accrual receipts minus total accrual expenses when cash income is adjusted for changes in crop and livestock inventories.[5] Defined as such, *NFI* thus measures the return to operator and unpaid family labor, management, and equity capital. Lins, Ellinger, and Lattz (1987) find that profitability, which is an indicator of farm financial performance that measures the extent to which a business generates a profit from the use of land, labor, management, and capital is better represented when based on an accrual rather than on a cash measure of income.

The second financial measure used in the analysis is the dairy enterprise's net returns per unit (cwt) of milk sold (*NRU*). Unlike *NFI* which is an absolute amount that relates to the performance of the farm business, *NRU* is defined as gross value of production less cash (both variable and fixed) expenses and capital replacement, per hundredweight of milk sold.[6] The fact that *NRU* is a relative amount makes this measure amenable for comparison between one farm and another.

[5]Based on financial guidelines set forth by the Farm Financial Standards Task Force (FFSTF), financial performance refers to the results of production and financial decisions, over single or multiple time periods (Forbes, 1991). FFSTF further notes that measures of financial performance such as *NFI* include the effect of external and uncontrollable forces (for example, drought and grain embargoes), and the results of operating and financing decisions made during the course of the production period. FFSTF provides detailed descriptions of other measures of profitability such as the rate of return on farm assets, rate of return on farm equity, and operating profit margin ratio. Another potentially useful performance measure that has been widely used in the farm management literature is that of management returns, which is computed as the residual remaining after imputed charges for interest on capital and unpaid labor (operator and family) have been deducted from net farm income (Sonka, Hornbaker, and Hudson, 1989).

[6]Capital replacement costs represent a charge sufficient to maintain production capacity over time and include a charge for purchased breeding stock, but not for replacement stock raised on the farm, which are accounted for in other items of the account (see Short and McBride for more detail).

Commercial dairy farms' financial performance (*FP*) is hypothesized to be a function of farm- and enterprise-specific characteristics, and of experience in dairy production as proxied by operators' age as in the following:[7]

$$FP_i = \alpha_0 + \sum_{k=1}^{11} \alpha_k X_{k,i} + \alpha_{12} TYPE_i + \sum_{k=13}^{15} \alpha_k PRACTICE_{k,i} + \varepsilon_i, \qquad (4)$$

where FP_i denotes either *NFI* or *NRU* of the i*th* farm (i=*1,..., n*), X_1-X_{11} are rented acres per total operated acres, size of largest tractor on farm, debt-assets ratio, cow inventory, square of cow inventory, milk sold per cow, forage cost per cow, purchased feed cost per cow, hired labor per cow, land and building and equipment cost per cow, and age of farm operator, respectively; $TYPE_i$, and *PRACTICE,* are dummy variables; α_0 is a constant denoting intercept and α_1-α_{15} are parameters to be estimated using weighted least squares; and ε is random disturbance. The variable *TYPE* takes the value unity if the commercial dairy farm is a multi-owner operation and takes the value zero otherwise. The variables $PRACTICE_{k,i}$ *(k=13,14,15)* take the value unity when the dairy operation's level of technological adoption is that of either a capital-intense, management-intense, or combination of capital- and management-intense technologies, respectively, and take the value zero otherwise.

Variability of Financial Performance. Using equation 4 *(k=1,...,11)* with *NFI* as the dependent variable for demonstration, the variation in *NFI* in the two groups of milk-producing States after performing weighted least squares can be apportioned to the contribution of different explanatory variables as in the two cases discussed next.

Variance effects of each explanatory variable. In the absence of any covariation effects, the unexplained variability in *NFI* can be decomposed into a variability component explained by the linear relationship between the dependent variable *NFI* and each of the explanatory variables, and an unexplained variability component due to the error term as in the following:

$$\sigma_{NFI} = \sigma(NFI \mid \alpha_0, \alpha_1, \ldots, \alpha_k) = \alpha_1^2\sigma_{11} + \alpha_2^2\sigma_{22} + \alpha_k^2\sigma_{kk} + \sigma_\varepsilon, \qquad (5)$$

[7]Estimation of a profit equation is not plausible here since the FCRS does not collect information on prices of inputs and of output.

where σ_{NFI} is the unexplained variance of net farm income (NFI_i), α denotes an estimated parameter, σ_{gg} (where $g = 1,.., k$) is variance of variate X_g, and σ_ε is variance of error term ε.

The individual effect (V_j) in percentage terms that each of the explanatory variables has on the variation in *NFI* can be measured as:

$$
\begin{aligned}
V_1 &= \left[(\alpha_1^2\sigma_{11}) / \sum_{j=1}^{k}\alpha_j^2\sigma_{jj}\right]100 \\
V_2 &= \left[(\alpha_2^2\sigma_{22}) / \sum_{j=1}^{k}\alpha_j^2\sigma_{jj}\right]100 \\
&\;\;\dots \\
&\;\;\dots \\
V_k &= \left[(\alpha_k^2\sigma_{kk}) / \sum_{j=1}^{k}\alpha_j^2\sigma_{jj}\right]100
\end{aligned}
\qquad (6)
$$

Variance effects of all explanatory variables. While equation 6 shows the extent that each variable alone contributes to the variation in net farm income, relative to other variables, a more useful variance decomposition allows for the incorporation of the variance effects along with those of the covariances as in the following:

$$
\begin{aligned}
&\sigma_{NFI} = \sigma(NFI|\alpha_0, \alpha_1, \dots, \alpha_k) = \\
&\alpha_1^2\sigma_{11} + \alpha_1\alpha_2\sigma_{12} + \dots + \alpha_1\alpha_k\sigma_{1k} + \\
&\alpha_2\alpha_1\sigma_{12} + \alpha_2^2\sigma_{22} + \dots + \alpha_2\alpha_k\sigma_{2k} + \\
&\dots \\
&\dots \\
&\alpha_k\alpha_1\sigma_{k1} + \alpha_k\alpha_2\sigma_{k2} + \dots + \alpha_k^2\sigma_{kk} + \sigma_\varepsilon
\end{aligned}
\quad , \qquad (7)
$$

where σ_{gg} and σ_{gh} ($g \neq h$) are variance of variate X_g and covariance of variates X_g and X_h, respectively. The variance of *NFI* as described in equation 7 can, hence, be described as the sum of explained variance-covariance effects attributed to the model's explanatory variables (Ω) and unexplained variance due to an error term. Thus, equation 7 can be rewritten as:

$$\sigma_{NFI} = \Omega + \sigma_\varepsilon \qquad (8)$$

Consequently, the coefficients of separate determination are computed as:

$$
\begin{aligned}
C_1 &= (\alpha_1^2\sigma_{11} + \alpha_1\alpha_2\sigma_{12} + \dots + \alpha_1\alpha_k\sigma_{1k}) / \sigma_{NFI} \\
C_2 &= (\alpha_2\alpha_1\sigma_{21} + \alpha_2^2\sigma_{22} + \dots + \alpha_2\alpha_k\sigma_{2k}) / \sigma_{NFI} \\
&\vdots \\
C_k &= (\alpha_k\alpha_1\sigma_{k1} + \alpha_k\alpha_2\sigma_{k2} + \dots + \alpha_k^2\sigma_{kk}) / \sigma_{NFI}.
\end{aligned}
\qquad (9)
$$

The explained variation of the dependent variable *NFI* is described by the goodness of fit measure, R^2, which is equivalent to the following:

$$R^2 = \sum_{j=1}^{k} C_j = \Omega / \sigma_{NFI}, \qquad (10)$$

where C_j indicates the j^{th} coefficient of separate determination. The unexplained variation in *NFI* is, hence, equal to 1 minus R^2.

By replacing *NRU* for *NFI*, the estimation procedures outlined by equations 5-10 become those that measure the variability in financial performance based on per-unit returns rather than on income per-farm.

Variability of States' Farm Financial Performance. Net farm incomes NFI_i, where $i=1,\dots, n$, and net returns per unit of output are first sorted by the 11 States that comprise the two major groupings of milk-producing States used in the report. Second, weighted means of $NFI_i(\overline{NFI}_s)$ and $NRU_i(\overline{NRU}_s)$ and Gini coefficients ($Gini_{v,s}$) for *v* variates (debt capital, farm assets, equity, cow inventory, and milk sales) are computed for the respective *s* milk-producing States. Third, linear regression models are used to express the relationships between $\overline{NFI}$ and $\overline{NRU}$ and each of the *v* concentration ratios. Using $\overline{NFI}$ for demonstration, the relationships between the weighted means of NFI_t by milk-producing State and each of the *v* concentration ratios result in *v* regressions that take the following general form:

$$\overline{NFI}_s = \alpha_0 + \alpha_1 Gini_{v,s} + \varepsilon_s, \qquad (11)$$

where α_0 and α_1 are parameters to be estimated and ε_s ($s=1,\dots,11$) is the error term. The explained variation of $\overline{NFI}_s$ is described by the goodness of fit measure, R^2, also known as the coefficient of determination, and is expressed as:

$$R^2 = \alpha_1^2\sigma_{11} / \sigma_{\overline{NFI}}, \qquad (12)$$

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

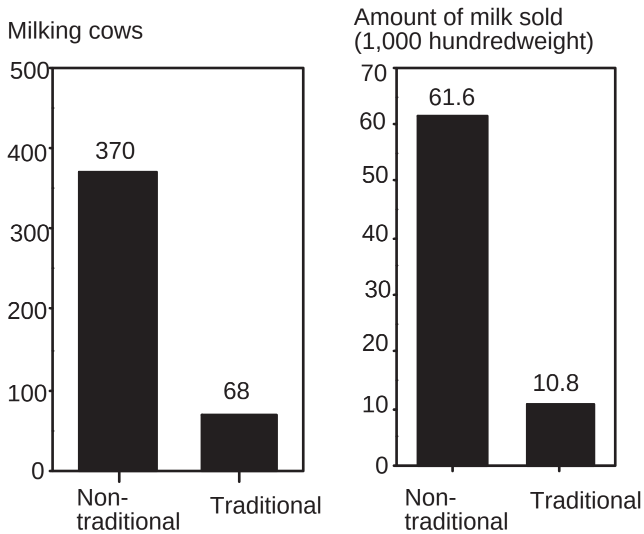
Figures 5-10 provide a pictorial representation of the differences among dairy farms in terms of size, labor availability, balance sheet, and farm profitability based on the location of the dairy operation. The following is a summary of these differences:

• 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

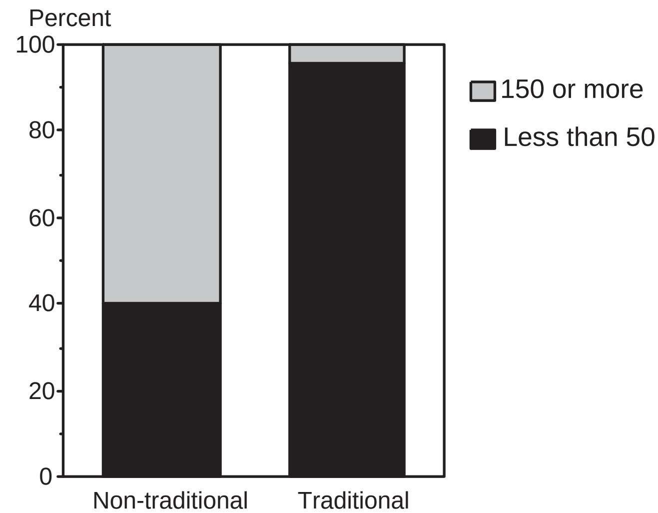
Average size of commercial dairy farms, in selected milk-producing States, 1993



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.

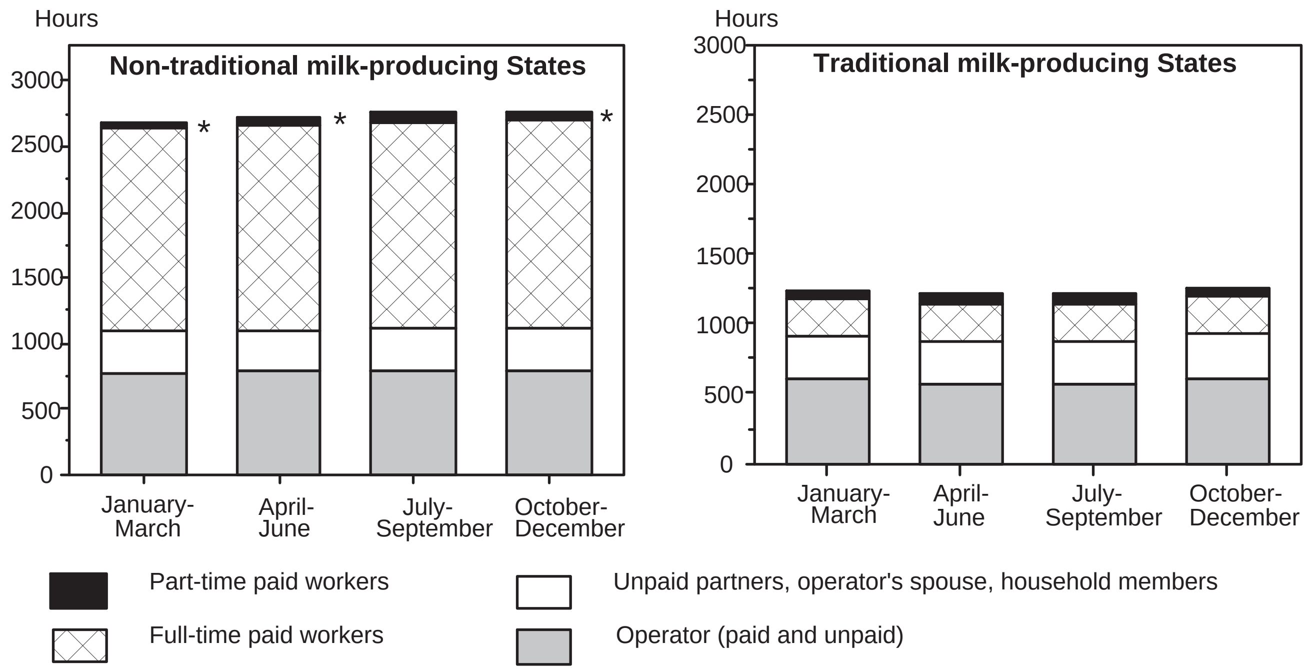
• Figure 9 shows that a commercial dairy farm, particularly if located in a non-traditional milk-producing State, tends to exhibit declining debt-to-asset (*DA*) ratios and, correspondingly, tends to exhibit increasing equity value, as the farm operator gets older. The fact that farmers 60 years or older 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

[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]

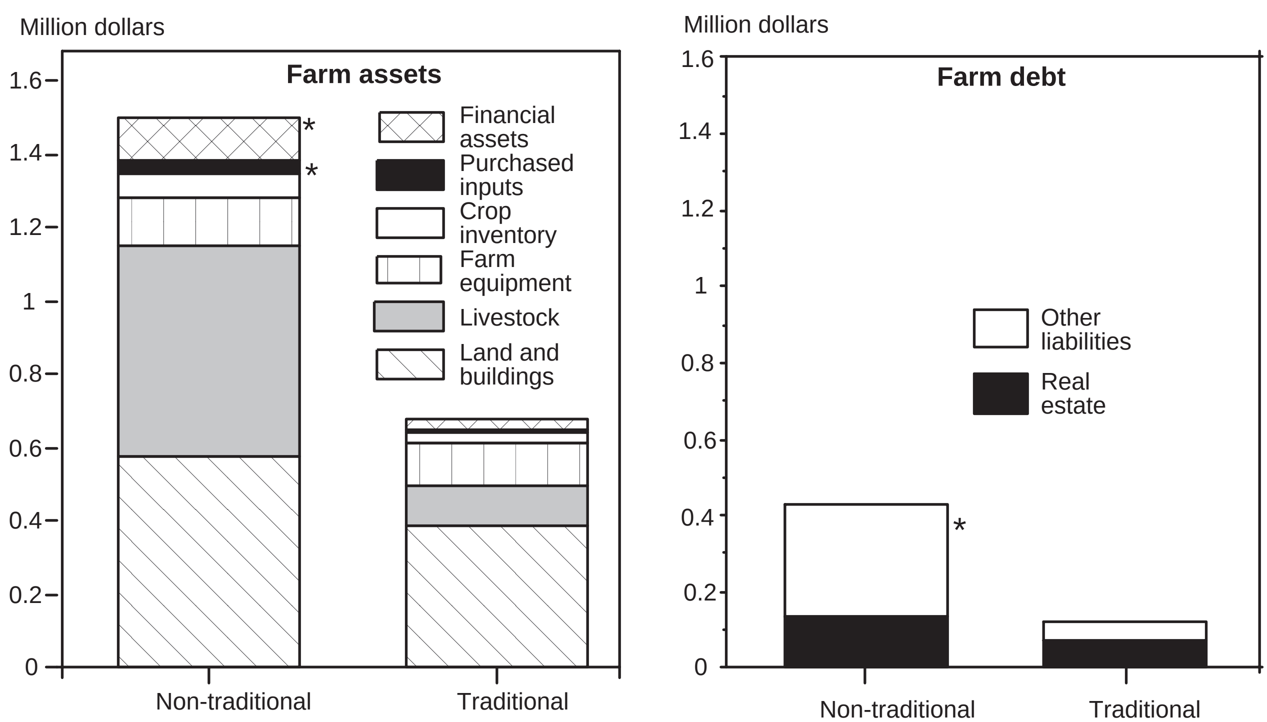
The figures discussed above reveal that farms in non-traditional milk-producing States are, on average, larger, more in debt, wealthier, and more likely to financially outperform farms in the traditional milk-producing States. While this information in and by itself is useful, it falls short in revealing 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

[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).

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.

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

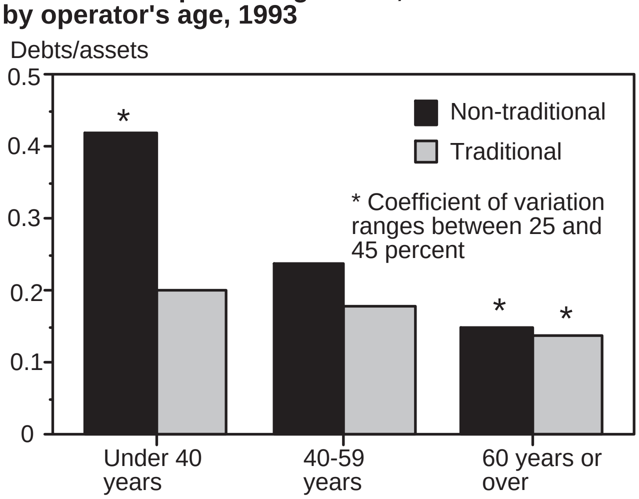
Figures 11-13 present Lorenz curves that provide a graphical description of the distributions of commercial dairy farms in the non-traditional and in the traditional milk-producing States, and of all dairy farms (i.e., regardless of their economic size) in all the FCRS sampled States, by the various 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

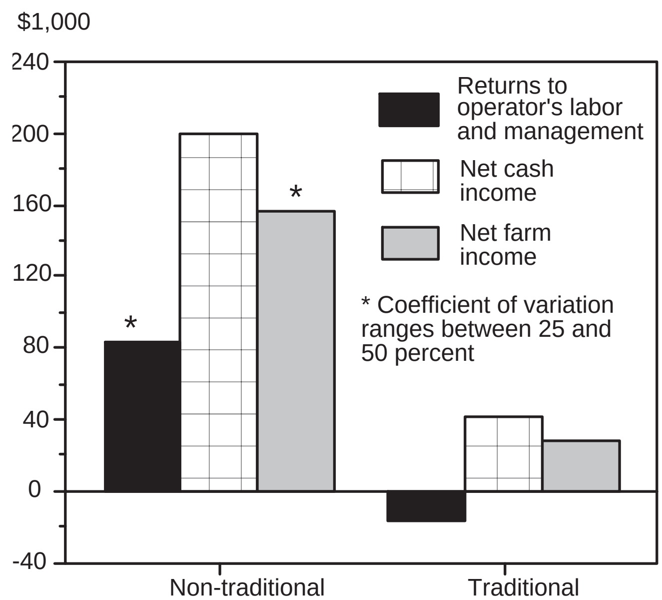
Commercial dairy farm's debt-asset ratios, in selected milk-producing States, by operator's age, 1993



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.

[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.

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.

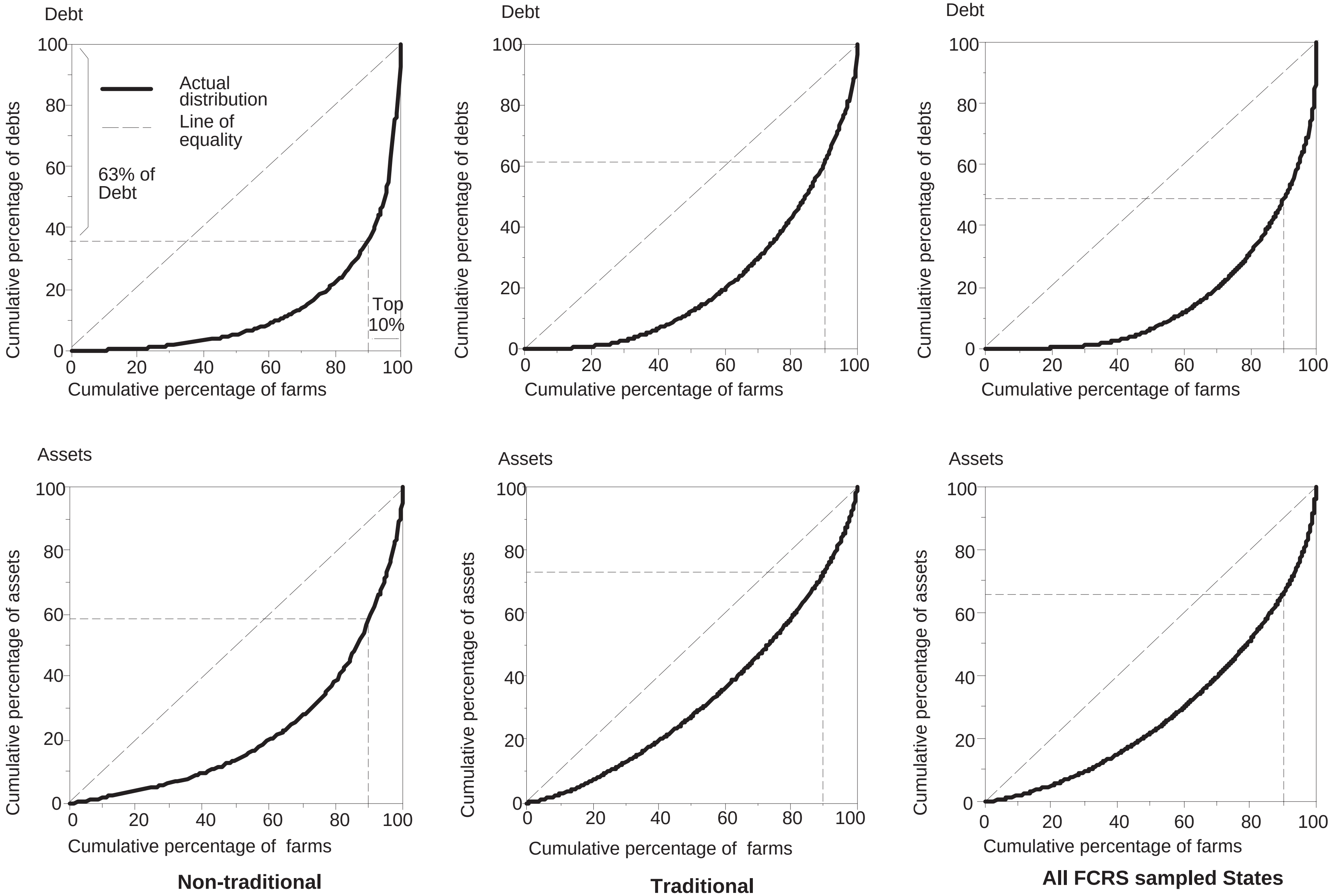
To demonstrate, prolonged drought in the West caused premium-quality alfalfa in 1993 to be scarce, and the damage from the 1993 excessive rains in some of the Lake States reduced the availability of premium-quality alfalfa (U.S. Department of Agriculture, 1993a, p. viii; U.S. Department of Agriculture, 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.

[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

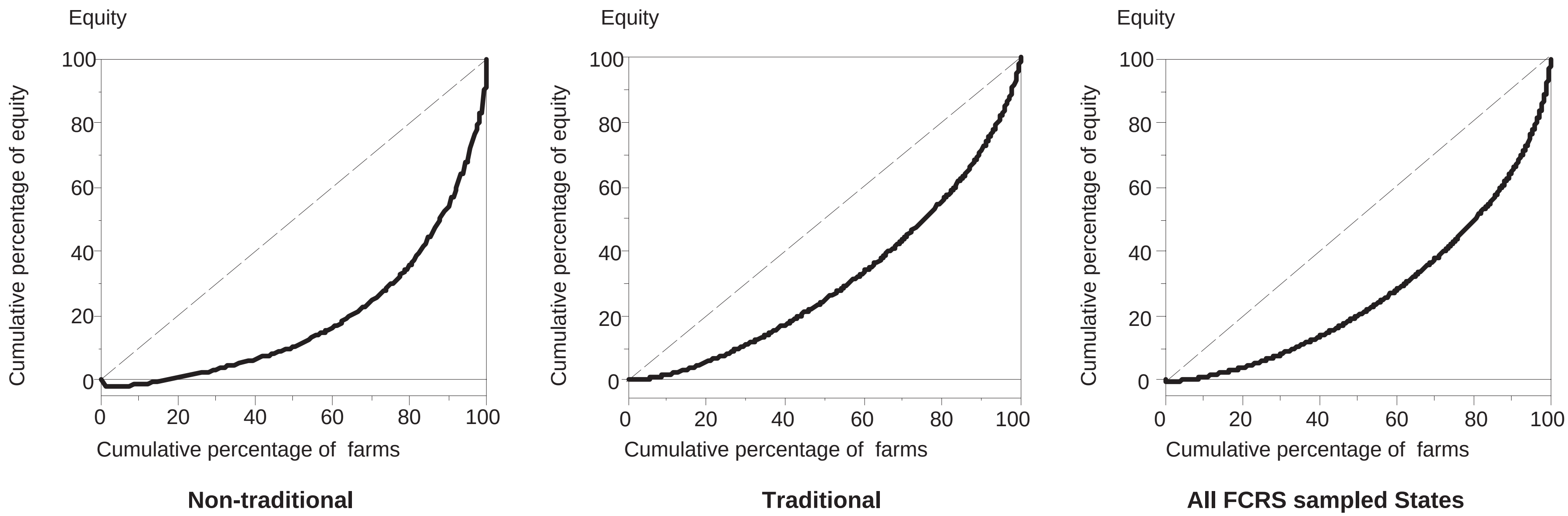
Lorenz curves of farm debt, assets, and equity: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993



continued--

Figure 11

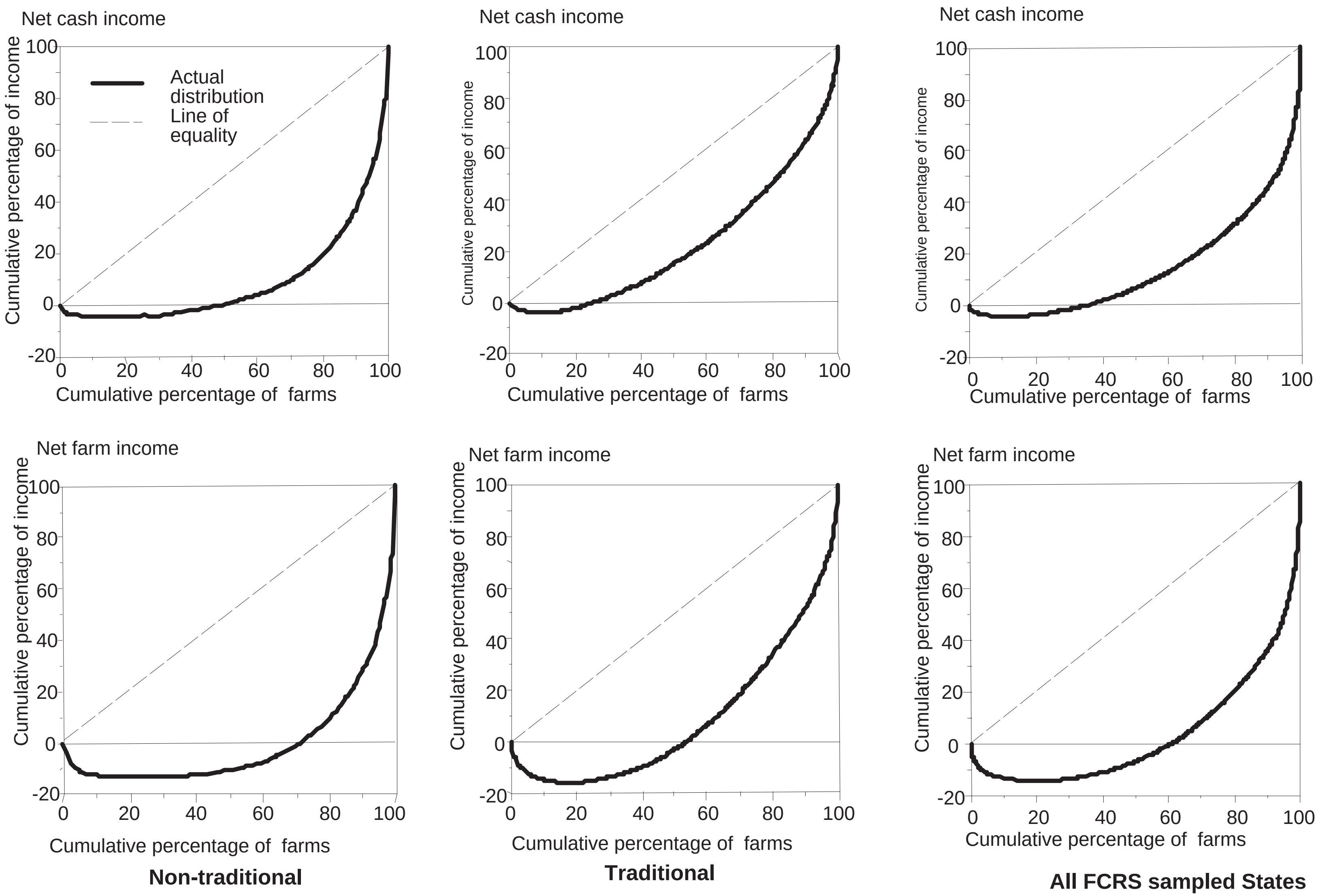
Lorenz curves of farm debt, assets, and equity: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993--continued



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

Figure 12

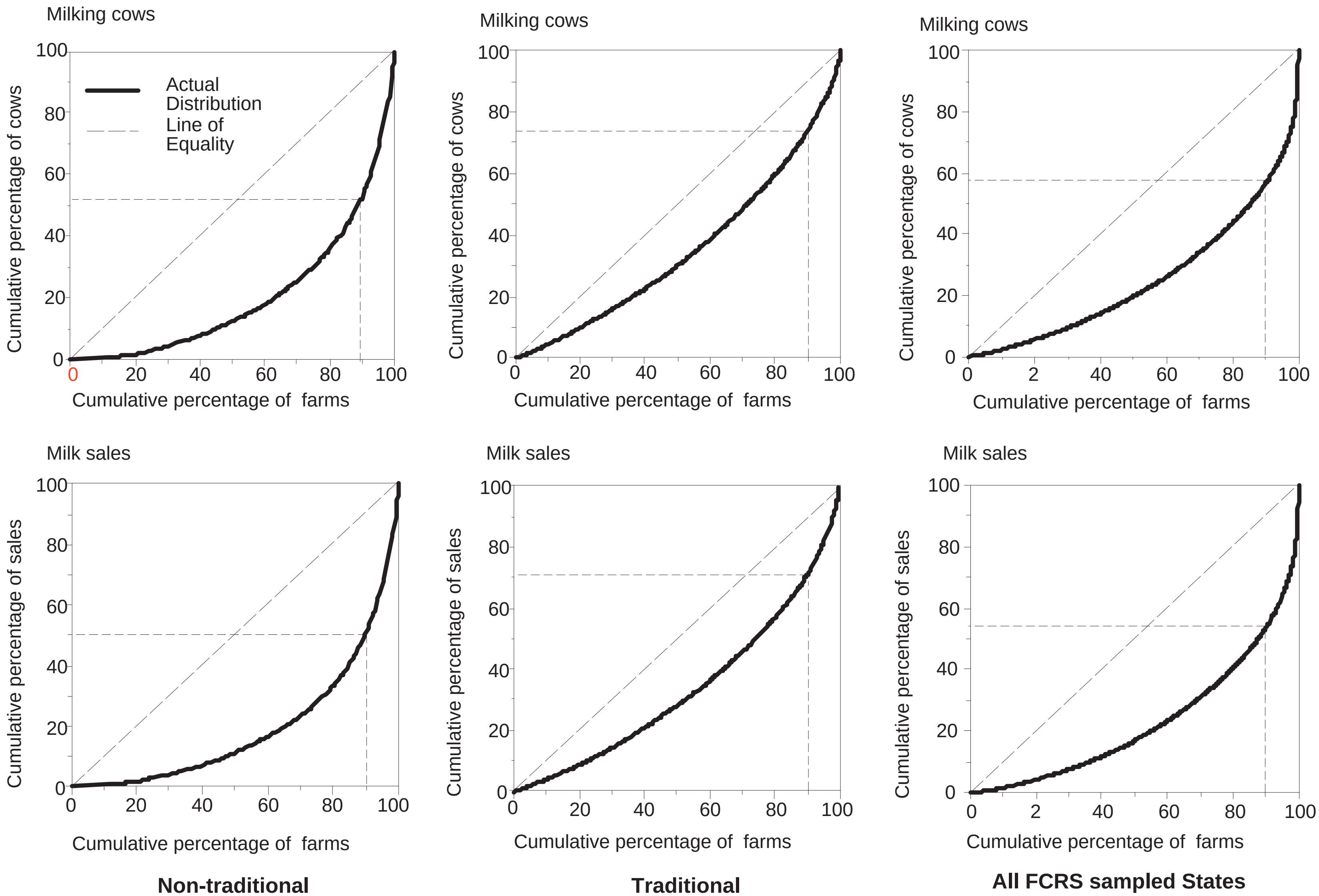
Lorenz curves of net cash and net farm income: Commercial dairy farms in selected milk-producing States, and all dairy farms in all FCRS sampled milk-producing States ,1993



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

Variables	Definition	Unit	Means[1] 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	<u>156,147</u>[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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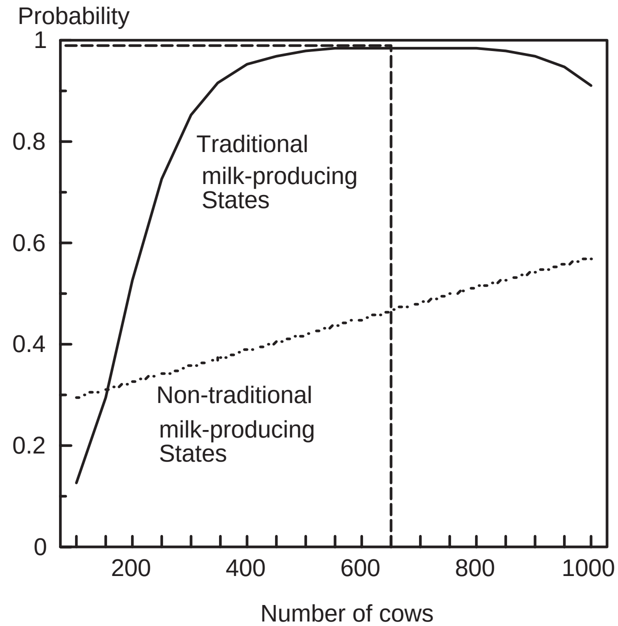
[13]As one reviewer notes, if net farm income decreases by $431 due to a 1-percentage point increase in rented acres, that may be interpreted as indicating that the rent paid by a dairy operator in the traditional milk-producing States exceeds the amount that should be paid as land rent (i.e., the economic 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]

[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.

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.

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.

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

[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

Variable included	Regression variates (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

Test of independence	F-statistic	
	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.

commercial dairy farms in the traditional milk-producing States, in addition to improving cow performance, returns are found to increase significantly if the debt-to-assets ratio is lowered, and if per-cow forage and purchased feed costs are controlled.

Dairy farming is labor intensive. The increase in the minimum wage enacted in 1996 is likely to make it harder for many dairy operations to afford farm labor (Findeis, 1995). This study finds that an increase in the cost of labor in the non-traditional milk-producing areas will dramatically affect the farms' profitability levels. To these farms, reducing the amount of hired labor, while implementing production methods capable of increasing labor productivity might be a viable strategy. Since farm labor accounts for about 10 percent of all farm production expenses on dairy farms (Oliveira, 1991), it is evident that rising labor costs on farms without labor-saving technologies can be substantial.

The study provides evidence of the linkage of herd size to the profitability of the farm business, particularly for commercial dairy farms in the non-traditional milk-producing States. The incidence of large farming operations in these milk-producing States (at an average size of 370 milking cows) and the evidence from this study that points to higher net farm income resulting from continued farm expansion indicate the presence of some underlying incentives. Incentives that provide impetus for farm enlargement include production and marketing economies, management expertise, tax incentives, specialization, labor-saving equipment and timeliness in getting things done, nonfarm investment, and farm consolidation (Krause and Kyle, 1970; Stanton, 1978).

For a commercial dairy producer in the traditional milk-producing States, profitability of the farm business seems to be highly correlated with the adoption of capital- and management-intensive technologies. Dairy farms in this group have much lower adoption rates for the combined technologies, at 9 percent compared with 42 percent for farms in non-traditional milk-producing States (table 3). Efforts by policymakers to widen access to relatively inexpensive credit to allow for the purchase of costly labor-saving equipment, particularly to low-equity farms operated by young farmers, should assist commercial dairy farms in these milk-producing States to remain competitive.

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Appendix

Test of Difference Between Means

The decision rule for testing the null hypothesis (H_0) that the means μ_1 and μ_2 of variate X across two groups of sample sizes n_1 and n_2 are equal starts by computing the following t-statistic (t*):

$$t^* = \frac{\mu_1 - \mu_2}{\sqrt{\sigma_{\mu_1} - \sigma_{\mu_2}}}, \qquad (13)$$

where σ denotes variance. If $|t^*| <= t(1-\alpha/2; n_1+n_2-2)$, conclude H_o (that is, H_o: $\mu_1 = \mu_2$) where α is the attained significance level. The alternative hypothesis (H_a) that the means are significantly different (that is, H_a: $\mu_1 \neq \mu_2$) is concluded if $|t^*| > t(1-\alpha/2; n_1+n_2-2)$.

It is important to note that because FCRS has a complex survey design, the formulation for the variance differs from that if data were based on simple random samples (Fuller and others, 1986, p. 75; Dubman, 1997). Further, the proper degrees of freedom to be used in establishing the critical t-statistic, particularly when $n_1+n_2<30$, is the number of segments (that is, primary sampling units) minus the number of strata (that is, mutually exclusive groups of farms that partition the targeted population of farms) instead of n_1+n_2-2. For further detail regarding FCRS survey design, see U.S. Department of Agriculture, 1994.

Test of Equivalency of Two Regressions

The data for the commercial dairies in the non-traditional and in the traditional milk-producing States are pooled. A dummy variable *D* is constructed with *D* = 1 if the dairy operation is located in a traditional milk- producing State, *D* = 0 otherwise. Using the model in equation 4 less the dummy variables as an example, the following regression for the pooled data is formed:

$$NFI = \alpha_0 + \sum_{k=1}^{11} \alpha_k X_k + \delta_{12} D + \sum_{k=13}^{23} \delta_k D_k + \xi, \qquad (14)$$

where α and δ denote coefficients to be estimated, and ξ is an error term.

The decision rule for testing the null hypothesis (H_0) that the dummy coefficients $\delta_{12},...,\delta_{22}$ are all jointly equal to zero originates by performing the following *F*-statistic (*F**):

$$F^* = m^{-1} \hat{A}'_m C^{-1}_{mm} \hat{A}_m, \qquad (15)$$

where A_m denotes the m-dimensional vector, a subset of the vector *A* ($A=[\alpha_0,..., \alpha_k, \delta_{12},...,\delta_{23}]$), for which it is hypothesized that $A_m = 0$, and where Cmm is the *m x m* portion of the estimated covariance matrix of $\hat{A}$ that is associated with $\hat{A}m$ (Fuller and others, 1986, p. 81).

If $F^* <= F(12;$ segments-strata), conclude H_o where H_o: $\delta_{12} = \delta_{13} =...= \delta_{23} = 0$, and where α is the attained significance level. The alternative hypothesis (H_a) that the coefficients of the dummy variables are significantly different from zero (that is, H_a: $\delta_{12} \neq \delta_{13} \neq ... \neq \delta_{23} \neq 0$) is concluded if $F^* > F(12;$ segments-strata). Rejecting H_0 is equivalent to rejecting the adequacy of one profit equation representing the net farm incomes of commercial dairy farms across the two milk-producing States considered in the analysis.

Logistic Regression

Benefiting from Pindyck and Robinfeld's (1981) discussion on logistic regression, let *I* be a binary index coded 1 if the i^{th} (i=1,..., n) commercial dairy farm has adopted a combination of capital- and management-intensive technology (*AMP-PRS*), and zero otherwise. The probability (*P*) of technological adoption is represented by the following:

$$P_i = E(I = 1|X_i) = \frac{1}{1 + e^{-\beta' X_i}}, \qquad (16)$$

where *e* is the base of the natural logarithm, *E* is the expectation operator, β is a vector of coefficient to be estimated, and *X* is a vector of explanatory variables.

The probability of not adopting *AMP-PRS* can be written as:

$$1 - P_i = \frac{1}{1 + e^{\beta' X_i}}, \qquad (17)$$

and, correspondingly, the odds ratio in favor of technological adoption can be represented as:

$$\frac{P_i}{1-P_i} = \frac{1+e^{\beta' X_i}}{1+e^{-\beta' X_i}} = e^{\beta' X_i}. \qquad (18)$$

The log of the odds ratio (ζ), commonly known as the logit, is derived by taking the natural logarithm of equation 18:

$$\zeta_i = \ln\left[\frac{P_i}{1-P_i}\right] = \beta' X_i. \qquad (19)$$

Maximum likelihood procedures are employed using *PC-CARP* to estimate the coefficients and test hypotheses regarding the factors that affect the technology adoption decision of the dairy operator. Substituting the values of the estimated coefficients in equation 16 allows for the estimation of the adoption probabilities.

Test of Equivalency of Separate Coefficients Across Two Regressions

Demonstrating with equation 4 after dropping the dummy variables, let the following represent the regression performed on pooled data:

$$NFI = \alpha_0 + \sum_{k=1}^{11} \alpha_k X_k + \delta_{12} D + \sum_{k=13}^{23} \delta_k D_k X_k + \xi, \qquad (20)$$

where D is a dummy variable that equals one if the dairy operation is located in a traditional milk-producing area, zero otherwise. Since each of the dummy coefficients $\delta_{12},...,\delta_{23}$, also known as differential slope coefficients, measures the difference in slopes across the two groups of milk-producing States, resulting t-tests from the regression performed on equation 20 provide useful information. For example, if the *t*-test that corresponds to δ_{13} indicates that δ_{13} is significantly different from zero, then this is equivalent to the finding that the coefficients of *RAC* based on two separate regressions, one for each of the two milk-producing States, are significantly different. If the resulting *t*-ratio is positively signed, this indicates that the *RAC*'s coefficient in the traditional milk-producing States is significantly larger than its counterpart in the non-traditional milk-producing States.