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Dairy Farm Management and Long-Term Farm Financial Performance

Brent A. Gloy, Jeffrey Hyde, and Eddy L. LaDue

The financial performance and relationships between several management factors and financial performance are examined in a panel of 107 New York dairy farms. A panel regression model with fixed effects is estimated in an effort to identify management factors that influence profitability. The model is estimated with two-stage least squares to account for endogenous farm size and debt use variables. Production management factors such as farm size, rate of milk production, and milking system had a positive impact on farm profitability. Financial management variables for the type of accounting system used and the debt use were also significantly related to profitability. Unlike the findings of many other studies, measures of human capital did not have a statistically significant impact on profitability.

Key Words: dairy farm management, financial management, fixed-effects regression analysis

From 1980 to 2000, the number of New York dairy farms declined from 19,000 to 7,900 [U.S. Department of Agriculture (USDA), 2002]. This decline is troubling to those involved with New York agriculture because the sale of dairy products accounted for slightly over half of the market value of agricultural products sold and 58% of the state's agricultural net cash income in 1997 (USDA, 1999). While many factors have led to this decline, the profitability of individual dairy operations is central to this issue.

The declines in New York dairy farm numbers have been accompanied by increases in the average herd size of the state's dairy farms. For example, from 1980 to 2000, the average herd size in New York increased from 48 cows to 87 cows. Simultaneously, the average rate of milk production per cow also increased, from 12,046 pounds per cow to 17,378 pounds per cow (USDA, 2002).

Declines in the number of farms, increases in productivity, and increases in farm size are not unique to New York dairy production. Nearly every commodity and farm segment in the United States

has undergone similar changes. Several factors have led to these changes. One possible explanation is that, in general, the most profitable farms have remained in production and have profitably expanded production as a natural course of business, while less profitable farms have exited the industry. However, neither the extent to which long-term profitability varies among farms nor the factors enabling some farms to generate superior long-term profits are well known.

To the extent there are wide differences in farm profitability, we theorize it is possible to identify factors that have allowed some farms to be more profitable than their peers. By examining the factors having a strong influence on the profitability of dairy farms, it may be possible to improve the profitability of the remaining farms.

Developing a better understanding of the factors that influence dairy farm profitability is potentially important to many parties. Farm managers should be able to use this knowledge to improve their operations and increase profitability. Extension educators and other firms that interact with farmers can use the results to assist farmers in improving the profitability and long-term viability of their operations. The results may also serve to guide extension programming as topics are prioritized for educational emphasis. Finally, farm management researchers and educators can enhance their understanding of

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the factors influencing long-term profitability of farms and guide future research and teaching efforts aimed at improving farm management.

The relationship between farm profitability and farm management has been examined by many researchers [see Fox, Bergen, and Dickson (1993) for a thorough review]. Frequently, analysts have relied on cross-sectional data sets to determine important relationships between farm characteristics and farm performance. These studies have identified a large number of factors that appear to be related to farm economic performance, particularly those characteristics observed to be important in achieving superior profitability in the short term.

However, as argued by Rougoor et al. (1998), in order to understand the importance of farm management, it is necessary to measure farm performance and management over time. Because an important goal of farm management is to achieve superior long-term financial performance, there is a continuing need to examine the relationship between farm management practices and long-term financial performance.

This study examines profitability in a panel of dairy farms. The analysis is unique because it evaluates farm-level financial performance over a seven-year time period. Unlike many previous farm management studies, the methodology employed here accounts for the potential problem of endogenous explanatory variables.

The first objective of this research is to compare the long-term financial performance of a panel of 107 dairy farms participating in Cornell University's Dairy Farm Business Summary over the period 1993–1999. Both the annual distributions of the rate of return on assets and the distribution of the compound rate of return on assets over the seven-year time period are described and analyzed. This comparison provides an estimate of the magnitude of the differences in long-term financial performance of New York dairy farms. Next, the panel data set and a fixed-effects regression model are used to test hypotheses regarding the impact of several managerial factors on the annual rate of return on assets over the same time period.

The following section describes the conceptual framework employed in the study. Next, the literature related to dairy farm profitability is reviewed and the data and methodology are discussed. The data description examines the general characteristics of the data as well as distributions of annual and long-term profitability. The panel data regression model is then presented and specified, and

results are reported. Our conclusions are summarized in the final section.

Conceptual Framework

Farm management researchers have spent a considerable amount of effort examining the factors underlying farm profit differentials (Fox, Bergen, and Dickson, 1993). At its most basic level, long-term farm profitability is dependent upon both the amount of the factors of production employed and the methods by which these factors are combined. The amount of the factors the manager will employ is subject to many considerations, including initial resource endowments, factor prices observed by the manager, factor availability, expectations regarding the productivity of the factors, and risk preferences. The ability to productively combine the factors of production is also critical. Different managers will use different production techniques and practices which influence output quantity and quality. In other words, in the face of many constraints, farm managers maximize profits while taking prices as given.

Ignoring risk preferences and uncertainty, the profit-maximization problem might be expressed as:

$$\begin{aligned} (1) \quad & \text{Max}_{\mathbf{x}} \text{Profit} = \sum_i p_i q_i(\mathbf{x}; \boldsymbol{\alpha}) - C_i(\mathbf{w}, q_i(\mathbf{x}; \boldsymbol{\alpha})) \\ & \text{s.t.: } g_j(x_j) \leq X_j, \quad j = 1, 2, \dots, n, \end{aligned}$$

where p_i is the price of output i ; q_i is the production function for output i which determines the amount of product i produced; \mathbf{x} is a vector of inputs from which the farmer can choose to produce product i ; $\boldsymbol{\alpha}$ is a vector of personal characteristics of the farmer which influence his or her choices of these inputs and the manner in which they are combined; C_i is the cost function for product i which is dependent upon the price of the inputs \mathbf{w} , and the amount of output i produced. The constraint on the profit-maximization problem reflects the presence of factor endowments and other initial conditions affecting the profit-maximization decision. The function $g_j(\cdot)$ ensures that the total demands for the n inputs (x_j) subject to these conditions cannot be greater than the initial endowments of the inputs (X_j).

Obviously, actual farm management and profit maximization present a complex and complicated problem. Consequently, different managers employ different amounts of the factors of production, and use many different management practices and strategies. It is quite reasonable to hypothesize that some

managers are more successful in maximizing profits than others.

Our first objective is to examine the extent to which farms achieve different levels of long-term profitability. We then examine several factors, practices, and strategies hypothesized to explain these profit differentials. Because managers employ a variety of strategies and managerial practices to combine the factors of production, it is useful to organize or categorize these various practices and strategies. We have chosen to organize the factors, practices, and strategies around the management functions of production, human resources, and finance. Through examination of the practices and amounts of resources employed in each of these areas, we hope to learn more about the factors influencing long-term profitability.

Empirical data collected from a panel of 107 New York dairy farms over a seven-year time span (1993–1999) are used to estimate the impact of various management practices and strategies. The model used in this study employs a fixed-effects formulation to address heterogeneity of the farms arising from factors such as initial resource endowments. It is also quite possible that variables used to measure farm size and debt use are endogenous with farm profitability. For instance, when considering long-term farm performance, profitability would be expected to influence the decision to expand. Specifically, it would be unlikely for an unprofitable farm to undergo sustained expansion, but profitable farms have an incentive to reinvest in their operations and would tend to increase farm size.

The amount of debt used by the farm is also seemingly a function of farm profitability. More profitable farms should be able to carry more debt. Conversely, unprofitable farms wishing to continue farming likely use debt out of necessity. Both of these situations would violate the standard regression assumption that the explanatory variables are not correlated with the error term of the regression equation. As a result, the estimates of these parameters are inconsistent. A two-stage least squares approach is used to address the problem of endogenous explanatory variables.

Literature Review

Fox, Bergen, and Dickson (1993) and Rougoor et al. (1998) review a large number of farm management and farm performance studies. Our review focuses on studies of dairy farm management and is organized around the management functions of

production, finance, and human resources. Because nearly all of the dairy farms considered here market their milk on a monthly basis, do not employ value-added marketing strategies, and do not use dairy futures markets, there is relatively little variation in their marketing practices. For this reason, we do not consider marketing strategies and practices.

Production Management

Farmers can choose from a wide variety of production technologies and practices. The relationship between production factors and profitability has generated a great deal of research. These studies have examined issues such as efficiency, scale, technology employed, and input cost control.

Efficient production has been shown to be an important factor affecting farm financial performance. Using a test for violation of the weak axiom of profit maximization, Tauer and Stefanides (1998) found that over the period 1984–1993, a sample of New York dairy farms could have improved profitability by approximately 20% of total receipts by selecting a different mix of inputs and outputs. However, the authors did not identify any production management variables to explain why these farms were less efficient or made sub-optimal profit-maximizing decisions. Rather, the variables found to have a significant relationship to inefficiency were related to human resources such as age, education, and the number of farm operators.

Featherstone, Langemeier, and Ismet (1997) examined the technical, allocative, and scale efficiency of Kansas beef cow farms. Although overall inefficiency was related to farm size, technical efficiency was observed to have a greater impact on overall efficiency than farm size. Similarly, Ford and Shonkwiler (1994) found milk sold per cow had a greater impact on profitability than farm size.

Production efficiency measured by pounds of milk sold per cow is often thought to be a strong indicator of management ability, and is frequently considered to have an important impact on profitability. Many studies have reported a positive relationship between milk production per cow and various measures of financial success (e.g., Short, 2000; El-Osta and Johnson, 1998; Kauffman and Tauer, 1986; Sonka, Hornbaker, and Hudson, 1989).

The relationship between the adoption of various production practices or technologies and profitability has also been examined by previous research. Assessing the factors which influenced the adoption

of capital- and management-intensive technologies, El-Osta and Morehart (1999) found these adoption decisions were related to several measures of human resources, such as age and education.

El-Osta and Johnson (1998) considered the use of advanced milking parlors, which they define as herringbone, side opening, polygon, or carousel. They concluded this technology does not have a significant effect on net farm income in traditional milk producing states. However, advanced milking parlor use was actually negatively related to net farm income in nontraditional dairy states, including Florida, California, Washington, Texas, and Arizona.

Other researchers have examined issues such as the use of recombinant bovine somatotropin (rBST) (Stefanides and Tauer, 1999) and grazing practices (Gloy, Tauer, and Knoblauch, 2002; White et al., 2002; Winsten, Parsons, and Hanson, 2000; Dartt et al., 1999; Hanson et al., 1998).

There has been a great deal of interest in the relationship between farm size and profitability. The findings of studies addressing this topic are somewhat mixed. Kauffman and Tauer (1986) and Tauer and Stefanides (1998) report inconclusive results with respect to the relationship between farm size and profitability. Yet, other studies have shown farm size is positively related to farm profitability (Mishra and Morehart, 2001; Short, 2000; Cocchi, Bravo-Ureta, and Cooke, 1998; El-Osta and Johnson, 1998; Ford and Shonkwiler, 1994; Haden and Johnson, 1989).

It is important to note, however, that these studies frequently use different measures of financial success, and often they establish a relationship between farm size and measures of net cash income, not relative or size-neutral measures of profitability. Because most of the studies are cross-sectional in design, it is appropriate to treat farm size as an exogenous variable. However, it is quite possible that, over time, farm size and farm profitability exhibit a more complex relationship. Because we might reasonably assume profitable farms are likely to expand and unprofitable farms are unlikely to expand, it is important to consider this issue when investigating long-term financial performance.

Other studies have explored the relationship between input cost control and farm profitability. Langemeier, Schroeder, and Mintert (1992) found input price control had a significant effect on profitability for Kansas cattle finishers. Also, Mishra, El-Osta, and Johnson (1999) showed that cash operating expenses are significantly related to net farm income on cash grain farms in the United States. With

respect to dairy, some studies have found a negative relationship between expenditures for purchased feed per cow and measures of financial profitability (El-Osta and Johnson, 1998; Kauffman and Tauer, 1986).

Financial Management

Dairy farm managers must make a variety of financial management decisions. These decisions often relate to acquiring financial resources either through borrowing or leasing, determining the amount of debt used to finance the business, developing the appropriate structure of debt claims (among short-, intermediate-, and long-term obligations), and keeping and analyzing farm records. Each of these topics has received some attention from researchers. Most of the empirical work in this area has explored the relationship between farm profitability and various measures of financial leverage. Other studies have examined the use of leasing and record-keeping practices.

Financial ratios are often used as measures of financial management. The debt-to-asset ratio is the most commonly used measure (Purdy, Langemeier, and Featherstone, 1997; Mishra and Morehart, 2001; Kauffman and Tauer, 1986; El-Osta and Johnson, 1998; Haden and Johnson, 1989). This ratio reflects the proportion of the farm's assets that are financed with debt. Using a sample of Kansas farms to examine the impact of risk and specialization on mean financial performance, Purdy, Langemeier, and Featherstone (1997) include several other financial management measures (inverted current ratio, total assets, net worth, asset turnover ratio, operating expense ratio, depreciation expense ratio, interest expense ratio, and net farm income ratio). In their analysis of managerial ability and farm financial success, Ford and Shonkwiler (1994) use a ratio of equity to assets, operating margin, interest as a percentage of cash expenses, and debt per cow.

Measures of the amount of debt used by the farm are typically treated as exogenous variables. However, with long-term farm profitability, there are several reasons to expect debt levels may be endogenous. Farms with a track record of achieving a rate of return on assets above the rate of interest on debt should have greater access to leverage and be more willing to use debt, because such a strategy will positively leverage the rate of return on equity. At the same time, the cost of capital is assumed to be less for high-profit farms. In contrast, if farms have gone through periods of low profitability, it is

possible they would have greater need for debt funds. Regardless of the scenario, it seems possible that profitability would impact debt use.

The empirical findings related to the impact of debt on farm profitability reveal mixed results. Mishra and Morehart (2001) observe no significant effect. Kauffman and Tauer (1986) and El-Osta and Johnson (1998) report mixed results, depending upon what measure of farm performance is used as the dependent variable. In general, the sign tends to be negative when the coefficient is statistically significant. On average, the Kansas farms in Purdy, Langemeier, and Featherstone's (1997) study earned a rate of return on assets which was less than the cost of debt capital. As a result, the debt-to-asset ratio was negatively related to the rate of return on equity.

Other studies have examined the relationship between profitability and record-keeping practices, leasing practices, and forward contracting practices. For example, based on the findings of Mishra, El-Osta, and Johnson (1999), financial management practices—such as use of forward contracting practices, renting land, keeping formal records, and using extension information—were significantly related to the net farm income of U.S. cash grain farmers.

Human Resource Management

The relationship between the amount of human capital employed by the farm and farm profitability has been explored in many studies. Frequently, measures such as age and/or education are used to proxy for the amount of human capital employed on the farm. Rougoor et al. (1998) reported that age, education, and personal goals or motivations are the personal characteristics most often determined to be important in explaining profitability differences across farms. Haden and Johnson (1989) found operator age is negatively related to net farm income and returns to operators' labor and management, but is not important in explaining cash farm income. Results obtained by El-Osta and Johnson (1998) suggest age is negatively related to net farm income in traditional dairy states (i.e., Minnesota, Michigan, Wisconsin, Pennsylvania, New York, and Vermont), while Stefanides and Tauer (1999) established a negative relationship between both age and education and economic inefficiency.

In their investigation of factors affecting returns to labor and management on U.S. dairy farms,

Mishra and Morehart (2001) incorporate two measures of human capital—educational attainment and use of extension services. Their results suggest attainment of a college degree has a positive impact on the returns to labor and management. Further, farmers who use extension services were found to have higher returns to labor and management than those who do not use extension services.

Human resource management goes beyond the amount of human capital possessed by the primary operator of the farm. However, it is difficult to obtain accurate data regarding human resource strategies and practices related to issues such as leadership, motivation, and recruiting. Instead, several studies use measures of labor expenses to capture the quantity and value of the labor hired by the farm. Kauffman and Tauer (1986) and El-Osta and Johnson (1998) include hired labor cost per cow as a measure of labor efficiency. The former study found a negative relationship with farm financial performance, and the latter reported a statistically significant relationship only when measuring net income per hundredweight in nontraditional dairy states.

Data

The data used in this study come from the New York State "Dairy Farm Business Summary 2000" (DFBS) (Knoblauch, Putnam, and Karszes, 2001). The DFBS program collects financial, operational, and descriptive data from farms which voluntarily participate in the program. In 2000, the summary contained the records of 294 New York farms specializing in dairy production. The data are collected by Cornell University Cooperative Extension personnel who assist participating farms and verify the quality of the data. The financial records obtained through the DFBS program generally conform to the recommendations of the Farm Financial Standards Council (1997).

Farms with cash crop sales in excess of 10% of milk sales, part-time farmers, and dairy farm renters were not included in this study. Our data represent commercial family farms whose primary source of income is the dairy operation. Although the data do not constitute a random sample and are not representative of the "average" farm in the region, they represent an important segment of commercial dairy farmers who make their living from dairy farming. The data have also been consistently and accurately collected for a number of years.

Table 1. Summary Statistics for Return on Assets (ROA), 1993–1999 (N = 107 farms)

Year	Mean (%)	Standard Deviation (%)	Coefficient of Variation	Difference Between Highest & Lowest ROA (%)
1993	4.18	5.42	1.30	38.47
1994	4.39	5.33	1.21	40.05
1995	3.21	6.30	1.96	38.14
1996	5.15	5.36	1.04	28.37
1997	1.92	5.43	2.82	29.75
1998	10.00	6.15	0.61	32.21
1999	8.35	5.61	0.67	30.83

Description of Financial Returns over Time

The financial performance data from 1993–1999 were analyzed to determine the extent to which profitability differences persist over time. The data contain annual observations for 107 farms that participated in the summary over the entire seven-year period. Although the data were also collected for earlier time periods, a major change in the data collection and storage system makes it difficult to compare records collected prior to 1993 with current records.

Several analyses were conducted in order to assess the degree to which profitability differences persist through time. To conduct these analyses, it was necessary to calculate a measure of farm performance that is comparable across all farms. The measure used in this study is the rate of return on assets (ROA), calculated as follows:

$$(2) \text{ ROA} = (\text{Net Farm Income} - \text{Operator Labor and Management} + \text{Interest Expense}) / \text{Average Farm Assets},$$

where *Net Farm Income* is the farm's accrual net farm income, *Operator Labor and Management* is the operator's estimate of the value of unpaid labor and management expenses, *Interest Expense* is the interest expense for the year, and *Average Farm Assets* is the average of the beginning and ending market value of farm assets.

Because no data are collected on taxes, ROA is a pre-tax performance measure. Nonfarm income is not included in this measure. Because ROA accounts for the amount of unpaid labor and management, use of debt financing, and farm size, it is a particularly useful measure of farm financial performance. Ignoring the extent to which the use of these resources

differs for the dairy farms in this study would result in distorted measures of farm profitability.

The mean, standard deviation, coefficient of variation, and range (difference between largest and smallest) of ROA for each of the years from 1993–1999 are given in table 1. Likewise, figure 1 shows the distribution of the annual ROA for each year from 1993–1999. In this figure, each year is shown on the vertical axis, ROA is shown on the horizontal axis, and the ROA for each farm is plotted. In most years, the average annual ROA is quite low. The greatest average annual ROA was 10% in 1998, and the lowest was 1.92% in 1997. The annual standard deviation of ROA was relatively stable over the time period, ranging from a maximum of 6.3% in 1995 to a minimum of 5.33% in 1994.

Figure 1 reveals a wide range in ROA for any given year. Of the years considered, 1998 and 1999 were the most profitable; only four farms earned a negative return on assets in each of these years. The difference between the most profitable and least profitable farms in any given year is also striking. This difference varied from a maximum of 40.05 percentage points in 1994 to a minimum of 29.75 percentage points in 1999 (table 1). It is also useful to note that in most years there appear to be both positive and negative outliers (figure 1). In many cases, the farms with the largest negative annual ROA were farms with multiple operators, each estimating the value of their labor and management to be significantly in excess of the net farm income generated by the farm.

The compound ROA was calculated for each farm. This measure was calculated as the geometric mean of the annual return on assets for a given farm:

$$(3) \text{ CROA}_i = \left(\prod_{j=1993}^{1999} (1 + \%ROA_{ij}) \right)^{1/7},$$

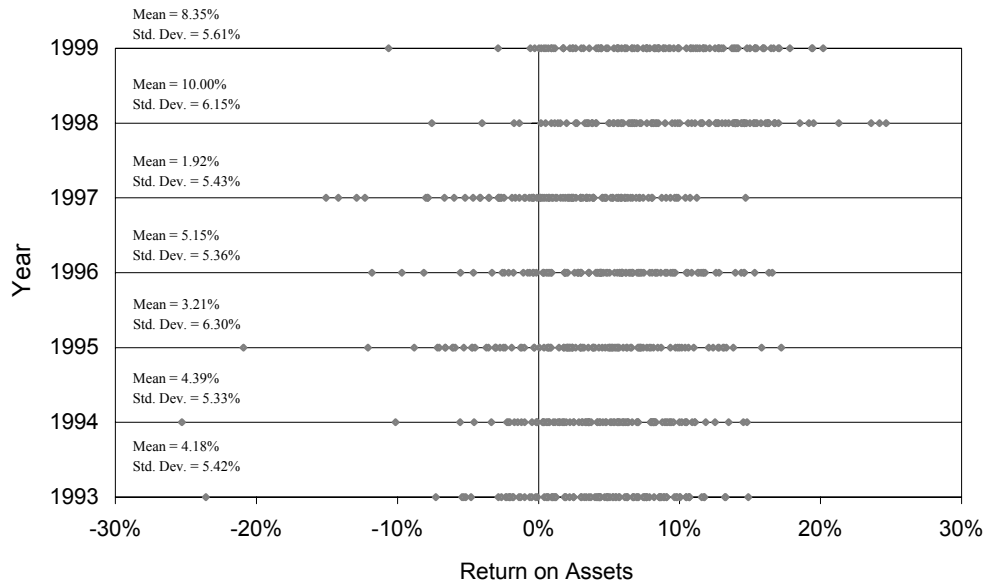


Figure 1. Annual distribution of return on assets (ROA) for sample of 107 New York dairy farms, 1993–1999

where $CROA_i$ is the compound rate of return on assets for farm i , and ROA_{ij} is the rate of return on assets for farm i in year j .

Figure 2 plots the cumulative distribution of compound return on assets for the 107 farms participating in the DFBS from 1993 through 1999. The average compound rate of return on assets was 5.22%, and the standard deviation was 4.39%. As seen from figure 2, the distribution of compound return on assets ranges from less than -15% to nearly +15%.

Clearly, it is nearly impossible to earn a compound return on assets of negative 15% over seven years. Consequently, the farms with extremely low compound ROAs were investigated further. We determined these farms generally consisted of operations with multiple operators who placed relatively large values on their unpaid labor and management skills. Since these are noncash expenses, the farms are able to continue to operate.

Nearly 20% of the farms were able to earn a compound ROA in excess of 9%, and nearly 20% earned a compound ROA of less than 2%. Because the compound ROA measures economic performance over the entire period, figure 2 gives some indication that the most profitable farms are consistently the most profitable, and the least profitable farms are consistently the least profitable.

To further explore the relationship between profitability in various years, profit deciles were

calculated for each year. For each year, the 10% of farms with the greatest ROA were placed in the top profitability decile, the 10% of the farms with the next greatest ROA were placed in the second profitability decile, and so on. Then, the frequency with which a farm appeared in each decile was recorded. Finally, the percentages of farms appearing from one to seven times in each decile were calculated. These percentages are reported in table 2. For example, 59.81% of the farms were never found in the most profitable decile. Similarly, 65.42% never appeared in the least profitable decile.

If the probability of a farm appearing in a decile is random, we can calculate the probability of the number of appearances in a decile with the binomial probability distribution, where $N = 7$ and $p = 0.10$. Specifically,

$$(4) \Pr(X = i) = \left(\frac{7!}{(7-i)!i!} \right) p^i (1-p)^{7-i},$$

where the probability of i appearances in a decile is calculated by the number of ways to choose i items from seven possible outcomes with probability p . For instance, the probability of never appearing in a decile is roughly 0.48, and the probability of appearing in a decile once is 0.37.

The results show that the fifth, sixth, and seventh deciles were achieved with frequencies near those implied by the binomial distribution. Somewhat surprisingly, many more farms than expected were

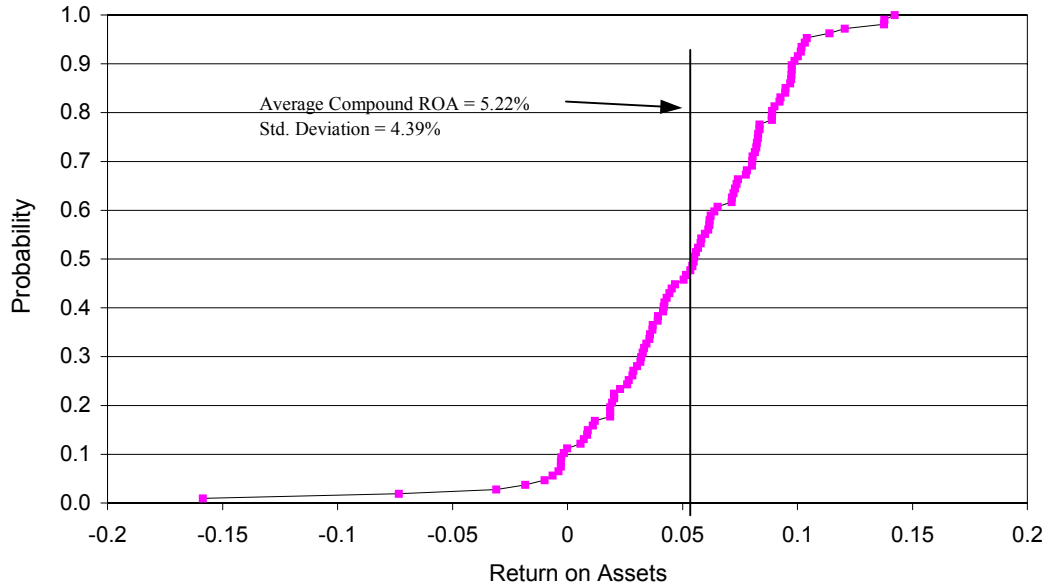


Figure 2. Cumulative distribution of compound return on assets (CROA) for sample of 107 New York dairy farms, 1993–1999

never found in the least profitable decile. Similarly, fewer farms than expected were found in the least profitable decile once, and more farms than expected were consistently found in the least profitable decile (four or more times).

Together, the results shown in table 2 appear to confirm the same farms are consistently the worst performing farms. Similar evidence is provided for the most profitable decile. Again, the percentage of farms never appearing in the most profitable decile is greater than expected, and some farms are achieving this level of profitability with greater consistency than implied by the binomial distribution.

Methodology

A fixed-effects regression model was developed to examine the relationship between farm profitability and several production, finance, and human resource factors. The balanced panel data set covers the seven-year period 1993–1999. The model was estimated with two-stage least squares, where the herd size and debt-to-asset variables were replaced with instrumental variables estimated from a first-stage regression. The exogenous variables excluded from the second-stage ROA regression equations included variables to measure the use of rBST, the ratio of nonfarm equity to farm equity, business type, average education, veterinary expenses per cow, milk

marketing receipts per cow, and breeding expenses per cow. (Results of these first-stage regressions are not reported here, but are available on request from the authors.)

The two-stage procedure was used to address the concern that these variables were endogenous with farm profitability. If the variables are endogenous, ordinary least squares estimates of these parameters are inconsistent. A Durbin-Wu-Hausman test was performed to test the hypothesis that any endogeneity arising from the farm size and debt variables had no impact on the estimated parameters (Davidson and MacKinnon, 1993). The fixed-effects formulation reflects the assumption that the heterogeneity across farms is contained in the intercept term estimated for each farm, and that the effects of the remaining explanatory variables are constant across farms. The following panel model was estimated:

$$\begin{aligned}
 (5) \quad ROA_{it} = & \beta_0 + \beta_1 Cows_{it} + \beta_2 MilkCow_{it} \\
 & + \beta_3 OthMilkSys_{it} + \beta_4 Parlor_{it} + \beta_5 Ledger_{it} \\
 & + \beta_6 Computer_{it} + \beta_7 RService_{it} + \beta_8 DA_{it} \\
 & + \beta_9 LTAssets_{it} + \beta_{10} Rent_{it} + \beta_{11} NumOper_{it} \\
 & + \beta_{12} AgeDiff_{it} + \beta_{13} Age_{it} + \beta_{14} MaxEd_{it} \\
 & + \beta_{15} Wage_{it} + g_{it},
 \end{aligned}$$

with $E(g_{it}) = 0$, and $Var(g_{it}) = \sigma_g^2$.

use, an instrumental variable was used to estimate the impact of the debt-to-asset ratio on ROA. For example, less profitable farms may be forced to borrow to continue operations. DA_{it} is the instrumental variable for the debt-to-asset ratio for farm i in year t . The relationship between the proportion of assets financed with debt and ROA is unclear. Because interest expense is added to net farm income in the calculation of ROA, the effect of debt use on ROA should, in theory, be zero. However, managers would be expected to use debt funds to acquire resources they consider to be highly profitable and which would enable them to increase ROA. If farmers' expectations regarding the profitability of additional investments are accurate, then debt use should have a positive impact on ROA. Conversely, it is possible managers will use the debt funds to acquire resources that actually reduce overall profitability. This outcome would be likely if the farmer held unrealistic expectations or if the additional investments required more managerial talent than the farm manager possessed.

The impact of the structure of the farm's assets is measured by the proportion of long-term assets owned by the farm. LTA_{it} is the proportion of total assets which are long-term for farm i in year t . For this study, long-term assets include land and buildings. Farms with a smaller proportion of long-term assets are expected to generate a higher ROA because long-term assets are typically thought to be less productive than short-term assets.

Another major financial management decision involves determining whether to control assets through leases or ownership. All farms in the sample owned some cropland, but not all farms rented cropland. The ratio of crop acres rented to crop acres owned is included as a measure of the extent to which the farm uses leasing. $Rent_{it}$ is the ratio of rented acres to owned acres for farm i in year t . Renting rather than owning allows the farmer to invest in assets with greater productivity than land. However, cropland leases are not always available in close proximity to the farm, and few long-term leases are offered, making it difficult and perhaps risky to control farmland with leases. Other things equal, farms renting more land relative to the acres owned are conjectured to earn a greater rate of return than farms renting proportionately less land.

Several characteristics of the human resources of the farm were examined. $NumOper_{it}$ is the number of operators on farm i in year t . Farms with more operators are expected to generate a greater net farm income than farms with fewer operators. The

effect of the number of operators on ROA is dependent upon the magnitude of increases in relation to the value of the additional management. The number of operators on the farm is a measure of the human capital stock of the farm. Thus it is hypothesized that farms with more operators will generate a greater ROA than farms with fewer operators.

Although the presence of more than one operator allows the farm manager to consider multiple points of view, undoubtedly differences of opinion will arise. These differences can present challenges to the efficient operation and coordination of activities unless adequate decision-making or reporting mechanisms are implemented. To the extent that decision makers have varying life and business experiences, differences of opinion could be important. This factor is measured by calculating the age difference between the oldest and youngest operators. $AgeDiff_{it}$ is the age difference between the oldest and youngest farm operator on farm i in year t . As the age gap between the decision makers widens, it becomes more likely the decision makers will have much different life and business experiences, and ROA will consequently decrease.

The experience of the farm's human capital is measured by the average age of the operators. Age_{it} is the average age of farm i 's operators in year t . Older managers have more business experience, but may be less up to date with new developments in production science and technology.

The level of formal education of the farm's decision maker(s) is a measure of the quality of the human capital stock of the farm. Because many farms have more than one operator, the measurement of this component is complicated. We have chosen to include a variable identifying the highest level of formal education (in years) attained by the farm's operators. $MaxEd_{it}$ is the maximum formal education attained by farm i 's operators in year t . This measure is hypothesized to have a positive impact on profitability.

Finally, the quality of a farm's labor force is influenced by the amount of training conducted by the employee's current and previous employers and the quality of the labor provided by the employee. The average annual wage rate paid to hired labor (both family and nonfamily paid labor) is a measure of the quality of the farm's labor force. $Wage_{it}$ is the average annual wage per paid worker (including paid family labor) for farm i in year t . Because labor is assumed to be priced efficiently, it is not clear that higher wages will result in greater ROA.

Table 3. Means and Standard Deviations of the Regression Variables: Beginning and Ending Panel Dates ($N = 107$ farms)

Variable	Unit	1993		1999	
		Mean	Std. Dev.	Mean	Std. Dev.
Return on assets (<i>ROA</i>)	%	4.18	5.42	8.35	5.61
Number of cows (<i>Cows</i>)	no.	183	264	269	342
Milk production per cow (<i>MilkCow</i>)	pounds	18,901	2,589	20,450	3,332
Farms using combination parlor and stall milking systems (<i>OthMilkSys</i>)	%	12		9	
Farms using parlor milking system (<i>Parlor</i>)	%	44		55	
Farms using bucket-and-carry, dumping station, or pipeline milking system [omitted]	%	44		36	
Farms using hand ledger accounting system (<i>Ledger</i>)	%	23		16	
Farms using an accounting service (<i>RService</i>)	%	10		21	
Farms using computerized accounting system (<i>Computer</i>)	%	38		59	
Farms using other record systems [omitted]	%	28		4	
Debt-to-asset ratio (<i>DA</i>)	%	33	18	33	20
Proportion of long-term assets (<i>LAssets</i>)	%	45	11	42	10
Ratio of crop acres rented to owned (<i>Rent</i>)	%	1.16	3.74	0.97	1.52
Number of operators (<i>NumOper</i>)	no.	1.63	0.82	1.67	0.91
Maximum age difference (<i>AgeDiff</i>)	years	6.90	11.14	8.74	12.62
Average age of operators (<i>Age</i>)	years	44.29	8.41	47.31	6.59
Maximum education of operators (<i>MaxEd</i>)	years	13.89	1.96	14.10	2.10
Farm average wage rate for hired labor (annual dollars per paid worker equivalent) (<i>Wage</i>)	\$	18,117	9,951	23,180	11,439

Table 3 provides a listing of the mean and standard deviation of each variable for both the starting and ending years of the 1993–1999 time period under consideration. The farms in our sample are relatively large. In 1999, the average farm was milking 269 cows, with some farms milking substantially more cows. Over the time period considered, the average milk production level began at 18,901 pounds per cow in 1993, and trended upward to reach 20,450 pounds per cow by 1999. These production levels were attained through the use of modern production techniques and technology. For instance, by 1999, 55% of the farms used a parlor milking system, and nearly 60% of the farms used a computerized record-keeping system. In both 1993 and 1999, the farms financed their assets with 33% debt. Long-term assets such as land and buildings accounted for 45% of total assets in 1993, and 42% in 1999.

The model was estimated using a two-stage least squares procedure in the SYSLIN application of SAS V8.01 (SAS Institute, Inc., 1999). The parameter estimates for the model are reported in table 4. A variety of tests were conducted to evaluate the performance of the model. The F -statistic associ-

ated with the Durbin-Wu-Hausman test led to the rejection of the hypothesis that the endogenous relationship between either the number of cows or the debt-to-asset ratio and profitability had no impact on the estimated parameters. The F -test statistic for overidentifying restrictions related to excluding the first-stage variables from the second-stage regression was not significant.

While the individual fixed-effect intercept terms are not reported, the F -statistic for the test that the fixed effects were zero was sufficiently large to reject the null hypothesis. The importance of the fixed effects provides evidence that heterogeneity arising from factors such as initial endowments and resource constraints has a significant impact on farm profitability. The F -statistic for the test that all of the parameters were zero was 6.16, and seven of the non-intercept parameters were statistically different from zero at the 0.10 significance level. For each group of indicator variables, it was possible to reject the hypothesis that the group had no impact on ROA.

All of the production management variables had a positive and statistically significant impact on ROA. The results suggest there are likely some

Table 4. Parameter Estimates for Fixed-Effects Panel Model of 107 New York Dairy Farms, 1993–1999

Parameter	Estimate	Standard Error	t-Statistic
Intercept	5.33E-03	9.51E-02	0.06
Production Factors:			
< Cows	0.000339**	0.000147	2.30
< MilkCow	0.000003*	0.000002	1.75
< OthMilkSys	0.038800*	0.023800	1.63
< Parlor	0.046400**	0.020700	2.24
F-statistic for significance of “milking system” group = 2.73*			
Financial Factors:			
< Ledger	! 0.009850	0.014200	! 0.69
< Computer	0.010100	0.011600	0.87
< RService	0.021600*	0.011400	1.90
F-statistic for significance of “record-keeping” group = 2.26*			
< DA	! 0.341000*	0.199000	! 1.71
< LTAssets	! 0.001590	0.102000	! 0.02
< Rent	0.001300	0.001390	0.94
Human Resource Factors:			
< NumOper	! 0.003390	0.009470	! 0.36
< AgeDiff	0.000117	0.000481	0.24
< Age	! 0.000110	0.000888	! 0.13
< MaxEd	! 0.000290	0.003340	! 0.09
< Wage	! 0.000001*	0.000000	! 1.79

F-statistic for identification restrictions = 1.18			
F-statistic for no fixed effects = 3.38***			
R ²	= 0.5442		
Adjusted R ²	= 0.46		
F-statistic for joint significance of parameters = 6.16***			

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

economies of scale present in the dairy industry. Other things equal, a farm with 30 more cows would be expected to achieve an ROA which is 100 basis points greater than the ROA of the smaller farm. The rate of milk production per cow also had a positive impact on ROA, indicating, other things equal, higher producing herds generated a higher ROA. As expected, farms with parlor style milking systems had the highest ROA, and farms with stall milking systems generated the lowest ROA.

Only two of the financial management factors had a statistically significant impact on ROA. As a group, the type of record-keeping service used by the farmer had an important impact on profitability. However, the effect was not necessarily as hypothesized. Farms using either a hand ledger or computerized record-keeping system did not generate a significantly greater ROA than farms electing not to use a formal record-keeping system. Based on this finding, some farmers performing their own accounting are not efficiently allocating their managerial

resources. The greatest ROA was achieved by farms hiring an outside record-keeping service to construct all of their accounting information. This finding may indicate these farms receive better and more accurate accounting than those farmers who are doing their own accounting. In addition, many accounting services also provide some basic benchmark and trend analyses of the farm's records.

Of the variables measuring the balance sheet and leasing decisions of the farmer, only the debt-to-asset ratio had a statistically significant impact on ROA. As the debt-to-asset ratio increased, ROA fell. Specifically, a 100 basis point increase in the debt-to-asset ratio resulted in a 34 basis point decrease in ROA. This finding provides some evidence suggesting, on average, farmers have not realized the returns they anticipated when they used debt to purchase additional assets. There are several possible explanations for this result: (a) the farmers may have unrealistic expectations regarding the profitability of the assets they are purchasing with additional

debt, (b) the farmers may have generally underestimated the additional management resources necessary to most productively employ the assets, and (c) it is possible the two-stage procedure did not remove all of the correlation between the instrument and the error term of the ROA equation.

The variable representing the proportion of long-term assets owned by the farm did not have a statistically significant impact on ROA. Farms with a greater proportion of their assets invested in short-term assets were not more profitable than those with a relatively greater amount of long-term assets. Similarly, farms that controlled a greater proportion of their land assets with leasing as opposed to ownership were not measurably more profitable than those who owned a larger proportion of their land assets.

The human resource results were rather surprising. Many previous studies have found these variables to be important indicators of profitability (Haden and Johnson, 1989; El-Osta and Johnson, 1998; Rougoor et al., 1998; Stefanides and Tauer, 1999). Only the annual wage rate paid to hired family and nonfamily employees had a statistically significant impact on profitability. Thus, other things equal, farms acquiring cheaper labor resources tend to be more profitable than farms acquiring more expensive labor inputs. An implication of this result is that either the quality of the labor commonly hired by these farms is not sufficiently different to demand higher wage rates, or quality differences in the labor resources are not accurately captured in wage rates.

Many of the farms have more than one decision maker, making it difficult to accurately measure the human capital stock of the farm. This study accounted for the human capital contributed by operators in addition to the primary decision maker. Moreover, models were also estimated in which only the age and education of the primary decision maker were considered, and no statistically significant relationship was observed between profitability and operator age and education. While both methods have their benefits, it seems inappropriate to ignore the fact that 44% of the sampled farms have more than one operator. Regardless, neither approach found these variables had a statistically significant impact on profitability.

Conclusions

This study examines the financial performance on a panel of 107 New York dairy farms participating in Cornell University's Dairy Farm Business Sum-

mary program from 1993 through 1999. The farms considered in this study are not representative of the nation's dairy farms. These farms are much larger than the "average" dairy farm. It is also likely this sample benefits from better than average management. The farms represent a group of full-time commercial dairy farms that rely on the dairy operation for their income.

The results of this research provide an estimate of the degree to which farm profitability is persistently high or low. In general, the level of profitability [measured by the rate of return on assets (ROA)] of the farms considered in this study was low. However, the evidence clearly shows that the most profitable and least profitable farms are consistently so. Over the seven-year study period, farms were consistently found in the most and least profitable groups. To the extent these profit differences are attributable to management factors, this finding would suggest that management factors have a consistent and important impact on farm performance.

The study examines several management factors hypothesized to impact farm profitability. Importantly, the analysis considers the rate of return on assets generated by a farm over a number of years. As such, the results overcome a major shortcoming of research which only considers the impact of these factors in a particular year. Further, the study investigates the possibility that variables such as farm size and debt use are potentially endogenous.

A panel regression model with fixed effects was estimated in an effort to identify management factors that influence profitability. Because profitable farms likely tend to expand and adjust debt usage, instrumental variables were used to measure the impact of farm size and the debt-to-asset ratio on farm profitability. In general, the model explains a relatively high degree of the variation in profitability as measured by the rate of return on assets (ROA).

Individual firm effects were important in explaining farm profitability, highlighting the role played by factors such as initial endowments and resource constraints in determining farm profitability. Of the management factors considered, production management factors were the most important explanatory variables. These factors included farm size, rate of milk production, and type of milking system used by the farm. Both farm size and the rate of milk production per cow were positively related to profitability. These findings provide some evidence of economies of scale, and reveal that farmers adopting higher yield production techniques

tended to be more profitable than their smaller or lower yielding counterparts. However, it is important to note it would clearly be a poor decision for a highly unprofitable farm to expand just to capture modest economies of scale.

The type of record-keeping system and the amount of debt used by the farm were the only financial management variables having a significant impact on ROA. Farms which hired others to construct all of their accounts were the most profitable. Farms using computerized record-keeping systems and those maintaining a hand ledger did not, on average, generate a greater ROA than farms that did not keep records. It is likely many farmers are not yet adept at keeping records and turning their records into profitable information.

Interestingly, the proportion of debt used by the farm was negatively related to profitability. This result points to the possibility of a learning period during which the assets acquired with debt funds are assimilated into the business. It is also possible that, due to a lack of adequate instruments, the two-stage least squares procedure did not remove all of the correlation between the error term of the regression and the debt-to-asset variable.

Unlike results of previous studies, variables measuring the farmer's human resource characteristics, such as age and education, were not significantly related to farm profitability. This result could be a consequence of the inclusion of additional explanatory variables related to farm profitability. Likewise, this study considered ROA over several years as opposed to one year. It also controlled for heterogeneity with fixed firm effects. Only the wage rate paid to employees had a significant impact on profitability. Other things equal, farms that paid higher wage rates were less profitable, suggesting either that quality differences are not accurately reflected in wage rates, or the quality of the labor hired on these farms is not highly variable.

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