Dairy Farm Management and Long-Term Farm Performance:

Evidence from Panel Data

.

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by

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ABSTRACT: The financial performance and relationships between several management factors and farm financial performance are examined in a panel data set of 107 New York dairy farms. The overall level of compound and annual return on assets of the farms considered in this study was quite low. However, the evidence clearly suggests that the most profitable and least profitable farms are consistently so. Correlations of the yearly rankings of farm profitability were always positive and significantly different from zero. Two regression models were estimated in an effort to identify management factors that influence profitability. In general, the models explain a relatively high degree of the variation in both compound return on assets and annual return on assets. These models tend to indicate that farm size, changes in farm size, and production management factors, such as milk production per cow, were positively related to farm profitability. While farm size was positively related to both compound return on assets and annual return on assets, the practice of undertaking expansions that were large relative to farm size was negatively related to compound return on assets.

Introduction

The relationship between farm management and farm profitability is of great interest to many farm management researchers and extension educators. Results of research on this subject are frequently used to identify managerial practices that may improve farm economic performance. This, in turn, may serve to guide extension programming as topics are prioritized for educational emphasis.

The presence of differences in farm profitability at any point in time is not unexpected because farms experience many random events that could impact performance, either positively or negatively. Thus, to the extent that these random events cause farm performance to differ, one would expect that the effects would tend to average out over time. As a result, time would tend to mitigate differences in farm performance. On the other hand, if performance differences persist through time this would suggest that other, non-random factors are at play causing some farms to consistently outperform their peers. Although it is generally assumed that the latter is the case, the magnitude of the differences in performance due to superior management is not generally known.

Rougoor et al., (1998) point out that most differences in farm profitability are attributed to the management ability of the farmer. Further, they argue that in order to understand the importance of farm management it is important to measure farm performance and management over time. Before examining the relationship between farm performance and management capacity it is important to examine the extent to which farm performance varies across farms and across time. After examining the performance differences of farms through time one can begin the process of identifying the factors that cause these differences to persist.

Many researchers have examined the relationship between farm profitability and farm management. Frequently, researchers examining the relationship between farm management and profitability have relied on cross-sectional data sets to identify important relationships between farm characteristics and farm performance. As a result, these studies have identified a large number of factors or characteristics that appear to be related to farm economic performance. Such studies have helped identify several factors that may be important in achieving superior profitability in the short-term. However, because an overall goal of farm management is to achieve superior long-run financial performance, there is a continuing need to examine the relationship between farm management practices and long-term financial performance. Likewise, most studies do not examine how changes in managerial practices affect farm performance. For instance, do changes farm size or farm expansions have long-term effects on farm performance?

The first objective of this paper is to compare the long-term financial performance of dairy farms participating in Cornell's Dairy Farm Business Summary over the period 1993 – 1999. This comparison provides an estimate of the magnitude of the differences in dairy farm performance over time and the extent to which these differences average out. Then, the study tests hypotheses regarding the impact of several managerial factors on dairy farm financial performance measured by the compound rate of return on assets over the time period 1993 – 1999. Finally, we examine the relationship between annual return on assets and managerial characteristics over the time period 1993 – 1999.

<u>Dairy Farm Performance Over Time</u>

Cornell's Dairy Farm Business Summary (DFBS) program collects a great deal of information on the financial performance of participating farms. This data has been collected for a number of years. The financial performance data from 1993 to 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 period. Although these farms do not represent a random sample, they represent one of the best consistently collected data sets on dairy farm performance in the United States.

Several analyses were conducted in order to assess the degree to which performance differences persist through time. In order to conduct these analyses, it is necessary to calculate a measure of farm performance that is comparable across all farms. The measure used in this study is return on assets, ROA. Specifically, ROA was calculated according to (1).

$$\boldsymbol{ROA} = \frac{\left(\text{Net Farm Income - Operator Labor and Managment } + \text{Interest Expense}\right)}{\text{Average Farm Assets}} \quad (1)$$

Where *net farm income* is the farm's accrual net farm income, *operator labor and management* is the operator's estimate of unpaid labor and management, *interest expense* is the interest expense for the year, and *average farm assets* is the average of the beginning and ending farm assets. Thus, ROA is a relative measure and is not generally biased by the size, number of farm operators, or financing of the farm.

The mean, standard deviation, coefficient of variation, and range (difference between largest and smallest ROA) for each of the years from 1993-1999 are given in Table 1. Likewise, Figure 1 shows the distribution of the annual return on assets for each year from 1993 to 1999. In this figure, each year is shown on the vertical axis, the return on assets is shown on the horizontal axis, and each farm is plotted according to its return on assets. In general, the average annual return on assets for these farms is quite low.

The greatest average return on assets was 10 percent in 1998 and the lowest was 1.92 percent in 1997. The returns within each year are also relatively variable across farms, with a maximum standard deviation of 6.3 percent and a minimum of 5.36 percent. In general the standard deviation was relatively stable, while the average returns varied considerably from year to year.

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

In order to assess the degree to which farms consistently generated a higher or lower ROA, the compound ROA was calculated. The compound return on assets was calculated as the geometric mean of the annual return on assets for a given farm and is shown in (2).

$$\boldsymbol{CRoa_i} = \left(\prod_{\boldsymbol{j}=1993}^{1999} \left(1 + \boldsymbol{ROA_{ij}}\right) \right)^{\frac{1}{7}} \qquad (2)$$

Where $Croa_i$ is the compound return on assets for farm i and ROA_{ij} is the return on assets for farm i in year j. Figure 2 shows the cumulative distribution of compound return on asset for the 107 farms participating in the DFBS from 1993 to 1999. For the 107 farms, the average compound return on assets was 5.22 percent and the standard deviation was 4.39 percent. Figure 2 shows that the distribution of compound return on assets ranges from less than –15 percent to nearly 15 percent. Because it is nearly impossible to earn a negative compound return on assets of negative 15 percent over 7 years, the farms with extremely low compound ROA's were investigated further. These farms generally consist of operations with multiple operators who place relatively large values on their unpaid labor and management skills. Because these are non-cash expenses, the farms are able to continue to operate. Nearly 20 percent of the farms were able to earn a compound ROA in excess of 9 percent and nearly 20 percent earned a compound ROA of less than 2 percent. Because the compound ROA measures economic performance over the entire period, this figure gives some indication that the farms that are the most profitable are consistently the most profitable and that the least profitable farms are consistently the least profitable.

The relationship between the farms' ROA in 1999 and 1998 is shown in Figure 3. In this figure, the 1998 ROA is shown on the horizontal axis and the 1999 ROA is measured on the vertical axis. The figure also shows the results of regressing 1998 ROA on 1999 ROA. The estimated regression line has a positive slope of 0.5094. In general, this indicates that farms with a high ROA in 1998 followed it with a relatively high ROA in 1999.

To the extent that random events influence profitability in any given year, one could argue that an event occurring in one year could impact profitability in more than one year. If this were the case, one would expect that the relationship between ROA would be stronger for adjacent years than for years separated by more than one year's time. Figure 4 shows the relationship between 1993 and 1999. Again the slope coefficient is positive and significant.

To further explore the relationship between profitability in various years, the farms were ranked according to their ROA for each year. For each year the farm with the highest ROA was assigned a ranking of 1, the second most profitable was assigned a ranking of 2, and so on. These rankings were then analyzed with correlation analysis. Table 2 presents the results of this analysis. For instance, the 1993 rankings and the 1994 rankings had a correlation coefficient of 0.46. This indicates that the highest ranked farms in 1993 tended to be the highest ranked farms in 1994. The lowest correlation coefficient in Table 2 is 0.31, for the rankings of 1994 and 1999. The highest correlation between the rankings is 0.55 which occurred between the 1998 and 1999 rankings and the 1996 and 1995 rankings. Again, to the extent that a farm is able to capitalize on the favorable events that occurred in one year in the following year, or that the unfavorable events that occurred in one year impact the earnings of the following year, one would expect that the correlation between adjacent years would be higher than years separated by time. In the case of 1994, 1995, 1998 this is the case. In the other years, the correlation is higher for years separated by at least one year in time.

The profit deciles were also calculated for each year. For each year, the 10 percent of farms with the highest profitability were placed in the top profitability decile, the 10 percent of the farms with the next highest profitability were placed in the second profitability decile, and so on. The frequency that farms appeared in each decile over the entire period of 1993 to 1999 is shown in Table 3. For instance, 59.81 percent of the farms were never found in the most profitable decile. On the other hand, 65.42 percent of the farms never appeared in the least profitable decile. If the probability that a farm appears in a decile is random, one 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,

$$\Pr(\boldsymbol{X} = \boldsymbol{i}) = \binom{7}{\boldsymbol{i}} \boldsymbol{p}^{\boldsymbol{i}} (1 - \boldsymbol{p})^{7-\boldsymbol{i}} \quad (3)$$

where the probability of i appearances in a decile is calculated by the number of ways to choose i items from 7 possible outcomes with probability p. For instance, the probability of never appearing in a decile is roughly 0.47 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 randomness. On the other hand, many more farms than expected were never found in the least profitable decile. Similarly, fewer farms than expected were found in the least profitable decile once. Many more farms than expected were consistently found in the least profitable decile (4 or more times). Similar evidence is provided for the most profitable decile.

Factors Influencing Profitability

The above results demonstrate that some farms are consistently generating the highest and lowest return on assets. The characteristics that tend to distinguish these farms were investigated with regression analysis. In order to perform this investigation, it is necessary to hypothesize management factors that might cause farms to consistently achieve a high or low ROA.

Rougoor, et al., (1998) review the literature on farm management and farm performance from 1980 to present. Like Fox, Bergan, and Dickson (1993) the authors conclude that a complete conceptualizations of the construct of farm management are difficult to find. They suggest that management capacity can be divided into personal characteristics of the farmer and aspects of the decision making process that farm managers use to make decisions. Because the data is difficult and costly to collect information regarding the decision making process is frequently omitted from farm management studies. Age, education, and personal goals or motivations were the personal characteristics most often found to be important in explaining profitability differences across farms (Rougoor, et al., 1998).

For instance, Tauer and Stefanides (1998) examine the profitability of DFBS farms over the period 1984-1993. They find that these farms violated the weak axiom of profit maximization (WAPM) roughly half of the time. Further, they found that these farms could have, on average, improved their performance by approximately 20 percent by selecting a better mix of inputs and outputs. The authors then related the deviations from the WAPM to age, education, number of farm operators, and the number of cows. They found that age, education, and the number of operators on the farms were important explanatory variables, but that these variables explained only a modest amount of the deviation from the WAPM.

In a study of Pennsylvania dairy farms, Ford and Shonkwiler (1994) related several observable characteristics to financial management ability, dairy management ability, and crop management ability. They then related these management abilities to farm profitability. They found that financial structure, labor efficiency, and milk per cow were some of the most important characteristics of managerial ability. Further, they concluded that increasing dairy managerial ability would have a larger impact on profitability for many farms than increasing herd size. Unfortunately, the study did not consider farm performance beyond one period in time.

Cocchi, Bravo-Ureta, and Cooke (1998) found that small dairy farms were 12 to 20 percent less efficient than larger dairy farms. Langemeier, Schroeder, and Minert (1992) found that output prices and input price control were some of the most significant influences of profitability for Kansas cattle finishers. Mishra, El-Ostra, and Johnson (1999) found that non-farm income, machinery costs, cash operating expenses, 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.

The literature suggests that a variety of factors may lead to superior financial performance. As Rougoor, et al., (1998) point out, one should construct variables designed to measure a farmer's management capacity, the management practices in use on the farm, and how those factors change over time. As Tauer and Stefanides (1998) point out, the DFBS contains somewhat limited information on the management characteristics of these farms. However, the DFBS does contain some information that can be used to assess both management capacity and management practices. In this study, variables were defined to measure farm practices in three of the four functional areas of management (financial management, human resource management, and production management). In addition variables were included to measure the individual management capacity of the farmer such as age and education. The DFBS contains varying amounts of information on each of these areas. Because marketing is less relevant for dairy farms, and because little useful information is collected on the marketing practices of DFBS farms, marketing management practices were not considered.

With respect to the functional practices of the farms, the greatest amount of information collected by the DFBS is relevant to the production management practices of the farms. Variables were included to measure the size of the farm, the per cow milk production level, changes in the production level, the use of the production enhancing hormone rBST and the milking system used by the farm. The financial management characteristics considered were the type of record keeping system, the proportion of debt, the proportion of long and short term assets, the amount of rented versus owned crop land, and the proportion of assets invested off the farm. The human resource characteristics considered were the number of operators, the age difference between the operators, the average age of the operators, the maximum education achieved by the operators, and the amount of labor hired.

The compound return on assets summarizes seven years of farm performance into one measure, essentially making the analysis cross-sectional. For this reason, one must also summarize the conditions on the farm over seven years even though the management characteristics are not constant. This was accomplished by using the averages for several of the measures. In addition the year-to-year changes in management variables were averaged over the time period. The panel model estimated in the next section relaxes these assumptions.

For the case of compound return on assets the model in 4 was estimated.

$$
\begin{aligned}
CRoa = {} & \boldsymbol{b}_0 + \boldsymbol{b}_1 Cows + \boldsymbol{b}_2 ChCows + \boldsymbol{b}_3 MaxChCows + \boldsymbol{b}_4 MilkCow \\
& + \boldsymbol{b}_5 TrendMilkCow + \sum_{i=6}^{8} \boldsymbol{b}_i BST_{i-5} + \sum_{i=9}^{10} \boldsymbol{b}_i MilkSys_{i-8} + \sum_{i=11}^{13} \boldsymbol{b}_i RECSYS_{i-10} \\
& + \boldsymbol{b}_{14} DA + \boldsymbol{b}_{15} ChDA + \boldsymbol{b}_{16} LTassets + \boldsymbol{b}_{17} RENT + \boldsymbol{b}_{18} OffFarmEquity \qquad (4) \\
& + \boldsymbol{b}_9 NumOper + \boldsymbol{b}_{20} AgeDiff + \boldsymbol{b}_{21} Age + \boldsymbol{b}_{22} MaxEd + \boldsymbol{b}_{23} Labor \\
& + \boldsymbol{b}_{24} ChLabor
\end{aligned}
$$

Where *Croa* is the compound return on assets, the $\hat{a}_i$*'s* are parameters to be estimated, *Cows* is the average number of cows; *ChCows* is the average percent change in cows for the farm; *MaxChCows* is the maximum percent change in cow numbers over the period 1993 to 1999; *MilkCow* is the average milk production per cow in pounds; *TrendMilkCow* is the trend in per cow milk production in pounds; *BST* is a series of 3 indicator variables identifying farms that used rBST on less than 25 percent of their cows, farms that used rBst on 25 to 75 percent of their cows, and farms that used rBst on over 75 percent of their cows (never or stopped using rBST is the omitted group), and all BST variables indicate the degree of rBst use in 1999; *MilkSys* is a series of two indicator variables indicating that a farm used a parlor milking system or combination parlor/stall milking system (stall milking system is the omitted group); *RECSYS* is a series of 3 indicator variables identifying farms that used an accounting service, farms that used a computerized accounting service, and farms that used other accounting services (hand ledger is the omitted group); *DA* is the average debt to asset ratio; *ChDA* is the average change in the debt to asset ratio; *LTassets* is the average proportion of long-term assets; *RENT* is the average ratio of rented acres to owned acres; *OffFarmEquity* is the average proportion of equity invested off the farm; *NumOper* is the number of operators in 1999; *AgeDiff* is the average age difference between the youngest and oldest farm operator; *Age* is the average age of the farm operator; *MaxEd* is the maximum education attained by the farm's operators; *Labor* is the average months of labor hired by the farm; and *ChLabor* is the average change in months of labor hired by the farm.

The descriptive statistics for the explanatory variables are shown in Table 4. On average the farms are relatively large, milking 228 cows per farm, with some farms milking substantially more cows. Although the farms increased cow numbers at an average rate of 5 percent per year, the average of each farm's largest percentage expansion in cow numbers was 17.53 percent. This indicates that while many expansions were incremental, occasionally farms undertook major expansions. Over the analysis period the production levels per cow were relatively high (19,729 lbs/cow) and production per cow trended upward by 186 pounds per cow. These production levels were attained through the use of modern production techniques and technology. For instance, 57 percent of the farms were using rBST and 55 percent used a parlor milking system. On average the farms financed their assets with 39 percent debt, a proportion that on average, did not change over the time period.

The parameter estimates for the compound ROA model are shown in Table 5. The F-statistic for the F-test of the joint significance of all the parameters is highly significant. The model R-square indicates that the explanatory variables explain roughly 60 percent of the variation in compound ROA. The adjusted R-square is 0.48. Based on the t-statistics for the test that an individual parameter is equal to zero one can conclude that only six of the parameter estimates are non-zero at the 0.10 significance level. The explanatory variables exhibit a relatively high degree of multicollinearity. The condition index calculated as the ratio of the square roots of the largest to smallest eigen values of the data matrix was 65.

Four of the significant explanatory variables can be characterized as production management indicators. Farm size measured by the number of cows that the farm milked was positively related to return on assets. Likewise, the average growth rate of the number of cows was positively related to compound ROA. However, the greater the size of the farm's largest expansion relative to farm size, the lower compound ROA. This indicates that larger farms tended to be more profitable, and farms with larger growth rates tended to have a large compound ROA. Farms that produced more milk per cow also tended to generate a larger compound ROA. The parameters for the remaining production variables such as the use of rBST and the type of milking system that the farm used were not statistically different from zero. This does not mean that these practices were not important for profitability. Typically, rBST, tends to lead to higher production levels, which were positively related to profitability.

The variable measuring the ratio of rented cropland to owned cropland was the only financial management variable considered to have a parameter statistically different from zero. Here, the relationship indicated that farms that rented a greater proportion of farmland tended to have a lower compound ROA than farms that owned a large proportion of cropland. The parameters for the remaining financial management variables were not statistically different from zero. Again, this does not indicate that factors such as the proportion of debt used by the farm are not important to profitability. Rather, it suggests that on average, the highest performing farms did not tend to be financed differently than the lowest performing farms.

Several human resource variables were included in the model. Only the parameter for the months of hired labor was statistically different from zero. In this case, other things equal farms that hired more labor tended to have a lower compound ROA. Unlike the findings of Tauer and Stefanides (1998), variables measuring education, age, and the number of operators were not important indicators of compound ROA. This could be a result of a number of factors. First, the model included many other explanatory variables and represents a different time period. Second, the dependent variable for the model, compound ROA, is different from that in Tauer and Stefanides (1998).

Because many of the variables change over the time period it is important to examine how these variables might impact ROA in any given year. This was examined with a fixed effects panel data model. The explanatory variables are generally the same as those examined with the compound ROA model except that it is not necessary to average each farm over the time period, 1993 to 1999. Rather, the model estimates an intercept parameter for each farm and assumes constant effects for each of the explanatory variables. The model assumes that the differences across farms are contained in the intercept term estimated for each farm. Because several variables are based on changes from period to period, the initial year is dropped from the analysis. Specifically, the panel model in 5 was estimated.

$$\begin{aligned} \boldsymbol{ROA_{it}} = {} & \boldsymbol{b_i} + \boldsymbol{b}_0 + \boldsymbol{b}_1\boldsymbol{Cows_{it}} + \boldsymbol{b}_2\boldsymbol{ChCows_{it}} + \boldsymbol{b}_4\boldsymbol{MilkCow_{it}} \\ & + \boldsymbol{b}_5\boldsymbol{BST}25_{\boldsymbol{it}} + \boldsymbol{b}_6\boldsymbol{BST}75_{\boldsymbol{it}} + \boldsymbol{b}_7\boldsymbol{BST}100_{\boldsymbol{it}} + \boldsymbol{b}_8\boldsymbol{OthMilkSys_{it}} + \boldsymbol{b}_9\boldsymbol{Parlor_{it}} \\ & + \boldsymbol{b}_{10}\boldsymbol{Act_{it}} + \boldsymbol{b}_{11}\boldsymbol{Computer_{it}} + \boldsymbol{b}_{12}\boldsymbol{OtherREC_{it}} + \boldsymbol{b}_{13}\boldsymbol{DA_{it}} \\ & + \boldsymbol{b}_{14}\boldsymbol{ChDA_{it}} + \boldsymbol{b}_{15}\boldsymbol{LTassets_{it}} + \boldsymbol{b}_{16}\boldsymbol{RENT_{it}} + \boldsymbol{b}_{17}\boldsymbol{OffFarmEquity_{it}} \\ & + \boldsymbol{b}_{18}\boldsymbol{NumOper_{it}} + \boldsymbol{b}_{19}\boldsymbol{AgeDiff_{it}} + \boldsymbol{b}_{2\boldsymbol{o}}\boldsymbol{Age}_{20} + \boldsymbol{b}_{21}\boldsymbol{MaxEd_{it}} + \boldsymbol{b}_{22}\boldsymbol{Labor_{it}} \\ & + \boldsymbol{b}_{23}\boldsymbol{ChLabor_{it}} \end{aligned} \tag{5}$$

Where *Croa* is the compound return on assets in year *t*, the $\hat{a}_i$*'s* are parameters to be estimated, *Cows* is the number of cows in year *t*; *ChCows* is the percent change in the number of cows from period *t* to *t + 1*; *MilkCow* is the milk production per cow in pounds in year *t*; *BST* is a series of 3 indicator variables identifying farms that used rBst on less than 25 percent of their cows in year *t*, farms that used rBst on 25 to 75 percent of their cows in year *t*, and farms that used rBst on over 75 percent of their cows in year *t* never or stopped using rBst in year *t* is the omitted group); *MilkSys* is a series of two indicator variables indicating that a farm used a parlor milking system or combination parlor/stall milking system in year *t* (stall milking system is the omitted group); *RECSYS* is a series of 3 indicator variables identifying farms that used an accounting service in year *t*, farmers that used a computerized accounting service in year *t*, and farms that used other accounting services in year *t* (hand ledger is the omitted group); *DA* is the debt to asset ratio in year *t*; *ChDA* is the change in the debt to asset ratio from year *t* to *t + 1*; *LTassets* is the proportion of long-term assets in year *t*; RENT is the ratio of rented acres to owned acres in year *t*; *OffFarmEquity* is the proportion of equity invested off the farm in year *t*; *NumOper* is the number of operators in year *t*; *AgeDiff* is the age difference between the youngest and oldest farm operator in year *t*; *Age* is the average age of the farm operator in year *t*; *MaxEd* is the maximum education attained by the farm's operators in year *t*; *Labor* is the months of labor hired by the farm in year *t*; and *ChLabor* is the change in months of labor hired by the farm from year *t* to *t +1*.

The model was estimated using the TSCS procedure in SAS V8.01. Because the fixed effects formulation was used this model is estimated with ordinary least squares. The parameter estimates for the model are shown in Table 6. The F-test of the hypothesis that the individual farm effects were unimportant was soundly rejected. The R-square for the model indicates that the explanatory variables explain 63 percent of the variation in annual ROA. Only five of the non-intercept parameters were statistically different from zero at the 0.10 significance level. The firm specific intercept variables are not reported and are available from the authors.

As in the compound ROA model, variables for the number of cows, percent change in cow numbers, and milk production per cow were significantly different from zero. All of the effects are again positive. This indicates that farms with more cows and farms increased cow numbers at a higher rate tended to be more profitable than smaller farms with smaller growth rates. Clearly, this relationship could be endogenous, as one would expect that more profitable farms would be more likely to reinvest resources in their operations than unprofitable farms. In the future this relationship will be investigated with tests for endogeniety.

Two financial management parameters (*ChDA* and *LTassets*) are different from zero. Neither of these variables was different from zero in the compound ROA model. In this case, farms that made larger changes in the proportion of debt used to finance their operations tended to be less profitable than those making small changes or those reducing the proportion of debt. This relationship could reflect the ability of more profitable farms to pay down debt. Because the parameter for overall level of debt was again not statistically different from zero, this indicates that high and low profit operations were not typically financed differently. Thus, poor financial management (unprofitable farms using debt) could contribute to poor earnings. As expected, other things equal, the larger the proportion of long term assets the less profitable the farm. This indicates that farms employing more short-term assets are able to generate a larger ROA. However, this result should be interpreted with caution as the variable measuring the proportion of rented crop acres to owned crop acres was not different from zero.

None of the human resource variables were different from zero. This is again surprising, as previous studies have consistently found relationships between the personal characteristics of farmers and farm profitability.

Conclusions

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 of the farms considered in this study was low. However, the evidence clearly suggests that the most profitable and least profitable farms are consistently so. Farms were consistently found in the most and least profitable groups. Likewise, correlations of the rankings of farm profitability were always positive and significantly different from zero. To the extent that these profit differences are due to management factors, this would suggest that management factors have a consistent and important effect on farm performance.

Two regression models were estimated in an effort to identify management factors that influence profitability. In general, the models explain a relatively high degree of the variation in both compound ROA and annual ROA. These models tend to indicate that farm size, changes in farm size, and production management factors, such as milk production per cow, were positively related to farm profitability. Because it is quite likely that profitable farms tend to expand, the relationship between changes in farm size and profitability is potentially endogenous and needs further investigation. Clearly, it would be a poor decision for a highly unprofitable farm to expand. Nonetheless, farm size was positively related to both compound return on assets and annual return on assets.

The study also found unique evidence that the practice of undertaking expansions that were large relative to farm size was negatively related to compound return on assets. This suggests that smaller expansions tended to be more profitable, and that other things equal, major expansions tended to reduce profitability.

Variables intended to measure the financial management practices were not generally important explanatory factors. These results do not indicate that financial management is unimportant. Rather, they suggest that most farms are using financial management practices that do not lead to either superior or inferior financial performance. Unlike previous studies variables measuring the personal characteristics of the farmer such as age and education were not related to farm profitability. This result could be related to the inclusion of additional explanatory variables that are related to farm profitability.

The existence of the potential endogeneity of several explanatory variables deserves consideration. Further work is being conducted to determine the degree to which the explanatory variables used in this study are endogenous with farm profitability. Likewise, more work is needed to identify actual management practices rather than the output measures of management practices.

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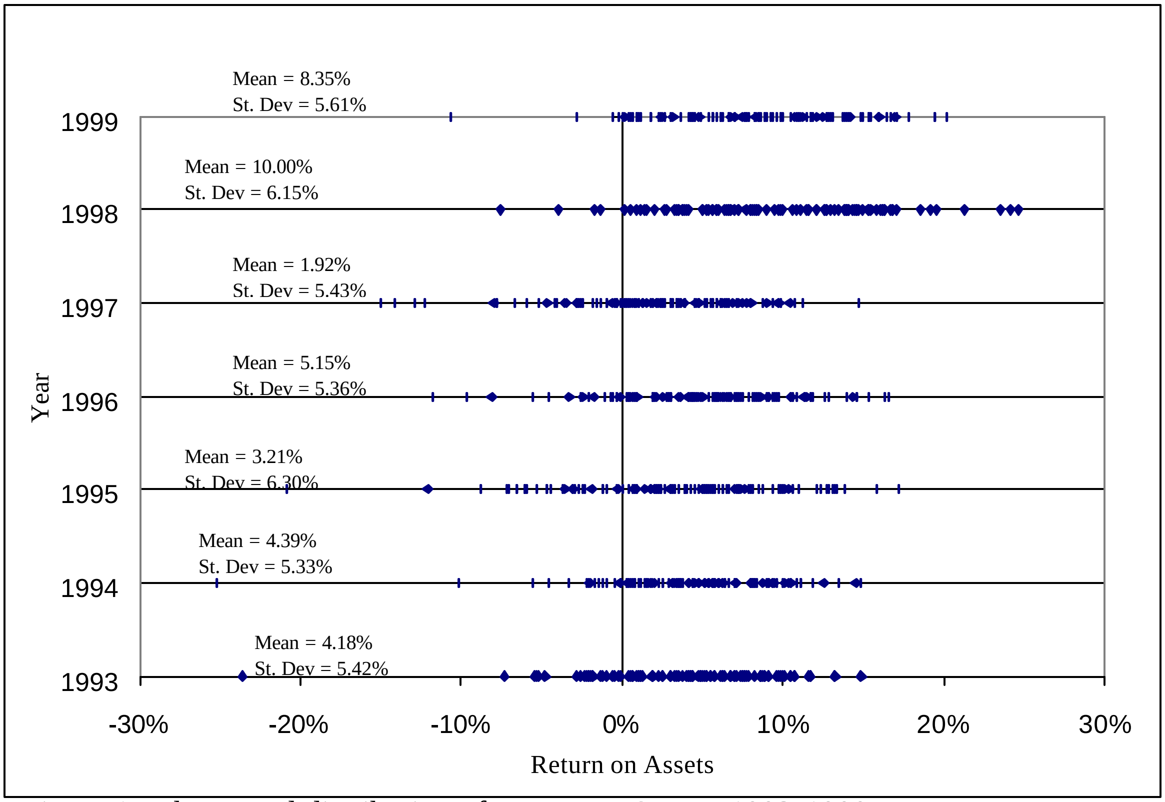

Figure 1. The annual distribution of Return on Assets, 1993-1999.

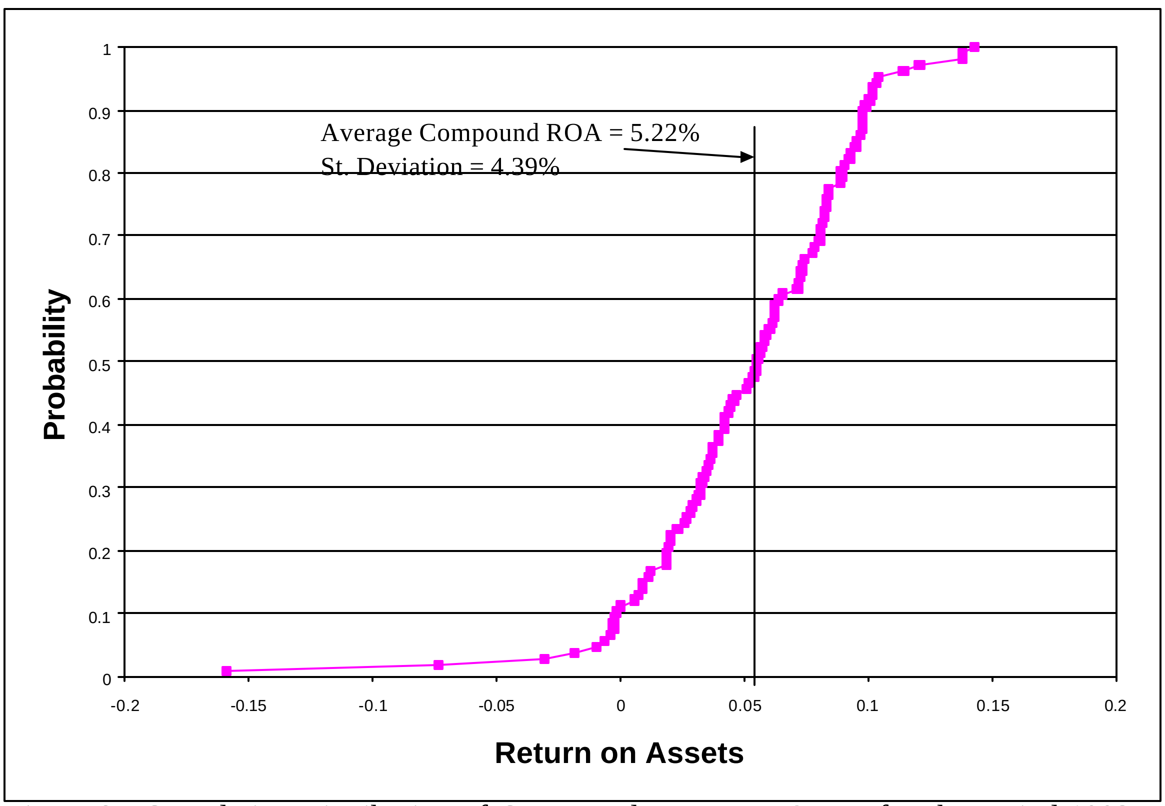

Figure 2. Cumulative Distribution of Compound Return on Assets for the Period 1993 – 1999.

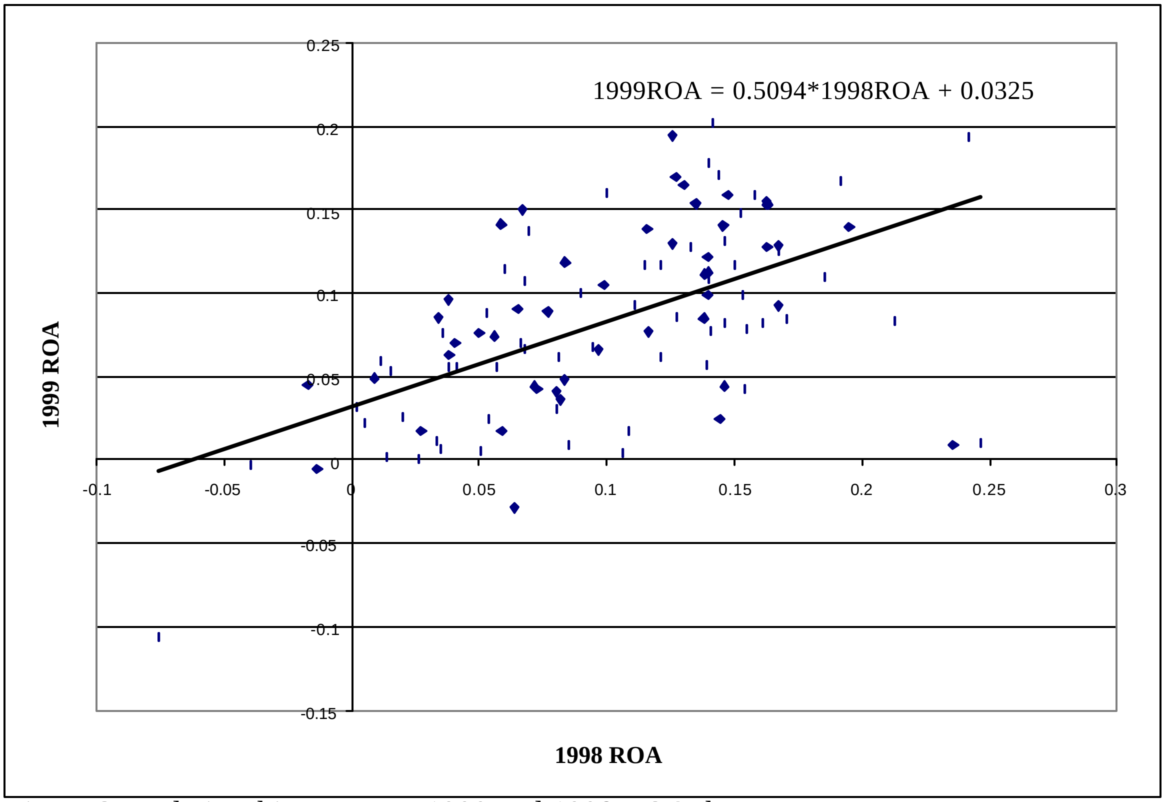

Figure 3. Relationship Between 1999 and 1998 ROA, by Farm.

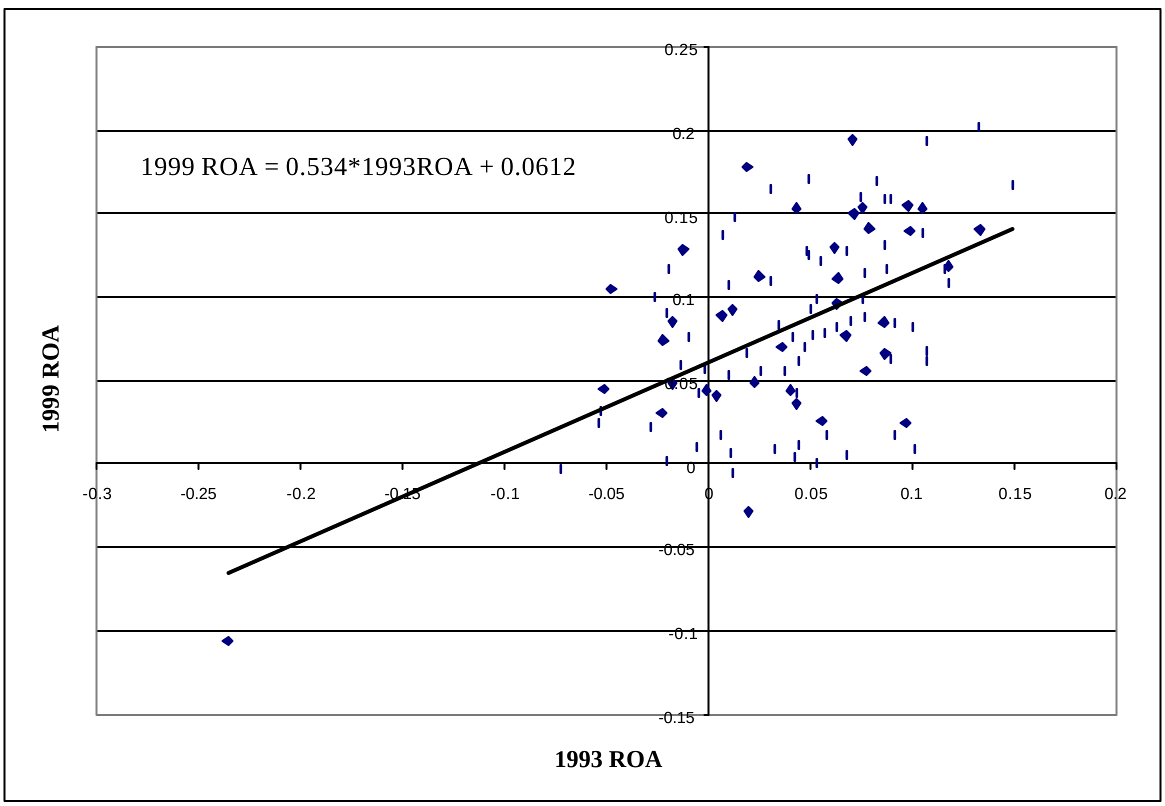

Figure 4. Relationship Between 1999 and 1993 Return on Assets.

Table 1. Summary statistics for Return on Assets: 1993 to 1999.

Year	Mean	Standard Deviation	Coefficient of Variation	Range Between Highest and 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%

Table 2. Correlation Matrix for the ROA Rankings of Profitability: 1993 – 1999.

	1993 Ranking	1994 Ranking	1995 Ranking	1996 Ranking	1997 Ranking	1998 Ranking	1999 Ranking
1993 Ranking	1.00						
1994 Ranking	0.46	1.00					
1995 Ranking	0.48	0.56	1.00				
1996 Ranking	0.48	0.48	0.55	1.00			
1997 Ranking	0.42	0.47	0.48	0.50	1.00		
1998 Ranking	0.43	0.51	0.47	0.61	0.51	1.00	
1999 Ranking	0.43	0.31	0.45	0.48	0.48	0.55	1.00

Table 3. Frequency of Farms in Each Percentile: 1993-1999

Times in Percentile	Top 10%	Second 10-20%	Third 20-30%	Fourth 30-40%	Fifth 40-50%	Sixth 50-60%	Seventh 60-70%	Eighth 70-80%	Ninth 80-90%	Tenth 90-100%
0	59.81%	57.94%	56.07%	51.40%	47.66%	50.47%	48.60%	56.07%	54.21%	65.42%
1	25.23%	22.43%	28.04%	30.84%	36.45%	36.45%	36.45%	27.10%	24.30%	19.63%
2	6.54%	12.15%	12.15%	12.15%	12.15%	11.21%	10.28%	12.15%	16.82%	5.61%
3	3.74%	4.67%	1.87%	5.61%	3.74%	0.93%	3.74%	4.67%	4.67%	4.67%
4	1.87%	2.80%	1.87%	0%	0%	0.93%	0.93%	0%	0%	0.93%
5	1.87%	0%	0%	0%	0%	0%	0%	0%	0%	0.93%
6	0.93%	0%	0%	0%	0%	0%	0%	0%	0%	0.93%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	1.87%

Table 4. Summary Statistics for Data in Compound Return Model

Variable	Mean	Standard Deviation	Range
Compound Return on Assets, *Croa*	5.22%	4.39%	30%
Average Number of Cows, *Cows*	228	309	2,523
Average Year to Year Cow Change as a Percent of Average Cows, *ChCows*	5.07%	5.42%	29.43%
Maximum Change in number of cows as a percent of average cows, *MaxChCows*	17.53%	13.18%	66.54%
Average Milk Production per cow (pounds), *MilkCow*	19,729	2,844	14,334
Trend in Milk Production per Cow (pounds), *TrendMilkCow*	186	394	2,201
Percent of Farms Using rBst in less than 25% of cows, BST_1	9%	29%	
Percent of Farms Using rBst in 25% to 75% of cows, BST_2	43%	50%	
Percent of Farms Using rBst in over 75% of cows, BST_1	5%	21%	
Percent of Farms Not Using rBst, *omitted*	43%	50%	
Percent of Farms using other milking systems, $MilkSys_1$	9%	29%	
Percent of Farms using a parlor milking system, $MilkSys_2$	55%	50%	
Percent of Farms using a bucket and carry, dumping station, or pipeline milking system, *omitted*	36%	48%	
Percent of Farms using a hand ledger accounting system, $RecSys_1$	16%	37%	
Percent of Farms using an accounting service, $RecSys_2$	21%	41%	
Percent of Farms using a computerized accounting system, $RecSys_3$	59%	49%	
Percent of Farms using other record systems, *omitted*	4%	19%	
Average Debt to Asset Ratio, *DA*	34%	19%	69%
Average Year to Year Change in Debt to Asset Ratio, *ChDA*	0%	2%	9%
Average Proportion of Long-term Assets, *LTassets*	44%	10%	49%
Average Ratio of Crop Acres Rented to Owned, *RENT*	0.90	1.54	12.85
Average Ratio of Non-farm Equity to Farm Equity, *OffFarmEquity*	0.08	0.14	0.80
Number of Operators 1999, *NumOper*	1.67	0.91	5.00
Average Maximum Age Difference, *AgeDiff*	7.23	10.11	39.29
Average Age of Operators, *Age*	45.88	7.03	38.36
Maximum Education of Operators (Years), *MaxEd*	14.30	1.97	10.00
Average Labor Hired (months), *Labor*	41.35	72.03	585.33
Average Change in Labor Hired (months), *ChLabor*	3.10	5.23	26.05

Table 5. Parameter Estimates for Compound ROA Model.

	Estimate	Standard Error	T-Statistic
Intercept	-0.0297	0.0489313	-0.61
Cows	0.00021***	6.934E-05	3.05
ChCows	0.36175**	0.1382667	2.62
MaxChcows	-0.1312***	0.0527134	-2.49
MilkCow	5.9E-06***	1.743E-06	3.40
TrendMilkCow	-7E-06	1.002E-05	-0.69
BST_1	0.01051	0.0148065	0.71
BST_2	0.00582	0.0099609	0.58
BST_3	0.01883	0.018469	1.02
F-Test for Significance of BST Group	1.11		
$MilkSys_1$ (other milking system)	0.00117	0.0146032	0.08
$MilkSys_2$ (parlor milking system)	0.00756	0.0089285	0.85
F-Test for Significance of *MilkSys* Group	0.18		
$RecSys_1$ (accounting service)	0.01183	0.0117359	1.01
$RecSys_2$ (own computerized accounting system)	-0.0026	0.0105616	-0.24
$RecSys_3$ (other record systems)	-0.0204	0.0203795	-1.00
F-Test for Significance of *RecSys* Group	0.11		
DA	0.0109	0.0212932	0.51
ChDA	-0.0452	0.1878911	-0.24
LTassets	-0.06	0.0381378	-1.57
RENT	-0.0036*	0.0021575	-1.68
OffFarmEquity	0.02247	0.0259212	0.87
NumOper	-0.0041	0.0059808	-0.68
AgeDiff	-0.0007	0.0004905	-1.36
Age	-0.0005	0.0005325	-0.90
MaxEd	0.00022	0.0021586	0.10
Labor	-0.0007**	0.0003328	-2.23
ChLabor	-0.0002	0.0014141	-0.16
F-Statistic for test all parameters = 0	5.08***		
R-Square	0.5981		
Adjusted R-Square	0.4805		

*indicates significance at the 0.10 level, **indicates significance at the 0.05 level, and ***indicates significance at the 0.01 level

Table 6. Parameter Estimates for Panel Model.

Parameter	Estimate	Standard Error	T-Statistic
Intercept	-0.00204	0.0812	-0.03
Cows	0.00012*	0.000069	1.78
ChCow	0.08080***	0.0201	4.01
MilkCow	0.00000*	1.91E-06	1.92
BST_1	-0.00245	0.00917	-0.27
BST_2	0.00827	0.00861	0.96
BST_3	0.01605	0.0154	1.04
F-Test for Significance of BST Group	0.69		
$MilkSys_1$ (other milking system)	0.01087	0.0164	0.66
$MilkSys_2$ (parlor milking system)	0.02012	0.0167	1.2
F-Test for Significance of *MilkSys* Group	0.97		
$RecSys_1$ (accounting service)	0.00531	0.0175	0.3
$RecSys_2$ (own computerized accounting system)	0.01584	0.0116	1.37
$RecSys_3$ (other record systems)	-0.00549	0.0144	-0.38
F-Test for Significance of *RecSys* Group	0.18		
DA	-0.00368	0.0461	-0.08
ChDA	-0.29902***	0.0413	-7.23
LTassets	-0.21565***	0.0697	-3.09
RENT	0.00007	0.00154	0.04
OffFarmEquity	0.01570	0.0573	0.27
NUM_OPER	0.00088	0.00996	0.09
NumOper	0.00007	0.00052	0.14
AgeDiff	0.00066	0.000635	1.04
MaxEd	-0.00052	0.0034	-0.15
Labor	-0.00006	0.000287	-0.2
ChLabor	0.00024	0.000242	0.98
F-Test for No Fixed Effects	2.77***		
R-Square	0.6316		

*indicates significance at the 0.10 level, **indicates significance at the 0.05 level, and ***indicates significance at the 0.01 level