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Characteristics and Performance of New York Dairy Farms

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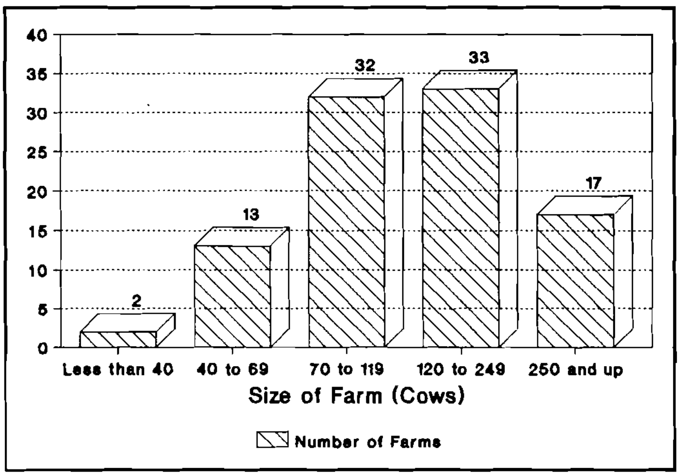

Herd Size Distribution, Top Return on Investment Quartile, 97 DFBS Farms, 1989

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PREFACE

Kevin Jack is an extension associate, and Wayne Knoblauch and Andrew Novakovic are professors in the Department of Agricultural Economics at Cornell University. This is the first publication done as part of the Dairy Farm Analysis Project of the Cornell Program on Dairy Markets and Policy. Funding for this project is provided by a research grant through the U.S. Department of Agriculture--Cooperative State Research Service.

Important contributions to earlier drafts and the design of the project were made by our collaborators on the Dairy Farm Analysis Project--Robert Yonkers and Stephen Ford, assistant professors in the Department of Agricultural Economics and Rural Sociology at The Pennsylvania State University; and Mark Stephenson, assistant professor in the Department of Agricultural Economics at the University of Wisconsin--River Falls.

Assistance in assembling the data from the Cornell Dairy Farm Business Summary records was provided by Linda Putnam. Dr. Cindy van Es provided advice in designing some of the statistical analysis.

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ABSTRACT

A combination of a more punitive policy situation and the greater range in size and financial performance in farms, especially across regions, has led to policy-makers focusing more on how new policies or policy proposals affect regions or types of farms, not just the national aggregates or average. While some new research is focusing on the implications of policy changes on farms in different areas and of different sizes, less has been done to improve how one goes about identifying and defining a "representative" farm.

The basic objective of this study is to explore the relationship between structural, technical efficiency, and financial performance data for a large sample of New York dairy farms. To what extent are financial or technical performance related to farm size or some other structural characteristic? If we conclude that most highly profitable farms are large, for example, can we also infer that most large farms are highly profitable? Ultimately, we want to be able to improve how we go about defining and talking about "representative farms."

This research provides an improved understanding of the differences between top performing and low performing dairy farms. Performance is measured by five financial criteria; four profitability and one cash flow measure. The distinction between high and low performance is specified as being in the top 25 percent versus the low 25 percent by financial performance criteria.

As judged by the four profitability measures, top performers from the 387 specialized, large breed farms participating in the 1989 New York Dairy Farm Business Summary are significantly higher, in herd size, crop yields, net milk prices and milk sold per cow. Top performing farms are significantly lower in capital investment per cow, feed and crop expense per cwt. of milk, purchased feed per cwt. of milk, and labor and machinery costs per cow. The cash flow criterion provides fewer significant differences between low and high performing farms.

The high performing farms average 170 cows and the low performing farms 70 cows. Of course, this does not mean that farms of 170 cows or so are necessarily more profitable than smaller farms. An analysis of 10 percent of the farms clustered around each herd size is conducted to determine if very large farms or very small farms bias the analysis. The comparison reveals significant differences exist <u>between</u> clusters for all four profitability measures, but not cash flow. However, milk sold per cow, feed costs, and non-feed costs are not significantly different.

<u>Within</u> clusters, farms are ranked by return on investment, and differences between upper and lower ranking halves are analyzed. Significant differences are found in all four measures of profitability, but again, not in cash flow. Significant differences in performance exist in capital efficiency and machinery expense per cow for the 70 cow group and only in debt to asset ratio and corn silage yield for the 170 cow group.

Thus, the New York data suggest that large herds tend to be more profitable <u>and</u> more profitable herds tend to be large. While herd size does account for important differences in profitability and technical performance, it is not an important factor in determining cash flow. This suggests that herd size plays a greater role in long-term survival and is not especially significant in terms of shorter-term survival.

The profitability analysis suggests that larger farms are profitable. To further explore the effects of farm size, an analysis of the performance of dairy farms for herd size groups of less than 40 cows, 40 to 69, 70 to 119, 120 to 249, and more than 249 was undertaken. Significant differences exist in cows per worker and milk sold per worker between all size groups. Milk sold per cow is significantly different between the largest herd size group and all other groups, and between the 40 to 69 and 120 to 249 cow groups. However, there are no significant differences between other herd size groups. Differences in capital efficiency and labor cost per cow are found only between large and small herd size groups, not between the groups in the middle size ranges.

Introduction

During the mid- to late-1980s, Congress came to realize that it had to take measures to reduce the cost of the Dairy Price Support Program. From 1983 to 1990, various other measures were combined with persistent cuts in the support price, resulting in a reduction of net government expenditures from $2.6 billion to $500 million (USDA/ASCS, 1991). These cuts were anything but easy. Congress struggled with the fiscal necessity to reduce supports and the political repercussions of doing so within the dairy farm community. In the process, it became clear that how we evaluate support policy had entered a new era. The distinguishing feature was that in the past we had tended to think of dairy farmers across the U.S. as a fairly homogeneous group, equally deserving of any favorable or unfavorable policy changes that might be made. When policy analysts were asked to analyze the implications of a new policy, it was almost always in the context of aggregate production or national average price. If any consideration was given to effects on farms, it was in the context of the "average" farm, with little concern about how many farms were "average". In the 1980s, a new attitude emerged, fostered by many in the dairy farm community and reflected by Congressional politicians who have a clear sense of who their constituents are. In this environment, legislators began asking how a proposed policy would affect a "family farm" or an average farm in their state or district. To be sure, policies still had to address aggregate, national needs, but the implications of a policy for different types of farms, often associated with regions, became an important element in deciding which approach to support. In fact, the "regionalization" of dairy policy became a topic of much discussion and concern.

Two major factors help explain this phenomenon. From 1976 to 1981, dairy price support policy was changed in ways that benefitted farmers substantially, at least in terms of short term price increases. Perhaps in this situation it is not so surprising that farmers, farm leaders, and members of Congress had a very egalitarian attitude. There was not much concern about who or what kind of farm benefitted more from a higher support price. The ecumenical spirit dissipated after 1983, when the overall direction of support policy turned negative. Price supports were reduced and farmers were asked to pay assessments. Thus, the first factor is that price support policy went from being beneficial and pleasant to being decidedly unpleasant for farmers.

The second factor has to do with changes in the structure of the milk production sub-sector, from being fairly homogeneous to being very diverse. Data from the Census of Agriculture dramatically underscore this transition. In 1950, the year after the Dairy Price Support Program was enacted, the average number of cows on farms which owned cows was six, and 99.5% of farms in the U.S. had fewer than 50 cows. By 1987, only 66% of farms had fewer than 50 cows and the average size had risen to 50. Most of the increase in the average could be explained by the sharp reduction in diversified or general farms that had a small number of cows. However, in addition, the growing number of very large, specialized dairy farms also had an important psychological as well as a statistical effect. Furthermore, it was quite clear that the distribution of farm sizes varied considerably around the country. Ten percent of the farms which owned dairy cows in the U.S. had 100 or more cows in 1987. This group represented 60% of the farms in California and 25 to 35% in Florida, Georgia, Arizona and Washington. In Iowa, Indiana, Minnesota, Missouri, Kentucky, Nebraska, and Wisconsin, these larger farms represented 6% or less of the states' dairy farms. Generally speaking, the traditional milk/forage producing states in the Northeast and Midwest had a greater proportion of smaller farms and the newer, more specialized dairy "ranches" in the Southeast and West had a greater proportion of larger farms. As these differences became more obvious and stark, it is probably little wonder that it became harder for the people at the different ends of the spectrum to think of themselves as being "all in this together."

Thus, the combination of a more punitive policy situation and the greater contrasts in farms, especially across regions, led to policy-makers focusing more on how new policies or policy proposals would affect their constituent regions or types of farms, not just the national aggregates or average. Policy analysts or agricultural economists have not been especially well equipped to answer such questions. Although farm modeling had been quite popular in the 1950s and 1960s, it had long gone out of vogue by the 1980s. Farm records and data which could provide a basis for new models were on the brink of extinction.

The first agricultural economists to approach this current need in a comprehensive and organized way were James Richardson, Ronald Knutson, and their associates at Texas A&M University. Richardson et al. had developed a sophisticated and fairly generic firm-level, recursive Monte Carlo simulation model, known as FLIPSIM, that could be adapted to milk production, given the necessary structural and financial data. The model simulates a representative farm over a 10-year planning horizon, using the ending financial position for one year as the beginning position of the next year, but it does not include a normative objective function (Richardson et al., 1983). Because of the lack of other data sources, as well as a desire to use data that would be considered more credible by farmers and legislators, the Texas researchers chose a modified Delphi approach to develop "representative" farms for different regions and size groups in several key states. Local dairy farmers were invited to define the size and associated parameters for the model farm representing them or their area. The completed models have been used to analyze the short-run and long-term profitability of dairy farms of different sizes and in different locations under alternative policy scenarios.

Cornell agricultural economists assisted in the development of four New York FLIPSIM data sets. In the process, we began to think about how one might go about identifying and defining "representative" farms. New York milk production occurs on a wide variety of farms. The state has a large number of small and medium sized farms, typical of the North, but it is fairly unique among northern states in also having a substantial number of very large farms--500 cows and more. Moreover, as is true everywhere, technical efficiency and financial performance varies considerably within size groups. So, how does one decide what an average New York dairy farm is, or an average 100 cow farm? Or, is it even reasonable to specify one or two farms and think of them as being representative of a state?

Cornell is one of the few land-grant universities that still collects farm-level business data; hence we have a rare opportunity to use these data to explore these sorts of questions. This paper is a report of the first phase of our analysis, focusing on the performance and characteristics of dairy farms in New York.

New York Dairy Farm Business Summaries

George F. Warren conducted his first pioneering survey of New York farm businesses in the first decade of this century. From this first study came the impetus for many later research and extension studies in farm management. Since the 1950s, the availability of a comprehensive set of annual dairy farm business summaries collected from cooperators throughout New York has afforded personnel in the Department of Agricultural Economics at Cornell University unique research opportunities.

The Dairy Farm Business Summary (DFBS), as it is now called, has been utilized for many analyses. Earlier works, such as Casler and Bratton (1960) and LaDue and Bratton (1967), were followed by Fowers (1978), Williams (1985), Kauffman and Tauer (1986), and Murray-Prior (1989). While the techniques of analysis may have grown more sophisticated over time, from cross-tabulation and simple correlation to linear programming and logit regression, the underlying objective has remained largely the same; namely, to associate and quantify particular management strategies or resource endowments with dairy farm profitability.

These studies have also helped analysts understand the forces that are changing the structure of dairy farming in New York and elsewhere. Based on state and federal marketing order data, the number of New York dairy farms decreased over 30 percent, from 14,725 to 10,255 between December 1980 and December 1990 (Jack and Novakovic). The magnitude of this reduction in producer numbers, while not unprecedented, begs questions like: "who survived, who did not, and why?" In the volatile economic climate experienced by dairy farms in the 1980s and early 1990s, and in the face of what might transpire for the rest of this decade, a more fundamental but related question must be asked, "what differentiates successful dairy farms from others?"

A substantial volume of published literature has been devoted to these questions and closely-related issues over the years. A sample of titles and publication dates of bulletins and journal articles is listed below:

"Factors Affecting Costs and Returns in Producing Milk" (Cunningham, 1934),

"Factors Affecting Labor Incomes on New York Dairy Farms" (Bratton, 1959),

"Influence of Specified Farm Management Factors on Dairy Farm Net Income" (Speicher and Lassiter, 1965),

"An Analysis of Net Income Level and Variability for Selected Dairy Business Management Strategies" (Knoblauch and Connor, 1976),

"Factors Which Contribute to the Financial Performance of Selected Tennessee Dairies" (Haden and Johnson, 1989), and

"Relationship of Management and Financial Measures Among Dairy Herds in Virginia" (Zweigbaum et al., 1989)

This suggests that academic interest in the subject is neither recent nor waning.

While Cornell farm management studies have specialized in using year-end business summaries to conduct their analyses, other published agricultural economics research studies have relied, in part, upon Dairy Herd Improvement Association records (DHIA) (Brown and

White; Stallings et al.) or dairy producer panels utilizing a modified Delphi technique to collect data (Richardson et al., 1991).

Overview of the Study

The theory of production economics is concerned with the process of how producers combine and coordinate inputs, factors, resources and productive services to efficiently produce a product, given the existing technology (Beattie and Taylor). It speaks of resource endowments, technical efficiency, the optimal allocation of purchased inputs, and profits. This study uses similar distinctions. Dairy Farm Business Summary data are split into three categories to indicate:

- -- structural characteristics (resource endowments)
- -- technical performance, including physical and cost measures of efficiency which reflect, at least in part, management performance
- -- financial performance, i.e. net returns and other measures of financial outcomes

The basic objective of the analysis is to explore the relationship between these three categories of information about New York dairy farms. To what extent are financial or technical performance related to farm size or other structural characteristics? If we conclude that most highly profitable farms are large, for example, can we also infer that most large farms are highly profitable? Ultimately, we want to be able to improve how we go about defining and talking about "representative farms."

Data and Methods

The choice of factors to compare across financial measures, especially those relating to input costs, is complicated by their very multitude. In addition, the difficulty is compounded because these factors may be expressed on an input- (i.e., per cow, per worker) or output-basis (i.e., per hundredweight of milk). In this analysis, twenty-two descriptive cost and efficiency factors covering nine broad performance categories are used, as listed in Table 1. Factors found useful in previous studies (Fowers; Murray-Prior) utilizing DFBS records and several others thought important for distinguishing dairy farms are the basis of our selection.

This research focuses on farm size, cost and efficiency factors, and how these factors differ between "high performing" and "low performing" dairy farms. A farm is deemed "high performing" for a particular financial measure if it lies in the top 25% of the frequency distribution for that measure. Conversely, "low performing" farms are those located in the lower quartile. This statistical analysis was conducted one financial factor at a time, thus no joint distributions of variables are considered. In all, five financial measures are considered here: net farm income, labor and management income per operator, percent return on equity, percent return on investment, and cash flow coverage ratio (Table 2). These measures are defined and more fully explained later in this report.

Data were obtained from farms participating in Cornell's Dairy Farm Business Summary (DFBS) in 1989. The data set used in this analysis includes only "specialized" dairy farm operations, and purposely excludes dairy farm renters, dairy-cash crop farmers with crop sales exceeding 10 percent of milk sales, and part-time dairy operators. Farms participate in DFBS

Table 1. Descriptive and Performance Variables Used in Analysis of Dairy Farm Business Summary Records

Category or Variable Description	Variable Name	Units
Size		
Milking Herd	COWS	Head
Milking Herd & Replacement Animals	ALLSTOCK	Head
Total Pounds of Milk Sold	MILK	Lbs.
Productivity		
Cows per Worker	COWS/WORK	Head
Milk Sold per Worker	MILK/WORK	Lbs.
Milk Sold per Cow (weighted by herd size)	MILK/COW	Lbs.
Capital Efficiency		
Machinery Investment per Cow	MINV/COW	$
Capital Investment per Cow	KINV/COW	$
Capital Investment per Worker	KINV/WORK	$
Debt-Equity Position		
Debt-to-Asset Ratio	D:A	
Debt per Cow	DEBT/COW	$
Equity per Operator	EQ/OP	$
Feed Cost Control		
Feed and Crop Cost per cwt. of Milk	FCCST/COW	$
Purchased Feed Cost per Cow	F/COW	$
Purchased Feed Cost per cwt. of Milk	F/CWT	$
Non-Feed Cost Control		
Labor Cost per Cow	LCST/COW	$
Machinery Cost per Cow	MCST/COW	$
Cropping Practices		
Yield of Corn Silage/Acre	CORNYLD	Tons
Yield of Dry Hay Equivalent/Acre	HAYYLD	Tons
External Factors		
Net Milk Price/cwt.	MBPRICE	$
Standardized Net Milk Price/cwt.	MBSPRICE	$
Operator Attribute		
Age of Principal Operator	AGE	Years

on a voluntary basis, and their average tends to be better than the average of all farms in New York. For example, the 413 farms participating in 1989 had a weighted (by number of cows) average of 17,253 pounds of milk sold per cow, while the state average for all farms was 14,267 pounds produced per cow, according to the most recently revised figures available from the National Agricultural Statistics Service (USDA/NASS, 1991). Although the average for DFBS farms is higher and the distribution is more skewed to the right, the DFBS data certainly do include the full range of New York farms, from top to bottom. (Additional statistical background on the 1989 dairy farm summary may be found in Smith et al.)

DFBS dairy herds with more than 10% non-Holstein cows were deleted from this analysis in order to prevent confusing results from poorly managed farms with those from lower producing non-Holstein herds. Cornell Cooperative Extension agents responsible for enrolling farms in the DFBS program were contacted to establish which herds met this criterion. Twenty-six herds were identified, reducing the total number of useable observations to 387.

Table 2. Financial Performance Measures Used in Analysis of Dairy Farms Business Summary Records

Financial Measure Description	Variable Name	Units
Net Farm Income (without appreciation)	NFI	$
Labor and Management Income per Operator	LMIO	$
Rate of Return on Equity Capital (without appreciation)	ROE	%
Rate of Return on Total Capital (without appreciation)	ROI	%
Cash Flow Coverage Ratio	CFCR	n.a.

Description of Farm Characteristics Variables

Records in the Dairy Farm Business Summary are analyzed using accrual accounting methods, which are considered to be more accurate than cash accounting methods in measuring profitability (Seger and Lins). In this analysis, cash accounting is used only to calculate cash flow.

A brief explanation of how certain farm factors are calculated follows below. In addition, definitions of the five financial measures used in this analysis are presented in the following section. This latter section draws heavily from Smith et al., and the interested reader should consult this reference for more background.

The farm factors in the "Size" and "Productivity" categories are, for the most part, self-explanatory (Table 1). Factors expressed on a "per-worker" basis are calculated counting all labor, including unpaid family and operator labor. Throughout this analysis, the milk per cow variable is weighted by herd size to calculate mean values.

Machinery investment per cow is a simple average of year-beginning and year-ending equipment inventory divided by average number of cows. Capital investment covers all farm assets including financial assets, prepaid expenses, accounts receivable, livestock inventory, machinery inventory, feed and supplies and land and buildings. The debt per cow variable includes all current-, intermediate- and long-term debt amounts.

Within the "Feed Cost Control" category, FCCST/CWT includes purchased concentrates and roughage, machinery fuel, oil and grease, seed, spray, fertilizer and lime. Purchased Feed includes both concentrates and roughage.

LCST/COW is calculated by summing hired labor expense, unpaid family labor valued at $750 per month, and operator labor valued at $1050 per month. MCST/COW includes 1989 machinery depreciation, machine hire, rent and lease, parts and repairs, farm share of auto expense, machinery fuel, oil, and grease, and 5% of the value of machinery owned in 1989. This last segment of machinery expense represents the real interest rate on capital invested in machinery.

Two milk prices are used here. MBPRICE is an implicit net price per hundredweight calculated by taking gross dairy receipts less marketing charges and divided by number of hundredweight sold in 1989. MBSPRICE is MBPRICE standardized to a 3.5% butterfat content, using the simple average butterfat differential in effect in Federal Milk Marketing Order #2 (New York-New Jersey) during 1989, which was $0.147 per 0.1% fat test (USDA, 1990). Differences in MBSPRICE help isolate price differences attributable to premiums (awarded in the form of subsidized marketing costs or outright premiums) from differences due to butterfat content.

Description of Farm Financial Performance Measures

In this analysis, financial performance is calculated five different ways; two income measures, two rates of return and one liquidity measure were employed. Net farm income is a staple accrual income measure often used in these types of analyses and is well-accepted, but it says nothing about the opportunity cost of using unpaid family labor or equity capital. Thus, labor and management income per operator was also utilized as a financial performance measure to complement net farm income. It is not without its pitfalls, too, as the monthly charge for family labor and the interest rate charge on owned capital are subjective. However, when these two income measures were combined with percent return on investment, percent return on equity and cash flow coverage ratio, a balanced analysis emerges. A brief definition of each is given below; again, Smith, et al. provide more detailed definitions.

Net Farm Income (without appreciation) (NFI)

Net Farm Income (without appreciation) is the total combined return to the farm operator(s) and other unpaid family members for their labor, management, and equity capital. It is calculated as the difference between total accrual receipts and total accrual expenses. Accrual receipts represent the value of all farm commodities produced and services actually provided by the farmer during the year.

Labor and Management Income per Operator (LMIO)

Represents the return to one full-time operator's labor and management. Calculated as:

Net Farm Income (without appreciation)
\- Charge for Unpaid Family Labor (@ $750 per month)
\- Cost of Using Equity Capital (@ real interest rate of 5%)
= Labor and Management Income Per Farm (LMI)

LMIO = (LMI)/(Number of Operators)

Rate of Return on Equity Capital (without appreciation) (ROE)

Return on equity capital is the residual return after deductions to LMI are made for the imputed value of the owner-operator's management and labor. ROE, as a percentage, is calculated as:

Labor and Management Income (without appreciation)
\- Value of Operators' Labor and Management (operator determined)
= Return on Equity Capital

$$\text{ROE} = \frac{\text{(Return on Equity Capital)}}{\text{Equity Capital}} * 100$$

Rate of Return on Total Capital (without appreciation) (ROI)

The rate of return on investment or total capital is expressed as the percentage return on equity capital plus interest relative to all farm assets:

$$\text{ROI} = \frac{\text{(Return on Equity Capital + Interest Paid)}}{\text{Average Farm Assets}} * 100$$

Cash Flow Coverage Ratio (CFCR)

This is the only non-accrual financial measure considered in this report. It gauges the ability of the dairy farm to meet its planned debt payment schedule. Here it is interpreted as the percentage of payments planned for 1989 (as of December 31, 1988) that could have been made with the amount available for debt service in 1989. The ratio is calculated as:

Cash Farm Receipts
\- Cash Farm Expenses
\+ Interest Paid
\- Net Personal Withdrawals from Farm
(A) = Amount Available for Debt Service

(B) = Debt Payments Planned for 1989
(as of December 31, 1988)

(A/B) = Cash Flow Coverage Ratio for 1989 (CFCR)

As a ratio, CFCR is not expressed in any formal units, but it measures how many dollars of cash flow are available per one dollar of planned debt payments. A CFCR of one implies planned debt payments exactly equals the available cash. A CFCR less than one implies available cash will not cover all planned payments. If the farm has no debts, CFCR becomes an infinite number. Hence, a very large CFCR can mean either the farm has large amounts of available cash or very small debts, or both. Therefore, this ratio must be interpreted with care.

Distribution of Farm Characteristics and Financial Performance Measures

Twenty-two descriptive cost and efficiency variables and five financial performance variables are used in this analysis. The minimum, maximum, mean, standard deviation and coefficient of variation for each variable are reported in Table 3. All statistics are calculated using the entire 387 farm sample with the following exceptions: corn silage yield--359 farms; dry hay yield--standardized milk price--381 farms; age of principal operator--385 farms; and, coverage ratio--297 farms.

Calculations for cash flow coverage ratio require prior year's data, and because only 306 of the 387 farms analyzed here participated in both 1988 and 1989, the 1989 ratio is only available for these farms. Moreover, nine farms have ratios of infinity (eight positive and one negative), thus the statistic is only meaningful for the remaining 297 farms. However, these other nine observations are used to determine quartile breaks for the coverage ratio statistic.

The distributions of several variables are widely dispersed as evidenced by their large coefficients of variation (C.V.). Of the nine descriptive variable categories, the "Size" and "Debt-Equity Position" categories have the widest dispersion. The wide distribution of factors in the "Size" category is not unexpected considering the smallest farm has 20 cows and the largest 1336. Total pounds of milk shipped is even more widely dispersed with the data ranging from just under 300,000 pounds to over 27 million. Although it is listed under the "Debt-Equity Position" category, EQ/OP is in many ways also a "Size" factor; because it is reasonable to expect that under similar operating conditions, larger dairy operations will have more equity per operator.

With the exception of machinery investment per cow at 47 and milk sold per cow at 144, all variables in the productivity, capital efficiency, feed and non-feed cost, and cropping practice categories have coefficients of variation ranging between 15 and 34, with most hovering around 30.

The external factors and operator attribute categories have the tightest overall dispersion. The MBPRICE and MBSPRICE variables each have a C.V. of less than 7, while the C.V. for AGE is less than 23.

All financial performance measures have large coefficients of variation--in excess of 100. Percent return on equity (without appreciation) (ROE) has an especially wide dispersion with a C.V. of 913. LMIO is also of interest. It might be thought that because this variable is computed on a "per operator" basis, it would have the effect of shrinking the dispersion found in net farm income (NFI). Instead, the dispersion in this variable is almost twice that of NFI. In addition, in a comparison of the 1975-77 and 1985-86 periods, Stanton found that the variability of LMIO had more than doubled over that ten year period (p. 5).

Table 3. Descriptive Statistics of Selected Dairy Performance Variables, 387 DFBS Farms, 1989

Variable	Minimum	Maximum	Mean	Std. Dev.	C.V.
Size					
No. of Cows	20	1336	107	104	97.7
No. of Animals	33	2160	192	183	94.9
Milk Sold	291,061	27,140,652	1,862,891	2,054,897	110.3
Productivity					
Cows/Worker	10.2	77.4	30.5	9.3	30.4
Milk/Worker	116,748	1,187,138	514,296	169,524	33.0
Milk/Cow	8,406	23,562	17,414	25,011	143.6
Capital Efficiency					
Machinery Investment/Cow	90	6,823	1,278	606	47.4
Capital Investment/Cow	3,003	15,639	6,853	1,949	28.4
Capital Investment/Worker	58,104	430,487	203,734	68,539	33.6
Debt-Equity Position					
Debt to Asset Ratio	0.00	1.12	0.33	0.19	59.6
Debt/Cow	0.00	7313	2166	1314	60.7
Equity/Operator	16,325	3,209,749	355,845	324,519	91.2
Feed Cost Control					
Feed & Crop Cost/cwt	2.86	10.40	5.27	1.07	20.2
Purchased Feed Cost/Cow	159	1,295	674	198	29.4
Purchased Feed Cost/cwt of Milk	1.20	8.22	4.00	1.10	27.6
Non-Feed Cost Control					
Labor Cost/Cow	171	997	470	134	28.4
Machinery Cost/Cow	138	948	446	130	29.2
Cropping Practice					
Corn Silage Yield (T/A)	0.00	34.7	13.5	4.3	31.7
Dry Hay Equiv. Yield (T/A)	0.79	6.90	2.67	.87	32.7
External Factors					
Net Milk Price/Cwt	10.23	17.57	13.89	.62	4.5
Standardized Net Milk Price/Cwt	9.79	17.28	13.60	.60	4.6
Operator Attribute					
Age	24	77	45.8	10.4	22.8
Financial Performance					
Net Farm Income	-32,687	1,114,615	52,019	76,331	146.7
Labor & Management Income/Operator	-68,077	868,388	20,275	56,216	277.3
Return on Equity (%)	-225.53	49.31	1.58	14.41	913.0
Return on Investment (%)	-13.10	22.10	4.41	4.88	110.7
Cash Flow Coverage Ratio	-3.91	43.44	1.79	3.35	187.6

Milking systems and barn types can affect technical performance measures, such as milk per worker or cost efficiency measures such as capital investment per cow. As shown in Table 4, 47% of the sample used a pipeline system in a stanchion or tiestall (conventional) barn and 35% used a milking parlor with a freestall barn. Thus, these two combinations represent the vast majority of the sample of farms.

Table 4. Summary of DFBS Farms, by Barn Type and Milking System

	Barn Type			
Milking System	Stanchion/ Tiestall	Freestall	Combination	Total
Bucket & Carry	3	0	0	3
Dumping Station	21	1	2	24
Pipeline	183	5	21	209
Herringbone	7	125	5	137
Other Parlor	1	12	1	14
Total	215	143	29	387

Given the importance of these two combinations, a cumulative frequency polygon showing the cumulative distribution of herd sizes using each combination was constructed (Figure 1). This figure shows, for example, that farms in this sample with 75 cows or less represented approximately 70% of the farms with pipelines and conventional housing, but only about 15% of those with milking parlors and freestall barns. On the other hand, farms with 150 cows or less, only accounted for 60% of those with parlors, but about 95% of those pipelines.

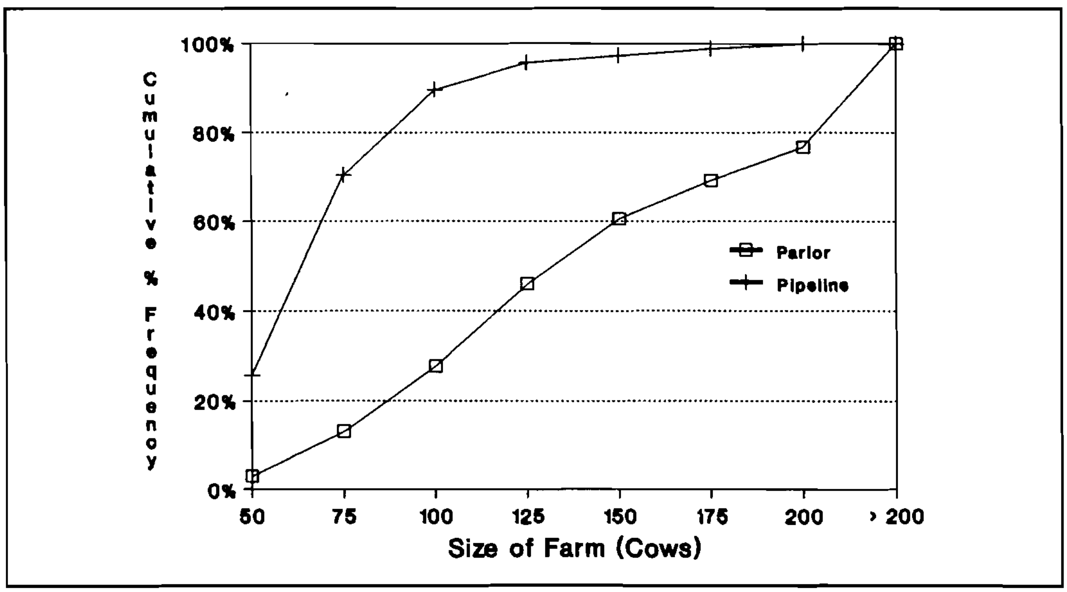

Figure 1. Cumulative Percentage of Herd Sizes, by Milking System Technology, 320 DFBS Farms, 1989

An analysis of variance was performed to find out which cost, efficiency and financial performance variables differed significantly between the two groups. These results are presented in Table 5.

Table 5. Mean Values of Descriptive and Performance Measure Variables, by Milking System Technology

Category or Variable	Mean Values		F statistic
	Parlor[1]	Pipeline[2]	
Number of Observations[3]	137	183	
Size			
COWS	175	69	84.82***
ALLSTOCK	309	125	87.44***
MILK	3,104,695	1,158,633	74.33***
Productivity			
COWS/WORK	35.5	27.6	69.67***
MILK/WORK	616,175	461,428	83.46***
MILK/COW	17,931	16,809	17.47***
Capital Efficiency			
MINV/COW	1,214	1,317	2.88*
KINV/COW	5,706	6,312	9.47***
KINV/WORK	225,927	192,830	20.77***
Debt-Equity Position			
D:A	.3397	.3230	.60
DEBT/COW	2,156	2,271	.58
EQ/OP	526,230	259,916	54.78***
Feed Cost Control			
FCCST/CWT	5.39	5.16	3.49*
FCST/COW	698	665	2.08
FCST/CWT	4.05	3.95	.55
Non-Feed Cost Control			
LCST/COW	454	467	.83
MCST/COW	451	449	.02
Cropping Practice			
CORNYLD	14.0 (131)	13.4 (173)	1.89
HAYYLD	2.79 (136)	2.62 (182)	2.89*
External Prices			
MBPRICE	14.06	13.81	14.60***
MBSPRICE	13.74 (136)	13.55 (179)	7.99***
Operator Attribute			
AGE	48.1 (136)	44.6 (182)	9.91***
Financial Performance			
NFI	86,030	32,053	37.26***
LMIO	37,841	10,447	16.46***
ROE	4.70	-.12	7.94***
ROI	6.16	3.48	25.07***
CFCR	1.79 (109)	1.77 (139)	0.00

[1] Farms with milking parlor and freestall barn only.
[2] Farms with pipeline and conventional barn only.
[3] Means represent 137 or 183 observations, respectively, unless otherwise indicated in parentheses.
Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Relative to herds with a pipeline/conventional housing combination, milking parlor/freestall herds are approximately 100 cows larger, ship an additional two million pounds of milk, and sell 1,000 pounds more milk per cow and 150,000 more pounds per worker. Parlor farms have significantly lower machinery and capital investment per cow, but higher capital investment per worker. There are no differences in debt-to-asset ratio or debt per cow figures, but parlor farms have twice as much equity per operator. Purchased feed statistics are essentially the same, as are labor and machinery costs per cow. Pipeline farms receive significantly lower net milk prices and are owned by younger operators. Finally, parlor farms average $50,000 and $25,000 more in net farm income and labor and management income per operator, respectively.

A farm business chart, which provides detailed information on basic statistics for individual farm factors and financial performance measures used in this analysis, is especially useful for establishing a farm's relative performance with respect to a particular variable (Table 6). Within each variable, data were sorted into deciles with each decile representing approximately 39 observations (exceptions were previously noted). In turn, within-decile means were calculated and are reported in the farm business chart.

There are several important caveats when interpreting a farm business chart. Columns are independent of one another, so farms in the top 10 percent for one factor are not necessarily the same farms in the top 10 percent of another. In addition, cost control variables are ranked from lowest- to highest-cost, but lowest-cost does not necessarily translate into most profitable.

Analysis of Five Financial Performance Variables

For each financial performance variable, the data were sorted by that variable, and the top- and bottom-performing quartile of farms were established, as shown in Tables 7 through 11. Mean values for all 27 descriptive and financial performance variables were calculated for the top- and bottom-performing quartile, and tested against a null hypothesis of no difference between quartiles (two-tailed).

To facilitate additional analysis, frequency distributions of two financial performance variables, net farm income and percent return on investment, were constructed (Figures 3 and 4). Figures 5 though 8 present histograms of herd sizes found in the upper and lower quartiles of these two variables.

Separating farms on the basis of the net farm income (NFI) variable reveals significant differences. In fact, of the 27 variables analyzed, only FCST/COW was not significant at the 10% level. Compared to the low quartile, the top-performing quartile of NFI farms earned an average NFI of $116,859 greater, had three times as many cows, got 20% more milk per cow and receive a statistically higher milk price. In addition, these farms may be characterized as carrying significantly less debt and capital investment per cow, obtaining significantly higher crop yields, and spending less per cow on labor and machinery.

Similar comments could be applied to the analysis of LMIO. This is not surprising considering the close relation between the NFI and LMIO measures. Of the descriptive variables, only KINV/WORK, D:A, FCST/COW and AGE are not significant at the 10% level. CFCR is the only financial measure not significantly different between the top and bottom quartiles of LMIO.

Table 6. Farm Business Chart for Farm Management Cooperators, 387 New York Dairy Farms, 1989

Size			Productivity		
COWS	ALLSTOCK	MILK	COWS/WORK	MILK/WORK	MILK/COW
333	597	6,224,574	48.7	852,639	21,023
157	282	2,735,120	39.8	683,183	19,281
123	223	2,103,846	36.2	616,931	18,364
101	185	1,759,004	33.2	565,013	17,693
85	156	1,451,160	30.3	524,799	17,223
72	132	1,221,001	28.3	464,538	16,680
63	115	1,043,417	26.2	431,571	16,202
56	99	890,384	23.8	396,134	15,500
47	82	751,505	21.6	352,454	14,648
36	60	537,066	16.8	253,551	12,213

Capital Efficiency			Debt-Equity Position		
MINV/COW	KINV/COW	KINV/WORK	D:A	DEBT/COW	EQ/OP
$ 556	$ 4,301	$102,981	.2345	$ 158	$1,063,112
750	5,098	136,881	.1108	740	546,953
882	5,597	153,260	.1768	1,195	434,721
1,009	5,935	169,118	.2346	1,597	356,587
1,123	6,288	186,488	.2969	1,909	307,023
1,249	6,639	204,461	.3450	2,229	251,766
1,390	7,183	222,875	.3976	2,645	211,512
1,555	7,764	248,534	.4580	3,043	168,195
1,780	8,759	275,566	.5394	3,553	124,241
2,514	11,060	340,279	.6777	4,650	81,858

Feed Cost Control			Productivity	
FCCST/CWT	FCST/COW	FCST/CWT	LCST/COW	MCST/COW
$ 3.60	$ 327	$ 2.09	$ 271	$ 242
4.20	464	2.93	338	313
4.59	539	3.26	372	359
4.88	595	3.60	413	390
5.09	653	3.90	446	423
5.30	704	4.14	477	456
5.57	756	4.36	503	482
5.87	812	4.65	543	523
6.31	872	5.05	605	582
7.38	1,022	6.08	742	701

Cropping Practice		External Prices		Operator Attribute
CORNYLD	HAYYLD	MBPRICE	MBSPRICE	AGE
21.3	4.46	$14.94	$14.62	65.2
17.5	3.53	14.38	14.09	57.7
16.0	3.15	14.23	13.94	53.1
15.0	2.91	14.09	13.79	49.6
14.2	2.67	13.95	13.67	46.7
13.3	2.47	13.84	13.56	43.6
12.3	2.24	13.72	13.42	40.7
10.8	2.04	13.57	13.29	37.9
9.5	1.81	13.41	13.10	34.9
5.8	1.42	12.78	12.53	29.5

Financial Performance				
NFI	LMIO	ROE (%)	ROI (%)	CFCR
$196,019	$111,439	13.06	17.07	8.98
84,088	36,956	9.11	9.34	2.58
62,269	26,017	7.23	6.39	1.86
50,519	19,626	6.11	4.83	1.60
41,325	15,904	5.08	3.39	1.29
32,823	12,181	4.14	1.92	1.12
26,643	8,319	3.01	.43	.99
20,379	3,626	1.57	-2.15	.85
12,561	-4,009	-.43	-4.82	.66
-3,431	-25,292	-4.59	-20.15	-.08

Table 7. Mean Values of Descriptive and Performance Measure Variables, by Net Farm Income Quartile

Category or Variable	Mean Values: Top Performing[1]	Mean Values: Low Performing[2]	Absolute Value of t-statistic
Number of Observations[3]	97	97	
Size			
COWS	198	65	7.66***
ALLSTOCK	355	115	8.11***
MILK	3,641,717	1,001,604	7.68***
Productivity			
COWS/WORK	35.9	27.1	6.77***
MILK/WORK	647,077	417,098	10.71***
MILK/COW	18,430	15,407	8.80***
Capital Efficiency			
MINV/COW	1,167	1,351	1.91*
KINV/COW	6,267	7,588	4.41***
KINV/WORK	220,947	199,924	2.09**
Debt-Equity Position			
D:A	.2673	.3658	3.67***
DEBT/COW	1,643	2,574	5.13***
EQ/OP	579,600	270,702	5.57***
Feed Cost Control			
FCCST/CWT	5.19	5.56	2.37**
FCST/COW	697	667	1.06
FCST/CWT	3.88	4.31	2.64***
Non-Feed Cost Control			
LCST/COW	460	503	2.16**
MCST/COW	430	469	2.02**
Cropping Practice			
CORNYLD	14.1 (95)	12.5 (84)	2.56**
HAYYLD	2.97	2.29 (95)	5.89***
External Prices			
MBPRICE	14.06	13.72	3.80***
MBSPRICE	13.76 (96)	13.45 (93)	3.56***
Operator Attribute			
AGE	49.1 (96)	44.9 (96)	2.69***
Financial Performance			
NFI	124,175	7,316	9.25***
LMIO	60,378	-9,229	6.88***
ROE	9.64	-9.18	7.72***
ROI	8.95	-1.01	18.59***
CFCR	2.23 (79)	0.92 (70)	3.63***

[1] Farms earning more than $61,272.
[2] Farms earning less than $20,363.
[3] Means represent 97 observations unless otherwise indicated in parentheses.
Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Table 8. Mean Values of Descriptive and Performance Measure Variables, by Labor and Management Income per Operator Quartile

Category or Variable	Mean Values		Absolute Value of t-statistic
	Top Performing[1]	Low Performing[2]	
Number of Observations[3]	97	97	
Size			
COWS	181	74	5.94***
ALLSTOCK	323	131	6.21***
MILK	3,345,528	1,149,891	6.16***
Productivity			
COWS/WORK	36.0	26.6	7.29***
MILK/WORK	650,373	410,851	10.85***
MILK/COW	18,530	15,620	8.34***
Capital Efficiency			
MINV/COW	1,096	1,395	3.23***
KINV/COW	6,205	7,940	5.71***
KINV/WORK	220,941	205,709	1.46
Debt-Equity Position			
D:A	.3152	.3182	.11
DEBT/COW	1,944	2,352	2.18**
EQ/OP	552,126	320,191	4.25***
Feed Cost Control			
FCCST/CWT	5.04	5.59	3.43***
FCST/COW	695	662	1.13
FCST/CWT	3.84	4.25	2.54**
Non-Feed Cost Control			
LCST/COW	453	525	3.63***
MCST/COW	413	475	3.47***
Cropping Practice			
CORNYLD	14.2 (91)	11.7 (84)	4.04***
HAYYLD	2.97	2.36 (95)	4.94***
External Prices			
MBPRICE	14.03	13.70	4.18***
MBSPRICE	13.79 (96)	13.41 (94)	4.82***
Operator Attribute			
AGE	47.6 (96)	45.9	1.05
Financial Performance			
NFI	115,886	9,345	8.19***
LMIO	64,295	-11,299	7.60***
ROE	11.14	-8.88	8.14***
ROI	9.76	-1.38	23.65***
CFCR	2.05 (81)	1.56 (72)	.75

[1] Farms earning more than $20,044 per operator.
[2] Farms earning less than $3,355 per operator.
[3] Means represent 97 observations unless otherwise indicated in parentheses.
Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Table 9. Mean Values of Descriptive and Performance Measure Variables, by Return on Equity (%) Quartile

Category or Variable	Mean Values: Top Performing[1]	Mean Values: Low Performing[2]	Absolute Value of t-statistic
Number of Observations[3]	97	97	
Size			
COWS	174	70	5.79***
ALLSTOCK	312	122	6.09***
MILK	3,211,174	1,093,178	5.91***
Productivity			
COWS/WORK	35.6	26.7	6.87***
MILK/WORK	632,995	416,459	9.73***
MILK/COW	18,420	15,661	7.61***
Capital Efficiency			
MINV/COW	1,044	1,234	2.99***
KINV/COW	5,961	7,193	4.63***
KINV/WORK	209,106	186,841	2.34**
Debt-Equity Position			
D:A	.3312	.3915	2.33**
DEBT/COW	1,987	2,691	4.02***
EQ/OP	503,380	232,220	4.98***
Feed Cost Control			
FCCST/CWT	5.15	5.56	2.70***
FCST/COW	709	678	1.10
FCST/CWT	3.98	4.32	2.13**
Non-Feed Cost Control			
LCST/COW	442	502	3.08***
MCST/COW	398	458	3.13***
Cropping Practice			
CORNYLD	13.9 (90)	12.6 (85)	1.96*
HAYYLD	2.94	2.36 (94)	4.86***
External Prices			
MBPRICE	14.03	13.76	3.11***
MBSPRICE	13.74 (95)	13.48 (93)	2.98***
Operator Attribute			
AGE	47.3 (96)	43.4	2.57**
Financial Performance			
NFI	112,201	10,469	7.73***
LMIO	62,256	-7,273	6.93***
ROE	11.85	-10.57	9.27***
ROI	10.24	-1.31	25.21***
CFCR	1.74 (82)	1.47 (70)	.46

[1] Farms with return on equity greater than 6.19%.
[2] Farms with return on equity less than -2.27%.
[3] Means represent 97 observations unless otherwise indicated in parentheses.
Level of significance; '***': p ≤ .01, '**': p ≤ .05, '*': p ≤ .10.

Table 10. Mean Values of Descriptive and Performance Measure Variables, by Return on Investment (%) Quartile

Category or Variable	Mean Values: Top Performing[1]	Mean Values: Low Performing[2]	Absolute Value of t-statistic
Number of Observations[3]	97	97	
Size			
COWS	175	68	5.97***
ALLSTOCK	314	119	6.28***
MILK	3,231,292	1,055,308	6.09***
Productivity			
COWS/WORK	35.9	25.9	7.64***
MILK/WORK	639,766	400,338	10.89***
MILK/COW	18,424	15,526	8.00***
Capital Efficiency			
MINV/COW	1,043	1,368	3.64***
KINV/COW	5,930	7,728	6.01***
KINV/WORK	209,740	193,727	1.65*
Debt-Equity Position			
D:A	.3435	.3172	.96
DEBT/COW	2,058	2,265	1.12
EQ/OP	501,937	275,650	4.16***
Feed Cost Control			
FCCST/CWT	5.16	5.58	2.53**
FCST/COW	712	665	1.64
FCST/CWT	3.99	4.29	1.83*
Non-Feed Cost Control			
LCST/COW	443	526	4.19***
MCST/COW	403	471	3.55***
Cropping Practice			
CORNYLD	13.9 (91)	11.6 (83)	3.63***
HAYYLD	2.95	2.39 (95)	4.43***
External Prices			
MBPRICE	14.04	13.76	3.18***
MBSPRICE	13.76 (95)	13.46 (93)	3.40***
Operator Attribute			
AGE	46.6 (96)	45.4	.71
Financial Performance			
NFI	110,955	11,503	7.52***
LMIO	62,068	-8,459	7.03***
ROE	11.61	-9.65	8.69***
ROI	10.35	-1.79	29.45***
CFCR	1.72 (82)	1.58 (73)	.24

[1] Farms with return on investment greater than 7.32%.
[2] Farms with return on investment less than 1.52%.
[3] Means represent 97 observations unless otherwise indicated in parentheses.
Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Table 11. Mean Values of Descriptive and Performance Measure Variables, by Cash Flow Coverage Ratio Quartile

Category or Variable	Mean Values: Top Performing[1]	Mean Values: Low Performing[2]	Absolute Value of t-statistic
Number of Observations[3]	77	77	
Size			
COWS	134	100	1.58
ALLSTOCK	241	179	1.66*
MILK	2,432,085	1,682,599	1.73*
Productivity			
COWS/WORK	31.7	29.5	1.45*
MILK/WORK	557,485	475,692	2.96***
MILK/COW	18,096	16,868	3.11***
Capital Efficiency			
MINV/COW	1,366	1,191	1.88*
KINV/COW	7,040	7,308	.80
KINV/WORK	216,601	209,795	.59
Debt-Equity Position			
D:A	.1563	.3999	9.40***
DEBT/COW	1,083	2,817	9.10***
EQ/OP	539,644	325,924	3.28***
Feed Cost Control			
FCCST/CWT	5.17	5.35	1.11
FCST/COW	675	676	.04
FCST/CWT	3.84	4.16	1.83*
Non-Feed Cost Control			
LCST/COW	466	493	1.25
MCST/COW	472	420	2.39**
Cropping Practice			
CORNYLD	14.5 (71)	12.8 (72)	2.27**
HAYYLD	2.67	2.59 (75)	.56
External Prices			
MBPRICE	13.91	13.80	1.10
MBSPRICE	13.60	13.55 (76)	.48
Operator Attribute			
AGE	47.7 (76)	46.2	.83
Financial Performance			
NFI	87,796	31,737	3.42***
LMIO	39,339	7,837	2.56***
ROE	5.68	-3.84	3.04***
ROI	5.74	2.58	4.32***
CFCR	4.48	.40	5.73***

[1] Farms with cash flow coverage ratio greater than 1.8256.
[2] Farms with cash flow coverage ratio less than .8572.
[3] Means represent 77 observations unless otherwise indicated in parentheses.
Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Labor and management income per operator is approximately $75,000 greater in the top quartile. In fact, the 97 farms in the bottom quartile average $ -11,299, indicating negative returns after deductions are made to NFI for unpaid family labor and a charge for equity capital is applied. As with the NFI analysis, farms with the highest LMIO are more than 100 cows larger, sell 19% more milk per cow, and receive statistically significant higher MBPRICE and MBSPRICE prices.

Farms in the top-performing quartile of rate of return on equity capital (ROE) are significantly different than those in the bottom-performing quartile at the 10% level, except for FCST/COW, MBSPRICE and CFCR. Relative to the bottom-performing farms, the top farms are: 100 cows larger, ship three times the total amount of milk, sell 18% more milk per cow, have less capital investment and debt per cow, are lower cost producers, have older operators, and generated $100,000 more in net farm income.

There were fewer significantly different variables in the ROI analysis. The two debt variables and the age variables were not significant this time. Many of the general characterizations made of the top-performing quartiles in the above analyses hold true here. The farms are more productive on a per-cow and per-worker basis, have less investment per cow, and obtain significantly higher crop yields.

Relative to the lower quartile of ROI farms, the top ROI farms possess over 100 more cows, sell about 2,900 more pounds of milk per cow, and receive $0.28 more per hundredweight. There is essentially no difference in cash flow coverage ratio between the two quartiles.

The CFCR analysis provided some different perspectives. For example, only ALLSTOCK and MILK in the "Size" category proved significantly different between quartiles, but not as dramatically as in some of the earlier analyses. The top CFCR farms average about 34 more cows than those in the bottom quartile and sell about 1,200 more pounds of milk per cow. Both debt-to-asset ratio and debt per cow figures on the bottom-performing quartile farms are twice as high as top quartile farms, which is no great surprise because CFCR is directly related to debt load.

The top CFCR farms are still significantly more profitable by every measure used in this study. However, the difference between quartile averages for these measures is less dramatic than those found in the NFI, LMIO, ROE, or ROI analyses. In particular, the labor and management income per operator and the return on investment figures for the bottom-performing CFCR quartile farms are, for the first time, both positive.

Distribution of NFI, ROI and Herd Size

Figure 2 presents the herd size groupings used throughout this analysis. Figures 3 through 8 present more in-depth information on the distribution of NFI and ROI, and the farm sizes found in the upper and lower quartiles of each.

As shown in Figure 3, approximately 5% of participating farms reported negative net farm incomes in 1989. In contrast, 10% of the farms had incomes in excess of $100,000. The largest number of farms had incomes of between $20,000 and $40,000, representing about 30%

of the total sample. The 25th and 75th percentiles for net farm income in this sample were $20,363 and $61,272, respectively.

Figures 5 and 6 elaborate on the herd sizes of the farms found in the upper and lower NFI quartiles. Two-thirds of the farms in the top net farm income quartile had at least 120 cows, and one-fifth had least at 250 cows. In fact, 95% of the herds with at least 250 cows are present here. Only two farms with less than 70 cows are found in this category, and neither had less than 40 cows. In contrast, the majority of farms in the low net farm income quartile have 40 to 69 cows. Two-thirds of the herds with less than 40 cows are found in this quartile. Also, no herds with more than 250 cows are present in the low NFI quartile.

Negative return on investment was found on 17% of DFBS farms in 1989 as shown in Figure 4. On the other hand, little more than 10% of the farms had returns in excess of 10%. The largest number of farms experienced returns of between 2.5% and 7.5%, representing about 45% of the total sample. The 25th and 75th percentiles for return on investment in this sample were 1.52% and 7.32%, respectively.

Larger farms do not dominate the top ROI quartile to the extent they do the top NFI quartile. In Figure 7, farms with at least 120 cows, which represent one-quarter of the total DFBS sample, account for one-half of the farms in the top ROI quartile. Fifteen farms with less than 70 cows, including two with less than 40 cows, are found in this quartile. In contrast, almost half of the farms in the low ROI quartile have 40 to 69 cows. Over half of the herds with less than 40 cows are found in the low ROI quartile. Also, no herds with more than 250 cows are present in the lower quartile.

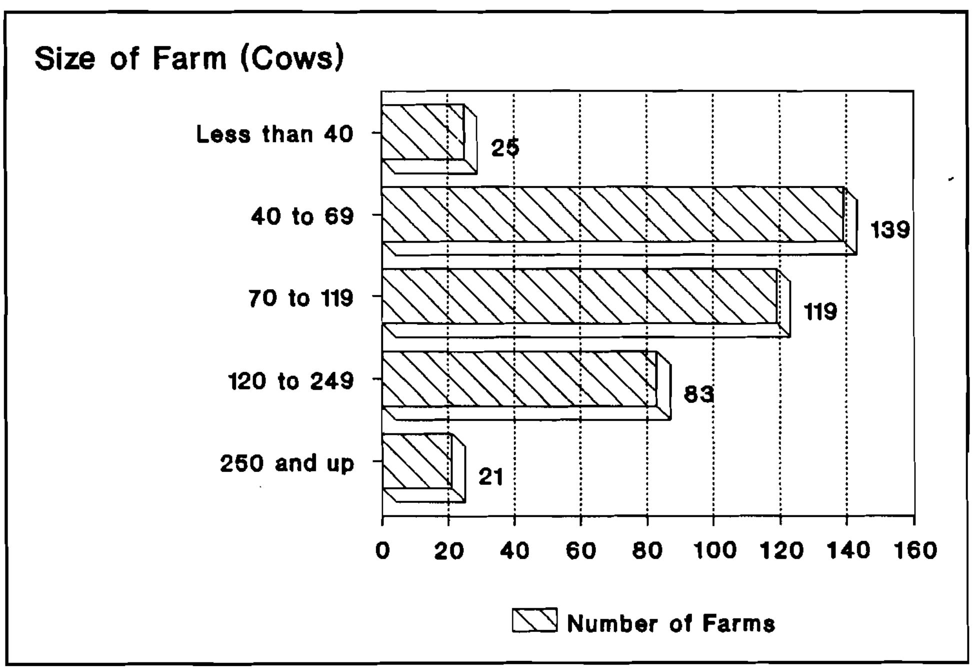

Figure 2. Herd Size Distribution, 387 DFBS Farms, 1989

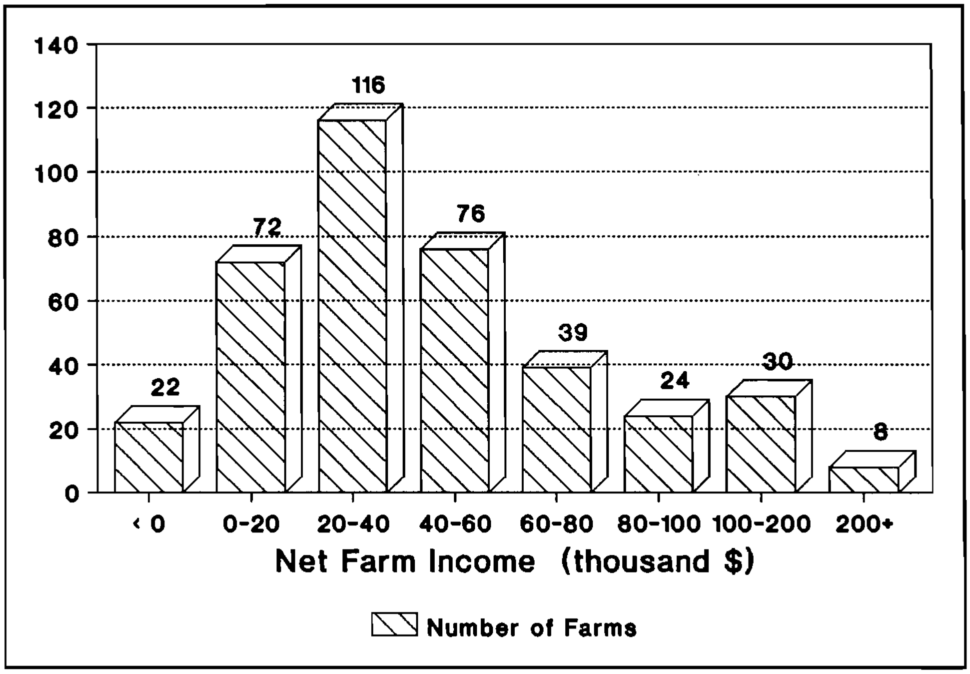

Figure 3. Number of Farms by Net Farm Income, 387 DFBS Farms, 1989

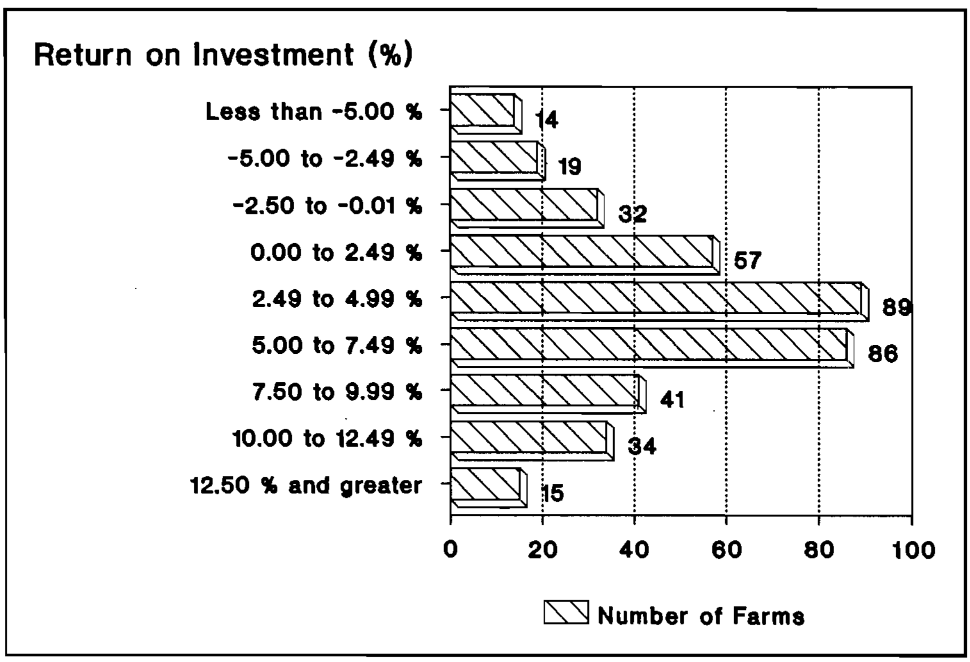

Figure 4. Number of Farms by Return on Investment (%), 387 DFBS Farms, 1989

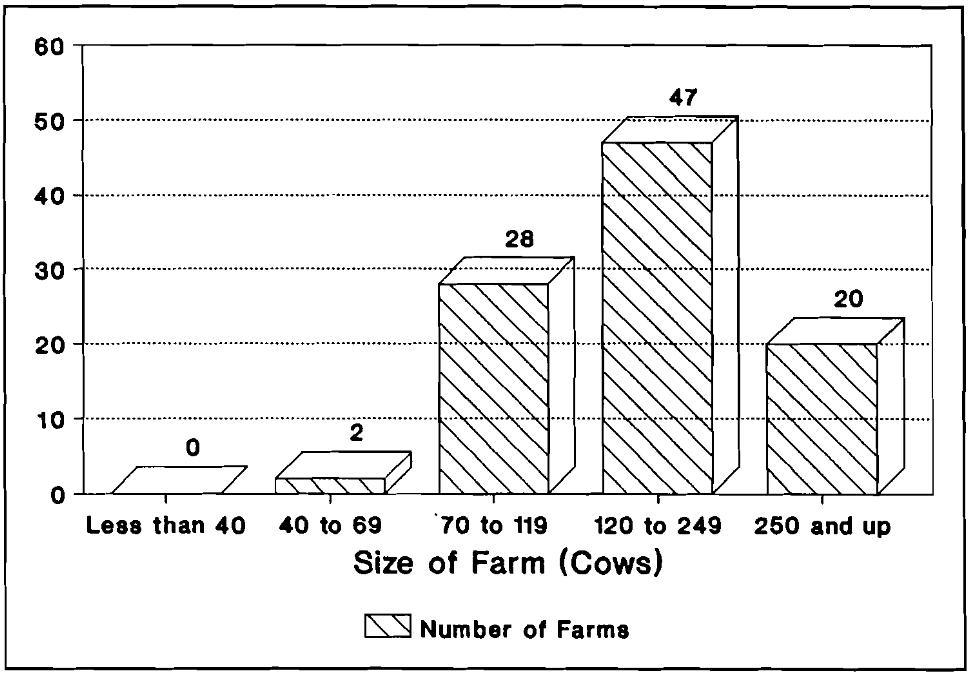

Figure 5. Herd Size Distribution, Top NFI Quartile, 97 DFBS Farms, 1989

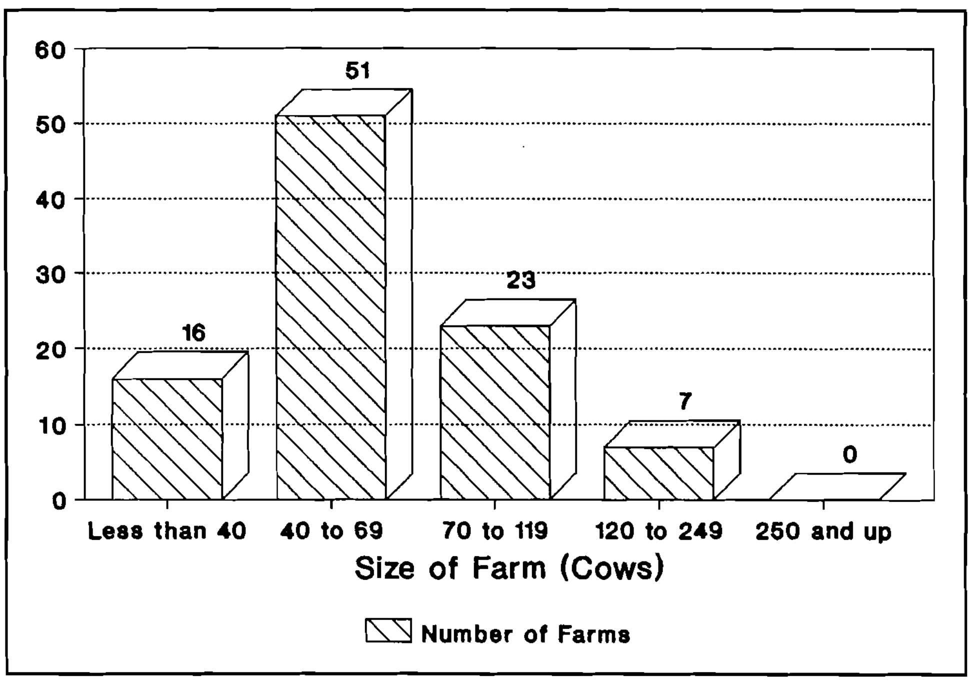

Figure 6. Herd Size Distribution, Low NFI Quartile, 97 DFBS Farms, 1989

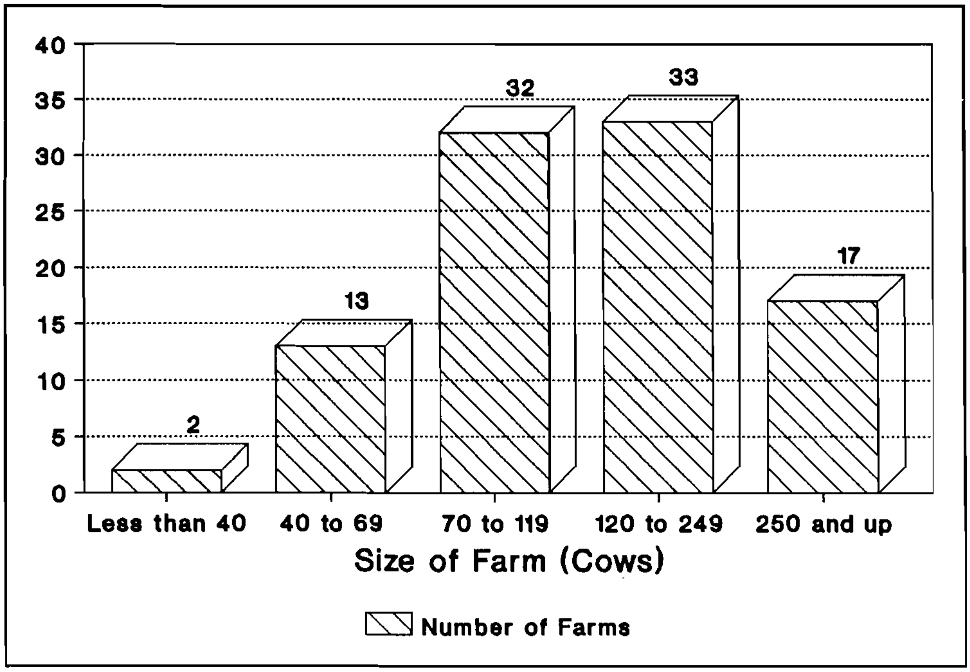

Figure 7. Herd Size Distribution, Top ROI Quartile, 97 DFBS Farms, 1989

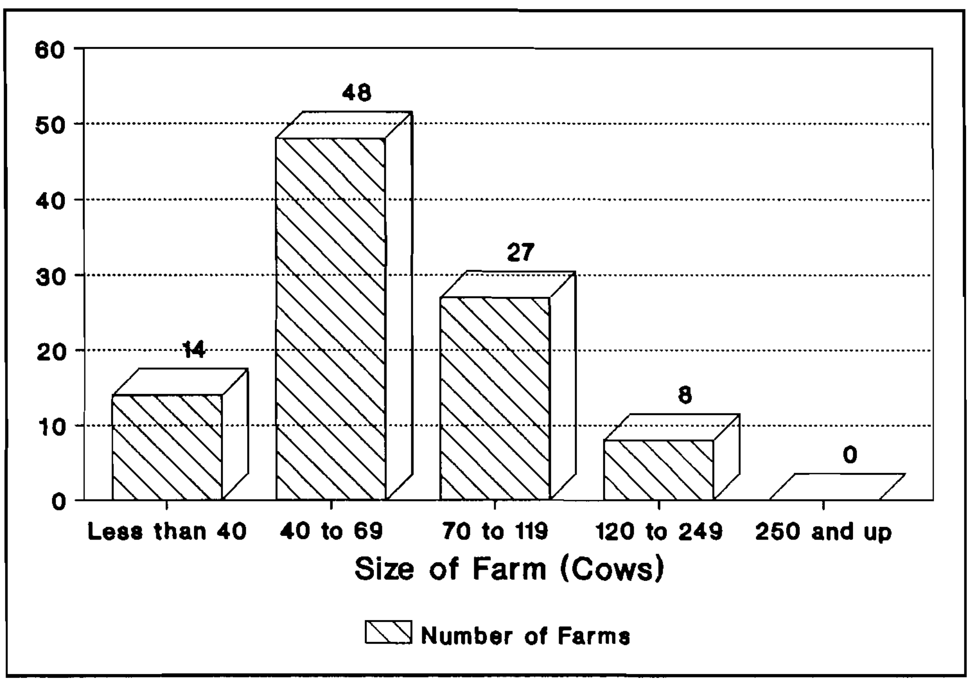

Figure 8. Herd Size Distribution, Low ROI Quartile, 97 DFBS Farms, 1989

One other analysis entailed dividing all 387 DFBS herds into two groups: those under 200 cows and those with more than 200 cows. The most telling fact to emerge out of this analysis was that the ROI 25th percentile on farms with more than 200 cows (7.22%) was larger than the ROI 75th percentile on farms with less than 200 cows (6.57%).

The results presented above reiterate the idea that net farm income and percent return on investment are closely aligned with the size of the farm business. This is especially true with the net farm income variable and is not unexpected. The top ROI quartile is also skewed toward larger farms despite the use of percent return on investment instead of absolute return.

Analysis by Size of Operation

All 387 DFBS farms were grouped by herd size into the five categories previously illustrated in Figure 2. The number of herds with less than 40 cows is approximately equal to the number with more than 250 cows. Herds with between 40 to 69 cows and herds with between 70 and 119 cows, each account for about one-third of the total number of observations.

Initial Data Summary

The degree of association between herd size and the cost and efficiency variables, and with the five financial performance measures, was quantified using simple Pearson correlation coefficients. Previously published research has linked increased herd size with lower unit costs and higher profitability (Johnson and Haden). The information reported in Table 12 is the correlation coefficient and its level of significance (if any) using a two-tailed test under a null hypothesis that the coefficient is equal to zero.

All variables in the "Productivity" category are significant and positively associated with herd size, with COWS/WORK and MILK/WORK having the largest correlation coefficients. In contrast, the association between the two "per cow" "Capital Efficiency" variables and herd size is significant and negative.

There is nothing particularly noteworthy in the "Debt-Equity" group of variables. Much the same can be said of total feed and crop expense per hundredweight and purchased feed expense per hundredweight, which have barely positive insignificant coefficients.

Both machinery and labor expense per cow are negatively correlated with herd size, but only the former is significant. Of the two crops, only hay dry matter yield is significantly correlated (positively), with herd size, while both milk prices are also positively associated with larger operations.

The performance yardsticks measured in dollars, NFI and LMIO, are very much linked with herd size. The rate of return measures, ROI and ROE, are also strongly positively associated with herd size, but much less in magnitude. CFCR is not significantly related to herd size.

The apparently large number of variables that are significantly correlated with herd size should be interpreted with caution. It is relatively easy to obtain a statistically significant coefficient with 387 observations. With a two-tailed test and a null hypothesis of zero correlation, the minimum significant coefficient (absolute value) is .0994 at the 5% level and .1302 at the 1% level. Thus, a correlation coefficient of .15 is statistically significant at the 1% level, but this may have little economic importance, a phenomenon deemed the "cult of the asterisk" by Dillon.

Table 12. Simple Pearson Correlation Coefficients, Descriptive and Performance Measures with Herd Size

Category or Variable	Pearson Correlation Coefficient
Size	
ALLSTOCK	.988***
MILK	.989***
Productivity	
COWS/WORK	.494***
MILK/WORK	.574***
MILK/COW	.226***
Capital Efficiency	
MINV/COW	-.250***
KINV/COW	-.283***
KINV/WORK	.179***
Debt-Equity Position	
D:A	.032
DEBT/COW	-.078
EQ/OP	.745***
Feed Cost Control	
FCCST/CWT	.008
F/COW	.115**
F/CWT	.014
Non-Feed Cost Control	
LCST/COW	-.023
MCST/COW	-.172***
Cropping Practice	
CORNYLD	.073
HAYYLD	.169***
External Prices	
MBPRICE	.220***
MBSPRICE	.223***
Operator Attribute	
AGE	.069
Financial Performance	
NFI	.876***
LMIO	.789***
ROE	.278***
ROI	.465***
CFCR	.071

Level of significance; '***': p≤.01, '**': p≤.05, '*': p≤.10.

Analysis of Two Herd Size Categories

Comparisons Between Herd Size Categories

Prior analyses sorted farms according to financial performance levels. The average herd sizes found in the bottom and top quartiles of the LMIO, ROI and ROE financial performance indicators were approximately 70 and 170 cows, respectively. It will be recalled that these were also the respective average herd sizes found in the comparison of pipeline/conventional barns with parlor/freestall barns. To see whether or not similar differences would be observed when the data were explicitly sorted by herd size first, herds were sorted in two groups centered on 70 and 170 cows. Each sample represents approximately 10% of the total data set (40 observations), and was selected such that sample means are approximately equal to the average herd size for the financial indicators listed above. The smaller farms range in size from 69 to 78 cows, and the larger farms from 144 to 220 cows.

Means from the two samples were compared with ordinary t-tests, appropriate for equal cell sizes. The results of this analysis are presented in Table 13.

Given that these samples were constructed on the basis of herd size, it is not surprising that they significantly differ for all "Size" measures. In addition, while the larger farms have significantly higher COWS/WORK and MILK/WORK averages, MILK/COW is not.

The smaller farms carry higher investment in machinery per cow (significant) and investment per cow (non-significant), but investment per worker is significantly lower. Debt per cow levels and the debt-to-asset ratio are not significantly different between farm samples. Equity per operator is half that found on the larger operations.

None of the "Feed Cost Control" or "Non-Feed Cost Control" factors are significantly different between samples, although feed costs are a little higher for the larger farms. Both corn silage and hay yields are higher on the larger farms, but only corn silage is significant at the 10% level.

Both MBPRICE and MBSPRICE are significantly higher in the larger farm sample, with means of $0.44 and $0.36 higher, respectively. The standardized milk price statistic indicates that the larger farms are receiving higher milk prices, after netting out marketing expenses, for reasons <u>not</u> due to higher fat content.

Both "Financial Performance" income variables (NFI and LMIO) are approximately twice as large on the bigger farms, and statistically significant. Also, the ROI and ROE rate of return measures are significantly higher on the larger farms. Finally, the CFCR on the larger farms is over twice that on the smaller farms, but still not significantly different at the 10% level.

Distributions Within Herd Size Categories

A further inquiry was conducted to determine differences that existed between farms <u>within</u> the two samples outlined above. Within each sample, farms were ranked by ROI and then the sample was split in two, creating two sub-samples of 20 farms each. Ordinary t-tests were used to analyze differences between the sub-samples.

Table 13. Mean Values of Descriptive and Performance Measure Variables, 69 to 78 Cow and 144 to 220 Cow Herd Sizes

Category or Variable	Mean Values: 144 to 220 Cow Herds	Mean Values: 69 to 78 Cow Herds	Absolute Value of t-statistic
Number of Observations[1]	40	40	
Size			
COWS	169	73	29.19***
ALLSTOCK	305	131	20.33***
MILK	2,888,140	1,204,343	22.28***
Productivity			
COWS/WORK	36.1	29.5	3.86***
MILK/WORK	612,540	474,796	5.35***
MILK/COW	17,047	16,436	1.09
Capital Efficiency			
MINV/COW	1,116	1,349	2.37**
KINV/COW	6,483	6,824	.95
KINV/WORK	230,519	201,249	2.05**
Debt-Equity Position			
D:A	.3295	.3004	.74
DEBT/COW	2,139	2,015	.48
EQ/OP	524,896	281,574	4.98***
Feed Cost Control			
FCCST/CWT	5.69	5.63	.19
FCST/COW	730	699	.70
FCST/CWT	4.29	4.28	.01
Non-Feed Cost Control			
LCST/COW	445	448	.09
MCST/COW	436	436	.00
Cropping Practice			
CORNYLD	13.9	12.2 (38)	1.93*
HAYYLD	2.75 (39)	2.46	1.39
External Prices			
MBPRICE	14.17	13.73	3.18***
MBSPRICE	13.87	13.48	3.03***
Operator Attribute			
AGE	47.0	45.0	.87
Financial Performance			
NFI	68,744	32,527	4.63***
LMIO	18,695	8,125	1.78*
ROE	4.37	1.31	1.92*
ROI	5.75	3.73	2.15**
CFCR	3.57 (30)	1.52 (27)	1.23

[1] All means represent 40 observations unless otherwise indicated in parentheses.
Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Table 14. Mean Values of Descriptive and Performance Measure Variables, 69 to 78 Cow Herd Sizes, Ranked by Return on Investment (%)

Category or Variable	Mean Values: Top Performing[1]	Mean Values: Low Performing[2]	Absolute Value of t-statistic
Number of Observations[3]	20	20	
Size			
COWS	73	74	.52
ALLSTOCK	130	132	.28
MILK	1,233,543	1,175,143	.94
Productivity			
COWS/WORK	28.3	30.6	.90
MILK/WORK	469,243	480,348	.31
MILK/COW	16,898	15,977	1.15
Capital Efficiency			
MINV/COW	1,184	1,514	2.21**
KINV/COW	6,168	7,480	2.81***
KINV/WORK	176,680	225,818	2.34**
Debt-Equity Position			
D:A	.2886	.3121	.44
DEBT/COW	1,764	2,266	1.51
EQ/OP	264,727	298,420	.77
Feed Cost Control			
FCCST/CWT	5.46	5.81	.81
FCST/COW	715	684	.45
FCST/CWT	4.26	4.31	.12
Non-Feed Cost Control			
LCST/COW	464	432	.81
MCST/COW	392	479	2.12**
Cropping Practice			
CORNYLD	13.1 (18)	11.4	1.24
HAYYLD	2.66	2.26	1.27
External Prices			
MBPRICE	13.79	13.67	.85
MBSPRICE	13.53	13.42	.84
Operator Attribute			
AGE	45.5	44.6	.31
Financial Performance			
NFI	48,059	16,995	5.54***
LMIO	22,592	-6341	6.86***
ROE	6.95	-4.33	6.62***
ROI	6.96	.49	7.86***
CFCR	1.68 (14)	1.36 (13)	1.18

[1] Farms with return on investment greater than 3.72%.
[2] Farms with return on investment less than 3.56%.
[3] All means represent 20 observations unless otherwise indicated in parentheses.
Level of significance; '***': p≤.01, '**': p≤.05, '*': p≤.10.

Table 15. Mean Values of Descriptive and Performance Measure Variables, 144 to 220 Cow Herd Sizes, Ranked by Return on Investment (%)

Category or Variable	Mean Value: Top Performing[1]	Mean Value: Low Performing[2]	Absolute Value of t-statistic
Number of Observations[3]	20	20	
Size			
COWS	171	168	.39
ALLSTOCK	306	304	.11
MILK	3,002,330	2,773,951	1.69*
Productivity			
COWS/WORK	35.5	36.8	.56
MILK/WORK	619,788	605,292	.38
MILK/COW	17,588	16,497	1.60
Capital Efficiency			
MINV/COW	1,094	1,139	.38
KINV/COW	6,083	6,882	1.59
KINV/WORK	216,009	245,028	1.66
Debt-Equity Position			
D:A	.3958	.2632	2.37**
DEBT/COW	2,450	1,827	1.66
EQ/OP	466,398	583,395	1.35
Feed Cost Control			
FCCST/CWT	5.71	5.66	.14
FCST/COW	753	708	.80
FCST/CWT	4.30	4.28	.05
Non-Feed Cost Control			
LCST/COW	452	438	.34
MCST/COW	425	446	.72
Cropping Practice			
CORNYLD	13.0	14.8	1.71*
HAYYLD	2.83	2.66 (19)	.65
External Prices			
MBPRICE	14.31	14.02	1.23
MBSPRICE	14.00	13.73	1.23
Operator Attribute			
AGE	46.2	47.8	.46
Financial Performance			
NFI	89,657	47,830	3.44***
LMIO	38,028	-637	4.76***
ROE	8.55	.19	5.42***
ROI	8.83	2.67	6.65***
CFCR	1.22 (16)	6.25 (14)	1.68

[1] Farms with return on investment greater than 6.13%.
[2] Farms with return on investment less than 6.03%.
[3] All means represent 20 observations unless otherwise indicated in parentheses.
Level of significance; '***': p<=.01, '**': p<=.05, '*': p<=.10.

The two sub-samples in the 69 to 78 cow group are very similar for all "Size," "Productivity," "Feed Cost Control," "Cropping Practice," and "Operator Attribute" variables with no significant differences. The higher ranking ROI farms have statistically lower levels of machinery investment per cow, capital investment per cow, and capital investment per worker. In addition, the higher ranking ROI farms have statistically higher equity per operator and lower machinery expense per cow.

The higher ranking ROI farms are superior for all "Financial Performance" variables and all differences are statistically significant except cash flow coverage ratio. The lower ranking ROI farms have negative labor and management income per operator and negative percent return on equity, while return on investment is barely positive.

A somewhat different set of significant variables emerges from the two sub-samples in the 144 to 220 cow group. The top ROI herds sell more milk, have a much higher debt-to-asset ratio and possess more equity per operator. The lower ROI herds have significantly higher corn silage yields.

All "Financial Performance" variables except cash flow coverage ratio are statistically superior for the higher ranking ROI farms. In contrast, cash flow coverage ratio is much higher (though not significantly) on the lower ROI farms. This is consistent with the much lower debt-to-asset ratios reported above for lower ROI farms.

Analysis of All Herd Size Categories

Data for herd size classes were tested by analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS). All pair-wise comparisons of class means were simultaneously estimated using the Tukey-Kramer (TK) procedure. The TK procedure uses the studentized (Q) range as its sampling distribution, and has several useful statistical attributes making it attractive for the current analysis.[1]

Class means and F-statistics for each descriptive and performance variable are listed in Table 16, and results of all pair-wise comparisons between class means are reported in Table 17.

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[1] The TK procedure maintains the experiment-wise error rate (probability of at least one false claim of significance), α_e at some pre-established α level for all pair-wise comparisons (Stoline). Secondly, the TK method facilitates the analysis of multiple comparisons of class means with disparately unequal number of observations in a one-way imbalanced ANOVA model (Hinkle et al.). Such analysis may be conducted without empirical Type I error probabilities exceeding their nominal significance level, even when the ratio of sample sizes approaches 40:1 (Keselman et al.). Finally, while the TK procedure has been proven to be statistically conservative, it generates narrower confidence intervals than other statistical procedures (Dunnett). In sum, Hochberg and Tamhane write, "(we) recommend the use of the TK-procedure over other alternative procedures proposed for pair-wise comparisons" (p. 93).

Table 16. Mean Values of Descriptive and Performance Measure Variables, by Herd Size

Category or Variable	Herd Size Categories (Number of Cows): Less than 40	40 to 69	70 to 119	120 to 249	250 and Up	F statistic
Class Number	I	II	III	IV	V	
Number of Observations	25	139	119	83	21	
Size						
COWS	33	55	90	159	429	222.61***
ALLSTOCK	57	100	163	287	755	235.65***
MILK	526,019	902,398	1,537,496	2,733,840	8,213,544	195.72***
Productivity						
COWS/WORK	20.6	25.9	31.7	35.7	44.7	54.33***
MILK/WORK	331,102	424,339	535,892	606,894	839,442	76.98***
MILK/COW	16,037	16,463	17,007	17,197	19,150	17.83***
Capital Efficiency						
MINV/COW	1,749	1,346	1,275	1,161	749	9.81***
KINV/COW	8,158	7,308	6,611	6,421	5,367	10.10***
KINV/WORK	164,558	188,330	209,263	224,833	237,609	7.75***
Debt-Equity Position						
D:A	.3166	.3377	.3018	.3334	.3516	.72
DEBT/COW	2,377	2,361	1,971	2,128	1,875	1.87
EQ/OP	165,724	223,524	322,307	490,924	1,105,136	66.98***
Feed Cost Control						
FCCST/CWT	5.22	5.13	5.38	5.39	5.20	1.26
FCST/COW	663	645	684	688	759	1.96*
FCST/CWT	4.20	3.90	4.05	4.02	4.05	.56
Non-Feed Cost Control						
LCST/COW	606	479	441	448	504	9.77***
MCST/COW	484	461	441	441	357	3.60***
Cropping Practice						
CORNYLD	13.8	12.9	13.4	14.3	15.1	2.10*
HAYYLD	2.33	2.48	2.67	2.96	3.12	6.45***
External Prices						
MBPRICE	13.67	13.80	13.83	14.09	14.23	5.88***
MBSPRICE	13.44	13.53	13.52	13.79	13.95	5.15***
Operator Attribute						
AGE	42.6	44.6	46.2	48.3	45.5	2.40**
Financial Performance						
NFI	16,135	25,951	42,099	72,646	241,974	67.51***
LMIO	4,280	8,175	13,706	24,094	141,547	37.20***
ROE	-3.82	-2.44	2.94	5.17	12.73	8.96***
ROI	.13	2.70	4.81	6.37	10.84	27.82***
CFCR	1.63	1.44	1.70	2.36	2.39	.93

Level of significance; '***': $p \leq .01$, '**': $p \leq .05$, '*': $p \leq .10$.

Table 17. Tukey-Kramer Analysis of Pair-wise Comparisons of Herd Size Classes

Category or Variable	Comparison of Classes: I and II	I and III	I and IV	I and V	II and III	II and IV	II and V	III and IV	III and V	IV and V
Size										
COWS		***	***	***	***	***	***	***	***	***
ALLSTOCK		***	***	***	***	***	***	***	***	***
MILK		***	***	***	***	***	***	***	***	***
Productivity										
COWS/WORK	**	***	***	***	***	***	***	***	***	***
MILK/WORK	***	***	***	***	***	***	***	***	***	***
MILK/COW				***		**	***		***	***
Capital Efficiency										
MINV/COW	**	***	***	***			***		***	**
KINV/COW		***	***	***	**	***	***		**	
KINV/WORK		**	***	***	*	***	**			
Debt-Equity Position										
D:A										
DEBT/COW										
EQ/OP		**	***	***	**	***	***	***	***	***
Feed Cost Control										
FCCST/CWT										
FCST/COW							*			
FCST/CWT										
Non-Feed Cost Control										
LCST/COW	***	***	***	*						
MCST/COW				***			***		**	*
Cropping Practice										
CORNYLD										
HAYYLD			**	**		***	**			
External Prices										
MBPRICE			**	**		***	**	**	**	
MBSPRICE			*	**		**	**	**	**	
Operator Attribute										
AGE						*				
Financial Performance										
NFI			***	***		***	***	***	***	***
LMIO				***			***		***	***
ROE			**	***	**	***	***		**	
ROI	*	***	***	***	***	***	***	*	***	***
CFCR										

Level of significance; '***': p≤.01, '**': p≤.05, '*': p≤.10.

Generally speaking, sorting by herd size does a very good job of obtaining statistically significant F-statistics. Two-thirds (19/27) of the variables used in this analysis are statistically significant at the 1% level across class means. This figure climbs up to 74% (20/27) and 81% (22/27) when the significance level is increased to 5% and 10%, respectively.

Not unexpectedly, all "Size" variables proved significant at the 1% percent level with F-statistics around 200 and above. In fact, all possible pair-wise comparisons are significant at the 1% level for COWS, ALLSTOCK, and MILK.

The three "Productivity" variables all have overall F-statistics significant at the 1% level. There is a particularly strong association between both milk sold per worker and cows per worker, with larger herd size. Reinforcing this conclusion, with one exception at the 5% level, all pair-wise contrasts for COWS/WORK and MILK/WORK are significant at the 1% level. Average MILK/WORK for the largest herd class is more than 2.5 times that of the under 40 cow herds, approximately double that of farms in the 40 to 69 cow category, and one-third higher than 120 to 249 cow farms. Similarly, the average COWS/WORK for farms with over 250 cows is more than twice that of under 40 cow herds, and is approximately 25% higher than that found in herds with 120 to 249 cows.

MILK/COW, which is milk sold per cow weighted by herd size, has a range of almost 3,000 pounds between the smallest and largest herds. Four of the five significant class comparisons involve the largest herd; the other is between the 70 to 119 cow class and the 120 to 249 cow class.

All three "Capital Efficiency" variables are significant at the 1% level. Both machinery and capital investment per cow figures successively decline as herd size group increases. The pair-wise comparisons indicate that the mean values for these two statistics are significantly higher for the under 40 cow herd class (except for the KINV/COW contrast with the 40 to 69 cow herd class) and significantly lower for the over 250 cow herd class (except for the KINV/COW contrast with the 120 to 249 cow herd class). Conversely, there is a positive relation between total capital investment per worker and herd size. The two smallest herd sizes have significantly smaller KINV/WORK means, but they are not significantly different from one another.

The variables in the "Debt-Equity" and "Feed Cost Control" categories seem largely unaffected by herd size grouping. There is no discernable pattern between debt-to-asset ratio and herd size, although the highest average is found on farms with at least 250 cows. Average debt per cow is highest on farms with less than 70 cows, but not significantly so. EQ/OP is the only variable in these two categories with a significant F-statistic at the 1% level. All herd size contrasts for this variable are significant at the 5% level, with the exception of that between the two smallest groups.

Of the variables in the "Feed Cost Control" category, neither FCCST/CWT nor FCST/CWT display any relation with herd size class. FCST/COW is barely significant at the 10% level, and the only significant contrast (at the 10% level) is between farms with 40 to 69 cows with an average expense of $645, and farms with more than 250 cows which average $759.

Both "Non-Feed Cost Control" variables have significant F-statistics. Labor expense per cow is significantly higher on farms with under 40 cows compared with every other herd class. In contrast, machinery expense per cow is significantly lower on the very largest farms relative to all other herd classes.

Corn silage and hay dry matter yields are significant at the 10% and 1% levels, respectively. However, for corn silage yield, no one pair-wise comparison was significantly different. For hay yield, both herd classes over 120 cows have significantly higher yields than the herd classes under 70 cows.

MBPRICE, average milk price less marketing charges, steadily increases as herd size expands. Dairy farms with more than 120 cows received a significantly higher average net milk price than did farms with less than 120 cows. More specifically, farms with 250 and more cows received an average of $0.56 and $0.43 more per hundredweight than herds with less than 40 cows and 40 to 69 cows, respectively. However, farms with more than 250 cows did not receive a significantly higher average price than operators with 120 to 249 cows.

The standardized net milk price, MBSPRICE, behaved like MBPRICE in that it increased as herd size got larger (with one exception) and the same herd class contrasts were significant. These significant contrasts reveal differences in price other than those attributable to fat content. The higher prices could be due to quality bonuses, subsidized marketing charges or outright payments, but data limitations prevent further investigation.

Curiously, age of principal operator had a F-statistic significant at the 5% level. The only significant contrast involves operators of 40 to 69 cow herds who average 44.6 years compared with operators of 120 to 249 cow herds who average 48.3 years. The results for this variable are counter-intuitive, although not inexplicable, due to the very unequal number of observations per herd class. Although average age for operators of farms with less than 40 cows is 42.6 and average age for operators with over 250 cows is 43.3, these means are not significantly different from the 120 to 249 cow group because there are so few observations in each class.

All "financial performance" variables with the exception of CFCR have highly significant F-statistics and are positively associated with herd size. The net farm income of farms with 250 or more cows is almost one-quarter million dollars, which is more than three times that of farms with 120 to 249 cows and fifteen times more than farms with less than 40 cows. Only three of the ten contrasts are not significantly different from one another. The herd size categories and amounts involved, include: under 40 cows, $16,135; 40 to 69 cows, $25,951; and, 70 to 119 cows, $42,099.

The relative differences for LMIO class means are actually wider than for NFI class means. The mean value for the largest herd size class is more than thirty times the under 40 cow category, and approximately six times the 120 to 249 class mean. The only significant contrasts involve the largest herd size class relative to the four smaller herd classes.

The average percent return on equity (without appreciation) is negative for dairy farms in the two smallest herd classes, and turns positive for farms in the 70 to 119 cow category. The contrasts have some interesting results. The ROE for the 250 and more cow class (12.73%)

is significantly larger than all others except for the 120 to 249 cow class (5.17%). Also of interest is that average ROE for under 40 cow herds (-3.82%) is not significantly different from mean values for 40 to 69 cow herds (-2.44%) and 70 to 119 cow herds (2.94%), but that these latter two are significantly different from each other at the 5% level.

Average percent return on investment (without appreciation) is positive for all five herd size categories. ROI is only one of three of the twenty-seven variables used in this study which has ten significant pair-wise comparisons. As with the other "Financial Performance" variables, ROI increases markedly as herd size increases.

The F-statistic for cash flow coverage ratio is non-significant. There appears to be a general tendency for CFCR to increase as herd size increases, although the less than 40 cow group possesses a higher ratio than the 40 to 69 cow group.

Summary and Conclusions

This research has examined the interrelationships between selected structural, technical and financial performance characteristics on 387 New York dairy farms. Structural and technical attributes under the control of the farm manager, including number of cows milked, cows per worker, milk sold per cow and choice of milking technology, provide one indication of a manager's relative ability and success at farming. However, this information can be coupled with financial performance data to obtain a more definitive picture of the overall health of the dairy farm business.

The farms with the best financial performance, defined here as being among the top 25% of farms for that measure, were:

- larger in size
- sold more milk per cow and per worker
- carried less capital investment and debt per cow
- incurred lower machinery and labor costs per cow
- required less purchased feed per hundredweight of milk
- harvested more hay and corn silage per acre
- received higher milk prices

In general, the same structural and technical variables were significantly different between the upper and lower quartile, regardless of the financial performance variable under review. The one major exception to this trend was the measure of liquidity, cash flow coverage ratio, which had significant differences between the upper and lower quartiles for only half as many structural and efficiency variables as the four profitability measures.

Given the finding that high performing farms averaged much larger, farm records were also sorted and analyzed according to herd size. Herd size was selected because it is one of the most commonly used and understood structural variables, and because of some disagreement in the literature on the existence of economies of scale in dairying.

Matulich found significant unit cost reductions through herd sizes of 750 cows in California, while Haden and Johnson found a strong, positive relationship between net farm income and herd size on Tennessee dairy farms. On the other hand, in their examination of New York dairy farms using first-degree stochastic dominance analysis, Kauffman and Tauer found a significant, positive relationship between herd size and labor and management income per operator and with return on equity without appreciation (two of the measures used here), but little relationship with labor and management income per operator per cow or return on equity with appreciation. Stanton generalized that given typical resource conditions found in the Northeast, most significant reductions in unit costs occur by the time herd size reaches 100 to 150 cows.

On a related note, Weersink and Tauer assessed the linkage between increase in productivity per cow, adoption of technology at the farm level and increasing average herd sizes. Using multivariate causality tests of milk production per cow and average herd size, they concluded that in New York higher milk production per cow leads to larger herd size and that larger herd size leads to higher levels of milk production. They explain this by noting that to adopt certain technologies such as milking parlors requires larger herd sizes, and once adopted, the advanced technology contributes to increased milk production.

In this study, the two income measures, the two "scale neutral" financial performance variables (ROI and ROE) and the cash flow coverage ratio increased progressively with herd size. Two debt-equity measures, two feed cost control measures, and cash flow coverage ratio were the only variables to not have an overall significant F-statistic. Larger farms were significantly more productive, carried less machinery and capital investment per cow, but had higher capital investment per worker. They also had significantly lower machinery and labor expense per cow, experienced higher crop yields and received higher milk prices.

A final analysis was a hybrid of the two described above. It will be recalled that farms with a milking parlor/freestall barn combination averaged approximately 170 cows and that farms with a pipeline/conventional barn combination averaged approximately 70 cows. These were also the respective means for the high performing and low performing farm quartiles. To better explore the proposition that all farms in each size range perform similarly, two clusters of forty farms each were developed such that each was centered on the respective means listed above. Comparisons were then made within and between clusters. The analysis across clusters came away with similar results as presented above, except that milk sold per cow, feed cost control and non-feed cost control variables were not significantly different. Farms within clusters were ranked by percent return on investment and clusters were divided in two. The two groups in the 70 cow cluster were only different for eight variables, including four of the financial performance variables. For the 170 cow cluster, only six variables, four of which were financial performance variables, were significantly different across the two groups.

The above analysis indicates that number of milking cows shares a large, positive relationship with the four accrual financial performance measures in this analysis. It is true that larger farms have a larger cash flow coverage ratio, thus are considered "more liquid", but the differences between herd size groups were not significant.

From a farm management perspective, can we conclude that all large farms are profitable, or that to become profitable, a farm operation needs to be expanded? Stanton has observed that with substantial variability in profitability within any individual size group, "there are always opportunities for successful managers on small farms to equal the profits of average managers on much larger farms." (p. 18) Implicit in this statement is an acknowledgement that, everything else being equal, larger farms tend to be more profitable than smaller farms. However, he goes on to note that the "interests, skills, and capacities of individual farm operators are different ... (and) so are the physical resources... Each situation is somewhat unique." (p. 18) Given this, few generalizations can legitimately be made regarding the linkage between herd size and profitability. In this analysis, larger farms were more profitable using the financial performance measures employed here, but is this due to better managerial ability? Yes, if managerial ability is gauged by the performance measures used in this study. The larger farms have more highly automated milking systems, sell more milk per cow, grow more hay and corn silage per acre. Differences in these factors contribute to the overall success of larger dairy farms in this sample.

Suggestions for Further Research

The primary characteristic typically used in defining representative dairy farms is herd size (Jeffrey). The preceding analysis suggests that top and low performing representative farm types can be identified according to farm characteristics, in particular herd size. For example, in both the comparison of milking system/barn type combinations and the comparison of financial performance quartiles, lower performing farms were typified by 70 cow herds milked in a conventional barn using a pipeline. In contrast, top performing farms were characterized by herds of approximately 170 cows, housed in a freestall barn and milked in a parlor.

This is not to suggest that all 170 cow herds are superior or that all 70 cow herds are inferior with respect to financial performance. After all, the small sample of top performing (based on ROI) 70 cow farms analyzed in Table 14 sold more milk per cow, and had higher levels of return on investment and return on equity than the bottom performing 170 cow herds listed in Table 15. However, on average, the larger herds which are milked with more technologically advanced systems will tend to have better financial performance results than their smaller counterparts. Assignment of higher performance levels to larger farms when constructing representative farms is certainly not unprecedented, especially when the data warrant such a conclusion (Jeffrey).

It is important to note the wide variability in particular performance variables, even within a small band of herd sizes. For example, the 70 cow herds analyzed in Table 14 had significant differences in the four financial performance indicators used in this study. Obviously, these farms are far from homogeneous in their performance outcomes. To what do we ascribe these differences in outcomes? What variable(s) is (are) most important in further differentiating between farms of similar sizes? In his study of Minnesota dairy farms, Jeffrey further distinguished representative farms of the same herd size by level of milk production per cow, intermediate debt load and long-term debt load. Four herd size levels resulted in 24 representative farms.

Given the above information, it appears likely that representative New York dairy farms created on the basis of herd size will need to be further differentiated by other variables. The choice of secondary farm characteristics to further differentiate similar-sized farms will no doubt be a central issue. Although this stage is still very preliminary, milk sold per cow, soil productivity and region of the state, milking system technology, and debt level are all possible candidates to further distinguish between farms of a given herd size.

Further work will entail enumerating detailed dairy farm characteristics to allow for more complete and realistic analysis. It is envisioned that the representative dairy farms constructed via the process above will subsequently be analyzed using various methods of analysis (e.g. simulation, linear programming), given expected policy or economic scenarios likely to be important in the future. The results of these future analyses will better enable researchers and policy makers to evaluate the differential impact of alternative economic situations or dairy policies on selected herd sizes. In addition, if low performing farms are projected to be unable to survive, a determination of changes in performance that would be required for survival would be valuable in both dairy policy and farm management.

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