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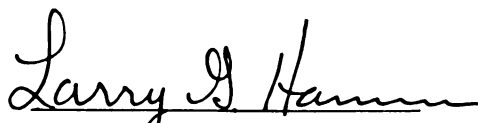
POTENTIAL SOURCES OF STRATEGIC ADVANTAGE FOR MICHIGAN
DAIRY FARMERS: AN ANALYSIS OF MANAGERIAL PRACTICES
AND DEMOGRAPHIC CHARACTERISTICS FROM THE 1987 MICHIGAN
STATE UNIVERSITY SURVEY OF MICHIGAN DAIRY FARMERS

presented by

John Larrabee Mykrantz

has been accepted towards fulfillment
of the requirements for

Masters degree in Agricultural Economics


Major professor

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FROM THE 1987 MICHIGAN STATE UNIVERSITY
SURVEY OF MICHIGAN DAIRY FARMERS

By

John Larrabee Mykrantz

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ABSTRACT

POTENTIAL SOURCES OF STRATEGIC ADVANTAGE FOR MICHIGAN DAIRY FARMERS: AN ANALYSIS OF MANAGERIAL PRACTICES AND DEMOGRAPHIC CHARACTERISTICS FROM THE 1987 MICHIGAN STATE UNIVERSITY SURVEY OF MICHIGAN DAIRY FARMERS

By

John Larrabee Mykrantz

Recent trends in and projections of capacity adjustments, both intra-regionally and more importantly inter-regionally, portend a loss of dairy production capacity in the traditional dairy regions of the Upper Midwest and the Northeast. The present analysis of certain aspects of the 1987 Michigan State University Survey of Michigan Dairy Farmers attempts to add to the present knowledge as to the current structure of and relationships within Michigan's dairy farm and farmer population. Using both regression and factor analysis, areas of research that have the potential of benefitting Michigan's dairy farmer in the 1990's are identified and assessed. The conclusions drawn from this analysis have as their primary purpose to provide a basis for further hypothesis testing as to operative and significant factors affecting dairy production in Michigan.

For C.S.G. and
in loving memory of
Jinx Mykrantz
(1902-1988)

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There are many thank-you's to be made, some of which I will no doubt forget. I apologize in advancement for an inadvertent exclusions.

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A heartfelt thanks goes to all the students with whom I had the pleasure of interacting; without them I would have never come so far.

Finally, to forget to make mention of the Spartan coaches, the fathers of our proud teams; Sparty, the only son; and Jack Breslin, the holy spirit of Michigan State University, the premier Land Grant institution founded in 1855, would be a sin (of omission).

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The 1970's and the 1980'S have been a period of significant change for the U.S. dairy industry, most particularly for the traditional dairy regions of the Upper Midwest and the Northeast. Change has taken the form of not only intra-regional capacity adjustments but also inter-regional shifts in capacity, both actual and predicted (Hamm and Mykrantz 1989; OTA 1986). In the 1980's these shifts have begun to threaten the dairy industry within the traditional regions in general and within Michigan in particular. Due to these perceived threats to an industry vital to Michigan's agricultural and general economies, efforts have been made to avert a down-sizing in production capacity. Michigan Dairying 1995 and the Survey of Northern Dairy Farms have been part of a multi-faceted response designed to aid Michigan dairy farmers in adapting to the national and regional trends in the dairy industry. The primary objective of the present analysis is to identify areas of research which can potentially benefit Michigan's dairy industry in the process of adaptation and reconfiguration.

1.2 OVERVIEW OF THE U.S DAIRY INDUSTRY SINCE THE 1970'S

Since the mid to late 1970's the U.S. dairy has faced unprecedented turmoil. Such a confluence of political and economic forces within the U.S. dairy industry. In the mid to late 1970's economic problems within the national dairy industry were addressed by federal legislation. To counteract inflation driven feed cost increases, the Food and Agricultural Act of 1977 amended the Agricultural Act of 1949 to raise the dairy price support level to 80 percent of parity and provide for semi-annual adjustments of 50 cents per hundredweight in the event of increased dairy production costs. By 1979, it had become evident that the 1977 legislation had created a severe situation of excess capacity in the national dairy industry.

Attempts to deal with the growing cost of the surplus to U.S. taxpayers took a variety of forms. The Agricultural Act of 1981, which linked the dairy price support level to Commodity Credit Corporation (CCC) purchases on the open market, addressed the price received by dairy farmers in relation to surpluses generated. After it became evident that the 1981 legislation had a limited effect, voluntary supply reduction programs were seen to be the solution to the problem of excess supply. The 1984-85 Dairy Diversion Program (DDP) and the more drastic 1985 Dairy Termination Program (DTP) were designed to reduce the amount of milk marketed and bid excess capacity out of the industry, respectively. Included in the Food Security Act of 1985, of

which the DTP was a part, the Secretary of Agriculture was empowered to lower the DPS level by 50 cents in the event that USDA net removals were expected to exceed 5 billion pounds per year. Lastly, an attempt to increase demand for dairy products took the form of industry funded generic promotions of dairy products in the Dairy and Tobacco Adjustment Act of 1983.

Concerns about excess capacity in the U.S. dairy industry have been temporarily quieted due to trends in demand which began around 1979. Since 1983, the combination of reduced price supports resulting in stable real dairy product prices, the rapid growth in the U.S. economy and the increase in dairy industry promotion, all resulted in a significant change in the pattern of, i.e., an increase in demand for dairy products in general (Hamm and Mykrantz 1989). Disagreements have yet to be settled as to whether the change in consumption patterns is due to a change in demand -promotion- or a change in quantity demanded -moderating real prices (Haidacher, Blaylock and Myer 1988).

Trends in dairy product consumption in combination with the noted legislation to force the rationalization of excess capacity appear to have brought the U.S. dairy industry to or near a capacity equilibrium (Hamm and Mykrantz 1989). Spot shortages of milk occurring in the traditional dairy regions (Northeast and Midwest) have, however, resulted in open market prices well above the U.S. price support (NMPF 1989). For Michigan, recent margins between market prices

and price supports have been the largest since the inception of the dairy price support program in 1949. Whether the U.S. dairy industry continues to be in alignment will depend on many factors including whether dairy product consumption increases can continue, the abatement of financial stress and production decreases in the traditional dairy regions, and the health of the U.S economy in general.

1.3 PAST AND PRESENT CAPACITY ADJUSTMENTS

Past capacity adjustments have affected the traditional regions significantly (see Table 1.1). Though the Corn Belt and Northern Plains regions, and the Appalachian, the Southeast and the Delta regions have been more severely affected by past dairy capacity adjustments other equally profitable agricultural enterprises were available. Debate over the loss of dairy capacity in the traditional regions has been quieted of late by high open-market prices for raw milk. The growing capacity in the Southern Plains, Mountain, and Pacific regions, however, has the potential of displacing Upper Midwestern dairy products from some of their traditional markets in those regions. Debate is occurring as to why the adjustments are taking place and primarily stems from those regions which are projected to lose capacity because of the newly expanding capacity in the non-traditional regions of dairy production.

Table 1.1. Regional Shares of U.S. Milk Production: 1965-1988

(percentages)

Regions	Year	1965	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	Change 1965-88	Change 1975-88
Northeast		20.7	20.4	20.4	20.2	20.2	20.3	20.4	20.0	20.1	19.8	19.2	-1.5	-1.2
Lake States		28.3	28.0	28.7	28.7	28.7	28.8	28.9	28.7	28.3	28.4	28.2	-0.1	+0.2
Corn Belt and Northern Plains		22.4	18.2	16.5	16.4	16.1	16.2	15.7	15.7	15.6	15.4	15.3	-7.1	-2.9
Appalachia, Southeast and Delta		17.1	13.0	12.1	13.0	11.9	11.5	11.1	11.0	10.9	10.7	10.7	-6.4	-2.3
Southern Plains		3.5	3.7	3.7	3.6	3.6	3.7	3.7	3.6	3.7	3.8	4.2	+0.7	+0.5
Mountain and Pacific		12.9	16.7	18.6	18.9	19.3	19.3	20.1	21.0	21.3	21.9	22.4	+9.5	+5.7

Source: Dairy Situation and Outlook. ERS, USDA, DS-420, August 1989.

A recent USDA study investigating the inter-relation between the introduction of bovine somatotropin (bST) and the structure of The US dairy industry provides some simulation results as to the possible future structure of the US dairy industry (Fallert et al. 1987). The Economic Research Service study linked a quarterly model of the US dairy sector with a farm level model that projected net worth of representative dairy farms. The purpose of the model was to investigate the introduction of bST. The study attempts to look at the projected regional shifts in dairy farm numbers and cow numbers across regions in the United States between 1986 and 1996. Under one scenario which assumed a price support in 1990 of \$10.10 the ERS study projected that only the Lake States and the Northeast have a greater percentage changes than those anticipated for the US as a whole. Both these regions, according to the model, will lose farm numbers and cow numbers faster than other regions. Since both of these regions have significantly lower average production per cow than the Pacific region, the regional share of production that could be expected to come from the traditional areas will drop off. The traditional regions, none-the-less, will maintain their combined ranking as the largest U.S. milk production region.

The USDA's simulation model also looked at the distribution of farms by average herd size (Fallert et al. 1987). The model projected that the Lake States and the Northeast would lose a total of 26,332 dairy herds milking

under 100 cows. These two regions are projected to lose over one million dairy cows. All new farms in the region were projected to be larger than 100 cows with the greatest gain coming from farms with 200 or more dairy cows (see also OTA 1986). Despite the fact that the traditional regions are projected to maintain their historic dominance and the largest share of the US dairy industry, disruptions caused by the removal of resources/capacity will be noticed.

1.3.1 IMPLICATIONS OF INTER-REGIONAL SHIFTS

The projections presented above seem to suggest that although the regional production adjustments to date have taken place in areas other than the traditional dairy regions, adjustments are coming to the Lake States. One can argue that intra-regional evolution to fewer and larger farms is but a continuation of the long-term historic capacity adjustment. But given the hiatus from gradual and systematic adjustment taken between 1979 and 1985, the potential forthcoming inter- and intra-regional adjustments may seem severe.

The dairy sectors in the traditional dairying regions appear to be at a crucial point in their structural evolution. The analysis thus far indicates that the character of the industry will change. If the models are correct, the traditional dairy regions will lose approximately 1 million cows and 25,000 dairy farms over the next decade. These losses will account for approximately 90 percent of the capacity adjustment within the industry.

Michigan's dairy industry will no doubt be affected by such capacity adjustments. The Lake States, and Michigan in particular, can only maintain their respective positions in total US milk production through a major commitment to change.

1.3.2 RESPONSES TO POTENTIAL LOSS OF CAPACITY

The industry response to date contains both firm level (micro) and industry (macro) level elements. The micro or farm level strategies are best summed up as 'better before bigger' (Wisconsin Dairy Task Force 1995). These are obvious recommendations which will be difficult but not impossible to achieve.

Getting better may require significant changes in traditional dairy operations. The capital structure of Northern dairy farms locks them into rigid scales of operation. The combinations of milking, feeding, housing, and waste handling facilities often precludes non-marginal changes needed to move toward greater profitability. Major capital restructuring is currently being constrained by both lender and producer attitudes.

In the 1980's many ag lenders have been wary of dairy loans because of constant talk of the excess capacity and dairy surpluses, the projected impact of bST, and the reported low returns to management all have made capital markets leery of major commitments to new dairy capacity in the traditional dairy regions.

The efficient producers, having survived the turmoil of the 1980's, are having difficulty finding the drive and desire to undergo major operational restructuring. Many of these dairy producers have their current operations running as efficiently as possible given the constraints imposed by their current situation. The next step requires the reconfiguration of management, labor, capital, and perhaps, enterprise mix.

1.3.3 IMPLICATIONS FOR MICHIGAN¹

Historically, dairy farming and milk production has been of strategic importance to Michigan's general economy. Dairy farming and milk production is not only the single largest agricultural enterprise in Michigan but also accounts for a large proportion of cash receipts (approximately 28 percent in 1987) generated by Michigan's diverse agricultural sector. Milk production provides a relatively stable income base in the majority of Michigan's counties.

As part of the Upper Midwest, Michigan's long-run competitive position has come into question. Through changes in dairy markets, the economics of specialized dairy management, and changing profitability relationships, the distribution of dairy capacity is shifting (Connor, et al. 1989). Numerous data and many opinions exist to corroborate this shift in capacity and its causes. Since 1980, the Lake

¹ Much of this section has been drawn from Connor, et al. (1989).

States have lost 0.5 percent of their share of total U.S. production and Michigan has lost 0.2 percent of its share. While these may seem minor adjustments it must be remembered that for Michigan this represents approximately 290 million pounds of milk production or some 200-odd dairy operations with 90 cow milking herds, all producing at the 1988 state average production per cow (14,937 pounds per cow). If projections of the forthcoming capacity adjustments cited above materialize, the economic effects of lost capacity will be significant.

Tables 1.2 and 1.3 demonstrate Michigan's relative position within the U.S. dairy industry. Since 1967, Michigan's position has changed considerably. Michigan has had one of the largest percentage declines in cow numbers of any area in the U.S. A shift in relative shares of milk cow numbers toward the Southern Plains and Pacific regions is clearly evident in Table 1.2.

Despite Michigan's loss of cow numbers, it has consistently led the traditional dairy areas in the northern tier in productivity per cow (see Table 1.3).

Table 1.2. Number of Milk cows: U.S., state, and region, 1967-77-87

(Thousands of cows)					
Year State/region	1967	1977	1987	\$ change 1967-77	\$ change 1977-87
Michigan	499	403	361	-19.9	-10.4
Lake States/1	3,523	3,071	2,979	-12.8	-3.0
Northeast	2,562	2,202	2059	-14.0	-6.5
Corn States	2,124	1,526	1,299	-28.2	-14.9
S. Plains	543	431	438	-20.6	+1.6
Pacific	1,107	1,111	1,312	+0.2	+18.1
Total U.S.	13,501	10,977	10,337	-18.7	-5.8

/1 Michigan statistics are included in Lake State calculations.
Source: United States Department of Agriculture.

Table 1.3. Milk production per cow: U.S., state, and region, 1967-77-87

(pounds)

Year State/region	1967	1977	1987	% change 1967-77	% change 1977-87
Michigan	9,430	11,814	14,537	25.3	23.0
Lake States ^{1/}	9,414	11,490	13,595	22.0	18.3
Northeast	9,533	11,187	13,645	17.4	22.0
Corn States	8,972	10,608	12,702	18.2	19.7
S. Plains	8,002	10,422	12,667	30.2	20.5
Pacific	10,649	14,160	17,835	33.0	26.0
Total U.S.	8,797	10,977	13,786	27.1	23.3

^{1/} Michigan statistics re included in Lake State calculations.

Regional averages are weighted to reflect the relative importance of each state in the region.

Source: United States Department of Agriculture.

Despite Michigan's position within the traditional northern dairy states, recent shifts in population distributions, technological advancements, and changing relative cost and profitability conditions portend a shift in the location of dairy capacity in the U.S. The potential for Michigan to avoid the loss of a portion of its capacity and possibly capitalize on the diminishing supply in other areas within the northern tier depends upon its ability to reconfigure management, labor, capital, and perhaps enterprise mix in a more profitable manner (Hamm and Mykrantz 1989).

1.3.4 MICHIGAN'S RESPONSE

The dynamics of the U.S. dairy industry at the national, regional, and state levels has prompted many research initiatives by the land grant university system to explore possible reconfigurations of management, labor, capital, and enterprise mix. A primary and common goal of these initiatives has been to formulate strategic plans and models to guide the respective dairy industries into the 1990's. One of those initiatives began in April 1987 and took the form of a study project entitled "Michigan Dairying 1995." "Michigan Dairying 1995" is composed of researchers from Michigan State University's Colleges of Agricultural and Natural Resources and Veterinary Medicine. A primary focus of the study group was the development of several prototype farming systems for Michigan's dairy farms in 1995. Because the current knowledge base concerning the

present structure of Michigan dairy operations was considered insufficient, a survey of Michigan dairy farms was undertaken. The survey was conducted for the calendar year 1987 and addressed demographic characteristics of Michigan's dairy operations and operators, associated management practices, financial conditions, etc. (Connor, et al. 1987). Among the major findings of the 1987 survey, two are particularly noteworthy:

1) Of the 470 farms that reported their net farm income, 77.7 percent (366 farms) reported net farm income below 40,000 dollars. Of these farms, 32 percent had to share that income among two or more families.

2) ...a significant number of respondents are also undergoing financial stress caused by excessive debt loads. Servicing debt is an on-going stress that hangs over the families and the operation of the units.²

The incidence of low incomes and high debt-to-asset ratios is a primary rationale for an in-depth investigation into relationships present on Michigan dairy farms. An equally important rationale for such a study is that if Michigan dairy farmers are to successfully adapt their operations to the economic conditions now and in the future, information needs to be developed to aid in the reconfiguration process. The development of proto-type dairy systems has been one method which can serve as a guide for Michigan's dairy producers. An analysis of the data on

² Larry J. Connor, et al. "Michigan Dairy Farm Industry: Summary of the 1987 Michigan State University Dairy Farm Survey" (Michigan State University Agricultural Experiment Station Research Report No. 498, July 1989) 28-29.

the present structure and relationships among aspects of Michigan's dairy operations can also add to the knowledge base necessary to the process of reconfiguration. The 1987 survey serves as a data set for the present analysis of potential areas of reconfiguration in dairy operations for Michigan's dairy farmers.

1.4 OBJECTIVES

The proposed research has the following objectives:

1) to assess the 1987 MSU survey data set and analyze two aspects of the data set: management practices and selected demographic characteristics;

2) to establish the validity of two methodologies of statistical analysis -regression and factor analysis- and identify both the benefits and caveats of their use in general and considering the data set at hand; and

3) to assess the potential of further research to improve productivity per cow and understand the position and potential of Michigan dairy farmers using the two methodologies, identifying those areas which, given further research, portend beneficial information for Michigan dairy operations.

1.5 OUTLINE OF CHAPTERS

The research is laid out in the following manner. Chapter 2 discusses in detail the nature and structure of the data set and identifies and describes the variables to be used in the analysis. Attention is given to explanatory limitations inherent in the data set. Chapter 3 contains a

literature review of industry studies and identifies an historical evolution of process and form. Special attention is given to studies of Michigan's dairy industry. The methodologies to be used in the analysis of the survey data, regression and factor analysis, are defined and discussed in chapter 4. The results of: 1) the regression analysis; and 2) the factor analysis and regression of the defined factors on the dependent variables, are discussed in chapters 5 and 6, respectively. The conclusions that can be drawn from the present analysis are detailed in chapter 7.

CHAPTER 2

LITERATURE REVIEW

2.1 FOCUS

In an attempt to assess the viability of an industry and identify potentially profitable areas of future research it is important not only to look at present day and historical industry conditions but also historical perspectives on these conditions. A method which may be helpful in this task is the examination of past industry assessments at the national, regional, and sub-regional or state levels. A distribution of studies through time can also be of substantial help in providing a historical context of present day studies and an indicator of relative utility and limitations.

2.2 HISTORICAL PROGRESSION OF DAIRY INDUSTRY RESEARCH

Numerous studies have been undertaken to assess the viability and future direction of the dairy industry at the national, regional and state levels. The literature review is limited to dairy industry studies of the last twenty years. The initial studies represent a continuation of previous, i.e., pre-1970, dairy industry studies. The studies included: 1) research reports examining both state level and national dairy industry characteristics and

potential future economic directions through secondary data sources (1970's); 2) reports assessing competitive positions of state and regional dairy industries via secondary data sources (1980's); 3) studies at the state and regional levels involving the collection of industry specific primary data (mid to late 1980's). From this list of studies undertaken since the 1970's it is apparent that the focus has migrated from a concern for state level industry to national level industry to a combination of state, regional and national industry and the competitive forces within the U.S. dairy industry. This progression is somewhat natural given the growing interdependence of the milk markets and the convergence of industry economies both politically and monetarily.¹ Interaction between the effects of changes and methods of change in the federal dairy support price and Federal Milk Market Orders (FMMO) and inter-regional capacity distribution is an increasingly important topic. Suggestions for changes in the structure of the FMMO system and the form of the DPS are now rather prevalent. Recent changes in the dairy support price have also come under fire. The proposed changes have the basic thrust of creating independent but interactive milk markets.

¹ Grain sector policy has been identified in the literature as an integral aspect of the U.S. dairy economy. Demographic trends giving rise to increased out-of-home consumption and their role in increases of per capita consumption of dairy products have also been and will continue to be important.

2.3 DAIRY INDUSTRY RESEARCH: NATIONAL

In May, 1975, C.R. Hoglund published a research report, again through the Agricultural Experiment Station of Michigan State University, entitled The U.S. Dairy Industry: Today and Tomorrow. Hoglund's study represents a somewhat innovative study of an industry. Not only was census data utilized but extensive interaction with "14 major and secondary dairy states" at the levels of "research and extension personnel, county extension staff, dairy cooperative marketing personnel, fluid milk and manufacturing plant managers and economists, credit agency personnel and commercial firms serving the dairy industry" was also used.² Hoglund's study extends from an examination of shifts in milk production, changes in the distribution and characteristics of processing capacity, dairy farm demographics to trends concerning percentage distributions of housing, milking, manure handling systems, feed storage facilities, and selected equipment. Additionally, a number of macro-oriented issues are addressed. They include: farmer and credit agency attitudes toward firm growth and technological development; differences in climate, land resources; locations and types of dairy markets; and perhaps most importantly, future adjustments in regional dairy industries' production capacity and structure.

² C.R. Hoglund, "The Competitive Position of Michigan's Dairy Industry" (Michigan State University, Agriculture Experiment Station Report No. 275, June 1976) 3.

There are several conclusions at which the author arrives worth noting. They are worth noting not only for their significance at the time of the study but also because of their continued pertinence to the structure and nature of the dairy industry:

- 1) Dairymen will continue to be cautious about installing liquid manure systems until more definitive pollution control measures are adopted;
- 2) dairy farming in all areas of the U.S. is adjusting to larger, more highly mechanized and usually more profitable operations;
- 3) the trend during this period (1954-74) was toward free-stall housing, parlor milking and more highly mechanized feed harvesting and storage and manure handling systems.

Hoglund identifies the primary trends in the U.S. dairy industry, providing a basic understanding of the state and direction of the national industry.

In 1986, the Office of Technology Assessment (OTA) published Technology, Public Policy and the Changing Structure of American Agriculture. Prior to the 1986 OTA study, dairy industry research focused primarily on static competitive positions (Hoglund 1976; Wright 1971). Dairy industry studies limited themselves to the description of present forms and structures and the prescription of intra-regional capacity adjustment.

2.4 DAIRY INDUSTRY RESEARCH: REGIONAL AND STATE

Relative to previous trends, the OTA projections were extremely dramatic. The major regional shifts in milk production from the Upper Midwest and the Northeast to the

Southwest and the loss of the traditional regions former comparative advantage threatened an industry vital to the affected regions economies. Regional research efforts have been undertaken to understand national and regional industry dynamics. A number of studies have focused on the changing comparative advantage between regions (Buxton 1987; Hamm and Mykrantz 1989; Becker 1987; Boynton 1986; Sawyer 1986; Richardson 1986). Implicit in many of these arguments is the recognition that institutional biases (e.g. Food Security Act of 1985) have a major role in changing comparative advantages (Novakovic 1989). Other studies have taken the perspective of analyzing regional competitiveness (Stanton 1989; Wisconsin Dairy Task Force 1995 1987; Jesse 1988; Watrin 1988; Alberts 1988). Many of the Upper Midwestern studies that address competitive advantage also give attention to the development of strategic plans to avert severely down-sized production (Wisconsin Dairy Task Force 1995 1987; Alberts 1988).

More prescriptive studies and analyses of dairy industries have appeared since the inception of the 1980's. Details of two of the above mentioned regional and state studies may prove helpful in understanding the orientation of present day research.

B. F. Stanton in his "Competitiveness of Northeast Milk Producers in the National Market" (1987) questions the accuracy of OTA forecasts, stating that they are "biased" against the Northeast and the Upper Midwest. The definition

of "biased" in this case implies that the traditional regions would lose their competitive advantage to the Southwest. Stanton responds to these forecasts with an examination of "current data and evidence for the Northeast relative to the rest of the country about competitive position, production costs and response to technical change."³ The data studied include 1) milk production by region; 2) distribution of milk cows by herd size, by region, and by state; 3) cash costs of production and returns per hundred weight by region and between California and Washington, and the Northeast; 4) size of dairy herd and efficiency and costs of milk production by herd size and milk sold per cow for New York; 5) distribution of costs per hundred weight for three herd sizes -100 to 149, 150 to 199, and 200+ cow herds; and 6) a comparison of USDA and New York Farm Business Summary Data on estimated costs of production.

Stanton notes that the conclusions drawn by the OTA report concerning future loss of market share for the Northeast and the Lake States "must be based on something other than trends in the past 25 years for these traditional dairy areas"⁴ Points which tend to support a stable market share for the Northeast and the Upper Midwest include:

- 1) obtaining high levels of sales per cow, by itself will not insure efficiency or low cost production.

³ B.F. Stanton, "Competitiveness of Northeast Milk producers in the National" (Cornell University, Agricultural Economics Staff Paper No. 87-5, March 1987) 2.

⁴ Stanton 3.

Making the best use of quite different natural resources will continue to be the key to success;

2) ability to and acceptance of lower land values or lower payment for the use of owned capital than is acceptable to farm operators and their lenders where dominant size of dairy farms is 1000 cows or more;

3) it is the region's production base, primarily still a set of resources controlled and partially owned by individual farms that will provide the flexibility in terms of the returns they (producers) will accept for the use of their capital, labor, and management that will maintain the competitiveness with other regions;

4) comparative budgets may not provide an effective picture of regional differences as capacity shifted in the 1970's out of the Corn Belt occurred because of viable alternatives; a lack of productive alternatives for the use of basic resources in the Northeast and the Upper Midwest would imply potentially effective competition;

5) because of physical and economic resource availability in the traditional regions economies and dis-economies of scale occurs over different ranges in herd size, moreover, it is not difficult or unusual to find some large farms that sustain sizeable losses or to find large farms with above average costs per hundred weight. The near absence of more 1000 cow herds in the Northeast is not lack of capital nor knowledge about the latest technologies.

While the OTA would have cutting edge regional trends dictate national and all other regional trends, Stanton makes the counter argument that national trends will only be the average of regional trends. Stanton also offers one prescriptive measure -albeit general- for maintaining the Northeast's competitiveness: "build on the capability and vision of the family-based dairy entrepreneur(s)."⁵

The threat of inter-regional shifts in production capacity have prompted more strategic responses in the Upper

Midwest. In July of 1987, the Wisconsin Dairy Task Force 1995 produced a document -henceforth known as the Wisconsin study- addressing the competitive position of the Wisconsin dairy industry. The overall objective of the study "was to develop a comprehensive strategy to maintain and further develop a profitable and viable Wisconsin dairy industry."⁶ Similar in scope to Hoglund's studies in 1975 and 1976, the Wisconsin study attempts to address a number of levels within the dairy sub-sector important to Wisconsin. The aspects of Wisconsin's dairy sub-sector include: 1) milk processing and milk and dairy product marketing; 2) farm milk pricing; 3) secondary, post secondary, and university levels of education (as relating to the dairy industry); 4) a continuing education plan for the dairy industry; 5) future research needs; 6) animal health issues; 8) exit, entry, financing, alternative business arrangements; 9) farm management practices for profitability; 10) adjustments in the dairy farm input and service industry; 11) veal, dairy beef, and replacements; 12) farm taxes- property, income, and death; and most importantly 13) establishing a consensus for Wisconsin's dairy industry. Through 75 recommendations, the Wisconsin study establishes goals for 1995, the achievement of which will "ensure the competitive and

⁶ Wisconsin Dairy Task Force, "The Future Challenges of the Dairy Industry in Wisconsin (Final Report, July 1987) 1.

profitable position of Wisconsin's dairy industry."⁷ Of particular interest to the present study is the chapter in the final report dedicated to farm management practices for profitability. Management related issues include: 1) forage production and harvesting; 2) feeding; 3) Dairy Herd Improvement records; 4) artificial breeding (AI); 5) herd health; 6) farm records, enterprise budgets, computers; 7) use of consultants; and 8) new technologies. While a states dairy herd can not operate efficiently if other levels of the dairy sub-sector operate inefficiently, increased efficiency in dairy production is seen to be critical to the maintenance of Wisconsin's competitive position within the national dairy industry.

2.5 DAIRY INDUSTRY RESEARCH: MICHIGAN

In March of 1971, Karl Wright published a multi-faceted research report through the Michigan State University Agricultural Experiment Station concerning census data from 1959 and 1964 with projections for the then soon to be published 1969 census results. The document, entitled Characteristics of Michigan Farms and Farmers by Income Level and the sub-publication Dairy Farm and Farmer Characteristics by Income Level have as their over-riding purposes:

- 1) a comparison of the general characteristics of the farms and farmers of Michigan when classified by age of operator, acres in the farm, level of farm income and type of farming;

2) to show for Michigan's four types of farming, the percentage distribution of farms in the six income level groups and the great range in income for farms;

3) to analyze the differences in the characteristics of the farms and farmers between high and low income farms of the four types; and

4) to generalize, if possible, from the preceding as to the major factors responsible for the income differences.

The above analysis was done, as Wright notes, "in order that farmers and others interested in improving their chances of higher incomes on individual farms ... and those interested in broader agricultural policies (that they) can gain a clearer insight into the impact of different policies on farm operation and income."⁸

With regard to the more specific study of the dairy sector of Michigan's agricultural industry, Wright set forth the following purposes:

1) to show for this type of farming the percentage of the farms in each of the six groups based on income level, the percentage of total dairy farm sales originating in each income group and the average sales per farm for each of those groups;

2) to analyze the differences in the characteristics of the farms and farmers between the high and low income groups and to point out the major factors responsible for the income differences; and

3) to show the changes from 1959 to 1964 in dairy farms, and make projections as to the probable results of the 1969 census.

⁸ Karl T. Wright, "Dairy Farm and Farmer Characteristics by Income Level" (Michigan State University, Agriculture Experiment Station Research Report No. 134a, 1971) 1.

The basic unit of analysis referred to in the list of purposes for Wrights study is "economic class." Economic class was defined categorically as follows:

- 1) Super Class I= farm product sales (fps) of greater than 100,000 dollars;
- 2) Class I= fps of greater than 40,000 dollars;
- 3) Class II= fps of between 20,000 and 39,999 dollars;
- 4) Class III= fps of between 10,000 and 19,999 dollars;
- 5) Class IV= fps of between 5,000 and 9,999 dollars;
- 6) Class V= fps of between 2,500 and 4,999 dollars; 7) Class VI= fps of between 50 and 2,499 dollars.

The additional classification of Super Class I farms was added so as to capture a rather significant group of extremely large-scale farms. Within the economic class categories, a variety of comparative facets were studied: 1) number of farms, size, and product sales; 2) crop information; 3) dairy information; 4) specified expenses per crop acre; 5) machinery owned; 6) farmer characteristics; 7) labor and input efficiency measures; and 8) non-farm income. Beyond the above categories, a number of important farm/farmer characteristics were examined controlling for: 1) age of operator; and 2) acreage size of farm. Wright provides a "comparison summary" to enumerate his conclusions; conclusions are limited to the identification of intra-state demographic shifts and comparisons between high and low income dairy farms.

The use of census data in the assessment of an agricultural industry poses a number of problems. Although census data eliminates the potential for sampling bias, the nature of the information within the data set is restricted

to aggregates. Variable averages (eg. per farm, per crop acre, per head, etc.) and percentages within categories are the upper bound of statistical analysis. The distributions at the base of the variable averages and distributions within the categories remain unknown. A second problem associated with census data is that the number of parameters upon which an industry -agricultural or not- can be judged is limited to the slow pace of bureaucratic evolution. Important short-term and medium-term issues are also ignored because of real time constraints.

In 1976, Hoglund published a study entitled The Competitive Position of Michigan's Dairy Industry. The competitive region identified crossed from the Lake States into the Corn Belt and included the states of Michigan, Ohio, Indiana, Wisconsin, and Minnesota. The parameters or competitive characteristics upon which comparisons are made in this study are:

- 1) the structural aspects of production and manufacturing as in the national study just examined;
- 2) population composition, changes and densities; and
- 3) general and comparative financial data (eg. cash receipts, cash operating expenses, net cash income).

The future adjustments identified by Hoglund, however, are not primarily prescriptive, i.e., they do not indicate necessary measures to maintain or increase the competitive advantage of Michigan dairy producers, but only which trends are likely to continue. The purely prescriptive measures are limited to: 1) increase production per cow, man, and

farm; and 2) adopt labor efficient methods and systems of operations.

A continuing source of Michigan dairy industry analysis are yearly business analyses of specialized Michigan dairy farms enrolled in the Telfarm record program.⁹ The business analysis summaries identify a number of key characteristics which include: 1) trends in average size of business, income and costs; 2) income, average capital and labor utilization rates; 3) feed disappearance; 4) average dairy factors (e.g. productivity per cow, etc.; 5) value of farm production, sales and purchases of income items for value of production; 6) dollar inventory changes for value of farm production; 7) crop yields per acre, averages of crop acres grown, and values per acre; and 8) farm costs in total and allocated to crops and milk cows for herd sizes of less than 50 cows, between 50 and 74.9 cows, between 75 and 99.9 cows, and greater than 100 cows. While the data in the business summary does not purport to be representative of all Michigan farmers, the data reported is said to be typical of Grade A commercial dairy farms with gross incomes greater than \$50,000. The business summary reports have three purposes: 1) to provide statistical information about the financial results on Michigan dairy farms; 2) to provide information on trends in costs and returns on dairy farms

⁹ e.g., Sherrill B. Nott, **Telfarm Business Analysis Summary for Specialized Dairy Farms** (Michigan State University, Agricultural Economic Report No. 499, November 1987).

from year to year; and 3) to provide a workbook for individual farm comparative analyses and forward planning.

A final piece of research has been that produced by Michigan Dairying 1995, an inter-departmental task force set up to address the strategic orientation of Michigan's dairy industry and dairy industry research over the next several years. To date, the task force has undertaken a survey of Michigan dairy farmers to provide an up-to-date understanding of the characteristics of Michigan's dairy farmers and provide a basis for the development of several prototype farming systems for Michigan dairy farms in 1995. Survey results have been reported in Michigan Dairy Farm Industry: Summary of the 1987 Michigan State University Dairy Farm Survey (Connor, et al. 1989). The survey addressed the following areas: 1) characteristics of farm ownership and operation; 2) age and education profiles of principle operators; 3) labor force characteristics; 4) land tenure and cropping patterns; 5) characteristics of the dairy Michigan's dairy herd; 6) age and characteristics of housing systems, feed handling systems, manure-handling practices and facilities; 7) distribution of dairy farm responsibilities; 8) management practices employed; 9) financial profiles of dairy farms; 10) age of facilities future plans for expansion; and 11) various industry and dairy policy issues. The data set created by the survey is primarily descriptive; it serves as a basis for the

development of prototype dairy farm systems and the present analysis.

2.6 SUMMARY

Prior to Wright's 1971 research report, there are a number of research projects which address the structure and direction of Michigan's dairy industry. The research identified exemplifies continued efforts on the part of Michigan's Land Grant system to understand the forces of change and their impact on Michigan's dairy industry. The present statistical analysis further develops an already comprehensive body of research through the identification of areas of research interest which have the potential of aiding Michigan's dairy farmer's adapt to the competitive challenges of the future.

CHAPTER 3

DATA

3.1 1987 MICHIGAN STATE UNIVERSITY DAIRY FARM SURVEY

As a project of *Michigan Dairying 1995*, the 1987 Michigan State University Dairy Farm Survey was coordinated by the Department of Agricultural Economics at Michigan State University. A primary goal of the survey was to obtain an understanding of the present structure and characteristics of Michigan's dairy industry through a representative sample of 10 percent of Michigan's dairy farms with six or more cows. Because of this goal, the survey was designed for descriptive purposes not for an in-depth statistical analysis of the relationship between component questions.

3.1.1 SURVEY METHOD

The survey committee contracted with the Michigan Agricultural Statistics Service (MASS) to have them prepare a sample of Michigan farms.¹ The utilization of MASS allowed for the compilation of a comprehensive and up-to-date list of names and addresses of dairy farms while

¹ MASS is the federal agency charged with generating nearly all of the current state agricultural statistics for the U.S. Department of Agriculture.

maintaining strict confidentiality. From the comprehensive list, the Michigan Agricultural Statistics Service drew a stratified random sample of 1,500 dairy farmers to assure that all of the regions of the state were sampled in proportion to their number of dairy farms.

Pretesting of the survey questionnaire involved the input of some dairy farmers and industry experts. Their suggestions resulted in a number of changes.

The initial 1,500 surveys were mailed by MASS in late February and early March of 1988. After 3 weeks a second mailing was sent to non-respondents. A copy of the survey's initial results was promised to respondents.

To conclude the surveying procedures, the MASS office performed a telephone survey of a randomly selected group of non-respondents (10 percent) of the first mailing.

3.1.2 SURVEY RESPONSE RATE

Of the 1,500 farms surveyed, 670 returned the questionnaire. Table 3.1 shows an abbreviated break-down of respondents. Out of the 670 returned surveys, 508 or 75.8 percent of the respondents were still active dairy farmers. The remaining 24.2 percent had already left active dairy farming at the time of the survey but not necessarily farming in general. Of the 508 active dairy farmers responding to the survey many left certain questions unanswered. The effective number of respondents, or the respondents who completely answered the same questions in the survey, therefore, changes with the questions and number

Table 3.1. Current status of Michigan Dairy Farm Survey, respondents, 1987

Current dairy farming status	Number of farms reporting	Percent of total farms reporting
Active dairy farmers	508	75.8
No longer in dairying	162	24.2
Total	670	100.0

Table 3.2. A comparison of USDA and Survey estimates

	Michigan total	MSU survey/1	MSU survey as a percent of state
Total pounds of milk produced	5,248,000,000	517,705,173	9.86%
Total cow inventory (1/1/88)	358,000	35,672	9.96%
Average production per cow	14,537	14,513	-.17%

/1 Data represents 508 cases.

of questions being analyzed.

3.1.3 SCIENTIFIC VALIDITY OF SURVEY SAMPLE

Table 3.2 makes comparisons between survey and 1987 U.S.D.A., National Agricultural Statistics Service figures for milk production, milk cow numbers, and average production per cow. The comparisons demonstrate the achievement of a valid 10 percent sample.

3.1.4 SAMPLE USED IN THE PRESENT ANALYSIS

While it is true that 508 of the 1,500 surveys mailed were returned and serve as a representative sample of Michigan's active dairy farms, not all respondents answered all survey questions. In fact, the surveys differ greatly in the response rate between questions and between sections. The valid number of responses therefore differs between questions and sections and the sample used in the present

Table 3.3. A comparison of USDA and reduced sample Survey estimates

	Michigan total	MSU survey/1	MSU survey as a percent of state
Total pounds of milk produced	5,248,000,000	389,056,629	7.4%
Total cow inventory (1/1/88)	358,000	26,335	7.4%
Average production per cow	14,537	14,773	1.6%

/1 Data represent 340 cases.

analysis is smaller than that reported in the research report. Table 3.3 shows a comparison of the figures from Table 3.2 and those calculated from the abridged sample used in the present analysis.

3.2 VARIABLES IN THE PRESENT ANALYSIS

Because of the economic environment faced by Michigan dairy farmers, the data examined relate more to the form (eg. types of management practices, primary operator characteristics, etc.) of the dairy operation rather than the structure (eg. types of housing, milking facilities, etc.). The primary goal of the present analysis is to identify potential avenues for further profitable research among the non-structural elements of the survey data set.

In an attempt to extract as much legitimate and interesting information as possible without getting bogged down in a mass of variables and numbers, the analysis has been limited to certain aspects of the data set.

3.2.1 CRITERIA FOR VARIABLE SELECTION

In addition to the expected explanatory power of both the dependent and independent variables, an additional criterion was used to determine the number of independent variables to be included in the regression and factor analysis. The criterion was utilized for the following reason. While it is true that 508 dairy farmers did fill out a survey, there are only a number of cases where they filled them out completely. Certain independent variables were therefore eliminated so as to maximize the number of

cases available with complete responses across all variables for analysis. In most cases, large amounts of information was not lost. The cases resulting from the use of this criterion numbered 340 and represent just over 7% of dairy production in Michigan (see Table 3.3). Extensive statistical comparisons were made between this smaller number of cases and those available for each variable. Through an examination of correlations among the variables and their means, standard deviations, etc., it was concluded that the 340 cases were a legitimate sample of the original sampling.

3.2.2 DEPENDENT VARIABLES

Two dependent variables for regression equations were chosen: productivity per cow (MILKPER) and net farm income (NETFINC). These dependent variables serve as indices of efficiency and profitability.

3.2.3 INDEPENDENT VARIABLES

The independent variables also formed two groups: 1) management practices used by Michigan dairy farmers in the form of 0,1 dummy variables; and 2) demographic characteristics of Michigan dairy farms in the form of reformulated categorical data.

3.2.4 SIMPLE DEFINITION OF VARIABLES

Survey questions concerning the use of management practices were defined as 0,1 dummy variables. Survey questions appearing in a categorical form with different widths were reformulated. Category ranges were redefined as

their mean value, i.e.,

Cash receipts=10,000 to 19,999= 15,000.

Categories with upper ends, i.e.,

Cash receipts=500,000 and above,

were conservatively defined as the lower bound of the category -in this case 500,000.

3.2.5 COMPLEX DEFINITION OF VARIABLES

An alternative and more complex definition of the independent variables is achieved through the use of factor analysis. The complex definition of the independent variables utilizes the variables in the simply defined form but redefines them as subsets of multiple groups, i.e., aligns them with theoretical underlying "factors".

3.2.6 HYPOTHESES AS TO RELATIONSHIPS BETWEEN VARIABLES

The descriptive nature of the survey data set establishes certain caveats with respect to the formulation of hypotheses. The present analysis therefore does not attempt to identify the exact form of the relationship between variables but attempts to identify relationships which may provide a direction for further research. Hypotheses in the present analysis take a very general form.²

3.3 SUMMARY

The Michigan State University 1987 Survey of Michigan

² A list of variables, their definitions, and their accompanying hypotheses can be found in Appendices A and B at the end of the text.

Dairy Farms provides a good sample of Michigan dairy farms. The data set which resulted from the 1987 survey, though fraught with certain limitations, will allow for the development of information as to the relationships between indices of efficiency and profitability in the forms of productivity per cow and net farm income and managerial practices utilized by and demographic characteristics of Michigan dairy farms.

CHAPTER 4

METHODOLOGIES: REGRESSION AND FACTOR ANALYSIS

4.1 ORDINARY LEAST SQUARES REGRESSION

4.1.1 UTILITY OF REGRESSION ANALYSIS

Ordinary Least Squares Regression (OLS) is used in the present analysis for a number of reasons. One of the reasons is that OLS is useful in sorting out relationships, isolating the effects of one variable from those of others. Secondly, OLS summarizes information in historical or experimental data through the estimation of equations for lines and surfaces (Wallace and Silver 1988). The third reason for using regression is that it permits forecasts and predictions. One of the primary assumptions of OLS is that the variable to be explained -the dependent variable- can be explained by one or more other variables -independent variables. A further assumption which establishes the statistical validity of OLS is that there exists causality between the dependent and independent variables, i.e., the relationships between the dependent and independent variables is not spurious.¹

¹ To save time and space, the algebraic manipulations to explain and statistically justify the OLS methodology will be done in matrix algebra. An easy to follow non-matrix (continued...)

4.1.2 THE FORM OF ORDINARY LEAST SQUARES

The relationship between the dependent variable (Y) and the independent variables (X) can be written in the form of a linear equation. The linear equation can be written

$$(1) \quad Y = Xb + e$$

where Y is an $nx1$ vector of observations on the dependent variable; X is an nxk matrix of n observations on k independent variables and a constant; b is a $kx1$ set of estimated values which minimize the sum of squared errors function (see equation 2); and e is an $nx1$ vector of stochastic errors. The sum of squared error function is chosen because its minimization provides for a plausible and good fit. The sum of squared errors (SSE) function takes the form

$$(2) \quad SSE = \sum_{i=1}^n e_i^2 = \sum [Y_i - a + bX_i]^2.$$

4.1.3 DERIVING AN ESTIMATE OF β

Prior to detailing the statistical assumptions upon which OLS is necessarily based, a simple solution for b is derived.

Equation (1) is representative of the equation

$$(3) \quad Y = X\beta + \epsilon,$$

which is the same as (1) but β represents the unknown vector of parameters estimated by b, and defines some hypothetical relationship between X and Y. Using matrix manipulations

¹(...continued)
formulation of the OLS can be found in Wallace and Silver (1988).

and pre-multiplying both sides of (2) by the transpose of X , i.e., X' , we get

$$(4) \quad X'Y = X'X\beta.$$

Multiplying each side by the inverse of $(X'X)$, $(X'X)^{-1}$, we get

$$(5) \quad (X'X)^{-1}X'Y = (X'X)^{-1}X'X\beta.$$

But since a matrix P multiplied by its inverse (P^{-1}) is equal to the identity matrix (I) ,

$$(6) \quad \beta = (X'X)^{-1}X'Y$$

where $(X'X)^{-1}$ is a weighting matrix. b can thus be estimated by equation (6).

4.1.4 NECESSARY ASSUMPTIONS TO OBTAIN B.L.U.E. ESTIMATES

While β can be estimated by simple matrix manipulations, there are certain statistical assumptions concerning the characteristics of b which need to be met if confidence is to be guaranteed. What needs to be proved before confidence can be placed in b is for b to be a Best Linear Unbiased Estimate of β , i.e., a BLUE estimate. The desirable characteristics of b are based upon the Gauss-Markov or Classical assumptions concerning the vector of error terms ϵ . The assumptions can be compactly written as

$$(7) \quad \epsilon \text{ - i.i.d. } (0, \sigma^2).$$

This is to say that the error terms are identically and independently distributed with mean 0 and variance σ^2 . A violation of these assumptions (eg. autocorrelation, heteroskedasticity, $E(X_i\epsilon_j) \neq 0$, for all i and j , etc.) leads to poor and non-BLUE estimates of β .

4.1.4.1 ESTIMATES OF β ARE LINEAR (L)

It was indicated above that $(X'X)^{-1}$ is a weighting matrix whose contents represent weights attached to each observation on Y . This allows the slope and constant estimates to be written as a weighted average of the sample data on Y . Equation (6) illustrates that b is a random variable since it is a linear combination of the random variables Y and X . The product of two random variables is of course itself a random variable. By being a random variable, b will have a sampling distribution which can be used to judge its accuracy and functional relations with Y .

4.1.4.2 ESTIMATES OF β ARE UNBIASED (U)

For b to be unbiased an estimator of β then the expected value of b must equal β , i.e., $E(b) = \beta$. Recall that the expectation of a sum is the sum of the expectations and that the expectation of a constant times a random variable is the constant times the expectation of the random variable. Thus, given equation (6), then

$$(8) \quad E(b) = E[(X'X)^{-1}X'Y].$$

Remembering that $Y = X\beta + \epsilon$, then

$$\begin{aligned} (9) \quad E(b) &= E[(X'X)^{-1}X'(X\beta + \epsilon)] \\ &= E[(X'X)^{-1}X'X\beta] + E[(X'X)^{-1}X'\epsilon] \\ &= (X'X)^{-1}(X'X)[E(\beta)] + (X'X)^{-1}X'[E(\epsilon)] \\ &= I\beta + 0 \\ &= \beta. \end{aligned}$$

b is therefore an unbiased estimator of β .

4.1.4.3 ESTIMATES b OF β ARE THE 'BEST' (B)

It seems fairly logical that the 'best' estimates of β are the most desirable. The measure of this quality of the estimate is its variance. We would like, therefore, to have a least variance estimate of β . The variance of b can be written as

$$\begin{aligned}(10) \text{Var}(b) &= E\{ [(b - E(b)) (b - E(b))'] \} \\ &= E\{ [b - \beta][b - \beta]' \}.\end{aligned}$$

Reforming equation (5) we get

$$(11) b - \beta = (X'X)^{-1}X'\epsilon.$$

Replacing values in equation (10) with (11) it follows that

$$\begin{aligned}(12) \text{Var}(b) &= [(X'X)^{-1}X'\epsilon] [(X'X)^{-1}X'\epsilon]' \\ &= [(X'X)^{-1}X'\epsilon] [\epsilon'X(X'X)^{-1}]'\end{aligned}$$

by the rules of transposition. Yet since $E(\epsilon\epsilon') = \sigma^2$ is one of the Gauss-Markov assumptions,

$$(13) \text{Var}(b) = \sigma^2(X'X)^{-1}.$$

That the above b is a least variance estimator of β can be easily proved. Let b^* be any linear, unbiased estimator of β , i.e.,

$$(14) b^* = AY$$

where A is some $n \times k$ matrix. If it is true that

$$\begin{aligned}(15) C &= A - (X'X)^{-1}X' \\ CY &= [A - (X'X)^{-1}X']Y \\ CY &= AY - (X'X)^{-1}X'Y \\ AY &= (X'X)^{-1}X'Y + CY,\end{aligned}$$

then

$$(16) b^* = [(X'X)^{-1}X' + C]Y.$$

It can be easily proved that b^* is an unbiased estimator of β given certain restrictions. The variance of b^* can then be calculated as

$$(17) \text{Var}(b^*) = E\{ [(b^* - E(b^*)) (b^* - E(b^*))'] \}.$$

By the same logic used in (10) and (11) it follows that

$$\begin{aligned} (18) \text{Var}(b^*) &= \{ [(X'X)^{-1}X' + C]\epsilon \\ &\quad [(X'X)^{-1}X' + C]\epsilon' \} \\ &= [(X'X)^{-1}X' + C]\epsilon\epsilon'[X(X'X)^{-1} + C]' \end{aligned}$$

which reduces to

$$= \sigma^2 [(X'X)^{-1}X' + C] [X(X'X)^{-1} + C]'$$

Simplifying the quantities within the brackets we get

$$(19) \text{Var}(b^*) = \sigma^2 [(X'X)^{-1} + CC'].$$

Thus $\text{var}(b)$ is less than $\text{var}(b^*)$ by some positive semi-definite matrix and b is the least variance estimator of β .

4.1.5 INDICES OF GOODNESS OF FIT AND ACCURACY

Indices of goodness of fit include statistics for R^2 and adjusted- R^2 and t-tests and F-tests. The statistics for R^2 and adjusted- R^2 -also referred to as coefficients of determination- are indices which tell how well the estimated regression line explains the variation of Y around its mean. The equations for both statistics are as follows:

$$R^2 = 1 - \left\{ \frac{\sum_{i=1}^n e_i^2}{\sum_{i=1}^n (Y_i - \bar{Y})^2} \right\}$$

and

$$\text{adj.}R^2 = 1 - \left\{ \frac{(n-1) \left(\sum_{i=1}^n e_i^2 \right)}{(n-k-1) \left[\sum_{i=1}^n (Y_i - \bar{Y})^2 \right]} \right\},$$

respectively. The statistic for the adjusted- R^2 is more

conservative. Both statistics produce values which lie between 0 and 1, where 0 implies that there is no statistical proof that there is a relationship between X and Y and 1 implies that all the variance in Y is accounted for by X. In the later case the potential of spurious correlation exists.

The t-test and the F-test are statistics which measure the probabalistic accuracy of the coefficient estimates (b). The t-test assesses the statistical accuracy of individual parameter estimates, while the F-test assesses the statistical accuracy of all parameter estimates simultaneously. Hypotheses as to the above tests take the form: $H_0: \beta_i=0$ versus $H_1: \beta_i \neq 0$ for t-tests and $H_0: \beta_i=0$ versus $H_1: \beta_i \neq 0$ for any number of i for F-tests. Calculation of t- and F-test sample statistics is rather simple:

$$t = (b - \beta) / (s_x / \sqrt{n})$$

$$F = \{[SSE(\text{Rest}) - SSE(\text{Unr})]/3\} / \{[SSE(\text{Unr})]/(n-k-1)\}$$

where s_x is an estimate of the standard error of b; n is the number of observations; k is the number of estimated variable coefficients; SSE(Rest, Unr) is the sum of squared errors of the restricted and unrestricted regressions, respectively.

4.2 FACTOR ANALYSIS

4.2.1 UTILITY OF FACTOR ANALYSIS

The second mode of analysis to be used in this assessment of potential areas of profitable research for Michigan's dairy industry is factor analysis. Within

regression analysis the relationships among sets of variables was defined prior to the analysis and the direction of relationships between independent and dependent variables is specified. Factor analysis redefines the predetermined set of variables so as to examine the interrelationships among variables. In a sense, every variable is both an independent and dependent variable at the same time. The main goals of factor analysis are:

- 1) to identify groups of inter-correlated variables;
- 2) to reduce the number of variables being studied; and
- 3) to rewrite the data set in an alternate form.

Two general principles combine to provide the basis for factor analysis:

- 1) that each variable can be subdivided into several independent parts in terms of association with other variables; and

- 2) that each correlation coefficient similarly is made up of different segments. A simple but not truly realistic characterization of these 'segments' or groups of variables is a large degree of intra-correlation and a low degree of inter-correlation.

4.2.2 DETERMINATION OF FACTORS

The method by which factor analysis defines factors within a particular data set is conceptually rather simple. Each variable is first split into two parts: its common variance is that part of its pattern which is related to the other variables in the system; its unique variance is the

residual from that multiple relationship. The common variance is then divided into a set of factors. It may be helpful to point out that factor analysis differs from principal components analysis in that it does not address total variance but only common variance. Thus a set of regression equations that represents a four variable - simple- data set can be written:

$$(20) \quad x_i = f(F_1, F_2, \dots, F_k) + U_i$$

$$i = 1, 2, \dots, n$$

$F_1, F_2, \dots, F_k$ = set of factors, and

U_i = unique variance of each variable.

When $\sum U_i = 0$ or $k=i$ then the number of factors equals the number of variables.

As factor analysis is somewhat similar to principal components analysis -differing only in the initial construction of the correlation matrix and with the addition of matrix rotations to better identify the factors- the extraction of principal components will first be explained. A rough translation to and expansion on factor analysis will then be made.

Principal component analysis "rewrites a data matrix, comprising n variables and N observations into another $n \times n$ form in which the new variables are: 1) weighted representations of the original set; and 2) are not

correlated with one another."² The number of components is therefore equal to the number of variables. The first principal component to be extracted from the correlation matrix is defined as the 'mean variable'. In a data set of, say, four (4) variables or vectors this implies the location of a new vector as close as possible to the existing ones. This is very much akin to finding the mean in a set of values. "Extraction of the first principal component thus involves, in the n -dimensional vector space of the correlation diagram, a new variable which is as close as possible to all of the original variables."³

The relationships between the component and the original variables is defined by three indices:

1) the angle between the component and each of the original variables;

2) the correlation, which is the cosine of the angle; and

3) the squared correlation, which indicates the proportion of the variance associated with the component.

The correlations between the component and the variables are known as the *component loadings*. The squared correlations denote the proportion of variance common to both variable and component. Summing the squared loadings

² R. J. Johnston, Multi-variate Statistical Analysis in Geography: A Primer on the General Model (New York:Longman, 1980) 136.

³ Johnston 138.

indicates, therefore, the total variance accounted by the component; this is the eigenvalue (λ).

$$(21) \lambda_i = \sum_{j=1}^n L_{ij}^2$$

λ_i is also referred to as the *percentage of the trace*.⁴ Having defined the factor loadings and eigenvalues, we come to a forth index of the variable-component relationship: *communality*. *Communality* is the sum of the squared loadings for a variable:

$$(22) h_j^2 = \sum_{i=1}^k L_{ij}^2$$

where

L_{ij} is the loading for variable j on component i ;

k is the number of components ($k < n$); and

h_j^2 is the communality for variable j .

The communality then is the proportion of the variance for each variable accounted for by all the components. For factor models where $k < n$, communalities are less than 1.0.

4.2.3 METHODS OF FACTOR DEFINITION

4.2.3.1 A BI-VARIATE EXAMPLE

The primary mathematical tool by which such hierarchical decomposition or transformations are arrived at is referred to as the characteristic equations or eigenequations. Switching to matrix notation is necessary at times due to the complexity of the algebraic

⁴ Johnston 139.

manipulations. The eigenequation, using matrix notation, has the following form:

$$(23) \quad RV = \lambda V$$

where R is the matrix for which a solution is sought, V is the eigen vector to be found and lambda is an eigen vector.

A simpler determinantal equation can be written:

$$(24) \quad \text{Det}(R - I\lambda) = 0$$

which translates into a bi-variate -yet representative of a multi-variate matrix-

$$(25) \quad \text{Det} \begin{vmatrix} 1-\lambda & r_{12} \\ r_{21} & 1-\lambda \end{vmatrix}$$

which can be written as,

$$(26) \quad (1-\lambda)(1-\lambda) - r_{12} * r_{12} = 0$$

(by the definition of determinant), and

$$\lambda^2 - 2\lambda + (1 - r_{12}^2) = 0$$

Solving the equation, which is of the form $ax^2 + bx + c = 0$, the eigen values for a bi-variate correlation matrix are

$$(27) \quad \lambda_1 = 1 + r_{12}$$

$$\lambda_2 = 1 - r_{12}$$

4.2.3.2 FACTOR DEFINITION: THE MULTI-VARIATE CASE

Generalizing to the multi-variate case, the analysis is begun with the identification of a factor F_1 whose contribution to the communalities of the variables has as great a total as possible. Then the F_1 residual correlations are obtained. A second factor F_2 , independent of F_1 , with a maximum contribution to the residual

communality is next found. This process is continued until all communality is analyzed.

The complete factor pattern matrix can be written:

$$(28) \quad x_i = a_{i1}F_1 + \dots + a_{ij}F_j + \dots + a_{im}F_m,$$

where the unique factor is omitted. The sum of squares of the factor coefficients gives the communality of a particular variable, while any term $(a_{ik})^2$, indicates the contribution of the factor F_k to the communality of x_i . Thus the first factor coefficients, a_{i1} , are chosen so as to maximize the sum of the contributions of that factor to the total communality, i.e.,

$$(29) \quad \text{Max } V_i = \sum_{i=1}^n (a_{i1})^2,$$

subject to the conditions

$$(30) \quad r_{ij} = \sum_{k=1}^m a_{ik}a_{jk} \quad (i, k=1, 2, \dots, m)$$

where

$$(31) \quad r_{ik} = r_{ki}$$

and r_{ii} is the communality $(h_i)^2$ of x_i . The conditions (30) say that the reproduced correlations, are to be replaced by the observed correlations, implying the assumption of zero residuals. Using the method of Lagrangian multipliers, the n equations, one for each value i , can be represented as:

$$(32) \quad \begin{aligned} (h_1^2 - \lambda)a_{11} + r_{12}a_{21} + \dots + r_{1n}a_{n1} &= 0 \\ r_{21}a_{11} + (h_2^2 - \lambda)a_{21} + \dots + \dots &= 0 \\ \vdots & \\ r_{n1}a_{11} + r_{n2}a_{21} + \dots + (h_n^2 - \lambda)a_{n1} &= 0 \end{aligned}$$

Thus maximization of (29) subject to the conditions of (30) leads to a system of n equations (32) for the solution of the n unknown a_{i1} . A necessary and sufficient condition for this system of n homogenous equations to have a non-trivial solution is the vanishing of the determinant of coefficients of the a_{i1} . The condition can be written:

$$(33) \text{ Det } \begin{vmatrix} (h_1^2 - \lambda) & r_{12} \dots & r_{1n} \\ r_{21} & (h_1^2 - \lambda) \dots & r_{2n} \\ \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} \dots & (h_n^2 - \lambda) \end{vmatrix}$$

which is the multi-variate equivalent to (24). Solving (33) results in an n -order polynomial, and is known as a 'characteristic equation.' [see (24)-(27)]

There are a family of solutions for (33) all of which are proportional to one particular solution. From the above, it follows that the factor of proportionality is

$$\lambda_1 = \sum_{i=1}^n a_{i1}^2 = V_1,$$

where V is the quantity that was to be maximized. Therefore V_1 is equal to one of the roots of the characteristic equation, namely the largest root. The largest root, λ_1 is substituted into (32) and any solution $a_{11}, a_{21}, \dots, a_{n1}$ is obtained. To satisfy (30) these a_{i1} ($i=1, 2, \dots, n$) values are divided by the square root of the sum of their squares and then multiplied by the square root of λ_1 , resulting in

$$(34) \ a_{i1} = \alpha_{i1}(\lambda_1)^{1/2} / \left(\sum_{i=1}^n \alpha_{i1}^2 \right)^{1/2} \text{ for } (i=1, 2, \dots, n)$$

which are the desired coefficients of F_1 in the factor pattern matrix.

Having determined the coefficients a_{i1} of F_1 , the next task involves finding a factor accounting for a maximum of the residual communality. First factor residual correlations -denoted by a pre-subscript '1'- become

$$(35) \ {}_1r_{ik} = r_{ik} - a_{i1}a_{k1} = a_{i2}a_{k2} + a_{i3}a_{k3} + \dots + a_{im}a_{km}$$

which in matrix form is

$$(36) \ R_1 = R - Q_1$$

where

$$(37) \ Q_1 = a_1 a_1'$$

represents the nxn symmetric matrix of products of first factor coefficients which appear in the column vector a_1 .

Coefficients of the second factor are achieved by maximizing

$$(38) \ V_2 = a_{12}^2 + a_{22}^2 + \dots + a_{n2}^2,$$

i.e., the sum of the contributions of F_2 to the residual communality, subject to conditions which are analogous to (30).

Such a process could continue until all factors are defined. Yet it can be shown that the required maximum eigenvalue of r_1 is, in fact, the second largest

eigenvalue of the original correlation R .⁵ The theoretical development above provides the logical basis for the principle components (Harman refers to components as factors) solution. The direct solution of a characteristic equation, as Harman (1971) notes, entails insuperable algebraic efforts. SPSS, however, performs such tasks in an efficient and timely manner, and permits the use of factor analysis in the present case.

4.2.4 IMAGE ANALYSIS

Image analysis distinguishes between the common part of a variable and the unique part. The common part is that portion of a variable which can be predicted by a linear combination of all other variables. This is referred to as the "image" of a variable. It follows that the unique part is not predictable by a linear combination of the other variables. The unique portion is known as the "anti-image."

The image and anti-images defined for a sample of variables are called partial images and partial anti-images, respectively.⁶ Although the partial images only approximate

⁵ Harry H. Harman, Modern Factor Analysis. (Chicago: University of Chicago Press, 1962) 155-164.

⁶ In defining this decomposition, it is assumed that one is dealing with the universe of variables as well as a population of individuals: sampling of either kind is assumed not to be in operation.

Image analysis also assumes that this universe is potentially infinite. In image analysis, an n variable grouping would be considered as a sample from an infinite
(continued...)

the total image, it is completely specified by the observed variables. Given a sample of variables and their correlations, the image analysis constructs a partial image covariance matrix which is given by:

$$(39) \text{MSA}_i = \frac{\sum_{i \neq j} r_{ij}^2}{(\sum_{i \neq j} r^2 + \sum_{i \neq j} a_{ij}^2)}$$

where r is the simple correlation coefficient between i and j , and a is the partial correlation coefficient between i and j . In matrix form:

$$(40) R = (R - S^2)R^{-1}(R - S^2)$$

where R is the correlation matrix and S^2 is the diagonal matrix whose elements are the variance of each variable unexplained by the other variables- or the anti-image covariance matrix. The process involved in equation number (20) is:

- 1) to replace the diagonal of R with the squared multiple correlation of each variable with the rest; and

- 2) to readjust the off-diagonal elements in order to make the resulting matrix Gramian. An examination of the main diagonal of the anti-image correlation matrix provides

⁶(...continued)

universe of variables pertaining to the psychometric domain covered by X number of common factors.

If, however, we had all the variables in the potential universe for examination the squared image of a variable would be equivalent to the communality of a variable defined in common factor analysis, and the squared anti-image would be equivalent to the unique variance. (An assumption of standardized variables is made) In other words, the squared multiple correlation between a variable and the remainder of the variables in this universe is the same as the communality of a given variable.

information on the relative worth of keeping individual variables in the factor analysis. A suggested interpretation of the main diagonal elements -measures of sampling adequacy- of the anti-image correlation matrix is to eliminate those variables with MSA's below 0.5. A gross measure of sampling adequacy can be found in the Kaiser-Meyer-Olkin (KMO) statistic which compares the magnitudes of the observed correlation coefficients to the magnitude of the partial correlation coefficients. It is computed as

$$(41) \text{ KMO} = \frac{\sum_{i \neq j} r_{ij}^2}{(\sum_{i \neq j} r_{ij}^2 + \sum_{i \neq j} a_{ij}^2)}.$$

(Norusis 1988) If the sum of the squared partial correlation coefficients between all pairs of variables when compared to the sum of the squared correlation coefficients, the KMO measure is close to 1. Relatively large values for the KMO statistic indicate the appropriateness of factor analysis.⁷ One final statistic is Bartlett's test of sphericity which can be used to test the hypothesis that the correlation matrix is an identity matrix.⁸

4.2.5 FACTOR SELECTION

Initial factor selection is a bit ad hoc but there do exist some rules of thumb which can be followed to ascertain the true number of factors with which the data can be

⁷ Kaiser [1974] characterizes measures in the 0.90's as marvelous, in the 0.80's as meritorious, in the 0.70's as middling, in the 0.60's as mediocre, in the 0.50's as miserable, and below 0.50 as unacceptable.

⁸ Marija J. Norusis, *SPSS/PC+ Advanced Statistics™ V2.0*. (Chicago: SPSS, Inc. 1988) B-45.

represented. One criterion, though not always a viable one, suggests that only factors that account for variance greater than 1.0, i.e., an eigenvalue greater than 1.0, should be included. Factors with variance less than one are no better than a single variable since each variable has a variance of 1. The use of this criterion, however, has the potential of indicating the inclusion of spurious factors.

An alternate and perhaps more capable criterion is an examination of a plot of the eigenvalues of each factor in a descending order of the amount of variance explained. Typically, the plot shows a rather distinct break between the steep slope defined by the factors with larger eigenvalues and the gradual trailing-off of the remaining factors. This gradual trailing-off is referred to as the *scree* because it resembles the rubble that accumulates at the foot of mountains and steep slopes. Experimental evidence indicates that the *scree* begins at the K^{th} factor, where K is the true number of factors." ⁹ Examination of the *scree* slope can be sufficient in determining the number of factors to be included in the factor analysis.

4.2.6 ROTATION OF FACTOR MATRICES

4.2.6.1 ORTHOGONAL ROTATIONS: A PRELIMINARY UNDERSTANDING

The primary goal of rotation is to achieve a simplified, easily interpretable factor structure. That is, it is desirable to have non-zero loadings for only some

⁹ Norusis, B-47.

variables, preferably only one. In this way the difference between factors can be easily discerned.

Rotation does not change the goodness of fit of a factor solution. That is, although the factor matrix changes, the communalities and the percentage of total explained variance do not change. The percentage of variance accounted for by each factor, however, does change. Rotation redistributes the explained variance for the individual factors. Different rotation methods may result in the identification of somewhat different factors. There are several rotation methods which maintain the orthogonality of the initial factors. They include:

Varimax: minimizes the number of variables with high loadings on a factor, enhancing the ease of interpretation of the factors;

Quartimax: minimizes the number of factors needed to explain a variable, usually resulting in a general factor with high to moderate loadings on most variables; and

Equamax: a combination of Varimax which simplifies factors and Quartimax, which simplifies variables.

In addition to orthogonal methods of factor rotation there are also oblique methods. Certain circumstances may prescribe their use. Orthogonal rotations can produce results which may be inappropriate. Because it is unlikely that influences in nature are not correlated, orthogonal rotations can overstate the independence of underlying factors.

4.2.6.2 OBLIQUE ROTATIONS

The use of an oblique rotation provides for the possibility that the defined factors are inherently correlated. Oblique rotations result in factors that are correlated. Like orthogonal rotations, an oblique rotation (Oblimin) preserves the communalities of the variables. Oblique rotation, however, results in the loss of identity between the factor loadings (pattern matrix) and the factor variable correlations (structure matrix). The factor loadings do remain as partial regression coefficients, but because the factors are correlated, they are no longer equal to the simple factor variable correlations (structure matrix). The algebraic criterion for "direct" Oblimin is:

$$(42) D = \sum_{j=k=1}^r \left[\sum_{i=1}^n b_{ij}^2 b_{ik}^2 - \delta \left(\sum_{i=1}^n b_{ij}^2 b_{ik}^2 \right) / n \right]$$

where b_{ij} are the factor loadings in the pattern matrix. In general, greater values of δ produce more oblique solutions and smaller (negative) values produce more orthogonal solutions.¹⁰

4.2.7 CALCULATION OF FACTOR SCORES

After rotating the factors to obtain a simpler factor structure, factor scores can be estimated. While principal component scores can be computed directly, factor scores can

¹⁰ Jae-on Kim and Charles Factor Analysis: Statistical Methods and Practical Issues. (London: Sage Publications, 1978) 39.

only be estimated.¹¹ Factor analysis deals only with common variance; principal component analysis combines both common variance and unique variance, yet in unknown proportions. Algebraically, factor scores, the standardized value for observation i on variable j - D_{ij} - is composed of the score for i on each of the k factors, plus its score on the unique variance of j . Thus:

$$(43) D_{ij} = \left(\sum_{m=1}^k S_{im} L_{jm} \right) + S_{ij} U_j$$

where

S_{im} is the score for observation i on factor m ; L_{jm} is the loading of variable j on factor m ;

S_{ij} is the score for observation i on variable j ;

U_j is the unique variance; and

D_{ij} is the standardized value of observation i on variable j .

4.3 CAVEATS OF FACTOR ANALYSIS

There are a number of caveats involved in the present use of factor analysis to analyze the data from survey of Michigan dairy farmers. The use of dichotomous data (eg. 0,1 dummy variables) in factor analysis presents certain problems. In factor analysis, each variable is assumed to be a weighted sum of at least two underlying factors (one common and one unique). Even if these factors have two values -an unlikely occurrence in real factor models- the

¹¹ Johnston 137 and 150.

resulting values in the observed variable must contain at least four values. In general, the lesser the number of the categories characterized by a variable the more severe the measurement distortion. A question is therefore raised as to the compatibility of the management practice questions and the factor analytic model.

However, factor analysis also has value as a heuristic device. If one considers that the observed variables represent the crude measurement of adjacent values, the question is no longer whether the data are incompatible with the factor analysis model but how much the non-random measurement errors distort the factor analytic results, factor analysis can be considered. Kim and Mueller (1974), however, note that relatively low correlations among variables -less than 0.6- the distorting effects of using dichotomous variables is negligible. The grouping attenuates correlations in general but does not affect the structure of the clustering in the data. Factor analysis may therefore be justified if the researchers goal is to search for clustering patterns. While the identification of clustering patterns was not the primary goal of my thesis research, rather the relationships between the clusters and productivity per cow and net farm income, the factor analytic approach is not wholly without base. Regression analysis on the untransformed variables helped in sorting out possible distortions by the use of factor analysis - though none were identified. Also, if it is true that

managerial practices have more than simple additive effects, then factor analysis would appear to be a more suitable methodology than a regression analysis on the untransformed variables.

4.4 REGRESSION OF FACTOR SCORES ON DEPENDENT VARIABLES

After having defined the factor scores, regressions can be run to ascertain the relationship between factor scores and the dependent variables as in section 4.1.

4.5 ALGORITHMS

The algorithms represented above are the same as those within the Statistical Package for the Social Sciences (SPSS). SPSS has been used to generate all of the statistics related in the following pages.

4.6 SUMMARY

In the preceding sections, two methods of statistical analysis have been discussed -regressions analysis and factor analysis in combination with further regression analysis of the defined factors.

The two methods were chosen because each possessed characteristics which aid in the interpretation of relationships between the independent variables -managerial practices and factors and demographic characteristics and factors- and their relationships with the dependent variables -productivity per cow and net farm income. Regressions analysis isolates the effects of one variable from those of another. Factor analysis rewrites the data set in a more compact form by identifying "underlying

factors" within the correlation matrix. Such a rewriting allows for the study of the effects of natural groupings of the variables. While factor analysis does imply certain risks relating to the distortion of data, the risk is considered negligible relative to the potential information to be gained. The simultaneous use of both methods of analysis -using untransformed and transformed data- also permits corroboration of the results.

CHAPTER 5

REGRESSION ANALYSIS

5.1 STRUCTURE OF REGRESSION ANALYSIS

The focus of regression analysis is to statistically assess relationships between a set of independent variables and an dependent variable. Implicit in the assessment is a causal link between changes in the independent variables and changes in the dependent variable.

In this chapter and in the latter half of Chapter 6, the independent variables to be estimated by linear combinations of the independent variables are productivity per cow (MILKPER) and net farm income (NETFINC). The independent variables consist of two sets of variables: managerial practices and demographic characteristics. Both dependent and independent variables, of course, stem from Michigan State Universities' 1987 Survey of Michigan Dairy Farms.

An exploratory regression analysis is used due to the descriptive nature of the data set. The estimation of exact relationships among the variables is impossible given the lack of continuous variables and the complexity of interactions between human capital and managerial tools (Johnson 1988).

In order to better understand the variables and the relationships within the data set, the regressions were divided into a number of categories. The categories chosen relate to the size of the dairy operation in terms of cow numbers, interactions between net farm income and debt-to-asset ratio, and specialization and non-specialization in dairy production.

The cases were first broken down according to herd size, with categories: less than 60 cows (both milking and dry), greater than 59 and less than 120 cows, and greater than 119 cows. These categories were chosen so as to capture the presence of a predominant technology -stanchion barns- in the lower herd sizes and the limits of family labor in the mid-range herd sizes. The second grouping is designed to look at the interaction between debt-to-asset ratio and net farm income. Net farm income is divided into two categories: less than 40,000 dollars and greater than 40,000 dollars. Debt-to-asset ratio is separated into two levels: greater than 69 percent and less than 70 percent. It is thought that financial stress becomes a problem in need of immediate attention at this level. The third and final category controls for specialized and non-specialized dairy operations. The criterion for a dairy operation to be considered specialized is that 75 percent of all cash receipts stem from dairy-related operations; this includes dairy milk sales, and pure-bred dairy animal and dairy livestock sales. Figures 5.1 through Figure 5.4 may prove

helpful in providing an initial understanding of how productivity per cow varies within the above categories. The mean number of management practices used by the respondents are also noted as a secondary point of reference. When controlling for herd size, productivity per cow and mean number of management practices increase with herd size (Figure 5.1). Standard deviations from the mean also tend to fall off with increasing herd sizes. Looking at the group using net farm income and debt-to-asset ratio as controls (Figure 5.2), it is apparent that productivity per cow increases with net farm income, not debt asset ratio, i.e., between low and high debt-to-asset ratios, there appears to be only slight differences in productivity per cow. Relatively large differences, however, exist between operations with low and high net farm incomes. The number of management practices increase as a function of both. Although debt-to-asset ratio appears to be unrelated to productivity per cow, this is only true in aggregation. Figure 5.3 demonstrates that there is a point at which productivity may tend to fall off, i.e., for heavily indebted dairy operations. Whether this is a function of financial stress or other factors has yet to be shown. Figure 5.4 shows the mean productivity per cow for specialized versus non-specialized dairies. Specialized dairy operations demonstrate a slightly higher average productivity per cow than their non-specialized counterparts.

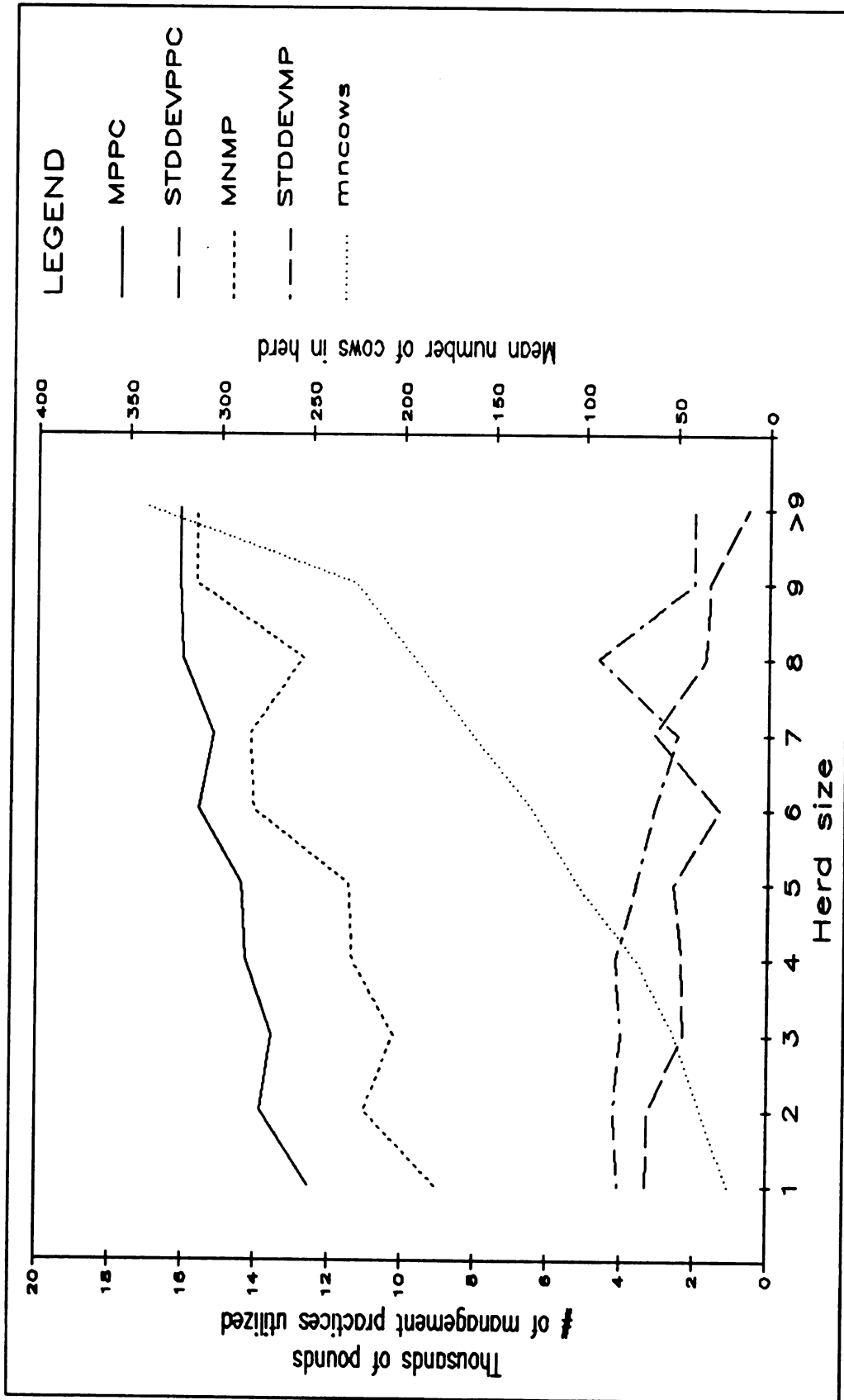


Figure 5.1. Productivity, management practices, and herd size
(see key on page 72)

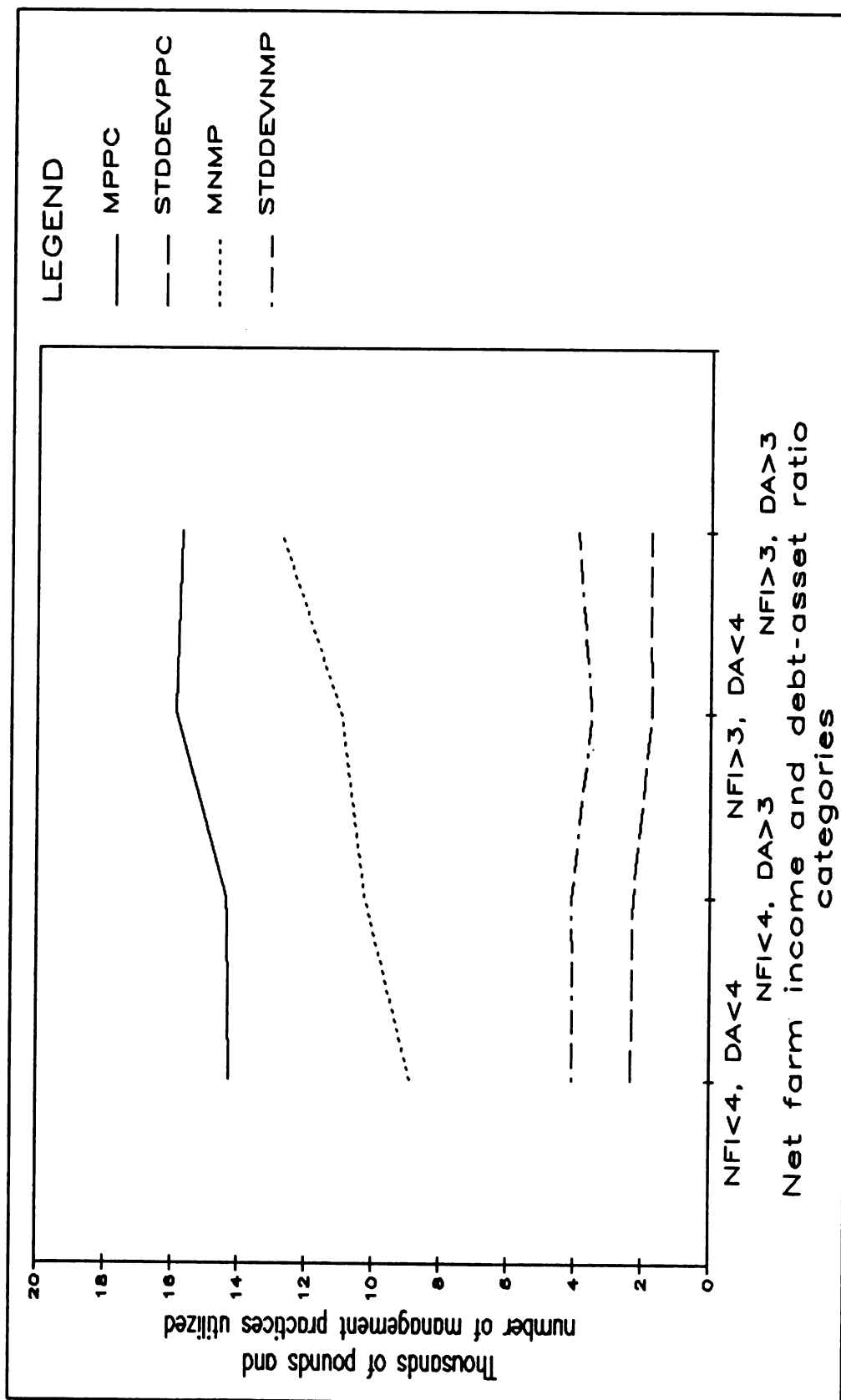


Figure 5.2. Productivity, management practices, and financial status
(see key on page 72)

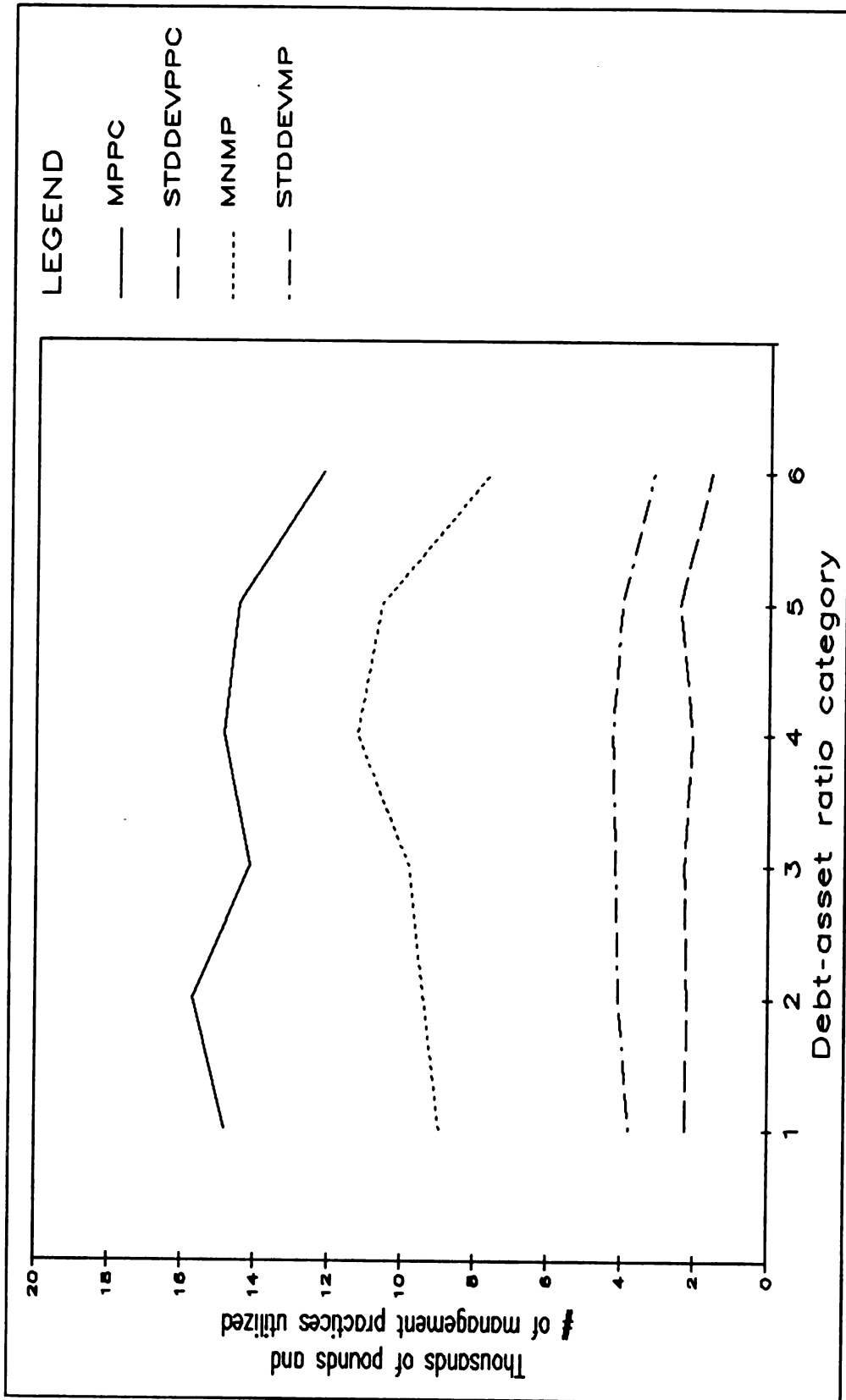


Figure 5.3. Productivity, management practices, debt-to-asset ratio
(see key on page 72)

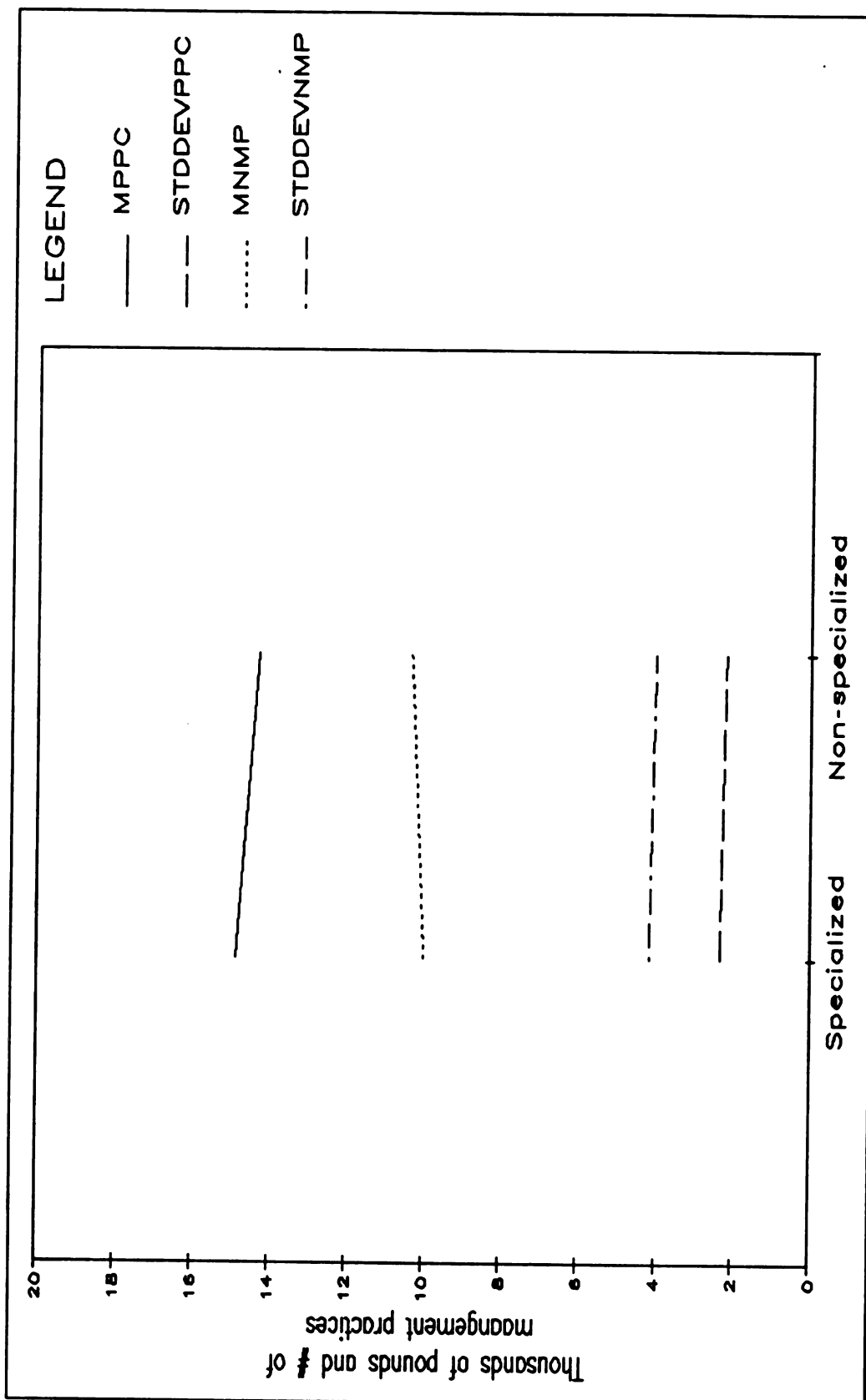


Figure 5.4. Productivity, management practices, and specialization
(see key on page 72)

Key for Figures 5.1 through 5.4.

1) Figure 5.1.

a) Abbreviations:

MPPC= Mean productivity per cow
 STDDEVPPC= Standard deviation from MPPC
 MNMP= Mean number of management practices used
 STDDEVMP= Standard deviation from MNMP
 MNCOWS= Mean number of cows in category

b) Categories:

Herd size=

1:	<= 29 cows
2:	30-44
3:	45-59
4:	60-89
5:	90-119
6:	120-149
7:	150-179
8:	180-209
9:	210-239
>9:	>=240

2) Figure 5.2.

a) Abbreviations: same as above

b) Categories:

NFI<4, DA<4= Net farm income less than \$40,000,
 debt-to-asset ratio less than 70 percent
 NFI<4, DA>3= Net farm income less than \$40,000,
 debt-to-asset ratio greater than 69 percent
 NFI>3, DA<4= Net farm income greater than \$40,000,
 debt-to-asset ratio less than 70 percent
 NFI>3, DA>3= Net farm income greater than \$40,000,
 debt-to-asset ratio greater than 69 percent

3) Figure 5.3.

a) Abbreviations: same as above

b) Categories:

Debt-asset ratio

1:	0 percent
2:	1-19
3:	20-39
4:	40-69
5:	70-100
6:	>100

4) Figure 5.4.

a) Abbreviations: same as above

b) Categories:

Specialized= 75 percent of cash receipts stem from
 dairy operations
 Non-specialized= less than 75 percent of cash
 receipts stem from dairy operations

The preceding categories were chosen so as to identify the different relationships between the independent and dependent variables. It is hypothesized that unique differences exist between categories and that, if further researched could provide information that can ease transitional problems relating to increasing herd size or reconfiguring the dairy operation.

The regression equations take four forms - the control categories withstanding. The dependent variables to be estimated, productivity per cow (MILKPER) and net farm income (NETFINC), are regressed upon the two sets of independent variables separately, i.e., two sets of regression equations are estimated for both MILKPER and NETFINC. In the first set of regression equations, MILKPER and NETFINC are estimated to be a function of:

- 1) Forage quality testing by cutting (FORQU),
- 2) Hiring of pest scouts (HIREPS),
- 3) Soil testing for crops for fertilizer application (SOILT),
- 4) Micro computer used for farm records (MICROC),
- 5) Mail-in services for farm records (MAILIN),
- 6) DHIA performance testing (DHIA),
- 7) Other than DHIA performance testing (NDHIA),
- 8) Subscribe to somatic cell count (SOMCC),
- 9) A.I. in the majority of cow matings (AICOW)
- 10) A.I. in the majority of heifer matings (AIHF),
- 11) Feed ration formulation on a regular basis (FRATF),
- 12) Group cow by production and feed accordingly (GROUP),
- 13) Pregnancy check within 40 days after breeding (PREGCHK),
- 14) Systematic post-partum exams (POSTPEX)
- 15) Purchase majority of replacement cows (PURREC),
- 16) Heat synchronization check (HEATSYN),
- 17) Use regularly scheduled vet services (VET),
- 18) Milk three times a day (3X),
- 19) Teat dip all cows before milking (PDIP),

- 20) Teat dip all cows after milking (DIPP),
- 21) Treat dry cows for mastitis prevention (DRYCMP),
- 22) Average age of first calving for heifers, 24-25 months (1STCALF),
- 23) Culling rate greater than 15 percent (CULL1),
- 24) Culling rate greater than 30 percent (CULL2),
- 25) Registered cattle account for a majority of the herd (REGCAT),
- 26) Purchase 16 percent dairy ration (16PER),
- 27) Purchase by-product feeds (eg. brewer's grain, cotton seed, etc.) (BYPROD).

and take the general form with the hypothesized sign preceding the variable:

$$\begin{aligned} \text{MILKPER, NETFINC} = & \alpha + \beta_1 \text{FORQU} + \beta_2 \text{HIREPS} + \beta_3 \text{SOILT} + \\ & \beta_4 \text{MICROC} + \beta_5 \text{MAILIN} + \beta_6 \text{DHIA} + \beta_7 \text{NDHIA} + \beta_8 \text{SOMCC} + \\ & \beta_9 \text{AICOW} + \beta_{10} \text{AIHF} + \beta_{11} \text{FRATF} + \beta_{12} \text{GROUP} + \beta_{13} \text{PREGCHK} + \\ & \beta_{14} \text{POSTPEX} + \beta_{15} \text{PURREC} + \beta_{16} \text{HEATSYN} + \beta_{17} \text{VET} + \beta_{18} 3X + \\ & \beta_{19} \text{PDIP} + \beta_{20} \text{DIPP} + \beta_{21} \text{DRYCMP} \text{ -, + } \beta_{22} 1\text{STCALF} + \beta_{23} \text{CULL1} \\ & + \beta_{24} \text{CULL2} \text{ -, + } \beta_{25} \text{REGCAT} + \beta_{26} 16\text{PER} + \beta_{27} \text{BYPROD} + e.^1 \end{aligned}$$

In the second set of regressions, MILKPER and NETFINC are estimated to be functions of:

- 1) Ownership patterns: a) other than individual ownership (OWNER1); and b) limited partnership or corporate family farm (OWNER2),
- 2) The number of families involved in the dairy operation (FAM),
- 3) Planned percentage change in herd size for 1993 (PCHERDS),
- 4) Propensity to acquire BST technology (BST),
- 5) Total value of all cash receipts (CASH),
- 6) Net dairy farm income for all families (NETFINC),
- 7) Non-farm income (NONFINC),
- 8) Debt-to-asset ratio of operation (DARATIO),
- 9) The number of cows, both dry and milking (COWS).

¹ The meaning within the estimated equations of "-", "+" is that the hypothesized sign changes between the regressions with productivity per cow and net farm income as dependent variables, respectively.

and take the form:

$$\text{MILKPER, NETFINC} = \alpha + \beta_1 \text{OWNER1} + \beta_2 \text{OWNER2} + \beta_3 \text{FAM} + \beta_4 \text{EDU1} + \beta_5 \text{EDU2} + \beta_6 \text{EDU3} + \beta_7 \text{PCHERDS} + \beta_8 \text{BST} + \beta_9 \text{CASH} + \beta_{10} \text{NETFINC} - , + \beta_{11} \text{NONFINC} - \beta_{12} \text{DARATIO} - \beta_{13} \text{COWS} + e.$$

Variable definitions can be found in Appendix A.

5.1.1 FORMULATION OF HYPOTHESES

The formulation of hypotheses was done in a manner which utilized expert opinion of several Michigan State University faculty, intuition and reference to general and semi-specific regression equations.² The former method was used so as to prevent gross errors and to define a finer, more exact understanding of dairy farm demographics and management practices. A list of hypotheses can be found in Appendix B.

5.2 REGRESSION RESULTS

It is no surprise that the regressions did not perform equally well. Performance, however, is a relative concept. The regressions, unlike those using time series data, do not attempt to explain a large proportion of the variation in the dependent variables productivity per cow and net farm income. In this respect, the regressions presented are incompletely specified. But this does not mean that the hypotheses to be tested will necessarily be inadequately

² Dr. Ted Ferris, Associate Professor, Department of Animal Science; Dr. Larry Hamm, Associate Professor, Department of Agricultural Economics; and Dr. Sherrill Nott, Professor of Agricultural Economics.

judged. There are many factors involved in the determination of productivity per cow and net farm income; the independent variables that are chosen represent facets of and proxies for the mentioned set of factors. Low R-squared's and adjusted R-squared's, therefore, do not indicate failure but a relative proportion of complete information.

5.2.1 OMITTED REGRESSIONS

In order to save time and to present the more interesting results, the variables discussed will be limited to those that are significantly related to the dependent variables and which also result from fairly successful sets of regressions. Sets of regressions that have been completely omitted from this presentation for poor performance include:

- 1) that of management practices on productivity per cow
 - a) controlling for all categories but specialized and non-specialized dairies; and
- 2) all categories of the regressions of management practices on net farm income.

5.2.2 MANAGEMENT PRACTICES ON PRODUCTIVITY PER COW

Only one category in this set of regressions performed acceptably well, that of specialized and non-specialized dairy operations. For specialized dairy operations, four management practices were significant: [+]DHIA, [+]3X, [+]CULL1, and [-]REGCAT. The regression had an adjusted- R^2

of 0.2268.³ As can be seen in Table 5.2, all of the significant variables had the expected sign. While the significance of DHIA and CULL1 might be expected, that of REGCAT indicates an area of further research. If the composition of a herd characterized by a majority of registered cattle indicates a lower productivity per cow, what is its purpose. Of the 340 cases studied, 50 or 15 percent indicated that their herds were composed of a majority of registered cattle. A question is raised as to the costs -in lost productivity per cow- and possible benefits of their sale as replacements and breeding stock. Further research could assess these costs and benefits.

In the regressions controlling for non-specialized dairy operations, five management practices were significant: [+]SOILT, [-]MICROC, [-]NDHIA, [-]GROUP, and [+]CULL2. Both NDHIA and GROUP have signs contrary to those hypothesized. A possible reason for group to have a negative sign is that an insufficient amount of attention is given to the grouping of cows by production level or attempts to feed accordingly. The cost of reduced productivity due to poor judgement or insufficient/bad information requires further yet potentially

³ A variety of terms are used to describe the statistic 'adjusted-R².' They include: R-BARSQRD and percent of the variance in the dependent variable explained by the independent variables. 'Adjusted' simply means that the degrees of freedom are taken into consideration when calculating the R² statistic. See also Chapter 4, section 4.1.5.

beneficial information.

Performance testing by a service other than DHIA also has a sign contrary to the one hypothesized. An examination of DHIA, NDHIA and operations which do not utilize formal services for performance testing may be helpful in understanding the strange effect of NDHIA in this category. DHIA and NDHIA have a rather low negative correlation so it can be assumed that NDHIA is sometimes used to complement and/or substitute aspects of DHIA. The negative sign on NDHIA may indicate that the complementary use of DHIA and NDHIA may be a hinderance to higher productivity per cow. This conclusion is, however, somewhat problematic as the exact nature of the performance testing implied by NDHIA is unknown. A comparison of all possible combinations of performance testing -including none- shows that herds using either DHIA or NDHIA have slightly higher productivity per

Table 5.1. A comparison of mean effects of performance testing

Performance Testing	# cases	Mean	Standard Deviation
DHIA only	175	15438.15	1876.5
NDHIA only	22	15044.21	2574.9
neither DHIA nor NDHIA	135	14772.96	2858.5
DHIA and NDHIA	8	14786.48	2160.1

*340 cases were used to generate these numbers, see Chapter 3.

cow than their combination DHIA-NDHIA and no-formal-performance-testing counterparts.

5.2.3 DEMOGRAPHIC CHARACTERISTICS ON PRODUCTIVITY PER COW

The statistics from this set of regressions were fairly good. Only two regressions, i.e., large herds and non-specialized dairy operations, failed the F-test. The adjusted- R^2 's of the remaining regressions ranged from a low of 0.1387 to 0.3983. Not including the lowest figure, 6 regressions have adjusted- R^2 's above 0.2500 and 3 are above 0.3200.

Throughout the categories controlling for herd size, net farm income and debt-to-asset ratio, and specialized and non-specialized dairy operations, certain patterns are evident in the significance of the variables. The education variables, when significant, take on their expected positive sign. The coefficient of EDU2, greater than a high school education -which includes technical training- is never significant. The substitutability of a high school education and technical training is a topic for further research. EDU3, education of at least college, is significant in the low net farm income and low debt-to-asset ratio operations, specialized dairy operations and herds with less than 120 cows and possesses relatively large coefficients of around 2,000 pounds per cow.

Another variable which appears to be interesting is non-farm income (NONFINC) in that it identifies a strong relationship between the employment of family members in

non-farm activities and productivity per cow. The presence of non-farm income has a depressing effect on productivity per cow with an increasingly negative effect between: small (-0.0596) and medium (-0.1136) sized herds; and low net farm income (-0.0616) and high net farm income (-0.1318) with low debt-to-asset ratios. Within specialized dairy operations (-0.0668), the effect is also negative. The value of the non-farm use of family labor in terms of lost productivity per cow are most likely the same for smaller operations. For medium sized operations, the value of non-farm income versus the value of increases in productivity per cow needs to be established. Any investigation of the relationship between the employment opportunity of family labor in non-farm activities would require extensive information on the distribution of farm labor, training, and returns per man-hour.

A strange result occurs for the number of cows, both dry and milking ([-]COWS). For small herds (-61.3700), low net farm income and low debt-to-asset ratio (-22.8339) and specialized dairy operations (-20.6140), increases in herd size result in significantly lower productivity per cow. Whether this is a function of diseconomies of scale or attempts to become bigger before better must be determined by further research.

Table 5.2. Summary results: regressions of demographic characteristics on productivity per cow

Variable Category	OWNER1	OWNER2	FAM	EDU1	EDU2	EDU3	PCHERDS	BST	CASH	NETFNC	NONFINC	DARATIO	COLUS
Herd size:													
<60 cows	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:-	+	+	+	-	+	-	+	+	+	-	-	-
	S:0	0	0	***	0	***	+	0	***	***	**	0	***
60-119 cows	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:-	-	+	-	-	+	+	+	+	-	-	-	-
	S:0	0	0	0	0	**	0	0	***	0	***	+	0
>119 cows	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:+	-	-	-	-	-	-	-	-	-	-	+	-
	S:0	0	0	0	0	0	0	0	**	0	0	0	0
Net farm income/													
debt-to-asset ratio < \$40,000 < 70%	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:-	-	-	+	-	+	-	+	+	+	-	-	-
	S:0	0	0	***	0	**	**	**	***	0	**	0	**
> \$40,000 < 70%	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:-	+	-	0	-	+	-	-	+	-	-	-	-
	S:0	0	0	0	0	0	0	0	**	0	***	0	0
< \$40,000 > 70%	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:-	-	+	+	-	+	-	+	+	+	-	-	-
	S:0	0	0	+	0	0	0	0	**	***	0	0	0
> \$40,000 > 70%	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:+	-	-	+	-	+	+	+	+	+	-	-	-
	S:0	***	0	0	0	0	0	0	0	0	0	0	0

(cont'd. on next page)

Table 5.2. (cont'd.)

Variable Category	OWNER1	OWNER2	FAM	EDU1	EDU2	EDU3	PCMERDS	BST	CASH	NETFNC	NONFNC	DARATIO	COUS
Specialization:													
specialized	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:-	-	+	+	-	+	-	+	+	+	-	-	-
	S:0	0	0	***	0	**	0	0	***	***	***	0	**
non-specialized:													
	N:+	+	+	+	+	+	+	+	+	+	-	-	-
	A:+	-	+	-	-	+	-	-	+	+	-	-	-
	S:0	0	0	0	0	0	0	0	**	0	0	0	0

1) N= hypothesized sign

2) A= actual sign

3) S= significance (eg. *.10; **.05, ***=.01)

4) Bold lettered categories and variables indicate interesting results

5) Variable definitions can be found in section 5.1.

5.2.4 DEMOGRAPHIC CHARACTERISTICS ON NET FARM INCOME

The final group of regressions to be presented are those using net farm income and demographic characteristics as dependent and independent variables, respectively.

All of the F-statistics in this category of regressions were significant to at least 0.10. Adjusted- R^2 's ranged from 0.0554 to 0.3788; all but three were above 0.2000 and two were above 0.3000.

The education variables again provide some interesting results yet not merely because of their significance. For the categories of medium sized herds (-47,758.10), high net farm income and low debt-to-asset ratio (-157,882.32) and specialized dairy operations (-19,727.56), EDU1 has a negative effect on net farm income. If education is used as a proxy for age and older operators tend to have less formal education than their younger counterparts, the negative effect could be attributed to differences in the operations' life cycles.

Non-farm income demonstrates interesting relationships for low net farm income operations. The previous set of regressions (section 5.2.3) showed that increases in non-farm income are associated with generally lower productivity per cow. That a similar, negative effect occurs in relation to net farm income emphasizes the importance of family labor on small and possibly medium- sized dairy operations as well.

Debt-to-asset ratio (DARATIO) behaves strangely between

the regressions controlling for herd size, and net farm income and debt-to-asset ratio. DARATIO has a significant and increasingly negative effect between medium and large herds. Furthermore, it is significant, negative and fairly constant in its effect in the low net farm income categories. It would appear that the debt loads significantly affect net farm income in the lower category. Yet it is the medium and larger herds -most likely with high net farm incomes- that demonstrate significant relationships between net farm income and debt-to-asset ratio. Further research could possible explain this seeming contradiction.

Lastly, a variable which has a very unlikely negative sign is cash receipts ($[-]0.1938 \times \text{CASH}$) in the category of high net farm income and high debt-to-asset ratio. That is for one dollar increases in cash receipts, net farm income falls off by 19 cents. Debt payments, it would appear are rather significant in this category. Further research could confirm this relationship.

Table 5.3. Summary results: regressions of demographic characteristics on net farm income

Variable/ Category	OWNER1	OWNER2	FAM	EDU1	EDU2	EDU3	PCHERDS	BST	CASH	NETFINC	NONFINC	DARATIO	CONS
Herd size:													
< 60 cows	H:+	+	+	+	+	+	+	+	+	X	+	-	+
	A:-	+	+	+	-	+	-	-	+		+	+	+
	S:0	0	0	0	0	0	0	0	0		0	0	***
60-119 cows	H:+	+	+	+	+	+	+	+	+	X	+	-	+
	A:+	+	+	-	-	+	-	-	-		-	-	+
	S:0	0	0	***	0	0	0	0	0		0	**	***
> 119 cows	H:+	+	+	+	+	+	+	+	+	X	+	-	+
	A:-	-	+	-	-	-	-	+	+		-	-	+
	S:0	0	0	***	0	0	0	0	0		0	***	0
Net farm income/ debt-to-asset ratio													
< \$40,000	H:+	+	+	+	+	+	+	+	+	X	+	-	+
< 70%	A:+	+	-	+	-	-	-	+	+		-	-	-
	S:0	0	0	0	0	0	**	**	*		*	**	0
> \$40,000	H:+	+	+	+	+	+	+	+	+	X	+	-	+
< 70%	A:+	+	+	-	+	-	-	+	-		+	+	+
	S:0	0	0	***	0	0	0	0	0		0	0	***
< \$40,000	H:+	+	+	+	+	+	+	+	+	X	+	-	+
> 70%	A:+	+	-	+	-	+	-	-	+		-	-	+
	S:0	0	0	0	0	0	0	0	0		**	**	0
> \$40,000	H:+	+	+	+	+	+	+	+	+	X	+	-	+
> 70%	A:+	+	-	+	-	+	+	+	-		-	+	+
	S:0	**	0	0	0	0	0	0	-		0	0	*

(cont'd. on next page)

Table 5.3. (cont'd.)

Variable Category	OWNER1	OWNER2	FAM	EDU1	EDU2	EDU3	PCHERS	BSY	CASH	NETFNC	NONFNC	DARATIO	COLS
Specialization:													
specialized													
H:+	+	+	+	+	+	+	+	+	+	X	+	-	+
A:-	+	+	+	-	-	+	+	-	+		+	-	+
S:0	0	*	*	**	0	0	0	0	0		0	0	**
non-specialized													
H:+	+	+	+	+	+	+	+	+	+	X	+	-	+
A:+	-	+	+	-	-	+	-	+	-		+	-	+
S:0	0	0	0	0	0	0	0	0	0		0	0	**

1) H= hypothesized sign

2) A= actual sign

3) S= significance (eg. *.10; **.05, ***=.01)

4) Bold lettered categories and variables indicate interesting results.

5) Variable definitions can be found in section 5.1

5.3 SUMMARY RESULTS

Varying proportions of the variation in productivity per cow and net farm income on Michigan dairy farms can be explained by management practices in the form of dummy variables and reformulated demographic characteristics.

Regressions of productivity per cow on the management practices demonstrated a number of areas of interest. A more complete detailing of the regression results can be found in Appendix C. The variables which are significant in these regressions and may identify areas of research beneficial to Michigan dairy farmers include: [+]DHIA, [-]REGCAT, and [+]CULL1.

A study focusing on DHIA herds to assess the managerial characteristic needed for successful use of DHIA performance testing would be extremely helpful.

The negative impact of REGCAT on productivity per cow indicates a potential target for a cost-benefit analysis.

Education of at least high school has a positive effect on productivity per cow yet a negative impact on net farm income. Whether the latter is a function of the life-cycle of a dairy farm, i.e., with respect to debt payments and the managerial capability present in a dairy operation remains unknown. The significance of EDU3, at least some college, in: 1) small and medium herds; 2) low net farm income/low debt-to-asset ratio; and 3) specialized dairy operations indicates the potential for future growth. Small herds in and specialized dairy operations also have significant

coefficients for PCHERDS which identifies a propensity to expand herd size in herds with a relatively lower productivity per cow. Research is needed to identify the means of expanding herd size in these categories.

A very profitable piece of research would be a study focusing on the utility of non-farm income and dairy farm and farmer characteristics which accompany a reliance on or simply the presence of non-farm income.

One last area of interest is the relationship between [-]COWS and both productivity per cow and net farm income. A study analyzing the relationship between herd size, productivity per cow, and costs per hundredweight within and between herd size categories in Michigan would be helpful in determining areas for more concerted extension effort.⁴

Though the regression analysis has indicated many areas of research interest it must be remembered that the data is in a form which may lead to errors in significance. However, the errors are not due to violations in the assumptions noted in Chapter 4, but errors related to: 1) the translation of categorical data into a continuous form; and 2) the nature of the interactions between human capital and the stated managerial practices used on the respective dairy operations. The fact that many times combinations of managerial practices and demographic characteristics are

⁴ B.F. Stanton, in his "Competitiveness of Northeast Milk Producers in the National Market," provides a good framework for such a study. See bibliography.

characterized by interactive systems and may represent some underlying factors demonstrates a need for a different form of analysis. Factor analysis is chosen to study the possible effects of this latter consideration.

CHAPTER 6

RESULTS FROM FACTOR ANALYSIS AND FACTOR REGRESSIONS

As has been noted, the primary aims of factor analysis are to: 1) identify groups of inter-correlated variables; 2) reduce the number of variables being studied; and 3) rewrite the data set in an alternate form. The last step, of course, allows for further regression analysis but with a reduced number of variables. The factor regression analysis of the data contained in Michigan State Universities' 1987 Survey of Michigan Dairy farmers is similar to that of the previous regression analysis. A difference exists in the approach: only the categories of regressions that were significant in the regressions using simple variables are addressed in the factor/regression analysis. The definitions of the categories remain the same.

6.1 FOCUS OF FACTOR ANALYSIS AND FACTOR REGRESSIONS

The process of factor analysis proceeds in the following manner:

- 1) examination of and observations on preliminary statistics (eg. KMO, AIC, Bartlett's Test of Sphericity);
- 2) observations on the initial factor extraction statistics and plots of the eigenvalues;

3) notations on the factor structure, pattern and factor correlation matrices; and

4) assessment of the regressions of various dependent variables (eg. productivity per cow, net-farm income) on the factor scores with controls for: a) herd size; b) debt-to-asset ratio and net farm income; and c) specialized and non-specialized dairies.

6.2 MANAGEMENT PRACTICE FACTORS

6.2.1 PRELIMINARY STATISTICS

The purpose of the preliminary statistics is to establish the appropriateness of the use of factor analysis. For the management practices, the following observations were made. Without excluding any variables from the group of management practices, the Kaiser-Meyer-Olkin measure of gross sampling adequacy (KMO) is 0.7867, quite near Kaiser's (1974) 'meritorious' range. A Bartlett Test of Sphericity (BTS) resulted in a value of 1588.683 which is significant to 0.0000, i.e., the observations are significantly correlated. While the preceding statistics would appear to indicate the appropriateness of factor analysis, examination of the anti-image correlation matrix shows that culling at greater than 30 percent (MSA=0.3866) and performance testing other than DHIA (MSA=0.3909) have relatively low measures of sampling adequacy. These variables are excluded from the present analysis. Their elimination results in slight increases in the pertinent statistics (KMO=0.7973 and

BTS=1537.2367 with a significance of 0.0000) and MSA_1 's within acceptable limits.

6.2.2 INITIAL FACTOR EXTRACTION AND EIGEN PLOT

Using the principle component method of factor extraction eight factors with eigenvalues greater than 1.0 resulted. Examination of the eigen value plot, however, reduced the probable number of true factors to four (4). A four factor model sufficiently explains 36.3 percent of the variance in the data set. Although this may appear to be a rather low proportion to have confidence in the results, there also is the necessary consideration of seemingly random elements in managerial regimes which can be better studied over longer periods of time. The results obtained in this analysis do, however, represent what can be termed "less random" tendencies in managerial regimes. An abbreviated structure matrix including variable definitions can be seen in Table 6.1.

6.2.3 HYPOTHEZIZED RATIONALE FOR A FOUR FACTOR MODEL

The hypothesized rationale for the preceding four(4) factor model is the following. The predominant variables in Factor 1 appear to be both herd health (VET, POSTPEX, PREGCHK, DIPP, DRYCMP) and feed management practices (SOILT, FORQU, FRATF, GROUP). Also included in factor 1 are two reproduction/replacement practices (CULL1 AND HEATSYN). Finally, the presence of MAILIN with VET may indicate specialization of managerial duties. The composition of factor 1 tends to indicate a possible measure of managerial

intensity of general dairy farm management, or informal managerial practices. As a measure of informal managerial intensity, MGT1 is hypothesized to have a positive relationship with productivity per cow and net farm income.

Factor 2 is a bit more difficult to explain. The inclusion of a health, a reproductive, and a feed management practice and number of milkings per day could be an indicator of size. According to Dr. Ted Ferris, the elements in this factor are management practices which are rarely used by Michigan dairy farmers. Efforts to incorporate heifers into the milking herds earlier; milking 3 times a day; hiring pest scouts and teat dipping before milking may also indicate attempt to spread fixed costs over more units of production for medium and larger herds with larger yet tenuous relative dependencies on grown feed and forage crops. MGT2 is hypothesized to have a positive relationship with both productivity per cow and net farm income.

Factor 3, composed of two feed/protein source variables ([-]16PER and BYPROD), a herd replacement practice ([-]PURREC) and a general management tool (MICROC), appears to indicate the relative independence/capability of the dairy operation with respect to dairy ration formulation and herd replacement.

**Table 6.1. Selected variable-factor correlations:
Management practices /1**

Factor Variable	Correlation /2
MGT1. /3	
Systematic post-partum exams (POSTPEX)	0.7238
Regularly scheduled vet services (VET)	0.7122
Pregnancy check within 40 days of breeding (PREGCHK)	0.6853
Forage quality testing by cutting (FORQU)	0.6470
Feed ration formulation on a regular basis (FRATF)	0.5978
Teat dip cows after milking (DIPP)	0.4907
Soil testing for crops for fertilizer application (SOILT)	0.4639
Treat dry cows for mastitis prevention (DRYCMP)	0.4536
Group cows by production and feed accordingly (GROUP)	0.4069
Mail-in services for farm records (MAILIN)	0.3639
Culling rate greater or equal to 15 percent (CULL1)	0.3583
Heat synchronization check (HEATSYN)	0.3332
MGT2. /3	
Pre-dip all cows (PDIP)	0.5879
Average age of first calving for heifers is 24-25 months (1STCALF)	0.5412
Hire pest scouts (HIREPS)	0.4589
Milk three times a day (3X)	0.4254
MGT3. /3	
Purchase 16 percent plus dairy ration (16PER)	-0.6161
Purchase a majority of replacement cows (PURREC)	-0.5089
Purchase by-product feeds (BYPROD)	0.4849
Micro computer for farm records (MICROC)	0.4668
MGT4. /3	
A.I. in majority of heifer matings (AIHF)	0.7423
A.I. in majority of cow matings (AICOW)	0.7319
DHIA performance testing (DHIA)	0.6429
Registered cattle account for a majority of herd (REGCAT)	0.5709
Subscribe to DHIA somatic cell count (SOMCC)	0.5079

/1 No correlations are listed which are below 0.3.

/2 [-] indicates a negative correlation with the factor.

/3 As was indicated in Chapter 5, the factor analytic model identifies underlying factors. There are many ways to score highly upon a factor. There is no reason to believe that because some variables are more highly correlated with a factor that they are necessarily more important than lesser correlated variables in the determination of the factor score. The lesser correlated variables do make a smaller contribution but they can not be discounted.

The inclusion of the micro-computer for farm records also tends to indicate a degree of independence with respect to record keeping. It is worth noting that MICROC is somewhat correlated with FORQU and POSTPEX; causality, however, does not necessarily exist. MGT3 is hypothesized to have a positive relationship with both productivity per cow and net farm income.

Factor 4 is a tricky factor to interpret. Since an oblique method of rotation was chosen the extracted factors are not orthogonal in their rotated form. Although in most cases the factors are negligibly correlated, the correlation between factors 1 and 4 (0.3102) could indicate interpretational problems. Looking at the composition of Factor 4 (AIHF, AICOW, DHIA, REGCAT, SOMCC) managerial intensity appears to be a common trait among the variables. That DHIA and AICOW (0.3624) and AIHF (0.3068) and SOMCC (0.5549) and REGCAT (0.2680) are somewhat correlated may indicate the presence of a similar yet distinct vector of managerial intensity relating to DHIA herds. 'Formality' in managerial intensity or a tendency to track herd production and genetics effectively might be a good definition of this factor. To expand upon the above a discussion of probable causality may be in order. Data from the MSU 1987 survey in Table 5.1 for relative performance of DHIA herds versus NDHIA herds versus both DHIA and NDHIA versus neither shows that DHIA herds perform better on average than non-DHIA herds and both DHIA and NDHIA perform better than herds with

no performance testing. Data from the USDA's Agricultural Statistics confirms the superiority of DHIA herds productivity. This fact, however, may be a function of inherent managerial ability which parallels contracting for DHIA services in which case a causal relationship does not exist. DHIA, considering the above could be a flag denoting general managerial ability. It may follow then that an affirmative response on DHIA implies a high score on factor 1. However, a high score on factor 1 does not necessarily imply a high score on factor 4. The degree of correlation between factors 1 and 4 (0.3102) indicates the diluting effect of NDHIA and no contracted performance testing of managerial intensive dairy farmers. That contracting for DHIA and NDHIA produces a lower herd average -comparable to no performance testing- is difficult to explain. In general, however, factor 4 tends to indicate a formal aspect of the dairy operation. MGT4 is hypothesized to have a positive relationship with both productivity per cow and net farm income.

6.3 DEMOGRAPHIC FACTORS

6.3.1 PRELIMINARY STATISTICS

In the preceding section on management practices, the purpose of the preliminary statistics was established. It is sufficient now to report the observations made concerning the demographic characteristics. The variables for demographic characteristics remain the same as those reported for the regression analysis, i.e., OWNER1, OWNER2,

FAM, EDU1, EDU2, EDU3, BST, PCHERDS, CASH, NETFINC, NONFINC, DARATIO, COWS. The KMO measure of gross sampling adequacy is 0.6223, a somewhat mediocre sample. A Bartlett Test of Sphericity resulted in a value of 928.42927 which has a significance of 0.0000. Measures of individual variable sampling adequacy are all within acceptable limits.

6.3.2 INITIAL FACTOR EXTRACTION AND EIGEN PLOT

Again using the principle component method of factor extraction, 5 factors were extracted with eigenvalues greater than 1.0. Examination of the eigenvalue plot confirmed that a five factor model would sufficiently explain the variance in the data set. A five factor model explains 62.0 percent of the variance in the data set. The five factor model results in the following abbreviated structure matrix:

**Table 6.2. Selected variable-factor correlations:
Demographic characteristics /1**

Factor Variables	Correlation /2
DEM1. /3	
Total Cash receipts (CASH)	0.9136
Number of cows both dry and milking (COWS)	0.9101
Net farm income (NETFINC)	0.5391
DEM2. /3	
Education of greater than high school (EDU2)	0.7996
Education of at least high school (EDU1)	0.7261
Education of at least some college (EDU3)	0.6204
DEM3. /3	
Limited partnership or corporate family farm (OWNER2)	0.9066
Other than individual ownership (OWNER1)	0.7828
Number of families (FAM)	0.4785
DEM4. /3	
Non-farm income (NONFINC)	-0.8120
DEM5. /3	
Debt-to-asset ratio (DARATIO)	0.6437
Planned percentage change in herd size (PCHERDS)	0.6151
Propensity to use BST technology (BST)	0.5394

/1 No correlations are listed which are below 0.3.

/2 [-] indicates a negative correlation with the factor.

/3 As was indicated in Chapter 5, the factor analytic model identifies underlying factors. There are many ways to score highly upon a factor. There is no reason to believe that because some variables are more highly correlated with a factor that they are necessarily more important than lesser correlated variables in the determination of the factor score. The lesser correlated variables do make a smaller contribution but they can not be discounted.

6.3.3 HYPOTHESIZED RATIONALE FOR A FIVE FACTOR MODEL

The hypothesized rationale for the preceding five (5) factor model is the following: factor 1 appears to include the three variables distinctly related to the size of the dairy operation (CASH, COWS, and NETFINC). Though it is apparent that net farm income is somewhat less correlated with Factor 1 than the other two variables this can be explained by the fact that size is not a good indicator of profitability, only fair. Information on the size of the dairy operation is contained in Factor 1. Size is a distinct advantage in organizing managerial tasks and therefore DEM1 is hypothesized to have a positive relationship with productivity per cow (MILKPER). The relationship between DEM1 and net farm income (NETFINC) will not be addressed because of the composition of DEM1.

The implication of Factor 2 is fairly obvious, it being composed of education variables. Although the structure of Factor 2 may indicate the likelihood of multicollinearity in the original data set (adding confusion to the present interpretation), correlations among the untransformed education variables are minimal. Education (DEM2) is hypothesized to have a positive relationship with both productivity per cow and net farm income.

Factor 3 is similarly easy to explain; composed of OWNER1, OWNER2, and FAM, Factor 3 relates information as to the complexity of the ownership structure. Correlations between FAM and OWNER1 (0.2838), and OWNER2 (0.1309) in the

original data set tend to indicate that complexity of ownership patterns increase somewhat with the number of families involved in the dairy operation. Complexity of ownership structure (DEM3) is hypothesized to have a positive effect on both productivity per cow and net farm income.

Factor 4 is somewhat strange in that it is composed of only one variable, NONFINC which is negatively correlated (-0.8120) with its factor. Interpretation of Factor 4 is simply the relative absence of non-farm income. The presence of non-farm income, (-)DEM4, is hypothesized to have a negative relationship with productivity per cow, yet a positive relationship with net farm income.

Factor 5 presents some problems. Containing the variables DARATIO, PCHERDS and BST, Factor 5 appears to demand a rather intuitive interpretation. In the preceding chapter on regression analysis of the demographic characteristics it is hypothesized that PCHERDS is a weak proxy for a dairy farmer's optimism for future economic/political trends. That all three variables are positively correlated with Factor 5 would may imply that given the present financial condition (DARATIO) of a dairy farm, there may be a concomitant propensity to adopt BST and/or a plan to expand herd size. In sum, plans to expand production are positively associated financial stress. Optimism despite present financial status is hypothesized to

have a negative relationship with both productivity per cow and net farm income.

6.4 MANAGEMENT FACTORS AS INDEPENDENT VARIABLES

In an attempt to ascertain the relative importance of the defined managerial and demographic factors (independent variables) in the determination of productivity per cow and net farm income (dependent variables) regressions were performed as defined in Chapter 4. At times relationships are somewhat tautological due to a characteristic of a factor and its inherent identification with a dependent variable (eg., DEM1 -composed of CASH, COWS, and NETFINC). That the definition of a factor is somewhat different than its component variables allows for interpretation, albeit limited. To partially alleviate the biasing effect of these respective factors on the regression statistics, certain appropriate factors will be dropped. While comparability between regressions will be hampered, interpretation within regressions will be enhanced. Because the number of independent variables is greatly reduced the relative size of the coefficients between regressions will be examined at times in addition to the explanatory value of variables within regressions.

6.4.1 MANAGEMENT FACTORS ON PRODUCTIVITY PER COW

The regression of the management factors on productivity per cow (MILKPER) while controlling for certain dairy farm characteristics resulted in a fairly wide range of adjusted- R^2 's. The percent of variation in productivity

per cow explained by the management factors ranged from a low of 0.0000 to a high of 0.5657. The majority of the adjusted- R^2 's were in the 0.1000 to 0.2500 range. Three regressions demonstrated relatively high adjusted- R^2 's: 1) non-specialized dairy operations (0.4164); 2) low net farm income and low debt-to-asset ratio (0.3695); and 3) high net farm income and high debt-to-asset ratio (0.5657).

One of the most significant variables within and between categories is the factor of informal managerial practices (MGT1). This factor, representing primarily health and nutrition practices, is significant in all categories but large herds. Further research could establish the true effect of many of the variables which make up MGT1, both singly and combined.

The second most significant variable within and between regressions was the factor for formal managerial practices (MGT4). MGT4 was significant in: 1) small herds; 2) low net farm income and low debt-to-asset ratio; and 3) specialized/non-specialized dairy operations. Though the magnitude of MGT4 is less than that of MGT1, it is larger than that of any other variable. The incorporation of performance testing and Artificial Insemination (A.I.) in a managerial regime indicates a potential increase in productivity per cow. Further research is need to ascertain the education/experience level necessary to adopt these practices. Such a study could also address the information contained in MGT3, the independence factor.

Lastly, a strange sign occurs on MGT2, the factor representing infrequently used practices. In none of the regressions does the factor take on the hypothesized positive sign. In the category of non-specialized dairy operations is the coefficient significant (-1155.8173). Clearly, the effect is unrelated to some of the component variables (eg. 3X and HIREPS). Yet in the next set of regressions -with net farm income as the dependent variable- it will be shown that MGT2 changes signs between regressions. Questions are therefore raised as to the exact meaning of this factor.

Table 6.3 shows a summary of the results from this set of regressions.

Table 6.3. Summary results: regressions of management factors on productivity per cow

Variables Categories	MGT1	MGT2	MGT3	MGT4
Herd size:				
less than 60 cows	H:+	+	+	+
	A:+	-	+	+
	S:***	0	**	***
60 to 119 cows	H:+	+	+	+
	A:+	-	+	+
	S:**	0	0	0
more than 119 cows	H:+	+	+	+
	A:+	-	+	+
	S:0	0	0	0
Net income/debt-to-asset ratio:				
low net farm income/ low debt-to-asset ratio	H:+	+	+	+
	A:+	-	+	+
	S:***	0	0	***
high net farm income/ low debt-to-asset ratio	H:+	+	+	+
	A:+	-	+	+
	S:*	0	0	0
low net farm income/ high debt-to-asset ratio	H:+	+	+	+
	A:+	-	+	+
	S:*	0	*	0
high net farm income/ high debt-to-asset ratio	H:+	+	+	+
	A:+	-	+	+
	S:***	0	0	0
Specialization:				
specialized	H:+	+	+	+
	A:+	-	+	+
	S:***	0	**	***
non-specialized	H:+	+	+	+
	A:+	-	+	+
	S:***	***	0	**

Key:

1) H= hypothesized sign;

2) A= actual sign;

3) S= significance (0=non-significance; *=0.05; **=0.01; ***=0.001);

4) Bold lettered variable and categories indicate the presence of interesting results

5) Factor definitions:

a) MGT1= the informal managerial factor, primarily composed of health and nutrition variables;

b) MGT2= the factor that represents infrequently used managerial practices, characterized by the spreading of costs over more units of production;

c) MGT3= the factor which indicates a degree of independence of a dairy operation, i.e., dairy ration tends to be formulated no bought and a majority of the replacement cows are not bought;

d) MGT4= the formal managerial factor, primarily composed of contracted performance testing and A.I. in cows and heifers.

6.4.2 MANAGEMENT FACTORS ON NET FARM INCOME

Efforts to explain net farm income by means of the management factors led to somewhat mediocre statistics but interesting results for smaller dairy operations. Though the adjusted- R^2 's range from 0.0000 up to 0.2734, the majority are around 0.1000. Only in the regression controlling for high net farm income and high debt-to-asset ratio did a relatively noteworthy adjusted- R^2 result (0.2734).

As in the regression using the management factors to explain productivity per cow, MGT1 dominates the other factors in overall significance across all categories. MGT1, however, is significant only for: 1) small herds; 2) low net farm income and low debt-to-asset ratio; and 3) specialized dairy operations. The value of health and nutrition practices for smaller dairy operations is a promising target of future research, especially when to "get bigger" successfully requires "getting better" with respect to managerial ability.

As was indicated in the last section, MGT2 changes sign between categories when regressed on net farm income. Again, further research is needed to determine whether the effect of MGT2 is a function of the practices it characterizes or the dairy operations indicating their usage.

The independence fact (MGT3), is significant for: 1) small herds; 2) low net farm income and high debt-to-asset

ratio; and 3) specialized dairy operations. the effect on net farm income is positive and ranges in magnitude from around \$5,000 to \$7,000. Although the definition of "one" unit of independence is difficult to measure, efforts to "make" not "buy" tend to result in lower costs and increased net farm income.

One final note relates to MGT4, the formal managerial factor. MGT4 is significant in none of the regressions and changes sign. The reason for this is difficult to determine though it may be related to the variable (REGCAT; Registered cattle account for a majority of the herd). Further research could no doubt uncover the reason behind this strange relationship.

Table 6.4 shows a summary of the results from this section.

Table 6.4. Summary results: regressions of management factors on net farm income

Variables Categories	MGT1	MGT2	MGT3	MGT4
Herd size:				
less than 60 cows	H:+ A:+ S:***	+ + *	+ + **	+ + 0
60 to 119 cows	H:+ A:- S:0	+ - 0	+ + 0	+ - 0
more than 119 cows	H:+ A:- S:0	+ + *	+ + 0	+ - 0
Net income/debt-to-asset ratio:				
low net farm income/ low debt-to-asset ratio	H:+ A:+ S:*	+ - *	+ + *	+ - 0
high net farm income/ low debt-to-asset ratio	H:+ A:+ S:0	+ + 0	+ - 0	+ + 0
low net farm income/ high debt-to-asset ratio	H:+ A:+ S:0	+ + 0	+ + ***	+ - 0
high net farm income/ high debt-to-asset ratio	H:+ A:- S:*	+ + *	+ + 0	+ - 0
Specialization:				
specialized	H:+ A:+ S:**	+ + 0	+ + *	+ + 0
non-specialized	H:+ A:+ S:0	+ - 0	+ + 0	+ + 0

Key:

1) H= hypothesized sign;

2) A= actual sign;

3) S= significance (0=non-significance; *=.05; **=.01; ***=.001);

4) Bold lettered variable and categories indicate the presence of interesting results

5) Factor definitions:

a) MGT1= the informal managerial factor, primarily composed of health and nutrition variables;

b) MGT2= the factor that represents infrequently used managerial practices, characterized by the spreading of costs over more units of production;

c) MGT3= the factor which indicates a degree of independence of a dairy operation, i.e., dairy ration tends to be formulated no bought and a majority of the replacement cows are not bought;

d) MGT4= the formal managerial factor, primarily composed of contracted performance testing and A.I. in cows and heifers.

6.5 DEMOGRAPHIC FACTORS AS INDEPENDENT VARIABLES

6.5.1 DEMOGRAPHIC FACTORS ON PRODUCTIVITY PER COW

Attempts to explain variations in productivity per cow with the demographic factors resulted in fairly average statistics, i.e., a lesser proportion is explained.

Although there are many and consistently significant factors in these regressions none of the adjusted- R^2 's are very large; the category of low net farm income and low debt-to-asset ratio possessed the largest (0.2295). While most of the remaining statistics were above 0.1500, some were around 0.0500.

The factor indicating economic size, DEM1, was most significant in explaining the variation in productivity per cow, but only in: 1) small herds; 2) low net farm income and low/high debt-to-asset ratio; and 3) specialized/non-specialized dairy operations. Though this would indicate expansion for smaller operations, the necessary managerial capability to successfully expand remains an unknown. Future research should concentrate on size and requisite managerial ability to establish a better understanding of the relationship between the two.

The value of DEM2, the education factor, appears to be similar to that of DEM1. Larger herds (> 60 cows) and high net farm income farms are categories in which DEM2 is not significant. Additionally, DEM2 is not significant in the category of low net farm income and high debt-to-asset ratio. As with DEM1, the value of managerial ability needs

further study. It is likely that the age of the principle operator in combination with the age of the operation are key components in the determination of the value of education and therefore the degree of managerial capability.

The only other variable to be discussed in this section is DEM4, the factor indicating the absence of net farm income. In Chapter 5, non-farm income was identified as a variable which was not only associated with lower productivity per cow, but also lower net farm income. Because DEM4 is rather highly correlated with non-farm income (-0.8120), the effect should be virtually the same. Non-farm income is clearly identified as a variable which could well benefit from further research.

Table 6.5 provides a summary of the results from this last section.

Table 6.5. Summary results: regressions of demographic factors on productivity per cow

Variables Categories	DEN1	DEN2	DEN3	DEN4	DEN5
Herd size:					
less than 60 cows	H:+	+	+	+	-
	A:+	+	+	+	-
	S:***	***	0	0	0
60 to 119 cows	H:+	+	+	-	-
	A:+	+	-	+	-
	S:0	0	0	*	0
more than 119 cows	H:+	+	+	-	-
	A:+	-	-	+	-
	S:0	0	0	0	0
Net income/debt-to-asset ratio:					
low net farm income/ low debt-to-asset ratio	H:+	+	+	-	-
	A:+	-	+	+	-
	S:***	**	0	*	0
high net farm income/ low debt-to-asset ratio	H:+	+	+	-	-
	A:+	-	+	+	-
	S:0	0	0	**	0
low net farm income/ high debt-to-asset ratio	H:+	+	+	-	-
	A:+	+	-	+	-
	S:**	0	0	0	0
high net farm income/ high debt-to-asset ratio	H:+	+	+	-	-
	A:+	+	-	-	+
	S:0	0	0	0	0
Specialization:					
specialized	H:+	+	+	-	-
	A:+	+	-	+	-
	S:**	***	***	**	*
non-specialized	H:+	+	+	-	-
	A:+	+	+	+	-
	S:*	0	0	0	0

Key:

1) H= hypothesized sign;

2) A= actual sign;

3) S= significance (0=non-significance; *=.05; **=.01; ***=.001);

4) Bold lettered variable and categories indicate the presence of interesting results

5) Factor definitions:

a) DEN1= the factor indicating the economic size of the operation;

b) DEN2= the education factor;

c) DEN3= the factor indicating ownership patterns as they correlate with the number of families involved in the dairy operation;

d) DEN4= the factor indicating the absence of non-farm income;

e) DEN5= the factor that represents a weak proxy for optimism despite present financial status.

6.5.2 DEMOGRAPHIC FACTORS ON NET FARM INCOME

The last set of regressions to explore are those regressing the demographic factors on net farm income. The statistics for the adjusted- R^2 ranged from a low of 0.0300 to a high of 0.4246. The regressions that performed rather well on the basis of the size of the adjusted- R^2 are: 1) high net farm income and low debt-to-asset ratio (0.4246); 2) medium sized herds (0.2949); and 3) non-specialized dairy operations (0.2457).

In this set of regressions, DEM1 is left out because of its implicit identification with the dependent variable, net farm income.

DEM2, the education factor, while having a positive effect on productivity per cow demonstrates a predominantly negative relationship with net farm income. For: 1) small and medium-sized herds; and 2) high net farm income and low debt-to-asset ratio, the effect is negative. Only for specialized operations is the effect positive and significant, and then with an insignificant coefficient. Whether this is the result of life-cycle differences among dairy operations or the occasional masking of total education/experience available by that of the principle operator is a topic for future research.

As in Chapter 5, the effect of non-farm income on net farm income is hypothesized to be negative. Oddly, DEM4, the non-farm income factor has a positive effect in medium-sized and large herds, operations with high net farm income

and low debt-to-asset ratio, and non-specialized dairy operations. DEM4 has a negative effect in low net farm income and low debt-to-asset ratio and specialized operations. Efforts to explain this change in sign resulted in one possible scenario: those operations which are not specialized in dairy production -possibly larger farming operations- are affected less by the loss of family labor to non-farm employment. Future research to identify the value of family labor to dairy operations, whether specialized or not, could help in evaluating non-farm income streams.

The weak proxy of optimism despite present financial conditions of the operation (DEM5) is consistent in sign -negative- across all categories, i.e., optimism increases as net farm income falls off. The value of this variable may well only be in demonstrating that Michigan dairy farmers with larger herds (>60 cows) have made a commitment to dairy production now and in the future as well.

Table 6.6 provides a summary of the results of the regressions of this last section.

Table 6.6. Summary results: regressions of demographic factors on net farm income

Variables Categories	DEM1	DEM2	DEM3	DEM4	DEM5
Herd size:					
less than 60 cows	H:X	+	+	+	-
	A:X	-	-	-	-
	S:X	*	0	0	0
60 to 119 cows	H:X	+	+	+	-
	A:X	-	+	-	-
	S:X	***	0	***	***
more than 119 cows	H:X	+	+	+	-
	A:X	-	+	-	-
	S:X	0	0	**	*
Net income/debt-to-asset ratio:					
low net farm income/	H:X	+	+	+	-
low debt-to-asset ratio	A:X	+	+	+	-
	S:X	0	0	*	0
high net farm income/	H:X	+	+	+	-
low debt-to-asset ratio	A:X	-	+	-	-
	S:X	**	0	**	0
low net farm income/	H:X	+	+	+	-
high debt-to-asset ratio	A:X	+	+	+	-
	S:X	0	0	0	0
high net farm income/	H:X	+	+	+	-
high debt-to-asset ratio	A:X	-	+	+	-
	S:X	0	0	0	0
Specialization:					
specialized	H:X	+	+	+	-
	A:X	+	+	+	-
	S:X	0	0	**	0
non-specialized	H:X	+	+	+	-
	A:X	-	+	-	-
	S:X	0	0	**	0

Key:

1) H= hypothesized sign;

2) A= actual sign;

3) S= significance (0=non-significance; *=.05; **=.01; ***=.001);

4) Bold lettered variable and categories indicate the presence of interesting results

5) Factor definitions:

a) DEM1= the factor indicating the economic size of the operation;

b) DEM2= the education factor;

c) DEM3= the factor indicating ownership patterns as they correlate with the number of families involved in the dairy operation;

d) DEM4= the factor indicating the absence of non-farm income;

e) DEM5= the factor that represents a weak proxy for optimism despite present financial status.

6) X indicates a factor left out of the regression because of an inherent identification with the dependent variable.

6.6 SUMMARY RESULTS

The use of factor analysis on the data set leads to the identification of several areas in which further research could be potentially profitable. Attempts to explain the variation of productivity per cow and net farm income with the management and demographic factors are rather successful.

The management factors performed relatively well. MGT1, the factor representing informal managerial practices -primarily POSTPEX, VET, PREGCHK, FORQU, and FRATF-¹ is extremely consistent. Those dairy farmers that score highly on MGT1 are generally more successful in terms of productivity per cow and have higher net farm incomes than those that do not. MGT1 demonstrates that additional research on health and nutrition practices and specific combinations of those practices would prove useful to Michigan dairy farmers. More information of MGT2, composed of infrequently used managerial practices, may prove to be beneficial to non-specialized dairy operations and low net farm income/ low debt-to-asset ratio operations. The value of MGT3, the factor indicating the degree of independence of the dairy operation, parallels that of MGT1. Finally, MGT4 or the factor of formal managerial practices appears to be important in determining productivity per cow, but not net farm income. This last point may also indicate the

¹ These variables have a correlation of 0.5 or greater with MGT1.

potential benefit of an in-depth financial analysis comparing DHIA herds with no performance testing.

With respect to the demographic factors, many interesting relationships are apparent. Education (DEM2) while having a positive relationship with productivity per cow, sometimes makes a negative contribution to net farm income (see also section 5.3). The relative absence of non-farm income, DEM4, again is indicated as having a negative effect on productivity per cow and net farm income. An exception lies in specialized dairy operations. DEM5, the factor defining a relative optimism despite of present financial status, demonstrates an interesting, negative relationship with net farm income in many categories. By this last relationship Michigan dairy farmers, i.e., medium to large herds with relatively low debt-to-asset ratios appear to be fairly committed to dairy production. However, specialized operations and those with low net farm income and low debt-to-asset ratios seem more likely to cash in on that optimism given that these operations are experiencing a lesser amount of financial stress. Given the present open market price of milk, the relevance of DEM5 may be momentarily moot.

Despite the potential problems identified in Chapter 4 relating to the data distorting effect of dichotomous variables, the low correlations among variables and the corroboration of many of the findings of this chapter in

Chapter 5, leads to the conclusion that factor analysis can provide valuable information.

CHAPTER 7
CONCLUSIONS, RESEARCH RESULTS AND TOPICS
FOR FURTHER RESEARCH

7.1 THE DAIRY INDUSTRY: U.S., TRADITIONAL REGIONS, AND MICHIGAN

7.1.1 THE U.S. DAIRY INDUSTRY

The 1970's and 1980's have been a period of significant change for the U.S. dairy industry and for the traditional dairy production regions in particular. The confluence of economic and political forces acting upon and within the U.S. dairy industry in this period are unprecedented. Political responses to the effects of inflation on the costs of production and returns to dairy producers (Food and Agricultural Act of 1977) spurred the development of excess dairy production capacity which became evident in 1979.

Attempts to alleviate the burden of excess capacity imposed on the Commodity Credit Corporation and federal government expenditures. Solutions evolved from efforts to lower milk marketings (Dairy Diversion Program 1984-85) to efforts to bid excess capacity out of the industry (Dairy Termination Program 1985) and reduce support prices when USDA net removals were projected to be burdensome. In addition to the above was the Food Security Act of 1985 which changed

profitability relationships which previously favored dairy production in the traditional regions over the Southern Plains and Pacific regions. The confluence of forces has affected change which has taken the form of not only intra-regional capacity adjustment but inter-regional shifts in capacity as well.

7.1.2 THE TRADITIONAL REGIONS

In the 1980's capacity adjustments have begun to threaten the dairy industry within the traditional regions. Past capacity adjustments have affected the traditional regions significantly. Though the Corn Belt and Northern Plains regions have been more severely affected by past dairy capacity adjustments, other equally profitable agricultural enterprises were available. The growing capacity in the Southern Plains, Mountain, and Pacific regions has the potential of displacing Upper Midwestern dairy products from some of their traditional markets in those regions.

The capacity adjustments alluded to above have been corroborated by a number of studies (Fallert et al. 1987; OTA 1986, to name two). These studies agree in their conclusions that the traditional regions will be greatly affected by future capacity adjustments, the former stating that they will account for approximately 90 percent of the capacity adjustment in the industry.

The industry response to date contains both firm (micro) level and industry (macro). The micro level

strategies are best summed up as 'better before bigger.' This is a rather obvious recommendation yet it will be difficult but not impossible to achieve. Getting better may require significant changes in traditional dairy operations. The capital structures of Northern dairy farms locks them into rigid scales of operation. The combinations of milking, feeding, housing, and waste handling facilities often precludes non-marginal changes needed to move toward greater profitability. Moreover, major capital restructuring is currently being constrained by both lender and producer attitudes. Many of the traditional region dairy producers who have survived the turmoil of the 1980's have their current operations running as efficiently as possible given the constraints imposed by their current situations.

7.1.3 MICHIGAN'S DAIRY INDUSTRY

Dairy farming has been historically important to Michigan's agricultural and general economies. Not only is dairy farming the single largest agricultural enterprises in Michigan, it also accounts for a large proportion of cash receipts generated by Michigan's diverse agricultural sector. Furthermore, dairy farming provides a relatively stable income base in the majority of Michigan's counties.

As part of the traditional regions, Michigan's long-run competitive position has come into question. Through changes in dairy markets, the economics of specialized dairy management, and changing profitability relationships, the

distribution of dairy production may well shift further. Due to these perceived threats to an industry vital to Michigan's agricultural and general economies, efforts have been made to avert a down-sizing in production capacity. Michigan Dairying 1995 and the Survey of Northern Dairy Farms have been part of a multi-faceted response designed to aid Michigan dairy farmers in adapting to the national and regional trends in the dairy industry.

7.2 1987 MICHIGAN STATE UNIVERSITY SURVEY OF MICHIGAN DAIRY FARMERS

The economic and political turmoil within the U.S. dairy industry in the 1970's and the 1980's prompted a number of research initiatives by the Land Grant university system to explore possible reconfiguration of management, labor, capital, and enterprise mix. A primary and common goal of these initiatives has been to formulate strategic plans and models to guide the respective dairy industries into the 1990's. One of those initiatives began in April 1987 and took the form of a study project entitled "Michigan Dairying 1995." "Michigan Dairying 1995" is composed of researchers from Michigan State University's colleges of Agricultural and Natural Resources and Veterinary Medicine. The main focus of the study group was the development of several prototype farming systems for Michigan's dairy farms in 1995. Because the current knowledge base concerning the present structure of Michigan dairy operations was

considered insufficient, a survey of Michigan dairy farms was undertaken.

The 1987 Michigan State University Survey of Michigan Dairy Farmers had as its primary goal produced a representative sample of Michigan's dairy producers, including information concerning their present structure and their demographic and managerial characteristics.

Among the major findings of the 1987 survey are that a majority of Michigan's dairy farms have net farm incomes below \$40,000 and a significant number are experiencing financial stress. If Michigan dairy farmers are to successfully adapt their operations to the economic conditions now and in the future, information needs to be developed to aid in the reconfiguration process.

The 1987 Michigan State University Survey of Michigan Dairy Farms has helped in the development of a better understanding of Michigan's dairy operations. At present there is relatively little information as to how Michigan's dairy farms can be reconfigure to better cope with past decisions and present and future economic conditions. The development of proto-type dairy systems using information from the 1987 Survey has been one method which can serve as a guide for Michigan's dairy producers. An analysis of the data relating to the present structure and relationships among aspects of Michigan's dairy operations can also add to the knowledge base necessary to the process of reconfiguration. The 1987 Survey has also served as a data

set for the present analysis of potential areas of further research on the reconfiguration Michigan's dairy operations.

The analysis attempts to analyze two aspects of the data set: management practices and certain demographic characteristics. These areas were addressed in order to assess the potential of further research to improve productivity and understand the position and potential of Michigan dairy farmers. The present analysis attempts to identify areas within typical dairy operations where such restructuring might prove beneficial. It has not been the intention of this thesis to conclude that the areas identified are the method of restructuring needed. Rather, the areas identified have a relatively greater potential of leading to research that will be both beneficial and profitable to Michigan's dairy farmers. Thus the primary objective of the present analysis has been to identify areas of research which can potentially benefit Michigan's dairy industry in the process of adaptation and reconfiguration.

7.3 RESEARCH METHODS

Given the preceding, both regression analysis and factor analysis in combination with further regression analysis of the defined factors was used to analyze the data set. The goal of the analysis was to identify relationships among the managerial and demographic characteristics of Michigan dairy farms and indices of efficiency and profitability in the form of average productivity per cow and net farm income. In examining these relationships the

isolation of the effects of one variable from those of another is desirable and thus some rationale exists for the utilization of regression analysis. But since a dairy operation can also be thought of as a firm or described as a composite of different managerial and demographic traits or factors, a redefinition of the characteristics using factor analysis also has a certain rationale. Using the defined factors in further regression analysis allows for an understanding of the relationships between the certain natural groupings of managerial activities and demographic characteristics and the indices of efficiency and profitability. While factor analysis does imply certain risks relating to the distortion of data, the risk is considered negligible relative to the potential information to be gained. The simultaneous use of both methods of analysis -using untransformed and factored data- also permits corroboration of the latter's results.

The descriptive nature of the survey data set, however, establishes certain caveats with respect to the formulation of hypotheses. The present analysis therefore does not attempt to identify the exact form of the relationship between variables but attempts to identify relationships which may provide a direction for further research.

An important consideration relates to the statistics produced by the methodologies utilized. While the methodologies do not produce statistics comparable to those one would expect from the analysis of time series data, it

must be remembered that cross-section data is the basis of this analysis of Michigan dairy farms and farmer characteristics. Moreover, the relationships implicit in the equations estimated are necessarily incomplete. Nonetheless, even the explanation of a modest proportion of the variance in average productivity per cow or net farm income is worthy of further investigation.

7.4 CONCLUSIONS OF REGRESSION ANALYSIS

7.4.1 SIMPLE MANAGEMENT VARIABLES

The set of regressions with productivity per cow and the management practices as dependent and independent variables, respectively, resulted in the identification of a few yet important areas of potential research. For specialized dairy operations, the following variables demonstrated significant relationships with productivity per cow: 1) DHIA performance testing; 2) [-] registered cattle accounting for a majority of the herd; and 3) culling at a rate of 15 percent or more annually.¹ Milking three times a day is also significant, but this can only be expected. Non-specialized dairy operations indicated the significance of: 1) soil testing for crops for fertilizer application; 2) micro-computer used for farm records; 3) [-] other than DHIA performance testing; 4) subscribe to DHIA somatic cell count; 5) [-] group cows by production and feed accordingly; and 6) cull at a rate greater than 30 percent annually.

¹ [-] indicates a negative relationship between independent and dependent variable.

Areas for future research which indicate potential benefits for Michigan dairy farmers include:

1) An assessment of performance testing (DHIA and others), possibly by means of factor analysis, focusing on managerial characteristic necessary for successful adoption and use of the service;

2) The negative relationship between productivity per cow and those dairy operations with herds composed of a majority of registered cattle is difficult to explain. While there has been an improvement in the average productivity of registered cattle, that improvement does not seem to wholly justify an operation focusing on that form of herd quality. A cost-benefit analysis examining the utility of registered cattle could reveal why: 1) some operations deem the composition of a herd to be more important than productivity or 2) at what point the proportion of registered cattle within a herd becomes a burden rather than a benefit;

3) A negative relationship between productivity per cow and "other than DHIA performance testing" raises questions as to the value of these services in non-specialized dairy operations. Efforts could be made to discover exactly what these services are and their relevant costs and benefits in relation to DHIA performance testing;

4) Organizational skill as defined by a micro-computer for used for farm records and the grouping of cows by production and feeding them accordingly presents some

contradictory results. Research into general organizational ability could uncover the reason for this seeming contradiction;

5) The degree of significance and magnitude of culling at a rate greater than 30 percent in non-specialized dairy operations along with the knowledge that these operations do not purchase a majority of their replacement cows indicates an area of interest. Further research could explore the nature of these non-specialized operations and determine whether specialization is an appropriate parameter by which a dairy operation can be classified.

7.4.2 SIMPLE DEMOGRAPHIC VARIABLES

Among the demographic characteristics a number of potentially beneficial research areas were identified and include:

1) Education of at least high school for the principle operator has a positive effect on productivity per cow yet a negative impact on net farm income. Whether the latter is a function of the life-cycle of a dairy farm, i.e., with respect to debt payments and the managerial capability present in a dairy operation remains unknown. Further research could help identify the possible causes of these relationships;

2) Despite some possible problems of variable definition relating to EDU2 -greater than a high school education for the principle operator-, the positive effect

of education in general is clear.² Education of the principle operator may be a point by which operations with the potential for successful reconfiguration can be identified.

3) The significance of at least some college for the principle operator, in: 1) small and medium herds; 2) low net farm income/low debt-to-asset ratio; and 3) specialized dairy operations indicates potential areas for future growth.

4) Small herds and specialized dairy operations also have significant coefficients for the percent change in herd size planned for 1993 (PCHERDS). PCHERDS identifies a propensity to expand herd size by operators whose herds are characterized by a relatively lower productivity per cow. Research is needed to identify the means of expanding herd size, or better, increase productivity per cow in these categories;

5) The importance of non-farm income, NONFINC, to Michigan dairy operations needs to be addressed. A study focusing on the financial composition of a dairy operation and the distribution and form of labor could help in explaining the value of non-farm income versus the employment of that labor or capital in dairy operations.

² Again, EDU2 is defined as "1" for greater than high school education, else "0". Implicit in this definition is that "technical training" denotes a high school education. This is not necessarily the case.

5) One last area of interest is the relationship between (-)COWS, herd size, and both productivity per cow and net farm income. A study analyzing the relationship between herd size and productivity per cow within and between herd size categories in Michigan would be helpful in determining areas for more concerted extension effort.

7.5 CONCLUSIONS OF FACTOR REGRESSION ANALYSIS

The results of the factor analysis and the regressions run on the factor scores adds to the information drawn from the regressions using simple variables.

7.5.1 COMPLEX MANAGEMENT VARIABLES

The complex definition of the management practices and subsequent regression analyses resulted in the identification of a number of areas of research interest and include:

1) The significance of the factor of informal managerial practices (MGT1), provides crucial information for researchers and Michigan dairy farmers. Further study of the importance of health and nutrition practices individually and as components of the dairy farm managerial regime will lead to a better understanding of their contribution to productivity per cow and profitability.

2) The factor indicating a degree of independence in dairy operations (MGT3) parallels the importance of informal managerial practices.

3) Further study of infrequently used managerial practices as identified by MGT2 only show a slight potential

adding to the knowledge base as to the configuration of Michigan dairy operations.

4) The formal managerial aspect of a Michigan dairy operation as defined by MGT4 is of secondary interest relative to informal practices. Although the factors of formal and informal managerial practices (MGT4 and MGT1) are correlated (0.3102), the magnitude of MGT1's coefficient is consistently larger and is more frequently significant than that of MGT4. Properly utilized performance testing and artificial insemination (A.I.) can be tools critical in raising productivity per cow. However, when combined with generally poor managerial efforts, formal systems within a dairy operations are of little use.

7.5.2 COMPLEX DEMOGRAPHIC VARIABLES

The regression of productivity per cow and net farm income on the complex demographic variables identified a number of areas of potential research interest including:

1) The factor defining economic size (DEM1) demonstrates that research on the effect of economic size may be of very important for smaller dairy herds and operations. The potential benefits to accrue to these smaller operations are likely to be highly correlated with managerial ability. Further research could identify effective combinations of size and managerial ability/practices for smaller farms

2) Education is a significant factor in determining productivity per cow. With occasional negative

relationships with net farm income, further research into the changing dynamics of the life-cycle of Michigan dairy operations, i.e., with respect to the education level of not only the principle operator but secondary operators/partners as well, may prove useful.

3) Ownership patterns in combination with the number of families involved in a dairy operation do not indicate any potential for further research. This area, however, is a long term consideration with potential benefits to a dairy operation's long term financial and inter-generational stability, and may therefore be better studied over a longer period of time. It is recommended that this question is included in subsequent surveys;

4) The presence of non-farm income is clearly identified as a detrimental element in the determination of productivity per cow. Further study could prove fruitful in determining why this is so. The value of diversification of income sources should also be addressed.

5) Lastly, the indicator of optimism despite present financial status (DEM5), indicates that many Michigan dairy farmers are committed to dairy production. Whether this commitment to dairy farming in Michigan is logical and rational will depend upon the ability of Michigan dairy operators to successfully adapt their operations to the economic and political environment of the dairy industry in the US as a whole and within Michigan in particular. Without a reconfiguration of management, labor, capital, and

perhaps enterprise mix, a commitment to dairy production could well be folly.

7.6 POTENTIAL METHODOLOGIES

Beyond the areas identified above, there exists additional aspects of further research. These aspects relate to methodologies. The utility of probit/logit equations in the analysis of the 1987 Michigan State University Dairy Farm Survey data set appears to have potential. The structure of the analysis may be somewhat different than the present research, i.e., examining the probabilities of finding a dairy operation in a given category of debt-to-asset ratio given certain operation characteristics.

7.7 FINAL STATEMENT

The formulation of a strategic plan to safe-guard Michigan's dairy industry is a necessary given the rapidity of change in today's economic and political environment and the crucial role that the dairy industry plays in Michigan's economy. The present study has attempted to identify areas which have the potential, given further research, of guiding Michigan dairy farmers through a process of enterprise reconfiguration. The ultimate goal of a reconfiguration is to maintain the position of Michigan's dairy industry within the traditional dairy region and nationally as well. Only through a commitment to further research concerning the managerial and demographic make-up of Michigan's dairy farms

will the development of an adequate strategic plan to carry Michigan's dairy industry into the 1990's and beyond.

APPENDICES

APPENDIX A

APPENDIX A

DEFINITIONS OF VARIABLES AND ABBREVIATIONS

N= Number of observations in category

R-BARSQRD = R^2 adjusted for the degrees of freedom

F= F-statistic

DEMOGRAPHIC CHARACTERISTICS OF DAIRY FARMS

OWNER1= Other than individual ownership (1), ELSE (0)

OWNER2= Limited partnership or corporate family farm (1),
else (0)

FAM= Number of families involved in the dairy operation

EDU= Education level of the principle operator

EDU1= At least high school education (1), else (0)

EDU2= Greater than high school education (1), else (0)

EDU3= At least college graduate (1), else (0)

BST= No intention of using bST (0), else (1)

PCHERDS= Planned percent change in herd size for 1993

CASH= Total cash receipts

1= Less than 10,000	= 5,000
2= 10,000 to 19,999	= 15,000
3= 20,000 to 39,999	= 30,000
4= 40,000 to 99,999	= 70,000
5= 100,000 to 174,999	= 137,500
6= 175,000 to 249,999	= 212,500
7= 250,000 to 499,999	= 375,000
8= Over 500,000	= 500,000

APPENDIX A (cont'd.)

NETFINC= Net farm income

1= Less than 10,000	= 5,000
2= 10,000 to 19,999	= 15,000
3= 20,000 to 39,999	= 30,000
4= 40,000 to 99,999	= 70,000
5= 100,000 to 174,999	= 137,500
6= 175,000 to 249,999	= 212,500
7= 250,000 to 499,999	= 375,000
8= Over 500,000	= 500,000

NONFINC= Non-farm income

0= None	= 0
1= Under 5,000	= 2,500
2= 5,000 to 9,999	= 7,500
3= 10,000 to 14,999	= 12,500
4= 15,000 to 19,999	= 17,500
5= 20,000 to 39,999	= 30,000
6= 40,000 And up	= 40,000

DARATIO= Debt-asset ratio

0= 0	= 0
1= 1 to 19 Percent	= 15
2= 20 to 39 Percent	= 30
3= 40 to 69 Percent	= 55
4= 70 to 100 Percent	= 85
5= 100 Percent and over	= 100

MILKPER= Productivity per cow

SPECDAIR= Specialized dairy operations, i.e., with greater than 75 percent of total cash receipts stemming from sales related to the dairy operation

COWS= Number of cows, both dry and milking**HERDSIZE= Size of herd**

1= Less than 30
2= 30 to 44
3= 45 to 59
4= 60 to 89
5= 90 to 119
6= 120 to 149
7= 150 to 209
8= 210 to 269
9= 270 and up

APPENDIX A (cont'd.)

MANAGEMENT PRACTICES

FORQU= Forage quality testing by cutting
HIREPS= Hire pest scouts
SOILT= Soil testing for crops for fertilizer application
MICROC= Micro computer for farm records
MAILIN= Mail-in service for farm records
DHIA= DHIA performance testing
NDHIA= Other than DHIA performance testing
SOMCC= Subscribe to DHIA somatic cell count
AICOW= A.I. in majority of cow matings
AIHF= A.I. in majority of heifer matings
FRATF= Feed ration formulation on a regular basis
GROUP= Group cows by production and feed accordingly
PREGCHK= Pregnancy check within 40 days after breeding
POSTPEX= Systematic post-partum exams
PURREC= Purchase majority of replacement cows
HEATSYN= Heat synchronization check
VET= Use regularly scheduled vet services
3X= Milk 3 time a day
PDIP= Predip all cows
DIPP= Teat dip all cows after milking
DRYCMP= Treat dry cows for mastitis
1STCALF= Average age at first calving for heifers is 24-25 months
CULL1= Culling rate greater than or equal to 15 percent

APPENDIX A (cont'd.)

CULL2= Culling rate greater than or equal to 30 percent

REGCAT= Registered cattle account for a majority of the herd

16PER= Purchase 16% plus dairy ration

BYPROD= Purchase by-product feeds(brewer's grain,
cottonseed, etc.)

APPENDIX B

APPENDIX B

HYPOTHESES FOR DAIRY SURVEY VARIABLES

- I. Dependent Variables= Productivity per cow (MILKPER) and net farm income (NETFINC).
- II. Independent Variables= Demographic characteristics and Management practices.

DEMOGRAPHIC CHARACTERISTICS

OWNER(#): (risk/liability, 508)

The dairy industry in Michigan is characterized more by single and multiple family units than investor-owned corporate farms. The corporate mode of ownership, however, is not limited to investor funded business ventures but also includes multiple family farms. Single owner, partnership arrangements and other less formal ownership patterns are necessarily characterized by a greater exposure to risk. Some financial aspects of risk may be the same for both modes. By this logic, it is assumed that non-corporate dairy farms will be characterized by a greater productivity per cow than those of corporate ownership yet will demonstrate relatively lower net farm incomes. There were no dairy farms in the data set that were corporate non-family.

FAM(ilies): (number dependent on farm income, 506)

In a similar manner to the above, multiple families are apt to be associated with a higher productivity per cow because of inter-generational concerns associated with multiple-family units. There is most likely some interaction between the number of families and mode of ownership.

APPENDIX B (cont'd.)

EDU(cation): (knowledge, ability to think logically, 506)

Education is hypothesized to be positively correlated with productivity per cow. Education of the principle owner in multiple-family units may mask the cumulative education available for managing the dairy farm. The level of education of the principle operator is hypothesized to be negatively correlated with his/her age.

(planned)P(ercent)C(hange in)HERDS(size for 1993):
(indicator of expectations, 419)

One would expect PCHERDS to be Positively associated with MILKPER and NETFINC as an indicator of optimism concerning economic trends. It may occur, however, that planned changes in herd size run counter to the above argument, i.e., dairy farmers may expand their herds so as to cope with debt payment problems and insufficient net farm income.

BST: (risk/technology adoption, 450)

A dummy for a propensity to use BST was formed which takes on value of "0" if the primary operator indicated that he/she would not use BST and "1" if there is a remote or greater possibility of adoption. BST serves as a weak proxy for the propensity to adopt new technologies in general. BST is hypothesized to be positively associated with productivity per cow and net farm income.

CASH(receipts): (gross economic size, 482)

Will be Positively associated with productivity per cow though the magnitude will most likely be greater in specialized dairy farms than those that are non-specialized, i.e., dairy receipts are 75% or more of total CASH.

NETF(arm)INC(ome): (net economic size, 470)

Similar to the above, but will include the effect of debt service in addition to other costs.

NONF(arm)INC(ome): (non-farm diversification, 460)

May be associated with managerial abilities (herd and financial). If managerial abilities are poor and herd size is small there may be a need to supplement dairy income with outside, non-farm income, i.e., a negative correlation with

APPENDIX B (cont'd.)

productivity per cow. It may be that smaller herds -which have lower productivity per cow in general- regardless of managerial ability, simply do not generate enough cash from dairy operations to support the household. Also, with respect to multiple-family units, there may not be enough dairy-related work available to keep all participants employed, thus forcing/allowing that extra labor to work off the farm and to provide a net increase in income.

D(ebt/)A(sset)RATIO: (financial management/stress, 482)

Though in general one would expect debt load to affect only NETFINC, it may also indicate efforts to get bigger (herd size) before getting better (managerial ability) and thus would be negatively correlated with productivity per cow. This negative relationship may also be a function of herd/farm size. Tel-Farm data supports this contention (Nott). DARATIO was a categorical variable which was converted to a semi-continuous form by taking the mean value for each category.

HERDSIZE: (physical size, 499)

As economies of size become more evident in larger herds and management costs can be distributed over a greater amount of investments, HERDSIZE, will be positively correlated with MILKPER and also NETFINC. Within herd size ranges, however, higher productivity per cow will be evident in those farms at the lower end of each range because at these levels relevant technologies/demographics are not stressed.

COWS: (physical size, 499)

Same as above, but in the continuous form.

MANAGEMENT PRACTICES

FOR(age)QU(ality testing): (472)

Positively associated with MILKPER and NETFINC With the fact that smaller herds will tend to rely on 16-odd percent dairy ration purchases to meet protein requirements FORQU may have a greater significance with respect to HERDSIZE than with MILKPER.

APPENDIX B (cont'd.)

HIREP(est)S(couts): (472)

Positively associated with MILKPER and NETFINC. Since the hiring of pest scouts may effectively improve feed quality (or at worst prevent radical variations in harvests) and limit pesticide applications to that which is necessary.

SOILT(esting for crops for fertilizer application): (472)

Positively associated with NETFINC, more so than with MILKPER. Same logic as in HIREPS.

MICROC(omputer for record keeping): (472)

Because of DHIA and TELFARM, Positive correlation may only occur in the upper herd sizes and ownership modes. Question: because farmers - with larger operations- in general may sometimes hire book-keepers who use micro-computers to manipulate the books (and perhaps production information), could it be said that they are indirectly yet effectively tapping the utility of computers for financial and production decision-making. Utilized by logical thinkers and speeds payroll.

MAILIN(record service for farm records): (472)

Usually, like DHIA users, those that take advantage of such services are those herds that perform better than average. A causal link is difficult to identify. Farm Credit System, AGRIFAX.

DHIA(performance testing): (472)

Will demonstrate a Positive correlation with MILKPER. Same logic as above. Within herd sizes effect may be muted because of changing economies of scale. Positively associated with NETFINC.

NDHIA(other than DHIA performance testing): (472)

Positively associated with MILKPER and NETFINC. Same logic as DHIA.

APPENDIX B (cont'd.)

(subscribe to)SOM(atic)C(ell)C(ount): (472)

This is difficult to interpret as SOMCC is an option of DHIA which can be included/excluded from month to month depending upon the dairy farms needs/practices. Usually, SOMCC is used as a preventative measure. Incentive programs could also have an effect on the interpretation of this variable, i.e., acquisition and utility may be a function of the amount of time it has been utilized. The rate of adoption may also be skewed by a certain class of farms/operators. In general, however, use of SOMCC will be associated with a higher productivity per cow than in herds of non-users.

AICOW(Artificial insemination in majority of cow matings): (472)

Positive correlation, i.e., represents managerial intensity. 75% of replacement cows. An option lies in the use of a good bull. Many times, however, AI is complemented with the use of a clean-up bull.

AIHF(Artificial insemination in majority of heifer matings): (472)

Positive correlation, i.e., represents managerial intensity. 25% of replacement cows. Option of good bull. Complement with clean-up bull.

F(eed)R(ation)F(ormulation on a regular basis): (472)

Positive correlation, i.e., represents managerial intensity in all herd sizes.

GROUP(cows according to productivity and feed accordingly): (472)

Positive correlation with MILKPER, i.e., it represents managerial intensity. Positively correlated with herd size.

PREG(nancy)CH(ecK within 40 days of breeding): (472)

Positive correlation, i.e., represents managerial intensity.

(systematic)POSTP(artum)EX(ams): (472)

Positive correlation, i.e., represents managerial intensity.

APPENDIX B (cont'd.)

PURC(hase majority of)RE(placement)C(ows): (472)

Positive correlation, i.e., represents managerial intensity. As a cost, with cheaper yet just as effective substitutes, PURREC is hypothesized to be negatively associated with NETFINC. It may also depend on the relative cost of raising heifers to maturity and/or sanitary/health conditions of calves.

HEATSYN(chronization check): (472)

Positive correlation, i.e., represents managerial intensity. Heat Synchronization: this a treatment to bring a number of heifers into heat at the same time, not a "check". A misunderstanding of this management practice is a possibility.

(use regularly scheduled)VET(erinary services): (472)

Positive correlation, i.e., represents managerial intensity. Could also be a function of the age and adequacy of the facilities in which case VET would be a function of need and not a preventative measure.

(milk)3X(a day): (472)

Positive association with productivity per cow. This hypothesis is dependent upon the assumption that operators that milk three times a day have a sufficient managerial expertise to address increased feed requirements of the milking herd.

P(re)DIP(all cows): (472)

Somewhat effective in preventing mastitis infections though probably less effective than DIPP. Still positively correlated with productivity per cow.

(post)DIPP(Teat dip all cows after milking): (472)

Effective in preventing mastitis infections and therefore associated with greater productivity per cow. A possible interaction effect is likely when PDIP and DIPP are both used.

APPENDIX B (cont'd.)

DRYC(ow)M(astitis)P(revention): (472)

Positive correlation with MILKPER and NETFINC, i.e., represents managerial intensity. It is easier to administer and less milk production is lost if mastitis is treated in dry cows than in milking herd.

1STCALF(Average age of first calving for heifers is 24-25 months): (472)

Negative correlation with MILKPER and positive with NETFINC, i.e., represents a trade-off between feed costs and milk production. It may also depend on method of feeding heifers prior to first heat. Heifers bred in later months usually produce more than those bred earlier, a matter of development/maturity.

CULL1 (Cull at a rate greater than or equal to 15 percent): (472)

CULL1 takes on the value "1" for culling rates greater than or equal to 15 percent and "0" otherwise. It is hypothesized that culling at a rate greater than 15 percent will have a positive effect on productivity per cow. Due to both involuntary culls and voluntary culls, a natural rate of culling may lie between 25 and 30 percent. The validity of this variable is questionable (see Chapter 5).

CULL2 (Cull at a rate greater than or equal to 30 percent): (472)

CULL2 takes on the value "1" for culling rates greater than equal to 30 percent and "0" otherwise. It is hypothesized that culling at 30 percent or more will have a positive effect on productivity per cow but the effect will be less significant than CULL1.

REG(istered)CAT(tle account for majority of herd): (472)

REGCAT is hypothesized to be negatively associated with productivity per cow and net farm income. Due to recent development in breeding, having a majority of registered cattle may not necessarily imply that productivity per cow will be less.

APPENDIX B (cont'd.)

(purchase)16PER(cent dairy ration): (472)

16PER may be a function of amount of acreage in forage and feed with low income crop farmers being associated with smaller acreage and/or less productive acreage. Smaller herds may rely relatively more on 16PER as a protein source rather on corn, etc. production and BYPROD purchases and FRATF. None-the-less, 16PER will be associated with a higher productivity per cow and lower net farm income.

(purchase)BYPROD(uct feeds): (472)

Positive correlation, not only with MILKPER but also with NETFINC as well. Similar to the above rational, the purchase of supplements may indicate insufficient cropping practices and/or less than adequate crop acreage -with respect to land quality- for the production of feeds and forages.

APPENDIX C

APPENDIX C

Appendix C contains the results of the regressions run using simple variables, i.e., those management variables which are either in the form of dummy variables and the demographic characteristics in only slightly modified form. The data are laid out as follows:

1234.00**
(350.00)

The top number is the estimated coefficient as to the relationship of that variable with the dependent variable. The stars to the right of the coefficient estimate signify the degree of significance of the estimate. (eg. *.10; **=.05; ***=.01) The bottom number represents the standard error of the coefficient estimate. The statistics for R^2 and an F-test and its significance are shown at the bottom of each category. Where the category is indicated, i.e., at the top, the relevant dependent variable and the number of observations used are also indicated.

APPENDIX C (cont'd.)

Regression results: no controls					
I.V.: Controls: D.V.'s	MILKPER none N=340	NETFINC none N=340		(cont'd.) MILKPER	NETFINC
FORQU	130.52 (422.34)	-4837.77 (7410.43)	PURREC	-306.17 (762.10)	-18116.68 (13371.97)
HIREPS	-662.4437 (997.48)	879.06** (17501.85)	HEATSYN	582.20 (562.46)	-19180.88* (9869.12)
SOILT	-204.43 (453.33)	12945.34 (7954.29)	VET	10.48 (439.40)	7758.70 (7709.78)
MICROC	220.85 (585.34)	-740.37 (10270.54)	3X	2641.63*** (808.02)	49125.52** (14177.60)
MAILIN	815.18* (429.56)	-834.40 (7537.08)	PDIP	-333.22 (438.88)	3530.88 (7700.68)
DNIA	993.96** (479.73)	-3540.77 (8417.40)	DIPP	111.28 (424.74)	292.37 (7452.62)
NDHIA	182.26 (611.14)	10621.48 (10723.20)	DRYCHP	288.19 (9498.85)	259.25 (8752.86)
SOMCC	-155.70 (446.60)	2845.92 (7836.08)	1STCALF	-652.56* (356.16)	3021.64 (6249.20)
AICOW	764.48 (499.70)	1465.86 (8767.74)	CULL1	1296.73*** (383.95)	13341.34** (6736.96)
AINF	461.40 (416.42)	6257.95 (7306.55)	CULL2	350.59 (517.10)	-1688.24 (9073.22)
FRATF	577.81 (426.38)	5099.22 (7481.34)	REGCAT	-877.70 (485.01)	-15736.67* (8510.11)
GROUP	-271.13 (358.57)	4955.78 (6291.65)	16PER	-304.11 (340.83)	-9221.27 (5980.32)
PREGCHK	945.54* (441.43)	4773.18 (7745.51)	BYPROD	35.31 (396.04)	-2166.74 (6949.02)
POSTPEX	232.62 (433.59)	3356.73 (7606.86)			
R-barsqrd				0.2513	0.0656
F				5.2143	1.8811
Significance				0.0000	0.0061

APPENDIX C (cont'd.)

Regression results: controlling for specialized and non-specialized dairy operations					
I.V. Controls:	MILKPER SPECDAIR=1 N=283	MILKPER SPECDAIR=0 N=57	(cont'd.)	MILKPER SPECDAIR=1	MILKPER SPECDAIR=0
FORQU	117.07 (481.56)	605.17 (1050.67)	PURREC	-389.17 (806.21)	constant=0
HIREPS	-761.82 (1096.53)	7.55 (3246.68)	HEATSYN	827.55 (647.14)	1476.97 (1457.34)
SOILT	-494.78 (504.96)	2573.16* (1467.17)	VET	-173.16 (504.31)	-2098.99 (1395.06)
MICROC	-140.64 (684.00)	3920.94** (1586.82)	3X	2477.32*** (885.51)	-195.99 (3365.65)
MAILIN	712.27 (484.14)	1731.84 (887.82)	PDIP	-207.92 (509.81)	-1034.64 (998.78)
DHIA	906.97* (545.85)	-1725.75 (1340.50)	DIPP	90.22 (491.33)	-1554.03 (1121.93)
NDHIA	629.83 (698.08)	-3864.17* (1954.51)	DRYCHP	162.67 (557.90)	1047.26 (1344.93)
SOMCC	-106.14 (513.55)	3016.84* (1587.82)	1STCALF	-530.24 (409.75)	-901.22 (916.36)
AICOW	728.38 (567.49)	1335.41 (1281.06)	CULL1	1630.96*** (446.17)	726.89 (935.55)
AINF	528.57 (472.18)	-563.01 (966.82)	CULL2	69.04 (582.09)	5745.61*** (1834.10)
FRATF	846.34 (487.18)	-345.58 (1026.99)	REGCAT	-929.32* (554.82)	-223.61 (1349.38)
GROUP	-152.07 (409.31)	-1900.20* (1098.88)	16PER	-304.85 (397.96)	502.01 (963.65)
PREGCHK	995.08 (503.52)	1014.40 (1235.60)	BYPROD	235.30 (468.30)	-715.45 (1030.08)
POSTPEX	260.36 (515.03)	1477.37 (1239.76)			
R-barsqrd				0.2268	0.4319
F				4.0631	2.6377
Significance				0.0000	0.0058

APPENDIX C (cont'd.)

Regression results: no controls		
I.V.: Controls:	MILKPER none N=340	NETFINC none N=340
D.V.'s		
OWNER1	-109.02 (493.24)	-1894.21 (8033.24)
OWNER2	-693.95 (664.09)	3582.91 (10815.82)
FAM	160.92 (317.26)	8486.49 (5167.03)
EDU1	1524.96*** (470.40)	-19993.66*** (7661.23)
EDU2	-739.84* (390.82)	-9719.29 (6365.12)
EDU3	1821.74*** (580.25)	3614.19 (9450.31)
PCHERDS	-426.95 (277.89)	244.30 (4525.96)
BST	386.56 (349.50)	-4850.39 (5692.12)
CASH	0.0513*** (.0026)	0.0410 (.0428)
NONFINC	-.0632*** (.0150)	0.1872 (.2450)
DARATIO	-10.0001* (5.4037)	-233.55* (88.0085)
COWS	-13.5268*** (5.1602)	234.0139*** (84.0429)
R-barsqrd	0.2371	0.1796
F	9.7790	7.1854
Significance	0.0000	0.0000

APPENDIX C (cont'd.)

Regression results: controlling for herdsize			
I.V. Controls:	MILKPER HERDSIZE<60 N=168	MILKPER 59<HERDSIZE<120 N=107	MILKPER HERDSIZE>119 N=65
Variables			
OWNER1	-687.68 (1063.03)	-25.88 (692.22)	766.71 (726.89)
OWNER2	293.08 (1386.44)	-1337.59 (985.62)	-515.69 (867.06)
FAM	737.67 (587.83)	46.66 (507.65)	-488.07 (438.30)
EDU1	2826.83*** (709.30)	-133.86 (883.21)	256.84 (851.76)
EDU2	-887.08 (595.38)	-243.26 (683.91)	-693.14 (654.80)
EDU3	2609.72*** (975.26)	2261.89** (945.48)	-645.38 (985.64)
PCHERDS	-576.92* (345.81)	398.49 (961.21)	-1019.71 (777.52)
BST	766.08 (531.59)	61.11 (568.75)	468.21 (695.61)
CASH	.0312*** (.0064)	.0156*** (.0050)	.0086** (.0040)
NETFINC	.0243*** (.0080)	-0.00130 (.0054)	.0014 (.0044)
NONFINC	.0546** (.0241)	-.1136*** (.0240)	-0.0304 (.0253)
DARATIO	-10.3476 (8.1310)	-18.9773* (9.8629)	6.0316 (11.3119)
COWS	-61.3700*** (27.4172)	-20.3741 (22.3234)	-4.6240 (4.8074)
R-barsqrd	0.2795	0.2584	0.0900
F	5.9829	3.8404	1.4872
Significance	0.0000	0.0000	0.1574

APPENDIX C (cont'd.)

Regression results: controlling for net farm income and debt-asset ratio				
I.V.:	MILKPER	MILKPER	MILKPER	MILKPER
Controls:	NETFINC<4 DARATIO<4 N=127	NETFINC<4 DARATIO>3 N=142	NETFINC>3 DARATIO<4 N=43	NETFINC>3 DARATIO>3 N=28
OWNER	1128.59 (797.34)	-592.50 (914.14)	-464.59 (1002.98)	2026.30 (3117.02)
OWNER2	-619.98 (1090.48)	-1168.93 (1251.20)	1312.30 (1309.05)	-12363.54*** (3313.48)
FAM	-208.46 (486.56)	548.17 (581.60)	-15.10 (800.89)	-864.75 (1935.96)
EDU1	2866.88*** (805.47)	1375.56* (785.18)	-160.12 (1541.75)	693.10 (1789.30)
EDU2	-852.20 (587.63)	-632.45 (668.03)	-351.99 (1056.32)	-793.93 (1537.88)
EDU3	2340.43** (895.70)	850.11 (1004.91)	2038.17 (1808.57)	1857.03 (1670.37)
PCHERDS	-788.13** (351.45)	-197.84 (573.19)	-13.76 (939.31)	1408.37 (1700.90)
BST	1394.21** (562.17)	266.00 (566.42)	-757.12 (965.46)	2060.85 (1772.35)
CASH	.01880*** (.0052)	.0132** (.0052)	.0137** (.0050)	0.0059 (.0075)
NETFINC	-0.0049 (.0264)	.0751*** (.0263)	-0.0020 (.0056)	0.0290 (.0180)
NONFINC	-.0616** (.0238)	-0.0381 (.0280)	-.1318*** (.0327)	-0.0183 (.04771)
DARATIO	-28.8738 (21.0565)	-34.5464 (17.6354)	-34.2689 (36.00)	-46.0952 (40.7822)
COWS	-22.8339** (10.3578)	-18.5130 (12.0434)	-16.9070 (10.8168)	-10.7419 (9.5708)
R-barsqrd	0.3478	0.1387	0.3246	0.3983
F	6.1694	2.7469	2.5526	2.3746
Significance	0.0000	0.0018	0.0175	0.0605

APPENDIX C (cont.)

Regression results: controlling of specialized and non-specialized dairy operations		
I.V.: Controls:	MILKPER SPECDAIR=1 N=283	MILKPER SPECDAIR=0 N=57
OWNER1	-327.45 (549.93)	1451.01 (1202.11)
OWNER2	-568.63 (717.35)	-2020.57 (1867.39)
FAM	51.50 (354.87)	440.54 (737.62)
EDU1	1824.10*** (508.75)	-135.15 (1350.61)
EDU2	-583.18 (430.22)	-437.64 (955.16)
EDU3	1961.33** (652.74)	1739.11 (1319.99)
PCHERDS	-453.02 (373.99)	-269.08 (437.62)
BST	398.88 (383.82)	-240.86 (951.56)
CASH	.0191*** (.0031)	.0154** (.0076)
NETFINC	.0076*** (.0036)	0.0018 (.0106)
NONFINC	-.0668*** (.0169)	-0.0357 (.0343)
DARATIO	-8.6922 (6.0379)	-17.4034 (14.8093)
COWS	-20.6140** (5.7696)	-32.1060 (22.3787)
R-squared	0.2826	0.0283
F	9.5465	1.1256
Significance	0.0000	0.3651

APPENDIX C (cont'd.)

Regression results: controlling for herdsize			
I.V.: Controls:	NETFINC HERDSIZE<60 N=168	NETFINC 59<HERDSIZE<120 N=107	NETFINC HERDSIZE>119 N=65
OWNER1	-3437.11 (10599.59)	4552.80 (13273.04)	-7635.33 (23140.71)
OWNER2	14219.02 (13782.27)	17057.45 (18828.60)	-3751.33 (27913.99)
FAM	2837.46 (5859.14)	6270.79 (9718.53)	16813.50 (13772.05)
EDU1	1316.81 (7074.38)	-47758.10*** (16213.92)	-72487.40*** (25214.51)
EDU2	-9313.57 (5890.59)	-16672.48 (13008.64)	-1019.33 (20867.14)
EDU3	4935.16 (9720.05)	31139.47 (17853.86)	-32952.69 (31234.87)
PCHERDS	-762.59 (3448.88)	-7789.31 (18424.72)	45052.05 (23997.94)
BST	-7525.39 (5267.00)	-19034.54 (10734.31)	22951.08 (21938.42)
CASH	0.0477 (.0639)	-0.0421 (.0963)	0.1230 (.1262)
NONFINC	0.3558 (.2384)	-0.0252 (.4503)	-0.7127 (.8109)
DARATIO	16.0783 (81.0926)	-378.8654** (185.1562)	-1251.8330*** (315.9402)
COMS	713.3673*** (267.4136)	1145.3355*** (411.6948)	156.9971 (151.6489)
R-squared	0.0620	0.2006	0.2927
F	1.9201	3.2168	3.2073
Significance	0.0358	0.0007	0.0017

APPENDIX C (cont'd.)

Regression results: controlling for net farm income and debt-asset ratio				
I.V.:	NETFINC	NETFINC	NETFINC	NETFINC
Controls:	NETFINC<4 DARATIO<4 N=127	NETFINC>3 DARATIO<4 N=142	NETFINC<4 DARATIO>3 N=43	NETFINC>3 DARATIO>3 N=28
OWNER1	1144.52 (2832.04)	16692.58 (29807.36)	1096.66 (3054.00)	60057.74 (41215.99)
OWNER2	4013.96 (3837.73)	2933.13 (39102.60)	2227.56 (4177.58)	103560.58** (38467.47)
FAM	-1866.33 (1720.58)	290.15 (23925.58)	-842.38 (1942.58)	-36184.39 (25727.97)
EDU1	3670.59 (2843.31)	-157882.32*** (35922.76)	681.21 (2623.80)	21519.60 (24680.40)
EDU2	-2687.74 (2073.45)	16173.14 (31417.73)	-1257.68 (2230.15)	-16518.12 (21321.07)
EDU3	-1519.40 (3180.48)	-18233.41 (53296.16)	5284.92 (3326.56)	2204.05 (23609.81)
PCHERDS	-2715.27** (1223.02)	-3335.27 (28054.32)	-1982.65 (1907.92)	27519.99 (22974.59)
BST	4576.42** (1951.64)	15288.25 (28706.69)	-1834.47 (1886.30)	4773.12 (25028.14)
CASH	.0323* (.0183)	-0.2173 (.16209)	0.0190 (.0174)	-.1938* (.0930)
NONFINC	-.1599* (.0831)	0.2706 (.9753)	-.1874** (.0923)	-0.3145 (.6696)
DARATIO	-158.7123** (73.3520)	272.1014 (1082.2528)	-117.4562 (58.0325)	**247.2181 (573.0581)
COWS	-34.5692 (36.6720)	796.6544*** (288.5553)	7.7002 (40.2496)	246.9438* (119.3545)
R-barsqrd	0.1527	0.3788	0.0554	0.3465
F	2.8928	3.1340	1.6896	2.1929
Significance	0.0055	0.0762	0.0763	0.0000

APPENDIX C (cont'd.)

Regression results: specialized and non-specialized dairy operations		
I.V.: Controls:	NETFINC SPECDAIR=1 N=283	NETFINC SPECDAIR=0 N=57
OWNER1	7635.64 (9207.00)	-22532.68 (16733.39)
OWNER2	9915.88 (12104.33)	-16803.28 (26413.20)
FAM	10739.76* (5959.68)	488.70 (10467.78)
EDU1	-19727.56** (8518.80)	-16687.15 (19018.36)
EDU2	-9690.11 (7244.47)	-11171.78 (13462.12)
EDU3	4308.68 (11024.65)	6239.94 (18725.41)
PCHERDS	875.66 (63180.10)	-620.11 (6215.29)
BST	-7409.81 (6468.46)	741.24 (13515.36)
CASH	0.0407 (.0521)	-0.0110 (.1063)
NONFINC	0.0936 (.2862)	0.5301 (.4811)
DARATIO	-191.2390 (101.3406)	-273.4470 (206.2716)
COWS	22.56013** (96.5201)	762.1618** (296.3722)
R-barsqrd	0.1593	0.2696
F	5.4521	2.7223
Significance	0.0000	0.0077

APPENDIX D

APPENDIX D

Appendix D contains the results of the regressions run using complex variables, i.e., those managerial and demographic variables which are defined by means of factor analysis. The data are laid out as follows:

1234.00**
(350.00)

The top number is the estimated coefficient as to the relationship of that variable with the dependent variable. The stars to the right of the coefficient estimate signify the degree of significance of the estimate. (eg. *.05; **.01; ***=.001) The bottom number represents the standard error of the coefficient estimate. The statistics for R^2 and an F -test and its significance are shown at the bottom of each category. Where the category is indicated, i.e., at the top, the relevant dependent variable and the number of observations used are also indicated.

APPENDIX D (cont'd.)

Factor regression results: no Controls		
D.V.:	MILKPER	NETFINC
Controls:	none	none
	N=340	N=340
Factors		
MGT1	1163.8171*** (162.3138)	8649.0000*** (3008.2952)
MGT2	-344.2980** (163.5111)	4590.5027 (2856.8892)
MGT3	428.5542*** (163.3660)	6864.7660** (2854.3547)
MGT4	738.5443*** (171.2741)	315.5707 (2992.5265)
R-barsqrd	0.2288	0.0456
F	26.1453	5.0499
Significance	0.0000	0.0006
DEM1	1167.0259*** (171.6322)	X
DEM2	627.3451*** (172.0229)	-11824.00*** (2683.34)
DEM3	-55.0013 (172.3713)	5954.26* (2669.69)
DEM4	517.9215*** (170.7946)	-13834.46*** (2663.67)
DEM5	-341.4363 (171.9843)	-10029.40*** (2682.76)
R-barsqrd	0.1600	0.1817
F	13.7964	19.6459
Significance	0.0000	0.0000

APPENDIX D (cont'd.)

Factor regression results: controlling for herd size				
D.V.:	MILKPER	NETFINC	MILKPER	NETFINC
Controls:	HERDSIZE<60	HERDSIZE<60	60<HERDSIZE<120	60<HERDSIZE<120
	N=168	N=168	N=107	N=107
Factors				
MGT1	1487.9681*** (293.2694)	10717.3931*** (2873.8043)	925.5266** (305.4419)	-850.2792 (5938.6177)
MGT2	-297.0995 (236.2495)	3953.4326* (2315.0550)	-328.1873 (232.3412)	-8292.8254 (6294.4586)
MGT3	722.1618** (245.6338)	5322.8529** (2407.0140)	233.2412 (329.4272)	1438.3824 (6404.9581)
MGT4	1116.3442*** (244.0741)	3.8811 (2391.7295)	125.0902 (317.8237)	-1542.7747 (6179.3536)
R-barsqrd	0.2833	0.0996	0.0785	-0.0200
F	17.5025	5.6157	3.2563	0.4807
Significance	0.0000	0.0003	0.5722	0.7499
DEM1	2511.4971*** (636.3636)	X	1153.6856 (594.0904)	X
DEM2	1007.0095*** (286.0203)	-5867.7988* (2597.8565)	606.0904 (277.6451)	-15512.3370*** (4573.5227)
DEM3	313.0976 (303.2886)	-1076.0644 (2597.9513)	-77.5187 (297.3111)	6671.0793 (4836.6087)
DEM4	418.9694 (295.5479)	-7138.5352 (2672.6694)	664.6235* (264.5427)	-15660.5213*** (4243.4967)
DEM5	-188.0489 (249.8914)	-4696.4152 (2240.9024)	-340.1281 (345.9425)	-19068.9179*** (5672.1041)
R-barsqrd	0.1413	0.0731	0.0653	0.2949
F	6.4966	4.2930	2.4529	11.8721
Significance	0.0000	0.0025	0.0386	0.0000

APPENDIX D (cont'd.)

Factor regression results: controlling for herd size		
D.V.:	MILKPER	NETFINC
Controls:	HERDSIZE>119	HERDSIZE>119
	N=65	N=65
Factors		
MGT1	176.3888 (401.3652)	-10443.0659 (14097.1977)
MGT2	-333.7469 (294.5789)	23958.3492* (10346.5296)
MGT3	76.9397 (272.8266)	5756.3277 (9582.5213)
MGT4	460.7330 (335.3810)	-7770.7794 (11779.6280)
R-barsqrd	-0.0169	0.0399
F	0.7342	1.6652
Significance	0.5722	0.1699
DEM1	578.3593 (301.6063)	X
DEM2	-307.2244 (289.3498)	-14954.6038 (8978.5133)
DEM3	-136.9039 (261.7916)	13316.7438 (8196.0924)
DEM4	507.5985 (293.1144)	-28508.9249** (9226.9853)
DEM5	-376.6479 (284.8000)	-19854.4957* (9067.5699)
R-barsqrd	0.0723	0.2705
F	1.9821	6.8399
Significance	0.0948	0.0001

APPENDIX D (cont'd)

Factor regression results: controlling for net farm income and debt-asset ratio				
D.V.:	MILKPER	NETFINC	MILKPER	NETFINC
Controls:	NETFINC<4 DARATIO<4 N=127	NETFINC<4 DARATIO<4 N=127	NETFINC>3 DARATIO<4 N=142	NETFINC>3 DARATIO<4 N=142
Factors				
MGT1	1449.4841*** (262.6119)	2170.4737* (994.0819)	895.5699* (512.6256)	16451.0662 (16502.1082)
MGT2	-370.1534 (254.9971)	-2230.8100* (965.2571)	-602.3475 (491.8936)	28724.7908 (15835.4926)
MGT3	171.2779 (280.0882)	2286.4065* (1060.2358)	185.1914 (486.2602)	-2766.6356 (15654.1614)
MGT4	1154.5841*** (250.9483)	-283.9984 (949.9308)	601.7237 (467.8099)	4430.4288 (15060.1689)
R-barsqrd	0.3695	0.0709	0.0840	0.0216
F	19.4602	3.4061	1.9632	1.2323
Significance	0.0000	0.0112	0.1199	0.3135
DEM1	1390.9505*** (402.4086)	X	254.4620 (350.6215)	X
DEM2	1029.0013** (308.2646)	888.0406 (1010.1351)	-142.9498 (452.5793)	-43599.8773* (11483.9769)
DEM3	8.2198 (300.3920)	1675.9990 (1025.6540)	170.4836 (420.5695)	15764.7762 (10905.8261)
DEM4	730.8808* (327.2224)	2802.4574* (1108.6773)	1259.9633** (365.5407)	-28085.2699* (9491.8064)
DEM5	-64.8911 (307.2866)	-1015.7308 (1046.3225)	-151.3404 (648.1414)	-16032.0703 (16804.2203)
R-barsqrd	0.2295	0.0473	0.1722	0.4246
F	8.3854	2.5391	2.7477	8.7488
Significance	0.0000	0.0434	0.0330	0.0000

APPENDIX D (cont'd.)

Factor regression results: controlling for net farm income and debt-asset ratio				
D.V.:	MILKPER	NETFINC	MILKPER	NETFINC
Controls:	NETFINC<4 DARATIO>3 N=43	NETFINC<4 DARATIO>3 N=43	NETFINC>3 DARATIO>3 N=28	NETFINC>3 DARATIO>3 N=28
Factors				
MGT1	676.7498* (295.7101)	1437.5806 (935.5447)	2734.9806*** (542.7542)	-25509.38876* (9524.2593)
MGT2	-433.7627 (293.1788)	998.0863 (927.5365)	-224.5515 (300.7185)	14515.2944* (5277.0136)
MGT3	558.7261* (261.1600)	3468.4772*** (826.2379)	172.8726 (329.9560)	3664.0140 (5790.0744)
MGT4	398.4125 (294.5532)	-1400.4254 (931.8846)	468.8454 (446.6875)	-15494.6739 (7838.4802)
R-barsqrd	0.0924	0.1083	0.5657	0.2734
F	4.5897	5.2813	9.7928	3.5404
Significance	0.0017	0.0005	0.0001	0.0216
DEM1	1108.1328** (370.5648)	X	922.4879 (585.5291)	X
DEM2	451.7321 (288.9141)	680.2457 (946.6728)	603.0538 (487.6087)	-10511.3564 (6613.3292)
DEM3	-377.1689 (312.1442)	1855.7350 (988.3863)	-464.3088 (765.5432)	10670.4328 (9587.5112)
DEM4	378.0135 (281.1791)	680.8447 (918.3024)	-588.1410 (727.2139)	5181.8359 (9891.0463)
DEM5	-426.2688 (389.8977)	-3090.6777* (1280.0617)	408.4201 (950.3183)	-6457.9715 (12107.9586)
R-barsqrd	0.0685	0.0364	0.0378	0.0311
F	3.0586	2.3205	1.2120	1.2167
Significance	0.0120	0.0600	0.3364	0.3309

APPENDIX D (cont'd.)

Factor regression results: controlling for specialized and non-specialized dairy operations				
D.V.:	MILKPER	NETFINC	MILKPER	NETFINC
Controls:	SPECDAIR=1 N=283	SPECDAIR=1 N=283	SPECDAIR=0 N=57	SPECDAIR=0 N=57
Factors				
MGT1	1134.2112*** (198.8057)	9267.3991** (3396.3591)	1294.5756*** (304.9932)	5548.2387 (6686.7703)
MGT2	-217.3952 (182.6178)	5905.4036 (3119.8081)	-1155.8173*** (352.1110)	-3859.0962 (7719.7950)
MGT3	490.97** (181.2517)	7294.9447* (3096.4696)	452.7592 (402.4538)	6026.2445 (8823.5267)
MGT4	715.7154*** (197.9083)	199.6518 (3381.0278)	893.1359** (300.3745)	467.8544 (6585.5075)
R-barsqrd	0.2093	0.0524	0.4164	-0.0453
F	19.6584	4.8995	10.9871	0.3931
Significance	0.0000	0.0008	0.0000	0.8127
DEM1	1261.8120*** (192.7100)	X	956.4694* (396.5458)	X
DEM2	729.3069*** (193.7014)	677.3604** (207.6524)	380.5248 (380.9220)	-6300.3694 (5847.4744)
DEM3	-180.8698 (189.2979)	39.1963 (199.8752)	521.1090 (465.0197)	12361.6624 (7184.9960)
DEM4	564.1962** (193.2808)	571.6381** (207.3719)	303.3758 (372.1173)	-17609.1964** (5629.8042)
DEM5	-841.3946* (-481.3946)	-385.2080 (213.9328)	-58.6329 (351.0838)	-13279.0808 (5245.9971)
R-barsqrd	0.1760	0.1677	0.0617	0.2457
F	13.0073	15.1573	1.7107	5.3984
Significance	0.0000	0.0000	0.1498	0.0011

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