RELATIONSHIP OF DAIRY FARM NET INCOME TO SPECIFIED FARM MANAGEMENT FACTORS

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TO SPECIFIED FARM MANAGEMENT FACTORS

By

John A. Speicher

AN ABSTRACT OF A THESIS

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ABSTRACT

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by John A. Speicher

Michigan dairy farms that utilized both Mail-In Farm Account records and D.H.I.A. or Owner-Sampler records for any year in the period from 1958 through 1962 were used as a source of data. A total of 1,041 farm record years was included in the study. A prediction equation was developed based upon a multiple regression model. The degree of curvilinearity of each management factor was established by singularly correlating the factor to net income. The 38 farm management factors were then classified into groups measuring characteristics of the farm enterprise, and the effects of different combinations of factors within groups were studied as a means of reducing the number of factors to those making a significant ($P < .01$) contribution in the explained variation in net income. Selected factors measuring size, crop efficiency, livestock efficiency, labor efficiency, costs, intensity and organization were combined to form the prediction equation.

The correlation of the 14 management factors accepted as the independent variables in the prediction

equation with net income gave a coefficient of determination (R^2) of .75. The average net income was $8,174 with a standard error of estimate of $2,577. Farm management factors which were measures of size exhibited a slight degree of curvilinearity when correlated with net income. The two size factors used were number of cows and number of tillable acres and were found to account for 28 percent of the total computed direct and indirect effect of the factors on net income.

Measures of crop efficiency used were crop value per tillable acre, soil value rating, and percent cash crops. Net income was found to increase at a decreasing rate as any of the crop efficiency factors increased. The combination of crop factors explained 25 percent of the computed direct and indirect effect of the management factors on net income. Crop value per tillable acre was credited with the major portion of this effect. Livestock efficiency factors which were measures of output were linear while those measuring price were curvilinear. Livestock factors accounted for 29 percent of the total computed direct and indirect effect of the factors on net income. Livestock income per $100 feed expense was credited with 75 percent of this effect. The presence of the income to expense ratio appeared to mask the effect of both level of production and milk price. Machinery expense per tillable acre and number of tillable acres per cow accounted for 12 percent and 4 percent, respectively, of the computed direct and indirect effect of the factors on net income.

When the sample was sorted according to breed, the relationship of the factors to net income for Holstein herds was comparable to that reported for the total sample. Jersey and/or Guernsey herds, however, were effected to a greater extent by the size and crop factors and to a lesser extent by the livestock efficiency factors.

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INTRODUCTION

The income derived from a dairy farm operation is the ultimate concern of the dairyman in his role as manager of that business.

Dairying as practiced in Michigan is basically a means of marketing the products of land and labor. With a system of dairying where the majority of the feed for the dairy herd is produced on the farm, factors such as the cropping system and crop yields, size and organization of the farming operation as well as dairy sales and expenses are of importance if maximum income is to be achieved.

A tool in analyzing farm operations and organization used by workers in the field of farm management is the adaption of certain measures of farm business to a scale or standard to serve as reference points. The reasoning advanced in defense of this method of analysis is that it has the advantage of speed of analysis and that by comparing a series of farm management standards against a particular farm it is possible to spot the weaknesses and strong points of that farming operation.

This study was designed to study the effect of a number of these measures of farm business activity or farm management factors on the net income derived from the dairy farm. The major objective set forth in carrying out this study was to determine which of these farm management factors were of importance in explaining the variation in net income.

The primary means of studying the association of net income with these farm management factors was with multiple correlation analysis. The sources of the financial and production records for this study were the Michigan Mail-In Farm Account Record Project under the direction of the Department of Agricultural Economics as well as the Dairy Herd Improvement Association and Owner-Sampler records under the supervision of the Department of Dairy. The sample used for the analysis consisted of those Michigan dairy farms on which both record systems were utilized for any of the years of 1958 through 1962.

REVIEW OF LITERATURE

Financial success in dairy farming results from technical operations involving cows, acres, crop yields, milk production, feed consumption, and other physical factors. Measures of the technical efficiency in the various farm enterprises have been used in the analysis of farm operations almost since the first attempts to develop and use farm records. Boss (3) in discussing the history of farm cost accounting records stated that in the search for satisfactory measures of cost, emphasis was turned toward determining the physical factors of cost encountered in farm operation and management. These measures of the man, horse and machine input, and the physical quantities of the elements used in production allowed a determination of the cost on the basis of prevailing wage and price factors. Boss further points out that these physical measurements allowed comparison between farms and farming areas which then spotlighted the most efficient operators and the most profitable practices in production.

Description of the Various Farm Management Factors[1]

Farm management factors have been developed which measure a large number of the aspects of farm organization and operation. Many of the factors are repetitive in that they measure the same characteristics. This repetition of measurement requires a classification and description of the various factors which have been used before a fuller review can be made as to their influence on farm returns. Hopkins and Heady (8) in discussing farm management factors classified them into groups measuring eight different characteristics of the farm enterprise. This classification is presented below:

1. Size of Business. Size may be measured in relation to land, labor, capital, or some particular characteristic of the type of farming under study.

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[1]In trying to give a general title to these varied measures of farm activity, farm management workers have suggested and used numerous terms. Some of the titles more commonly used are farm management factors (14,17), farm practices (13), farm efficiency factors (8,14), farm factors (15), factors in success (7), and farm business measures (19). In reporting the findings of the various studies, the term farm management factors will be used as a general title throughout this paper so as to furnish more continuity.

<u>Total acres under cultivation</u>.

<u>Gross investment</u> measures the value of all inventories involved in the farming operation. This includes the value of the land.

<u>Numbers of livestock</u> measured in terms of cows, sows, hens, or animal units. An animal unit is used as a common denominator for different types of livestock and is ordinarily considered to be an amount of livestock equivalent to one cow, bull, steer, or horse and is based primarily on feed consumption.

<u>Acres in a selected crop</u> is often used where there is an extremely predominant crop grown in the locality in question.

<u>Labor input</u> as measured by the number of men involved in the farming operation.

<u>Productive man work units</u> (P.M.W.U.) measure size in terms of the total labor input that would be required if work on the productive enterprises were done with the normal efficiency found in the region. This factor requires the establishment of normal efficiency before it can be used.

<u>Total annual input</u> when used as a measure of size includes both fixed and operating expenses.

2. Efficiency in Cropping System. Factors used to examine the cropping program may consider yields, inputs or composition of crops.

   Percent of land in a selected crop is an effort to show the effect of growing crops with a higher value per acre or simply to demonstrate the effect of some particular crop.

   Fertilizer expense per tillable acre is a measure of crop input.

   Soil productivity rating may also be considered a measure of crop input as land is an input in crop production.

   Crop value per tillable acre measures the results of yield difference as well as the effect of kind of crop grown.

   Crop yield index has been developed to furnish a comparison of crop yields between different farms. The index is basically the relation of the weighted average of the crop yields on a given farm to the weighted average of the crop yields for all farms in a given locality or sample.

3. Livestock Efficiency. The livestock program may be examined in terms of effect of physical output

and/or input, marketing efficiency, enterprise combination or any combination of the three.

Returns per $100 feed fed reflects the degree to which livestock is marketed to advantage, the efficiency of physical production, and the degree to which a profitable combination of enterprises has been attained.

Value of animal product is used to reflect both marketing and physical efficiency as it is in essence price times output.

Quantity of animal product is a measure of physical output and may be reported as pounds of milk, number of eggs, or rate of gain.

Feed fed may be reported as feed used to produce a unit of livestock product, kind or quality of feed, or simply a measure of total nutrient intake.

4. Labor Efficiency. The productivity of labor is ordinarily measured by relating it to the quantity of either land, livestock, or both.

Crop acres per man is most commonly used where the kinds of crops grown in the studied locality are reasonably uniform.

Livestock production per man has been used in such a manner as to relate the man to either the value of livestock output, livestock numbers, or output in terms of physical quantity for a particular class of livestock.

<u>Work units per man</u> is designed to reflect the influence of both crops and livestock as it is calculated by dividing the number of productive man work units by the number of men.

5. Machinery Economy.

<u>Machinery cost per crop acre</u> is designed to get at the effect of machinery expenditures. This factor is computed by dividing the total annual cost of power and crop equipment, including repairs, fuel, depreciation, and equipment supplies, by the number of crop acres.

6. Cost Ratios. Such ratios are sometimes used when working with a restricted type of farming within a limited locality to determine whether costs are high or low.

<u>Costs per acre</u> is a factor used to study total cost or in some instances a particular type of expense such as veterinary expenses.

<u>Operating ratio</u> is the percentage which operating expenses absorb out of the gross income,

and is designed to show the proportion of total income used in hiring labor, buying feeds, fuel, and supplies, and in keeping equipment in operation. It is computed by dividing total operating expenses by gross income and expressed as a percentage or ratio.

7. Capital Ratios. Ratios involving capital have been developed in an effort to get at the effects of capital balance.

   Capital per $100 gross income is intended to show how much capital is required to yield $100 of total income.

   Capital per man was developed to express resource combination.

8. Enterprise Selection. The farm management factors included under this category are those indicating the degree of intensity and conversely the extent of diversification.

   Proportion of income from a single enterprise is designed to show the importance of any one selected enterprise.

   Percent income from livestock indicates the relative importance of livestock in the farming operation for the locality in question.

> Diversity index as exemplified by a simple index which shows the number of enterprises that contribute more than 10 percent of the gross income.

Black *et al*. (2) divided farm management factors into five categories as follows:

1. Size of farm business.
2. Balance and diversity of enterprises.
3. Index of crop yields.
4. Returns per $100 of feed fed to livestock.
5. Efficiency factors.

These workers placed factors dealing with enterprise combination as well as percent of a given crop under balance and diversity of enterprise. Efficiency factors were considered to be all output-input ratios as well as simple ratios between inputs such as crop acres per man.

It is soon realized in observing this list of farm management factors and their descriptions that one of several factors may be chosen to measure any given characteristic of the farm operation. This was demonstrated by Kyle (11) in comparing three measures of size of business with other farm management factors. Records from 599 Indiana farms for the year 1950 were used to establish the correlation between total capital investment, P.M.W.U., and tillable acres and five other farm management factors as well as net farm income.[1] The author concluded that for the Indiana farms studied total capital investment was the better measure of size and reduced the variation in the other farm management factors and net farm income more than did the other two measures of size. Productive man work units appeared to be the poorest measure of size. The sample observed in this study was drawn from the entire state of Indiana and was representative of varying soil and climatic conditions as well as different kinds of farming operations. It appears that in this study total capital investment did the better job of serving as a common denominator and describing the effects of size for all the farms involved.

In a study reported by Misner (12) in 1927, however, seven measures of size were studied using tabular analysis as the analytical tool. When records for 755 farms in Tompkins County, New York, were used to show the association of these measures of size with labor income, it was observed that a small change in P.M.W.U. was accompanied by a greater change in labor income than with any of the

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[1]Gross income is defined as total cash income + inventory change. Net income is defined as gross income - total cash expenses. Net farm income is defined as net income - value of family labor. Labor income is defined as net farm income - interest on investment at 5 percent. Management income is defined as labor income - value of operators labor.

other measures of size. The number of dairy cows per farm approached P.M.W.U. in this respect. It should be noted that this study occurred in 1927, an entirely different era in time, and over a smaller locality with more uniformity in type of farm as well as in soil and climatic conditions than that reported by Kyle.

Association Between Farm Incomes and Farm Management Factors

In 1924 Case and Mosher of Illinois (5) examined farm accounts kept by 19 Woodford County farmers. Farms were divided on the basis of the seven high and seven low for each of the five factors examined. The average management income was computed for each high and low group, and the difference between the two groups was felt to be indicative of the effect of the factor on management income. Crop index, an index of the yields of corn, oats, and wheat, and expense per $100 gross income resulted in differences in management income of over $2,000 whereas results from $100 invested in productive livestock[1] furnished a difference of only $1,600. The difference in management income between the high and low groups was less than $1,000 when the remaining two farm management factors, crop acres worked per man and crop acres worked per horse, were

[1]Productive livestock was all livestock except horses and mules.

examined. This particular study lacked the size of sample or the refinement of analysis to allow very much inference regarding the results. It did, however, represent a pioneer attempt at analyzing the farming operation by the use of farm management factors. The authors felt that the study had additional value in pointing out that the farm which does fairly well in most of the factors studied was more likely to be a profitable operation than the farm that excells in one or two factors and does poorly in others.

New York workers (18) were among the first to make use of farm management factors. This early work culminated in the Tompkins County farm management survey in 1927 in which the relationship of a large number of factors to returns were studied. Sample size in this study as reported by Misner (12) was 755 farms. A total of 29 farm management factors was examined by tabular analysis, and for each of the factors the farms were divided into three groups, with the groups being reported by their class limits. The labor income reported was the average for each group. The relationships of the more meaningful farm management factors to labor income are shown in Table 1. The tabulations as presented point out several things to be considered. The

Table 1

Relationship of Various Farm Management Factors to Labor Income, 755 Farms, Tompkins County, New York, 1927.[1]

Productive Man Work Units	Labor Income
- - 196	$ -12
196 - 314	167
315 - -	572

Number of Cows	Labor Income
- - 5	$ 93
5 - 9	175
10 - -	632

Total Capital Investment	Labor Income
- - $ 7,000	$ 91
$ 7,000 - $10,000	245
$11,000 - -	423

Acres of Crop	Labor Income
- - 50	$162
50 - 79	238
80 - -	355

Man Equivalent	Labor Income
- - 1.2	$239
1.2 - 1.6	296
1.7 - -	207

Percent of Receipts from Livestock	Labor Income
- - 59	$126
60 - 89	330
90 - -	224

Percent of Cattle Units Heifers	Labor Income
1 - 10	$302
11 - 20	256
20 - -	348

Percent of Receipts from Crop	Labor Income
1 - 15	$359
16 - 35	316
36 - -	283

Pounds of Milk Sold Per Cow	Labor Income
None	$ 91
- -5,500	105
5,500- -	731

Value of Dairy Products Per Cow	Labor Income
None	$ 6
$ 1 - $ 79	-4
80 - 139	150
140 - -	685

Crop Index	Labor Income
- - 96	$ 57
96 - 114	272
115 - -	597

P.M.W.U. Per Man	Labor Income
- - 150	$-129
150 - 209	178
210 - -	641

Acres of Crop Per Man	Labor Income
- - 31	$142
31 - 45	190
46 - -	374

Percent of Receipts Spent for Labor	Labor Income
- - 46	$396
46 - 75	180
76 - -	-242

Acres of Crops Per Animal Unit	Labor Income
- - 4	$469
4 - 5	222
6 - -	79

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[1]Misner, E. G. Thirty Years of Farming in Tompkins County, New York. New York Agr. Expt. Sta., Bull. 782. 1942.

marked difference between the make up of farms in the era under which the study was made and the present era becomes most obvious as factors such as the number of cows, total capital investment, acres of crop, and value and pounds of milk are examined. Another point which comes to light in observing the data is the failure of the author to present the number of farms in each of the groups under the various farm management factors. This lack of information makes it impossible to attach any real meaning to the analysis. At the same time the work does represent a pioneer study and certain inferences can be drawn from it regarding factors of importance in farming for the time and locality in question.

Several of the farm management factors have a range in labor income between the low and high groups of over $580, these being P.M.W.U., milk sold per cow, value of dairy products per cow, and P. M. W. U. per man. In addition crop index and number of cows have a $540 difference between the low and high groups. The factors mentioned above are either measures of size of business, labor efficiency, or yield factors. Further examination of the factors reveals little difference between groups for factors which measure enterprise combinations. Percent of receipts from livestock and percent of crops are examples of this type of farm management factors. The greatest difference for any factor is that shown for percent of receipts spent for labor. The difference of $1,138 coupled with the observation that man equivalent was associated with no consistent difference in labor income might well lead to the conclusion that under Tompkins County conditions in 1927 moving to a two-man farm was of little value in increasing labor income, particularly if this move involved hiring labor.

Warren (18), in discussing the Tompkins County survey, states that while the results obtained may not have the mathematical precision required by the laboratory technician, they are sufficiently accurate to lead to accurate conclusions. In proceeding with the discussion, he attributes the discovery of the principles of size of business, crop yield, and production per animal to the Tompkins County survey.

Hopkins (7) made use of 323 Iowa Farm Business Records in 1927 and 430 in 1928 in an effort to discover what relationship exists between some of the more common farm management factors and the net farm incomes under Iowa conditions. An increase in acres in corn was associated with a corresponding decrease in net farm income up to about 40 acres in corn at which point net farm income increased and followed the increase in acres. Increase in yield of corn from 20 to 50 bushels was associated with an increase of income of only about $600, while an increase in yield from 50 to 70 bushels resulted in about $1,100 more income. Size of the hog enterprise as measured by the number of sows exhibited diminishing returns in that net farm income rises to 40 sows and then decreases. The author observed that more than 40 sows were in excess of what one man could handle and that the same care for the sows was not forthcoming beyond this point. Percent receipts from livestock as well as equipment expense per crop acre contributed very little to the analysis. An increase in net farm income accompanied an increase in returns per $100 feed to approximately $200 returns per $100 of feed, then leveled off and decreased. It was stated that this decrease was due to expenses other than feed increasing. When percent of expense to income was treated as a farm management factor and compared to returns, it was observed that net farm income increased as expense increased for a very short range and then decreased rapidly with an increase in expense. When increases in either months of labor or crop acres per man were associated with net farm income, income was found to increase at a decreasing rate.

Net farm incomes were estimated for the 753 farms included in the study. When the estimated net farm incomes were correlated with the actual incomes, a correlation coefficient of +.85 was obtained from the 1927 figures and +.83 for 1928. The standard deviation of the differences between the actual and the estimated net farm incomes was reduced 46% in 1927 and 44% in 1928. The author does not give the method used to make the estimations of net farm income.

Schrumpf (15), in studying potato farms in Aroostook County, Maine, found the relationship of size of business, as measured by bushels of potatoes per acre, to be positive in a year of relative prosperity, but negative in 1928 and 1930 when most farmers sustained losses. In 1928, 98% of the farms having less than 25 acres of potatoes had labor incomes larger than the average of all farms. In comparison, only 5% of the farms having 53 or more acres of potatoes per farm returned larger than average labor incomes. In 1929, a year of profit, only 3% of the farms having less than 25 acres of potatoes per farm had a labor income exceeding the average of all farms. Of the farms with 53 or more acres, 86% had larger than average labor incomes. This study over the three-year period, 1928 through 1930, was based on information collected by personal interviews with 165 farmers. The study also found the yield rate of potatoes to be significantly related to labor income. Increased yield of potatoes per acre was associated with decreased losses in the unprofitable years and increased

gains in the profitable year. There was no significant relationship between size of business and yield. A negative correlation was observed between investment in potato machinery per acre and labor income. Small farms had a larger machinery investment per acre than large farms.

The difference in crop yields had more to do with placing farms in the different income groups than any other one factor in an examination of farm management factors by Mosher and Case (13). The 57 Illinois farms studied in 1937 were sorted on the basis of crop yields, and it was observed that the 19 farms in the high group received $484 more labor income than the 19 farms in the low group. Second only to crop yields was the efficiency of livestock.[1] The high one-third of the farms with respect to livestock efficiency received a labor income $389 above the lowest third. When the value of feed fed per acre was tabulated on the same basis as the two farm management factors above, it was accompanied by a difference of $176 in labor income in favor of the high group. In addition to examining the effects of the farm management factors on labor income, the authors also studied the effects of several factors on returns for feed fed to dairy

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[1]Efficiency of livestock was defined by the authors as a percentage figure which measures the returns for feed fed weighted according to the amount fed to each kind of livestock.

herds. It was found that such returns were influenced about equally by the proportion of the herds consisting of cows being milked and the amount of milk produced per cow. Herds were grouped so that the high group consisted of 14 herds in which 71.1% of all cattle were milked and which produced an average of 8,815 pounds of milk per cow, while the low group consisted of 14 herds in which only 43.5% of the cattle were cows being milked and which produced an average of only 6,107 pounds of milk per cow. Average returns for the high and low groups were $168 and $107 per $100 worth of feed fed, respectively. The authors failed to define the term percent of all cattle being milked.

Thibodeaux et al. (17), in reporting on a study of farm organization in the cotton area of Texas, stated that six major farm management factors accounted for approximately 63% of the variations in labor income on the 137 farms studied during the two-year period, 1931-1932. The approximate effect of each factor on labor income also was determined while simultaneously eliminating any variations in earnings caused by the other five factors studied. On the basis of the relative importance of their effects on farm earning, the factors were classed in the following order: (1) Yield of cotton per acre; (2) percentage of farm land in cotton; (3) returns per $100 of feed fed to produce livestock; (4) productive man work days per man;

(5) size of farm; and (6) number of animal units per 100 acres of farm land.

Czarowitz and Bonnen (6), in following up the earlier Texas work (17), reported that in the rolling plains area of Texas three factors accounted for 40% of the variations in net farm incomes. Crop yield was reported to account for 21%, acres of crop land for 15%, and percentage of crop land in cotton for 4% of the variation in net farm income. This study was conducted in 1935 with a sample size of 200 farms.

The importance of several farm management factors was studied under the conditions of northwestern Indiana by Robertson (14). The study was of 10 years duration, 1929 through 1938, and was based on the financial records of 50 farms. Efficiency in handling livestock was the most important single factor causing differences in labor incomes among farms. For the 10-year average, the highest one-third of the farms in livestock efficiency had a labor income $974 above the lowest one-third. Robertson stated that livestock efficiency was largely the result of production per animal, price of livestock products, and economy of feeding. No mention was made, however, regarding the method of construction of the livestock efficiency index used. The importance of crop yields approached that of livestock efficiency. As the average for crop yield index

moved from 75 to 126 labor income moved from $276 to $1,192, a difference of approximately $900. A positive correlation was observed between crop yields and both livestock per tillable acre and fertilizer expense.

The author reported that large farms had higher labor incomes than small farms, but that the large farms which were not well managed were the ones with the greatest losses. During the depression years there was a negative correlation between size and income. It was stated the advantage of size was the greater economy in labor, power, and machinery. The basis for this statement was that the farms with the lowest costs for these items per crop acre were larger in size than the other farms. Labor efficiency measured in terms of P.M.W.U. per man ranged from less than 100 to more than 500, and was correlated with size of farms, differences in equipment, seasonal distribution of labor, intensity of operation, and physical and managerial ability. When tabulated on the basis of P.M.W.U. per man, the high one-third showed an average labor income $450 greater than the low one-third.

A number of farm management factors affecting Michigan farms were studied by Wright (20) in a study period of 1933 through 1938 involving 1,016 farm record years.[1]

[1]Farm record years are defined as each farm involved in the study times the number of years that farm is included.

The effect of the cropping system was studied by several farm management factors. Farms were divided into three classes of soil productivity and it was observed that as soil productivity increased crop index and labor income increased. The study showed that as the percent of cash crops on the better land increased labor income increased, but that the reverse of this is true on the poorer land; that a higher percent of high value crops increased labor income; and that high yields were essential to high labor income. Livestock influence on labor income was examined by use of the farm management factors of dairy sales per farm and productive animal units per tillable acre. An increase of either one of these factors was associated with an increase in labor income.

Size of business was examined by two factors. The first of these two size factors, number of cows, showed that the average labor income increased from $588 to $1,206 as the number of cows increased from 6.4 for the low group to 17.3 for the high group. The effect of the other size factor, number of tillable acres, is shown in Table 2. This two-way tabular analysis in which the farms are divided by size and intensity shows the interrelationships of some of the problems involved when a sort is made on one or even two farm management factors and then all changes in income are attributed to these factors. It is to be observed that as intensity in the form of P.M.W.U. per tillable acre increased labor efficiency, shown by P.M.W.U. per man, also increased for both the large and

Table 2

Association of Labor Income and Several Farm Management Factors With Size and Intensity of Farming Operation. 1016 Farm Record Years on Selected Michigan Farms, 1933-1938[1]

P.M.W.U. per Till. Acre	Number of Farms	Tillable Acres	P.M.W.U. per Man	Crop Value per Till. Acre	Productive A.U. per 10 T.A.	Labor Income
(Small Farms--130 acre average)						
2.6	85	107	200	$13.36	1.5	$392
3.5	211	96	221	14.24	1.9	535
4.9	308	82	254	16.67	2.6	751
(Large Farms--260 acre average)						
2.4	162	191	231	$12.80	1.6	$688
3.4	167	179	262	14.54	2.2	1,096
4.6	83	172	281	18.34	2.7	1,585

[1]Wright, K. T. Dollars and Sense in Farming. Michigan State University Farm Management Publ., Special Bull. 324. 1941.

small farms. Crop value per tillable and productive animal units per 10 tillable acres also follow the increase in intensity in both size groups. With such correlation between factors, the job of attributing causation becomes

extremely difficult, if not impossible, with this type of analysis. The author points out that farmers with small businesses, less than 300 P.M.W.U., had less than one chance in 100 to make a labor income of $2,000, whereas farmers with large businesses, 900 P.M.W.U., had 35 chances in 100 of making a $2,000 labor income.

In studying Indiana farm accounting procedures, Kyle (11) analyzed farm records by several systems to discover significant relationships of various farm management factors with measures of success of the farm business. The years studied were 1930 through 1934 and 1946 through 1950. All the farm records summarized as a part of the Indiana farm record project for these years were used in the study, a total of 6,562 individual farm records. The methods of analysis used were tabular, paired sample,[1] and linear correlation analysis. When the relationships of size to net farm income and to labor income were examined by grouping according to tillable acres, a positive relation was shown with the measures of success in 8 of 10

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[1] The method of analysis by paired sample analysis was to first rank all records on one factor such as size. Then each successive pair was split into a low and high half on another factor such as P.M.W.U. per man. The merit of the method over standard tabular was stated to be that interrelationship of variables was reduced.

years. In 1931 and 1932 there was a negative relationship. Size was shown to have a more pronounced effect in the high income period 1946 through 1950 than during 1930 through 1934. Paired sample analysis demonstrated a difference of approximately $4,000 in 1948, $2,000 in 1949, and $6,000 in 1950 as farms were divided on either tillable acres or P.M.W.U. Net farm income was treated as the dependent variable and each of five measures of size as the independent variable with simple correlation. Total capital investment accounted for 66% of the variation in net farm income, and with each additional $1,000 in investment net farm income increased $161.95. The number of tillable acres accounted for 56% of the variation in net farm income, while number of sows farrowing and total pigs weaned accounted for 45 and 44 percent, respectively. P.M.W.U. accounted for only 37% of the variation in net farm income and was considered to be a poor measure of size in this study.

The function of livestock intensity in the farming operation was studied with the farm management factor, feed fed per tillable acre. Tabular and paired sample analysis showed little relationship between the factor and net farm income. The multiple linear correlation of tillable acres and feed fed per tillable acre with net farm income revealed a correlation coefficient of 0.59. Tillable acres

alone had a coefficient of 0.55. P.M.W.U. per man, tillable acres in corn, and crop yield index each exhibited a positive effect on net farm income when analyzed by either tabular or paired sample analysis. The addition of any one of the three factors as a second independent variable of a multiple correlation analysis with tillable acres as the other independent variable raised the multiple correlation coefficient from 0.55 to approximately 0.60.

A multiple linear correlation analysis was undertaken with net farm income and five farm management factors. A multiple correlation coefficient of .66 was obtained and the following prediction was developed: $X_1 = 45.65\ X_2 + 80.72\ X_3 + 9.77\ X_4 + 117.82\ X_5 + 25.63\ X_7 - 14{,}971.56$. The variables in the equation were listed as: X_1 = net farm income; X_2 = tillable acres; X_3 = crop yield index; X_4 = P.M.W.U./man; X_5 = percent tillable acres in corn; and X_7 = feed fed/tillable acres. The partial correlation coefficients were computed for each of the above variables to determine the relationship of each with net farm income while eliminating the effects of the other four variables. The coefficients are as follows: tillable acres = .7667; crop yield index = .2951; P.M.W.U. per man = .1796; percent tillable acres in corn = .2389; and feed fed per tillable acre = .1430.

Association of nine farm management factors and labor income was studied by Wilkes (19) using 1952 data from 124 South Central Michigan farms. The mean labor income for the farms involved was \$3,590 with a standard deviation of \$3,698. Three measures of size were used: P.M.W.U., tillable acres, and number of cows. The author stated that of these three only P.M.W.U. proved reliable in estimating labor income. The correlation coefficient indicated that changes in P.M.W.U. were associated with only 25% of the variation in labor income. The author further stated that for the purpose of estimating either the level of or change in labor income, the three farm management factors dealing with size were poor, with the exception of P.M.W.U. which had some value.

The simple correlation coefficients were referred to as the percent of explained variation in income associated with each of the six remaining farm management factors and were as follows: Income per \$100 expense = 74.0%; livestock income per tillable acre = 17.5%; P.M.W.U. per man = 16.4%; dairy sales per cow = 14.9%; crop yield index = 8.4%; and tillable acres per animal unit = 0.1%. Since changes in the level of the farm management factors are often advocated as a means of increasing incomes, the efficiency with which changes in labor income can be predicted from changes in these measures was investigated. Estimating changes in labor income from changes in income per $100 of expense proved to be effective, the regression coefficient being $93.64 with a standard error of $5.02. The regression coefficients for the other efficiency measures also had low standard errors.

Management factors influencing the percent return on capital investment for 39 Los Angeles County commercial dairies were studied by Albright (1). The dairies studied purchased all or most of their herd replacements, ranged in herd size from 141 to 659 cows, handled an average of 63 cows per man, and had an investment per cow figure ranging from $663 to $1,640. The production levels of the herds varied from 11,619 pounds of milk and 391 pounds of fat to 15,893 pounds of milk and 547 pounds of fat, with an average yearly concentrate consumption of 5,620 pounds per cow. Standard partial regression coefficients were calculated on a within-year basis for the data compiled from 1956 through 1960. The most important management factor for the study was production cost on a per cow basis. Feed costs, roughage and concentrate, were significant at the .05 level of probability 3 out of the 5 years studied; labor costs 2 out of 5 years; and the cost of herd replacements and operating costs were significant 5 out of 5 years studied. Prices received for butterfat and the pounds of butterfat produced were significant at the .05 level of probability 4 out of the 5 years studied.

The farm management factors of cows per man, hours per cow, percent cows dry, milk produced per cow, culling rate, investment per cow, feeding efficiency, number of cows per herd, prices paid for hay and concentrate, and interest on assets failed to show a significant relationship at the .05 level of probability.

Numerous farm record projects are carried on under the direction of the various agricultural economics departments of land grant institutions in the United States. In some instances these results are summarized and the summary published as a part of the program which serves as an educational tool, a research program, and an in-service training situation for the personnel involved. The published report tends to be descriptive in scope, however, as its prime purpose is to point out to farmers some of the items which will be of interest and of aid to them. Examples of such reports are the 1962 Summary of Illinois Farm Business Records (16), which reports on all types of farming and is general in nature, and the report Dairy Farming Today--Southern Michigan (9), which has been restricted to one type of farming and in a restricted area.

Kelsey and Brown (9), in reporting on Southern Michigan dairying, divided the 234 dairy farms into three groups according to total investment. Within each of the size groups, the farms were divided into two groups on the basis of gross income per $100 total cost. The average of the farms in the high income-cost ratio group had more cows, tillable acres, and gross income than the low income-cost ratio group. The authors noted that there did not appear to be any consistent differences in total investment and tillable acres per man, but gross income and number of cows per man were greater for the groups with over $100 income per $100 expense. The well-balanced farms achieved higher production per cow and consequently higher product sales per cow. It was felt that the fact that labor income increased on well-balanced farms as size increased and that it decreased on poorly balanced farms as size increased was of particular significance.

This type of descriptive analysis as used by farm management workers is of particular benefit in working with dairymen but does not lend itself to such a study as this one.

The number one thing derived from this review of farm management factors is the difference resulting from various kinds of farms, localities, and periods of time in which the studies were undertaken. The relative importance of most any farm management factor studied has been dependent upon type of farms studied, date at which the information was collected and the locality from which the farms were drawn.

It is felt that a study involving Michigan dairy farms operating under current conditions can be of particular significance to the Michigan dairy industry by determining the relative importance of the various farm management factors in the profitable dairy farm operation. It, likewise, is not out of line to assume that these relationships will be of some merit in localities where dairying is practiced in a similar manner to that practiced in Michigan.

EXPERIMENTAL PROCEDURE

I. Acquisition and Development of the Sample

The development of high speed computers capable of interpreting and processing large masses of data has opened the way for centralization in the processing of farm record programs. A movement has been made from dispersed centers using hand computation methods to a central location where high speed handling and computing equipment can be utilized. This shift has been coupled with a growth in the breadth and depth of data being summarized, analyzed, and returned to the participating farmers in the form of usable information. In the process of handling and working with these farm records, a large concentration of information concerning farm operations has resulted

This study, as mentioned earlier, utilized two such sources of data: the Michigan Dairy Herd Improvement Association records and the Michigan Mail-In Farm Record Project. Dairy Herd Improvement Association (D.H.I.A.) records and Owner-Sampler records are dairy production records which are processed as a part of the Michigan Dairy Herd Improvement Association record system. The D.H.I.A.-I.B.M.

records, as the machine tabulated records were first known, came into general usage for all herds on D.H.I.A. for the testing year of 1958. The D.H.I.A.-I.B.M. program is a continuation of the D.H.I.A. records which were previously calculated by the local supervisor. Owner-Sampler records were first machine tabulated in 1959. The Mail-In Project is a continuation and up-dating of the Michigan Farm Record Project initiated in 1928. The program of farm financial records started as a pilot project in two counties as a machine calculated project in 1955, at which time the words Mail-In were added to the title and, in fact, became the working title of the project. The success of the pilot project led to the conversion of the entire program to this basis in 1957.

An alphabetical card listing of all cooperators on the Mail-In Project was obtained, by county and year, for the years 1958 through 1962. The listing obtained represented approximately 1,600 different Michigan farmers for the year 1958 and 1,200 farmers for each year after that. A listing according to farm number, and county, was obtained for all herds completing a testing year on D.H.I.A. for any year during the 5-year period. The years completed, along with name and address were on this list. Approximately 2,000 herds were included each year on the D.H.I.A. listing. It was not possible to obtain a listing

of herds on Owner-Sampler testing; and it was therefore necessary to go to copies of monthly reports to find the herds that had completed any of the years studied. Herd numbers on Owner-Sampler testing ranged from 800 in 1959 to 1,275 in 1962.

The two systems of records both operate by assigning a farm or herd number to each cooperator. Numbers assigned are permanent and are removed from circulation should the cooperator leave the project. The assigned numbers, however, are not common for both sets of records. It was, therefore, necessary to hand-match the farms which were common to both sets of records. Farms were matched as regards name and address of each cooperator. Any cooperator which appeared to be the same individual by virtue of the same mailing address and surname but not identical in given name was checked by referring to individuals who were personally acquainted with the cooperator in question.

A further check to establish that names from one record were the same as those obtained from the second record was undertaken later in the study. Data common to both sets of records were matched to determine any gross dissimilarities. The following data were found to be common to both systems: average number of cows, average milk produced per cow as compared to average milk sold per cow, total milk produced compared to total milk sold, value of product contrasted to dairy product sales, milk price, and breed of cattle. Dissimilarities were followed up by means of personal consultation with individuals acquainted with the cooperators. In no instance was a farm discarded on the basis of difference alone. A total of 448 farms and 1,404 farm record years was found to be common to both sets of records. These 1,404 observations were complete as regards all data normally included by either record system.

The production records, D.H.I.A. and Owner-Sampler, are operated on a testing year which begins on October 1 and ends on September 30 of the following year, while the accounting year used under the Mail-In project is from January 1 through December 31 of the same year. In order for the two sets of records to be comparable they must cover the same time span. A January to January testing year was computed for the production records by obtaining the monthly production cards used to calculate the original annual summary and then to re-sort and summarize these cards. The data reported by either type of record then represents information from the same farms and over exactly the same period of time.

In the process of shifting the testing year from an October beginning to a January beginning, the problem

of bi-monthly tests presented itself. As is occasionally the case with D.H.I.A. and Owner-Sampler records, months missed by the tester for any one of several reasons are usually covered by reporting days for a two-month period on the following month. The month missed is then computed by using milk weights and fat tests from both the proceeding month and the following month. Days from the forepart of the missed month are multiplied by milk weights from the preceeding month while days from the latter part of the missed month by weights from the following month. In reporting the information to the herd owner, however, the values are reported for a two-month period. This necessitated allotting appropriate values to December and January for any bi-months reported in January. In addition the decision had been reached to study the effect of seasonal milk production on income and this prohibited bi-monthly reports in August. To furnish greater flexibility in the use of the production records, all bi-monthly values were divided and allotted to the two months concerned.

The method of separating bi-monthly values for milk, fat, feed, and value of product was to divide each value by the total number of days in the two months and then multiply by the number of days in each month. The exception to this was in the case of certain feed factors, such as days on pasture, where it was obvious that the entire value given was for one or the other of the two months. A total of 109 bi-monthly records were divided between the appropriate months.

It was desired that the effect of the breed of cattle on net income as well as its effect on several of the farm management factors to be included in the study be considered. To study the effect of breed, it was first necessary to classify the herds in question according to breed. Both the accounting records and the D.H.I.A. and Owner-Sampler list the breed of cattle for each cooperator. D.H.I.A. records, however, are essentially individual cow records and furnish much more detailed information on the make-up of the breed of cattle in the herd. In particular D.H.I.A. records furnished the breed of any cow in the herd which had finished a 305-day lactation record. A study of D.H.I.A. records revealed several features regarding herd make-up. In many instances the breed reported for the herd simply designated the breed in the majority in the herd. It was also noted that the breed make-up within a herd often changed over a five-year period but the breed designation for the herd did not always follow this change. These two features of breed classification, along with the occasional error made as the information was punched into the data cards, made it necessary to devise a more accurate and realistic assignment of breed of dairy cattle.

Due to a restriction in numbers it became obvious that the study should be restricted to the Holstein, Jersey, and Guernsey breeds. The few cases involving other breeds were removed from the study. All herds on D.H.I.A. were then examined in detail and classified according to breed on the basis of the breed reported for individual cows within the herd which had completed 305-day lactations. A herd was accepted as Holstein or Jersey and/or Guernsey if 90% or more of the 305-day lactation records were completed by Holstein or Jersey and/or Guernsey cows, respectively.

It is commonly accepted that a difference exists between the Holstein breed and the two smaller breeds in regard to both pounds of milk produced per cow and percent of milk fat. With this in mind, a decision was made to classify according to breed on the basis of the average yearly fat test. Classification according to milk produced per cow was ruled out as level of production was one of the factors to be analyzed. If milk production had been used as a basis of classification, several high producing Jersey-Guernsey herds as well as several low producing Holstein herds would have fallen into the catagory of mixed breeds and consequently would have been discarded from the study. In this study involving the effect of yield on income the extremes are of particular interest.

Studies by Wunder (22) indicate a mean fat test for Michigan Holsteins of 3.66% with a standard deviation of .40. The average fat test on Guernsey and Jersey records studied was 4.84 and 5.38%, respectively. The respective standard deviations were .48 and .51. In studying 8,638 Michigan Holstein records, Burdick (4) found the average fat test to be 3.65% with a standard deviation of .40.

The finding of these workers indicates that with a herd size of eight, the smallest in this study, a standard deviation of .14 and .17 can be expected for the Holstein and Guernsey breeds, respectively. It was thus expected that 99% of the Holstein herds would have an average yearly test between 3.24 and 4.08%. In a like manner, 99% of the Guernsey herds would be expected to have a yearly milk fat test of between 4.33 and 5.35 percent. It then follows that any herd having between 4.08 and 4.33 percent milk fat should be considered as a mixed breed herd. When the average herd size of 39 cows was used in determining the standard deviations, the area between 3 standard deviations in fat test of Holsteins and Guernseys was from 3.87 to 4.60 percent. Examination of the fat test for the herds of known breed which were used in this study revealed that the test for Holstein herds ranged from 3.20% to 4.25% and that the fat tests for the Jersey-Guernsey herds ranged from 4.40% to 5.75% milk fat.

All herds with an average yearly milk fat test which fell between 4.23 and 4.52% were considered as mixed herds and excluded for this study. The basis for this exclusion was the studies of the above authors (4,21) coupled with observation of fat tests from herds which were a part of this study and for which the breed make-up was known. As a result of breed classification, 21 different herds and 86 farm record years were excluded from this study. This number includes both the herds rejected as minor breeds as well as those rejected for being a mixed herd.

Previous studies have demonstrated the necessity of unifying type of farm in such a study as this one. To obtain this uniformity, the farms were classified by source of income. The percents of crop, dairy, beef, swine, poultry, and off-farm incomes were computed by dividing gross income into that portion of gross income derived from each of the above mentioned sources. Dairy farms were considered to be those from which 70% or more of the gross income was derived from the dairy enterprise, either through sale of dairy products or dairy animals. Farms on which less than 70% of the gross income was derived from dairy and with only one other major source of income were classified as dairy-crop, dairy-beef, dairy-swine, or dairy-poultry farms. General farms were those with several sources of income, none of which served to contribute a majority of the income. Part-time farms were those with 20% or more of the gross income derived from off-farm sources. A total of 340 farms with 1,041 farm record years were classified as dairy farms.

II. Selection and Development of Farm Management Factors

The premise that the income derived from a dairy farm operation is the ultimate concern of the dairyman in his role as manager of that business has been accepted as a part of this paper. The assumption has been made that the manager desires to maximize his net income and that his success as a manager may be measured by his ability to do so. The measure of success used in this study was net income. Net income may be defined as gross income minus gross expense plus or minus the change in inventory. This value was computed in the Mail-In Account records by summing net cash income and inventory change, where net cash income was equal to total cash receipts minus total cash expense.

Alternate choices as measures to reflect the degree of success were net farm income, which deducts a charge for family labor, and labor income, which places a charge on both family labor and capital investment. Net income was selected for its capacity to reflect the earning

ability of the farm as a business unit, and because of the fact that net income is a more familiar term that is much more readily understood outside of the field of agricultural economics than either of the other two measures of income.

Several measures of size of business were considered and the following were accepted: total investment, tillable acres, number of cows, and number of men. The total investment figure used was the average of the beginning and ending total investment for the year in question. The total farm investment was considered to be the inventory value of land, buildings other than the farm dwelling, machinery, livestock, supplies, and feed on hand on January 1. Values used for machinery and buildings were based on the cost less the depreciation claimed for income tax. Land was priced on a bare land basis and represented a conservative market value for the particular land in question. Livestock values were estimates based on current livestock prices with purchased animals valued at their purchase price. Feed and supplies were represented by market costs. It should be understood that the investment figures used were those reported by cooperating farmers and the only computation needed to prepare the factor for this study was to change the beginning total investment to an average figure. The calculation of average total investment consisted of summing beginning total investment and ending total investment and dividing by two.

The selection of total investment as one of the farm management factors was as a consequence of the ability of the factor to measure size across differences in enterprise organization, land quality, and machinery input. An investment figure makes ure of the dollar as a common denominator to reduce all inputs so that they may be summed.

The acceptance of only those farms that received 70% of their income from the dairy enterprise would lead one to expect that any factor directly related to this enterprise would have a marked influence on returns. The number of dairy cows was then chosen for its expected ability to reflect the effect of size on a study in which all farms are dairy farms. Cow numbers were also considered important as a factor because of the emphasis currently placed on herd size by workers in the field of farm management and because of the continuing trend to larger herds.

The production records were accepted over the Mail-In records as the source of cow numbers because of a more systematic method of determining numbers. The number of cows was calculated as the number of cow days for the year divided by the number of days in the year, where a cow-day was equal to one cow in the herd for one day. Cow days are counted on all animals which have freshened but which are now dry as well as all cows in milk. Cow numbers used in the Mail-In records were those reported by the dairymen. Cooperators in the Mail-In project are advised to report the number arrived at through the use of D.H.I.A. and Owner-Sampler records whenever possible.

The number of tillable acres was used as another measure of size, in that acres are indicative of the size of the crop or feed enterprise. The inherent productivity is not the same on all tillable acres, but land does represent the first physical input in a system of farming which used dairy animals as the prime market for crops produced. Included under tillable acres was land in harvested crops, tillable pasture, land devoted to crops that failed, tillable land reserved for government programs and idle tillable land. The use of total acres was rejected due to the large amount of unproductive land included in such a figure and because of the unequal percentage of this unproductive land between different farms.

The number of men was used in an effort to obtain a factor reflecting the total labor input of the farms studied and the effect of labor input on returns. The source was the Mail-In records and was calculated as a part of these records by summing the number of months of operators labor, hired labor, and family labor then dividing by 12.

Other measures of size were considered unsatisfactory for this study. A productive man work unit or productive day of work represents the accomplishments of a man working at average efficiency for a 10-hour day. The P.M.W.U. on a farm is the estimated total number of 10-hour days of work required to care for the amount of crops and livestock kept. This farm management factor was a part of the information reported by the Mail-In project until 1961 at which time it was discontinued. The computation of P.M.W.U. for 1961 and 1962 was not undertaken as a part of this study. In the mechanization of agriculture, the values previously used for the calculation of P.M.W.U. have become unrealistic. Determination of values reflecting the organization of present day agriculture was beyond the scope of this study.

The same logic which prevented the use of P.M.W.U. also prevented the use of total animal units as a measure of size.

Returns resulting from cropping practices can be expected to be affected by crop yields, type of crop grown, prices received, land use, and crop disposal. Crop value per tillable acre was a factor obtained directly from the Mail-In records. The factor was computed as a part of those records by dividing total crop value by the number of tillable acres. Total crop value was obtained by

multiplying crop production by November prices. These prices are reported in the appendix. Crop value per tillable acre reflects crop yields, the market situation, relative value of crops grown, and land use. The major weakness of the factor was considered to be the large number of factors influencing it. It was felt that a number of farm management factors studying the effect of the cropping system on income might well be advantageous.

To establish the effect of level of crop yields on income, an index showing the relative productiveness of crops was computed. This crop yield index was calculated for the 1,318 farm record years that were a part of this study after the farms had been classified according to breed. The steps in the computation of such an index were as follows: (1) Determination of the average yield of each crop across all farms in the study, by year; (2) the acre index for each crop on each farm computed by dividing crop production per crop by average yield for that crop; (3) sum all acre index values per farm; (4) divide total acre index by total acres on the farm used to compute the index; and (5) multiply by 100. These computations may be algebraically expressed as follows:

$$\text{Crop yield index} = \frac{\sum_{i=1}^{N} \left(\frac{y_i}{Y_i} \cdot a_i\right)}{\sum_{i=1}^{N} a_i} \times 100$$

Where y = the yield on a "given" farm

Y = the average yield of the farms used as a base of comparison

i = the "ith" crop

a = acres on the "given" farm

Crop yield index was an expression of average crop yields on a weighted basis.

The distance above or below a crop yield index of 100 that a particular farm may be was indicative of level of production of crops on that farm. Values above 100 indicated production superior to the production of the average farm.

Crop acre value was designed to account for the variations in crop value per tillable acre resulting from the kind of crops grown. It was realized that some crops are relatively higher in value than others. Value constants were developed to reflect this difference in value between crops. The value constant for any crop is the November price for that crop times the average yield of the crop for all the farms in the study. In calculating the crop acre value for an individual farm the number of acres for each crop grown was multiplied by its respective value constant. The products of acres times value constants were then summed and divided by the total number of acres used to produce these crops. The resulting quotient was the crop acre value. Crop acre value differs from crop value per tillable acre in that the effect of yield and degree of land utilization have been removed. The removal of the yield effect was accomplished when the November price for each crop was multiplied by average yield for the crop rather than by the actual yield. The effect of land utilization was removed by dividing by the total acres in crop rather than by total tillable acres. An algebraic expression of the factor is as follows:

$$\text{Crop acre value} = \frac{\sum_{i=1}^{n} (Y_i \cdot P_i) \cdot a_i}{\sum_{i=1}^{n} a_i}$$

Where Y = the average yield of the farms used as a base of comparison

P = the November price

i = the "ith" crop

a = the acres on a "given" farm

The inherent productivity of the soil has been accepted as a major factor in effecting crop yields and to a lesser extent type of crops grown. The farm management factor, soil value rating, represents an attempt to measure the variation in income resulting from difference in the inherent productivity of the soil. The value was obtained from the Mail-In Account records and is expressed as a dollar value. In developing this rating, county personnel classified the farms within the individual counties on the basis of soil productivity. The classification ran from A through D, with A ranked farms being the best in that particular county. A dollar value was then assigned by county, for each of the soil productivity classifications. The values assigned for one county may be entirely different from those for another county in a different part of the State. It was this dollar value that has been used as the soil value rating. The weaknesses to be expected in the factor are first those due to errors of judgement in classifying soil. Another problem in such a method of classification of soil productivity is the difficulties involved in attempting to remove value imparted by uses other than agricultural. Closeness to urban or industrial areas are examples of conditions imparting additional value to land over that imparted by agricultural uses.

Fertilizer and lime expense per tillable acre represents the use of the dollar value of a crop input to predict net income. As this factor was selected it was realized that any effect on net income would be contingent upon a large number of other variables. Fertilizer and lime expense per tillable acre has been a widely used factor in the analysis of farm organizations by farm management workers.

Resources, such as land, that were not used to their full capacity would be expected to result in an income which was less than maximum. On the basis of this logic, the percentage of tillable acres idle was taken from the Mail-In Account records and used as a farm management factor.

The percentage of cash crops was developed as a measure of crop disposal. The value of the crops which were considered to be cash crops were summed. Cash crops were considered to be the following: wheat, dry beans, sugar beets, potatoes, legume seed, flax, truck crops, fruit, berries, canning peas and beans, crops sold standing, insurance payments on crop damage, and payments through the soil bank program. The value of crops grown as cash crops was added to sales of feed crops. The sum was then divided by total crop value to determine the percentage of cash crops. It was realized that this factor would be limited in value to the study in that the farms had previously been sorted to remove any farms which had less than 70% of their gross income from the dairy enterprise. It was felt, however, that the factor might account for enough variation in income in herds classed as dairy herd to justify its use.

A large number of farm management factors which deal with dairy efficiency have been included in this study. These dairy factors have been justified on the basis that the income of a sample such as the one used in this study could be expected to be markedly influenced by the different aspects of the dairy operation.

Dairy sales per cow might be expected to have much the same relationship to the dairy enterprise as might be expected between crop value per tillable acre and the crop enterprise. Dairy sales are influenced directly by pounds of milk sold, percent of milk fat, and price received. Mail-In accounts report dairy sales per cow, just as

D.H.I.A. records list the value of product per cow. Both measures are intended to represent the same factor; however, the figure reported by the financial records is one of income received divided by the number of cows, while the figure reported by D.H.I.A. is a calculated figure and assumes all milk produced has a value. The values used for this study were taken from the Mail-In accounts.

Milk production per cow has been studied in more detail than the other farm management factors due to the traditional emphasis placed on this measure of physical output by workers in the field of dairying. Milk produced per cow was taken from the D.H.I.A. and Owner-Sampler records and was based, as is the case with production records, on monthly weighing of the milk produced by the individual cows in the herd. Milk sold per cow was obtained from the Mail-In accounts where it was calculated as a part of those records by dividing pounds of milk reported sold by the average number of cows. A problem presented with this factor was the failure to have the pounds of product reported in 1.7% of the cases. The absence of values was circumvented by subtracting the average difference between milk produced per cow and milk sold per cow from average pounds of milk produced. A difference of 679 pounds was found between these two measures of milk per cow. The difference was obtained by subtracting the averages of all observations for milk sold per cow and milk produced per cow. Milk sold was then considered to be 679 pounds below milk produced in those cases where it had not been reported.

The two milk factors were converted to the factors of 4% fat corrected milk (FCM) produced per cow and 4% FCM sold per cow in an effort to determine if a comparison could be made across breeds of cattle. The multiplication of average pounds of milk by 0.4 plus average pounds of milk fat times 15 resulted in the pounds of 4% FCM. The fat test obtained from the production records was used in the computation of 4% FCM sold. The factors, milk produced per cow, milk sold per cow, 4% FCM produced per cow, and 4% FCM sold per cow were considered to be four measures of the same factor. It was felt, however, that a comparison of production ability was justified. It should be pointed out that both of the sales factors were dependent upon the production records either for missing values or for fat tests.

Pounds of milk fat per cow were obtained from the production records and were included because of past, if not present, emphasis by dairy scientists on this yield factor.

Two milk price factors were used. Milk price per cwt. was obtained from the financial records and in actuality was calculated by dividing total dairy sales by total pounds of milk sold. This figure is representative of the price received after the deduction of marketing expenses, hauling included. As with milk sold per cow,

the milk price per cwt. for those few herds not reporting pounds of milk is a calculated figure which is contingent upon the existence of production records. The second price factor used was 4% FCM price per cwt. The FCM price was developed from the above milk price and represents the price which would have been received if the milk sold was the pounds of 4% FCM sold per cow as computed previously. Computation of the factor consisted of obtaining the difference between the fat test from .04 and multiplying the difference by the average price on fat differential paid for the year. This product was then algebraically added to milk price per cwt. Price received on fat differential for the period of time in question was as follows and represents the increase in milk price per cwt. for a 0.1% increase in fat test: 1958 = 6.58¢; 1959 = 6.71¢; 1960 = 6.67¢; 1961 = 7.00¢; and 1962 = 6.63¢. The factor of FCM price was developed under the assumption that when FCM sold or FCM produced was used it also would be used.

The majority of the farms in the study sold milk under some type of base-surplus or base incentive plan. Percent base milk was developed to study the effect of seasonal milk production on income. The production records were used to obtain the total amount of milk produced from August 1 through December 31. The milk produced during this 5-month period was divided by the total yearly production to furnish the percentage of milk produced during the base period.

The farm management factor dairy cattle income per cow was obtained from the financial records and is the difference in the beginning and ending dairy cattle inventories plus dairy cattle sales minus dairy cattle purchases. It was felt that there might well be major differences in income as a result of cattle sales, particularly in as much as a number of cooperators were purebred breeders and as such have traditionally been assumed to obtain a sizeable portion of their income from the sale of breeding stock. Since inventory change and purchases were included in the computation of the factor, it was possible to have a negative dairy cattle income.

A factor was developed to study the effect that the number of young stock carried might have upon income. The replacement stock to cow ratio was calculated by summing the average number of heifers and the average number of calves, as determined from beginning and ending inventories, and dividing by the average number of cows. Both replacement and cow numbers were obtained from the Mail-In accounts. A point to be remembered with such a factor as this is that the replacement to cow ratio may depend more on the percent of heifers calves born than on dairy herd organization.

A study of the effect of dairy cattle housing on income was desired. The closest measure that could be obtained was improvement cost per cow. The inventory value of building and improvements, which represents building cost minus depreciation, was divided by the number of dairy cows. The major weakness was realized to be its inability to actually measure differences in types and extent of housing.

It was assumed that idle resources in the form of land would have a depressing effect on income, so it was reasoned that idle resources in the form of dairy cows would have a depressing effect on income. Percent of cows in milk was felt to be a measure of the productivity of resources. The factor was obtained from the D.H.I.A. records and was calculated as a part of those records by dividing total days in milk by total cow days.

The number of tillable acres per cow was designed as a measure of the intensity of the dairy operation. The number of tillable acres as reported by the Mail-In accounts was divided by the number of cows to furnish the value for the factor.

A number of feed input factors were computed for this study. Feed input as determined by Mail-In records is the value of the feed crops produced plus feed purchases minus feed crop sales plus or minus the change in the inventory value of those feed crops. Livestock income per $100 feed expense was based upon this calculation and was computed by dividing total livestock income by feed expense and multiplying by 100. Livestock income is the difference between beginning and ending inventory value of livestock plus livestock sales minus livestock purchases plus dairy product and egg sales. The factor of livestock income per $100 feed expense was accepted as a measure of the returns above feed cost for the livestock enterprise.

An effort was made to determine feed cost per cow through the use of the Mail-In records. Since feed quantities as measured by the financial records were allotted to all livestock on the farm, it was necessary to subtract that supposedly fed to livestock other than dairy cows. The method used in an attempt to remove the effect of other livestock was to divide the income for each type of livestock by the returns per $1 feed fed to the various classes of livestock for the year in question. The resulting figures then represented feed expense for each class of livestock and when summed represented total non-dairy feed expense. The values of the returns per $1 feed fed to different classes of livestock were obtained from Illinois data (16). These particular values, as shown in Table 3, were chosen because of their completeness. Feed cost figures used for heifers and calves were $105 and $65, respectively, and were obtained by multiplying feed required by local prices. The total cost of feed for

Table 3

Return per $100 Feed Fed to Different Classes of Livestock[1]

Year	Beef Cow Herds	Feeder Cattle	Hogs	Native Sheep Raised	Poultry
	$	$	$	$	$
1958	1.62	1.44	1.80	0.98	1.42
1959	1.47	1.12	1.14	1.02	1.23
1960	1.29	1.77	1.64	1.08	1.57
1961	1.39	1.16	1.64	1.10	1.50
1962	1.49	1.48	1.59	1.26	1.44

[1]Summary of Illinois Farm Business Records, 1962. University of Illinois, Coop. Ext. Ser. Cir. 874.

replacements was then computed using the stated values and subtracted from dairy feed costs. The remaining value was then assigned to the dairy cow herd and when divided by number of cows was listed as the farm management factor, feed cost per cow.

The remaining feed factors, as well as the percent cows in milk previously discussed, were taken from the D.H.I.A. records. Owner-Sampler records do not carry feed information and as a result the number of dairy farm record years with these factors was reduced to 814. Average feed cost, as taken from the D.H.I.A. records, was computed by summing the value of grain, hay, silage, and pasture fed.

Grain prices used were those reported by the supervisor, and represented market value of the grain mixture. Roughage prices used were constant for the entire sample and were based on market value. Pasture price used was $6 per month per cow.

Three physical measures of feed fed were determined from the D.H.I.A. records: pounds of grain per cow, pounds of hay equivalent per cow per day, and pounds total digestible nutrients (T.D.N.) per cow per day. All three of these factors were determined from values reported by the local supervisors. Grain per cow was based on the weight of the grain ration fed on test day and has been reported as total yearly pounds of grain per cow. Hay equivalent per cow per day is a measure of hay and silage fed during the winter months when all cows were in confinement. The factor was computed by dividing total silage by 3 and adding to total pounds of hay reported. Total hay equivalent was then divided by total cow days for the period of winter feeding to furnish pounds hay equivalent per cow per day. The grain quantities were derived from the weighing of grain fed to each individual cow. Roughage quantities were based on a report listing the average hay and silage consumed per cow daily.

Total digestible nutrients per cow per day were obtained by multiplying total grain for the winter feeding period by 0.75 and total hay equivalent for the same period by 0.50. The two products were then summed and divided by the total cow days for the winter feeding period. The factor, TDN per cow per day, was calculated over the winter feeding period, as was hay equivalent, due to the inability to allocate nutrient intake from pasture feeding in a study such as this.

Days on pasture was not considered to be a feed factor but rather a farm management factor reflecting dairy herd organization. Calculations of the factor consisted of summing total cow days on pasture and dividing by average number of cows.

The number of cows per man, milk sold per man, and 4% F.C.M. sold per man were the three farm management factors developed as a measure of labor efficiency. The three factors were considered to be an approximate measure of the same item. Milk sold per man or 4% F.C.M. sold per man were considered slightly more refined measures of efficiency of labor than the number of cows per man. The computations involved in the factors consisted of dividing the average number of cows, total milk sold, or total 4% F.C.M. sold by the average number of men.

Machinery expense per tillable acre was taken from the Mail-In Accounts where it was routinely assembled by summing the costs reported as repairs on tractors, crop

and livestock machinery and equipment, truck upkeep, gas, oil and grease and other machinery supplies, as well as the depreciation on all power crop and livestock machinery and equipment and dividing by the number of tillable acres. The division by tillable acres was undertaken in an effort to make machinery costs comparable between farms of different sizes.

The percent livestock income from dairying was included in an effort to study the existence of a secondary livestock enterprise on farms which were primarily dairy in character. Percent rented land, the last farm management factor included, was considered an organization factor, and was calculated from information presented in the Mail-In accounts. Acres of rented land were divided by total acres to furnish the factor percent rented land.

A total of 38 farm management factors were developed as a part of this study. These factors were chosen for use in an effort to compile a list of management factors which would consider all phases of the farm operation.

III. Analytical Design and Method

The relationship of an independent variable to the dependent variable may be either linear or curvilinear. A linear association is one where a constant amount of increase in the dependent variable is associated with a unit increase in the independent variable. Any other relationship would be curvilinear.

Economic theory precludes either constant returns to scale, constant input-output relationships, and consequently constant returns to the inputs of production, or even constant returns across organization or intensity changes over an unlimited range. An assumption of curvilinearity in some of the farm management factors was therefore felt to be valid.

The association between net income and each of the farm management factors was studied to establish linearity or the degree of curvilinearity. A tabular analysis was performed in which the separate farm management factors were independently ranked from low to high and then divided into 5 equal groups according to the number of observations. The average for the farm management factor and for net income was computed for each division. In addition the observations were sorted according to year and studied in the same manner as above. Results of the tabulation indicated that one of several basic relationships existed between net income and any given farm management factor and that this relationship was of the following order: Unit increases of the management factor resulted in a constant rate of increase or decrease in net income; unit increases in the farm management factor were accompanied by increases in net income at a decreasing rate, a relationship which could be expressed as movement along two or more segments of the curve defined by the law of diminishing returns. The diminishing returns curve may be described as one in which unit increases in the factor result in net income increasing at an increasing rate, increasing at a decreasing rate, reaching a maximum, and finally decreasing. A fourth type was observed which showed little or no relationship between the factor and net income. Tabular analysis then served as the basis for deciding to study the fit of each farm management factor to a linear, second degree, and third degree curve. It was felt that the study of functions other than those three would be of no value to this study.

Correlations used to study linearity were computed by the use of a Control Data Corporation (CDC) 3600 computer through the implementation of the CORE (10) routine, as were all correlations throughout this study. The basis for deciding which degree of linearity to accept consisted of computing the linear function where $Y = a + bX$, followed by the computation of the function $Y = a + bX + cX^2$. The coefficients of multiple determination, $R^2_{y.x}$ and $R^2_{y.xx^2}$, obtained by the two computations were observed. The hypothesis was tested that the two coefficients of determination were equal and as a consequence acceptance of the

function as being linear. The acceptance of the alternative hypothesis that the R^2 values were not equal was the acceptance that the additional variation explained due to the use of the quadratic expression was of significant magnitude and that unit increases in the farm management factor caused less than constant increases in net income. The hypothesis that $R^2_{y.x} = R^2_{y.xx^2}$ was tested at the .01 level of probability.

Computation of the function $Y = a + bX + cX^2 + dX^3$ followed and the function was accepted or rejected on the same basis as was movement from the linear function to the quadratic. That is, the hypothesis was tested that $R^2_{y.xx^2} = R^2_{y.xx^2x^3}$ at the .01 level of probability. The acceptance of the alternative hypothesis that $R^2_{y.xx^2}$ is not equal to $R^2_{y.xx^2x^3}$ is the acceptance of a function which follows the general form set forth by the law of diminishing returns. In addition to satisfying the statistical tests, the final functional relationship was expected to approach the expectation arrived at through logical deduction.

The prediction model developed was as follows: $Y_i = \alpha + \Sigma(\beta_i X_{ij} + \gamma_i X_{ij}^2 + \delta_i X_{ij}^3) + u_j$, where Y_i = the ith observation of the dependable variable; X_{ij} = the ith observation on the jth independent variable; α = a constant term computed from the sample and equal to $\overline{Y} - \Sigma(\beta_i \overline{X}_{ij})$;

β_i = the standard partial regression coefficient of Y on X_i, which is an expression of the weight given to X_i;
γ_i = the standard partial regression coefficients of Y on X_i^2, which is an expression of the weight given to X_i^2;
δ_i = the standard partial regression coefficient of Y on X_i^3, which is an expression of the weight given to X_i^3; and
u_j = the random component. The jth variable may be expressed as either $\beta_i X_i$; $\beta_i X_i + \gamma_i X_i^2$; or $\beta_i X_i + \gamma_i X_i^2 + \delta_i X_i^3$ dependent upon the relationship of the variable to net income. Variation in net income was explained by the function $\sigma y^2 = \sigma R^2 + \sigma u^2$, where σy^2 was the variance of Y, σR^2 was the variance of Y explained by the regression, and σu^2 is the variance of Y unexplained by the regression. $S^2 y.x$ was the estimate of $\sigma^2 u$ and $S^2 y$ was the estimate of σy^2. Therefore, $R^2 = \frac{Sy^2 - S^2 y.x}{S_y{}^2} = 1 - \frac{S_y{}^2 .x}{S^2{}_y}$.

Where variables approach independence, a prediction equation may be most efficiently developed by first including the entire list of studied variables and then singularly removing variables. The equations can then be tested at a predetermined level of probability to determine if there was a significantly greater amount of variation explained when the variable was included. By such a process of removal and test, a prediction equation may be developed

which contains only those variables which offer a definite contribution.

The farm management factors used in this study did not lend themselves to such a treatment. A continuum of correlations among farm management factors was to be expected. This continuum could be expected to extend in descending order from those factors which were measures of the same output, through those which indirectly measured the same characteristic, to those factors which, while they were not directly related, followed similar courses and finally to factors which did approach independence.

In arriving at the final prediction equation, the farm management factors were first divided into groups which measured size, crop efficiency, livestock efficiency, labor efficiency, costs, organization and intensity. The groups were then studied on an individual basis. Factors were studied so as to determine the correlations between farm management factors as well as between the management factors and net income. Classification reduced the number of variables studied at any one time and allowed greater comprehension of the relationships between management factors.

Due to the possible relationships between groups, more than one set of variables were accepted from groups containing numerous management factors. It was felt that

the relative value of a factor within a group might be substantially different from the relative value of the same factor in the presence of management factors from other groups. If such correlations existed, the farm management factors accepted for the final prediction equation might not be those which explained the most variation in net income when studied within groups.

The sets of farm management factors contributed by the groups were combined in all possible combinations, and the prediction equation accepted was the one which explained the greatest amount of variation in net income. The coefficient of determination (R^2) was used as the measure of the variation in net income which had been explained, and the equation selected was the one which exhibited the largest coefficient of determination. Farm management factors included in the prediction equation were removed one at a time and the coefficient of determination was determined using the remaining variables. The hypothesis that the values of R^2 for the two equations were equal was tested. Acceptance of the hypothesis was rejection of an increase in the explained variation in net income and the consequent deletion of the management factor from the prediction equation.

A study of the effect of breed was carried out. Farm record years were sorted into two breed groups, Holstein and Jersey-Guernsey, and the coefficient of determination was computed using the determined prediction equation.

RESULTS AND DISCUSSION

The farm management factors which were measures of size had a higher degree of correlation to net income than did any of the other management factors. Correlation coefficients along with other pertinent characteristics concerning the management factors are presented in Tables 4, 5, and 6. Economic theory states that as size increases beyond a certain magnitude diseconomies of scale will result in income increasing at a decreasing rate. Decreasing returns to scale were exhibited as cow numbers increased. Acceptance of the second degree curve resulted in predicted incomes for 50, 100, and 200 cow herds which were respectively \$487 above, \$723 and \$11,877 below that which would be expected under constant returns to scale. It should be pointed out, however, that although the range in cow numbers reported in the study extended to 216 cows, the number of farm record years reporting more than 100 cows was limited, and that the meaning of the regression line at this level should be seriously questioned.

The relationships of the remaining measures of size to net income was best explained by linear functions. It is possible that none, or an insignificant percent, of the farms studied were large enough to exhibit diseconomies to scale. It is suggested, however, that the number of tillable acres and number of men are not sufficient in themselves as measures of size, but rather that they can be expected to be of greater value when in combination with other management factors. Total investment is both a measure of size and quality of inputs in that soil and cows of high inherent ability are valued higher than those of lesser ability. This feature of the factor does not lessen its value in a prediction equation, but it does reduce its usefulness in a consideration of the effect of size on income.

The relationships of crop efficiency factors to net income are shown in Table 4 and are represented by the variables X_6 through X_{12}. The theoretical treatment of an output as represented by crop yields leads to the expectation that the crop production per acre would follow the curve outlined by the law of diminishing returns, and consequently that the total value of crop would likewise eventually reach a maximum and decrease. Crop yield index had such an effect on income just as did the sole factor representing a crop input, fertilizer and lime expense per tillable acre. Crop value per tillable acre, crop acre value, soil value rating, and percent cash crops exhibited a curvilinear relationship which increased at a decreasing rate when correlated with net income. The relationship between percent tillable acres idle and net income was linear.

Table 4

Relationships of Farm Management Factors to Net Income.
Michigan Dairy Farms, 1041 Farm Record Years, 1958-1962.
a. Measures of Size, Crop Efficiency, Machinery Cost, and Organization

	Farm Management Factors	Relationship to Net Income	Means of Factors	Standard Deviations	Coefficients of Determination	Multiple Correlation Coefficients	Standard Error of Estimate
X_1	Net Income		\$8,174	\$5,122			
X_2	Total Investment	Linear	\$84,456	\$46,961	.3822[a]	.6182	\$4,028
X_3	Number of Cows	Curvilinear	38.7	18.8	.4347[a]	.6593	3,855
X_4	Tillable Acres	Linear	213	96	.2857[a]	.5345	4,331
X_5	Number of Men	Linear	1.9	0.7	.2687[a]	.5184	4,383
X_6	Crop Value/T.A.	Curvilinear	\$53.79	\$15.42	.1983[a]	.4453	4,591
X_7	Crop Yield Index	Curvilinear*	98.6	21.0	.1416[a]	.3763	4,752
X_8	Crop Acre Value	Curvilinear	\$56.68	\$8.64	.0726[a]	.2695	4,937
X_9	Soil Value Rating	Curvilinear	\$151	\$53	.0879[a]	.2965	4,897
X_{10}	Fertilizer Cost/T.A.	Curvilinear*	\$6.26	\$3.50	.0414[a]	.2034	5,022
X_{11}	% Tillable Acres Idle	Linear	3.3	6.1	.0261[a]	.1616[b]	5,057
X_{12}	% Cash Crops	Curvilinear*	15.6	13.6	.0520[a]	.2280	4,995
X_{13}	Machinery Cost/T.A.	Curvilinear	\$22.54	\$7.36	.0061	.0783	5,112
X_{14}	% Lvst. Income from Dairy	Linear	97.3	5.5	.0003	.0160[b]	5,124
X_{15}	% Rented Land	Curvilinear	17.3	23.6	.0224	.1498	5,070
X_{16}	Number T.A./Cow	Linear	5.8	1.9	.0322[a]	.1794[b]	5,042

*The function which explains the most variation for the curvilinear factors designated by the asterisk is of the general form $Y = a + bX + cX^2 + dX^3$. Factors listed as curvilinear without the asterisk are characterized by the general formula $Y = a + bX + cX^2$. The general formula for linear regression is $Y = a + bX$.

[a]Significant at the .01 level of probability.

[b]The function computed exhibited a negative slope.

Table 5

Relationships of Farm Management Factors to Net Income.
Michigan Dairy Farms, 1041 Farm Record Years, 1958-1962.
b. Measures of Labor Efficiency and Livestock Efficiency.

	Farm Management Factors	Relationship to Net Income	Means of Factors	Standard Deviations	Coefficients of Determination	Multiple Correlation Coefficients	Standard Error of Estimate
X_{17}	Number Cows/Man	Linear	20.2	5.9	.1449[a]	.3807	4,739
X_{18}	Milk Sold/Man (lbs.)	Linear	216,822	71,087	.2418[a]	.4917	4,462
X_{19}	4% FCM Sold/Man (lbs.)	Linear	209,758	65,238	.2545[a]	.5044	4,425
X_{20}	Dairy Sales/Cow	Linear	$428	$65	.1588[a]	.3984	4,700
X_{21}	Milk Sold/Cow (lbs.)	Linear	10,666	1,735	.0911[a]	.3018	4,886
X_{22}	Milk Produced/Cow (lbs.)	Linear	11,345	1,790	.0664[a]	.2576	4,952
X_{23}	4% FCM Sold/Cow (lbs.)	Linear	10,323	1,415	.1019[a]	.3197	4,857
X_{24}	4% FCM Produced/Cow (lbs.)	Linear	10,980	1,431	.0732[a]	.2706	4,934
X_{25}	Milk Fat/Cow (lbs.)	Linear	429	54	.0627[a]	.2503	4,962
X_{26}	Milk Price/CWT	Curvilinear	$4.05	$0.43	.0429[a]	.2072	5,016
X_{27}	4% FCM Price/CWT	Linear	$4.16	$0.31	.0613[a]	.2476	4,965
X_{28}	Improvements/Cow	Curvilinear	$425	$212	.0075	.0869	5,107
X_{29}	Replacement:Cow Ratio	Linear	0.93	0.29	.0018	.0419	5,120
X_{30}	% Base Milk	Curvilinear	42.2	4.4	.0528[a]	.2299	4,990
X_{31}	Cattle Income/Cow	Curvilinear	$82.36	$45.65	.0433[a]	.2031	5,015
X_{32}	Lvst. Income/$100 Feed	Curvilinear	$183.97	$41.32	.0776[a]	.2785	4,924
X_{33}	Feed Cost/Cow	Curvilinear	$220	$72	.0132	.1149[b]	5,093

[a] Significant at the .01 level of probability.
[b] The function computed had a negative slope.

Table 6

Relationships of Farm Management Factors to Net Income.
Michigan Dairy Farms, 814 Farm Record Years, 1958-1962.
c. Measures of Feed Inputs and Percent Cows in Milk.

Farm Management Factors	Relationship to Net Income	Means of Factors	Standard Deviations	Coefficients of Determination	Multiple Correlation Coefficients	Standard Error of Estimate
X_{34} Average Feed Cost	Linear	$171.51	$36.52	.0230[a]	.1517	5,253
X_{35} % Cows in Milk	Linear	86.4	2.7	.0141[a]	.1189	5,277
X_{36} Days on Pasture	Curvilinear*	131.5	52.2	.0542[a]	.2329[b]	5,175
X_{37} Grain/Cow (lbs.)	Linear	3,443	896	.0309[a]	.1758	5,232
X_{38} Hay Equivalent/Cow/Day (lbs.)	Curvilinear	30.7	5.2	.0128	.1130	5,284
X_{39} TDN/Cow/Day (lbs.)	Curvilinear	23.0	3.4	.0392[a]	.1980	5,212

*The function which explains the most variation for the curvilinear factors designated by the asterisk is of the general form $Y = a + bX + cX^2 + dX^3$. Factors listed as curvilinear without the asterisk are characterized by the general formula $Y = a + bX + cX^2$. The general formula for linear regression is $Y = a + bX$.

[a] Significant at the .01 level of probability.

[b] The function computed had a negative slope.

Cropping factors failed to have the degree of correlation or to decrease the standard error of estimate to the extent exhibited by size factors. The contribution of several of these was meaningful, however, and indicated a definite relationship between cropping system and income.

As shown in Table 5, all management factors measuring the production of dairy products on a per cow basis as well as the dollar returns for the sale of these products were linear. Any decrease in the quantity of milk produced per unit of input with increasing levels of production was not reflected in the correlation of dairy output factors to net income. The relationship between the price of milk and net income was such that net income increased at a decreasing rate as price increased. This curvilinearity can be contributed to the relationship between fat test and price, which in turn can be substantiated by the linear relationship between price and net income when price was calculated on a constant fat basis. The association between the high fat test and the corresponding lower level of milk production was further borne out by a tabulation according to breed. A total of 909 farm record years for Holstein herds had an average fat test of 3.66%, produced 11,769 pounds of milk per cow, and received an average net income of $8,408. The total for 132 farm record years for Jersey herds showed an average test of 5.00% with 8,374 pounds of milk per cow and was accompanied by a net income of $6,562. This difference of $1,870 in net income was responsible for the greater part of the curvilinearity observed when milk price was correlated with net income.

The livestock efficiency factors which were measures of feed consumption are listed on Tables 5 and 6. Feed cost per cow was a factor calculated from farm account records and the coefficient of determination of .0132 indicates that the factor had no value in this study. The method of computation accounted for the meaningless results. Average feed cost, grain, hay, and TDN per cow were all measures of feed input. These measures all had low correlation coefficients, as was to be expected, as in reality they were secondary factors--secondary in the sense that they were factors which influenced milk production which in turn influenced net income.

The farm management factors measuring labor efficiency were second only to size factors in their degree of correlation to net income. The higher correlation for the two measures of milk sold per man over cows per man was not unexpected and reflected the effect of level of production as well as the efficiency involved in handling cow numbers.

Those management factors designed to measure organization or intensity showed surprisingly little correlation to net income. Improvements per cow, replacement to cow ratio, machinery cost per tillable acre, percent livestock income from dairy and percent rented land all lacked significance at ($P < 0.01$).

The farm management factors total investment, number of cow, number of tillable acres, and number of men were all measures of size of the farm operation. It can generally be stated that increased herd size demanded increased acreage to furnish a larger quantity of feed and an increased number of men to handle the larger herd and farm. As number of cows and/or acres increased total investment was also required to increase since the two factors, cows and acres, were a part of the computation of investment. The coefficients of determination computed when two or more of the measures of size were jointly correlated with net income demonstrated, however, that the relationship was not constant. The addition of total investment to number of cows increased R^2 from .4347 to .4580 while the addition of tillable acres to number of cows increased R^2 to .4445. When tested to determine if the added variable explained a greater amount of variation both total investment and tillable acres were significant at the .01 level of probability. The number of men did not significantly ($P < .01$) increase R^2 over that for number of cows alone, nor was the addition of number of tillable acres to a function utilizing number of cows and total investment significant ($P < .01$).

The functions accepted as measures of size were as follows: $Y = f(X_2, X_3, X_3^2)$ and $Y = f(X_3, X_3^2, X_4)$, where Y = net income; X_2 = total investment; $X_3 X_3^2$ = number of cows; and X_4 = number of tillable acres. The combination of cows and acres had a lower coefficient of determination than did the combination of cows and investment, however, it was retained to study its value when combined with factors representing other characteristics of the farm operation.

Crop value per tillable acre was arrived at through the multiplication of price and crop output, followed with division by the total tillable acres. Consequently, the factor was primarily a product of yields and values with consideration indirectly being given to the degree of utilization of land. The aspect of land utilization entered into crop value per tillable acre as a result of idle land being included as a part of total tillable acres. It followed that crop value per tillable acre might be considered in the role of a primary factor in the explanation of variation in net income as a result of cropping practices and crop yield index, crop acre value and percent tillable acres idle serving as secondary factors. It was felt that if crop value per tillable acre was used in predicting net income that the three secondary factors could not logically be included. This logic was extended to include soil value rating and fertilizer and lime expense per tillable acre which were considered to be tertiary factors in the explanation of variation in net income and primary in the explanation of variation in crop yield index. The concept, as stated, was tested by correlating the secondary and tertiary factors with crop value per tillable acre in such a manner as to receive a coefficient of determination after the addition of each factor. The function studied was as follows: $X_6 = f(X_7, X_7^2, X_7^3; X_8, X_8^2, X_8^3; X_{11}; X_{10}; X_9, X_9^2)$, where X_6 = crop value per tillable acre; X_7, X_7^2, X_7^3 = crop yield index; X_8, X_8^2, X_8^3 = crop acre value; X_{11} = percent tillable acres idle; X_{10} = fertilizer and lime expense per tillable acre; and X_9, X_9^2 = soil value rating. Prior to studying the above relationships the degree of curvilinearity was determined for the factors when singularly correlated with crop value per tillable acre. The curvilinearity established was that shown in the preceeding function, where both crop yield index and crop acre value were best explained by a third order curve; soil value rating by the quadratic; and percent tillable acres idle and fertilizer expense with a linear function.

The coefficient of determination was .6264 when crop value per tillable acre was correlated with crop yield index. With the addition of crop acre value, percent tillable acres idle, fertilizer and lime expense per tillable acre, and soil value rating the coefficient was raised to .8808, .9251, .9258, and .9285, respectively. Each of the five factors was significant at the .01 level of probability. The high percentage of explained variation in crop value per tillable acre bears out the concept of crop yield index, crop acre value and percent tillable acres idle as secondary factors. The acceptance of this concept logically leads to the examination of net income with either crop value per tillable acre or a combination of crop yield index, crop acre value, and percent tillable acres idle. An attempt to increase the variation explained in net income by adding the secondary crop variables confirmed this, as none of the three were able to significantly ($P < .01$) raise the coefficient of determination. Fertilizer and lime expense per tillable acre was of no value in increasing R^2 when added to either the primary crop factor or to the secondary factors. Soil value rating failed to follow the format set down for secondary or tertiary crop factors and was of significant ($P < .01$) value in explaining variation in net income when added to either crop value per tillable acre or to the combination of secondary factors measuring yield, value, and land utilization. The value of the factor extended beyond that of a simple measure of soil productivity.

The following measures of crop efficiency were accepted for future study: $Y = f(X_6, X_6^2; X_9, X_9^2; X_{12}, X_{12}^2, X_{12}^3)$ and $Y = f(X_7, X_7^2, X_7^3; X_8, X_8^2; X_{11}; X_9, X_9^2; X_{12}, X_{12}^2, X_{12}^3)$, where Y = net income; X_6, X_6^2 = crop value per tillable acre; X_7, X_7^2, X_7^3 = crop yield index; X_8, X_8^2 = crop acre value; X_9, X_9^2 = soil value rating; X_{11} = percent tillable acres idle; and $X_{12}, X_{12}^2, X_{12}^3$ = percent cash crops. The coefficient of determination for the function utilizing crop value per tillable acre was .2088 while R^2 for the function utilizing the three secondary functions was .2058. The two functions were considered to be of essentially equal value in the explanation of variation in net income.

The duplication of measures of milk production and milk price coupled with the existence of primary, secondary, and tertiary livestock efficiency factors resulted in the existence of a multiplicity of possible management factor combinations with which to measure the livestock enterprise. Dairy sales per cow served the role of a primary factor with milk per cow, fat per cow, and price of milk serving to explain variation in dairy sales. The concept of dairy sales as a primary factor was substantiated by the inability of any of the milk output or milk price factors to significantly ($P < .01$) increase the explained variation in net income over that explained by dairy sales per cow.

Measures of milk output per cow and milk price were converted to a 4% FCM basis under the assumption that breed differences might have less effect on the factors when studied on a constant fat basis. The singular correlation of factors showed higher coefficients for factors converted to a constant fat basis. Coefficients of determination for 4% FCM sold per cow, 4% FCM produced per cow, and 4% FCM price per cwt were .1019, .0732, and .0613, respectively. The respective R^2 values for milk sold per cow, milk produced per cow, and milk price per cwt were .0911, .0664, and .0429. When a 4% FCM output factor and the 4% FCM price factor were jointly correlated with net income, however, the advantage of the constant fat factors in explaining variations in net income was lost.

The effects of correlating five alternative sets of measures of livestock efficiency with net income are shown in Table 7. In each set the increased explanation of variation in net income due to the addition of dairy cattle income per cow or livestock income per $100 feed expense was significant ($P < .01$). The farm management factors of replacement stock to cow ratio and improvements per cow did not significantly ($P < .01$) increase the explained variation in net income. Feed cost per cow as derived from the Mail-In Accounts, while not shown on Table 7, failed to have a significant ($P < .01$) effect on R^2.

Table 7

Coefficients of Determination (R^2) as Various Livestock Efficiency Factors[1] are Added to Dairy Outputs in a Correlation with Net Income.

	Dairy Sales /Cow .1588[2]	Milk Sold /Cow .0911	Milk Produced /Cow .0664	4% FCM Sold /Cow .1019	4% FCM Produced /Cow .0732
Milk Price/CWT	-----	.1601	.1170	-----	-----
4% FCM Price/CWT	-----	-----	-----	.1623	.1260
Percent Base Milk	.1738	.1782	.1398	.1785	.1464
Cattle Income/Cow	.1361	.1933	.1577	.1915	.1635
Lvst. Income/$100 Feed	.2159	.2248	.1918	.2215	.1974
Replacements:Cow Ratio	.2181	.2270	.1941	.2241	.1999
Improvements/Cow	.2146	.2278	.1946	.2249	.2004

[1]All factors, with the exception of replacement stock to cow ratio and improvements per cow, were significant at the .01 level of probability.

[2]Values listed directly below the dairy output factors are the coefficients of determination between the individual output factors and net income.

Milk fat per cow was significant ($P < .01$) in its effect on net income when added directly to milk output, however, if the effect of milk price was also considered milk fat per cow was no longer of significant ($P < .01$) value in the explanation of variation in net income. Increasing levels of fat production appeared to be accurately accounted for through milk price.

The sets of factors measuring livestock efficiency which were carried forward for further study differed only in the measure of dairy output and were as follows: $Y = f(X_{20}; X_{30}, X_{30}^2; X_{31}, X_{31}^2; X_{32}, X_{32}^2)$, $Y = f(X_{21}; X_{26}, X_{26}^2; X_{30}, X_{30}^2; X_{31}, X_{31}^2; X_{32}, X_{32}^2)$, and $Y = f(X_{21}; X_{25}; X_{26}, X_{26}^2; X_{30}, X_{30}^2; X_{31}, X_{31}^2; X_{32}, X_{32}^2)$, where Y = net income; X_{20} = dairy sales per cow, X_{21} = milk sold per cow; X_{25} = milk fat per cow; X_{26}, X_{26}^2 = milk price per cwt; X_{30}, X_{30}^2 = percent base milk; X_{31}, X_{31}^2 = dairy cattle income per cow; and X_{32}, X_{32}^2 = livestock income per $100 feed expense. The management factors 4% FCM sold per cow and 4% FCM price were not carried forward since they failed to show any advantage over the conventional methods of measuring milk and price, and at the same time represented factors which ordinarily were not readily at hand.

The source of data for the feed efficiency factors was restricted to the 814 farm record years in which D.H.I.A. records were utilized. It was felt that feed factors acted in the role of primary factors in explaining variations in milk production, but as tertiary factors in the explanation of net income. The concept was studied that feed consumption and percent cows in milk effected net income as a consequence of their influence on milk production. An attempt was first made to explain variations in milk production per cow resulting from the various feed factors and percent cows in milk by means of the following function: $X_{24} = f(X_{37}, X_{37}^2; X_{38}, X_{38}^2, X_{35}, X_{36})$, where X_{24} = milk production per cow; X_{37}, X_{37}^2 = grain per cow; and X_{36} = days on pasture. The function was solved in such a manner that an R^2 value was computed with the addition of each management factor. Grain per cow explained 20.37 percent of the variation in milk production per cow. The addition of hay equivalent per cow per day raised the value of R^2 to .3155. Percent cows in milk and days on pasture increased the coefficients of determination to .3347 and .3350, respectively.

The farm management factors used in studying variations in milk output were singularly correlated with milk production per cow so as to establish the proper degree of curvilinearity when used in such a function. Unit increases in percent cows in milk and days on pasture were associated with constant increases in milk production. Unit increases in grain per cow and hay equivalent per cow per day were associated with an output curve for milk which increased at a decreasing rate. The linear function of days on pasture was of little concern since its effect on milk production was not significant ($P < .01$). The relationship of percent cows in milk to milk production was of logical design inasmuch as the relationship was a mathematical one since dry cows were included in the computation of average milk production.

The decreasing rate at which milk production increased with unit increases in feed consumption was of particular concern, since it substantiated the concept of the law of diminishing returns in the production of milk. The second degree curve obtained when grain or roughage intake was correlated with milk production also best explained the relationship of TDN per cow per day or average feed cost. To substantiate the finding on the relationship of feed efficiency factors to milk production, similar correlations were computed using 4% FCM produced as the dependent variable. The degree of curvilinearity was found to be the same for milk produced per cow and 4% FCM produced per cow. The sample was sorted according to breed to further examine the relationship between feed and milk output. A total of 703 Holstein herds and 111 Jersey-Guernsey herds were treated in the same manner as when previously combined. The second degree curve was found to best explain the variations in milk production resulting from feed consumption in the case of both Holstein and Jersey-Guernsey herds. The R^2 values arrived at when milk production was correlated with grain, roughage, percent cows in milk, and days on pasture were .2453 and .5533 for the Holstein and Jersey-Guernsey herds, respectively. Data from this study indicate that when dairy animals were considered on a herd basis increasing quantities of feed resulted in increasingly smaller outputs of milk per unit of feed. It is suggested by the author that if feed quantities had continued to increase a maximum in milk production would have been reached.

Several other farm management factors were correlated with milk production in an attempt to increase the explained variation in the dependent variable. Improvements per cow, number of cows, and crop yield index significantly raised the value of R^2 over that resulting from grain per cow, hay equivalent per cow per day, percent cows in milk, and days on pasture. The value of R^2 was raised from .3350 to .3903. Improvements per cow were measures of housing and improvement expenditures and indicated that physical facilities did have some effect on the level of milk production. The regression coefficient (b) for number of cows was negative and indicated a small but definite decrease in the level of milk production as herd size increased. Crop yield index was included as a test to determine if the concept that managers who are associated with high milk production from the dairy herd are also associated with high crop yields. The factor was not considered as having a causative effect on milk production. The number of cows per man did not have a significant effect on milk production per cow.

The influence of the feed efficiency factors and percent cows in milk on net income was examined. When added on to the previously accepted livestock factors and correlated with net income only days on pasture was significant ($P < .01$) in increasing the explained variation in net income. Grain per cow, hay equivalent per cow per day, TDN per cow per day, average feed cost, and percent cows in milk all followed the format set forth for tertiary factors. Each was of value in explaining milk output, but any influence they might have had on net income had previously been included in the computations when milk sold per cow was added. Days on pasture failed to follow the format for tertiary factors. The factor was of no value in explaining variations in milk production, but was of significant ($P < .01$) value in the explanation of variation in net income. This set of circumstances indicated that days on pasture was not a feed efficiency factor as previously had been supposed but an organizational factor.

Milk sold per man was accepted as the measure of labor efficiency over cows per man on the basis of the simple correlation coefficients, .4917 and .3979, respectively. The labor efficiency factor 4% FCM was considered as a companion to 4% FCM sold per cow and 4% FCM price and was excluded along with these two factors. Machinery expense per tillable acre, percent rented land, and number of tillable acres per cow were added to the list of factors studied for the final prediction equation as measures of cost and intensity.

All sets of farm management factors from within the groups of size, crop efficiency, livestock efficiency, labor efficiency, costs, organization, and intensity were combined in all possible combinations to produce 12 prediction equations. The largest coefficient of determination for any of the 12 equations was .7531 and was computed from the following equation: $Y = f(X_3, X_3^2; X_4; X_6, X_6^2; X_9, X_9^2; X_{12}, X_{12}^2, X_{12}^3; X_{13}, X_{13}^2; X_{15}, X_{15}^2; X_{16}; X_{18}; X_{21}; X_{26}, X_{26}^2; X_{30}, X_{30}^2; X_{31}, X_{31}^2; X_{32}, X_{32}^2)$. Size of farming operation was represented by number of cows (X_3, X_3^2) and number of tillable acres (X_4). Crop efficiency factors were best represented by crop value per tillable acre (X_6, X_6^2), soil value rating (X_9, X_9^2), and percent cash crops ($X_{12}, X_{12}^2, X_{12}^3$). Machinery expense per tillable acre (X_{13}, X_{13}^2) entered the equation as a measure of cost, and percent rented land (X_{15}, X_{15}^2) as an organizational factor. Intensity of operation was measured by number of tillable acres per cow (X_{16}) and labor efficiency by milk sold per man (X_{18}). The equation included 5 livestock efficiency factors; milk sold per cow (X_{21}), milk price per cwt (X_{26}, X_{26}^2), percent base milk (X_{30}, X_{30}^2), dairy cattle income per cow (X_{31}, X_{31}^2), and livestock income per $100 feed expense ($X_{32}, X_{32}^2$). Each factor was then singularly deleted and the function calculated without the effects of the deleted factor. The difference in the R^2 values was tested for equality.

Soil value rating, milk price per cwt, and percent base milk were significant at the .05 level of probability. All other factors were significant at the .01 level of probability.

Computation of the R^2 value with days on pasture included for the 814 herds utilizing D.H.I.A. records failed to show a significant ($P < .05$) difference in the explained variation in net income.

Several methods have been traditionally utilized in analyzing the results furnished through the use of multiple correlation procedures. A method often considered has been observation of the accumulative value of the coefficients of determination. As shown in Table 8, the value of R^2 was .4347 when number of cows was the only farm management factor correlated with net income. The value moved to .4445 when number of tillable acres was included, to .4946 with crop value per tillable acre, and finally up to the value of .7531 when all factors were considered. This method was of considerable value in the determination of significance for the individual factors, but proved to be of doubtful value for specifying the contribution of each factor when all 14 of the accepted management factors were simultaneously considered. The implications of the method were that number of cows explained 45.80% of the variation in net income in proportion

to the extent that R^2 increased. If this premise were accepted, it would mean that number of cows explained 45.80% of the variation in net income, tillable acres explained 0.98%, crop value per acre explained 5.01% of the variation, and so forth, as the 14 factors were added. This was not the case. Number of cows when singularly correlated with net income also reflected the many other management factors correlated with herd size.

Partial correlation coefficients have often been used to point out the relative importance of independent variables. As illustrated in Table 9, the partials were of little value in curvilinear regression as it was extremely difficult to comprehend the exact effect of a given factor when either two or three coefficients, usually with opposing signs, were listed.

A third method often utilized has been to singularly delete variables and determine the coefficient of determination in the absence of the variable. In this method the difference between R^2 with all variables included and R^2 with a variable deleted would then be considered to be the effect of the deleted variable. The deficiency of the method was centered around the assumption that a given variable explains only the variation remaining after all possible variation has been credited to the other variables in the equation. This would be true only in the case where the deleted variable was completely independent. The summation of the variation accounted for by the individual factors readily pointed out the shortcoming of the method since only a fraction (approximately 1/3) of the variation was accounted for.

To overcome the shortcoming inherent in the three methods discussed above, the direct and indirect effect of farm management factors were computed. For a linear function, the variation in net income accounted for by the factor was the square of the beta weights or standard partials. In the case of the second degree curve, the coefficient was computed as follows: Direct and indirect effect of X_i on $Y = \beta^2 X_i + \beta^2 X_i^2 + 2(\beta X_i \beta X_i^2 r X_i X_i^2)$ where $\beta^2 X_i$ and $\beta^2 X_i^2$ were considered to be the direct effects of X_i and X_i^2 on Y, and the covariance (product of the beta weights times the simple correlation coefficient between X and X^2) multiplied by 2 as the indirect effect of the factors through each other on net income (21).

This measure of the relative value of the farm management factors in the explanation of variation in net income proved to be greatly superior to any of the three previous methods discussed. Accuracy of estimation of the relative value of farm management factors was increased over the accuracy of accumulative values of R^2 or over R^2 values arrived at through deletion. This increased accuracy occurred since

Table 8

Measures of the Effectiveness of Various Farm Management Factors in Influencing Net Income
Michigan Dairy Farms, 1041 Farm Record Years, 1958-1962

Farm Management Factor	Accumulative Coefficients of Determination	R^2 Residuals Resulting From Deletion of Factors	Direct and Indirect Effect of Factors
Number of Cows	.4347	.0055	.0382
Tillable Acres	.4445	.0136	.1623
Crop Value/T.A.	.4946	.0605	.1631
Soil Value Rating	.4987	.0018	.0022
Percent Cash Crops	.5052	.0036	.0193
Machinery Cost/T.A.	.5244	.0417	.0857
Percent Rented Land	.5274	.0073	.0081
Tillable Acres/Cow	.5340	.0037	.0316
Milk Sold/Man	.5531	.0011	.0028
Milk Sold/Cow	.5905	.0024	.0059
Milk Price/CWT	.6036	.0014	.0019
Percent Base Milk	.6091	.0017	.0018
Cattle Income/Cow	.6592	.0145	.0194
Lvst. Income/$100 Feed	.7531	.0938	.1819

Table 9

Statistics Derived from the Prediction Equation of Net Income Using Farm Management Factors as Variables
Michigan Dairy Farms, 1041 Farm Record Years, 1958-1962

Farm Management Factors		Regression Coefficients (b)	Partial Correlation Coefficients	R^2 Deletes
Y axis intercept	(a)	-37,353.8583		
Number of Cows	X_3	45.2873	.0588	.7522
	X_3^2	.0664	.0193	.7530
Tillable Acres	X_4	21.4702	.2282	.7395
Crop Value/T.A.	X_6	154.7885	.1550	.7470
	X_6^2	-.1835	-.0225	.7529
Soil Value Rating	X_9	4.2666	.0179	.7530
	X_9^2	-.0279	-.0371	.7527
Percent Cash Crops	X_{12}	34.0524	.0308	.7528
	X_{12}^2	-1.2107	-.0226	.7529
	X_{12}^3	.0013	.0019	.7531
Machinery Cost/T.A.	X_{13}	-306.9900	-.1774	.7451
	X_{13}^2	1.9873	.0659	.7520
Percent Rented Land	X_{15}	46.7623	.1608	.7465
	X_{15}^2	-.5674	-.1682	.7459
Tillable Acres/Cow	X_{16}	-431.6366	-.1217	.7494
Milk Sold/Man	X_{18}	.0038	.0670	.7520
Milk Sold/Cow	X_{21}	.2269	.0963	.7508
Milk Price/CWT	X_{26}	4,502.6821	.0651	.7520
	X_{26}^2	-566.9532	-.0688	.7519
Percent Base Milk	X_{30}	558.1479	.0763	.7516
	X_{30}^2	-6.3899	-.0737	.7517
Cattle Income/Cow	X_{31}	18.5315	.1244	.7492
	X_{31}^2	-.0127	-.0230	.7529
Lvst. Inc/$100 Feed	X_{32}	100.5786	.2312	.7391
	X_{32}^2	-.1248	-.1192	.7495

both measures of R^2 discussed are computed from incomplete equations which do not satisfy the specifications of the model or specifications for selection of farm management factors. Computation of direct and indirect effects of management factors on net income placed a single value in each factor which was comparable for both linear and curvilinear functions. The single value for each factor allowed greater ease of comprehension over the multiple values of curvilinear functions when partial regression coefficients were utilized.

Observation of the direct and indirect effects of individual farm management factors on net income, as shown in Table 8, revealed values of .1819, .1631, .1623, and .0857 for livestock income per $100 feed expense, crop value per tillable acre, number of tillable acres, and machinery expense per tillable acre, respectively. These four management factors accounted for 82% of the explained effect of the factors on net income. The relative weights given to the individual factors shifted substantially when considered in the presence of 13 other variables as compared to those reported by singular correlation or by multiple correlation within farm characteristic groups. The shift in the effect of the farm management factors on net income as well as the difference in the relative importance in the factors must be attributed to the high correlation existing between the farm management factors.

The results clearly demonstrated the dangers inherent in a study placing major emphasis on a tabular analysis sorted on one factor or on simple correlations. A case in example of this was machinery expense per tillable acre which was not significant ($P < .01$) when singularly correlated with net income, yet which had a major effect on the final prediction equation. It should be understood, however, that the multiple correlation of 14 factors on net income would not have been possible in its present form without the development of a model and a statement of specifications for the management factors that were to be included. The fulfillment of these specifications required singular correlation as a test of linearity and the statistical and logical consideration of factors in enterprise groups.

The results indicate that a possible improvement in the method of analysis would have been to alter the specifications for management factors to be included. It was demonstrated that it was possible for a factor which was not significant when singularly correlated with net income to become of major importance in the multiple correlation. Therefore, exclusion of factors might well be made from an equation including all management factors exclusive of those measuring the same characteristic. The method would then be one where the degree of curvilinearity is established by singular correlation of factors with net income. The exclusion of duplicate measures of the same characteristic by acceptance of the factor with the highest R^2 value when singularly correlated with net income would follow. Lastly, the combining of all remaining farm management factors into a multiple correlation function. A test of significance for each factor could then determine whether it was to remain in the prediction equation.

The size factors, number of cows and tillable acres, accounted for 28 percent of the explained effect on net income. The major effect of size was credited to number of tillable acres. The cause for this relationship is not clear since the simple correlation between number of cows and number of tillable acres was .7988. The farms used in this study were ones producing the major portion of their feed. It follows that increased herd sizes would reflect increased acreage. Due to the restriction placed on the selection of the sample to those with 70 percent or more of their income from dairy, it follows that increased acreage reflected increased herd size.

Crop efficiency factors in accounting for 25 percent of the explained effect on net income followed the pattern set for it by earlier correlations. Machinery expense per tillable acre explained 12 percent of total direct and indirect effect of management factors on net income. This total was higher than that indicated when the factor was singularly correlated with net income. Percent rented land was of an insignificant value as was milk sold per man. The small weight given to milk sold per man does not follow the popular conception of the value of the management factor, nor does it reflect the importance placed on it by the simple correlation coefficient. Intensity of operation was shown to be relatively important in that number of tillable acres per cow had a value of .0316 for the computed direct and indirect effects on net income.

Livestock efficiency factors accounted for 29 percent of the explained effect of the factors on net income. Livestock income per $100 feed expense was credited with 86 percent of this effect. A consideration of the make up of livestock income per $100 feed expense showed it to be a primary livestock factor. The factor was composed of milk and egg sales plus or minus the change in livestock income and was divided by feed costs which represent over 50 percent of the costs of producing milk. The full effect of level of milk per cow, dairy cattle income per cow, and milk price per cwt are all effectively masked by livestock income per $100 feed expense. The simple correlation coefficient of .2704 failed to reflect the full weight of the factor in explaining variations in net income.

The farm record years were classified according to breed. The 909 Holsteins and the 132 Jersey-Guernsey herds were utilized in multiple correlations using the 14 farm management factors previously selected. The coefficients of determination were .7749 and .6784 for the Holstein and Jersey-Guernsey groups, respectively. A further indication of the increased accuracy resulting from the selected management factors for the Holstein herds over the Jersey-Guernsey herds was the relationship between average net income and the standard error of estimate. Average net income for the Holstein herds was $8,408 and the standard error was $2,491. For the Jersey-Guernsey herds the average net income was $6,562 with a standard error of $2,785. The direct and indirect effects of the farm management factors on net income are shown in Table 10. Observation of these values readily pointed out that they are valid only within the individual multiple correlation and could not be used as absolute terms to make comparisons between separate multiple correlations. It was possible, however, to convert the values to percentage figures and discuss them as a percent of the total direct and indirect effect on net income.

Holstein herds were typical of the entire sample. Jersey-Guernsey herds, however, differed to the extent that both size and crop efficiency factors were responsible

Table 10

Direct and Indirect Effects of Selected Farm Management Factors on Net Income when Herds were Classified by Breed. Michigan Dairy Farms, 1958-1962.

Farm Management Factors	Direct and Indirect Effect of Management Factors: Holstein Herds[1]	Jersey and/or Guernsey Herds[2]
Number of Cows	.0617	.0955
Tillable Acres	.1431	.3104
Crop Value/T.A.	.1737	.2463
Soil Value Rating	.0015	.0402
Percent Cash Crops	.0037	.1172
Machinery Cost/T.A.	.0928	.0454
Percent Rented Land	.0074	.0173
Tillable Acres/Cow	.0260	.0338
Milk Sold/Man	.0008	.0019
Milk Sold/Cow	.0071	.0000
Milk Price/Cwt	.0001	.0040
Percent Base Milk	.0023	.0019
Cattle Income/Cow	.0178	.0415
Lvst. Income/$100 Feed	.1843	.1423

[1] A total of 909 farm record years.

[2] A total of 132 farm record years.

for 74 percent of the explained direct and indirect effect of the management factors on net income with each explaining 37 percent. Livestock efficiency factors decreased to 17 percent of the total explained effect for the smaller breeds. These values were contrasted to 23 percent, 25 percent, and 29 percent for either the Holstein or for the entire sample. Further analysis of the management factors revealed that the average values for crop value per tillable acre, crop yield index, crop acre value, and fertilizer and lime expense were approximately equal for the two groups. Differences in the characteristics of the groups were reflected primarily in size of operation, dairy sales, and livestock income per $100 feed expense. The Holstein herds averaged 218 acres and 39 cows as contrasted to 179 acres and 36.8 cows for the Jersey-Guernsey group. Dairy sales were $435 and $382 for the Holstein and Jersey-Guernsey groups, respectively. Livestock income per $100 feed expense was $182 for Holstein herds and $198 for Jersey-Guernsey herds. The number of cows handled per man were 20.4 and 17.4 for the Holstein and Jersey-Guernsey herds, respectively.

The differences between the two groups centered around scale of operation. The Holstein herds had more producing units coupled with greater sales per cow. It would seem that for the two groups to be comparable the Jersey-Guernsey operations must be increased in scale and at the same time handle a greater number of animals per man and per acre to compensate for the increased sales per cow for the larger animals.

CONCLUSIONS

A definite relationship existed between management ability as measured by the farm management factors and net income. The management factors, however, were not independent measures of management success. The high degree of correlation between factors coupled with the primacy of factors prohibited a complete ranking of the management factors as to their relative importance.

Simple correlations between the individual management factors and net income appeared to furnish a measure by which factors might be ranked, however, to do so would be a meaningless gesture. The correlations between factors clearly indicated that they were not independent and that to credit the entire increase in net income associated with an increase in a given factor to that factor would be an obvious error. A case example would be where an increase in the number of cows given full credit for the corresponding increase in net income. Intercorrelations between the factors clearly indicated that as number of cows increased the number of tillable acres, total investment, and number of men increased in nearly equal proportions.

The values credited to the different farm management factors in the solution of the multiple correlation function indicated definite shortcomings in the method as a means of ranking those factors. The primacy of management factors accounted for a large portion of the inability to obtain values for management factors which lend themselves to a meaningful ranking. A production factor such as milk production per cow or crop yield index will not greatly contribute to the explained variation in net income when in the same prediction equation with livestock income per tillable acre or crop value per tillable acre. Yet, the secondary factor may be the major cause of variation in the primary factor. The speculation of which is more important crop yield per acre or crop value per acre is hardly fruitful meditation since one is a function of the other.

The results obtained from the prediction equation indicated that for the type of farms studied, namely Michigan dairy farms, three major sources of variation in net income existed. These were size of operation, cropping efficiency and livestock efficiency as measured by number of tillable acres, crop value per tillable acre, and livestock income per $100 feed expense. This was entirely in keeping with logic, since the farms studied, for the most part, utilized the dairy herd as a market for crops produced. The management factor crop value per tillable acre served to sum up the cropping enterprise while livestock income per $100 feed expense was a ratio of product

and cattle sales to that crop value previously measured. The number of tillable acres conveniently served as the important measure of size since income was in essence a multiple of crop value plus the added value returned by putting the crop raised through the dairy animals.

The evidence indicates that farm management factors can and do serve useful functions in the explanation of variations in net income, but that a great deal more consideration should be placed upon the primacy of these factors when used as an aid to farm organization and management. The logical step from the consideration of income variations due to size, cropping enterprise, and livestock enterprise is to an explanation of variation in crop efficiency and/or livestock efficiency. A correlation of three crop factors with crop value per tillable acre accounted for 92.5% of the variation in the factor. The factors were crop yield index, crop acre value, and percent tillable acres idle. In a similar manner dairy product sales, dairy cattle sales, and average feed cost could be expected to account for the major portion of livestock income per $100 feed expense. Movement to the tertiary factors indicated that the measurements of the causes of differences in production were incomplete and the factors considered were unable to explain the major portion of variation in either crop yields or livestock production.

SUMMARY

The effects of various farm management factors on net income were studied. Michigan dairy farms concurrently utilizing Mail-In Farm Account Records and D.H.I.A. or Owner-Sampler records for any year during the period of 1958 through 1962 were used as the source of data. A total of 340 dairy farms representing 1,041 farm record years were included in the study. The farms accepted for the study were those which received 70 percent or more of their income from dairying. All farms utilized were previously classified as having Holstein or Jersey and/or Guernsey cattle. Herds represented by a minor breed or by several breeds were excluded from the study.

A total of 38 farm management factors was selected for the study. Factors considered were grouped into those measuring size, crop efficiency, livestock efficiency, labor efficiency, costs, intensity, and organization. Management factors were singularly correlated with net income as a means of determining their degree of curvilinearity. Farm management factors which were measures of size of farming operation tended to be linear and highly correlated with net income. Measures of crop efficiency were primarily typified by functions which increased at a decreasing rate or those which followed the law of diminishing

returns. Labor efficiency factors were linear. Management factors which were a measure of livestock efficiency varied in their relationship to net income. Those livestock factors that served as a measure of production were linear, while those that were measures of price were curvilinear.

The development of a prediction equation with which to explain the variation in net income that could be attributed to the various farm management factors was based upon a regression model. Selection of the variables to be included in the prediction equation followed from the consideration of management factors within the groups representing different characteristics of the farm enterprise. Management factors representing measure of size of operation which could best explain the variation in net income were either number of cows and total investment or number of cows and number of tillable acres.

Crop efficiency factors accepted because of their superiority in explaining variations in net income were a combination of crop value per tillable acre, soil value rating, and percent cash crops or a combination where crop value was deleted and measures of yields, value, and land utilization substituted.

Machinery expense per tillable acre was included as a cost measure, while percent rented land represented a measure of farm organization. Number of tillable acres per cow and milk sold per man were measures of intensity and labor efficiency, respectively.

Livestock efficiency factors contributed 3 sets of factors for consideration in the final model. These sets centered around the substitution of milk sold per cow, milk price per cwt, percent base milk, and milk fat produced per cow for dairy sales per cow. Dairy cattle income per cow and livestock income per $100 feed expense were included in each of the sets. Values utilizing 4 percent FCM sold or produced per cow failed to improve on the absolute measure of quantity of milk sold when price was included with it. Milk sold was decidedly better than milk produced in explaining variations in net income. The measure of housing and improvement costs per cow and the replacement stock to cow ratio failed to add to the explanation of variation in net income.

Feed factors measuring quantities of grain, roughage, TDN, and average feed cost were unable to explain additional variation in net income when in the presence of milk sold and livestock income per $100 feed expense. In arriving at the appropriate factors to use as a measure of livestock efficiency, the various feed factors were correlated with milk production per cow. As units of feed increased milk production was found to increase at a decreasing rate. This was in accordance with the concept that increased quantities of a variable input in the presence of a fixed input will eventually cause a decrease in the input-output ratio.

The prediction equation accepted was the one with the largest coefficient of determination when all possible combinations of groups were considered. The equation accepted was one which considered net income as a function of number of cows, tillable acres, crop value per tillable acre, soil value rating, percent cash crops, machinery expense per tillable acre, percent rented land, number of tillable acres per cow, milk sold per man, milk sold per cow, milk price per cow, percent base milk, dairy cattle income per cow, and livestock income per $100 feed expense. The coefficient of determination was .7531 with a standard error of estimate of $2,577 when the mean net income was $8,174.

The relative importance of the management factors was presented by a measure of the direct and indirect effect of the individual factors on net income. The computation of the factor was such that effect of a linear function was the square of the beta weight, and the effect of a curvilinear function was equal to the sum of the square of the beta weights plus or minus two times the covariance of a variable and its square.

Size factors accounted for 28 percent of the total direct and indirect effect of the factors on net income. The greater portion of this effect was attributed to number

of tillable acres. Measures of crop efficiency were credited with 25 percent of the total computed effect on net income, with crop value per acre explaining 88 percent of this total and percent cash crops explaining 10 percent. Soil value rating contributed little to the total effect.

Machinery expense per tillable acre proved to be more important than previously indicated when the factor was singularly correlated with net income. This cost factor accounted for 12 percent of the total direct and indirect effect of the management factors on net income. The effect of either percent rented land or milk sold per man was inconsequential when considered in the presence of the other management factors. The number of tillable acres per cow accounted for 4 percent of the total computed effect.

The farm management factors which measure livestock efficiency contributed 29 percent of the total direct and indirect effect of the factors on net income. Livestock income per $100 feed expense was credited with the major portion of this effect. The make-up of this management factor which considers total livestock income and feed expense appeared to have masked the effect of the factors measuring output and price.

The effects of breed of cattle were considered. Holstein herds followed the format of the entire sample, while Jersey and/or Guernsey herds credited larger effects to size and crop efficiency factors and less to livestock efficiency factors.

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APPENDIX

Appendix Table 1

Average Yearly Values for Farm Management Factors
Michigan Dairy Farms, 1041 Farm Record Years.
a. Measures of Size, Crop Efficiency, Machinery Costs, and Organization.

	Farm Management Factors	Year[1]					Five Year Summary
		1958	1959	1960	1961	1962	
X_1	Net Income	$7,826	$8,003	$7,298	$9,135	$8,356	$8,174
X_2	Total Investment	$62,851	$77,831	$79,593	$96,087	$91,668	$84,456
X_3	Number of Cows	33.8	35.0	36.6	40.6	43.9	38.7
X_4	Tillable Acres	196	206	207	216	230	213
X_5	Number of Men	1.8	1.9	2.0	2.0	2.0	1.9
X_6	Crop Value/T.A.	$51	$53	$48	$58	$57	$54
X_7	Crop Yield Index	99	99	99	99	98	99
X_8	Crop Acre Value	$52	$56	$51	$61	$60	$57
X_9	Soil Value Rating	$155	$151	$150	$149	$151	$151
X_{10}	Fertilizer Cost/T.A.	$6.33	$5.56	$5.69	$6.62	$6.97	$6.26
X_{11}	% Tillable Acres Idle	2%	4%	5%	2%	2%	3%
X_{12}	Percent Cash Crops	15.7%	16.0%	16.0%	15.0%	15.5%	15.6%
X_{13}	Machinery Cost/T.A.	$22.01	$21.15	$22.19	$22.68	$24.04	$22.54
X_{14}	% Lvst. Income from Dairy	97%	97%	97%	98%	98%	97%
X_{15}	% Rented Land	14.6%	16.8%	16.6%	18.6%	18.0%	17.3%
X_{16}	Number T.A./Cow	5.9	6.0	5.9	5.6	5.5	5.8

[1] The number of observations by year are as follows: 1958 = 98; 1959 = 208; 1960 = 237; 1961 = 239; 1962 = 259.

Appendix Table 2

Average Yearly Values for Farm Management Factors
Michigan Dairy Farms, 1041 Farm Record Years
a. Measures of Labor Efficiency and Livestock Efficiency

Farm Management Factors	Year[1]		
	1958	1959	1960
X_{17} Number Cows/Man	18.7	19.0	19.7
X_{18} Milk Sold/Man	194,337 lbs.	202,598 lbs.	206,102 lbs.
X_{19} 4% FCM Sold/Man	189,255 lbs.	195,896 lbs.	200,189 lbs.
X_{20} Dairy Sales/Cow	$408	$411	$428
X_{21} Milk Sold/Cow	10,392 lbs.	10,613 lbs.	10,509 lbs.
X_{22} Milk Produced/Cow	11,202 lbs.	11,264 lbs.	11,118 lbs.
X_{23} 4% FCM Sold/Cow	10,091 lbs.	10,271 lbs.	10,203 lbs.
X_{24} 4% FCM Produced/Cow	10,876 lbs.	10,901 lbs.	10,790 lbs.
X_{25} Milk Fat/Cow	426 lbs.	426 lbs.	423 lbs.
X_{26} Milk Price/CWT	$3.98	$3.91	$4.10
X_{27} 4% FCM Price/CWT	$4.07	$4.02	$4.20
X_{28} Improvements/Cow	$473	$442	$425
X_{29} Replacement:Cow Ratio	0.89	0.92	0.92
X_{30} % Base Milk	43.3%	41.9%	41.9%
X_{31} Cattle Income/Cow	$96	$89	$78
X_{32} Livestock Income/$100 Feed	$187	$172	$194
X_{33} Feed Cost/Cow	$203	$219	$208

[1] The number of observations by year are as follows: 1958 = 98; 1959 = 208; 1960 = 237.

Appendix Table 2--Continued

Farm Management Factors	Year[1] 1961	1962	Five Year Summary
X_{17} Number Cows/Man	20.8	22.0	20.3
X_{18} Milk Sold/Man	219,305 lbs.	244,270 lbs.	216,822 lbs.
X_{19} 4% FCM Sold/Man	211,564 lbs.	235,739 lbs.	209,758 lbs.
X_{20} Dairy Sales/Cow	$442	$437	$428
X_{21} Milk Sold/Cow	10,580 lbs.	11,034 lbs.	10,666 lbs.
X_{22} Milk Produced/Cow	11,260 lbs.	11,752 lbs.	11,345 lbs.
X_{23} 4% FCM Sold/Cow	10,209 lbs.	10,667 lbs.	10,323 lbs.
X_{24} 4% FCM Produced/Cow	10,865 lbs.	11,363 lbs.	10,980 lbs.
X_{25} Milk Fat/Cow	424 lbs.	444 lbs.	429 lbs.
X_{26} Milk Price/CWT	$4.20	$3.99	$4.05
X_{27} 4% FCM Price/CWT	$4.34	$4.11	$4.16
X_{28} Improvements/Cow	$405	$414	$426
X_{29} Replacement:Cow Ratio	0.93	0.96	0.93
X_{30} % Base Milk	42.9%	41.8%	42.2%
X_{31} Cattle Income/Cow	$81	$78	$82
X_{32} Livestock Income/$100 Feed	$187	$181	$184
X_{33} Feed Cost/Cow	$226	$233	$220

[1] The number of observations by year are as follows: 1961 = 239; 1962 = 259.

Appendix Table 3

Average Yearly Values for Farm Management Factors
Michigan Dairy Farms, 814 Farm Record Years
a. Measures of Feed Efficiency and Percent Cows in Milk

	Farm Management Factors	Year[1] 1958	1959	1960
X_{34}	Average Feed Cost	$161	$167	$169
X_{35}	% Cows in Milk	86.1%	86.4%	86.5%
X_{36}	Days on Pasture	148	141	132
X_{37}	Grain/Cow	3,105 lbs.	3,113 lbs.	3,243 lbs.
X_{38}	Hay Equivalent/Cow/Day	31 lbs.	31 lbs.	31 lbs.
X_{39}	TDN/Cow/Day	22.3 lbs.	22.9 lbs.	22.6 lbs.
		Year[1] 1961	**1962**	**Five Year Summary**
X_{34}	Average Feed Cost	$173	$181	$172
X_{35}	% Cows in Milk	86.2%	86.5%	86.4%
X_{36}	Days on Pasture	132	115	132
X_{37}	Grain/Cow	3,546 lbs.	3,955 lbs.	3,443 lbs.
X_{38}	Hay Equivalent/Cow/Day	31 lbs.	30 lbs.	31 lbs.
X_{39}	TDN/Cow/Day	23.3 lbs.	23.5 lbs.	23.0 lbs.

[1] The number of observations by year are as follows: 1958 = 98; 1959 = 156; 1960 = 179; 1961 = 182; 1962 = 199.

Appendix Table 4

Average Acreages, Percentages, and Yields of Crops Grown on Cooperating Michigan Dairy Farms, 1041 Farm Record Years, 1958-1962.

Crop Grown	Average Number of Acres in Crop	Percent of Farm in Crop	Average Yield Per Acre
Forage (alfalfa or mixed hay)	66	31	3.0 Tons
Tillable Pasture	26	12	2.3 Tons
Corn Silage	22	11	11.7 Tons
Corn Grain	36	17	73 bu.
Oats	21	10	60 bu.
Other Cereal Grains (barley, spelts, rye)	2	1	--
Wheat	19	9	36 bu.
Other Cash Crops (beans, sugar beets, potatoes)	7	3	--
Idle or Fallow	7	3	--
Soil Bank	4	2	--
Truck Crops	1	**	--
Fruits and Berries	*	**	--
Miscellaneous (trees, cover crops	*	**	--
Average Farm Size	213	XXX	XXX

* Less than 1 acre.
** Less than 1% of total acreage.

Appendix Table 5

Crop Prices and Values as Used to Determine
Crop Value per Tillable Acre and Crop Acre Value for
Cooperating Michigan Dairy Farms, 1041 Farm Record Observations.

Crop Grown	Year[1] 1958 Price Constant /Unit	1958 Crop Acre Value	1959 Price Constant /Unit	1959 Crop Acre Value	1960 Price Constant /Unit	1960 Crop Acre Value
Corn Silage	$ 7.00	$ 80.00	$ 7.00	$ 80.00	$ 7.00	$ 73.00
Corn Grain	1.00	75.00	1.00	68.00	.86	56.00
Oats	.60	38.00	.70	37.00	.57	37.00
Barley	.80	41.00	.80	34.00	.77	26.00
Grass Silage	7.00	41.00	7.00	43.00	7.00	53.00
Alfalfa Hay	20.00	58.00	20.50	68.00	18.60	60.00
Mixed Hay	18.00	41.00	19.40	47.00	17.00	39.00
Tillable Pasture	9.00	18.00	9.00	21.00	9.00	22.00
Wheat	1.80	82.00	1.86	65.00	1.84	61.00
Beans	3.36	67.00	3.36	74.00	3.18	74.00
Soy Beans	1.85	44.00	2.00	48.00	1.94	30.00
Sugar Beets	11.20	149.00	11.00	155.00	14.00	197.00
Potatoes	.65	296.00	1.00	415.00	1.44	613.00
Buckwheat	--	---	1.00	8.00	1.13	23.00
Rye	--	---	1.00	14.00	.92	19.00
Spelts	.65	28.00	.70	30.00	.65	36.00

[1] The number of observations by year are as follows: 1958 = 98; 1959 = 208; 1960 = 237.

Appendix Table 5--Continued

Crop Grown	Year[1]			
	1961		1962	
	Price Constant /Unit	Crop Acre Value	Price Constant /Unit	Crop Acre Value
Corn Silage	$ 8.00	$102.00	$ 8.00	$ 98.00
Corn Grain	.90	72.00	.90	68.00
Oats	.60	35.00	.60	36.00
Barley	.80	35.00	.80	31.00
Grass Silage	--	---	--	---
Alfalfa Hay	20.00	62.00	20.00	60.00
Mixed Hay	---	---	---	---
Tillable Pasture	10.00	23.00	10.00	19.00
Wheat	1.75	68.00	1.95	66.00
Beans	3.50	92.00	3.60	87.00
Soy Beans	2.20	57.00	2.30	49.00
Sugar Beets	12.25	176.00	13.45	196.00
Potatoes	.90	435.00	1.10	363.00
Buckwheat	--	---	1.25	25.00
Rye	1.00	28.00	1.00	29.00
Spelts	.75	47.00	.75	40.00

[1] The number of observations by year are as follows: 1961 = 239; 1962 = 259.

Appendix Table 6

Range in Values Observed for Farm Management Factors. Cooperating Michigan Dairy Farms, 1041 Farm Record Years, 1958-1962.

	Farm Management Factors	Lowest Value Observed	Highest Value Observed
X_1	Net Income	-$8,483	$39,108
X_2	Total Investment	$9,927	$324,926
X_3	Number of Cows	9.9	215.7
X_4	Tillable Acres	60	666
X_5	Number of Men	0.8	6.0
X_6	Crop Value/T.A.	$15	$121
X_7	Crop Yield Index	32	165
X_8	Crop Acre Value	$31	$98
X_9	Soil Value Rating	$35	$300
X_{10}	Fertilizer Cost/T.A.	$0.00	$20.96
X_{11}	% Tillable Acres Idle	0%	49%
X_{12}	% Cash Crops	0.0%	61.9%
X_{13}	Machinery Cost/T.A.	$5.07	$55.85
X_{14}	% Lvst. Income from Dairy	71%	100%
X_{15}	% Rented Land	0.0%	100.0%
X_{16}	Number of T.A./Cow	1.1	15.3
X_{17}	Number Cows/Man	7.0	47.9
X_{18}	Milk Sold/Man	70,938 lbs.	512,852 lbs.
X_{19}	4% FCM Sold/Man	49,407 lbs.	490,343 lbs.

Appendix Table 7

Range in Values Observed for Farm Management Factors Cooperating Michigan Dairy Farms, 1041 Farm Record Years,[1] 1958-1962.

Farm Management Factors	Lowest Value Observed	Highest Value Observed
X_{20} Dairy Sales/Cow	$212	$611
X_{21} Milk Sold/Cow	5,396 lbs.	15,179 lbs.
X_{22} Milk Produced/Cow	5,533 lbs.	16,174 lbs.
X_{23} 4% FCM Sold/Cow	5,289 lbs.	14,336 lbs.
X_{24} 4% FCM Produced/Cow	5,138 lbs.	15,394 lbs.
X_{25} Milk Fat/Cow	195 lbs.	595 lbs.
X_{26} Milk Price/CWT	$2.43	$5.66
X_{27} 4% FCM Price/CWT	$2.58	$5.05
X_{28} Improvements/Cow	$44	$1,424
X_{29} Replacement:Cow Ratio	0.0	2.75
X_{30} % Base Milk	22.4%	55.5%
X_{31} Cattle Income/Cow	-$24	$406
X_{32} Lvst. Income/$ Feed	$81	$375
X_{33} Feed Cost/Cow	$45	$504
X_{34} Average Feed Cost	$111	$290
X_{35} Percent Cows in Milk	74.1%	95.3%
X_{36} Days on Pasture	0	217
X_{37} Grain/Cow	1,000 lbs.	7,453 lbs.
X_{38} Hay Equivalent/Cow/Day	14 lbs.	55 lbs.
X_{39} TDN/Cow/Day	13.5 lbs.	34.4 lbs.

[1] For farm management factors with D.H.I.A. only as the source of data, the farm record years are limited to 814.