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To the Graduate Council:

I am submitting herewith a thesis written by Hugh Lamar Spangler, entitled "Economic Analysis of Commercial Farming in the Elk River Watershed." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agriculture Economics.

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ECONOMIC ANALYSIS OF COMMERCIAL FARMING
IN THE ELK RIVER WATERSHED

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Hugh Lamar Spangler

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ABSTRACT

This study was an economic analysis of commercial farming in the Elk River Watershed. A random sample of 123 farms with sales of \$2,500 or more were selected for the study. In the study area only 34.2 percent of all farms sell \$2,500 or more of farm products, but they account for approximately 85 percent of all farm sales in the area.

The over-all objective was to collect and analyze data concerning the first five economic classes of commercial farms in the area. The specific objectives of the study were as follows: (1) to compare and determine differences among commercial farms in the area with respect to farm type, net income and size of operation; (2) to estimate the marginal productivity of specified resources on different types of farms; and (3) to develop and test the usefulness of management indexes for the commercial farms in the Elk River Watershed.

The t-test was used as the statistical tool for determining if any statistical difference existed regarding age, education, level of living index, index of records, net income, returns to management, size of operation and total investment for different types of farming categories, net income ranges and size of operation ranges.

In order to estimate the marginal value productivities for specified resources, production functions were estimated by the least-squares technique using the Cobb-Douglas function. Separate functions were estimated for the entire sample group of farms and for each of the five types of farming categories. Inputs used in these functions to

estimate net farm income were land investment in dollars, livestock investment in dollars, equipment investment in dollars, building investment in dollars and unpaid family and operator labor in dollars.

A management index was calculated for each farm as a ratio between actual and predicted net farm income. This ratio was derived from the residuals of the regression equation used to estimate the marginal productivities. The rationale for the procedure was based on the assumption that the unexplained variation in the regression function was due to exclusion of the managerial variable.

In general, the analysis indicated that Grade A dairy farmers had a larger size of operation, net income, returns to management, total investment and kept more farm records than any other type of farming category. Operators in the net income range of over \$7000 had more education, reported more home items, kept more farm records, and had a larger size of operation, returns to management and total investment than did the operators in the other net income ranges. The operators in the size of operation range of 300 acres or more had more education, higher level of living index, more net income, and had a larger total investment than did operators in the other size of operation groups.

All resources included in the analysis exhibited either decreasing or negative returns. Also the elasticity of production for the sample, cash crop, manufacturing milk, and beef-hog producers indicated they were operating in the stage of production necessary to maximize profits. However, Grade A dairy and beef producers need to

make adjustments in their resource use in order to be in the stage of production necessary for maximum profits.

Tests of significance and correlation analysis led to the conclusion that age, education, record index, size of operation and total investment were not related to the management indexes computed for the study.





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CHAPTER I

INTRODUCTION

In 1964 the value of all farm products sold in Tennessee amounted to over \$528 million dollars. Sales from commercial farms, however, accounted for 90.5 percent of the total farm sales, or an amount which was estimated to be approximately \$478 million. Furthermore, sales from the first five of the six economic classes of commercial farms accounted for 84.3 percent of the total. Monetary wise this would be around \$446 million dollars¹.

Farms are grouped into two main categories by the Census of Agriculture--commercial farms and other farms. This grouping is based primarily on the total value of farm products sold. Generally farms with a value of sales totaling \$2,500 or more are classified as commercial. However, farms with sales of \$50 to \$2,499 are classified as commercial if the farm operator was under 65 years of age and did not work off the farm 100 days or more during the year².

There are six economic classes of farms that become important when making reference regarding commercial farms. These economic classes are as follows:

¹United States Bureau of Census, United States Census of Agriculture: 1964, Tennessee, Vol. 1 (Washington: Government Printing Office, 1967), pp. 46-47.

²Ibid., p. A13.

Economic Classes of Commercial Farms	Total Value of Farm Sales
I	\$40,000 or more
II	\$20,000 to \$39,999
III	\$10,000 to \$19,999
IV	\$ 5,000 to \$ 9,999
V	\$ 2,500 to \$ 4,999
VI	\$ 50 to \$ 2,499

In 1964, according to the Census of Agriculture, there were 133,446 farms in Tennessee with 57.2 percent of these farms classified as commercial. Classes I, II, III, IV, and V included only 35.8 percent of all farms but accounted for 84.3 percent of all farm sales in Tennessee in 1964³.

In the Elk River Watershed, the area in which the study was made, the value of all farm products sold amounted to over \$36 million in 1964⁴. Nearly 89 percent of these sales or over \$32⁵ million was from commercial farms (Table I). The first five economic classes of commercial farms in this Watershed accounted for over \$30 million dollars or about 85 percent of the total agricultural sales.

³Ibid., pp. 36-37.

⁴Ibid., pp. 304-311.

⁵Ibid., pp. 294-301.

TABLE I
VALUE OF FARM SALES FROM DIFFERENT CLASSES,
ELK RIVER WATERSHED, 1964

Class	Value	Percent of Total
All Farms	\$36,435,317	100.0
All Commercial Farms	\$32,413,032	88.9
First Five Economic Classes of Commercial Farms	\$30,966,520 ^a	84.9

Source: United States Bureau of Census, United States Census of Agriculture: 1964, Tennessee, Vol. 1 (Washington: Government Printing Office, 1967), pp. 294-311.

^aThis value was estimated by taking the midpoint of each income range below \$2500 and multiply this by the number of farms in each county and subtracting this from the total of all farm sales.

In 1959, "commercial farms--those that make \$2,500 and up--accounted for the majority of agriculture production in the area. In fact, approximately 75 percent of the total value of farm sales come from only one-third of the farms in the Elk River"⁶. In 1964, these same classes of commercial farms accounted for the majority of the total farm sales, with approximately 85 percent coming from 34.2 percent of all the farms in the Elk River Watershed (Table II).

I. STATEMENT OF THE PROBLEM

It has been shown that commercial farming constitutes a very important part of Tennessee agriculture. However, many differences exist among these commercial farms. Are these commercial farms, especially the first five economic classes, using their resources in the most profitable manner? Farm operators are always faced with the need to make adjustments in their farming operation. Shifts in cost of production that result from changed technology and economic conditions make it imperative for farm resource adjustments to take place in order to maintain profitability of farm enterprises⁷.

⁶Tennessee Valley Authority, Elk River Watershed: Summary of Resources (Knoxville: Tennessee Valley Authority, August, 1962), p. A-1.

⁷J. T. Harris, An Analysis of Capital Use on Owner Operator Farms in the Lower Piedmont Area of Georgia, Bulletin N. S. 74 (Athens: The University of Georgia Agricultural Experiment Station, March, 1960), p. 7.

TABLE II
NUMBER OF FARMS IN DIFFERENT CLASSES,
ELK RIVER WATERSHED, 1964

Class	Number	Percent of Total
All Farms	10,711	100.0
All Commercial Farms	5,752	53.7
First Five Economic Classes of Commerical Farms	3,671	34.2

Source: United States Bureau of Census, United States Census of Agriculture: 1964, Tennessee, Vol. 1 (Washington: Government Printing Office, 1967), pp. 36-37.



One of the concerns of agriculture economists is the economic efficiency of the use of land, labor, capital and management in the farming operation. It is the task of the agriculture economist to furnish information which will be helpful to farm operators in organizing his limited resources in such a manner as to maximize profits.

The criterion for determining if resources are used in an efficient manner is based on the concept of marginal productivity of different productive resources. Where there is unlimited amount of resources available, an operator will maximize his income by using each resource to the point where marginal value product is equal to marginal factor cost. However, if there is limited capital available "the farm operator allocates each resource to the enterprise where the marginal value product of the resource is the greatest."⁸

Purpose. The purpose of the study will be to provide economic guides for determining the efficiency of resource use by the first five classes of commercial farmers in the Elk River Watershed. It will provide marginal productivity estimates for different resources and for different type farming operations. It will also provide a general description of the commercial farms in the area and will make comparisons designed to explain some of the differences that exist. The analysis

⁸ J. C. Gilson and M. H. Yeh, Productivity of Farm Resources in the Carman Area of Manitoba, Technical Bulletin No. 1 (Winnipeg: The University of Manitoba, September, 1959), p. 2.

will be of benefit to such groups as the Agricultural Extension Service, Tennessee Valley Authority and the Elk River Development Association in helping to develop and improve existing programs.

Objectives. The first five economic classes of commercial farms account for a large majority of the total sales of farm products in the Elk River Watershed. Therefore the over-all objective is to obtain and analyze information about the commercial farms that sell \$2,500 or more of farm products each year.

The specific objectives are as follows: (1) to compare and determine differences among commercial farms in the area with respect to farm type, net income and size of farm; (2) to estimate the marginal productivity of specified resources on the commercial farms in the area and for different types of farms; and (3) to develop and test the usefulness of management indexes for the commercial farmers in the Elk River Watershed.

II. DESCRIPTION OF THE STUDY AREA

The Elk River Watershed is located in South Central Tennessee and is in the Southern portion of the Highland Rim. Approximately 86⁹ percent of the Elk River Watershed is included in Tennessee and includes parts of the following counties: Coffee, Franklin, Giles, Grundy,

⁹The remaining 14 percent is located in the Limestone Valley area of Alabama.

Lawrence, Lincoln and Moore. The drainage area of the Elk contains around 2,250 square miles or nearly one and one-half million acres. Three-fourths of this land is suitable for agriculture purposes. Agriculture in the Elk is diverse, containing commercial, subsistence, advanced age and part-time farm operators.¹⁰

Land Use. Previous research in the Elk River Watershed indicated that 28 percent of the area was classified as cropland used for pasture and 22.4 percent as cropland harvested. Corn, cotton, tobacco and lespedeza were the major field crops grown. Corn was usually grown in the bottomland, while tobacco, cotton and hay crops usually were grown on upland soils.¹¹

Soil. Soil in the Elk River Watershed is made up of six different soil associations. These associations include the Cumberland-Waynesboro-Decatur, Muskingum-Hartsells, Hartsells-Muskingum, Sango-Bodine, Baxter-Dellrose-Mimosa and Dickson-Mountview-Bodine.¹²

¹⁰Elk River Watershed: Summary of Resources, p. A-1.

¹¹Daniel Bruce Smith, "An Analysis of Selected Livestock Practices and Enterprise Returns on Farms in the Elk River Watershed," (unpublished Master's thesis, The University of Tennessee, Knoxville, June, 1965), p. 14.

¹²Joe A. Martin and B. H. Lubke, Types of Farming in Tennessee, Bulletin 311 (Knoxville: University of Tennessee Agriculture Experiment Station, March, 1960), pp. 17-20.

Climate. The area is warm and humid with an average rainfall of around 52 inches. The average growing season in the area ranges from 190-200 days. The average annual temperature is around 60 degrees, ranging from 42 degrees in January to 78 degrees in July¹³.

III. PROCEDURE

Franklin, Lincoln, Giles and Moore were the counties sampled to represent the Elk River Watershed. (Figure 1). These four counties were selected because they were located in the middle of the drainage area and represented 65 percent of the farms in the Watershed area that sold \$2,500 or more of farm products each year.

These four counties were blocked off into two mile squares and each block was numbered. In order to obtain a random sample, numbers were picked from a table of random digits until enough blocks were obtained to provide the approximate 5 percent sample that was desired. The sample included 123 farm schedules; 27 from Franklin County, 36 from Giles County, 48 from Lincoln County and 12 from Moore County¹⁴. The number of schedules taken in each county was dependent upon the number of commercial farms in the county that sold \$2,500 or more of farm products each year. A more detailed explanation of the sampling

¹³Ibid., pp. 20-21.

¹⁴Seven schedules were discarded because of incomplete information regarding capital resources managed by the operator.

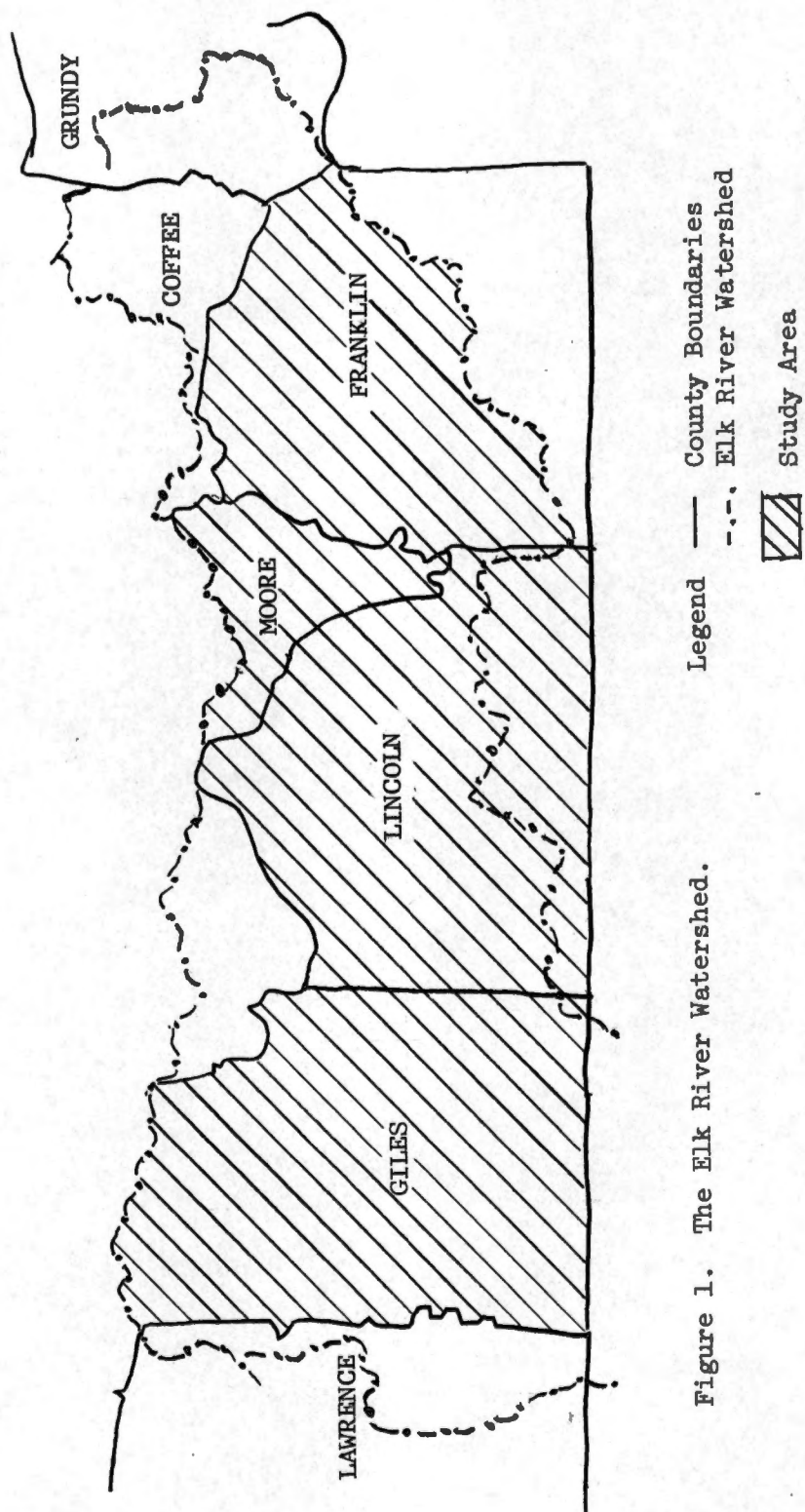


Figure 1. The Elk River Watershed.

procedure is included in Appendix A. The schedules were developed in the winter of 1967-68. The questionnaire was 11 pages long with a supplementary page for operators unable to provide their net income for 1967. Data were collected and coded in the winter of 1968 by a graduate assistant in the Agricultural Economics and Rural Sociology Department and the author. The information from the schedules was put on cards and analysis performed on the IBM 7040 Computer.

The following criteria was used for the selection of the sample farms: (1) farmer reported gross sales of \$2,500 or more in 1967; (2) living quarters were located in the blocks sampled; (3) operator was the major decision maker regarding control, organization and allocation of resources; and (4) operator had farmed in the role of decision maker at least one year.

Ordinarily data for this type study are obtained through personal interviews. However, for this study, data were obtained by leaving the schedules with the operators of commercial farms that meet the criteria for selection, and later picking them up after completion. The schedules were collected from operators over a period ranging from one to ten days after delivery. In terms of return rate, 178 schedules were delivered and 123 were collected for a return of 69.1 percent.

The schedule was divided into three sections: (1) biographical information; (2) activities and opinions of commercial farms; and (3) summary of the capital resources managed by the operator. Because of the objectives of this study, only Parts I and III were used by the

author. Chapter II is a descriptive analysis of the commercial farms in the Elk River Watershed showing comparisons among the farms by type, net income level and size of operation. Chapter III presents the marginal productivity estimates for the factors of production for the total sample and each type of farming category. Management indexes are also estimated for each farm and related to such characteristics as age of operator, educational level, net income and size of operation.



CHAPTER II

DESCRIPTIVE ANALYSIS OF COMMERCIAL FARMS IN THE STUDY

The purpose of this chapter is to compare the characteristics of the sample farms with respect to type of farming categories, net income levels and size of operation. Characteristics included for comparisons were age of operator, education of operator, level of living index, record index, net farm income, returns to management, size of operation and total investment.

I. DEFINITION OF TERMS USED

Level of living index measured the actual number of home items owned by the operator and could vary from 0 to 13. Each item owned represented one point in calculating the index score for each operator. The selected home items were: automobile (3 years or newer), telephone, piped hot water, bathroom (tub or shower plus flush toilet), automatic washer, clothes dryer, vacuum cleaner, color television, F-M radio, home freezer, gas or electric range, dishwasher, and air conditioning.

Index of records measured the actual number of records kept by the farm operator and could vary from 0 to 7. Each record kept represented one point in calculating the index score for each operator. The index of records was derived from the following seven farm records:

inventory of farm assets and liabilities, farm operating expenses and receipts, individual enterprise expenses and receipts, land use, crop yields and practices, livestock feeding and production, and labor records.

Net farm income was based on the actual income reported for tax purposes in 1967, except in some cases the net farm income figure was adjusted upward because of unusual cotton failures and was based on 1966 net income.

Size of operation included acres used only for crops and pasture.

Returns to management was derived in the following manner: (1) the value of farm products consumed by the family was added to net farm income, (2) a 5 percent interest was charged to land and building, breeding livestock and equipment investment, and (3) a charge of \$1.25 was made for each hour of unpaid family labor used on the farm (includes operators labor).

Returns to management was then obtained as a residual by adding the interest and labor charge and subtracting this from the total of net income and value of farm products consumed by the family. For many farms the return was negative.

Total investment included land, building, livestock and equipment investments. In determining land investment the following values were used: Woodland-\$100 per acre, pasture land-\$250 per acre, and cropland-\$350 per acre. Livestock investment included only breeding livestock and values were estimated by the operator. Equipment and building investments were based on their present value; estimates were provided

by the operator in most cases. However, in some instances building and equipment values were estimated based on age and size of the building or machine.

II. METHODS USED IN TESTING SIGNIFICANCE

The t-test was used as the statistical tool for determining if any statistical difference existed regarding age, education, level of living index, index of records, net income, returns to management, size of operation and total investment for the five different types of farming categories, net income ranges, and size of operation ranges. The t-test assumes that two populations being tested are normally and independently distributed with identical standard deviations. The following is the "working" formula used to compute the value of t for computing differences between means.¹

$$t = \frac{d}{\sqrt{s_x^2 + s_y^2}}$$

where: d = difference in the means of the variables in question

$$s_x^2 \text{ and } s_y^2 = (\text{standard error of the means})^2 .$$

¹Henry L. Alder and Edward B. Roessler, Introduction to Probability and Statistics (third edition: San Francisco: W. H. Freeman and Company, 1964), p. 130.

Correlation coefficients were tested at the 0.05 level for significance using the following general formula:²

$$t = \frac{r}{\sqrt{\frac{1 - r^2}{n - 2}}}$$

where: r = correlation coefficient

n = number of cases.

III. ANALYSIS BY TYPE OF FARMING CATEGORY

The sample farms were categorized into five types of farming categories: (1) cash crop, (2) Grade A dairy, (3) manufacturing milk, (4) beef, and (5) beef-hog. In order for a commercial farm to be classified as one of these types of farming categories, at least 50 percent of the farm income came from that enterprise or collection of enterprises. Analysis was based upon 116 of the 123 farms sampled which met the above criterion. In the following analysis, type of farming was considered as the dependent variable and was compared to several independent variables to determine in what respects the types of farming groups were or were not different. The results of these comparisons are shown in Table III. The distributions for each type of farming category with respect to age, education, level of living index, record index, net income, and size of operation are shown in Appendix B.

²Ibid., p. 163.

TABLE III

RELATIONSHIP BETWEEN TYPE OF FARMING AND SELECTED VARIABLES,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Variable	Type of Farming Category				
	Cash Crop	Grade A Dairy	Manufacturing		Sample
	(N = 19)	(N = 16)	Milk (N = 16)	Beef (N = 34)	Beef-Hog (N = 31)
Age	49.4	45.1	53.7	48.2	48.1
Education	10.0	10.4	8.6**	11.1	10.9
Level of Living Index	8.2	8.6	6.9**	9.0*	8.2
Record Index	3.2	4.5	3.6	2.9	3.2
Net Income	\$4868	\$8337**	\$2041*	\$2178	\$2510
Returns to Management	\$-3655	\$-2790	\$-3798	\$-5327	\$-3944
Size of Operation	224.5	248.1*	114.0	224.6	135.4**
Total Investment	\$110,031	\$121,821**	\$47,856**	\$92,059	\$62,471**
					\$85,104

* Significantly different from sample average at the 0.10 level with a two-tailed test.

** Significantly different from sample average at the 0.05 level with a two-tailed test.

Age Attainment and Type of Farming

The average age of the 116 sample operators was 48.5 years (Table III). Manufacturing milk producers were generally older and Grade A dairy farmers generally younger. Average age of operators was 45.1 for Grade A dairy farmers and 53.7 years for manufacturing milk producers. The average age of cash crop, beef and beef-hog farmers was 49.4, 48.2 and 48.1 years, respectively. The age distribution for each type of farming category is shown in Appendix B. Over 20 percent of the farmers in the sample were 60 years of age or older while only 4 percent were under 30. Thirty one percent of manufacturing milk producers were 60 and over while only 6 percent of Grade A dairy farmers were in this age category.

Tests of significant difference in the average ages of the type of farming groups indicated the following: (1) there was no significant difference between the average age for each type of farming category and the average age of the sample at the 0.05 level; (2) Manufacturing milk producers were found to be significantly older than Grade A dairy farmers at the 0.05 level.

Educational Attainment and Type of Farming

The average educational level of farmers in the sample was 10.4 years. Beef farmers had the highest average education with 11.1 years and manufacturing milk producers had the lowest average education with 8.6 years. As shown in Appendix B, 47.3 percent of cash crop farmers, 56.3 percent of Grade A dairy, 53.0 percent of beef farmers and 64.5

percent of beef-hog farmers had 10-12 years of education. However for manufacturing milk producers only 31.2 percent had 10-12 years of education. About 9 percent of the farmers had training beyond high school level (13 or more years) and 5 percent reported educational level of 6 or less.

The data indicated that the average education of manufacturing milk producers was significantly lower than the average education of the sample at 0.05 level. Further analysis indicated at the 0.05 level the average education of manufacturing milk producers was significantly less than the average education of Grade A dairy, beef and beef-hog farmers.

Level of Living Attainment and Type of Farming

The average number of the 13 selected home items for the sample was 8.3 items. The average living index was highest for beef farmers with 9.0 items and smallest for manufacturing milk producers with 6.9 home items. No manufacturing milk producer had more than 9 home items (Appendix B). The average level of living index for cash crop, Grade A dairy, and beef-hog farmers was 8.2, 8.6 and 8.2 items, respectively.

Results of tests of significant difference indicated the following:

- (1) the mean level of living index of manufacturing milk producers was significantly less than the sample average at the 0.05 level, while the average index for beef farmers was significantly larger than the sample average at the 0.10 level;
- (2) manufacturing milk producers were found

to have a significantly lower average level of living index than Grade A dairy farmers at the 0.05 level, beef farmers at 0.01 level and beef-hog farmers at the 0.10 level.

Relationship of Record Index and Type of Farming

The mean index of records for the sample was 3.3 from a possible index score of 7. Grade A dairy farmers kept the largest average number of records with 4.5 and beef farmers kept the smallest number with 2.9. The average record index of cash crop, manufacturing milk producers and beef-hog farmers was 3.2, 3.6 and 3.2 records, respectively. Thirty one percent of the Grade A dairy farmers kept all seven types of farm records (Appendix B).

Analysis of the data indicated that the mean index of records kept by Grade A dairy farmers was significantly larger than the average number of records kept by cash crop farmers at the 0.10 level and of beef farmers at the 0.05 level.

Relationship of Net Income and Type of Farming

The average net farm income of the 116 sample farms was \$3538. Grade A dairy farmers had the highest average net income with \$8337, while manufacturing milk producers had the smallest net income with \$2041. Net income of cash crop farmers, beef, and beef-hog farmers averaged \$4868, \$2178, and \$2510 respectively. For the sample, 29 percent of the commercial farmers had a net income of \$999 or less, while only 13 percent had a net income of \$7000 or more. Nearly 38

percent of the Grade A dairy farmers had a net income of \$7000 or more and only 6.3 percent of these farmers netted less than \$1000. The proportion of farms with less than \$1000 net income was 32 percent of cash crop farmers, 25 percent of manufacturing milk producers, 38 percent of beef producers and 29 percent of beef-hog producers.

Tests of significant differences indicated the following results:

(1) the average net income of Grade A dairy farmers was significantly larger and the average net income of manufacturing milk producers significantly smaller than the sample average at the 0.05 and 0.10 level, respectively; (2) Grade A dairy farmers reported an average net income which was significantly larger than the average net income for beef and manufacturing milk producers at the 0.01 level and beef-hog farmers at the 0.05 level and (3) the average net income of cash crop farmers was significantly larger than for manufacturing milk producers at the 0.10 level.

Relationship of Returns to Management and Type of Farming

Returns to management were obtained as a residual by deducting a 5 percent interest charge for capital investment and a \$1.25 per hour labor charge for unpaid family and operator labor from the total of net income and the value of farm products consumed by the family. Average returns to management were negative for all the types of farming categories and the sample, indicating that the returns to labor and capital were not sufficient to fully cover a market charge for these factors.

Estimated average returns to management for the sample was -\$4123. Grade A dairy farmers had the highest return to management with -\$2790 and beef farmers had the smallest returns with -\$5327. Management returns for cash crop, manufacturing milk, and beef-hog farmers were -\$3655, -\$4798 and -\$3944 respectively.

Test of significance indicated that no statistical difference existed for returns to management between any type of farming category and the sample or between any category at the 0.05 level.

Relationship of Size of Operation and Type of Farming

The average size of operation (including only cropland and pastureland) for the sample farms was 187.6 acres. Nearly 34 percent of the sample farms had 99 acres or less, while 16 percent had 300 acres or more. Grade A dairy farmers reported the largest size of operation; while manufacturing milk producers had the smallest average size of operation. Average acreages were 248.1 and 114.0 respectively for these two groups. The average size of operation of the cash crop, beef, and beef-hog farmers was 224.5, 224.6 and 135.4 acres, respectively. As shown in Appendix B, 21.0 percent of the cash crop, 25.0 percent of the Grade A dairy and 23.5 percent of the beef farmers had 300 acres or more.

Results of the tests of difference in the average size of operation were as follows: (1) the average size of operation of Grade A dairy farmers was found to be significantly larger and manufacturing milk producers significantly smaller than the sample

average at the 0.10 and 0.05 level, respectively; (2) the average size of operation of manufacturing milk producers was significantly smaller than cash crop farmers at the 0.10 level, beef farmers at the 0.05 level and Grade A dairy farmers at the 0.01 level; and (3) the average size of operation of beef-hog farmers was significantly smaller than the average size of operation of beef farmers at the 0.01 level.

Relationship of Total Investment and Type of Farming

The average total investment for the 116 sample farms was \$85,104. Grade A dairy farmers had the largest average investment and manufacturing milk producers had the smallest average investment. Average investments per farm was \$121,821 for Grade A dairies and \$47,856 for manufacturing milk producers. The average total investment for cash crop, beef and beef-hog farmers was \$110,031, \$92,059 and \$62,471, respectively.

The average amount and the percentage distribution of the total investment for each type of farming category are shown in Table IV. Investment in land and buildings was 81 percent of the total investment for all the sample farms and was 75 percent or more for all types of farming groups. Livestock investment accounted for 11 percent and equipment investment 8 percent of total investment on the 116 sample farms.

Analysis of the data indicated the following results: (1) manufacturing milk and beef-hog producers had average total investments significantly lower and Grade A dairy farmers had average investments

TABLE IV

AVERAGE INVESTMENT AND KIND OF INVESTMENT BY TYPE OF FARMING CATEGORY,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Type of Farming	N	Kind of Investment						Total
		Land and Buildings		Livestock		Equipment		
		Amount	Percent	Amount	Percent	Amount	Percent	
Cash Crop	19	\$90,866	82.6	\$ 5,246	4.8	\$13,918	12.6	\$110,031
Grade A Dairy	16	91,688	75.4	19,172	15.7	10,960	8.9	121,821
Manufacturing Milk	16	40,600	84.8	4,368	9.1	2,887	6.1	47,856
Beef	34	76,281	82.9	10,430	11.3	5,346	5.8	92,059
Beef-Hog	31	50,234	80.4	6,928	11.1	5,308	8.5	62,471
Sample	116	68,913	81.0	9,015	10.6	7,175	8.4	85,104

significantly larger than the sample average, all at the 0.05 level; (2) manufacturing milk producers had an average total investment significantly less than the average for cash crop and beef farmers at the 0.05 level and Grade A dairy farmers at the 0.01 level; and (3) beef-hog farmers had an average investment significantly less than Grade A dairy farmers at the 0.01 level.

Correlation Analysis

The relationship between different characteristics on particular types of farms are shown by the correlation coefficients in Table V. Each coefficient measures the degree of association between the variables in question. The coefficients were tested at the 0.05 percent probability level to determine statistical significance.

IV. ANALYSIS BY DIFFERENT NET INCOME RANGES

In the following section net income was considered as the dependent variable and comparisons were made between income groups and age, education, level of living index, record index, returns to management, size of operation and total investment. The farms were divided into 5 income groups with the following net income ranges: below \$1000, \$1000-\$1999, \$2000-3999, \$4000-6999 and over \$7000. A summary of the findings is shown in Table VI. The distributions for each net income range with respect to age, education, level of living index, index of records and size of operation are shown in Appendix C.

TABLE V

CORRELATION COEFFICIENTS FOR NET INCOME AND SIZE OF OPERATION AND
10 FACTORS BY TYPE OF FARMING CATEGORIES, 116 COMMERCIAL FARMS,
ELK RIVER WATERSHED, 1967

	Correlation Coefficients							
	Cash Crop		Grade A Dairy		Manufacturing Milk		Beef	
	NI	S of 0	NI	S of 0	NI	S of 0	NI	S of 0
	(N = 19)		(N = 16)		(N = 16)		(N = 34)	
Age	-.03	.20	.28	.21	.43	.23	-.15	-.12
Education	.35	.65*	.26	.48*	.34	.59*	.11	.43*
Level of Living	.53*	.56*	-.28	.22	.22	.14	.21	.41*
Record Index	.46*	.44*	-.07	.12	.33	.00	.12	-.04
Net Income		.44*		.57*		.02		.71*
Livestock Investment	.68*	.81*	.16	.31	.31	.38	.72*	.82*
Equipment Investment	.90*	.57*	.43	.26*	.26	.03	.27	.50*
Returns to Management	.37	-.61*	.89*	.46*	.26	-.29	.18	-.45*
Land and Building Investment	.57*	.98*	.74*	.85*	.10	.95*	.73*	.99*
Size of Operation	.44*		.57*		.02		.71*	
Total Investment	.65*	.96*	.70*	.79*	.15	.93*	.74*	.98*
							.48*	-.37*
							.45*	.96*
							.41*	
							.51*	.93*

*Significant at the 0.05 level.

Note: NI = Net Income; S of 0 = Size of Operation.

TABLE VI

RELATIONSHIP BETWEEN NET FARM INCOME AND SELECTED VARIABLES,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Variable	Net Income Ranges					Sample (N = 116)
	Below \$1000 (N = 33)	\$1000-\$1999 (N = 19)	\$2000-\$3999 (N = 34)	\$4000-\$6999 (N = 15)	Over \$7000 (N = 15)	
Age	49.1	56.8**	46.6	45.0	49.5	48.5
Education	10.8	9.4*	10.0	11.1	11.3	10.4
Level of Living Index	8.2	7.9	7.9	8.4	9.5*	8.3
Record Index	2.9	3.7	3.2	2.9	4.2	3.3
Returns to Management	\$-6380**	\$-4095	\$-4189	\$-2688	\$-478*	\$-4123
Size of Operation	153.0	127.1*	157.3	136.1	459.3**	187.6
Total Investment	\$62,345*	\$56,212**	\$68,813	\$69,787	\$224,229**	\$85,104

*Significantly different from sample average at the 0.05 level with a two-tailed test.

**Significantly different from sample average at the 0.01 level with a two-tailed test.

Age Attainment and Net Income

The commercial farmers in the \$1000-1999 net income range were the oldest while farmers in the \$4000-6999 range were the youngest with average ages of 56.8 and 45.0 years, respectively. The average age for farmers in the below \$1000, \$2000-3999, and over \$7000 ranges were 49.1, 46.6 and 45.9 years, respectively. The age distribution for each net income range is shown in Appendix C. Nearly 48 percent of the farmers in the net income range of \$1000-1999 were 60 years and older while none of them were under 30.

Analysis of the data indicated the following results: (1) farmers in the \$1000-1999 range were significantly older than the sample average at the 0.01 level; and (2) farmers in this same range were significantly older than the farmers in the other ranges at the 0.01 level.

Educational Attainment and Net Income

The level of educational attainment was highest for the farmers in the over \$7000 net income range and lowest for the farmers in the \$1000-1999 range, which was 11.3 and 9.4 years, respectively. Educational attainment was 10.8 years for farmers in the below \$1000 range, 10.0 years for farmers in the \$2000-3999 range and 11.1 for farmers in the \$4000-6999 range. As shown in Appendix C, 42.4 percent of the farmers in the below \$1000 range, 42.1 percent in the \$1000-1999 range, 52.9 percent in the \$2000-3999 range, 73.3 percent in the \$4000-6999 range and 66.7 percent in the over \$7000 range had 10-12 years of education.

In testing for significant differences between average education for each net income range and the sample, it was indicated that the farmers in the \$1000-1999 range had significantly less education than the sample at the 0.05 level. Further analysis indicated farmers in this same range had significantly less education than did the farmers in the below \$1000, \$4000-6999 and over \$7000 net income ranges at the 0.01 level.

Level of Living Attainment and Net Income

The average level of living index was highest for the farmers in the over \$7000 range with 9.5 items and lowest for the farmers in both the \$1000-1999 and \$2000-3999 ranges with 7.9 items. The average level of living index for the farmers in the below \$1000 range and \$4000-6999 range were 8.2 and 8.4 items, respectively. This index was calculated from a list of 13 selected home items. Appendix C showed that 60 percent of the farmers in the net income range of over \$7000 had 10 or more home items while this was true for only 18 percent of the farmers in the income range of below \$1000.

The farmers in the \$7000 and above net income range had significantly more home items than did the farmers in the sample at the 0.05 level, farmers in the below \$1000 range at 0.01 level, \$1000-1999 range at 0.05 level and the \$2000-3999 range at the 0.05 level.

Relationship of Record Index and Net Income

The average record index was largest for the farmers in the net income range of over \$7000 (4.2 records). In contrast, farmers in both

the below \$1000 and \$4000-6999 ranges kept the smallest number of records with 2.9. Farmers in the \$1000-1999 and \$2000-3999 ranges had an average record index of 3.7 and 3.2 respectively. This index was calculated from a list of farm records where an index of 7 was possible. However, only 20 percent of the farmers in the over \$7000 net income range kept the maximum number of 7 records (Appendix C).

Test of significant difference indicated that farmers in the \$7000 and above net income range had an average record index significantly larger than did the farmers in the below \$1000 range at the 0.05 level and \$4000-6999 range at the 0.10 level.

Relationship of Returns to Management and Net Income

Average returns to management was negative for each net income range used in this analysis. The farmers in the net income range of over \$7000 had the highest average returns with -\$478, and the farmers in the below \$1000 range had the lowest average returns to management with -\$6380. Average management returns for the farmers in the \$1000-1999, \$2000-3999 and \$4000-6999 ranges were -\$4095, -\$4189 and -\$2688, respectively.

Analysis of the data indicated the following results: (1) the average returns to management for farmers in the \$7000 and above range were significantly larger than the average returns to management for farmers in the sample at the 0.05 level, the below \$1000 range at the 0.01 level, \$1000-1999 and \$2000-3999 ranges at the 0.10 level; and (2) the average returns to management for farmers in the below \$1000

net income range were significantly smaller than the average returns to management for the sample at 0.01, \$1000-1999 range at 0.05, \$2000-3999 range at 0.01 and over \$7000 range at the 0.01 level.

Relationship of Size of Operation and Net Income

Farmers in the \$7000 and above range had the largest average size of operation (459 acres) while farmers in the \$1000-1999 range had the smallest operation (127 acres). The average size of operation for the farmers in the below \$1000, \$2000-3999 and \$4000-6999 ranges was 153.0, 157.3 and 136.1 acres, respectively. As shown in Appendix C, 15.2 percent of the farmers in the below \$1000 range, 5.3 percent in the \$1000-1999 range, 11.8 percent in the \$2000-3999 range, 6.7 percent in the \$4000-6999 range and 53.3 percent in the over \$7000 range had 300 acres or more.

In testing for significant difference between the average size of operation for farmers in each net income range and the sample, it was revealed that operators in the \$7000 and above range had an average size of operation significantly larger than the sample and the other income ranges at the 0.01 level. In contrast, operators in the \$1000-1999 income range had an average size of operation significantly smaller than the sample average at the 0.05 level.

Relationship of Total Investment and Net Income

A large range existed between the largest total average investment and the smallest. Farm operators in the \$7000 and above range had the largest average investment with \$224,229, while operators in

the \$1000-1999 range had the smallest average investment with \$56,212. The range in average investment for the first four net income groups was small (less than \$13,000). However operators in the \$7000 and above range had about three times as much investment as the other four ranges.

Results of the tests of differences in the average total investment were as follows: (1) when the average of each range was tested against the average of the sample, the average investment for farmers in the below \$1000 income range was significantly less than the sample average at the 0.05 level, and operators in the \$1000-1999 range had significantly less invested than did the sample at the 0.01 level; (2) average investment of farmers in the \$7000 and above income range was significantly larger than the sample and the other income ranges at the 0.01 level.

Correlation Analysis

Correlation coefficients between selected characteristics for each income group and the sample are shown in Table VII.

At the 5 percent level of significance, six factors were positively correlated with net income for the 116 commercial farms. These factors were livestock investment, equipment investment, returns to management, land and building investments, size of operation and total investment. For the net income range of below \$1000, education, level of living, land and building investment, size of operation and total investment were negatively correlated with net income. Also

TABLE VII

CORRELATION COEFFICIENT BETWEEN NET INCOME AND 10 FACTORS,
116 COMMERCIAL FARMS, ELK RIVER EATERSHED, 1967

Factor	Correlation Coefficients				
	Net Income Ranges				
	Sample (N = 116)	Below \$1000 (N = 33)	\$1000-\$1999 (N = 19)	\$2000-\$3999 (N = 34)	\$4000-\$6999 Over \$7000 (N = 15)
Age	-.03	.11	.19	.21	-.15
Education	.10	-.41*	-.03	-.28	-.39
Level of Living	.12	-.44*	-.16	-.05	.16
Index of Records	.13	-.16	.20	.55*	-.31
Livestock Investment	.48*	-.31	.31	.15	.12
Equipment Investment	.61*	-.27	-.05	.06	.38
Returns to Management	.52*	.62*	.26	.14	.14
Land and Building Investment	.57*	-.48*	.08	-.11	.08
Size of Operation	.50*	-.39*	.09	-.12	.05
Total Investment	.61	-.47	-.01	-.08	.15

*Significant at the 0.05 level.

for this range, returns to management was positively correlated with net income and was significant at the 5 percent level. Return to management was the only factor positively correlated with net farm income at the 5 percent level for the net income range of over \$7000.

V. ANALYSIS BY DIFFERENT SIZE OF OPERATION RANGES

In the following section size of operation was considered as the dependent variable and comparisons were made with respect to age, education, level of living index, record index, net income, returns to management and total investment for four size of operation groups. Farms were classified into size of operation ranges based on the amount of cropland and pastureland utilized. The following size of operation ranges were used: below 100 acres, 100-199 acres, 200-299 acres and over 300 acres. Table VIII contains a summary of the averages for the seven independent variables that were compared in this section and Appendix D gives the distributions for each size of operation range with respect to age, education, level of living index, index of records, and net income.

Age Attainment and Size of Operation

Commercial farmers in the size range of 100-199 acres were found to be the oldest while farmers in the 200-299 acre range were the youngest. The average age was 51.4 and 46.6 years, respectively. Average age for farmers in the below 100 acre and over 300 acre range was 47.0 and 48.6 years respectively. The age distribution for each

TABLE VIII

RELATIONSHIP BETWEEN SIZE OF OPERATION AND SELECTED VARIABLES,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Variable	Size of Operation Ranges				
	Below 100 (N = 39)	100-199 (N = 40)	200-299 (N = 18)	Over 300 (N = 19)	Sample (N = 116)
Age	47.0	51.4	46.6	48.6	48.5
Education	9.5*	10.3	10.7	12.3**	10.4
Level of Living Index	7.6*	8.1	8.4	9.7**	8.3
Record Index	3.2	3.3	3.2	3.3	3.3
Net Income	\$1977*	\$2272	\$3909	\$9054	\$3538
Returns to Management	\$-2630**	\$-4351	\$-5302	\$-5523	\$-4123
Total Investment	\$33,390**	\$61,546*	\$102,565	\$224,305**	\$85,104

*Significantly different from the sample average at the 0.05 level with a two-tailed test.

**Significantly different from the sample average at the 0.01 level with a two-tailed test.

size of operation range is shown in Appendix D. Nearly 22 percent of the farmers in the size of operation range of over 300 acres were 60 years or older, while none of them were under 30.

Test of significance difference in the average age for the different size ranges and the sample indicated the following: (1) no size of operation range was significantly different from the sample average at the 0.05 level and (2) farmers in the 100-199 acre range were significantly older than farmers in the below 100 acre range at the 0.10 level.

Educational Attainment and Size of Operation

Educational level was highest for operators in the over 300 acre range and lowest for operators in the below 100 acre range, with averages of 12.3 and 9.5 years, respectively. Operators in the 100-199 acre range had 10.3 years of education and operators in size range of 200-299 acres had 10.7 years. Appendix D showed that 21 percent of the farmers in the size of operation range of 300 acres or more had training beyond high school level (13 years or more) as compared to only 3 percent of those with less than 100 acres.

Test of significance difference showed the following: (1) the average education of operators in the over 300 acre range was significantly higher and the average education for operators in the below 100 range was significantly lower than the sample average at the 0.01 and 0.05 level, respectively; (2) operators in the 200-299 range had an average education significantly higher than the average of

farmers in the below 100 acre range at the 0.10 level; and (3) the average education of farmers in the over 300 acre range was significantly higher than the other ranges at the 0.05 level.

Level of Living Attainment and Size of Operation

Operators in the over 300 acre range had an average level of living index of 9.7, while operators in the below 100 acre range had a living index of 7.6. The average living index was 3.3 and 3.2 for the operators in the 100-199 and 200-299 ranges, respectively. As shown in Appendix D, over 63 percent of the farmers in the size of operation range of over 300 acres had 10 or more home items, while only 2.6 percent of the farmers in the below 100 acre range had 10 or more items.

Tests of significance indicated the following: (1) the average level of living index was significantly higher for farmers in the over 300 acre range and was significantly lower for farmers in the below 100 range than the sample average at the 0.01 and 0.05 level, respectively; and (2) the average level of living index of farmers in the over 300 acre range was significantly higher than both the below 100 and 100-199 acre ranges at the 0.01 and the 200-299 acre range at the 0.10 level.

Relationship of Record Index and Size of Operation

Operators in the 100-199 and over 300 acre ranges kept an average of 3.3 records and operators in the below 100 and 200-299 acre

ranges kept an average of 3.2 records. No significant difference existed in the average record index between any of the size of operation ranges and the sample.

Relationship of Net Income and Size of Operation

Net income was larger for operators in the over 300 acre range and smallest for operators in the below 100 acre range, which was \$9054 and \$1977, respectively. The average net income for farmers in the 100-199 and 200-299 acre ranges was \$2272 and \$3909, respectively. Only 5.2 percent of the farmers in the size of operation range of below 100 acres had a net income of \$7000 or more, while 42 percent of the farmers in the over 300 acre range had a net income of \$7000 or more (Appendix D).

Test of significant difference for average net income between the different ranges and the sample indicated that operators in the over 300 acre range had an average net income significantly larger than the sample mean at the 0.05 level, while operators in both the below 100 acre and 100-199 acre ranges had an average net income significantly smaller than the sample average at the 0.05 level. Further analysis indicated that operators in the 300 acre range had an average net income significantly larger than the below 100 and 100-199 acre ranges at the 0.01 level and the 200-299 acre range at the 0.10 level.

Relationship of Returns to Management and Size of Operation

The average returns to management were negative for each of the different size of operation groups. Operators in the below 100

acre range had the highest average returns to management with -\$2630. In contrast, operators in the 300 or above range had the lowest returns to management with -\$5523.

Tests of significant difference indicated that average returns to management for operators in the below 100 acre range was significantly higher than both the sample average and the 100-199 acre range at 0.01 level and the 200-299 acre range at the 0.10 level.

Relationship of Total Investment and Size of Operation

Average total investment varied considerably between the size of operation groups. Operators in the range of over 300 acres had the largest investment of \$224,305, while operators in the below 100 acre range had the smallest investment with \$33,390. The average total investment for operators in the 100-199 and 200-299 acre ranges was \$61,546 and \$102,565, respectively. Since land investment was an important component of total investment, these relationships follow largely from the system of stratification.

Results of the tests for significant differences in the average total investments were as follows: (1) the average total investment for operators in the over 300 acre range was significantly larger than the sample and the other ranges at the 0.01 level; (2) the average investments of operators in the below 100 acre range was significantly less than the sample and other ranges at the 0.01 level; and (3) operators in the 100-199 acre range had an average total investment

significantly less than the sample at the 0.05 level and the other ranges except the below 100 acre range at the 0.01 level.

Correlation Analysis.

The correlation coefficients obtained between size of operation and 10 selected factors are shown in Table IX. These coefficients measured the degree of association between the variables in question.

Assuming a 5 percent level of significance, there were seven factors positively and significantly correlated with size of operation for the 116 commercial farms. These factors were education, level of living index, net income, livestock investment, equipment investment, land and building investment and total investment. Returns to management were negatively and significantly correlated with size of operation.

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TABLE IX

CORRELATION COEFFICIENTS BETWEEN SIZE OF OPERATION AND 10 FACTORS,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Factor	Correlation Coefficients				
	Size of Operation Ranges				
	Sample	Below 100	100-199	200-299	Over 300
	(N = 116)	(N = 39)	(N = 48)	(N = 18)	(N = 19)
Age	.01	.03	.04	-.23	-.09
Education	.38*	.15	-.11	-.15	.60*
Level of Living Index	.37*	.13	.07	.01	.40
Index of Records	.07	.29	.12	.40	.15
Net Income	.50*	-.08	-.16	.31	.29
Livestock Investment	.66*	.20	.38*	-.12	.51*
Equipment Investment	.45*	-.20	.11	-.08	.19
Returns to Management	-.29*	-.35*	-.29	.37	-.29
Land and Building Investment	.97*	.81*	.81*	-.07	.94*
Total Investment	.95*	.70*	.75*	-.11	.91*

*Significant at the 0.05 level.

CHAPTER III

ESTIMATION OF MARGINAL PRODUCTIVITIES OF SPECIFIED FARM RESOURCES

Farm operators are always faced with the need to make adjustments in their farming operation. Shifts in cost of production that result from changed technology and economic conditions make it necessary for farm resource adjustments to take place in order to maintain profitability of the farm business. Marginal productivity estimates provide one means of determining the relative efficiencies in farm resource allocation. In this section marginal productivity estimates were developed for 5 different farm resource categories for the 116 sample farms and for each type of farming sub-group. An index of management was developed for each farm from the residuals of the regression estimates.

I. EMPIRICAL PROCEDURE

The analysis which follows depends primarily on the concept of the production function. The term, production function, simply expresses the relationship between factor inputs and product outputs. The relationship between varying quantities of fertilizer and wheat yields is a simple example of a production function.

The term marginal productivity will be used frequently in the analysis. "Marginal productivity" is the "additional" quantity that is added to the total output when a particular resource is increased

by one unit, other resources being held at a constant level. Marginal value productivity is simply the "additional" revenue added to the total revenue when a particular resource is increased by one unit, holding all other resources constant. In this analysis, all inputs are expressed in dollar terms; therefore, marginal productivity and marginal value productivity will be the same.

Selection of the Production Function

"One of the problems of deriving reliable estimates of production function parameters involves the choice of the mathematical form of the equation expressing the relationship."¹ Many equations can be used to express the input-output relationship; however, the following criteria should be considered in order to obtain the best equation.²

First of all, a mathematical form that best expresses the production function should be selected on the basis of the facility and ease with which the function can be fitted and used.

The second major criterion that must be considered is the "goodness of fit." In other words, how well does the mathematical expression being used fit the data? The goodness of fit is selected on

¹Luther H. Keller, "Estimating Market Supply Functions for Milk in the Louisville Milkshed from Firm Data," (unpublished dissertation, University of Kentucky, Lexington, 1966), p. 38.

²Ibid., p. 38; and J. C. Gilson and M. H. Yeh, Productivity of Farm Resources in the Carman Area of Manitoba, Technical Bulletin No. 1 (Winnipeg: The University of Manitoba, September, 1959), p. 9.

the basis of such statistical tests as R^2 , F and t. Goodness of fit is very useful in the selection of the mathematical form to express the production function but it has certain limitations:

It is theoretically possible to obtain a perfect fit to any set of observations by merely connecting all observations with a line or surface or by fitting a polynomial of degree $N-1$ to a set of observations. However, increasing the goodness of fit may decrease the degrees of freedom. There is no absolute criterion for selection of optimum combination of goodness of fit and degrees of freedom.³

The third criterion that should be considered is the underlying logic of the data being analyzed. For example, if diminishing marginal productivity is inherent in the data, a linear type of equation should not be used. Instead, a function that has the inherent ability to express diminishing returns would be necessary.

After considering the nature of the data and hypothesized relationships the Cobb-Douglas equation was selected as basis for estimating the production function relationships. The main reasons for its selection were: (1) convenience in interpreting elasticities of production for all the resources and also for each individual resource, (2) it was hypothesized that the resources in Elk River Watershed would exhibit diminishing marginal productivity, and this function can express diminishing returns, (3) due to the limited number of cases in certain types of farming categories, degrees of freedom

³Keller, op. cit., p. 37-38.

would create a problem, but the Cobb-Douglas equation "can estimate parameters with fewer degrees of freedom than other algebraic forms which allow increasing and decreasing returns to scale."⁴

Cobb-Douglas Function

The Cobb-Douglas function is one of the most widely used equations for estimating production functions. It is a power function of the following general form:

$$Y = a X_1^{b_1} X_2^{b_2} \dots X_n^{b_n}$$

where: Y = refers to output

X's = refers to inputs

b's = are estimated coefficients referred to as the "elasticity of production." They measure the percent change in output associated with a one percent change in the use of a particular input.

a = refers to a constant, the value of Y when all x_i are 0.

One of the advantages of the Cobb-Douglas Function is it can be transformed into logarithmic form, and the parameters can be estimated by the least-squares methods. When using the least-square method, the

⁴Earl O. Heady and John L. Dillon, Agricultural Production Functions (Ames: Iowa State University Press, 1966), p. 25.

residuals are minimized. When the results are unlogged the data exhibits non-linearity.⁵

The logarithmic form of the Cobb-Douglas function is of the following form:

$$\text{Log } Y = \log a + b_1 \log X_1 + b_2 \log X_2 + \dots + b_n \log X_n.$$

Marginal value productives are expressed in the following manner when using the Cobb-Douglas function if both inputs and output are measured in value terms:

$$\text{MVP}_{x_1} = \frac{(b_1)}{(x_1)} \hat{Y}.$$

The individual b's indicate the elasticity of production for each input, while the total elasticity of production is the sum of the b's. If $\sum b's > 1$, the function exhibits increasing returns to scale, if $\sum b's = 1$ constant elasticity prevails, and if $\sum b's < 1$ the function exhibits decreasing returns to scale. Increasing returns to scale indicate that if all resources are increased by one percent, the output increases by more than 1 percent. In contrast, if decreasing returns to scale exist, a 1 percent increase in all inputs results in less than a 1 percent increase in output.

⁵Linearity indicates that given and equal changes in the independent variable or variables are associated with uniform and equal changes in the dependent variable. Whereas, non-linearity indicates that equal changes in the independent variable results in unequal changes in the dependent variable.

Although there are several advantages to the Cobb-Douglas function, there are also limitations that should be mentioned. Some of the important limitations are listed as follows:⁶ (1) constant elasticity of production for both the individual resources and the sum of the resources, (2) does not permit both increasing and decreasing marginal productivity of resources in the same equation, (3) the marginal productivity of one resource depends directly on the level of other resources, (4) one resource can never be substituted entirely for another resource in producing a given output, and (5) the marginal rate of substitution between resources is constant along the scale line.

II. RESULTS OF THE ANALYSIS

Production functions were estimated for each of the types of farming categories and for the sample as a whole. The following variables were used for making the estimates in this section:

Y = Net Income

X_1 = Land Investment in Dollars

X_2 = Livestock Investment in Dollars

X_3 = Equipment Investment in Dollars

X_4 = Building Investment in Dollars

X_5 = Value of Unpaid Family and Operator Labor in Dollars.

⁶J. C. Gibson and M. H. Yeh, op. cit., pp. 9-10.

The method of determining investment values was discussed in an earlier section. Unpaid family and operator labor was valued at \$1.25 per hour.

All Farms

The Cobb-Douglas function was fitted to data obtained from the 116 sample farms in the Elk River Watershed. The values obtained for the regression equation are shown in the logarithmic form as follows:

$$\log Y = 2.8927 - .2121 \log x_1 - .0134 \log x_2 + .0701 \log x_3 + .3338 \log x_4 + .1283 \log x_5$$

Standard error: (.108) (.086) (.007) (.115) (.179) .

A comparison of the different elasticities for the total sample and each of the types of farming categories and their tests of significance are shown in Table X.

The multiple correlation coefficient for this function was statistically significant at the one percent level. However, as shown by the coefficient of multiple determination (R^2) only 11 percent of the variation in net income was explained by the five factors used in the analysis. In order to try to improve the R^2 for the sample, the transcendental function was also fitted.⁷ This function has the inherent ability to exhibit "non-constant elasticity and consequently

⁷The logarithmic form of the transcendental function is as follows: $\log Y = \log c + a_1 \log x_1 + b_1 x_1 + \dots a_n \log x_n + b_n x_n$.

TABLE X

PRODUCTION FUNCTION COEFFICIENTS AND TESTS OF SIGNIFICANCE FOR THE TOTAL SAMPLE AND
TYPES OF FARMING CATEGORIES, 116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Input category	Sample				Manufacturing				Beef-Hog			
	Value of elasticity test ^a	t	Cash Crop Value of elasticity test ^a	t	Grade A Dairy Value of elasticity test ^a	t	Milk Value of elasticity test ^a	t	Beef Value of elasticity test ^a	t	Beef-Hog Value of elasticity test ^a	t
Land Investment X_1	-.2121	5%	-.1457	40%	.9871	1%	-.1162	40%	-.1209	70%	-.1195	20%
Livestock Investment X_2	-.0134	--	.0501	60%	-.5367	5%	.0811	50%	.0229	--	-.0458	80%
Equipment Investment X_3	.0701	30%	.4452	1%	.6158	2%	.0552	60%	-.1033	50%	.1671	20%
Building Investment X_4	.3338	1%	.1407	20%	-.0251	--	.1063	40%	.4659	20%	.1653	10%
Unpaid Labor Investment X_5	.1283	40%	.2599	20%	.2261	20%	.4303	30%	-.3402	50%	.1648	40%
∑ of Elasticities	.3067		.7502		1.2609		.5567		-.0756		.3319	
R^2	.11		.67		.75		.37		.08		.19	

^aProbability of obtaining a t this large or larger in size by chance (sign ignored) from a population in which the true regression coefficient was actually zero.

can show increasing, decreasing, and negative marginal returns, singularly, in pairs, or all three simultaneously."⁸ The R^2 using the transcendental function was .18. The values obtained for the production function estimates using this equation are shown in Appendix E, Table XVII.

The estimated parameters of the Cobb-Douglas equation show the elasticities of the individual inputs. For the 116 farms the elasticities for land and livestock inputs were negative, while equipment, buildings and unpaid labor inputs were positive. The elasticity of equipment investment input was .07. Thus on the average, an increase of 1 percent in equipment investment, holding all other factors constant, would increase net income by .07 percent.

The sum of the individual input elasticities was .306, indicating diminishing returns to scale. This means that a 1 percent increase in all the inputs would result in less than a 1 percent increase in net income.

Marginal value productivity estimates. These estimates are shown in Table XI. The estimated marginal value productivities were derived at the geometric mean for each input used in the Cobb-Douglas function for the total sample. The marginal value productivities for the inputs may be interpreted as follows: (1) at the geometric mean,

⁸Keller, op. cit., p. 45.

TABLE XI

MARGINAL VALUE PRODUCT ESTIMATES AT MEAN INPUT LEVELS, FOR TYPES OF FARMING CATEGORIES
AND TOTAL SAMPLE, 116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Input category	Total Sample		Cash Crop		Grade A Dairy	
	Geometric mean	Marginal value product at the geometric mean	Geometric mean	Marginal value product at the geometric mean	Geometric mean	Marginal value product at the geometric mean
Land Investment	\$39,930	\$-.031	\$48,970	\$-.020	\$66,610	\$.147
Livestock Investment	5,193	-.014	3,019	.119	14,940	-.356
Equipment Investment	4,279	.096	8,755	.365	8,286	.738
Building Investment	4,832	.400	5,272	.191	15,720	-.015
Unpaid Labor Investment	3,597	.200	3,457	.541	5,195	.432

TABLE XI (continued)

MARGINAL VALUE PRODUCT ESTIMATES AT MEAN INPUT LEVELS, FOR TYPES OF FARMING CATEGORIES
AND TOTAL SAMPLE, 116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Input category	Manufacturing Milk		Beef		Beef-Hog	
	Geometric mean	Marginal value product at the geometric mean	Geometric mean	Marginal value product at the geometric mean	Geometric mean	Marginal value product at the geometric mean
Land Investment	\$30,250	\$-.020	\$46,420	\$-.010	\$26,470	\$-.025
Livestock Investment	3,726	.118	5,250	.016	4,924	-.052
Equipment Investment	2,239	.134	3,066	-.132	3,951	.240
Building Investment	3,583	.163	4,512	.406	3,135	.300
Unpaid Labor Investment	4,369	.537	2,871	-.466	3,499	.267

an additional dollar spent on land would return \$-.03 in additional income, holding all other inputs constant at their geometric mean, (2) an additional dollar spent on livestock, equipment, buildings and unpaid labor would result in a return of \$-.01, \$.09, \$.40 and \$.20 in additional net income, respectively for these inputs calculated at their geometric means. The reliability of these marginal value productivities are shown in Table X. The elasticity for building and land inputs were significantly different from zero at the one and five percent level, respectively.

Cash Crop Analysis

The Cobb-Douglas equation was fitted to the input data for the 19 cash crop farmers in the Watershed using the same variables. The logarithmic form of the equation is as follows:

$$\log Y = 1.1670 - .1457 \log x_1 + .0501 \log x_2 + .4452 \log x_3 + .1407 \log x_4 + .2599 \log x_5$$

Standard error: (.186) (.210) (.143) (.128) (.219).

The multiple correlation coefficient for this function was statistically significant at the one percent level. The coefficient of determination indicated that 67 percent of the variation in net income was explained by the five inputs used in this analysis.

The elasticity for the land input was negative, while the other inputs had positive elasticities. The elasticities of livestock, equipment, buildings, and unpaid labor inputs showed decreasing returns.

That is, for every 1 percent increase in each individual input, holding all other inputs constant, net income would increase but by less than 1 percent.

The sum of the individual elasticities for this function was .75, indicating decreasing returns to scale. A 1 percent increase in all factors would result in a .75 percent increase in net income.

Marginal value productivity estimates. These estimates are shown in Table XI. Marginal value productivity estimates were derived at the geometric mean for each input. The MVP's derived for the cash crop farm can be interpreted as follows: at the geometric mean, an additional dollar spent on land, livestock, equipment and buildings would return additional net income of \$-.02, \$.12, \$.37 and \$.19, respectively. The marginal value product for unpaid family and operator labor was \$.54.

Grade A Dairy Analysis

The regression equation obtained for the 16 Grade A dairy farms included in the sample is as follows:

$$\log Y = 1.6711 + .9871 \log x_1 - .5367 \log x_2 + .6158 \log x_3 - .0251 \log x_4 + .2261 \log x_5$$

Standard error: (.229) (.259) (.242) (.214) (.193).

The multiple correlation coefficient for this function was statistically significant at the 1 percent level. The coefficient of multiple determination indicated that 75 percent of the variation in net income was explained by the five inputs included in the analysis.

Two of the elasticities for this function, livestock and building inputs, were negative. Productivity coefficients for land, equipment and unpaid labor inputs showed decreasing returns. The elasticity for land input was rather high in this function, indicating that on the average, a 1 percent increase in land investment, holding all other factors constant, would increase net income by .98 percent.

The elasticity of production for the Grade A dairy farmers was 1.26, suggesting increasing returns to scale. A 1 percent increase in all inputs would result in a 1.26 percent increase in net income.

Marginal value productivity estimates. The marginal value productivities of the 5 input categories for the Grade A dairies are shown in Table XI. The marginal value productivities of livestock and building inputs were negative, indicating that the marginal earning rate at the geometric mean was \$-.35 for livestock and \$-.02 for building investment. The marginal earning rate for land, equipment, and unpaid labor was \$.15, \$.73 and \$.43, respectively at their geometric mean.

Analysis of Manufacturing Milk Producers

The regression equation obtained for the 16 manufacturing milk producers included in the sample is as follows:

$$\log Y = 1.8494 - .1162 \log x_1 + .0811 \log x_2 + .0552 \log x_3 + .1063 \log x_4 + .4303 \log x_5$$

Standard error: (.145) (.130) (.110) (.127) (.407).

The multiple correlation coefficient for this function was not significant at the 5 percent level. The coefficient of multiple determination indicated that 37 percent of the variation in net income was explained by these five inputs. The remaining variation was due to factors not included in the analysis.

The elasticity for the land input was negative while the elasticities for the other 4 inputs were positive and showed decreasing returns. As shown in Table X, the elasticity values for each input could have been obtained a majority of the time by chance from a population in which the true elasticities were actually zero.

The elasticity of production for the manufacturing milk producers was .56, indicating that a 1 percent increase in all factors would result in a .56 percent increase in net income.

Marginal value productivity estimates. The marginal value products for each input category for manufacturing milk producers at their geometric means are shown in Table XI. Land input had a negative MVP of \$-.02. In contrast, the marginal earning rate at the geometric mean for livestock, equipment, buildings, and unpaid labor was \$.12, \$.13, \$.16 and \$.53, respectively.

Analysis of Beef Farmers

Fitting of the Cobb-Douglas equation to the data for the 34 beef farms in the sample gave the following estimating equation:

$$\log Y = 3.9080 - .1209 \log x_1 + .0229 \log x_2 - .1033 \log x_3 + .4659 \log x_4 - .3402 \log x_5$$

Standard error: (.374) (.207) (.181) (.360) (.522).

The multiple correlation coefficient for this function was not significant at the 5 percent level. The coefficient of multiple determination was very small, indicating that only 8 percent of the variation in net income was explained by the five inputs used in the analysis.

Three of the parameters or elasticities in this equation, land, equipment, and labor were negative, while livestock and building elasticities were positive; but indicated diminishing returns. The statistical tests shown in Table X for the elasticities showed they could have been obtained a majority of the time by chance from a population in which the true elasticities were actual zero. The sum of the elasticities for beef farmers was $-.08$, suggesting negative returns to scale. This means that if all factors were increased by 1 percent, net income would decrease by $.08$ percent.

Marginal value productivity estimates. The MVP's for inputs used by beef farmers at their geometric means are shown in Table XI. Three inputs, land, equipment and unpaid labor had negative marginal value productivities of $\$-.01$, $\$-.13$, and $\$-.46$, respectively. Marginal value productivities for livestock and buildings were $\$.01$ and $\$.40$, respectively.

Analysis for Beef-Hog Farmers

The following function in the logarithmic form is for the 31 beef-hog farmers:

$$\log Y = 2.6904 - .1195 \log x_1 - .0458 \log x_2 + .1671 \log x_3 + .1653 \log x_4 + .1648 \log x_5.$$

Standard error: (.097) (.177) (.141) (.112) (.217).

The multiple correlation coefficient was not significant at the 5 percent level. The coefficient of multiple determination indicated that only 19 percent of the variation in net income could be explained by the five inputs used in this analysis.⁹

Statistical tests for the elasticities for this equation showed that they could have been obtained a majority of the time by chance from a population in which the true regression coefficient was actually zero. The sum of the elasticities in this analysis was .33, suggesting diminishing returns to scale for beef-hog farmers.

Marginal value productivity estimates. The MVP's for inputs used by farmers at their geometric means are shown in Table XI. Land and livestock inputs had negative marginal value products of \$-.02 and \$-.05, respectively. In contrast, equipment, buildings and unpaid family labor had positive marginal value productivities of \$.24, \$.30 and \$.27, respectively.

III. MANAGEMENT INDEX ANALYSIS

The Cobb-Douglas functions discussed in the preceding section were assumed to have included all the important measurable variables

⁹In order to try to improve the R^2 , beef and beef-hog farmers were combined; however, the R^2 decreased to .05.

that influenced net farm income. The only other important variable that could not be measured and was not included in the functions was management. Assuming that this variable was responsible for the unexplained variation in predicted net income, a quantitative method was developed to measure management. These management indexes were developed from the residuals or the difference between actual and predicted net income.

A predicted net income was calculated from the five different production functions in section II for each commercial farm in the study. For example, if a commercial farm was classified as a cash crop farm, the actual amount of land, livestock, equipment, buildings, and labor investments were multiplied by their respective "elasticities" in the cash crop production function to obtain a predicted income. A management index was then derived in the following way:

$$\frac{Y}{\hat{Y}} = \text{actual net income reported} \times 100.$$

$$\hat{Y} = \text{predicted net income}$$

If the management index was > 100 , this indicated above average performance, if the ratio = 100, average performance was suggested, and if the management index was < 100 , this indicated less than average performance. These calculated management indexes were geometric ratios. The geometric ratio was used since this was the form of the data used in the regression equation. The average managerial index when computed in this manner is 100.

In this analysis, the management indexes were divided into 4 groups: below 97, 98-99, 100-103 and over 104. The management index was then related to the selected variables used in the earlier analysis. The comparisons are shown in Table XII:

Age Attainment and Management Index

The average age of operators was greatest for those in the 100-103 management index group (50.7 years) and least for those operators in the over 104 management index group (46.5 years). However, there was not a wide spread in the mean age for the different groups. There was no significant difference in average age for any index range and the sample average or between any of the index groups at the 0.05 level.

Educational Attainment and Management Index

Average educational level was highest (10.6) for operators with management indexes of less than 97 and lowest (10.2) for those with management index of 100-103. Tests of significance indicated there was no significant difference in average education for any management index group and the sample or between any of the sub-groups at the 0.05 level.

Level of Living Attainment and Management Index

The highest average number of home items was reported by operators with a management index of less than 97, while the least average number of home items was reported by those with a management index of 100-103. However differences in average number of home items between the management index groups were small and were not significant at the 0.05 level.

TABLE XII

RELATIONSHIP BETWEEN MANAGEMENT INDEX AND SELECTED VARIABLES,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Variables	Management Index Ranges (Geometric Ratio)				Sample (n = 116)
	Below 97 (n = 24)	98-99 (n = 22)	100-103 (n = 38)	Over 104 (n = 32)	
Age	49.1	48.2	50.7	46.5	48.5
Education	10.6	10.4	10.2	10.4	10.4
Living Index	8.5	8.3	8.0	8.4	8.3
Record Index	3.0	3.3	3.6	3.2	3.3
Net Income	\$438**	\$1584**	\$5456	\$4928	\$3538
Returns to Management	\$-6907**	\$-5243	\$-2686	\$-2971	\$-4123
Size of Operation	171.5	179.5	178.7	215.7	187.6
Total Investment	\$79,284	\$72,802	\$87,777	\$94,751	\$85,104

*Significantly different from sample average at the 0.05 level with a two-tailed test.

**Significantly different from sample average at the 0.01 level with a two-tailed test.

Relationship of Record Index and Management Index

Those farmers with a management index of 100-103 kept the largest number of records on the average, while those with a management index below 97 kept the smallest number of records. There was no significant difference in the mean index of records kept for any management index range and the sample or between any of the management index sub-groups at the 0.05 level.

Relationship of Net Income and Management Index

Average net farm income was largest for the operators in the 100-103 index range with \$5,456, while operators in the below 97 index range had the smallest net income with \$438. Average net income of \$438 for the less than 97 index group and \$1584 for the 98-99 index group was significantly smaller than the sample average at the 0.01 level. Average net income for both the 100-103 and over 104 index ranges were significantly higher than both the below 97 and 98-99 ranges at the 0.01 level.

Relationship of Returns to Management and Management Index

The average returns to management was negative for all index groups. The operators in the 100-103 range had the highest return to management with \$-2,686. The below 97 index range had the smallest returns to management with \$-6,907.

Test of significant differences indicated the following: (1)
the average returns to management for farmers with management index

of less than 97 was significantly smaller than the sample average at the 0.01 level; (2) the average returns to management for those with an index of 100-103 were significantly higher than both the below 97 and 98-99 ranges at 0.01 and 0.05 level, respectively; and (3) the average returns to management for those with an index of over 104 was significantly higher than the below 97 and 98-99 range at 0.01 and 0.05 level, respectively.

Relationship of Total Investment and Management Index

Operators in the over 104 management index range had the largest investment, whereas operators in the 98-99 range had the smallest investment. Average investments were \$94,751 and \$72,802, respectively for these two groups. There was no significant difference between the average investment of any of the groups and the sample or between any of the sub-groups at the 0.05 level.

CHAPTER IV

SUMMARY AND CONCLUSIONS

This study was an economic analysis of commercial farming in the Tennessee portion of the Elk River Watershed. A random sample of 123 farms with sales of \$2,500 or more were selected for the study. In the study area only 34.2 percent of all farms sell \$2,500 or more of farm products, but they account for approximately 85 percent of all farm sales in the area.

The primary objectives of the study were: (1) to compare and determine differences among commercial farms in the area by type of farming categories, net income ranges and size of operation ranges; (2) to determine marginal productivity of particular resources on different type farms; and (3) to develop management indexes for the commercial farms in the study.

I. SUMMARY

The farms included in the sample were classified into five types of farming categories: cash crop, Grade A dairy, manufacturing milk, beef, and beef-hog. An analysis of the differences in the means of selected variables between types of farming categories and the sample revealed the following results: (1) there was no significant differences in average age, index of records kept, and returns to management for any type of farming category and the sample; (2) the average educational

level of manufacturing milk producers was significantly lower than the sample average; (3) the mean level of living index was significantly higher for operators of beef farms and significantly lower for manufacturing milk producers than the sample mean; (4) the average net income, size of operation and total investment of Grade A dairy farms was significantly higher than the sample average and significantly lower than the sample average on manufacturing milk farms; (5) the average total investment on beef-hog farms was significantly less than the sample average.

Comparisons were also made between groups of farms on the basis of net farm income ranges. The following ranges were selected: below \$1000, \$1000-\$1999, \$2000-\$3999, \$4000-\$6999, and over \$7000. A comparison of the different income groups led to the following conclusions: (1) average educational level was lower and average age greater for farmers in the \$1000-1999 net income range than for the sample average; (2) in no case was the average record index for a particular income group significantly different from the sample average; (3) the average level of living index for the \$7000 and above income group was significantly larger than the sample average; (4) the average returns to management for the \$7000 and above group were significantly higher than the sample average and, for the less than \$1000 net income group, the average returns to management was significantly lower than the sample average; (5) the average size of operation for the \$1000-1999 income group was significantly smaller than the sample average, and average

size of operation was significantly larger on the \$7000 and above group than for the sample; and (6) both the below \$1000 and \$1000-1999 groups had an average total investment significantly smaller than the sample average, and for farms in the \$7000 and over net income group, total investment was significantly larger than the sample average.

Comparisons were also made between the farms on the basis of size of operation, measured in terms of areas of crop and pastureland. The following size groups were used: below 100 acres, 100-199 acres, 200-299 acres and 300 acres and over. Comparisons between means of selected variables for the different size of operation ranges and the sample indicated the following: (1) no significant differences existed between average age or average record index for any size group and the sample; (2) the average educational level and level of living index of the over 300 acre group were significantly higher than the respective sample averages, operators in the below 100 acre group had an average educational level and living index significantly lower than the sample averages; (3) for the 300 acre and over size group, average net income and total investment was significantly larger than the sample average, for both the below 100 acre and 100-199 acre groups, average net income and total investment was significantly smaller than the sample average; and (4) the average returns to management for the less than 100 acre group were significantly less than the sample average.

The second primary objective of this research was to estimate marginal value productivities for different farm resources. In order

to obtain these estimates, production functions were estimated by the least-squares technique using the Cobb-Douglas function. Separate functions were estimated for the entire sample group of farms and for each of the five types of farming groups. Inputs used in these functions to estimate net farm income were land investment in dollars, livestock investment in dollars, equipment investment in dollars, building investment in dollars and value of unpaid family and operator labor priced at \$1.25 per hour.

A summary of the marginal value productivity estimates derived at the geometric means for the different types of farming categories and the sample is as follows: (1) for the sample two inputs, land and livestock, had negative MVP's, while the MVP for equipment, building and unpaid labor were positive; (2) on the cash crop farmers, the MVP of land was negative and the MVP's of the other inputs were positive; (3) on the Grade A dairy farms, the MVP of livestock and building investments were negative, while the MVP of land, equipment, and unpaid labor were positive; (4) on farms producing manufacturing milk the MVP was negative for land and positive for all other inputs; (5) the MVP of land, equipment, and unpaid labor were negative on beef farms and the MVP of livestock and buildings were positive; and (6) the MVP of land and livestock were negative on beef-hog farms and positive for the other inputs.

A management index was calculated for each farm as a ratio between actual and predicted net farm income. This ratio was derived from the residuals of the regression equation used to estimate marginal

productivities. The rationale for the procedure was based on the assumption that the unexplained variation in the regression function was due to the exclusion of the managerial variable.

Following the calculation of the indexes, the farms were grouped into the four management index groups as follows: below 97, 98-99, 100-103 and over 104. The averages of selected variables for each of the different management index groups were compared to the sample averages. Conclusions for this comparison are as follows: (1) no significant difference existed for age, education, level of living index, index of records, size of operation and total investment between any management index group and the sample; (2) for both the below 97 and 98-99 management index groups, the average net income was significantly less than the sample average; and (3) returns to management for operators in the below 97 index range was significantly smaller than the sample average.

II. CONCLUSIONS

General conclusions from the comparisons of different groups of commercial farms in the Watershed are as follows:

1. Grade A dairy farms had a larger size of operation, net income, returns to management, total investment and kept more farm records than any other type of farming category.
2. Operators in the net income range of over \$7000 had more education, reported more home items, kept more farm records,

and had a larger operation, returns to management and total investment than operators in the other net income groups.

3. Operators of farms with 300 acres or more had more education, a higher level of living index, higher net income, and more total investment than the other size of operation groups. As the size of operation groups increased, average education, level of living, net income and total investment increased while returns to management decreased.
4. Average returns to management was negative for all groups whether classification was by type of farming, net income or size of operation. This indicates that, in general, net income was not sufficient to provide a 5 percent return to capital and \$1.25 per hour for operator and family labor.
5. Tests of significant differences and correlation analysis led to the conclusion that age, education, record index, size of operation and total investment were not related to the management indexes computed for the study.

Marginal productivity estimates have many limitations and must be interpreted with caution. They do, however, provide some general guidelines with respect to which input categories are most limitational and would most likely have the most effect on net income. However, each individual commercial farmer would need to evaluate the results in terms of his own interests and existing circumstances. Therefore, the

following general conclusions were derived from the results generated from "averages from all farmers" in each category.

The marginal value productivity estimates for land indicate that it would be unprofitable to purchase more land, except for Grade A dairy farms. For Grade A dairy farms the MVP was \$.14 at the geometric mean. This would be more than sufficient to cover the capital cost and would provide some return for risk. For other types of farms the negative MVP for land indicated that land was not limitational.

The marginal value productivity estimates for livestock investments were either extremely low or negative for all farm types. Results of this analysis indicate that additional investment in livestock would not be very profitable.

Marginal productivity estimates for equipment were rather high for all categories except beef farms which had a negative return. With a \$.06 interest charge on equipment investment, it would seem to be profitable to expand equipment investments on all farm types except beef farms.

Building investment had high marginal returns for all farm type categories except Grade A dairy. Therefore, the analysis suggests expansion of building investments would likely be profitable on all farm types except cash crop farms and their most profitable investment would likely be in additional equipment.

The marginal value productivity of labor was positive for all farming categories except beef. Labor was measured in dollar terms and results suggested that returns for unpaid labor were rather high.

The last conclusions that were drawn from the research was that all resources used in the analysis exhibited either decreasing or negative returns. Furthermore the elasticities of production for the sample, cash crop, manufacturing milk, and beef-hog farms indicated they were operating in the "stage of production" necessary for maximizing profit. However Grade A dairies and beef farms need to make adjustments in their resource use in order to be in the stage of production necessary for maximum profit.

SELECTED BIBLIOGRAPHY



SELECTED BIBLIOGRAPHY

- Alder, Henry L. and Edward B. Roessler. Introduction to Probability and Statistics. Third edition. San Francisco: W. H. Freeman and Company, 1964.
- Carter, H. O. "Modification of the Cobb-Douglas Function to Destroy Constant Elasticity and Symmetry." Resource Productivity, Returns to Scale and Farm Size. Edited by E. O. Heady and others. Ames: Iowa State College Press, 1956.
- Gilson, J. C. and M. H. Yeh. Productivity of Farm Resources in the Carman Area of Manitoba. Technical Bulletin No. 1. Winnipeg: The University of Manitoba, September 1959.
- Halter, A. N., H. O. Carter and J. G. Hacking. "A Note on the Transcendental Production Function," Journal of Farm Economics, Vol. 39, No. 4, November 1957, pp. 966-69.
- Harris, J. T. An Analysis of Capital Use on Owner Operator Farms in the Lower Piedmont Area of Georgia. Bulletin N.S. 74. Athens: The University of Georgia Agricultural Experiment Station, March 1960.
- Haver, Cecil B. "Economic Interpretations of Production Function Estimates." Resource Productivity, Returns to Scale and Farm Size. Edited by E. O. Heady and others. Ames: Iowa State College Press, 1956.
- Headley, J. C. "Estimating Productivity of Agricultural Pesticides," American Journal of Agricultural Economics, Vol. 50, No. 1, February 1968, pp. 13-23.
- Heady, Earl O. and John L. Dillon. Agricultural Production Functions. Ames: Iowa State University Press, 1966.
- Keller, Luther H. "Estimating Market Supply Functions for Milk in the Louisville Milkshed from Firm Data." Unpublished Dissertation, The University of Kentucky, Lexington, 1966.
- Martin, Joe A. and B. H. Luebke. Types of Farming in Tennessee. Bulletin No. 311. Knoxville: The University of Tennessee Agricultural Experiment Station, March 1960.
- Smith, Daniel Bruce. "An Analysis of Selected Livestock Practices and Enterprise Returns on Farms in the Elk River Watershed." Unpublished Master's Thesis, The University of Tennessee, Knoxville, 1965.
- Tennessee Valley Authority. Elk River Watershed: Summary of Resources. Knoxville: Tennessee Valley Authority, August 1962.

United States Bureau of Census. United States Census of Agriculture:
1964. Tennessee, Vol. I. Washington: Government Printing Office.

Wirth, M. E. "Pattern-Analytics: A Method of Classifying Managerial
Types," The Quarterly Bulletin, Vol. 47, No. 2. East Lansing:
Michigan State University Agricultural Experiment Station, November
1964, pp. 181-82.





APPENDIXES

APPENDIX A

TABLE XIII

NUMBER OF COMMERCIAL FARMS SELLING
\$2,500 OR MORE OF FARM PRODUCTS,
SAMPLE AREA, 1964

Economic Class	County				Total
	Franklin	Giles	Lincoln	Moore	
I	15	14	11	2	42
II	31	22	43	4	100
III	96	85	94	20	295
IV	169	204	254	48	675
V	<u>290</u>	<u>407</u>	<u>495</u>	<u>102</u>	<u>1294</u>
Total	601	732	897	176	2406
Percent of Total	24.9	30.4	37.3	7.4	
Number of Farms Selected ^a	30	37	45	10	
Number of Farms Obtained	27	36	48	12	

^aThe number of farms selected in each county was equal to 120 (desired sample size) multiplied by the percent each county was of the total.

APPENDIX B

TABLE XIV

NUMBER AND PERCENT DISTRIBUTIONS FOR DIFFERENT FACTORS BY TYPE OF FARMING CATEGORIES,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Factor	Type of Farming Category											
	Cash Crop			Grade A Dairy			Milk			Beef		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Age	Manufacturing											
	Beef-Hog			Beef			Milk			Beef		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	1	5.2	1	6.2	0	0.0	1	2.9	2	6.5	5	4.3
	2	10.6	3	18.7	2	12.5	5	14.7	5	16.1	17	14.7
	7	36.8	6	37.5	3	18.7	12	35.3	12	38.7	40	34.5
60 and older	4	21.1	5	31.3	6	37.5	10	29.5	5	16.1	30	25.9
	5	26.3	1	6.3	5	31.3	6	17.6	7	22.6	24	20.6
	19	100.0	16	100.0	16	100.0	34	100.0	31	100.0	116	100.0
Education	Manufacturing											
	Beef-Hog			Beef			Milk			Beef		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	1	5.3	0	0.0	3	18.8	1	2.9	1	3.2	6	5.2
	8	42.1	6	37.5	8	50.0	8	23.5	8	25.8	38	32.8
13 and over	9	47.3	9	56.3	5	31.2	18	53.0	20	64.5	61	52.6
	1	5.3	1	6.2	0	0.0	7	20.6	2	6.5	11	9.4
	19	100.0	16	100.0	16	100.0	34	100.0	31	100.0	116	100.0
Level of Living Index	Manufacturing											
	Beef-Hog			Beef			Milk			Beef		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	6	31.6	3	18.8	4	25.0	5	14.7	4	12.9	22	18.9
10 and over	9	47.4	8	50.0	12	75.0	15	44.1	20	64.5	64	55.2
	4	21.0	5	31.2	0	0.0	14	41.2	7	22.6	30	25.9
	19	100.0	16	100.0	16	100.0	34	100.0	31	100.0	116	100.0

APPENDIX C

TABLE XV

NUMBER AND PERCENT DISTRIBUTIONS FOR DIFFERENT FACTORS BY NET INCOME RANGES,
116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Factor	Net Income Ranges											
	Below \$1000		\$1000-\$1999		\$2000-\$3999		\$4000-\$6999		Over \$7000		Sample	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Age												
29 or less	2	6.1	0	0.0		2.9	1	6.7	1	6.7	5	4.3
30-39	5	15.2	2	10.5	7	20.6	1	6.7	2	13.3	17	14.7
40-49	10	30.3	2	10.5	12	35.3	7	46.7	9	60.0	40	34.5
50-59	10	30.3	6	31.6	8	23.6	4	26.7	2	13.3	30	25.9
60 and older	6	18.1	9	47.4	6	17.6	2	13.2	1	6.7	24	20.6
Total	33	100.0	19	100.0	34	100.0	15	100.0	15	100.0	116	100.0
Education												
6 or less	2	6.0	1	5.3	3	8.8	0	0.0	0	0.0	6	5.2
7-9	10	30.3	10	52.6	12	35.3	3	20.0	3	20.0	38	32.8
10-12	14	42.4	8	42.1	18	52.9	11	73.3	10	66.7	61	52.6
13 and over	7	21.3	0	0.0	1	2.9	1	6.7	2	13.3	11	9.4
Total	33	100.0	19	100.0	34	100.0	15	100.0	15	100.0	116	100.0
Level of Living												
Index												
6 or less	5	15.2	3	15.8	8	23.5	4	26.7	2	13.3	22	18.9
7-9	22	66.6	12	63.2	19	55.9	7	46.6	4	26.7	64	55.2
10 and over	6	18.2	4	21.0	7	20.6	4	26.7	9	60.0	30	25.9
Total	33	100.0	19	100.0	34	100.0	15	100.0	15	100.0	116	100.0

TABLE XV (continued)

Factor	Net Income Ranges											
	Below \$1000		\$1000-\$1999		\$2000-\$3999		\$4000-\$6999		Over \$7000		Sample	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Record Index												
0-1	6	18.2	4	21.0	7	20.6	2	13.3	0	0.0	19	16.4
2-4	21	63.6	11	57.9	20	58.8	11	73.3	8	53.3	71	61.2
5-6	4	12.1	1	5.3	4	11.8	1	6.7	4	26.7	14	12.0
7	2	6.1	3	15.8	3	8.8	1	6.7	3	20.0	12	10.4
Total	33	100.0	19	100.0	34	100.0	15	100.0	15	100.0	116	100.0
Size of Operation												
99 or less	13	39.3	9	47.3	11	32.4	4	26.7	2	13.3	39	33.6
100-199	10	30.3	8	42.1	14	41.1	7	46.6	1	6.7	40	34.5
200-299	5	15.2	1	5.3	5	14.7	3	20.0	4	26.7	18	15.5
300 and over	5	15.2	1	5.3	4	11.8	1	6.7	8	53.3	19	16.4
Total	33	100.0	19	100.0	34	100.0	15	100.0	15	100.0	116	100.0

APPENDIX D

TABLE XVI

NUMBER AND PERCENT DISTRIBUTION FOR DIFFERENT FACTORS BY SIZE OF OPERATION
RANGES, 116 COMMERCIAL FARMS, ELK RIVER WATERSHED, 1967

Factor	Size of Operation					
	Below 100	100-199	200-299	Over 300	Sample	
	Number	Percent	Number	Percent	Number	Percent
Age						
29 or less	2	5.2	2	5.5	0	0.0
30-39	8	20.5	3	16.7	3	15.7
40-49	14	35.8	11	27.5	8	42.1
50-59	6	15.4	16	40.0	4	21.1
60 and over	9	23.0	8	20.0	4	21.1
Total	39	100.0	40	100.0	19	100.0
Education						
6 or less	5	12.8	1	2.5	0	0.0
7-9	17	43.6	13	32.5	6	33.3
10-12	16	41.0	22	55.0	2	10.5
13 and over	1	2.6	4	10.0	13	68.4
Total	39	100.0	40	100.0	4	21.1
					19	100.0
					116	100.0

TABLE XVI (continued)

Factor	Size of Operation									
	Below 100		100-199		200-299		Over 300		Sample Number Percent	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent		
Level of Living										
Index										
6 or less	10	25.6	8	20.0	2	11.1	2	10.5	22	18.9
7-9	24	61.5	24	60.0	11	61.1	5	26.3	64	55.2
10 and over	5	12.9	18	20.0	5	27.8	12	63.2	30	25.9
Total	39	100.0	40	100.0	18	100.0	19	100.0	116	100.0
Record Index										
0-1	7	17.9	7	17.5	3	16.7	2	10.5	19	16.4
2-4	26	66.7	23	57.5	11	61.1	11	57.9	71	61.2
5-6	3	7.7	5	12.5	2	11.1	4	21.1	14	12.0
7	3	7.7	5	12.5	2	11.1	2	10.5	12	10.4
Total	39	100.0	40	100.0	18	100.0	19	100.0	116	100.0
Net Income										
\$999 or less	13	33.3	10	25.0	5	27.8	5	26.3	33	28.5
\$1000-\$1999	9	23.1	8	20.0	1	5.5	1	5.3	19	16.4
\$2000-\$3999	11	28.2	14	35.0	5	27.8	4	21.1	34	29.3
\$4000-\$6999	4	10.3	7	17.5	3	16.7	1	5.3	15	12.9
Over \$7000	2	5.1	1	2.5	4	22.2	8	42.0	15	12.9
Total	39	100.0	40	100.0	18	100.0	19	100.0	116	100.0

APPENDIX E

TRANSCENDENTAL FUNCTION¹

The transcendental function is of the following general form:

$$Y = c x_1^{a_1} e^{b_1 x_1} x_2^{a_2} e^{b_2 x_2} \dots x_n^{a_n} e^{b_n x_n} .$$

The logarithmic form of the function is as follows:

$$\log y = \log c + a_1 \log x_1 + b_1 x_1 \dots a_n \log x_n + b_n x_n .$$

The marginal value product is calculated in the following manner:

$$MVP_{xi} = \hat{Y} \left(\frac{a_i}{x_i} + b_i \right) .$$

TABLE XVII

PRODUCTION FUNCTION COEFFICIENTS AND MARGINAL VALUE
PRODUCTIVITIES AT GEOMETRIC MEANS, 116 COMMERCIAL
FARMS, ELK RIVER WATERSHED, 1967

Input Category	Geometric Mean	Parameter	Marginal Value Product
Land Investment	\$39,930	a_1 -.19641 b_1 .0000004	\$ -.025
Livestock Investment	5,193	a_2 -.054398 b_2 .0000001	-.048
Equipment Investment	4,279	a_3 -.047175 b_3 .0000007	-.022
Building Investment	4,832	a_4 .018424 b_4 .0000063	.252
Unpaid Labor Investment	3,597	a_5 -.036745 b_5 .0000678	-.183

¹A. N. Halter, H. O. Carter and J. G. Hocking, "A Note on the Transcendental Production Function," Journal of Farm Economics, XXXIX (November, 1957), 966-69.

VITA

Hugh Lamar Spangler was born March 24, 1944, in Loudon County, Tennessee, the son of Mr. and Mrs. Hugh Spangler. He was reared on a farm in Greenback and attended Greenback Public School, graduating in May, 1962.

In September, 1962, he entered Tennessee Technological University as a student in the College of Agriculture, majoring in Agricultural Economics. He was awarded the Bachelor of Science Degree in Agriculture in June, 1966. He also received the Agricultural Award from Tennessee Technological University in June, 1966. He was a member of the Tech Aggies, Alpha Gamma Sigma and Delta Tau Alpha.

During the period of 1966-68, he was employed as an Assistant in Agricultural Economics by the Department of Agricultural Economics and Rural Sociology of the University of Tennessee. He is now completing the requirements for the Master of Science Degree in Agricultural Economics.