PRODUCTIVITY OF AGRICULTURAL RESOURCES ON FARMS OF WESTERN MANITOBA

A Thesis

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ABSTRACT

This study was based on the record analysis of 314 observations of farms in the Neepawa-Minnedosa-Hamiota-Miniota area of Western Manitoba. These 314 farms were stratified into three categories: (1) small, medium and large farms of capital less than \$60,000, \$60,000 to \$80,000 and more than \$80,000. Each size contains, 98, 168 and 48 farms respectively; (2) crop and mixed farms with crop production 80 percent or more and crop production less than 80 percent. Fifty-nine and 255 farms were included in each type of farming; (3) farms of 1961, 1962, 1963 and 1964 with 79, 77, 81 and 77 farms falling in each of the years respectively.

It was the general objective of the present study to determine the productivity of resources on these 314 farms and to identify problems of resource allocation, to make a comparison of the productivity of resources on crop and mixed farms, and to evaluate the shifts of farm production during the period from 1961 to 1964.

The Cobb-Douglas functions with general forms as shown below, were fitted to the sets of farm data stratified.

(1) Cobb-Douglas functions involving eight independent variables

$$y = ax_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6} x_7^{b_7} x_8^{b_8}$$

(2) Cobb-Douglas functions involving five independent variables

$$y = ax_1^{b_1} x_2^{b_2} x_9^{b_9} x_7^{b_7} x_8^{b_8}$$

where

y : Output (in dollars)

x_1 : Land (in dollars)

x_2 : Labor (in hours)

x_3 : Building Services (in dollars)

x_4 : Machinery and Equipment Services (in dollars)

x_5 : Cash Operating Expenses (in dollars)

x_6 : Livestock Investment (in dollars)

x_7 : Management (index)

x_8 : Weather (index)

x_9 : Capital (in dollars) $= x_3 + x_4 + x_5 + x_6$

It appeared from the analysis that a surplus of labor and a shortage of capital might generally exist in the studied area. The efficiency of capital might be improved annually from 1961 to 1964 due to such influences of weather conditions, changes in quality of resources including management and the impact of general economic conditions.

ACKNOWLEDGEMENTS

I am deeply indebted to Dr. M. H. Yeh under whose direction the major part of this work was carried out, and also to Dr. Ackerman who took over the supervision of this project in the latter stage. Special thanks go to Professor Harris for his many helpful suggestions. Mr. Neil Longmuir's help in the analysis and computational stage was appreciated.

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CHAPTER I

INTRODUCTION

Great changes in Canadian agriculture have occurred since 1940, from the standpoint of its relative importance in the general economy as well as in its structure.

The relative importance of agriculture has declined, although it has not declined in absolute terms. In the period 1935-39, the annual gross product (GDP) averaged 488 million dollars. By 1962, the total GDP had reached 35,931 million dollars. The value of agricultural products then was four times greater than that in 1935-39; however, it accounted for only 5.5 percent of the total GDP. The annual rate of growth in agriculture in the period 1935-39 has been much less than that in other industries, averaging about 1 percent, as compared with a rate of growth of 4.4 percent in goods producing industries--the smallest rate of growth among the industries other than agriculture--and 4.5 percent in the service industries, 4.7 percent in the commercial industries and of 8 percent in the electric power and gas utilities industries.[1]

The structural changes in agriculture have been tremendous over the last two decades and these changes are taking place continuously. According to the decennial census reports, the number of farms in Canada dropped from 723,858 to 623,091 during the decade ending 1951. This figure was

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[1] Canada Year Book, 1965. (Ottawa, Dominion Bureau of Statistics), p. 440.

down further to 480,903 by 1961. In Manitoba, the number of farms for the corresponding periods dropped from 58,024 to 52,383 and then to 43,306. The numerical acreage of farm land for Canada as a whole remained quite stable from 1941 to 1961 while the total capital investment doubled between 1941 and 1951, and was almost tripled by 1961. In Manitoba, average farm size in terms of acreage almost doubled between 1941 and 1961 and the average capital investment per farm was almost five times greater than it was twenty years ago. Among various forms of capital, machinery and equipment increased most dramatically; the investment per farm has increased over four times since 1941 and the cash expenditures per farm have risen over three times.[2]

In view of these facts, it is evident that capital in such forms as machinery and equipment, commercial fertilizer, concentrates, supplements etc., has been the factor of growing importance in farm operations. Farmers' decisions with respect to an optimum allocation of resources involve the adoption of new technology. Thus additional capital has become required under a situation where the demand for agricultural products has been relatively shrinking.

Because of such increased capital needs and the increased proportion of those that have to be purchased off-farm, farmers must now allocate their scarce resources even more carefully among competing enterprises in their attempts to

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[2] Year Book of Manitoba Agriculture, 1964. (Winnipeg, Manitoba Department of Agriculture and Conservation).

maximize profits. In a rapidly changing economy, farmers are therefore continuously forced to adjust their use of resources.

Western Manitoba, particularly the Neepawa-Minnedosa-Hamiota-Miniota area, is one of the most important farm areas in Manitoba. This study attempts to investigate explicitly the problems faced by farmers of this area by the application of the principles of production economics and with the aid of regression analysis.

Objectives, Hypotheses and Assumptions

Objectives

The general objective of the present study is to determine the productivity of farm resources in the Neepawa-Minnedosa-Hamiota-Miniota area. More specifically,

(1) to estimate the marginal value productivity of the following resources; land, labor, capital and management.

(2) to make a comparison of the productivity of resources on crop and mixed farms.

(3) to measure the change in resource structure of the farms over the studied period.

(4) to evaluate the changes in the on-farm organization during the period 1961-64.

(5) to provide information which may be useful to farmers involved in decision making with respect to an optimal allocation of farm resources.

Hypotheses and Assumptions

In achieving the objectives, the following hypotheses are to be tested:

(1) There exists a surplus of farm labor. During the past two decades from 1941 to 1961 Canadian agricultural labor force has declined about 45 percent while Manitoba's agricultural labor force has declined by 36 percent.[3] These empirical results show that the declining amount of labor force in farm operation was evidently true in Canada as a whole as well as in Manitoba, due to the advances of technology. However, the adjustment of a surplus of farm labor force could be lagging because of a slow response to changes in technology. The traditional and conservative attitudes of farmers, the durable nature of farm assets and the uncertainties and expenses involved in off-farm migration could be some of the reasons.

If these suggested reasons hold true, then the surplus of farm labor could be a general phenomenon and it might be reflected in low productivity of farm labor in the studied area.

(2) There exists a shortage of capital. The adoption of new technology, the mechanization of farm operation and the application of chemical fertilizer and insecticides require a substantial amount of additional capital.

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[3] *Ibid.*, p. 69.

However, certain institutional regulations limit the amount of capital available to agriculture. Some of these are:

(a) In addition to the price uncertainty, farmers are also confronted with yield fluctuations resulting from weather, diseases, and pests.

(b) There is a very close relationship between the household and the firm which makes it difficult to identify the effects of loans on production and consumption decisions.

(3) Management is a significant factor of production.

> 'Management is that part of human endeavor which guides the activities of individuals and organizations.' [4]

It consists of two distinct activities: co-ordination and supervision. Co-ordination is the main element of management when decisions have to be taken in an attempt to fulfill goals under the situation of uncertainty. After the plan of production has been completed, the managerial work is reduced to the work of supervision. The gain or loss of an activity involving uncertainty is closely related to the ability of the manager to make a right prediction.

Managerial ability affects the productivity of other resources. The lower managerial ability is, the

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[4] Vincent, W. H., Economics and Management in Agriculture, (Englewood Cliffs, N. J.: Prentice-Hall, 1962), pp. 10-12.

lower the productivity of other resources will be. The evaluation of the effects of managerial ability on capital might be of particular significance with regard to farm credit policy.

(4) Weather explains a significant part of variations in farm income.

Weather conditions in growing and harvesting seasons of crops had been generally regarded as one of the most important contingencies which cause crop yields' fluctuation from year to year, as well as from place to place.

In Manitoba, the value of crop production increased from 243 million dollars in 1963 to 285 million dollars in 1964. According to a survey conducted by the Manitoba Agricultural Department,[5] the major reason of higher farm incomes in 1964 than in 1963 was due to the more favorable weather prevailing in 1964.

(5) There are increasing returns to scale. This hypothesis is closely allied to the second hypothesis. Because of capital rationing, the entrepreneur may not be able to expand all farm resources in the same proportion.

In order to test the foregoing hypotheses, two assumptions are made for the purposes of this study. They are that

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[5] Year Book of Manitoba Agriculture, 1964. (Winnipeg, Manitoba Department of Agriculture and Conservation), p. 3.

(1) Farmers in the studied area aim at profit maximization.

(2) There is perfect competition in agricultural industry, that is, it "is one made up exclusively of numerous competitors who can sell all they wish at the going market price, but who are unable in any appreciable degree to raise or depress that market price."[6]

Order of Presentation

This study consists of five chapters. The introductory chapter gives a brief discussion of the problematic situation, objectives, hypotheses and assumptions. The theoretical background of this study will be discussed in Chapter II. Chapter III deals with the methodology employed in the study. The evaluation of empirical results and their interpretations will be presented in Chapter IV. The last chapter provides the conclusion and summary.

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[6] Paul A. Samuelson, Economics. (New York, McGraw-Hill Company), Fourth Edition, 1958, p. 454.

CHAPTER II

THEORETICAL BACKGROUND

The Firm

A firm has been defined as:

> "...a technical unit in which commodities are produced. Its entrepreneur (owner and manager) decides how much of and how one or more commodities will be produced, and gains the profit or bears the loss which results from his decision. An entrepreneur transforms inputs into outputs subject to the technical rules specified by his production function. The difference between his revenue from the sale of outputs and the cost of his inputs is his profit, if positive, or his loss, if negative." [1]

According to this definition, a farm is equivalent to a firm from the standpoint of an economic unit alone. The relationship between the quantities of inputs and outputs can be mathematically expressed by a production function.

The Classical Production Function

The characteristics of the classical production function have been described by the economists in terms of laws of return. One of these is the Law of Variable Proportions. The most compact statement of this Law is probably given by John M. Cassels. He stated:[2]

> "If, without change in the methods of production, successive physical units of one factor of production

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[1] Henderson, James M. and Quandt, Richard E., *Microeconomic Theory*. (New York: McGraw-Hill Book Company, 1958), p. 42

[2] John M. Cassels, "On the Law of Variable Proportions", *Readings on the Theory of Income Distribution*, Selected by the Committee of the American Economic Association. (Homewood, Illinois: Richard D. Irwin Inc., 1951), p. 103.

were added to fixed physical quantity of another factor (or constant combination of other factors), the total physical output obtained would vary in magnitude through three distinct phases;

(1) In the first phase, it would increase, for a time at an increasing absolute rate and then at a decreasing absolute rate, but always at a percentage rate greater than the rate of increase of the variable factor, until the final point in this phase was reached at which its rate of increase was exactly equal to the rate of increse of that factor.

(2) In the second phase, it would continue to increase, but at a decreasing absolute rate and at a percentage rate always less than that of the variable factor, until the final point of this phase was reached where the maximum output was attained.

(3) In the third phase, it would decrease, possibly for a time at increasing absolute rate but probably through most of this phase at a decreasing rate, until the final point was reached at which the product was reduced to zero."

The three phases described by the Law are geometrically illustrated in Figure 2.1. The quantity of factor A is taken as constant while increases of factor B are measured along the X-axis and units of output are measured along the Y-axis. The curves of total output, marginal output and average output represent the effects of increasing the applications of the variable factor to the fixed factor. All three curves rise from the origin. At the point M the marginal curve reaches its maximum and directly above it on the total output curve is a point of inflection, S. Up to this point the total-output curve rises at an increasing rate and beyond it the curve rises only at a decreasing rate. At the point D the average-output curve reaches its highest point and is intersected by the marginal curve. At T the

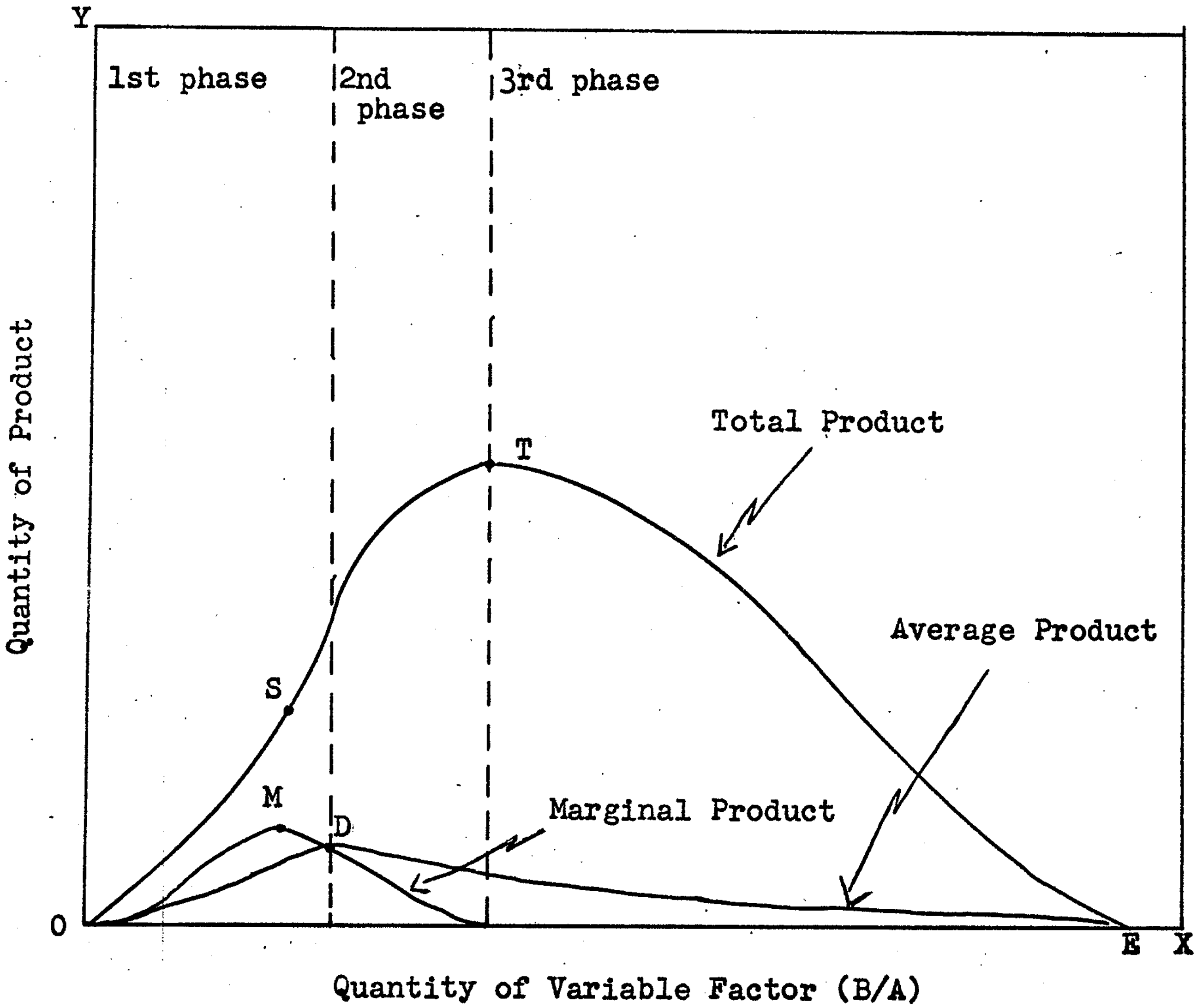

FIGURE 2.1

CLASSICAL PRODUCTION FUNCTION

highest total output is reached and the marginal curve cuts the X-axis at the corresponding level of variable inputs. Beyond this point the total product curve decreases continuously until it meets the X-axis along with the average-output curve at E. A vertical line through D marks the beginning of the second phase and the end of the first in the operation of the Law. The vertical line through T indicates the end of the second phase and the beginning of the third phase.

In the first phase, the proportion of the fixed factor to the variable factor is in such excess that it has the effect of suppressing output while in the third phase, the proportion of the variable factor in relation to the fixed factor is so great that returns are adversely affected. The two phases, I and III, are generally assumed by economists to be technically inefficient. The only economically relevant phase in the operation of the Law is the second. The economically relevant question to be asked here is--how much of variable factors should be used in this second stage, in order to maximize profits of the firm? To answer this question, the choice indicator in form of various price ratios should be introduced, and the equilibrium conditions should be examined.

The Equilibrium of the Firm

Assume a competitive firm whose ultimate end is profit maximization. It produces 'm' commodities by consuming 'n' inputs. Let y_i denote the quantity produced of the ith commodity, x_j the quantity consumed of the jth input, and the technical information of production is summarized by the production function:

$$F(y_1 \ldots\ldots y_m;\ x_1 \ldots\ldots x_n) = 0 \qquad (1)$$

Where equation (1) is assumed to possess continuous first- and second-order partial derivatives which are different from zero for all its solutions.

The entrepreneur desires to earn as high as possible profits subject to the technical rules given by his production function. This purpose can be achieved by the application of Lagrange's Method. The profit function with the restriction of his production function is shown in equation (2):

$$\pi = \sum_{i=1}^{m} p_i y_i - \sum_{j=1}^{n} q_j x_j - kF(y_1 \ldots\ldots y_m;\ x_1 \ldots\ldots x_n) \qquad (2)$$

Where $\sum_{i=1}^{m} p_i y_i$, $\sum_{j=1}^{n} q_j x_j$ are total revenue and total cost of the firm respectively. 'k' is the Lagrange Multiplier. The profit of the firm will be maximized if the set of first partial derivatives of equation (2) equals zero and if it satisfies the second order condition of maximization problem. The set of first partial derivatives is shown in the following equations:

$$\frac{\partial \pi}{\partial y_i} = p_i - kF_i = 0 \qquad (3)$$

$$\frac{\partial \pi}{\partial x_j} = q_j - kF_j = 0 \qquad (4)$$

$$\frac{\delta H}{\delta k} = F(y_1 \ldots\ldots y_m;\ x_1 \ldots\ldots x_n) = 0 \qquad (5)$$

Where $F_i = \frac{\delta F}{\delta y_i}$, is the partial derivative of production function with respect to product y_i. $F_j = \frac{\delta F}{\delta x_j}$, is the partial derivative of production function with respect to x_j.

The information implicit in equations (3), (4) and (5) can be summarized as follows:

$$\frac{\frac{\delta F}{\delta y_i}}{p_i} = \frac{\frac{\delta F}{\delta x_j}}{q_j} = \frac{1}{k} \qquad (6)$$

By simple operation, equation (6) leads to following results which define the first order conditions of equilibrium of the firm:

$$\frac{q_j}{p_i} = \frac{\delta y_i}{\delta x_j} \qquad (A)$$

$$\frac{q_{j1}}{q_{j2}} = \frac{\delta x_{j2}}{\delta x_{j1}} \qquad (B)$$

$$\frac{p_{i1}}{p_{i2}} = \frac{\delta y_{i2}}{\delta y_{i1}} \qquad (C)$$

These three conditions could be stated in Hicksian terminology[3] as follows:

(A) "The price-ratio between any factor and any product must equal the marginal rate of transformation between the factor and the product."

(B) "The price-ratio between any two factors must

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[3] J. R. Hicks, Value and Capital. (Oxford: Clarendon Press), Second Edition, 1961. p. 86.

equal their marginal rate of substitution."

(C) "The price-ratio between any two products must equal the marginal rate of substitution between the two products."

The second-order conditions for the maximization of profit require that the conditions of Hessian Determinant must hold. This has been demonstrated by Henderson and Quandt.[4] Actually, it could be a mathematical expression of the stability conditions as stated by Hicks.[5] The three stability conditions as stated by Hicks are:

(A) "For the transformation of a factor into a product we shall have the condition of diminishing marginal rate of transformation or diminishing marginal product."

(B) "For the substitution of one factor for another, we shall have the condition of diminishing marginal rate of substitution."

(C) "For the substitution of one product for another, we shall have a condition of increasing marginal rate of substitution."

These conditions imply the rational phase of production. Geometrically, the equilibrium position of production could only be found in the portion of, input-output transformation curve which is convex upward from the horizontal axis, the iso-quant curve which is convex to the origin and the production possibility curve which is concave to the origin.[6]

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[4] Henderson, James M., and Quandt, Richard E., Microeconomic Theory. (New York: McGraw-Hill Book Company, 1958), p. 54.

[5] Hicks, J. R., Value and Capital. (Oxford: Clarendon Press), Second Edition, 1961. p. 87.

[6] Henderson, James M., and Quandt, Richard E., Microeconomic Theory. (New York: McGraw-Hill Book Company, 1958), p. 51.

All the maximization conditions could be summarized into three types of factor-product relationships. They are: (1) factor-product relationship, (2) factor-factor relationship and, (3) product-product relationship.

Factor-Product Relationship

Assume a competitive firm producing 'm' commodities by employing 'n' factors. The general production function is given as:

$$F(y_1 \ldots\ldots y_m;\ x_1 \ldots\ldots x_n) \qquad (1)$$

The production function of a specific product y_1 then may be written explicitly as:

$$y_1 = G(y_2 \ldots\ldots y_m;\ x_1 \ldots\ldots x_n) \qquad (7)$$

The output of product y_1 depends on the quantity of input of the variable services $x_1 \ldots\ldots x_n$, as well as the outputs of its joint products $y_2 \ldots\ldots y_m$. Assuming all the productive service but x_1, and all the products other than y_1 are fixed at a certain level, the production function (7) gives the input-output relationship of y_1 to x_1. Figure 2.2 shows this relationship. The transformation curve AC is drawn convex upward indicating diminishing marginal product--the rational stage of production. ZZ' is the price line. It shows the ratio of price of variable service x_1 to the price of product y_1, that is $\frac{p_1}{q_1}$. According to the first condition of equilibrium, the price ratio between any factor and any product must equal the marginal rate of transformation between the factor and the product. This condition is

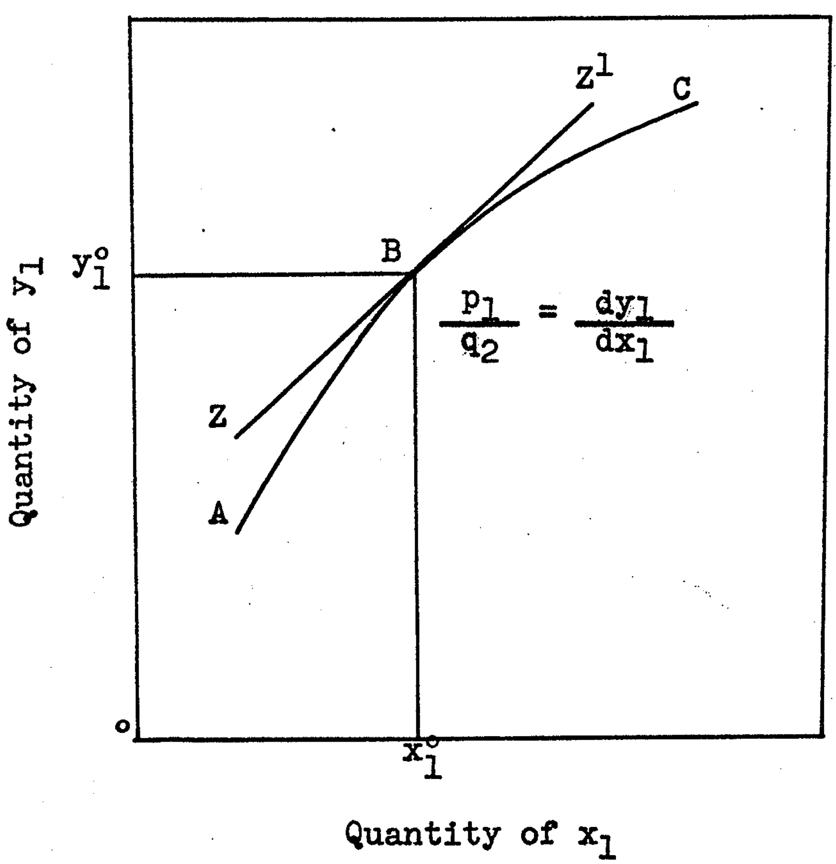

FIGURE 2.2

THE EQUALITY OF PRICE RATIO AND MARGINAL RATE OF TRANSFORMATION IN EQULIBRIUM identified by the tangency of price line to the transformation curve at point B as shown in Figure 2.2. The co-ordinates of B are x_1^o, y_1^o, which specify the optimum level of variable service x_1 and optimum amount of product y_1 respectively.

Factor-Factor Relationship

The production function of a firm which produces one product y_1 by using two variable productive services x_1 and x_2 may be written as:

$$y_1 = H(x_1, x_2) \qquad (8)$$

The iso-quant function can be derived from equation (8) and may be written in the following equation:

$$x_2 = I(x_1/y_1^o) \qquad (9)$$

Equation (9) shows that a given amount of output y_1^o can be produced from all combinations of two inputs x_1 and x_2. This iso-quant curve, AC, is shown in Figure 2.3. AC has a downward slope and is drawn convex to the origin indicating that the production is in the rational stage. The rate of substitution between factors x_1 and x_2 is diminishing. ZZ' is iso-cost line defined as $C^o = p_1x_1 + p_2x_2$. Its slope is the negative price ratio of factor x_1 to x_2, that is $-\frac{p_1}{p_2}$. According to the second price condition of equilibrium, the price ratio between any two factors must inversely equal their marginal rate of substitution. This condition holds as long as the iso-cost line is tangent to the iso-quant curve. In Figure 2.3, the iso-cost line ZZ' is tangent to the iso-quant curve AC at point B where it shows the optimum

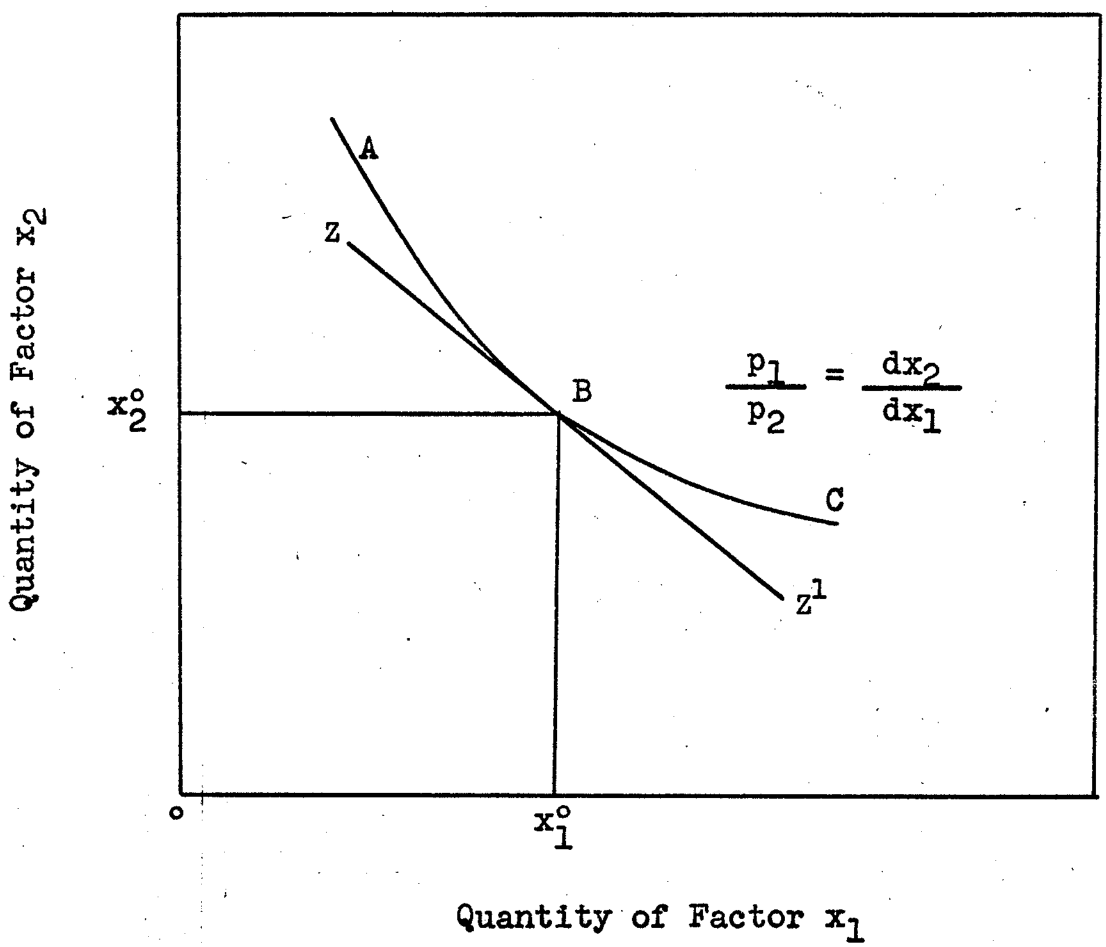

FIGURE 2.3

THE EQUALITY OF PRICE RATIO AND MARGINAL RATE OF SUBSTITUTION BETWEEN FACTORS IN EQUILIBRIUM quantities of x_1 and x_2 should be employed in order to produce that given amount of output y_1^o.

Product-Product Relationship

For a firm which produces two commodities with a given set of productive resources 'R', the production function may be written as:

$$J(y_1, y_2, R) = 0 \tag{10}$$

If the firm allocates a given amount of resources to produce both products, y_1 and y_2, the relationship of these two products derived from equation (10) could be identified by the following function:

$$y_2 = K(y_1/R) \tag{11}$$

Equation (11) is a production possibility function representing all combinations of y_1 and y_2 which could be derived from a given amount of factor inputs. This function is represented by curve AC in Figure 2.4. The production possibility curve AC is drawn concave to the origin and is negative in slope indicating that the technical rates of substitution between y_1 and y_2 are increasing and their production is competitive in nature. ZZ' is an iso-revenue line defined as: $r^o = q_1y_1 + q_2y_2$. The slope of line ZZ' is negative and is represented by the negative price ratio of product y_1 to product y_2; i.e., $\frac{q_1}{q_2}$. The condition of profit maximization can be identified by the tangency of the iso-revenue line (ZZ') and the production possibility curve (AC) specifies that the optimum quantities of products

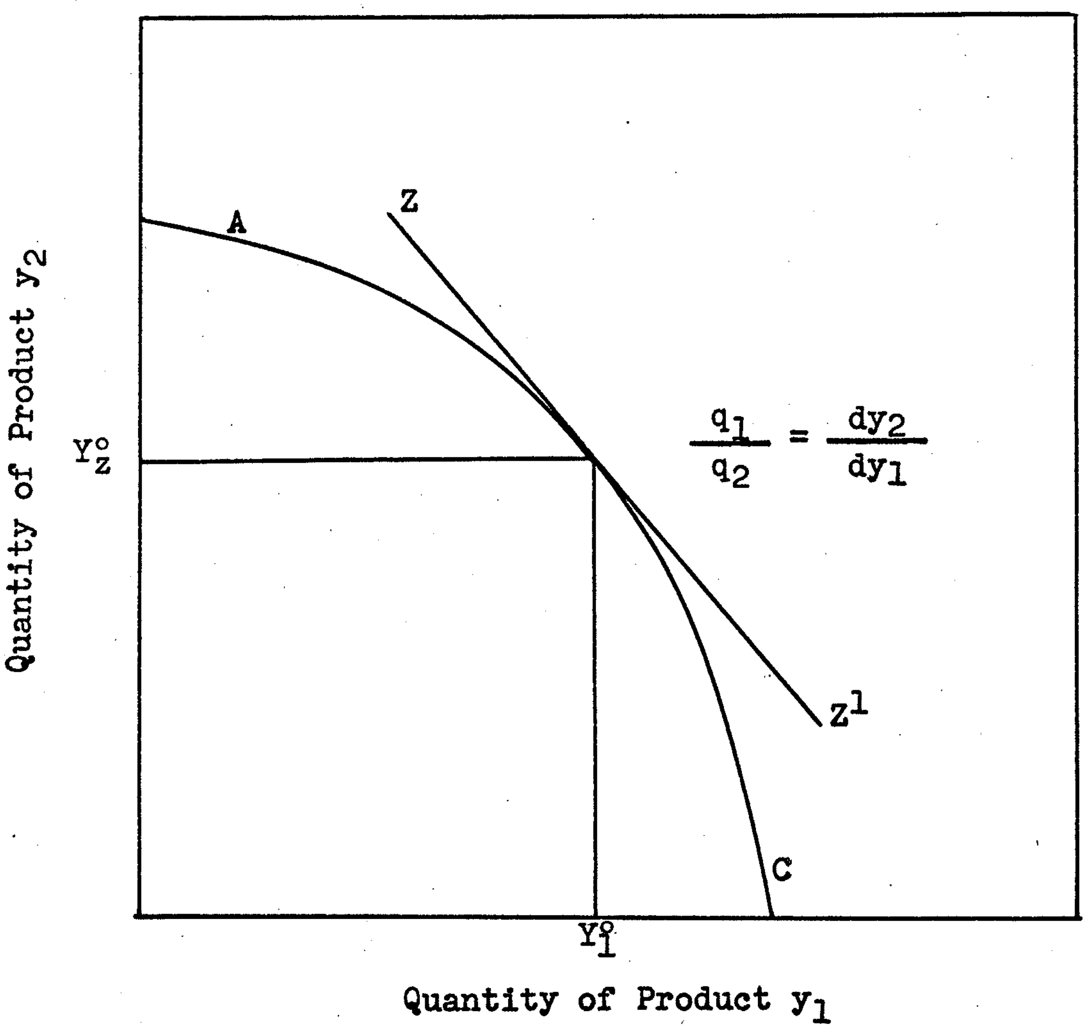

FIGURE 2.4

THE EQUALITY OF PRICE RATIO AND MARGINAL RATE OF SUBSTITUTION BETWEEN PRODUCTS IN EQUILIBRIUM

y_1 and y_2 should be produced respectively, with a given amount of resources, R.

The Returns to Scale

The discussion so far dealt with has emphasized the production relationships and the equilibrium of the firm in the short run. However, in the long run, the firm is able to adopt the 'scale' of operations to produce any output in the most possible efficient way. Scale relationship is concerned with the product-factor relationship when all factors change simultaneously. This could be defined thus: given an increase in all factor inputs by a certain percentage, if the output increases by same percentage, constant returns to scale holds true. If the output increases by a smaller or greater percentage, then increasing or decreasing returns to scale holds true. In terms of elasticity of production, if the summation of the elasticity of each individual factor equals one, constant returns to scale exists. If it is greater or less than one, increasing or decreasing returns to scale exists respectively.

The Cobb-Douglas Production Function

In this study regression analysis is employed in estimating the production functions which represent the production patterns of the studied area. The Cobb-Douglas type of function is assumed to be applicable to the farm data studied. It is an exponential equation in natural form and linear in logarithm. In natural form, the function is written as follows:

$$y = ax_1^{b_1} x_2^{b_2} x_3^{b_3} \ldots\ldots x_n^{b_n} e$$

In logarithm, it is written as:

$$\log y = \log a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + \ldots$$
$$\ldots + bn \log x_n + \log e$$

Wherein both of the equations y is the dependent variable representing the quantity of output; $x_1, x_2, x_3 \ldots\ldots x_n$ are independent variables measuring the inputs of factors of production; 'a' is a constant; $b_1, b_2, b_3 \ldots\ldots b_n$ are the elasticities of the dependent variable with respect to their corresponding independent variables $x_1, x_2, x_3 \ldots\ldots x_n$; and e is the random residuals.

Some of the characteristics of the Cobb-Douglas function are as follows:

(1) It assumes constant elasticity of production over all range of input.

(2) It allows increasing, constant, or decreasing marginal productivity.

(3) It allows both complementarity and substitution between variables.

(4) It assumes constant rate of substitution between variables for all yield, if the same proportions of resources are used.

CHAPTER III

THE METHODOLOGY

The Source of Data

The agricultural area of this study was located in the Neepawa-Minnedosa-Hamiota-Miniota area of Western Manitoba. The land was classified as well-drained or intermediate drained Newdale Undulating Soil and has been recognized as the best crop land available in Manitoba. General farming may be described as mixed-farming in which grain crops and beef cattle are the most common enterprises.

The data was collected from 314 annual farm records[1] covering the years from 1961 to 1964. These farms were stratified into small, medium, and large units on the basis of their capital situation. Those farms with total capital (owned and rented) less than $60,000 were defined as small units, those with capital ranging from $60,000 to $80,000 as medium units, and those with more than $80,000 were classified as large farms. There are 98, 168 and 48 farms in each of the three groups, respectively.

For the purpose of making a comparison of crop and mixed farming, the 314 farms were again stratified into two groups according to their sources of income. Those farms with 80 percent or more of their gross income derived from

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[1] The records are kept by the members of the Western Manitoba Farm Business Association, Department of Agricultural Economics & Farm Management, University of Manitoba.

crops were taken as crop farms, those with less than 80 percent of their gross income from crops were regarded as mixed farms. Each group has 59 and 255 farms, respectively.

For inter-year comparison, the annual farm business was analyzed covering the years of 1961, 1962, 1963 and 1964. Among 314 individual farms, 79 farm records were for 1961; 77 for 1962; 81 for 1963, and 77 for 1964.

General Aspects of the Studied Area

The Utilization of Land

The average farm size of the farms studied in the area was 709 acres of which improved acres accounted for 65 percent and the remainder was unimproved. Wheat, oats, barley, flax and rye or mixed grain were seeded nearly one-half of the area improved. Summer-fallow and new breaking occupied about 33 percent of the improved acres.

The average size of the small, medium and large farms was 505, 688 and 1,207 acres, respectively. The percentage distribution of improved and unimproved acres in different size of farms were quite the same. (Table 3.1)

The average farm size of crop farming was 811 acres. It was about 124 acres larger than mixed farming. Of total acres, 68 percent was improved on crop farm as compared to 64 percent on mixed farm. Cereal crops and summer-fallow constituted a large portion in both types of farming. However, they accounted for a greater proportion in crop farming than in mixed farming. (Table 3.2)

TABLE 3.1

UTILIZATION OF LAND ON SAMPLE FARMS BY SIZE

Land Utilization	Small Average Per Farm	Small % of Total	Medium Average Per Farm	Medium % of Total	Large Average Per Farm	Large % of Total	Average Average Per Farm	Average % of Total
	Acres		Acres		Acres		Acres	
Cereal Crops	162	51.1	240	52.4	416	53.2	241	55.4
Special Crops	2	0.6	2	0.4	11	1.4	3	.6
Annual Feed Crops	1	0.3	3	0.7	14	1.8	4	.9
Tame Hay and Grain Silage	34	10.7	48	10.5	65	8.3	47	10.2
Improved Pasture	10	3.2	15	3.3	20	2.6	14	3.0
Summer-fallow and New Breaking	108	34.1	150	32.7	255	32.7	153	33.1
Total Improved Land	317	100.0 (62.8)	458	100.0 (66.6)	781	100.0 (64.7)	462	100.0 (65.2)
Total Unimproved Land	188	37.2	230	33.4	426	35.3	247	34.8
Total Land	505	100.0	688	100.0	1,207	100.0	709	100.0

TABLE 3.2

UTILIZATION OF LAND ON SAMPLE FARMS BY TYPE OF FARMING

Land Utilization	Value of Crop Prod. "80% or More"* Average Per Farm Acres	% of Total	Value of Crop Prod. "Less than 80%"* Average Per Farm Acres	% of Total
Cereal Crops	307	55.4	227	51.3
Special Crops	11	1.4	6	1.1
Annual Feed Crops	14	1.8	1	0.2
Tame Hay and Grain Silage	29	5.2	51	11.5
Improved Pasture	8	1.4	16	3.6
Summer-fallow and New Breaking	203	36.7	141	32.0
Total Improved Land	554	100.0 (68.3)	442	100.0 (64.3)
Total Unimproved Land	257	31.7	245	35.7
Total Land	811	100.0	687	100.0

* Value of Crop Prod. "80% or More" farms are those with 80% of gross income from crops, while Value of Crop Prod. "Less than 80%" are farms with less than 80% of gross income from crops. The latter have livestock as a relatively more important enterprise than the former.

There was no significant difference in land utilization among years of 1961, 1962, 1963 and 1964 except the general tendency shows that acreages for cereal crops in terms of percentage were increasing, while acreages for summer-fallow and new breaking were declining. (Table 3.3)

Resource Structure and Farm Business Organization

As shown in Table 3.4, the average polyperiodic investment of a farm in the studied area was nearly 45 thousand dollars. Among all forms of investment, land, in terms of value, accounted for 43 percent, and was the most important investment in the farm business. Investment in farm machinery accounted for 27 percent and the remaining 30 percent of total investment was for farm buildings and livestock.

The monoperiodic capital on the sample farms averaged 5,824 dollars, of which over one-half was for machinery and equipment services and 39 percent incurred for cash operating expenses on crop, livestock and miscellaneous services.

Hours of labor worked on a farm in the studied area was 2,840, on an annual average. The ratios of labor-land and capital-land show that four hours of directly productive labor work and 8.2 dollars were invested on an acre of land annually. Furthermore, the capital-labor ratio indicates that one hour of labor usually was associated with $2.1 of capital in farming operation.

On the overall average, 63.5 percent of total farm

TABLE 3.3

UTILIZATION OF LAND ON SAMPLE FARMS BY YEAR

Land Utilization	1961 Average Per Farm Acres	1961 % of Total	1962 Average Per Farm Acres	1962 % of Total	1963 Average Per Farm Acres	1963 % of Total	1964 Average Per Farm Acres	1964 % of Total
Cereal Crops	221	49.5	236	52.4	245	52.3	264	55.0
Special Crops	4	.9	0	.0	3	.6	5	1.0
Annual Feed Crops	4	.9	3	.7	3	.6	5	1.0
Tame Hay and Grain Silage	44	9.8	44	9.8	48	10.2	50	10.4
Improved Pasture	17	3.8	14	3.1	13	2.8	13	2.7
Summer-fallow and New Breaking	157	35.1	153	34.0	157	33.5	143	29.9
Total Improved Land	447	100.0 (64.1)	450	100.0 (66.5)	469	100.0 (62.7)	480	100.0 (68.1)
Total Unimproved Land	250	35.9	227	33.5	279	37.3	225	31.9
Total Land	697	100.0	677	100.0	748	100.0	705	100.0

TABLE 3.4

INPUTS OF RESOURCES AND VALUE OF FARM OUTPUTS
ON SAMPLE FARMS BY SIZE

	Small		Medium		Large		Average	
	Average Per Farm	% of Total	Average Per Farm	% of Total	Average Per Farm	% of Total	Average Per Farm	% of Total
Capital Inputs($)								
Polyperiodic								
Adj. Land Value	12,584	47.4	19,588	42.7	32,568	41.1	19,380	43.4
Bldg. Investment	3,110	11.7	5,486	12.0	8,392	10.6	5,167	11.6
Mach. Investment	6,519	24.6	12,554	27.4	23,036	29.0	12,049	27.0
Lvstk. Investment	4,311	16.3	8,200	17.9	15,322	19.3	8,030	18.0
Total	26,524	100.0	45,828	100.0	79,318	100.0	44,626	100.0
Monoperiodic								
Bldg. Services	349	9.6	472	6.0	942	9.2	505	8.7
Mach. Services	1,890	52.1	2,963	37.4	5,439	53.3	3,009	51.7
Crop Services	485	13.4	3,075	38.8	1,797	17.6	951	16.3
Lvstk. Services	595	16.4	996	12.6	1,319	12.9	933	16.0
Misc. Services	306	8.5	416	5.2	712	7.0	426	7.3
Total	3,625	100.0	7,922	100.0	10,209	100.0	5,824	100.0
Labor Inputs(Hrs.)	2,130		2,890		4,100		2,840	
Capital*/Labor Ratio	1.7		2.7		2.5		2.1	
Labor/Land* Ratio	4.2		4.2		3.4		4.0	
Capital*/Land* Ratio	7.2		11.5		8.5		8.2	
Value of Outputs								
Value of Crop Prod.	5,010	55.3	9,765	62.9	17,501	68.9	9,469	63.5
Value of Lvstk. Prod.	4,047	44.7	5,761	37.1	7,892	31.1	5,451	36.5
Total	9,057	100.0	15,526	100.0	25,393	100.0	14,920	100.0

* Capital indicates monoperiodic capital investment. Land in terms of acreage.

income was derived from crop enterprise and 36.5 percent was from livestock production.

There were an increasing amount of polyperiodic and monoperiodic capital being invested on small, medium and large farms. In all cases, land, machinery and equipment were the most important forms of capital. On the average, 4.2, 4.2 and 3.4 hours of labor, and $7.2, $11.5 and $8.5 of annual capital were invested on an acre of land of small, medium and large farms respectively. These indicated that labor was used intensively and land extensively on small farms and that capital was used intensively on medium and large farms.

Table 3.5 shows the inputs of resources and value of farm outputs on sample farms by type of farming. There was no significant difference in the amount of polyperiodic capital invested on crop and mixed farms. Land and machinery investments were the most important investments in both types of farming. Livestock investment on mixed farm accounted for 20 percent whereas it constituted only 9 percent on crop farm.

There was a much higher monoperiodic investment on mixed farms than on crop farms. Machinery, livestock and miscellaneous services were the major annual capital inputs for the former whereas machinery and crop services constituted the largest portion for the latter.

By comparison of the labor-land and capital-land ratios of two types of farms, it was noted that both labor hours and annual capital in forms of building, machinery and equipment

TABLE 3.5

INPUTS OF RESOURCES AND VALUE OF FARM OUTPUTS ON SAMPLE FARMS BY TYPE OF FARMING

	Value of Crop Prod. 80% or More		Value of Crop Prod. Less than 80%	
	Average Per Farm	% of Total	Average Per Farm	% of Total
Capital Inputs($)				
Polyperiodic				
Adj. Land Value	23,462	51.6	18,436	41.2
Bldg. Investment	4,177	9.2	5,396	12.1
Mach. Investment	13,745	30.2	11,932	26.7
Lvstk. Investment	4,092	9.0	8,941	20.0
Total	45,476	100.0	44,705	100.0
Monoperiodic				
Bldg. Services	449	7.6	518	5.4
Mach. Services	3,317	56.5	2,937	30.7
Crop Services	1,389	23.6	849	8.9
Lvstk. Services	263	4.5	1,088	11.4
Misc. Services	460	7.8	4,175	43.6
Total	5,878	100.0	9,567	100.0
Labor Inputs(Hrs.)	2,020		3,030	
Capital/Labor Ratio	2.9		3.2	
Labor/Land Ratio	2.5		4.4	
Capital/Land Ratio	7.2		13.9	
Value of Outputs				
Value of Crop Prod.	12,784	88.8	8,702	57.9
Value of Lvstk. Prod.	1,608	11.2	6,340	42.1
Total	14,392	100.0	15,042	100.0

services and cash operating expenses invested on per acre of land were lower on the crop farms than those on the mixed farms.

Table 3.6 shows the inputs of resources and value of farm outputs in the years of 1961, 1962, 1963, and 1964. Both polyperiodic and monoperiodic capital investments were increasing during this four-year period. As that table shows, while the labor-land ratio was decreasing, the capital-land ratio was increasing. This fact might indicate that in the studied area, capital, in forms of machinery and equipment, chemical fertilizer, concentrates etc., has been in the process of substituting for labor. Another particular feature was that the (increasing) percentage of crop production from 50 to 70 percent of the total value of production during 1961 - 64 period. This indicates, on the average, that crop enterprise has become relatively more important in the studied area.

The Method of Analysis

The Models

The Cobb-Douglas functions were fitted to each of the groups of farm data and the total which combines 314 farms representing the general or average production situation over the period of four years from 1961 to 1964.

The independent variables in the production function or the factor inputs of production are categorized by grouping close complements or close substitutes together. The

TABLE 3.6

INPUTS OF RESOURCES AND VALUE OF FARM OUTPUTS
ON SAMPLE FARMS BY YEARS

	1961		1962		1963		1964	
	Average Per Farm	% of Total	Average Per Farm	% of Total	Average Per Farm	% of Total	Average Per Farm	% of Total
Capital Inputs($)								
Polyperiodic								
Adj. Land Value	18,130	46.0	19,030	43.1	20,252	42.9	20,098	41.3
Bldg. Investment	4,502	11.4	4,972	11.3	5,422	11.5	5,775	11.9
Mach. Investment	10,784	27.4	11,746	26.6	12,597	26.7	13,984	28.7
Lvstk. Investment	5,964	15.2	8,381	19.0	8,932	18.9	8,849	18.1
Total	39,380	100.0	44,129	100.0	47,203	100.0	48,706	100.0
Monoperiodic								
Bldg. Services	498	9.3	547	9.7	492	8.2	486	7.7
Mach. Services	3,021	53.4	3,094	51.9	3,185	50.3	3,009	51.7
Crop Services	605	11.3	845	14.9	1,059	17.8	1,297	20.5
Lvstk. Services	1,114	20.8	836	14.8	898	15.1	880	13.9
Misc. Services	397	7.4	405	7.2	423	7.0	478	7.6
Total	5,352	100.0	5,654	100.0	5,966	100.0	6,326	100.0
Labor Inputs(Hrs.)	3,370		3,290		2,290		2,410	
Capital/Labor Ratio	1.6		1.7		2.6		2.6	
Labor/Land Ratio	4.8		4.9		3.1		3.4	
Capital/Land Ratio	7.7		8.4		8.0		9.0	
Value of Outputs								
Value of Crop Prod.	5,980	50.3	10,421	65.1	9,690	65.0	11,863	69.9
Value Lvstk. Prod.	5,902	49.7	5,591	34.9	5,211	35.0	5,101	30.1
Total	11,882	100.0	16,012	100.0	14,901	100.0	16,964	100.0

complementarity and substitutability between inputs can be figured out by using a simple correlation test. Resources are complements when the correlation coefficient is zero or greater while resources are substitutes when the correlation coefficient is negative. The statistical test of simple correlations between variables is presented in Appendix I.

The general form of production functions used in the present study, broken into different categories of independent variables, are shown in the following equations:

(1) Production functions involving eight independent variables

$$y = ax_1^{b1}\ x_2^{b2}\ x_3^{b3}\ x_4^{b4}\ x_5^{b5}\ x_6^{b6}\ x_7^{b7}\ x_8^{b8}$$

(2) Production functions involving five independent variables

$$y = ax_1^{b1}\ x_2^{b2}\ x_9^{b9}\ x_7^{b7}\ x_8^{b8}$$

Where

y : output

x_1 : land

x_2 : labor

x_3 : building services

x_4 : machinery and equipment services

x_5 : cash operating expenses

x_6 : livestock investment

x_7 : management

x_8 : weather

x_9 : capital

Definitions of Variables

Output (y) is measured by the total values of farm production. The production of each farm was derived from the outputs of two major enterprises, the crop and livestock enterprises. Value of crop production was derived from the yields and grade of each crop estimated by farmers and prices assessed in the office of the Farm Business Association.[2]

Value of livestock production was the sale of livestock and livestock products plus increase or minus decrease in inventory minus livestock purchases.

Land Input (x_1) is measured by land assessment value, which was obtained from the Municipal Assessment Office. It measures not only the quantity, but also the quality of the land.[3] However, it has been almost fifteen years since its determination in 1951. During this period, the general price level increased substantially and the dollar value depressed accordingly. The marginal productivity of all resources will inevitably be biased if the assessment value were employed directly in our regression. To be unbiased in estimation of the productivity of resources, the original assessment values have to be adjusted to current dollar

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[2] Methods, Procedures and Order of Tasks for Farm Business Association Account Books. Department of Agricultural Economics, University of Manitoba, 1964, p. 5.

[3] Ludwig Auer, "Productivity of Resources on Farms in the Newdale-Hamiota Area of Manitoba",(Unpublished Master's Thesis, University of Manitoba, Winnipeg, 1959), p. 53.

values. For our analysis, the adjustment would be to double the original land assessment value. This procedure has been justified by Ludwig Auer.[4]

Labor (x_2) is measured in 'work units'. A work unit is equivalent to 10-hours of the directly productive work usually associated with a crop or a livestock program.

The directly productive works on a crop program may be the cultivation of land, seeding, fertilizer application, insecticide spraying, grain harvesting, etc., and on livestock programs it may be the feed preparation, feeding, breeding, etc. Time spent on fence fixing, building repairs, livestock transportation, etc., has been regarded as indirectly productive work and was not taken into account.

In the production function analysis the labor input has generally been measured in months available. If the input components in the production analysis should measure the amount of resource service used up in the production process, this method of measurement would overestimate labor input and would, therefore, underestimate the marginal productivity of labor resource. Work unit is preferred in the present study because it measures the actual labor service used up in the production.

Farm building service in dollars (x_3) is made up of depreciation and repairs.

Farm machinery and equipment services (x_4) are the sum

[4] Ibid., p. 26.

of depreciation and current machinery expenses such as gas, oil, grease, repairs, license, insurance, etc. The personal share of car expenses has been excluded.

Cash operating expenses (x_5) are made up of three categories : (1) Crop expenses--including fertilizer purchased, chemical spray, seed treatment, seed purchased, crop custom work, crop and hail insurance, etc. (2) Livestock expenses--including purchased feed, supplements, salt, mineral, veterinary and medicine etc. (3) Farm overhead expenses--including two-thirds of total expenditure on hydro, telephone, fire insurance, etc. (One-third of these expenses is considered to be the share of personal expenditures and therefore has been excluded from business expenditures).

Livestock investment (x_6) is taken as a 5 percent of the average of the beginning and end livestock inventory.

Capital (x_9) is total annual capital input including building services (x_3), machinery and equipment services (x_4), cash operating expenses (x_5) and livestock investment (x_6).

Managerial ability (x_7). The importance of management as a factor of production has been widely accepted. Attempts to measure management have been made in the past. In 1925 Bennett measured the management statistically by proposing the ratio 'Net Returns Over Farm Expenses' as an index of the individual farmer's managerial ability.[5] The validity

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[5] M. K. Bennett, "A Method of Measuring Managerial Ability in Farming", Journal of Farm Economics, VII, 3 (July, 1925), p. 347-358.

of the ratio can be questioned because the numerical value of this ratio is a function of not only managerial ability but also other factors of production and it would be also affected by the differences of price and weather conditions experienced by individual farmers.

Pond and Ezekiel took a new approach to measure the elements of managerial ability in 1930.[6] In this particular study, attributes of dairy management were set up according to the subjective judgment of the investigators. Some of the attributes are listed here:

1. Providing suitable barn conditions.
2. Supplying a variety of rations.
3. Keeping production records.
4. Displaying interest in dairy cows.
5. Practising regularity in care.
6. Showing a liking for the dairy business.

All farmers in the dairy enterprise survey were scored for each one of the attributes. Accordingly, the quality of management on each farm was classified as good, fair, unsatisfactory, or poor. In investigating the attributes listed above, it could be argued that the management in this study could reflect the farmer's qualities of 'supervision' rather than his qualities of co-ordination. Since most economists have accepted that co-ordination is a main task

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[6] G. A. Pond and M. Ezekiel, "Factors Affecting the Physical and Economic Cost of Butterfat Production in Pine Country, Minnesota". Minnesota Agricultural Experiment Station 270, 1930.

of an entrepreneur, the study of Pond and Wilcox in 1932[7] and the study of Glenn L. Johnson in 1955[8] have dealt with the problem of determining the elements of management in the light of the process of decision making or co-ordination. However, no scale for measuring managerial ability was developed.

In view of the importance of management as a factor of production and the shortcomings of other studies, in the present study a new approach in evaluating the elements of managerial ability was taken. It might be described as a combination of the approaches mentioned. Managerial ability in the present study is measured in terms of indexes. It takes into account both objective and subjective factors in its determination. The analysis of the management data was based upon two stages. Firstly, a set of indexes was derived on an objective basis. Secondly, the set of derived indexes was adjusted by a subjective evaluation.

The managerial index was defined as:

$$\frac{\text{Net Farm Income}}{\text{Beginning Net Worth}} \times 100\%$$

where the net farm income is the value of farm production less cost of farm production. It measures the returns to the

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[7] G. A. Pond and W. W. Wilcox, "A Study of the Human Factor in Farm Management", Journal of Farm Economics, XIV (July, 1932).

[8] Glenn L. Johnson, "The Friedman-Savage Utility Hypothesis in the Interstate Managerial Study", Journal of Farm Economics, XXXVII (December, 1955), p. 1110-1114.

operator and family for their labor, management and capital. Net worth is the total amount of assets owned less the amount of all liabilities owing. As a consequence, this ratio measures the returns to the operator and family for their labor, management and capital per dollar of the entrepreneur's investment expressed as a percentage.

The indexes were calculated for each of the sample farms and for each of the years from 1961 to 1964. Assuming no significant changes in managerial ability for the four-year period, the average of the four years' indexes of each individual farm was taken as the statistical measure of his managerial ability.

We may classify the quality of management in accordance with these statistical indexes as shown in Table 3.7.

TABLE 3.7

FREQUENCY DISTRIBUTION OF MANAGERIAL ABILITY ON SAMPLE FARMS BASED ON ORIGINAL OBJECTIVE INDEXES

Management Groups	Management Indexes	Frequency Distribution
Top	41 & over	9
Good	31 - 40	4
"Above Average"	21 - 30	49
"Below Average"	11 - 20	145
Poor	1 - 10	107
Total		314

For the subjective evaluation, the following factors were considered such as the degree of alertness, intelligence, technical knowledge, "drive", and the ability of decision-maker functioning in the context; i.e., in the light of the opportunities open to him for using his managerial ability. Accordingly, the sample farmers were classified into five groups: top, good, "above average", "below average", and poor management. Jerry Ackerman, Fieldman of the Western Manitoba Farm Business Association, has weighed individually the ability of the sample farmers, who are members of the Association. His subjective evaluation was relied on because, as a farm management specialist, he has been working with the farmers for several years and knows each individual farmer personally.

Regarding the objectively arrived indexes as a framework, necessary adjustments were made with reference to the subjectively arrived evaluation. If the computed index of a particular farm was low and fell in the "above average" group, but the entrepreneur was subjectively evaluated as a good farmer, the computed index would be adjusted in favor of the subjective evaluation. For example, a farmer with an objective index of 24 should be considered as an "above average" manager. Yet, this particular farm operator was subjectively classified into the 'good' management group, as he is a maker of opportunities rather than being a conservative or about to develop as is typical of the "above average" group. As a consequence, the index of this farm was raised from 24 to 34 and was thereby classified as a 'good' farm manager.

The frequency distribution of managerial ability of sample farms after adjustments is shown in Table 3.8.

TABLE 3.8

FREQUENCY DISTRIBUTION OF MANAGERIAL ABILITY ON SAMPLE FARMS BASED ON THE ADJUSTED INDEXES

Management Groups	Management Indexes	Frequency Distribution			
		Small	Medium	Large	All Farms
Top	41 & Over	3	8	2	13
Good	31 - 40	16	12	10	38
"Above Average"	21 - 30	16	23	9	48
"Below Average"	11 - 20	33	58	7	98
Poor	1 - 10	30	67	20	117
Total		98	168	48	314

As compared with Table 3.7, 37 out of 314 farmers or 8.5 percent of total number of farmers have changed in positions from "below average" and poor levels of management to the levels of "above average", good and top.

The <u>weather</u> effects (x_8) on farm production in the present study are measured by weather indexes, which was compiled in a weather study[9] conducted in the Department

[9] M. H. Yeh and L. D. Black, "Weather Cycle and Crop Predictions", Technical Bulletin No. 8, Department of Agricultural Economics, University of Manitoba, 1964, p. 15.

of Agricultural Economics, University of Manitoba. This study deals with cycles in the weather and production of wheat, oats and barley in the Brandon, Dauphin, Morden and Winnipeg areas. One of its four broad objectives was to formulate weather indexes exhibiting the effect of climate on crop yields.

In the analysis, the factors influencing crop yield per acre has been grouped under four general categories: (1) Resources inputs; (2) Technological improvement; (3) Weather--direct as well as indirect factors, and (4) Chance.

The effects of the first two input categories were assumed to be approximated by a linear trend. The actual yield per acre was then expressed by the model;

$$y_i = \partial_i + \beta_i X + w_i + e_i \qquad i = 1, 2, 3. \qquad (1)$$

where y_i refers to the actual yields of wheat, oats, barley per acre respectively. The first two terms constitute the linear trend approximating the effects of resources and technological improvement, 'w' is the composite weather cycle, and the last term represents chance effects which is assumed to be normally and independently distributed.

A model $\hat{y} = a_i + b_i x_i$ was designed to remove the average value and the trend from the original yield per acre data. They were assumed as being the effects of resources inputs and technological improvement. The reduced data $(y - \hat{y})$ would be the effects of weather and chance on crop production. The Modified Fourier Analysis was then applied to the reduced data in detecting the composite weather cycle.

Assuming that the same patterns of 1910-1960 had continued, crop yields had been predicted by substituting those values of a, b, and w into model (1).

The weather index was computed as the ratio of actual yield to the fitted trend. In the present study, 100% is used as standard weather index. Any index number below 100% indicates a negative or unfavorable effect on the crop yields due to direct and/or indirect weather influences while above 100% shows a positive or favorable effect on crop yields.

Weather indexes in various years have been computed with respect to wheat, oats, and barley for various crop districts of Manitoba. The sample farms in the present study are mainly scattered in districts 9 and 10. Weather indexes for wheat in these two districts covering the years of 1961 to 1964 are shown in Table 3.9. In general, weather was much below normal in 1961 as compared with that above and around normal in 1962 through to 1964.

TABLE 3.9

WEATHER INDEXES FOR WHEAT BY YEARS AND CROP DISTRICTS

	Years			
Districts	1961	1962	1963	1964
9	81.9209	97.2319	83.7690	88.7592
10	74.2343	104.8429	107.2514	123.2304

CHAPTER IV

EMPIRICAL RESULTS AND THEIR INTERPRETATIONS

The empirical results and their interpretations will be presented in this chapter in three separate sections. The first section is concerned with the general productivity of farm resources based on different sizes of farms. The second section provides a comparison of the resource productivity between crop and mixed farming. The last section is devoted to investigating whether there have been any shifts of production function or any changes in agricultural structure in the period from 1961 to 1964.

I. The General Productivity of Farm Resources by Sizes of Farm

The input-output data of 314 sample farms covering the period 1961 to 1964 were fitted for three different sizes of farms, namely; small, medium and large--of capital less than $60,000, $60,000 to $80,000 and more than $80,000. Each size of farm was fitted for two different forms of Cobb-Douglas equations. The first equation included four variables: land, labor, capital and management. A seven-variable equation was fitted to the same variables except that capital input was broken into farm buildings, farm machinery, cash operating expenses and livestock investment. The corresponding forms of the Cobb-Douglas equation were also fitted to these 314 observations representing the over-all average of the production of the studied area. The results for each of the production equations were derived by the method of least squares. They are presented and discussed in the following sections.

Results of Equations

The resultant regression coefficients (elasticities), coefficients of determination and standard error of estimate for the production function in each case are presented in Table 4.1. The regression coefficients of all variables in the equations of four independent variables were significant at a 5 percent level with the exception of farm labor in both small and large sizes of farm. In seven-variable equations the regression coefficients of all variables included were significant at a 5 percent level with the exception of buildings in all sizes of farms, farm labor in the small size and over-all average of farms, management in medium size, farm land, machinery and livestock investment of large farms. These regression coefficients are the elasticity of the dependent variable with respect to the independent variable. The results show that all regression coefficients or elasticities in each production function were less than one and greater than zero, $0 < b_i < 1$, indicating a diminishing marginal return of its corresponding resource, namely; land, labor, capital and management. The sign of regression coefficient for labor in the seven-variable equation was negative in the small size of farm and was not significant by 't'-test.

TABLE 4.1

REGRESSION COEFFICIENTS, COEFFICIENTS OF DETERMINATION, STANDARD ERRORS AND SIGNIFICANCE LEVELS

Order	Size of Farm	No. of Obs.	Constant in Log	Value of b_i: Land	Labor	Capital	Bldg.	Mach.	Cash Oper.	Lvstk. Invst.	Mgt.	b_i	R^2	S^2
(1)	Small	98	.4293	.2401[a]	.0497	.6020[a]					.1772[a]	1.0690	.62[a]	.1980
(2)	Med.	168	1.0199	.1440[b]	.1810[a]	.4767[a]					.1108[a]	.9123	.61[a]	.0690
(3)	Lge.	48	.8456	.1556	.0314	.6554[a]					.0980[b]	.9405	.61[a]	.0872
(4)	Avge.	314	.0600	.2744[a]	.1457[a]	.6099[a]					.1116[a]	1.1416	.80[a]	.0932
(5)	Small	98	.9581	.2185[b]	-.0291		.0216	.3173[a]	.2432[a]	.0672[b]	.1683[a]	1.007	.66[a]	.0984
(6)	Med.	168	1.2226	.1651[b]	.1454[a]		.0039	.2213[a]	.2101[a]	.0626[a]	.1111	.9194	.62[a]	.0672
(7)	Lge.	48	1.1907	.1697	.3254[b]		.0447	.0383	.2252[b]	.0329	.1178[b]	.9540	.78[a]	.0545
(8)	Avge.	314	.5521	.2575[a]	.0611		.0128	.3353[a]	.2283[a]	.0874[a]	.1196[a]	1.1021	.82[a]	.0829

a: Significant at 1 percent level

b: Significant at 5 percent level

According to Tintner and Brownlee,[1] negative regression coefficients within the range of inputs on most farms are meaningless. The coefficients of determination ranged from 61 to 82 and were all significant at 0.1 percent level. The results indicate that approximately 61 to 82 percent of the variation of farm incomes could be explained by the factors included in each of the regression equations. The remaining 39 percent or less of the variation of the farm incomes may have been due to other input factors such as weather which were assumed to be normally distributed.

The Marginal Value Productivity of Farm Resources

The marginal value productivities of corresponding resources of land, labor, capital and management are shown in Table 4.2. These results represent marginal returns of a specified resource when all other resources were held constant at their geometric mean.

In the general situation as shown in Table 4.2, the marginal value productivity or marginal returns of land was $0.21; of labor, $0.77; of capital, $1.48, and of managerial ability, $109. These results indicate that an additional dollar invested in land added $0.21 to gross returns, an additional hour of labor $0.77, an additional dollar of capital $1.48, and one more unit of managerial ability $109.

The marginal value productivity of land showed no

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[1] Tintner, G. and Brownlee, D. H., "Production Functions Derived from Farm Records", Journal of Farm Economics, XXVI (August 1944), pp. 566-572.

TABLE 4.2

MARGINAL PRODUCTIVITY OF LAND, LABOR, CAPITAL AND MANAGEMENT WITH ALL RESOURCES AT GEOMETRIC MEAN BY SIZES OF FARM

	Small		Medium		Large		Average	
Resources	G.M. of* Res. Input	MVP	G.M. of* Res. Input	MVP	G.M. of* Res. Input	MVP	G.M. of* Res. Input	MVP
Land	11,610	.17	18,620	.12	30,620	.13	17,340	.21
Labor	1,901	.21	2,636	1.02	3,715	.21	2,512	.77
Capital	3,614	1.36	5,875	1.21	10,300	1.58	5,508	1.48
Management	14	103.00	13	124.00	14	168.00	14	109.00

* All resource inputs are measured in dollars except for labor which is measured in directive work hours and management which is measured by a management index.

significant difference between size groups. The returns from an additional dollar invested in land would yield nearly the same returns from small ($0.17), medium ($0.12), and large ($0.13) farms. An additional dollar of capital invested in farm business added $1.36 to the gross income for the small size of farm, $1.21 for the medium size of farm, and $1.58 for the large size of farm. One more unit of management would earn $103, $124, and $168 in small, medium and large sizes, respectively. The marginal value productivity of labor was significantly different between three different sizes of farms. An additional hour of labor in a medium size farm yields a return of $1.02, while it earns only $0.21 in both the small and large size units.

Comparison of Marginal Value Productivity of Resources to Market Prices

The marginal value productivities of land, labor and capital at their geometric mean were then compared to their market prices or costs. For capital investment in land this cost was assumed to be $0.08 per dollar invested,[2] wages for labor were taken at $0.75[3] per hour and the rate for annual capital investment was set at $1.05 per dollar invested. No market price was attached to managerial ability. The comparison of marginal value productivities and market prices

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[2] It consists of a $0.05 charge for interest and a $0.03 charge for real estate taxes.

[3] The hourly rate of $0.75 was approximately equivalent to a monthly rate of $150 (including room and board).

is presented in Table 4.3.

TABLE 4.3

COMPARISON OF MARGINAL VALUE PRODUCTIVITIES AND MARKET PRICES OF RESOURCES

Resources	Marginal Value Productivity				Market Prices
	Small	Medium	Large	General	
	$	$	$	$	$
Land	.17	.12	.13	.21	.08
Labor	.21	1.02	.21	.77	.75
Capital	1.36	1.21	1.58	1.48	1.05

The marginal value productivities of land and capital were considerably above the market prices in all sizes, while the marginal value productivities of labor were considerably lower than the market price in the cases of small and large farms, and just higher than the market price for medium size as well as for the average of the area. The results indicate that resources were misallocated on these farms because the marginal productivities were above or below, but not equal to, market prices. Under the assumption of perfect competition, farmers have no control over the prices. In order to equate the marginal productivities of resources to their prices, the only alternative open to farmers is to reallocate their resources on their farms. Reallocation of resources can effectively change the marginal productivities. The change in the quantity of one of the resources with quantities of other resources kept unchanged affects the marginal productivities of resources in two ways: (1) The marginal productivity of that particular resource will change, and (2) the marginal productivities of other resources which have been held constant will be affected. The next sub-sections illustrate these situations.

Diminishing Marginal Returns

The marginal value productivity of a particular resource depends solely on its own quantity whenever all other resource inputs are held constant. If the elasticity of production of this resource is smaller than one, its marginal value productivity will fall if more inputs are employed. The production functions derived from the farm data directly indicate the elasticity of production for the different resources. The elasticity of production is defined as follows: The percent increase in production due to a one percent increase in the input of a given resource; other resources held constant. In Table 4.1, all regression coefficients or elasticities were less than one in the cases of all the resources revealing a diminishing marginal return. The overall average elasticity of production for the labor resource in the studied area is 0.15 in the four-variable equation. This implies that a one percent increase in the labor input results in a 0.15 percent increase in the total farm income. Thus, labor exhibits diminishing marginal productivity.

Table 4.4 shows the marginal value productivities of

TABLE 4.4

THE MARGINAL PRODUCTIVITIES OF LABOR OF THE AREA AS A WHOLE AT VARYING LEVELS OF INPUTS WITH OTHER RESOURCES: LAND, CAPITAL, MANAGEMENT AT THEIR RESPECTIVE GEOMETRIC MEAN

Resource Inputs(Hours)	Marginal Productivity
2,512	.77
5,024	.43
7,536	.30
10,048	.24

the labor in the studied area as a whole with other resources of land, capital, and management at their respective geometric mean. When the labor input is doubled from a mean value of 2,512 hours to 5,024 hours, the marginal value productivity of labor drops from \$0.77 to \$0.43 per hour. The marginal value productivity of labor falls to \$0.24 per hour when labor inputs are expanded to 10,048 hours (i.e., expanded to four times its geometric mean). Thus, the change in the allocation of one of the resources alters its marginal value productivity. At the same time, however, this change affected the marginal productivities of other inputs. This is shown in Table 4.5. Table 4.5 shows the effect on the marginal productivity of land, capital, management, when labor is increased from its geometric mean, 2,512 hours to the doubled number of 5,024 hours. With an increase

TABLE 4.5

THE EFFECTS OF CHANGES IN LABOR INPUTS UPON MARGINAL PRODUCTIVITIES

Input of Labor Resources	Marginal Productivities of			
	Labor	Land	Capital	Management
Hours	$	$	$	$
2,512	.77	.21	1.48	1.09
5,024	.43	.24	1.65	1.21

in labor inputs the marginal productivity of labor declines, but at the same time, the marginal productivities of other resources of land, capital and management increases. This demonstrates that the effect of changing one resource includes an impact on all other resources.

In view of this process, it is apparent that it is not sufficient to deal with the allocation of one particular resource without considering the effect upon the productivities of other resources in adjusting resource use from that which is existing to an optimum. For further insight into the process of resource allocation, the relationship of factor combination and substitution are next examined.

Factor Combination and Substitution

Factors of production which are substitutes for each other can be employed in many combinations to produce a given level of output. Various combinations of labor and capital yielding the average incomes are given in Table 4.6.

TABLE 4.6

LABOR AND CAPITAL COMBINATIONS YIELDING AVERAGE INCOMES WHEN THE INPUTS OF OTHER RESOURCES ARE HELD AT THEIR GEOMETRIC MEAN

Small		Medium		Large		General	
Income							
$8,204		$15,000		$25,060		$13,000	
Capital $	Labor Hrs.	Capital $	Labor Hrs.	Capital $	Labor Hrs.	Capital $	Labor Hrs.
3,200	8,308	5,400	3,292	9,800	10,560	4,900	4,100
3,400	3,985	5,600	2,990	10,000	6,934	5,100	3,467
3,614*	1,901*	5,875*	2,636*	10,300*	3,715*	5,508*	2,512*
3,800	1,035	6,000	2,494	10,500	2,507	5,700	2,176
4,000	556	6,200	2,288	10,700	1,692	5,900	1,884

* Geometric Mean

For the small farm for example, on the average, $3,614 of annual capital input and 1,901 hours of labor were used in producing an average income of $8,204. Another combination in producing this average income was 1,035 hours of labor and an investment in capital of $3,800. As more capital is used in production, corresponding less labor is required to produce the same amount of farm income. Vice-Versa, if less capital inputs were used, labor requirements would rise. Similar relationships characterized the combinations of labor and capital in medium, large, and the average farm situations. They are shown in the rest of the six columns of Table 4.6. The same relationships hold for the combinations of other resources. Whenever more inputs of one (substituting) resource were used, the identical output could have been obtained with less inputs of the other (substituted) resource. This relationship is illustrated by the negative value of the marginal rate of substitution.

Land, labor, and capital could only be substituted for each other at diminishing rates. This can be illustrated by the diminishing rates of substitution (in absolute terms). Table 4.7 shows the marginal rates of substitution of capital for labor at the levels of combination corresponding to that of Table 4.6.

The average marginal rates of substitution of capital for labor were 6.4 for the small farms, 1.2 for the medium farms, 7.5 for the large farms and overall was 1.9. That means, at average input levels, one additional dollar of capital could replace 6.4 hours of labor on small farms, only 1.2 hours of labor for the medium; and 7.5 hours of labor for large farms. On the average, one additional dollar of capital could replace 1.9 hours of labor of the studied area. If the capital inputs were enlarged from mean value, the marginal rates of substitution in absolute terms would diminish. For instance, on small farms, if the capital was increased from $3,614 to $3,800, the marginal rates of substitution would decrease from 6.4 to 3.3. It is equivalent to say that the hours of labor which could be replaced by one additional dollar of capital would decrease from 6.4 hours to 3.3 hours, if capital inputs were expanded from $3,614 to $3,800. This illustrates the phenomena of

TABLE 4.7

MARGINAL RATES OF SUBSTITUTION OF CAPITAL FOR LABOR WHEN ALL OTHER RESOURCE INPUTS ARE HELD AT THEIR GEOMETRIC MEAN

Small		Medium		Large		Average	
Capital Input $	Hrs. Labor Replaced by One Add. $ of Capital Hours	Capital Input $	Hrs. Labor Replaced by One Add. $ of Capital Hours	Capital Input $	Hrs. Labor Replaced by One Add. $ of Capital Hours	Capital Input $	Hrs. Labor Replaced by One Add. $ of Capital Hours
3,200	31.5	5,400	1.6	9,800	22.5	4,900	3.5
3,400	14.2	5,600	1.4	10,000	14.5	5,100	2.9
3,614*	6.4	5,875*	1.2	10,300*	7.5	5,508*	1.9
3,800	3.3	6,000	1.1	10,500	5.0	5,700	1.6
4,000	1.7	6,200	1.0	10,700	3.3	5,900	1.3

* Geometric Mean

diminishing marginal rates of substitution and the economic process of resource allocation. For, if two or more factors, all essential to the process of production, can be substituted for each other at only a diminishing rate, it must be decided how much of each should be employed to minimize cost and thereby optimize resource use.

Least-cost Combination of Resources

The optimum rate of farm resources can be obtained by using the principle of a least-cost combination of resources. In examining the least-cost combination of resources, the hypotheses set in Chapter I that there exists a surplus of labor and a shortage of capital, is tested.

The least-cost combination of resources is found where the cost of the added resources just balances the cost of the resource replaced. More specifically, the least-cost combination is determined where the following equality holds, $\frac{dx_1}{dx_2} = \frac{p_{x_2}}{p_{x_1}}$, where $\frac{dx_1}{dx_2}$ is the marginal rate of substitution of resources x_2 for x_1 and where p_{x_1} is the price of x_1, p_{x_2} is the price of x_2. The least cost combination of resources and its comparison to the actual use of resources are discussed below, separately, for small, medium, and large farms.

Small Farm

The least-cost and actual combinations of resources yielding an average income of $8,204 is shown in Table 4.8. As the first three columns show, farmers combined, on the

TABLE 4.8

COMPARISON OF ACTUAL AND LEAST-COST COMBINATIONS OF RESOURCES YIELDING AN INCOME OF $8,204 FOR SMALL FARM

	Capital and Labor			Capital and Land			Land and Labor		
	Capital $	Labor Hrs.	Cost $	Capital $	Land $	Cost $	Land $	Labor Hrs.	Cost $
Actual Combination	3,614*	1,901*	5,220	3,614*	11,610*	4,724	11,610*	1,901*	2,355
Least-Cost Combination	4,057	469	4,612	3,144	16,460	4,618	16,380	329	1,557

* Geometric Mean

average, \$3,614 of capital with 1,901 hours of labor to produce an income of \$8,204, providing land and management at geometric mean. In Figure 4.1, this combination is denoted by C_1 on the "average" iso-quant curve. With land and management held at the same level and with market prices set as in Table 4.3, the least-cost combination for yielding the same level of income would be \$4,057 of capital with 469 hours of labor (denoted by C_e in Figure 4.1). Farmers could have chosen this resource combination with fewer labor and more capital inputs to produce a same level of income. This reallocation of inputs would have reduced costs by \$608. It appears that farmers of this category misallocated labor and capital. On the average, they used an excess of labor and too little capital to produce the average income.

The marginal productivity of annual capital broken into various forms of building services, machinery and equipment services and cash operating costs at their geometric mean is also compared to their corresponding costs. This comparison might throw light on the extent and kind of misallocation of capital between various forms. As Table 4.9 shows, building services might be over-invested on small farms since their marginal productivity is lower than their cost. Machinery and equipment service and cash operating cost in forms of fertilizer, chemical spray, purchased feed,

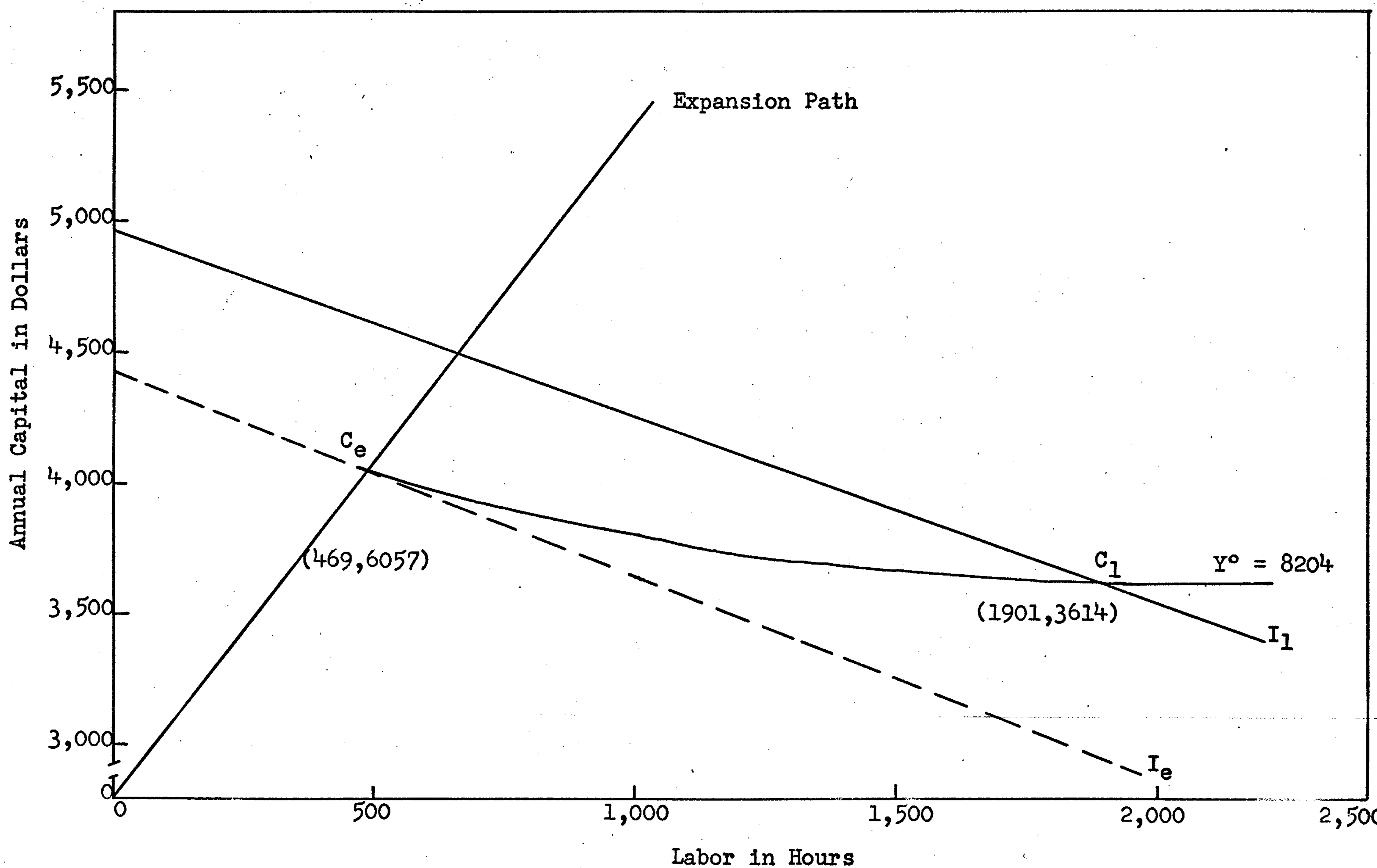

FIGURE 4.1 SUBSTITUTION BETWEEN ANNUAL CAPITAL AND LABOR ON SMALL FARM

TABLE 4.9

THE COMPARISON OF MARGINAL PRODUCTIVITY OF CAPITAL IN FORMS OF BUILDING SERVICES, MACHINERY AND EQUIPMENT SERVICES, CASH OPERATING EXPENSES AT THEIR GEOMETRIC MEAN TO THEIR COSTS FOR SMALL FARM

Resources	Geometric Mean Inputs	MVP	Costs
	$	$	$
Building Services	220	.81	1.05
Machinery & Equp. Services	1,758	1.41	1.05
Cash Oper. Expense	1,172	1.70	1.05

supplements, etc., could be under-invested in view of their substantially higher marginal productivities than their costs.

In the comparison of the actual and least-cost combinations of capital and land, the shortage of capital in the form of land on small farms is more serious than shortages of other forms of capital. By combining capital amounting to $3,144 which is $470 less than the average input, with land valued at $16,460 which is $4,850 more than the average input to produce the same income of $8,204, costs would be reduced by $106.

The shortage of capital invested (in land) and a surplus of labor would further be supported by the investigation of the actual and least-cost combination of land and labor. By using 572 fewer hours of labor and $4,770 more of land, on the average, would reduce cost by $798.

Medium Farm

The least-cost and actual combinations of resources yielding an average income of $15,000 was shown in Table 4.10. The first three columns show that farmers combined, on the average, $5,875 of capital with 2,636 hours of labor to produce an income of $15,000. The least-cost combination of capital and labor yielding the same level of output with land and management remained at same level would be $5,608 of capital with 2,980 hours of labor. On the contrary to small farms, medium size farms, on the average might be using too much capital and too little labor hours. However, its deviations from an optimum combination were not large. On the average, it would use excess capital of only $267, and be short of labor by only 344 hours to produce the average income with other resources held at mean levels. By the reallocation of labor and capital costs could be reduced by just $23. In view of this fact, we might say that resource allocation on this category of farm, on the average, appears to be quite efficient. The comparison of the actual and least-cost combinations of capital and land, land and labor in Table 4.9 would further support this point of view. The actual and least-cost combination of labor and capital is illustrated in Figure 4.2. Where C_e and C_1 show the least-cost and actual combinations of labor and capital to produce the average income of $15,000 with other resources held at the geometric mean. I_e and I_1

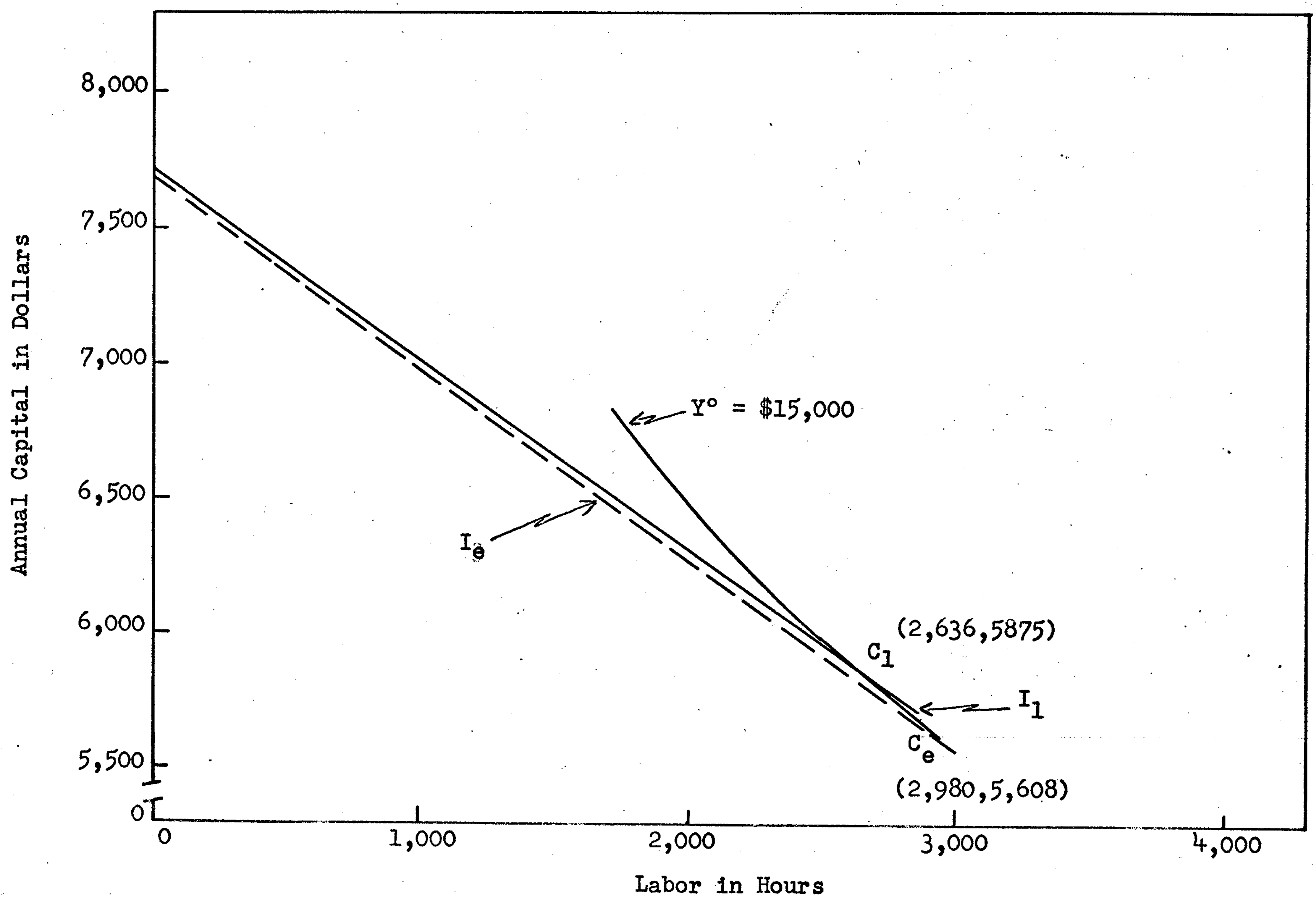

FIGURE 4.2 SUBSTITUTION BETWEEN ANNUAL CAPITAL AND LABOR ON MEDIUM FARM

TABLE 4.10

THE LEAST-COST AND ACTUAL COMBINATIONS OF RESOURCES YIELDING AN AVERAGE INCOME OF $15,000 ON MEDIUM FARM

	Capital and Labor			Capital and Land			Land and Capital		
	Capital $	Labor Hrs.	Cost $	Capital $	Land $	Cost $	Land $	Labor Hrs.	Cost $
Actual Combination	5,875*	2,636*	8,146	5,875*	18,620*	7,659	18,620*	2,636*	3,467
Least-Cost Combination	5,608	2,980	8,123	5,578	22,110	7,626	19,200	2,574	3,466

* Geometric Mean

representing the cost of optimum and actual combinations are close to each other.

However, if we examine the marginal productivity of capital in the form of building services, machinery and equipment services, and cash operating expenses and compared them to their costs, we find that misallocation of resources can exist among various forms of capital. Similarly to small farms, farmers of this category might invest too much capital on building, and too little on machinery and equipment as well as on cash operating expenses. The comparison of marginal productivity of capital in various forms is shown in Table 4.11.

TABLE 4.11

THE COMPARISON OF MARGINAL PRODUCTIVITY OF CAPITAL IN FORMS OF BUILDING SERVICES, MACHINERY AND EQUIPMENT SERVICES AND CASH OPERATING EXPENSES TO THEIR CORRESPONDING COSTS ON MEDIUM FARM

Resources	Geometric Mean Input	MVP	Cost
	$	$	$
Building Services	363	.20	1.05
Machinery & Equip. Services	2,838	1.45	1.05
Cash Operating Expenses	2,000	1.96	1.05

Large Farm

Table 4.12 shows the least-cost and actual combinations of resources yielding an average income of $25,060. As the

TABLE 4.12

COMPARISON OF ACTUAL AND LEAST-COST COMBINATIONS OF RESOURCES YIELDING AN INCOME OF $25,060 ON LARGE FARM

	Capital and Labor			Capital and Land			Land and Capital		
	Capital $	Labor Hrs.	Cost $	Capital $	Land $	Cost $	Land $	Labor Hrs.	Cost $
Actual Combination	10,300*	3,715*	13,590	10,300*	30,620*	13,265	30,620*	3,715*	5,236
Least-Cost Combination	11,130	747	12,246	10,209	31,810	13,264	40,950	882	3,938

* Geometric Mean

actual and optimum combinations of capital and labor show, on the average, large farm might be using too little capital and too much labor in producing the average income. A reallocation of resources by using $730 more capital and 2,968 fewer hours of labor with other resources at geometric mean would reduce cost by $1,344.

In Figure 4.3, the optimum and actual combinations of labor and capital are shown by C_e and C_1 respectively. I_e and I_1 are the iso-cost lines corresponding to the combinations of C_e and C_1. The difference of I_e and I_1 would represent the reduction of cost by reallocation of labor and capital from the existing combination to the optimum combination.

Table 4.13 shows that misallocation of capital among various forms of capital might also exist. However, on the contrary to medium and small farm, the large farm might be investing too much of their money on machinery and equipment, and investing too little money on building services and current operating expenses.

TABLE 4.13

THE COMPARISON OF MARGINAL PRODUCTIVITY OF CAPITAL IN FORMS OF BUILDING SERVICES, MACHINERY AND EQUIPMENT SERVICES AND CASH OPERATING EXPENSES TO THEIR CORRESPONDING COSTS ON LARGE FARM

Resources	Geometric Mean Inputs	MVP	Costs
	$	$	$
Building Services	789	1.42	1.05
Machinery & Equip. Services	5,152	.19	1.05
Cash Operating Expenses	3,334	1.70	1.05

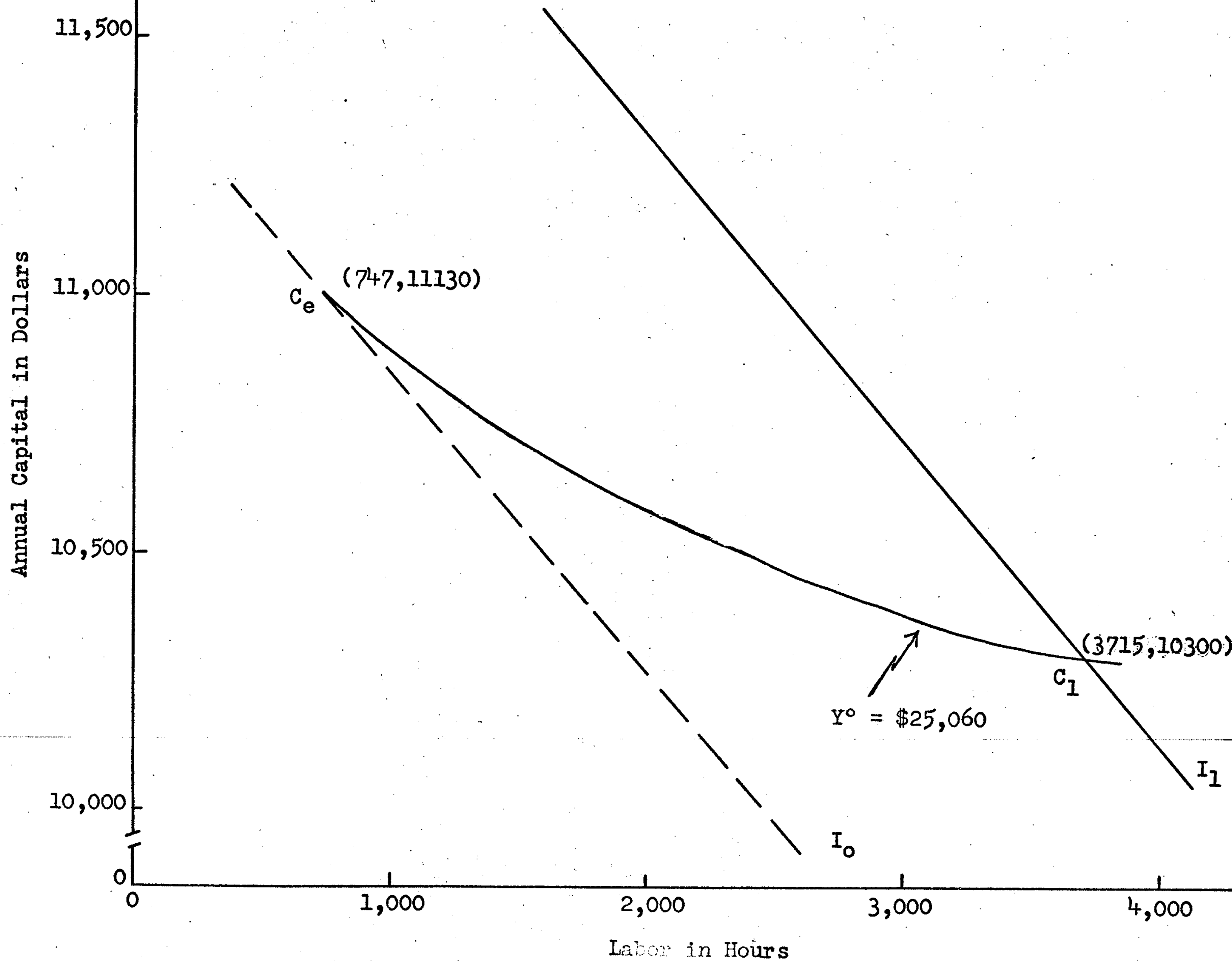

FIGURE 4.2 SUBSTITUTION BETWEEN ANNUAL CAPITAL AND LABOR ON LARGE FARM

With other resources kept at their geometric mean and with the market prices used in this study, the large farms might also, on the average, be using too little capital in the form of land to produce the mean income. The actual use of land would be lower than that optimum suggested by the $10,330. However, since the optimum amount of land, $40,950. as shown in the 8th column of Table 4.11, exceeds the upper limit of the observed land value by $25,459, the $10,330 difference might not be a very reliable measure of the true difference. Nevertheless, it is likely that this size of farm does suffer from a shortage of land.

The Effects of Management as a Factor of Production on the Productivity of Other Resources

The third hypothesis in Chapter I stated that management was a significant factor of production. The evidence which supports this hypothesis can be seen in Table 4.1, where, in each of the Cobb-Douglas equations, management, as a factor of production, tested significant at 0.1 to 5 percent except for the management of medium farm in the case of the seven-independent variables which was tested significant at 20 percent level. Other evidence is presented in Table 4.14. Management as it was measured in this study acted as a significant factor of production because a lowering of the management index reduced the marginal productivities of the other factors of production. When the management dropped from the first index group, which represents good managerial ability, to the last group, which

TABLE 4.14

THE EFFECTS OF CHANGES IN MANAGEMENT
UPON MARGINAL PRODUCTIVITIES#

Input of Management Resource (Index)	Marginal Productivities of Management	Land	Labor	Capital
	$	$	$	$
35.5	47	.24	.86	1.65
25.5	63	.23	.83	1.59
15.5	98	.21	.79	1.50
5.5	246	.19	.70	1.33

The marginal productivity calculated here is based on equation (4) in Table 4.1.

represents the poor managerial ability, the marginal productivity of land dropped from $0.24 to $0.19, almost 21 percent less, and that of labor dropped from $0.86 to $0.70, approximately 20 percent less. The marginal productivity of capital dropped from $1.65 to $1.33. It is also nearly 20 percent less.

In view of these facts, managerial ability is very important in the efficient use of land, labor and capital. The operation of rural credit facilities might well be improved by using credit ratings which take into consideration the managerial abilities of the farmer. Similar attention to managerial ability is desirable in other aspects of agricultural organization, e.g., in entry into the industry, the size structure of farms, farmers' participation in the rest of the economy, and the type and extent of their training and education, etc.

Returns to Scale

It has been hypothesized in Chapter I that increasing returns to scale may exist in agriculture. Here, the Cobb-Douglas function derived from farm data will indicate the nature of the returns to scale of farm business in the studied area. According to the principle, if the sum of the elasticities of production of all the resource inputs amounts to less than one, there are diminishing returns to scale, and if the sum of the elasticities are greater than one, there are increasing returns to scale and constant returns to scale where the sum of the elasticities equals one.

The summation of elasticities of resources of the derived Cobb-Douglas equations representing the production of small, medium and large farms and the overall average of the area involving four and seven independent variables are taken from Table 4.1, and are shown as follows:

Size of Farm	Sum of Elasticities
Category of four independent variable equations:	
Small	1.0690
Medium	.9123
Large	.9405
Average	1.1416
Category of seven independent variable equations:	
Small	1.0070

Medium	.9194
Large	.9540
Average	1.1021

Equations of both categories showed consistent results; that increasing returns to scale could exist for small farms and for the overall average of the area, whereas diminishing returns to scale could hold for medium and large farms. Under conditions of increasing returns to scale, a proportional increase in all resource inputs leads to a more than proportionate increase in output, whereas under conditions of diminishing returns to scale, it leads to a less than proportionate increase in output.

According to the average production functions, conditions of increasing returns to scale existed. However, a severe capital shortage could have limited or prevented gains in productivity that might have been achieved by expansion in scale of production. In the four-independent variable equation, the sum of elasticities amount to approximately 1.1416 for the average situation. Accordingly, an increase of 100 percent in all resource inputs raised average farm output from $13,000 to $26,070, or an increase of 101 percent. When land and capital inputs were held constant--a condition which might prevail under extreme capital shortage--total product increased by only 9 percent. If, on the other hand, labor inputs alone had been fixed at the average, a 100 percent increase in all other inputs would have raised output to $16,850 dollars or by as much as 30 percent. The fact that most farmers did not operate at these levels of inputs and output seemed to indicate conditions of severe capital limitation and labor surplus.

II. The Productivity Comparison of Crop and Mixed Farming

In this section a productivity comparison of crop and mixed farming is made.

The input-output data of 314 sample farms covering the period of 1961 to 1964 were divided into crop and mixed farming based on their source of income. Those farms deriving 80 percent or more of their income from crop enterprise were classified as crop farming. Those who derive less than 80 percent of their income from crop enterprise were classified as mixed farming. Each type of farming was fitted in two different forms of Cobb-Douglas equations: (1) Four-variable equations; land, labor, capital and management were the independent variables, and (2) seven-variable equations; including the same independent variables as the first category except that capital input was broken into farm building, farm machinery, cash operating expenses and livestock investment. The results for each of the production equations are presented and discussed in the following sections.

The Results of Equations

The resultant regression coefficients (elasticities), coefficients of determination and standard error of estimate for the production function in each case are presented in

Table 4.15. The regression coefficients of all variables in the equations of four independent variables were significant at a 5 percent level with the exception of labor of crop farming. In seven-variable equations, the regression coefficients of all variables included were significant at a 5 percent level with the exception of farm labor and farm building of crop farming. The results show that all regression coefficients or elasticities in each production function are less than one and greater than zero, indicating a diminishing marginal return of its corresponding resource. The sum of elasticities of production for crop and mixed farming was greater than one in both four- and seven-variable equations indicating increasing returns to scale could exist in both cases. The coefficient of determination ranged from 81 to 87 and was tested as significant at 1 percent level indicating that in 99 out of 100 cases, 81 to 87 percent of the variations in income could be explained by the factors included in each of the regression equations.

The Marginal Value Productivity of Farm Resources

The marginal value productivities of resources of land, labor, capital and management for crop and mixed farming at geometric mean are shown in Table 4.16. The marginal returns of one dollar in land was $0.36 for crop farming, whereas it was $0.22 for mixed farming. This means on the average an additional dollar invested in land for crop farming

TABLE 4.15

REGRESSION COEFFICIENTS, COEFFICIENTS OF DETERMINATION, STANDARD ERRORS AND SIGNIFICANCE LEVELS

Type of Farming	No. of Obs.	Constant in Log Form	Value of b_i: Land	Labor	Capital	Bldg.	Mach.	Cash Oper. Cost	Lvst. Inv.	Mgt.	Σb_i	R^2	S^2
Val. Crop Prod. 80% or More	59	-.1833	.6105[a]	-.0377	.4003[a]					.0861[b]	1.1346	.83[a]	.1024
Val. Crop Prod. Less than 80%	255	.0554	.2709[a]	.0953[b]	.6620[a]					.1152[a]	1.1434	.81[a]	.0852
Val. Crop Prod. 80% or More	59	.3051	.5305[a]	-.1363		.0355	.3180[b]	.1595[b]	.0640[a]	.1034[b]	1.0746	.87[a]	0.0802
Val. Crop Prod. Less than 80%	255	.5696	.2410[a]	.0719[b]		.0076[a]	.2700[a]	.2393[a]	.1741[a]	.1158[a]	1.1197	.84[a]	0.0730

a: Significant at 1 percent level
b: Significant at 5 percent level

TABLE 4.16

THE MARGINAL VALUE PRODUCTIVITIES OF LAND, LABOR, CAPITAL AND MANAGEMENT WITH ALL RESOURCES AT GEOMETRIC MEAN BY TYPE OF FARMING

	Value of Crop Prod. 80% or More		Value of Crop Prod. less than 80%	
	G.M. of Res. Input	MVP	G.M. of Res. Input	MVP
Land ($)	21,180	.36	16,560	.22
Labor (Hrs.)	1,782	.27	2,716	.48
Capital ($)	5,358	.94	5,534	1.62
Mgt. (Index)	16	68.00	13	118.00

added as much as $0.14 greater returns than that invested in land for mixed farming. However, the marginal productivities of labor and capital in mixed farming were greater than they were in crop farming by $0.21 and $0.68 respectively. This means on the average an additional hour of labor and an additional dollar of capital invested in the former would yield returns higher by $0.21 and $0.68 respectively than when invested in the latter, providing all resources were used at their geometric mean.

Comparison of Marginal Value Productivity of Resources to Market Prices

The marginal value productivities of land, labor and capital at their geometric mean were compared to their market prices or costs set in Table 4.3. The comparison is presented in Table 4.17. The marginal value productivities

TABLE 4.17

COMPARISON OF MARGINAL VALUE PRODUCTIVITIES AND MARKET PRICES OF RESOURCES

Resources	Marginal Productivity		
	Value of Crop Prod. 80% or More	Value of Crop. Prod. Less than 80%	Market Prices
	$	$	$
Land ($)	.36	.22	0.08
Labor(Hrs.)	.27	.48	0.75
Capital($)	.94	1.62	1.05

of land and capital were considerably above the market prices for both types of farming. On the other hand, the marginal value productivities of labor were considerably lower than market price. In the cases of land and labor, the extent of deviation from market price were greater for crop farming whereas in the case of capital, the reverse was true.

The fact that marginal value productivities of resources were above or below the assumed prices could indicate that resources were misallocated on both types of farming. If, as we assumed, farmers in this area aimed at profit maximization, and our pricing assumptions are also appropriate, the resources on these farms have to be reallocated from the existing pattern to an optimum one. In order to investigate the process of resource allocation, the relationship of factor combination and substitution is now examined.

Factor Combination and Substitution on Crop and Mixed Farming

In Table 4.18, various combinations of labor and capital yielding average incomes are given. On the average, crop farmers combined $5,358 of annual capital input with 1,782 hours of labor to produce an income of $12,620 whereas in mixed farming, $5,534 of annual capital was combined with 2,716 hours of labor to produce an income of $13,580.

TABLE 4.18

LABOR AND CAPITAL COMBINATIONS YIELDING AVERAGE INCOMES WHEN THE INPUTS OF OTHER RESOURCES ARE HELD AT THEIR GEOMETRIC MEAN

Value of Crop Prod. 80% or More		Value Crop Prod. Less than 80%	
Income $12,620		Income $13,580	
Capital $	Labor Hrs.	Capital $	Labor Hrs.
4,900	4,605	4,900	6,421
5,100	3,011	5,100	4,934
5,358*	1,782*	5,500	2,879
5,500	1,350	5,534*	2,716*
5,700	924	5,700	2,247

* Geometric Mean

If more capital had been employed, less labor would have been required in producing the same income, provided land and management remained at the same level; vice-versa, if less capital input had been used, labor requirement would have risen. In Table 4.18, when capital inputs increased from the mean value to $5,700 it would have required 924 hours of labor for crop farming to produce the average income with other resources kept at their geometric means, whereas it would have required 2,247 hours of labor for mixed farming.

Resources could only be substituted for each other at diminishing rates. The marginal rates of substitution of capital for labor at the levels of combination corresponding to that of Table 4.18 are shown in Table 4.19. On the average, one additional dollar of annual capital invested on crop farms would replace 3.53 hours of labor. It would replace 3.41 hours on mixed farms. If the capital inputs were enlarged from their mean values, the marginal rates of substitution in absolute terms would diminish. This means one additional dollar of capital would replace less and less labor hours in producing the average income, with other resources held at their geometric means. When the annual capital input increased to $5,700, one additional dollar of capital would replace 1.71 hours of labor for crop farming, and 2.74 hours of labor for mixed farming.

Least-Cost Combination of Resources on Crop and Mixed Farm

The least-cost and actual combination of resources on crop farm are shown in Table 4.20. For crop farming, on the average, $5,358 of annual capital was combined with 1,782 hours of labor to produce an average income of $12,620 with land, management at their geometric mean, however, if $5,800 of capital had been combined with 764 hours of labor to

TABLE 4.19

MARGINAL RATES OF SUBSTITUTION OF CAPITAL FOR LABOR WHEN ALL OTHER RESOURCE INPUTS ARE HELD AT THEIR GEOMETRIC MEAN

Value Crop Prod. 80% or More		Value Crop Prod. Less than 80%	
Capital Input	Hours of Labor Replaced by One Additional Dollar of Capital Input	Capital Input	Hours of Labor Replaced by One Additional Dollar of Capital Input
$	Hrs.	$	Hrs.
4,900	9.90	4,900	9.10
5,100	6.27	5,100	6.72
5,358*	3.53	5,500	3.64
5,500	2.61	5,534*	3.41
5,700	1.72	5,700	2.74

* Geometric Mean

produce the average income it could have reduced cost by $299. In other words, on the average, crop farms might have used too much labor and too little capital. This situation is illustrated in Figure 4.4. C_1 and C_e indicate the average and least-cost combination of labor and capital on crop farm respectively. I_1 and I_e are their corresponding costs. The difference between I_e and I_1 represent that amount of cost could be reduced by reallocation of labor and capital on farms.

The shortage of capital on crop farms might exist in all forms of capital, such as building services, machinery and equipment services, and cash operating expenses in the

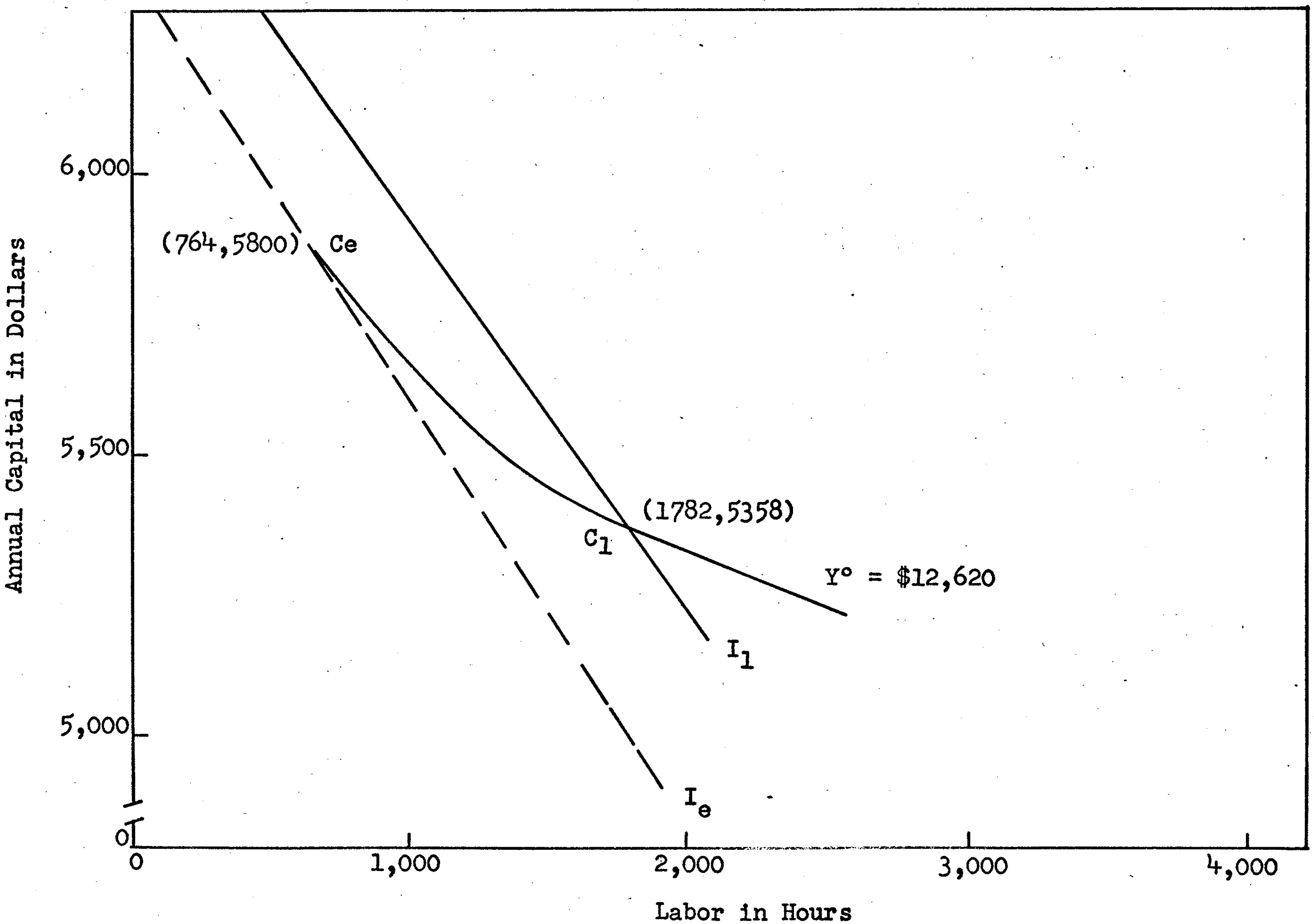

FIGURE 4.4 SUBSTITUTION BETWEEN ANNUAL CAPITAL AND LABOR ON CROP FARM

TABLE 4.20

THE COMPARISON OF ACTUAL AND LEAST-COST COMBINATIONS OF RESOURCES YIELDING AN INCOME OF $12,620 ON CROP FARM

	Capital and Labor			Capital and Land			Land and Labor		
	Capital $	Labor Hrs.	Cost $	Capital $	Land $	Cost $	Land $	Labor Hrs.	Cost $
Actual Combination	5,358*	1,782*	6,962	5,358*	21,180*	7,320	21,180*	1,782*	3,031
Least-Cost Combination	5,800	764	6,663	2,011	40,260	5,333	24,570	162	2,088

* Geometric Mean

forms of fertilizer, chemical spray, etc. The evidence is shown in Table 4.21. As this table shows, marginal value productivities of these forms of capital were all above their corresponding costs indicating that additional investment in such kinds of capital is required for profit maximization.

TABLE 4.21

THE COMPARISON OF MARGINAL PRODUCTIVITY OF CAPITAL IN FORMS OF BUILDING SERVICES, MACHINERY AND EQUIPMENT SERVICES AND CASH OPERATING EXPENSES TO THEIR COSTS ON CROP FARM

Resources	Geometric Mean Inputs	MVP	Costs
Building Services	264	1.69	1.05
Mach. & Equipment Services	2,951	1.36	1.05
Cash Operating Expenses	1,690	1.19	1.05

On the other hand, the crop farm, on the average, combined $5,358 of capital with $21,180 of land to produce average income with labor and management at geometric mean. However, the least-cost combination would be $2,011 of capital and $40,260 of land. In view of the fact that actual use of land was almost half what the suggested optimum is, we might conclude that capital in terms of land could also be substantially short for this type of farming. It might pay for the farmer to break land that is in native pasture or which is hayland into crop land since the return of an additional dollar invested in land, on the average, would yield a much higher return than its additional cost, and a much higher return than is possible from the other type of farming, as shown in Table 4.17.

The least-cost and actual combination of resources on mixed farm are shown in Table 4.22. Farmers, on the average, combined $5,534 of capital with 2,716 hours of labor to produce an income of $13,580 with land and management at mean. The least-cost combination of capital and labor with the prices of resources set in this study was $6,510 of capital with 1,250 hours of labor. If farmers had chosen the optimum combination of resources, the reduction of cost would be $400. In Figure 4.5, C_1 represents the average combination of labor and capital on farms, if less labor and more capital had been combined as denoted by C_e, the cost would have been reduced from I_1 to I_e.

The shortage of capital could mainly be in the forms of machinery and equipment and cash operating expenses for this type of farming. Building services had been over-invested. Table 4.23 shows this situation. The marginal value productivities of machinery and equipment services and cash operating expenses were substantially greater than their corresponding costs whereas the marginal value productivity of building service was substantially lower than its cost.

In the comparison of actual and least-cost combination of capital and land, land and labor yielding average income

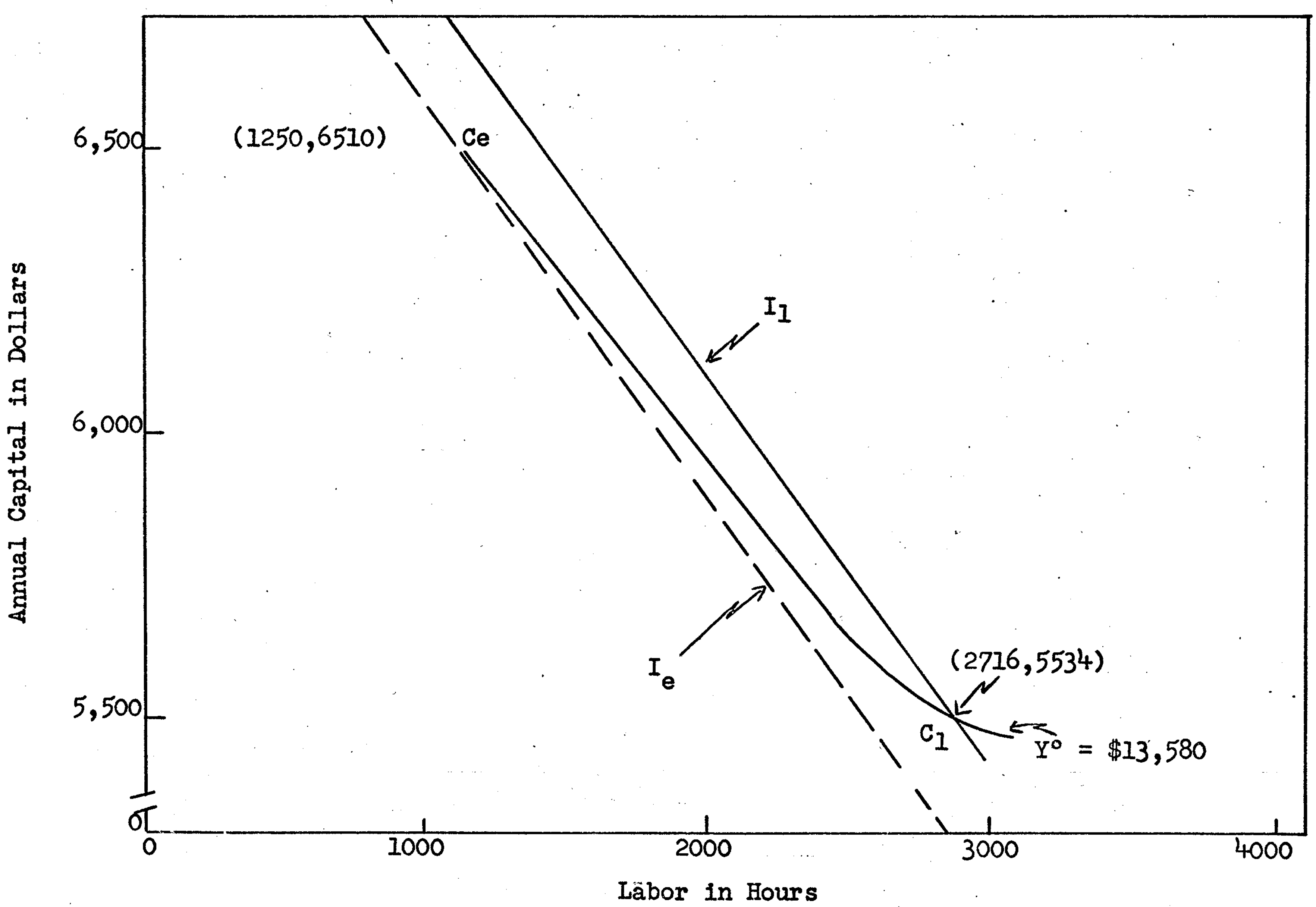

FIGURE 4.5 SUBSTITUTION BETWEEN ANNUAL CAPITAL AND LABOR ON MIXED FARM

TABLE 4.22

THE COMPARISON OF ACTUAL AND LEAST-COST COMBINATIONS OF RESOURCES YIELDING AN INCOME OF $13,580 ON MIXED FARM

	Capital and Labor			Capital and Land			Land and Labor		
	Capital $	Labor Hrs.	Cost $	Capital $	Land $	Cost $	Land $	Labor Hrs.	Cost $
Actual Combination	5,534*	2,716	7,848	5,534*	16,560*	7,136	16,560*	2,716*	3,362
Least-Cost Combination	6,510	1,250	7,448	4,676	25,120	6,920	24,310	912	2,629

* Geometric Mean

TABLE 4.23

THE COMPARISON OF MARGINAL PRODUCTIVITY OF CAPITAL IN FORMS OF BUILDING SERVICES, MACHINERY AND EQUIPMENT SERVICES AND CASH OPERATING EXPENSES TO THEIR COSTS ON MIXED FARM

Resources	Geometric Mean Inputs	MVP	Costs
	$	$	$
Building Services ($)	373	.28	1.05
Mach. & Equip. Services ($)	2,624	1.40	1.05
Cash Oper. Expenses	1,871	1.74	1.05

with other resources at geometric mean, it was found that land as a factor of production might also be under-invested. The extent of misallocation of land appears to be less on mixed farms, considered as a group, than on crop farms. However, the misallocation on mixed farms may persist as long as livestock enterprises are engaged in while that on the crop farms may be readily overcome without enterprise change and also by the transfer of land resources out of the mixed farms.

III. The Shifts of Production Functions Over the Years

This section is devoted to investigating any shifts of production functions over the period from 1961 to 1964 for the studied area.

The Cobb-Douglas functions derived from the farm data of the individual years of 1961, 1962, 1963, 1964 and the combined data covering the four years are shown in Table 4.24.

All regression coefficients are significant at a probability level of 5 percent. Except for management in year 1962, all the coefficients are also significant at 0.1 percent. That the sum of coefficients could exceed one in all cases indicates that increasing returns to scale could exist in each individual year as well as for the average of the four years. The coefficients of determination range from 82 to 90. This indicates that the range from 82 to 99 percent of total variation in income could be explained by the four independent variables involved in each of the equations.

Based on the Cobb-Douglas equations in Table 4.24, the total production of varying levels of capital with land, labor and management at general geometric mean were calculated and are shown in Table 4.25 and Figure 4.6. As the Figure shows, total production curves of capital of 1962, 1963 and 1964 lie above the average, whereas that of 1961 lies below the average curve. An amount of capital equal to $5,508, which is the average annual capital input of the four years, would yield a return of $10,260, $13,870, $14,260 and $15,000 in years 1961, 1962, 1963 and 1964 respectively, and would yield a return of $13,390 for the average of the four years. If total average income is taken as 100, the return of 1961 is 76.6 which is 23.4 lower than average. The returns of 1962, 1963 and 1964 are 103.6, 106.5 and 112.0 respectively,

TABLE 4.24

REGRESSION COEFFICIENTS, THEIR SUMS, COEFFICIENTS OF DETERMINATION AND SIGNIFICANCE LEVELS

Years	No. of Obs.	Constant in Log Form	Value of b_i Land	Labor	Capital	Mgt.	Weather	b_i	R^2
1961	79	-.2030	.1941[a]	.4345[a]	.4724[a]	.1291[a]		1.2301	.82[a]
1962	77	-.0259	.2331[a]	.3452[a]	.5067[a]	.0975[b]		1.1824	.86[a]
1963	81	.4526	.2474[a]	.2742[a]	.4310[a]	.0954[a]		1.0479	.85[a]
1964	77	.1020	.2667[a]	.2436[a]	.5262[a]	.1291[a]		1.1656	.90[a]
Avge.	314	-1.2168	.2581[a]	.2587[a]	.5380[a]	.1064[a]	.6216[a]	1.7827	.84[a]

a: Significant at 1 percent level
b: Significant at 5 percent level

TABLE 4.25

TOTAL PRODUCTION FOR DIFFERING LEVELS OF CAPITAL FOR INDIVIDUAL YEARS AND FOR THE AVERAGE OF THE FOUR YEARS WITH OTHER RESOURCES AT GENERAL GEOMETRIC MEAN

Capital Input	Total Value of Production 1961	1962	1963	1964	Average of Four Years
$	$	$	$	$	$
6,000	10,680	14,470	14,790	15,700	14,020
5,508#	10,260	13,870	14,260	15,000	13,390
5,500	10,250	13,860	14,250	14,990	13,380
5,000	9,797	13,200	13,680	14,260	12,710
3,000	7,695	10,190	10,970	10,890	9,654
1,000	4,581	5,841	6,836	6,112	5,346

Geometric Mean of the Four Years

which are 3.6, 6.5 and 12 percent higher than the average income accordingly. The difference in total value productivity of capital between years might be due to changes in price levels, technological change, changes in weather conditions, extent of success in appropriate decision-making by farmers, and variations in the quality of purchased inputs and levels of utilization of existing stocks of farm capital.

The technological improvement of the area over the period studied might be essentially labor saving in its nature. As Table 3.6 shows, capital-labor ratio increased and labor-land ratio generally declined in the period of 1961 to 1964. That means, on the average, more and more capital was required

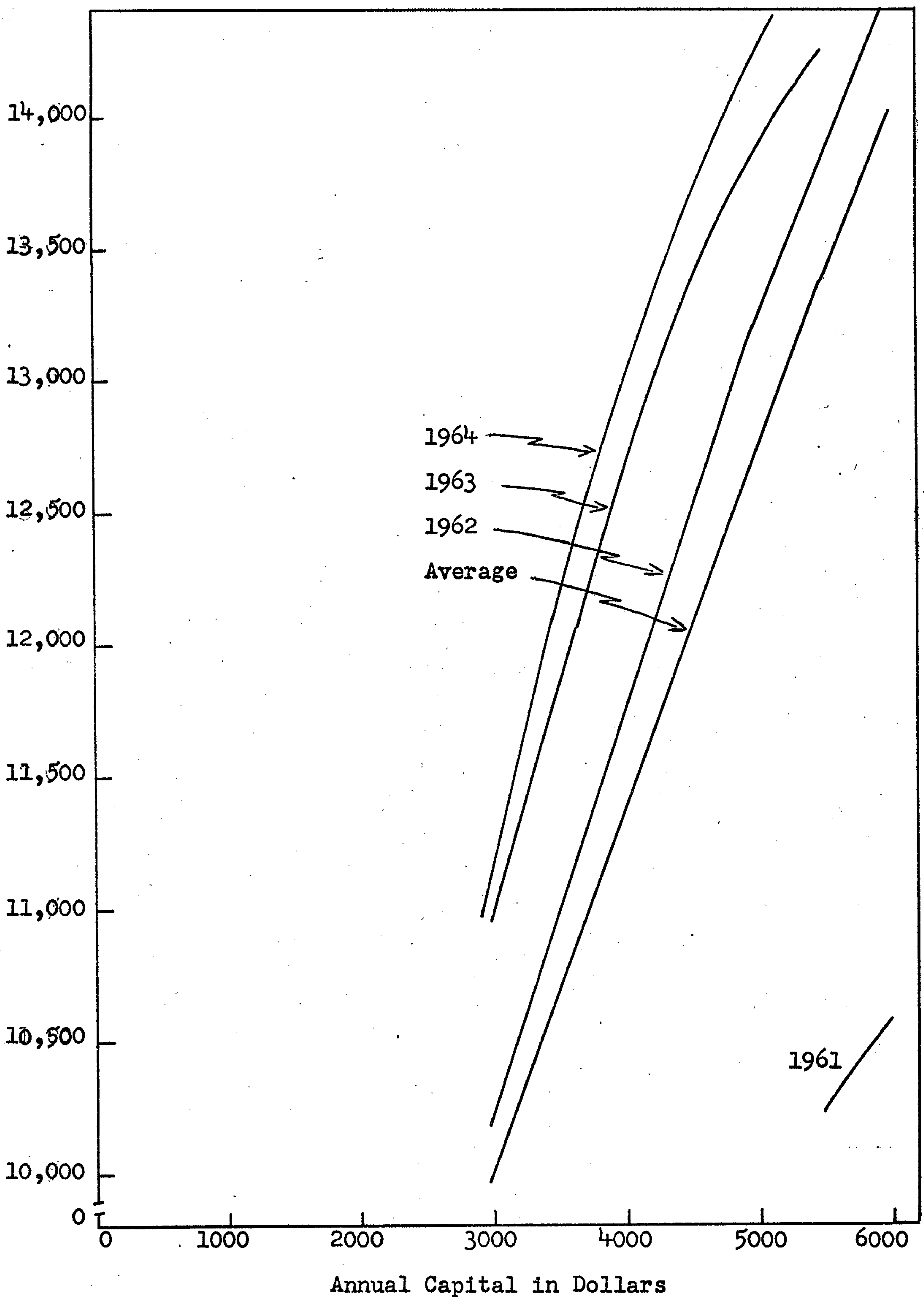

FIGURE 4.6 TOTAL PRODUCTIONS OF CAPITAL OF YEARS 1961, 1963, 1964 AND AVERAGE OF THE FOUR YEARS WITH OTHER RESOURCES AT GENERAL GEOMETRIC MEAN

in associating an hour of labor, and less and less labor hours were required per acre of land in the farm operation. For the studied area, one hour of labor was generally associated with $2.6 of annual capital in 1964. On the other hand, farm enterprises generally invested 4.8 hours of directive labor work to an acre of land in 1961 whereas only 3.4 hours in 1964 were required.

In view of the weather indexes as presented in Table 3.6 and the annual weather reports of the weather stations,[4] the studied area has evidently experienced a wide range of weather fluctuations in crop growing as well as harvesting seasons between the years 1961 to 1964. Its fluctuation would influence the productivity of all other resources as well as total farm income. The significance of weather conditions in explaining the variations of farm income has been subjected to statistical test. Table 4.26 shows the Cobb-Douglas equations representing various sizes and types of farming, with weather and without weather as an independent variable. As Table 4.26 shows, weather, as a factor of production, was tested significant at 0.1 percent level with the exception of the large farm. In all cases, R^2 were improved when weather was included in the equations. That means a greater proportion of variation in income can be explained by the production function when weather is

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[4] Ackerman, J. Annual Report of the Western Manitoba Farm Business Association, 1961, 1962, 1963, 1964. (Department of Agricultural Economics, University of Manitoba), September, 1962, 1963, 1964, 1965.

TABLE 4.26

REGRESSION COEFFICIENTS, COEFFICIENTS OF DETERMINATION AND TEST OF SIGNIFICANCE, BY SIZE AND TYPE OF FARMING WITH AND WITHOUT WEATHER AS ONE OF THE INDEPENDENT VARIABLES

Classification	No. of Obs.	Constant in Log Form	Value of b_i Land	Labor	Capital	Mgt.	Weather	b_i	R^2
Small Farm	98	.4293	.2401[a]	.0497	.6020[a]	.1772[a]		1.0690	.619[a]
		-1.0353	.2302[a]	.1860[b]	.5581[a]	.1549[a]	.6298[a]	1.7590	.691[a]
Medium Farm	168	1.0199	.1440[b]	.1810[a]	.4767[a]	.1108[a]		.4123	.608[a]
		- .3572	.1776[a]	.2532[a]	.4860[a]	.1092[a]	.4780[a]	1.5039	.665[a]
Large Farm	48	.8456	.1556	.0314	.6554[a]	.0980[b]		.9405	.614[a]
		.3081	.1413	.4558[a]	.3030[b]	.1234[a]	.2343	1.2578	.751[a]
*Crop Prod. 80% or More	59	- .1833	.6105[a]	.0377	.4003[a]	.0861[b]		1.1346	.830[a]
		1.6001	.5777[a]	.1553	.3413[a]	.0705[b]	.8185[a]	1.9631	.875[a]
*Crop Prod. Less than 80%	255	.0554	.2709[a]	.0953[b]	.6620[a]	.1152[a]		1.1434	.808[a]
		-1.1336	.2560[a]	.2105[a]	.5880[a]	.1149[a]	.5716[a]	1.7409	.848[a]
Average	314	.0600	.2744[a]	.1457[a]	.6099[a]	.1116[a]		1.1416	.800[a]
		-1.2168	.2581[a]	.2587[a]	.5380[a]	.1064[a]	.6216[a]	1.7827	.842[a]

a: Significant at 1 percent level.
b: Significant at 5 percent level.
* The farm with crop production 80% or more is defined as crop farm while that with crop production less than 80% is mixed farm.

considered as one of the factors of production. In some cases, the significance levels of the coefficients were reduced, especially in the case of labor. The coefficients of farm labor on small, medium and crop farms were not significant in equations without weather, but they were all significant at a 5 percent level in equations with weather as an independent variable. By including weather in the production functions, the sum of elasticities became greater, especially in the cases of medium and large farms, the sums of elasticities change from less than one to greater than one.

The effect of weather conditions on the productivity of land, labor, capital, management and total farm production based on average production function is shown in Table 4.27. Under the condition of normal weather (as represented by a weather index of 100) the marginal value productivities of one dollar of land, an hour of labor, one dollar of capital and one unit of management index at geometric mean on the average were $.20, $1.40, $1.33 and $106 respectively. The marginal value productivities of corresponding resources were higher because of the prevalence of good weather (represented by a weather index of 110) and lower because of bad weather (represented by index 90). When weather conditions were 10 units above or below normal, with other resources at geometric means, the total production would deviate upward or downward from normal by as much as 6 percent, i.e., $815 in terms of value. All this evidence indicates that weather is a significant factor influencing the

TABLE 4.27

MARGINAL VALUE OF PRODUCTIVITY OF LAND, LABOR, CAPITAL, MANAGEMENT AND TOTAL FARM PRODUCTION AT VARYING LEVELS OF WEATHER WITH ALL OTHER RESOURCES AT THEIR GEOMETRIC MEAN

Weather Index	Resource	G. M. Res. Input	MVP	Total Farm Production Value	Total Farm Production %
		$	$	$	
110	Land($)	17,340	.21	14,430	106
	Labor(Hrs.)	2,512	1.48		
	Cap.($)	5,508	1.41		
	Mgt.(Index)	14	112.		
100	Land($)	17,340	.20	13,590	100
	Labor(Hrs.)	2,512	1.40		
	Cap.($)	5,508	1.33		
	Mgt.(Index)	14	106.		
90	Land($)	17,340	.19	12,740	94
	Labor(Hrs.)	2,512	1.30		
	Cap.($)	5,508	1.25		
	Mgt.(Index)	14	99		

production of the studied area. Any policy relating to agricultural production should, therefore, give appropriate consideration to the effect of weather.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was based on the record analysis of 314 farms in the Neepawa-Minnedosa-Hamiota-Miniota area of Western Manitoba. These 314 farms were stratified into three categories: (1) small, medium and large farms of capital less than \$60,000, \$60,000 to \$80,000 and more than \$80,000. Each size contains 98, 168 and 48 farms respectively; (2) crop and mixed farms with crop production 80 percent or more and crop production less than 80 percent. Fifty-nine and 255 farms were included in each type of farming; (3) farms of 1961, 1962, 1963 and 1964 with 79, 77, 81 and 77 farms falling in each year respectively.

The Cobb-Douglas functions with general forms as shown below were fitted to the sets of farm data stratified.

(1) Cobb-Douglas functions involving eight independent variables

$$y = ax_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6} x_7^{b_7} x_8^{b_8}$$

(2) Cobb-Douglas functions involving five independent variables

$$y = ax_1^{b_1} x_2^{b_2} x_9^{b_9} x_7^{b_7} x_8^{b_8}$$

where

y: Output (in dollars)

x_1: Land (in dollars)

x_2: Labor (in hours)

x_3: Building Services (in dollars)

x_4: Machinery and Equipment Services (in dollars)

x_5: Cash Operating Expenses (in dollars)

x_6: Livestock Investment (in dollars)

x_7: Management (index)

x_8: Weather (index)

x_9: Capital (in dollars) $= x_3 + x_4 + x_5 + x_6$

The objectives of the present study were:

(I) to determine resource productivity on these farms and to identify problems of resource allocation.

(II) to make a comparison of the productivity of resources on crop and mixed farms.

(III) to evaluate the changes on farm production during the period 1961 to 1964.

Results of the Analysis

The results pertaining to the first objective are summarized as follows:

(1) Estimates of marginal value productivities were derived for small, medium, large and average of all farms. It was estimated, for the average of all farms, that marginal value product of one dollar invested in land was \$.21; of one directly productive hour of labor, \$.77; of one dollar of annual capital input, \$1.48 and of one unit of managerial ability, \$109, at the geometric mean of all resource inputs. For small farms, the marginal

value product of land, labor, capital and management at geometric mean were \$.17, \$.21, \$1.36 and \$103 respectively. For medium farms, the marginal value product of corresponding resources were \$.12, \$1.02, \$1.21 and \$124. For large farms, they were \$.13, \$.21, \$1.58 and \$168 respectively.

(2) Marginal rates of substitution between labor and capital were estimated. When all resource inputs were held at their geometric mean, one additional dollar of annual capital substituted for 1.9 hours of labor for the average of all farms. It substituted for 6.4, 1.2 and 7.5 hours of labor on small, medium and large farms respectively.

(3) It was found that a surplus of labor relative to capital generally existed. On the average, small farms combined \$3,614 of annual capital and 1,901 hours of labor with \$11,610 capital investment in land and 14 units of management to produce an income of \$8,204. Medium farms combined, on the average, \$5,875 of annual capital and 2,636 hours of labor with \$18,620 capital investment in land and 13 units of management to produce an income of \$15,000. Large farms combined 3,715 hours of labor and \$10,300 of annual capital with \$30,620 capital investment in land and 14 units of management to produce an income of \$25,060.

The same incomes could have been produced at lower cost if less labor were used or more capital had been invested in land and various forms of annual capital. For small and medium sizes of farms the shortage of annual capital was mainly in forms of machinery and equipment service and cash operating cost in the forms of fertilizer, chemical spray, purchased feed, etc. For large size farms, they were mainly building services and cash operating costs. Machinery and equipment could be, on the average, over-invested on large farms.

(4) Management as measured in the present study, acted as a significant factor of production because a lowering of management index reduced the marginal productivities of other factors. At an index representing good managerial ability (35.5), the marginal value product of an additional dollar of annual capital was $1.65, whereas at the index representing poor managerial ability (5.5), the marginal value product of an additional dollar of capital was only $1.33.

(5) For the average of all observations, increasing returns to scale existed. However, only small units had actually increasing returns. For medium and large farms diminishing returns to scale appear to be the case. Severe capital limitation could be what is preventing small farmers from taking

advantage of the condition of increasing returns to scale.

The results pertaining to the second objective are summarized as follows:

(1) The marginal value products of land, labor, capital and management at geometric means were compared for crop and mixed farms. The marginal value products of one dollar investment in land were \$.36 and \$.22; of one hour of labor were \$.27 and \$.48, of one dollar of capital investment were \$.94 and \$1.62, and of one unit of management were \$68 and \$118 on crop and mixed farms respectively.

(2) On the average, crop farms combined \$5,358 of annual capital and 1,782 hours of labor with \$21,180 of capital investment on land and 16 units of management to produce an income of \$12,620, whereas the mixed farm combined \$5,534 of annual capital and 2,716 hours of labor and \$16,560 of land and 13 units of management to produce an income of \$13,580.

Surplus of labor or shortage of capital could exist for both types of farming. The adjustment of reducing the use of labor or expanding the capital investment in land or various forms of annual capital were necessary for both types of farming. However, for crop farming, the annual capital in forms of building services, machinery and equipment services as well as cash operating expenses should all be expanded, whereas for mixed farming, the shortage of annual capital could only be in the forms of machinery and equipment and cash operating expenses.

The results pertaining to the third objective are summarized as follows:

(1) Total farm production curves of capital with land, labor, management at general geometric mean were estimated for the years of 1961, 1962, 1963 and 1964 and for the average of the four years. Generally speaking, the curve of 1961 lies below the average whereas that of 1962, 1963 and 1964 lies above. An annual capital amounted to $5,508 would yield a total farm production of $10,260, $13,870, $14,260, $15,000 and $13,390 in years of 1961, 1962, 1963, 1964 and in the average of the four years. If total average farm production was taken as 100, the total returns of the amount of capital would be 76.6, 103.6, 106.5 and 112.0 for 1961, 1962, 1963 and 1964 respectively.

The changes of total farm production from a given amount of farm capital between the years might be due to such influences as technological improvements, the influence of the weather conditions that prevail in the individual years, changes in quality of resources including management and the impact of general economic conditions.

(2) Weather was a significant factor influencing the production of the studied area because the occurrence of good weather would raise the marginal value productivities of other resources, whereas bad weather would lower their marginal value productivities. A weather index which was 10-units above or below normal, with other resources at their geometric means would result in total production deviating upward or downward by as much as 6 percent of normal farm production.

All the results suggested that surplus farm labor, misallocation of annual capital input and the shortage of farm land could be a general characteristic of the farms studied. They are indicative of the type of considerations needed for policy program formulation for greater efficiency in resource use.

All estimates of resource productivities were derived by production function analysis in the present study. They are indicative only of the average situation of the area. Further studies are needed to expand and adapt the economic, mathematic and statistical assumptions of production function analysis.

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APPENDIX

APPENDIX I

SIMPLE CORRELATION BETWEEN VARIABLES (IN LOGARITHM) (I)

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	1								
x_1	.4409	1							
x_2	.3017	.4944	1						
x_3	.6885	.5373	.4481	1					
x_4	.3744	.4622	.3699	.5558	1				
x_5	.2059	.5409	.3495	.2544	.2521	1			
x_6	.0628	.0277	-.0270	-.1571	.0839	-.0310	1		
x_7	.0213	-.2968	-.0357	.0587	.0415	.0412	.0104	1	
x_8	.6830	.6358	.4710	.7473	.7003	.4839	.1568	.1708	1

SIMPLE CORRELATION BETWEEN VARIABLES (IN LOGARITHM) (II)

	y	x_1	x_2	x_9	x_7	x_8
y	1					
x_1	.4409	1				
x_2	.5732	.6098	1			
x_9	.0627	.0277	-.0404	1		
x_7	.0218	-.2956	.0352	.0104	1	
x_8	.6830	.6358	.8344	.1569	.1711	1