RESOURCE PRODUCTIVITY AND RETURNS TO SCALE IN KANSAS COOPERATIVE ELEVATORS IN 1955

by

CHARLES STREETER

B. S., Kansas State College
of Agriculture and Applied Science, 1941

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Economics and Sociology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1959

LD
2668
T4
1959
S91
C.2
Document

TABLE OF CONTENTS

INTRODUCTION

Foremost in the thoughts of agricultural leaders and policy makers today are problems of American farmers. These problems are not confined to boundaries of individual farms but extend to many industries closely related to agriculture. Consequently changes in agricultural policy and government programs designed to aid farmers have implications and effects for industries serving or related to agriculture. This is particularly true of Kansas cooperative grain elevators.

Grain elevators are affected by agricultural programs first, because wheat is of major importance in the formation of agricultural policy by the government; second, because wheat, a crop furnishing over one-third of the cash farm income in Kansas, is also of vital importance to Kansas elevators; and third, because cooperative grain elevators are farmer owned and make up about one-fourth of the grain elevators in the state.

Following World War II, a shortage of grain storage developed in the United States as a result of relatively high levels of crop production and a decline in wheat exports. To alleviate this situation government programs such as accelerated depreciation write-off and occupancy agreements were provided to stimulate the construction of storage facilities.

As a result of these programs and other factors causing a need for modernization and expansion, average fixed assets of Kansas cooperative elevator associations more than doubled during the period 1950 to 1955.[1] This is an average increase of over $90,000 in new investment per elevator association. This increase in fixed assets is reflected in an increase in storage capacity of 228 per cent from 1946 to 1955.[2] During the period 1950 to 1957, storage capacity in all Kansas local elevators increased about two and one-half times over the 1950 level, or from 75,892,000 to 189,024,000 bushels.[3]

This rapid expansion in storage facilities is an indication that major shifts have taken place in resource use. There has been increased emphasis on storage activities and relatively less emphasis on grain merchandising since World War II. Apparently much more capital and relatively less labor is now being employed by grain elevators. Because of this, questions arise with regard to shifts in resource use which require study of resource productivities to derive satisfactory answers. Questions such as the following are of primary interest.

(1) Have resources been more profitably employed in the elevator industry than in other industries?

(2) Have shifts in resource use proven profitable for grain elevators? If so, does it appear that continued shifts

---

[1] Milton Manuel, Financial Summaries and Analyses for 192 Kansas Grain and 50 Petroleum Cooperatives for 1955-56. Kansas Agricultural Experiment Station Circular No. 361.

[2] Paul L. Kelley, John H. McCoy, Henry Tucker, and Virve Altau, Resource Returns and Productivity Coefficients in Central and Western Kansas Country Elevators of Modern Construction. Kansas Agricultural Experiment Station Bulletin No. 88. March 1957, p. 4.

[3] Unpublished data, Department of Agricultural Economics, Kansas State College. These figures do not include supplementary storage or space maintained by terminal elevators or headquarter mills.

will be profitable?

(3) In what areas of the state have resource inputs yielded the greatest returns?

(4) Should grain elevators continue to expand in size and/ or in numbers?

Answers to questions such as these are of vital importance to owners and operators of grain elevators as well as to agencies financing such facilities.

THE SETTING

In order to determine the existence of an economic problem the first step is to define the optimum or ideal condition which society would hope to achieve. Any deviation from this optimum condition constitutes a problem. It is assumed that a society composed of the owners of grain elevator facilities would consider maximum economic efficiency in resource use as a major economic goal. Maximum economic efficiency would be achieved when resources are organized to give a maximum profit.

Relatively high levels of grain production, declining exports, improved harvesting techniques, increased use of modern trucks for transporting grain, and the need for added storage space have been the major factors contributing to the need for modernization of elevators. Farmers are interested in harvesting the ripened grain as rapidly as possible in order to prevent unnecessary loss due to adverse weather conditions. Elevator operators realize that their ability to accept and process grain rapidly and efficiently plays a large part in the success of their operations.

During the 10 year period from 1946-1956 Kansas elevator operators have been pressed by the need for more adequate storage space and the equipment necessary for handling large quantities of grain as it is brought in from the farm. Pressure on storage facilities became a serious problem after the bumper wheat crop of 1952. In addition, the price support program has caused grains, particularly wheat, to be held relatively long periods of time thus increasing the need for added storage. Since 1952 Kansas wheat production has declined through the year 1957, but July 1 carryover stocks of Kansas wheat increased to a level in 1955 of approximately four and one-half times their previous 1951 level.[1] The fact that fixed assets including investments in land, buildings, machinery and equipment in cooperative elevator associations in Kansas have more than doubled from the year 1950 to 1955 is evidence that Kansas elevators have expanded facilities to meet modern needs. This huge increase in fixed assets probably was due largely to an increase in storage capacity. As was previously mentioned, the storage capacity of country elevators in Kansas increased 228 per cent from 1946 to 1955. As need for additional storage space became apparent, the United States Department of Agriculture called attention to newly enacted Federal legislation which permitted taxpayers to make amortization deductions for grain storage facilities over a period of 60 months. The amortization deduction was available on grain storage facility construction,

---

[1] Farm Facts 1955-1956. Reprinted from Kansas Agriculture 1953-56, the Thirty-ninth Report of the Kansas State Board of Agriculture, 1956, p. 38.

reconstruction, or erection completed after December 31, 1952 and on or before December 31, 1956. This rapid depreciation allowance, in addition to various occupancy guarantees, played an important part in the increase of storage capacity.

Every year except one during the 13 year period 1944 to 1957, total wheat production in the United States has been over 900 million bushels. It was over the one billion bushel mark nine of the 13 years. The low year was 1955, with 705 million bushels being produced. In only one year previous to 1944 (going back as far as 1909) did total wheat production in the United States reach the one billion bushel level.[1] It is evident that total United States wheat production has been relatively high during recent years.

Kansas normally produces about one-fourth of the total amount of wheat produced in the United States. In 1952, Kansas produced the largest wheat crop in its history, a total of 307,692,000 bushels.[2] This large production was due to the fact that the crop developed under extremely favorable conditions from the time of seeding in the fall of 1951. The acreage planted was relatively large with the abandoned acreage being well below the 10 year average (1941-50). Total crop production in Kansas in 1952 was 50 per cent above the flood-damaged 1951 harvest and 24 per cent above the 10 year average.

---

[1] The Demand and Price Structure for Wheat, United States Department of Agriculture Technical Bulletin 1136, November 1955, pp. 6-7.

[2] Farm Facts 1952, Report for Kansas State Board of Agriculture, September 1953, p. 4.

The remarks here are centered largely around the production of wheat since it is the major crop of Kansas and makes up over one-third of the total cash farm income in the state.[1] This places it in the position of primary importance in so far as Kansas farmers and their cooperative elevators are concerned. Table 1 illustrates the comparative importance of the leading Kansas grain crops on the basis of acres, production, and values for the year 1956.[2]

Table 1. State summary, acreage, yield, production, and value of major crops, Kansas, 1956.

Crops	Acres harvested	Yield per acre (bushels)	Production (bushels)	Farm value (dollars)
Wheat	9,244,000	15.5	143,282,000	286,564,000
Corn	1,527,000	21.0	32,067,000	44,894,000
All sorghums for grain	1,626,000	15.0	24,390,000	30,488,000
Oats	1,078,000	21.5	23,177,000	17,151,000
Soybeans (for beans)	355,000	8.5	3,018,000	6,338,000

Source: Fortieth report of the Kansas State Board of Agriculture, Kansas Agriculture 1956-1957, p. 153.

It will be noted from Table 1 that Kansas wheat production was about four and one-half times greater than corn production in 1956, ranking at the top of the list in bushels produced. The

[1] Kelley, McCoy, Tucker, and Altau, op. cit., p. 3.

[2] Farm Facts 1956-1957, Kansas State Board of Agriculture, pp. 15, 17, 19, 25, and 27.

relative importance of the proportion of cash farm income derived from wheat was previously mentioned but this is again reflected in the high farm value in 1956 of wheat as compared to other crops (Table 1). It is recognized that figures from one year are not sufficient evidence of the prevalence of this situation; however, examination of figures from records available indicates that this is a fairly typical relationship.

With wheat constituting by far the greatest volume of all crops produced in Kansas it becomes apparent that extreme variations in the production of this crop would constitute a complex problem for Kansas elevators. Table 2 illustrates the variations in acreages and production of wheat in Kansas from 1940-1956.[1]

It will be noted that wheat production in Kansas in 1955 was less than one-half the peak production of the year 1952. In addition, total production of all principal crops in Kansas in 1955 was the smallest since 1939.[2] This was a 27 per cent drop below the 10 year average (1944-53), and was largely attributed to sharp reductions in wheat, corn, and grain sorghums output. Adverse weather bringing heat and drouth conditions, along with dry winds, caused damage to all crops as well as loss of considerable wheat acreage. In contrast to the Kansas figures, United States production figures show that with the exception of winter and spring wheat, all other important farm grain production was above average

[1] Summary of Crop and Livestock Information, Kansas State Board of Agriculture Biennial Report and/or Annual Report, 1940-1957. (Table compiled from data reported in these years.)

[2] Farm Facts 1955-1956, op. cit., p. 12.

Table 2. Seeded acreage and production of wheat in Kansas, 1940-1956.

Year	Seeded acreage	Production (bushels)
1940	12,531,000	123,848,000
1941	13,091,000	173,332,000
1942	11,134,000	206,775,000
1943	10,741,000	144,241,000
1944	13,103,000	191,669,000
1945	14,148,000	207,939,000
1946	14,147,000	216,768,000
1947	15,404,000	286,702,000
1948	14,634,000	231,368,000
1949	16,244,000	164,208,000
1950	13,807,000	178,060,000
1951	14,773,000	126,113,000
1952	15,068,000	307,629,000
1953	14,315,000	144,662,000
1954	11,738,000	176,208,000
1955	10,799,000	128,385,000
1956	10,907,000	143,282,000
1957	6,871,000	94,054,000[a]

[a] This is a preliminary estimate.

Source: This table was compiled from data in annual crop reports of the Kansas State Board of Agriculture.

or near record levels.[1]

Acreage restrictions in the form of wheat acreage allotments were reenacted by the government in 1954. This was probably largely responsible for the reduction in the acreage of Kansas wheat of over four million acres from 1952 to 1955.

Extreme variations in the volume of grain handled during the past few years constitute only a part of the problem grain elevator managers have had to face. In spite of acreage allotment

[1] Crop Production, United States Department of Agriculture, 1955 Annual Summary, p. 6.

restrictions and the drought conditions prevailing in Kansas in the past few years, July 1 carryover stocks of wheat in Kansas have increased steadily from a level of 27,013,000 bushels in 1951 to a level of 256,874,000 bushels in 1956.[1] These figures provide a demonstration of the tremendous pressure on storage facilities of Kansas elevators which developed during that period. Exactness in long-range predictions of the production and carryover stocks of wheat is practically impossible, making it extremely difficult for Kansas elevators to become adapted to a level of production which will allow them to attain maximum economic efficiency.

THE PROBLEM

The relationship of income to resource use involves an important economic principle applicable to the grain elevator industry, as well as all other owners of resources. If owners of resources think that the resources can be more advantageously used in some other industry than in the one in which they are now employed, the resources will be transferred from the less advantageous to the more advantageous use.[2] For example, resources employed in a relatively unprosperous industry will be transferred to more prosperous industries providing the cost of transfer is less than the difference in remuneration. As resources are transferred, the returns to the resources remaining in the unprosperous industry become greater, while the returns to the resources in the

---

[1] Farm Facts, 1955-1956, op. cit., p. 38.

[2] Harold G. Halcrow, Agricultural Policy in the United States, Second printing. Englewood Cliffs: Prentice Hall, Inc., January 1956, p. 157.

prosperous industry become relatively less. The more mobile the resources, the faster is the transfer and greater is the progress in eliminating the differences in advantage.

This is known as the principle of equal advantage. The word "advantage" is used to refer to both monetary and nonmonetary values. This principle is applicable not only to inter-industry transfer of resources, but to resource transfer among firms within an industry, or transfer among geographic areas.

This study is concerned primarily with measurement of resource productivity in the elevator industry. These measurements will provide benchmarks which are valuable for purposes of comparison with similar measurements in other industries. Within the industry comparisons may be made among the areas studied. These comparisons will be valuable in expanding the knowledge of resource use and the flow of those resources resulting from differences in marginal productivities.

Additional information provided by the study will be estimates of the returns to scale existing in the elevator industry. This will provide information which will be valuable as a guide for future industry development.

In view of the changing conditions and the shifts which have taken place in resource use, measurements of resource productivity are of vital importance to owners and operators of grain elevators as well as to lending agencies. Needs arise as a result of changing conditions which require decisions often without adequate knowledge of conditions as they actually exist. Greater knowledge can assist in decisions as to whether new investments should be made, where new investments are most likely to succeed and in decisions as to the extent of such expansion.

This study was not intended to furnish recommendations for shifts in resource use fpr individual firms. It is primarily intended for those interested in the average or over-all situation in the elevator industry. These measurements should be useful for those dealing with the policy for future development of the industry.

The analytical method for the solution of the problem will be formulated in terms of the economic model discussed in a subsequent section.

THE ECONOMIC MODEL

The theoretical concept of the economic model is formulated in terms of efficiency criteria. The analytical method is outlined in this section which specifies the measurements required to solve the problematic situation.

General Framework of the Analysis

For the purposes of this study, a static model is assumed with firms operating under conditions of pure competition producing primary products. The prices of the products are assumed to be equal and constant. Both outputs and inputs are expressed in terms of dollar values. Ordinarily outputs are measured in dollars; inputs such as capital are measured in value terms, while inputs such as land and labor are measured in physical terms.[1]

---

[1] Earl O. Heady, Glen L. Johnson, and Lowell S. Hardin, Resource Productivity Returns to Scale and Farm Size, Iowa State College Press, 1956, p. 4.

Even if all outputs and inputs are measured in dollars, the technical relationships may be the same as if observations were in physical units. This is true, of course, only in the case of a purely competitive market and constant prices. In this situation the value production function is only a transformation from physical units to value units.

The Model

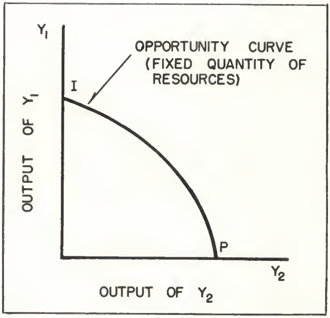
The economic model for the problem to be analyzed explains the basic relationships in resource use. Plate I shows production possibilities of two products (Y_1 and Y_2) from a given set of resources. The curve IP is an iso-resource or equal resource curve since it indicates all possible combinations of products Y_1 and Y_2 that can be produced, when an equal or total quantity of resources is available for the production of the two products. When all resources are directed to the production of product Y_1, OY_1 quantity of Y_1 may be produced but none of Y_2 is possible. When all resources are directed to the production of Y_2, OY_2 quantity of Y_2 can be obtained but none of Y_1. Figure 1 shows the maximum quantity of one product that can be produced from a given set of resources when the quantity of the other product is specified.

In Plate II, iso-revenue curves are illustrated. With price P_{y_2} of product Y_2 twice as high as the price P_{y_1} of product Y_1, two units of Y_1 are needed to equal the value of one unit of Y_2, hence $P_{y_2}/P_{y_1} = 2/1$ or a price ratio of 2. All points on

EXPLANATION OF PLATE I

Relationship of output of product Y_2 to output of product Y_1 given a fixed quantity of resource input.

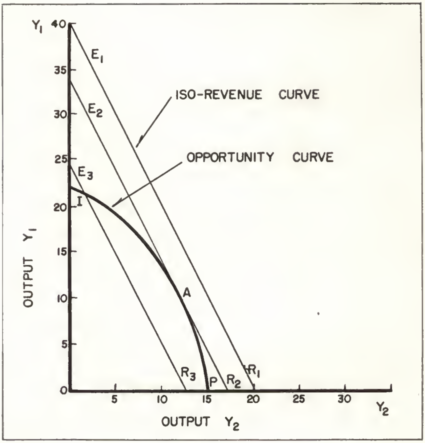
PLATE I


Y1
OPPORTUNITY CURVE
(FIXED QUANTITY OF
RESOURCES)
I
OUTPUT OF Y1
P
Y2
OUTPUT OF Y2

EXPLANATION OF PLATE II

Product-product model illustrating profit maximization under increasing rates of substitution.

PLATE II



Y_1
40
35
30
25
20
15
10
5
0
5
10
15
20
25
30
Y_2
E_1
E_2
E_3
I
A
P
R_1
R_2
R_3
ISO-REVENUE CURVE
OPPORTUNITY CURVE
OUTPUT Y_1
OUTPUT Y_2

iso-revenue curve E_3R_3 denote all production possibilities of products Y_1 and Y_2 which will return equal revenue. All points on iso-revenue curve E_2R_2 also denote all production possibilities of products Y_1 and Y_2 which will return equal revenue; however, the revenue represented by E_2R_2 is greater than that represented by E_3R_3. Likewise E_1R_1 is an iso-revenue curve denoting greater revenue than does E_2R_2. All iso-revenue lines will have the same slope as long as the product prices have the same ratio.

As indicated by the intersection of the iso-resource curve IP and the iso-revenue curve E_3R_3 in Plate II, one production possibility is 22 units of Y_1 and two units of Y_2. However, this combination does not represent maximum returns since iso-revenue curve E_2R_2 represents greater revenue than E_3R_3. Greater returns will be realized as more of Y_2 and less of Y_1 is produced. It is impossible to produce enough of products Y_1 and Y_2 to reach iso-revenue curve E_1R_1 with the given set of resources represented by the IP curve. It now becomes apparent that point A represents maximum returns possible from the given resources. Only at the point of tangency is the marginal value product of resources equal between products. Maximum returns are always denoted by the point of tangency of an iso-revenue curve and an opportunity curve and never by an intersection of the two curves. At this point, since the slopes are the same, the marginal rate of substitution of Y_2 for Y_1 is inversely equal to the price ratio.

$$\text{(I)} \quad \frac{\Delta Y_1}{\Delta Y_2} = \frac{P_{y_2}}{P_{y_1}}$$

or

$$\text{(II)} \quad \Delta Y_2 \cdot P_{y_2} = \Delta Y_1 \cdot P_{y_1}$$

These equations denote the optimum combination of products to produce when the ultimate goal is profit maximization. Once the substitution and price ratios have been equated as in Equation I, the following conditions of equal productivities are attained: Equation II derived from Equation I states that with resources allocated to maximize profits, the marginal value product of a unit of resource allocated to Y_1 is equal to the marginal value product of a unit of resource allocated to Y_2.

Certain allocation criteria may be used to demonstrate the theoretical aspect of this situation. Let P_{y_1} and P_{y_2} be prices of products Y_1 and Y_2 and let P_x be the price of the fixed resource X. The production possibilities of products Y_1 and Y_2 from resource X are given by the transformation function $X = f(Y_1, Y_2)$ where X is a constant as in Plate II. The slope of the transformation functions is needed at the point of tangency (A, Plate II). The total derivative of $f(Y_1, Y_2)$ with respect to Y_2 equated to zero is as follows:[1]

$$\text{(1)} \quad \frac{\partial X}{\partial Y_1} \cdot \frac{dY_1}{dY_2} + \frac{\partial X}{\partial Y_2} = 0$$

---

[1] Kelley, McCoy, Tucker, and Altau, op. cit., p. 6.

(2) $\frac{\partial X}{\partial Y_1} \cdot \frac{dY_1}{dY_2} = - \frac{\partial X}{\partial Y_2}$ or $\frac{dY_1}{dY_2} = - \frac{\frac{\partial X}{\partial Y_2}}{\frac{\partial X}{\partial Y_1}}$

(3) At point A, $\frac{dY_1}{dY_2}$ is equal to the slope of the iso-revenue line R_2R_2

(4) Therefore, at point A $\quad - \frac{\frac{\partial X}{\partial Y_2}}{\frac{\partial X}{\partial Y_1}} = - \frac{P_{y_2}}{P_{y_1}}$

(5) We multiply both the numerator and the denominator of the left side of equation (4) by the price of the resource P_x and we get:

$$- \frac{\frac{\partial X}{\partial Y_2} \cdot P_x}{\frac{\partial X}{\partial Y_1} \cdot P_x} = - \frac{P_{y_2}}{P_{y_1}}$$

(6) $\frac{\partial X}{\partial Y_2} \cdot P_x$ is the marginal unit cost of Y_2 or MUC_{y_2} and the $\frac{\partial X}{\partial Y_1} \cdot P_x$ is the marginal unit cost of Y_1 or MUC_{y_1}

(7) Therefore, $\frac{MUC_{y_2}}{MUC_{y_1}} = \frac{P_{y_2}}{P_{y_1}}$ or rearranging

$$\frac{P_{y_2}}{MUC_{y_2}} = \frac{P_{y_1}}{MUC_{y_1}}$$

Optimum resource use is attained when the marginal unit costs of two products are proportional to their prices. When a single resource is used to produce two products, the price of the resource is the same for both uses.

(8) When the price of the resources used to produce Y_1 and Y_2 are different but constant, the following equation denotes optimum resource allocation:

$$\frac{P_{y_2}}{\frac{P_{xy_2}}{MPPr_{xy_2}}} = \frac{P_{y_1}}{\frac{P_{xy_1}}{MPPr_{xy_1}}}$$

In this equation P_{xy_2} and P_{xy_1} are the prices of the resources used on Y_2 and Y_1, respectively and $MPPr_{xy_2}$ is the marginal physical product of resources used on Y_2 and $MPPr_{xy_1}$ is the marginal physical product of resources used on Y_1.

(9) Rearranging equation (8) gives:

$$\frac{P_{y_2} \cdot MPPr_{xy_2}}{P_{xy_2}} = \frac{P_{y_1} \cdot MPPr_{xy_1}}{P_{xy_1}} \text{ or } \frac{VMPPr_{xy_2}}{P_{xy_2}} = \frac{VMPPr_{xy_1}}{P_{xy_1}}$$

The ratio of $VMPPr_{xy_2}$ value marginal physical product of resources used on Y_2 to the price P_{xy_2} of the resource used on Y_2 must be equal to the ratio of the value marginal physical product of resource used on Y_1 to the price P_{xy_1} of the resource used on Y_1 for optimum resource allocation.

In this study the prices of the resources are assumed to be equal and constant. In this instance

(10) $VMPPr_{xy_1} = VMPPr_{xy_2}$

This equation states that the value of the marginal physical products of the resource used in the production of Y_1 and Y_2 are equal.

Estimates of resource productivity in eastern, western, and central Kansas can be derived from production functions fitted to the data provided by cooperative grain elevator associations in these areas. These estimates will allow comparisons of resource productivities among the various areas of the state.

THE OBJECTIVES

The general objective of the study is to analyze the economic efficiency of resource use in the Kansas cooperative grain elevator industry. One of the major objectives was to provide measurements of the productivity of resources used in the elevator industry, so that they would be available for purposes of comparison with similar measurements of other industries.

A second objective was to measure resource productivities of these firms in various areas of the state and to make comparisons among these areas.

Another objective was to compare the value of the marginal product of the resource inputs in each area of the state and for the state as a whole with their factor costs.

The last objective was to measure the returns to scale in the elevator industry.

THE DATA

The data used in this study were supplied by about four-fifths of all cooperative grain elevator associations operating in Kansas in 1955. Annual audits were submitted by 192 of approximately 237 in existence at that time. One of the audits was not used for the final analysis because of excessive losses suffered by that particular association. Some associations represent one elevator while others represent two or more. The approximate location of these associations is shown in Plate III.

An attempt was made to obtain data that were as nearly comparable as possible. It was not practical to obtain data covering identical dates for all associations due to auditing difficulties. It was possible, however, to obtain fiscal year records which were comparable in that they included the transactions for the 1955 wheat crop. This tended to minimize variations in data due to differences in time periods.

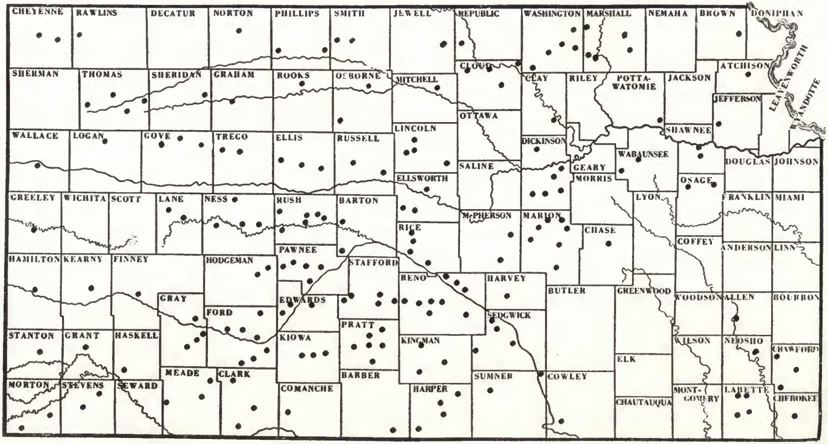
Considering aggregate figures for Kansas (1955), it was found that 47.6 per cent of the total gross margin was from storage and handling of grain while 37.0 per cent was from the sale of commodities including grain.

The relative importance of income derived from storage and handling and that derived from grain marketing in 1955, as compared to the relative importance of these same two revenues indicated from a similar study of 1949 data, is of interest. During 1949, grain merchandising was more important as a source of revenue while in 1955, income from storage and handling predominated. This is a result of the increased need for storage facilities during recent years and the rapid expansion of facilities to meet changing needs. Of the total gross margin derived from sales of various commodities in 1955, 34.4 per cent was derived from the sale of grain while 20.8 per cent was derived from the sale of petroleum and auto supplies. Wheat sales constituted 64.8 per cent of the

EXPLANATION OF PLATE III

Location of headquarters of 191 Kansas cooperative elevator associations for the 1955 wheat crop year.

PLATE III


CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTA-
WATOMIE
JACKSON
ATCHISON
JEFFERSON
LEAVENWORTH
WYANDOTTE
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
OTTAWA
DICKINSON
GEARY
WABAUNSEE
SHAWNEE
DOUGLAS
JOHNSON
SALINE
MORRIS
ELLSWORTH
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
RICE
McPHERSON
MARION
CHASE
LYON
FRANKLIN
MIAMI
COFFEY
ANDERSON
LINN
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD
RENO
HARVEY
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
FORD
EDWARDS
PRATT
SEDGWICK
STANTON
GRANT
HASKELL
KIOWA
KINGMAN
WILSON
NEOSHO
CRAWFORD
ELK
MEADE
CLARK
BARBER
SUMNER
COWLEY
MORTON
STEVENS
SEWARD
COMANCHE
HARPER
CHAUTAUQUA
MONT-
GOMERY
LABETTE
CHEROKEE

total gross margin derived from grain sales. Gross margin is defined as follows:

Gross margin = (ending inventory + sales) minus (beginning inventory + purchases). The remainder of the income of cooperative grain elevator associations is derived largely from the sale of other farm supplies such as hardware, feed, seed, fertilizer, building materials, machinery, coal, and groceries. The proportion of the various commodities handled varies within each association.

The environment in which firms operate has an important influence on operations within any one year. The 1955 wheat crop was the second smallest production since 1940. Yields per harvested acre were below the 10 year average and in addition, 20.7 per cent of the planted acres was abandoned due to drouth conditions and wind erosion.[1]

The acreage planted to all sorghum was the largest of record for the state. Dry, hot weather was very detrimental, resulting in heavy abandonment particularly in central, west central, and northwest counties. The yield of 11.5 bushels per harvested acre was the lowest since 1939 and 7 per cent below the 10 year average.

The corn harvested in 1955 represented the smallest corn crop grown in Kansas since 1937, being less than half the 10 year average. The corn crop made excellent early season progress. Moisture deficiencies and extreme high temperatures during July and August cut yields sharply, resulting in a near failure except in extreme

---

[1] Farm Facts, 1955-1956, op. cit., p. 16.

eastern Kansas counties.[1]

Plates IV and V illustrate the stability of prices influencing elevator operations during the year 1955. The index of wholesale prices (Plate IV) is computed using the 1947-49 base period equal to 100 per cent.

Prices of farm grains were fairly stable during the first half of 1955 with about a 10 point drop in the wholesale price index during July and August followed by fairly steady prices the remainder of the year.[2] The price index for general purpose machinery and equipment also remained stable during the first six months, but showed a slight upturn thereafter (Plate IV).

Average hourly earnings of workers in the grain mill products industry remained about steady during the 1955 calendar year.[3] Some fluctuation is evident, however, in average weekly earnings of workers in that industry (Plate V). This is probably due to workers working more hours during rush periods.

As illustrated in the above charts, there are some variations in the prices of products handled by grain associations and in the items constituting their costs. These changes, however, are believed to be insufficient to require adjustment of the data due to price variation among time periods.

---

[1] Farm Facts, 1955-1956, _ibid_., p. 17.

[2] United States Department of Labor, _The Handbook of Basic Economic Statistics_, Washington, April 1957, 11:123.

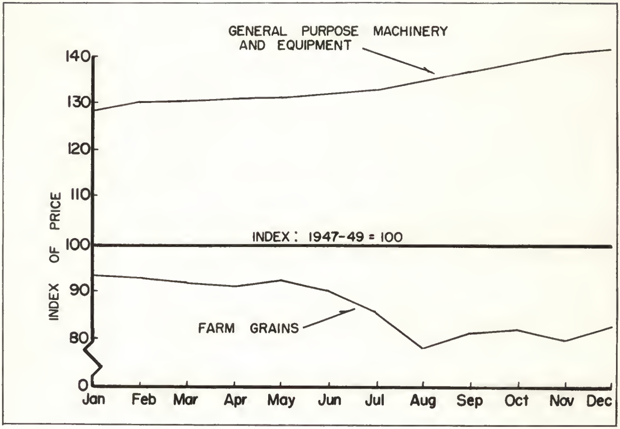
[3] _Kansas Labor and Industrial Bulletin_, Kansas Department of Labor, December 1955, 25:8.

EXPLANATION OF PLATE IV

Index of wholesale prices of general purpose machinery and equipment and farm grains by months, 1955.

Source: United States Department of Labor, Bureau of Labor Statistics.

PLATE IV

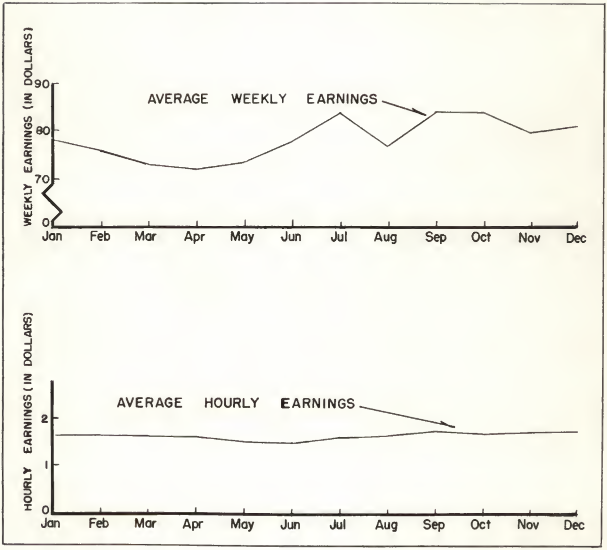

GENERAL PURPOSE MACHINERY AND EQUIPMENT
INDEX: 1947-49 = 100
FARM GRAINS
INDEX OF PRICE
140
130
120
110
100
90
80
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

EXPLANATION OF PLATE V

Average weekly earnings and average hourly earnings of workers in the grain mill products industry by months, Kansas, 1955.

Source: Kansas Labor and Industrial Bulletin, Kansas Department of Labor, December 1955.

PLATE V


WEEKLY EARNINGS (IN DOLLARS)
90
80
70
0
AVERAGE WEEKLY EARNINGS
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
HOURLY EARNINGS (IN DOLLARS)
2
1
0
AVERAGE HOURLY EARNINGS
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

METHOD OF ANALYSIS

The marginal products of the resource inputs are the basic estimates needed to make the necessary comparisons of elevator activities among areas of the state. These productivity estimates can be derived from production functions.

Estimates of the regression coefficients of resource inputs may be conveniently derived from a production function of the Cobb-Douglas type:

$$Y = aX_1^{b_1}, X_2^{b_2}, \ldots X_i^{b_i}, \ldots X_n^{b_n}$$

where Y is the value of output added in the production process and X_i's are the values of the resource inputs. The b_i's are the statistically derived regression coefficients.

The exponents in a function of this type are elasticities of production; that is, they denote the percentage change in output associated with 1 per cent change in input when all other inputs are held constant. The "a" term is constant in the equation.

Elasticity of production is assumed to be constant over the entire range of inputs, therefore, the Cobb-Douglas function does not reflect successive areas of constant, increasing, and decreasing returns.[1] The Cobb-Douglas function is easy to fit because it is linear in logarithms and the exponents in an ordinary least-squares equation are the elasticities of production of the respective input variables.

[1] James S. Plaxico, "Problems of Factor Product Aggregation in Cobb Douglas Value Productivity Analysis," Journal of Farm Economics, November 1955, 37:664.

Other functions could be fitted by the least-squares process which would allow different elasticities at different input levels. This condition could be fulfilled, for example, by a second or third degree polynomial. The use of a function of this type would require a substantial increase in computational effort while degrees of freedom would be sacrificed.

The Cobb-Douglas function is used in this study because it allows diminishing marginal productivity to the factor inputs and diminishing marginal rates of substitution between factors. Aggregation and interpretation problems in fitting a Cobb-Douglas function are difficult; however, alternative functions do not alleviate this situation.

From the Cobb-Douglas function several measurements of resource productivity can be obtained:

1. The value marginal product of a given factor.
2. The nature of returns to scale.
3. The nature of returns to a given factor.

The value of the marginal product may be obtained from the function by evaluating the partial derivative at a particular point. The value marginal product at the geometric mean is the partial derivative of $\overline{Y}$ with respect to $\overline{X}_1$ and may be found by the equation:

$$VMPr_{x_1} = \frac{\overline{Y}}{\overline{X}_1} \cdot b_1$$

In the above equation, $VMPr_{x_1}$ refers to the value marginal product of the resource in question, computed at the geometric mean; where $\overline{Y}$ refers to the value added to output at the geometric mean, and

$\overline{X}_i$ refers to the input at the geometric mean. b_i is the elasticity coefficient of the X_i in question and indicates the percentage increase in output associated with 1 per cent increase in input when other variables are held constant. Therefore, the value added to output is obtained for the addition of a single unit of resource input.

Where $b_i = 1$ returns to the X_i factor are constant or in other words, 1 per cent increase in input will produce 1 per cent increase in output when other factors are held constant. If $b_i > 1$ returns to the X_i factor are increasing and a 1 per cent increase in factor input will produce a greater than 1 per cent increase in output when other factors are held constant, conversely, if $b_i < 1$ returns to the X factor are decreasing and 1 per cent increase in factor input results in a less than 1 per cent increase in output.

If the sum of the elasticities ($\sum_{i=1}^{n} b_i = 1$) of all the factors were exactly 1.0, constant returns to scale would be denoted; an increase in all inputs by 1.0 per cent would increase output by 1.0 per cent.[1] Where $\sum_{i=1}^{n} b_i > 1$, increasing returns to scale are evident and conversely where $\sum_{i=1}^{n} b_i < 1$, there are decreasing returns to scale.

Upon determination of the estimates of resource productivity it is possible to answer the following questions:

---

[1] Earl O. Heady, Economics of Agricultural Production and Resource Use. New York: Prentice-Hall, Inc., 1952, p. 359.

1. Is resource productivity greater in one area of the state than in another area?
2. Are the various value marginal products greater or smaller than their costs?
3. What effect will a change in one resource input have on output when other inputs are constant?
4. If all inputs are increased proportionately, what effect will this have on output?
5. What adjustments can be made in resource use to attain greater economic efficiency?

DESCRIPTION OF RISK AREAS

The influence of differences in types of agriculture and in stability of production on resource productivity within the grain elevator industry has been determined in a previous study.[1] The western one-third of the state is generally accepted as being an area of relatively high risk in crop production. The eastern one-third is considered to be of relatively low risk. It was found in this study that the services of Kansas grain elevators tend to be highly correlated with crop production in areas where wheat is the major grain produced. This is true because the output of food grains such as wheat moves off the farm for processing. The output of feed grains tends to remain on the farm where produced or on farms near by where it will be consumed by livestock. The coefficients of variability of wheat yields per seeded acre and the

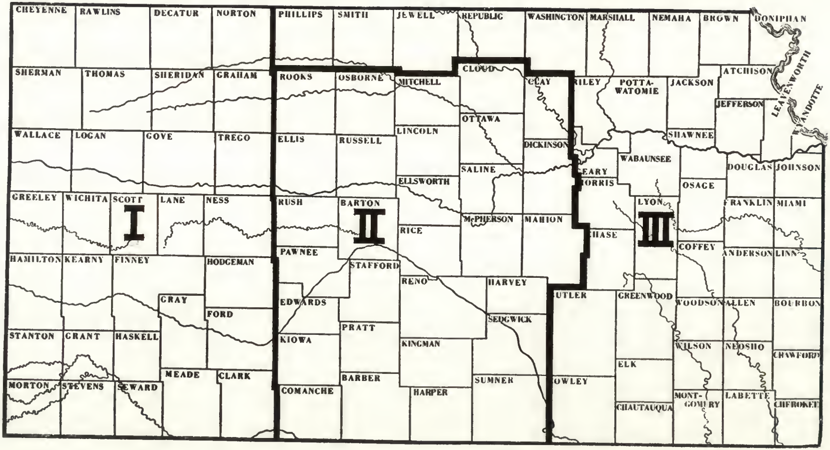
---

[1] Kelley, Tucker, and Manuel, op. cit., pp. 11-12.

EXPLANATION OF PLATE VI

Three major risk areas for 191 Kansas cooperative elevators for the 1955 wheat crop year.

PLATE VI



CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA
BROWN
DONIPHAN
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY
POTTA-WATOMIE
JACKSON
ATCHISON
LEAVENWORTH
WYANDOTTE
JEFFERSON
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
OTTAWA
DICKINSON
SHAWNEE
WABAUNSEE
DOUGLAS
JOHNSON
SALINE
ELLSWORTH
GEARY
MORRIS
OSAGE
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
LYON
FRANKLIN
MIAMI
McPHERSON
MARION
RICE
CHASE
COFFEY
I
II
III
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD
ANDERSON
LINN
RENO
HARVEY
GRAY
FORD
EDWARDS
BUTLER
GREENWOOD
WOODSON
ALLEN
BOURBON
SEDGWICK
PRATT
STANTON
GRANT
HASKELL
KIOWA
KINGMAN
WILSON
NEOSHO
CRAWFORD
ELK
MEADE
CLARK
BARBER
SUMNER
COWLEY
MORTON
STEVENS
SEWARD
COMANCHE
HARPER
MONT-GOMERY
LABETTE
CHEROKEE
CHAUTAUQUA

relative importance of the grain crops harvested were relevant criteria in outlining three major risk areas in the state.

In the order of risk, these areas were ranked as follows: Area I - relatively high risk; Area II - relatively medium risk; and Area III - relatively low risk. Area I represents the western one-third of the state. Wheat and grain sorghums are the predominant crops in this area. Area II is an important wheat producing area while Area III is important in corn production with considerable wheat being produced also.

The same area divisions are relevant in this study as were previously used.[1] Comparisons of resource productivities among these areas will be meaningful to elevator operators as users of resources as well as to credit agencies. If important differences in resource productivity do exist, redirection of resource use may be indicated so as to attain greater efficiency.

CLASSIFICATION OF DATA

Many problems arise in classifying both inputs and outputs into categories that will be manageable from the standpoint of the analyst. It is necessary that these classifications be made because the numbers of inputs and outputs involved often exceed the computational capacity of present computing equipment. The analysis is materially enhanced by classification of inputs, and often times outputs as well, into categories before the analysis is begun. Mr. Glen L. Johnson, Professor of Agricultural Economics,

---

[1] Loc. cit.

Michigan State University and James S. Plaxico of Oklahoma A & M College have outlined general procedures for making these classifications.[1]

Input Classification

According to Johnson, it is desirable that individual inputs remain in fairly constant proportions if the input category is to be meaningful. That is, inputs within a category should not be combined arbitrarily. If inputs within a category were all perfect complements, the proportions in which they would be used would not vary. If inputs within a category were good substitutes for each other, then proportions would vary widely but there would be a common denominator in terms of which inputs could be measured. Quoting Johnson,

> One reasonable rule for grouping inputs into categories is to group good complements together and good substitutes together, measuring the complements in terms of 'sets' and substitutes in terms of the common denominator which makes them good substitutes. Sets of complements and sets of substitutes can be grouped into the same category very conveniently if the sets are complementary to, or substitutes for, each other. The converse of the above two rules follows: The input categories defined should be neither good substitutes nor good complements for each other.

Farm inputs such as a tractor and a plow, together with a disc, a harrow, corn planter, and a corn picker may be used to illustrate the complementary relationship among inputs since these inputs would be combined in fixed proportions. Resourse substitution among inputs may be illustrated by using labor. Hired

---

[1] Heady, Johnson, and Hardin, op. cit., p. 90.

labor may be substituted for family labor or operator's labor. Since these resource inputs are substitutes for each other at constant rates they may be classed in the same input category. The range of substitution possibilities varies from perfect substitutes to fixed proportions. Actually, however, according to Kenneth E. Boulding, perfect substitution is not likely over the entire range or it would lead to the erroneous conclusion that we could make a product without any quantity of essential ingredient.[1]

Bradford and Johnson set forth several criteria in classifying categories of inputs to determine meaningful relationship between input and output. The criteria they use follow:

1. That the inputs within a category be as nearly perfect substitutes or perfect complements as possible.

2. That categories, made up of substitutes (a) be measured according to the least common denominator (often physical) causing them to be good substitutes and (b) be priced on the basis of the dollar value of the least-common-denominator unit.

3. That categories made up of complements (a) be measured in terms of units made up of inputs combined in the proper proportions (which are relatively unaffected by price relationships) and (b) be priced on an index basis with constant weights assigned to each complementary input.

4. That categories of inputs be neither perfect complements nor perfect substitutes relative to each other.

5. That investments and expenses be kept in separate categories.

6. That maintenance expenditures and depreciation be eliminated from the expense categories because of the difficulties encountered in preventing duplication. (This means that the earnings of the

---

[1] Kenneth E. Boulding, Economic Analysis, Revised edition. New York: Harper Brothers, 1948, p. 675.

investment categories must be large enough to cover maintenance and/or depreciation.)[1]

James S. Plaxico, Oklahoma A & M College, stated that the manner in which inputs are aggregated may influence the parameters which are a basis for marginal productivity estimates. When X represents the aggregated input categories and I represents the various individual input factors, the example he uses follows:

$X_1 = I_2$

$X_2 = I_2 + I_3$

$X_3 = I_4$

Another possibility may be:

$X'_1 = I_1$

$X'_2 = I_2$

$X'_3 = I_3 + I_4$

It is apparent, according to Plaxico, that if the Cobb-Douglas function is fitted to the same data aggregated in these two alternative fashions (1) goodness of fit will likely differ, and (2) the estimated parameters, including marginal productivity values, will be different. These differences apply to the parameters and value marginal products of X_1 and X'_1 categories although these categories consist of a single, therefore homogeneous, input which is the same in the two suggested aggregations.

This situation arises as a result of the differences in assumptions relative to inputs I_2, I_3, and I_4. In each case it is postulated that an increase in input will increase output

---

[1] Lawrence A. Bradford and Glen L. Johnson, Farm Management Analysis. New York: John Wiley and Sons, 1953, pp. 144-145.

(assuming elasticities of production >0). However, the first set of aggregates indicates that I_2 and I_3 are perfect substitutes and affect output in an additive manner. On the other hand, the second set of aggregates indicates a non-linear substitution relationship between these two factors and a non-additive relationship between these two inputs with respect to output.

Any set of inputs that must be used in fixed proportions (perfect complements) should be treated as one input; otherwise the estimated parameters will be biased.[1] In similar manner, if two inputs have precisely the same effect on production they must be weighted and combined. The latter condition implies a constant marginal (linear) rate of factor substitution where the inverse of the respective price ratio equals the marginal rates of substitution. It follows that failure to aggregate perfect complements and perfect substitutes will bias estimates just as will the aggregation of two inputs which are imperfect substitutes or complements. This is the case because the model specifies diminishing marginal rates of input substitution and assumes that the level of each input affects the productivity of others.

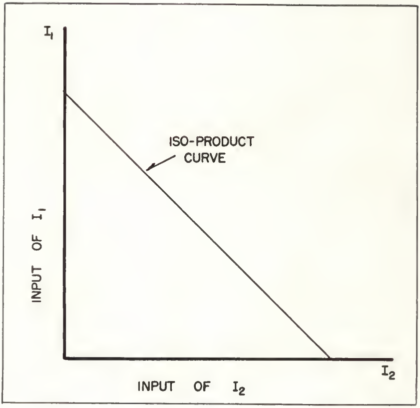
Plates VII, VIII, and IX illustrate three ways that two inputs may substitute for each other in the production of a given product. Plate VII implies a constant rate of substitution between I_1 and I_2. It would be proper to aggregate these two inputs into a single category (1) if the inverse of the price ratios equals the marginal rate of substitution or if the two inputs are used in

[1] Plaxico, op. cit., p. 666.

EXPLANATION OF PLATE VII

Iso-product curve showing constant rates of substitution between two inputs.

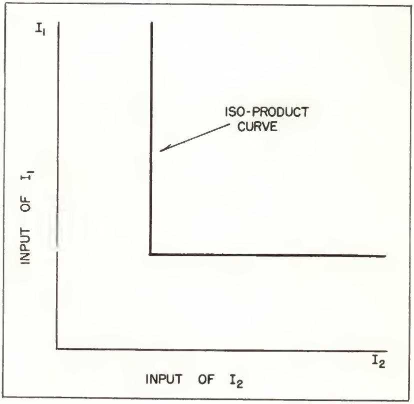
PLATE VII



EXPLANATION OF PLATE VIII

Iso-product curve showing complementary relationship between resource inputs.

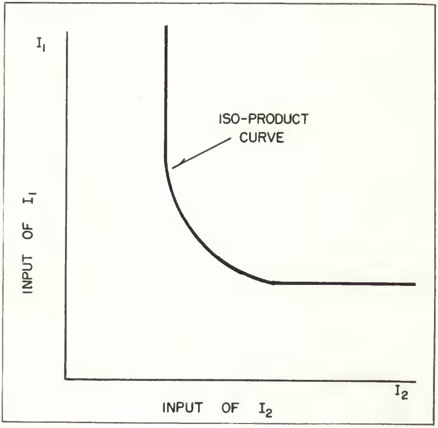
PLATE VIII



EXPLANATION OF PLATE IX

Iso-product curve showing complementarity among resource inputs with decreasing rates of substitution throughout the central range.

PLATE IX



the same proportion, and (2) if the two inputs substitute one for the other at the same rate in the production of each relevant product.[1] Plate VIII indicates that I_1 and I_2 are perfect complements and should be aggregated if this same relationship exists in the production of all products and if each observed firm combines I_1 and I_2 in the one optimum fashion. Plate IX indicates substitution at a diminishing rate throughout the central range of factor ratios only becoming parallel to each axis at the two extreme factor ratios.[2] Input substitution would be possible only within the central range of the factor ratios. The relationship becomes complementary at the two extremes. This is the type of relationship which is believed to exist between labor and machine services in the grain elevator industry. Labor and machines would not be classed in the same category. As has been stated earlier, resource inputs within a category should be as near perfect substitutes or perfect complements as possible.

Labor services for the purposes of this study were grouped as a single input category (X_1). They include managers' salaries, commissions, and wages paid other employees. The proportion of the manager's time that is spent in managing and that which is spent in physical labor about the plant varies considerably. Generally in smaller plants the manager spends a proportionately greater part of his time on labor and less on management while in larger firms the opposite is true. Since some of the labor services performed by the manager, office help and labor force

---

[1] Loc. cit.

[2] Loc. cit.

substitute at constant rates, labor services represent a reasonably homogeneous category.

The other input category considered was that of capital services. Included in this group is (a) repairs, (b) depreciation, and (c) other expenses such as utilities, gas and oil, rent, office, plant supplies, travel expense, railroad lease, directors' fees, etc. It would have been preferable to exclude certain items from other expenses but it was impossible to do so due to the form of the survey data. These items included donations, legal expense, license and bonds, subscription dues, auditing, and bad debts. Although it was desirable to exclude the latter items, it makes little difference in the final analysis since they represent only a small percentage of the total expenses.

It was possible to separate out the major expense items which had no immediate influence on output; therefore, the excluded expenses were as follows: (a) taxes (property, stock, and social security), (b) insurance, (c) interest, and (d) advertising and education.

The complementary relationship existing among inputs within the capital services (X_2) category is basis for the belief that these inputs are reasonably homogeneous. Limitations to this conception are recognized, however, and these limitations will be discussed in a later section. Both input categories are expressed in terms of dollar values.

Output Classification

Certain general statements relative to the aggregation of outputs may be made. Single aggregates stated in money terms, such as gross income or net income, have been used to describe output variables. Thus, prices are applied to outputs (products) and the sums added to reduce these products to a single output figure.

The aggregation of all products into a single output category may be accomplished without bias when the set of products are produced in fixed proportions. Also, sets of outputs may be properly combined if they are affected in the same manner by each input category.[1] The frequency with which this situation actually exists in the real world is questionable; therefore, there are limitations in the use of this concept. These limitations will be discussed in a later section.

For the purposes of this study a single output Y (value added in the production process) expressed in money value is considered to be the dependent variable. The value of added output was computed by the summation of total gross margin on sales, income from storage and handling grain, and income received for services performed such as grinding, auto service, etc. Total gross margin on sales was computed by the following equation. Total gross margin on sales = (ending inventory + sales) - (beginning inventory + purchases).

---

[1] Plaxico, op. cit., p. 668.

Patronage refunds from regional cooperatives and other income such as sale of junk and recovery of bad debts were excluded as part of value of added output. They were not directly dependent upon the inputs used.

General Classification Information

Separate functions were set up for elevator operations performed in each of the three major risk areas of the state. An additional one was set up in aggregate for the state as a whole. The four functions included the three variables mentioned above, all measured in dollar values. The variables may be classified as follows:

Dependent variable: Y = value added in the production process.

Independent variables: X_1 = value of labor services.

X_2 = value of capital services.

The production functions are assumed to be static with firms producing primary products under conditions of pure competition and constant prices. Under these conditions the same relationship that exists among variables, expressed in value terms, would exist had they been expressed in physical terms provided the physical terms reflected the same proportions.

In a static model the allocation of resources over time is not considered. It is assumed that all factors enter into production simultaneously, and that output is instantaneous. In this situation the production process is considered to begin and end at the same time, and the product is assumed to be produced at the end of the production period.

ECONOMIC ORGANIZATION OF ELEVATORS

The value of input and output services for individual elevators varied considerably within areas as well as among areas of the state. The value of added output varied the greatest in western Kansas, and the least in eastern Kansas. As indicated (Appendix, Table 10) from the data studied, the range of value of added output was over four times as great in western Kansas as that in eastern Kansas ($824,620 as compared to $195,910). The widest range of both labor and capital inputs occurred in central Kansas with the narrowest range of inputs in both categories being in eastern Kansas.

Based on the arithmetic means (Appendix, Table 11), relatively larger labor and capital resource inputs were used in western Kansas than in either central or eastern Kansas with eastern Kansas being the smallest. Capital service inputs were about twice as great in western Kansas as in eastern Kansas while labor service inputs were about one and one-half times as great. The arithmetic mean of value of added output was over two times greater in western Kansas than in eastern Kansas with central Kansas about midway between the two.

Capital-labor ratios (Appendix, Table 12) indicate the major differences in resource combinations among areas. In western Kansas less labor was required relative to capital services than in central or eastern Kansas. This is an indication of a higher degree of mechanization in that area. Stated in another way, for every \$1.00 spent on labor in the western area, \$1.03 was spent on capital; in central Kansas for every \$1.00 spent on labor, \$0.76 was spent on capital, and in eastern Kansas for every \$1.00 spent on labor, \$0.71 was spent on capital.

The percentage total inputs by input category is shown in the Appendix, Table 13. In central and eastern Kansas well over half of the total inputs were labor service inputs, while in western Kansas, capital and labor service inputs were about equally divided.

The residuum of the arithmetic mean (Appendix, Table 14) of the value of added output over the arithmetic mean of total labor and capital service inputs is nearly three times as great in western Kansas as in eastern Kansas, and nearly twice as great in central Kansas. In general, western Kansas is characterized by larger and more highly mechanized plants than is eastern Kansas, therefore, with larger amounts spent for labor and capital service inputs (average relationships, Appendix, Table 11), a larger residuum would be expected.

ANALYSIS

Regression Equations

Previous experience gained by those working with elevator data indicates that the Cobb-Douglas function is suitable for the analysis of this study. Since the exponents of the resource inputs (b_i's) are also the elasticity coefficients, the use of this particular function has the advantage of reducing the number of calculations required.

The following algebraic form of the Cobb-Douglas function was used for estimates of the marginal productivities of resource inputs within each area of the state and also for the state as a whole:

$$Y = aX_1^{b_1} X_2^{b_2}$$

The four functions computed by least squares analysis were:

Area I (western)	$Y = .64313\ X_1^{.637779}\ X_2^{.545840}$
Area II (central)	$Y = 3.1349\ X_1^{.532761}\ X_2^{.494355}$
Area III (eastern)	$Y = .92156\ X_1^{.512432}\ X_2^{.626435}$
Aggregate	$Y = 1.4195\ X_1^{.553596}\ X_2^{.550693}$

In the above equations, Y = value added in the production process, X_1 = value of labor services, and X_2 = value of capital services.

Elasticity Coefficients

The elasticity coefficients in the equations shown in the previous section represent the percentage increase in output associated with 1 per cent increase in input when all other inputs are held constant. The other inputs could be at any level within the range of the data.

In order for this type of procedure to be valid, however, the b_i values, as derived by least square analysis, must be tested to see if these estimates are actually significant. The size of the standard errors of the elasticities must be considered in making these tests (Appendix, Table 15). In each case, the null hypothesis, $b_i = 0$, was set up and tested by the t-test. In every case, the b_i's were found to be significant at the 1 per cent level (Appendix, Table 15). These included the labor and capital services significance coefficients for western, central, and eastern Kansas and for Kansas as a whole.

The values of the elasticity coefficients in every case were less than one, thus indicating decreasing returns to the individual factor. For example, the value .637779 for labor services in western Kansas indicates that an increase of 1 per cent in labor inputs in that area with other inputs held constant anywhere within the range of the data would increase product (value added of added output) by approximately .64 per cent.

Since in every case the b_i's were found to be significantly different from zero at the 1 per cent level, the null hypothesis $b_i = 0$ was rejected.

Marginal Products

A study of value of the marginal products is of particular interest as a measure of factor productivity for 191 Kansas elevator associations as a group and by specified risk areas. Marginal products may be computed from either the geometric or arithmetic mean. The geometric means were used in this study due to the wide range in the data. They are believed to be appropriate because their use places less emphasis on extreme items. Both geometric means and arithmetic means are shown in the Appendix, Table 11.

Marginal product values of resource inputs computed at the geometric mean for 191 Kansas cooperative elevator associations as a group and by specified risk areas are shown in Table 3. An interpretation of the meaning of these marginal productivities follows: If all resource inputs were at their geometric means, the addition of one more increment (one dollar) of a given resource input with other inputs remaining unchanged would return a value of added output due to the additional increment of input, equal to the amount shown in Table 3. For example, computation of the marginal product of labor service inputs in western Kansas at the geometric mean indicates that an additional $1.00 spent for labor services would return $2.47 value of added output. It must be remembered, however, that since the elasticity coefficient for labor services in western Kansas is less than one, returns to labor service inputs are decreasing in that area. Also, since the Cobb-Douglas function postulates constant elasticities throughout the range of the function, if the marginal product is figured for a resource input at a figure greater than its geometric mean for the function derived here, its estimated marginal productivity will be less than that shown in Table 3. Also, conversely, if the marginal product for a resource input is figured at less than its geometric mean for the function, the resulting estimated marginal product will be more than that shown in Table 3. Similar statements may be made regarding every other resource input in every other function used in this study since returns to each factor were decreasing in every case. In this study all marginal productivity estimates were highly significant.

It is interesting to note that (Table 3) the marginal productivity of labor increased consistently from east to west in comparing the three major risk areas while the marginal

Table 3. Marginal products of resource inputs for 191 Kansas cooperative elevator associations as a group and by specified risk areas, 1955.*

Function	Number of elevators	Resource input: Labor (dollars)	Resource input: Capital (dollars)
Western	54	2.47	2.17
Central	98	1.86	2.37
Eastern	39	1.38	2.53
Aggregate	191	1.88	2.42

* All marginal products are significant at the 1 per cent level.

productivity of capital increased from west to east. This introduces the following question regarding elevator operations in Kansas: In the future, can efficiency of the elevator industry be increased by an adjustment in resource use among areas? For example, with an estimated marginal product of $2.47 for labor in western Kansas as compared to $1.38 in eastern Kansas, there is, theoretically, pressure for the equalization of the marginal products between two areas. There is some question as to whether labor is sufficiently mobile to allow the complete equalization of the marginal product of labor among areas. Also, the nature of firms in western Kansas may be such that labor and capital service inputs must be combined in fixed proportions. In other words, it may not be possible or feasible to employ more labor in western Kansas without the employment of additional capital. Admittedly oftentimes decisions regarding expansion are influenced materially by short term gains which will largely pay for the additional expenditure within the first year.

For example, farmers may be faced with alternative decisions to expand storage facilities in their cooperative grain elevator in a given year or sustain heavy losses on grain by being forced to accept cash prices. The saving may be sufficient justification for the expansion which otherwise would have appeared impractical. There is a possibility that firms in western Kansas can benefit from the relatively high estimated marginal product of labor service inputs by the expansion of sidelines activities. Sidelines activities tend to use more labor inputs in proportion to capital inputs as compared to grain merchandising or grain storage activities.

In eastern Kansas an estimated marginal product of $1.38 for labor service inputs as compared to $2.53 for capital service inputs indicates that in the future, the use of relatively greater quantities of capital service inputs would likely increase efficiency in that area. It should be remembered, however, that a change in the input level of one variable influences the marginal product of both variables, so that efficiency recommendations are dependent upon simultaneous evaluation of the marginal products. The primary value in comparisons of marginal products of resource inputs in a study such as this lies in the formation of policy for the future development of the industry.

Differences in Marginal Productivity of Resources Among Major Risk Areas

Major interest within the grain elevator industry centers around the problem of increasing the existing efficiency. As has been mentioned previously, providing direction to resource use in the future development of the industry offers the greatest opportunity for increasing efficiency. Labor resources, for example, may be considered to possess at least some degree of mobility. More labor will be offered at an increased wage than was formerly offered at the previous lower wage. This would indicate that in areas where the marginal productivity of labor is high, it may be possible that grain elevators could increase efficiency through the adding of activities which use a greater proportion of labor services. Where more laborers are not available at the going wage, it may be possible to offer a higher wage to induce a flow of workers to that area and thereby increase efficiency. Some grain elevators may have the opportunity to use idle capital to expand operations and thus increase efficiency while it may not be possible in other areas. Management decisions must be made as to whether shifts should be made in resource use. Some notion may be gained as to the advisability of such contemplated shifts between areas by testing whether the elasticity coefficient of a particular resource input in one area differs significantly from the elasticity coefficient necessary to make the marginal product of that particular factor equal in both areas.

Heady and DuToit outlined the method used in this study for making these tests.[1]

In testing the significance of the differences in marginal products, the subscript (a) is used to denote the factor, product, and elasticity coefficients in one area whereas the subscript (b) represents similar measurements for another area. First, we wish to know whether the marginal product of the mean resource input of area (a) differs significantly from that of area (b). The elasticity coefficient b'_a is computed for area (a). This is the coefficient of the mean resource input necessary in area (a) to give a marginal product equal to that of area (b) MP_b. For example, we wish to determine b'_a in equation (1) where MP_b, $\bar{Y}_a$, and $\bar{X}_a$ are known. $\bar{X}_a$ is the mean resource input in area (a). MP_b is the marginal product of the mean resource input in area (b) and $\bar{Y}_a$ is the mean resource output in area (a).

Equation (1) $$MP_b = b'_a \frac{\bar{Y}_a}{\bar{X}_a}$$

In solving for b'_a, equation (1) may be transformed to equation (2) which follows:

Equation (2) $$b'_a = b_b \frac{\bar{Y}_b \bar{X}_a}{\bar{Y}_a \bar{X}_b}$$

The value t is then estimated by equation (3).

---

[1] Earl O. Heady and Schalk DuToit, "Marginal Resource Productivity for Agriculture in Selected Areas of South Africa and the United States," Journal of Political Economy, December 1954, p. 501.

Equation (3)
$$t = \frac{b_a - b_b\left(\frac{\bar{y}_b\ \bar{x}_a}{\bar{y}_a\ \bar{x}_b}\right)}{\sqrt{s^2 b_a + \left(\frac{\bar{y}_b\ \bar{x}_a}{\bar{y}_a\ \bar{x}_b}\right)^2 s^2 b_b}}$$

The elasticity coefficients b'_a necessary in area (a) to yield a marginal product equal to that of area (b), with the mean resource input and mean output of area (a) as computed by equation (2) are shown in Table 4. The t-values (Table 5) computed by equation (3) were used to determine whether the necessary elasticity coefficient b'_a was significantly different from the actual elasticity coefficient b_a obtained from the production function. The null hypothesis was set up that $b_a = b'_a$.

Table 4. Elasticity coefficients necessary to give marginal products in one function equal to the marginal product in another function, 191 Kansas cooperative elevator associations, 1955.

Resource and function against which test is made	Function for which test is made: Area I Western	Area II Central	Area III Eastern
Labor services			
Western	--	.708419	.918324
Central	.479637	---	.690619
Eastern	.355886	.395303	---
Capital services			
Western	---	.451853	.537822
Central	.597182	---	.588409
Eastern	.635775	.526302	---

It was found that at the 10 per cent level there was a significant difference in the marginal products of labor services between eastern and western Kansas. Other differences were not

Table 5. Values of t for comparison of differences in resource productivities by areas, 191 Kansas cooperative grain elevator associations, 1955.

Resource and function against which test is made	Function for which test is made		
	Area I Western	Area II Central	Area III Eastern
Labor services			
Western	---	-.987714	-1.767337*
Central	.987715	---	-1.277665
Eastern	1.767332	1.277645	---
Capital services			
Western	---	.326061	.570607
Central	.326055	---	.323452
Eastern	-.570617	.323442	---

* Significant at the 10% level.

significant at an acceptable level. Therefore, in a comparison of the elasticity coefficients of labor services between eastern and western Kansas, the null hypothesis $b_a = b'_a$ was rejected and the labor resource was considered not to be allocated optimumly.

Differences in the elasticity coefficients were not significant at an acceptable level in other comparisons. This included comparisons of the elasticity coefficients of the labor service inputs between eastern and central Kansas and between central and western Kansas. The same area comparisons were made for the elasticity coefficients of the capital service inputs but none were found to be significant. In all non-significant cases, the hypothesis was accepted and resources were considered to be allocated in an optimum manner among areas.

It is assumed that resources are allocated optimumly within the firm. Tests cannot be conducted within the realm of this study to determine the validity of this assumption due to lack of resource input price information.

Efficiency of Factor Pricing

The extent to which the factor prices approach the value marginal product of the factors is important in the interest of economic efficiency in a competitive capital market. Resources can be employed in production as long as the value marginal product of the resource input is as great or greater than its marginal cost. Value marginal products which are greater than the factor prices of resource inputs could exert pressure for funds for that particular use. Or, if the value marginal product of the resource input is significantly less than the price of the factor, the opposite effect would likely prevail.

To develop evidence to accept or reject the null hypothesis that there was no significant difference between the productivity and cost of a resource, the following equation was set up:

$$b_i \left(\frac{\bar{Y}}{\bar{X}_i}\right) = K$$

where $b_i \left(\frac{\bar{Y}}{\bar{X}_i}\right)$ is the marginal product of the resource input and K a constant or the value necessary to equal a \$1.00 input of the resource plus, in the case of capital, the interest cost of that \$1.00.

The equation for the t-test used to test the null hypothesis that $b_i \left(\frac{\bar{Y}}{\bar{X}_i}\right) = K$ is as follows:

$$t = \frac{b_i\left(\frac{\bar{Y}}{\bar{X}_i}\right) - K}{\sqrt{s^2_{b_i}\left(\frac{\bar{Y}}{\bar{X}_i}\right)^2}}$$

The interest charge was computed according to the following method. Capital service inputs of all 191 elevators for the period studied were divided into fixed and fluid capital inputs. The interest rate of 5 per cent was considered appropriate for fixed capital inputs while an interest rate of 4 3/4 per cent was used for fluid capital inputs. These rates were used by lending agencies financing fixed capital and operating loans at the time the study was made. The weighted average of the two interest rates was 4.88 per cent which was rounded to 4.9 per cent. For computations, see Appendix, Table 17. This rate was assumed to be appropriate for all functions in the study.

The t-values for the tests of differences between capital productivity and capital costs are shown in Table 6. In the aggregate, central, and eastern Kansas functions, the differences were found to be significant at the 1 per cent level, while in western Kansas the difference was significant at the 5 per cent level. This would constitute sufficient evidence to reject the null hypothesis that capital productivity and capital costs are equal. Since the value marginal products of capital service inputs are significantly greater than their marginal costs, this would indicate, assuming the static model of this analysis, that cooperative grain elevator associations have not used enough capital in the production process and that they could profitably use more.

Table 6. Values of t and level of significance for tests of difference between the productivity and cost of capital services of 191 Kansas cooperative elevator associations, 1955.

Function	Number of elevators	t values
Western	54	2.1192*
Central	98	3.9567**
Eastern	39	4.4005**
Aggregate	191	6.1392**

* Significant at the 5% level.
** Significant at the 1% level.

The difference between the productivity and cost of labor services was tested in the same manner, using $1.00 as the cost of a marginal increment of labor services. The t-values for the tests of differences between productivity and cost of labor services are shown in Table 7. The tests showed that in the aggregate function and in the central Kansas function, the productivity of labor was significantly greater at the 1 per cent level. In western Kansas the difference was significant at the 5 per cent level while in eastern Kansas it was significant at the 20 per cent level. This is considered to be sufficient evidence to reject the null hypothesis that the marginal productivity of labor service inputs is equal to their marginal cost. Indications are that efficiency in grain elevators could be improved by the use of more labor, especially in central and western Kansas and probably in eastern Kansas, although the evidence is not as clear-cut in the latter case. Labor is at least partially mobile and labor services

Table 7. Values of t and levels of significance for tests of difference between the productivity and cost of labor services in 191 Kansas cooperative elevator associations, 1955.

Function	Number of elevators	t-values
Western	54	2.6278**
Central	98	3.1979***
Eastern	39	1.4389*
Aggregate	191	4.4858***

* Significant at the 20% level.
** Significant at the 5% level.
*** Significant at the 1% level.

could be induced to flow to certain areas by competitive bidding for these services.

Returns to Scale

In determining scale relationships, all resource inputs are considered variable. "Pure scale relationships are involved only if all resources which go into production are increased by the same proportion; if the input of one is doubled, the input of all others must be doubled."[1] Returns to scale may be either (1) constant, (2) increasing, or (3) decreasing, according to whether output is constant, increasing, or decreasing as resource inputs are increased by the same proportion.

[1] Heady, op. cit., p. 350.

This study considers the economic aspect of returns to scale in the elevator industry in various sections of Kansas. Grain elevator associations may find it to their benefit to integrate in order to enjoy certain scale economies. As an example, this might come about through combining plants under one operation thus making more efficient use of labor and enjoying the economies of large scale purchases.

Since 1945, the number of elevator plants in Kansas has remained about stable. The large increase in assets with possibly a slight decline in numbers, indicates there is a tendency toward larger firms. There is little current information available to elevator owners to substantiate whether such a tendency contributes to greater efficiency of resource use. Also, owners of elevator facilities as well as lending agencies are interested in whether greater economic efficiency could be attained by fewer but larger firms. An answer to questions such as this would yield valuable information as to the advisability of the much discussed plan of "integration" as applied to the elevator industry. A summation of the coefficients of the variable resource inputs yields estimates as to the nature of the returns to scale existing in Kansas cooperative elevator associations.

The sums of the exponents in all functions provided evidence of increasing returns to scale. Table 8 shows the value of the sums of the exponents for each function.

The null hypothesis of constant returns to scale was set up for each area and for Kansas as a whole to ascertain whether the sums of the exponents were significantly different from unity.

Table 8. Sums of exponents for area and aggregate functions, 191 Kansas cooperative elevator associations, 1955.

Function	:Number of elevators :	Sum of exponents
Western	54	1.183619
Central	98	1.027116
Eastern	39	1.138867
Aggregate	191	1.104289

The results of these tests are shown in Table 9.

Table 9. F values for testing returns to scale, 191 Kansas cooperative elevator associations, 1955.

Function	:Number of elevators :	F values
Western	54	6.82**
Central	98	.340097*
Eastern	39	4.22**
Aggregate	191	9.240***

* Not significant.
** Significant at the 5% level.
*** Significant at the 1% level.

The sums of the exponents were found to be significantly different from unity at the 1 per cent level in the aggregate function and significantly different from unity at the 5 per cent level in eastern and western Kansas. In central Kansas there was no significant difference. These findings constitute sufficient evidence to reject the null hypothesis that constant returns to scale exist in the elevator industry in eastern and western Kansas whereas in the central Kansas function, the null hypothesis is not rejected.

Due to the presence of increasing returns to scale, the functions for eastern and western Kansas indicate that profits in the elevator industry could be increased through expansion to induce greater output. That is, a 1 per cent increase in all factors would increase output by more than 1 per cent. It should be pointed out, however, that there are limits to expansion possibilities for the purpose of grain storage or grain merchandising unless the number of elevators in operation is reduced. Limitations are imposed by the quantity of grain available for these purposes. The quantity available depends upon current surpluses of wheat and other grains, size of the trade territory, the importance of grain production and sales in the territory (which depends on climate, soil, and topography of the area), and the proportion of the total grain produced that the elevator can attract. A possibility of expansion and increasing profits exists through increased sidelines activities. This study was not designed to measure these possibilities, but a previous study conducted at this station from 1951 data indicates that returns to scale are increasing in sidelines operations in Kansas grain elevators.[1] According to this study, expansion in sidelines would enable firms (1) to use their facilities and labor more efficiently throughout the year; (2) to increase their business volume; and (3) to diversify and stabilize the business.

---

[1] Kelley, McCoy, Tucker, and Altau, _op_. _cit_., p. 25.

In central Kansas, the test performed indicates that returns to scale are about constant. In other words, as the level of labor and capital inputs are increased proportionally, output will also increase by about the same proportion. If returns to scale were constant we would expect that 1 per cent increase in all factors would increase output by 1 per cent. This would indicate that where profits are being made, greater profits would be forthcoming simply by expanding the level of inputs proportionally. The same limitations would prevail here, however, as were outlined for eastern and western Kansas.

LIMITATIONS

The measurements forthcoming from this study are general estimates of the productivity of capital and labor input services of Kansas cooperative grain elevator associations. These estimates are meaningful primarily for the period studied and are applicable from year to year only if factor and product prices increase and decrease proportionally or remain the same, if the physical relationships remain the same, and if similar economic, climatic, and political conditions exist.

Even though static conditions and constant prices in a purely competitive market are not completely attainable in the real world, such assumptions do not detract materially from the study. The problem has its setting in a dynamic world where uncertainty and imperfect knowledge cannot be eliminated.

The model adopted assumes that all managers within the industry are equal in managerial ability and desire for risk bearing.

It is known that managerial ability does have an important influence on production, yet, production economists know of no way of measuring it. The results of the study are based on an average of managerial ability among firms. Actually, one firm may benefit materially because of the superior ability of its manager, while another may suffer from poor management.

The Cobb-Douglas function is adapted to the measurement of inter-firm relationships and is of little value for individual firm estimates except on the assumption that the individual firms are average firms on essentially the same production function. If this were true, inter-firm production functions would be useful for individual planning. In general, if different firms use essentially the same techniques of production and produce essentially the same combination of products, it is not unreasonable to expect the production function of individual firms to closely resemble the derived inter-firm function.[1]

The Cobb-Douglas function does not reflect areas of constant, increasing and decreasing returns in the same function. In some respects this limits its usefulness, although it is an advantage from the standpoint of ease of calculation of estimates.

Marginal productivity estimates derived from the Cobb-Douglas function can be seriously biased by non-optimum aggregation of outputs; however, other functions have similar aggregation problems. It is known that in this study there is a limited amount of bias introduced into the depreciation figures used in capital

---

[1] Plaxico, op. cit., p. 672.

measurement. This is due to the rapid amortization plan used by some elevator associations. Depreciation itself is a conceptual notion and may not be completely accurate, although it is widely used for tax purposes.

The measurement of capital resource inputs is not strictly homogeneous in that certain minor expense items as indicated in the section on "Input Classification" could not be excluded. It would have been preferable to exclude these items since they did not influence production, but it was impossible to do so due to the form of the data.

In order for maximum economic efficiency to be achieved, optimum allocation of resources within the firm and among firms would be essential. The study assumes resources are already allocated in an optimum manner within the firm. In many cases this would not be true, but the average relationships represented by the functions would reduce this bias.

According to James S. Plaxico, Oklahoma A & M College, it is questionable whether a set of circumstances exists very frequently in the real world that would justify aggregation of all outputs into a single output category.[1] The aggregation of all outputs into one category implies constant rates of product substitution with reference to all inputs and all products with price ratios properly equated. Whether this situation actually exists in the elevator industry is questionable.

---

[1] Plaxico, op. cit., p. 668.

While possible limitations to the work done have been pointed out without reservations, still the nature of the data and the results achieved indicate that the analysis is fairly reliable. It should be remembered that the analysis applies to the average elevator association and not necessarily to any one. The study was designed for those who are interested in policy formation and are thus concerned with the general overall situation in the grain elevator industry.

RECOMMENDATIONS FOR FUTURE WORK

Alternative methods of measurement of resource productivities in the grain elevator industry would be of interest. Analysis derived from the use of simultaneous equations, linear programming techniques, or from the fitting of a second or third degree polynomial instead of the Cobb-Douglas function should yield valuable results.

Physical input-output relationships could be developed which would be meaningful over a longer period of time. This is because physical relationships do not change as rapidly as do relationships involving prices. Output per kilowatt hour would be a good physical measurement of output. Elevator associations could be stratified on the basis of per cent of output derived from sideline activities and the appropriate functions applied. This would minimize the discrepancy due to the low consumption of kilowatt hours in sideline activities.

If measurements of dynamic aspects and lag relationships could be developed, this would be an important contribution.

Output may be influenced by capital service flow in a previous period and the allocation of resources may be influenced by risk and uncertainties.

An insight into the causes of frictions in the labor and capital markets which tend to retard the mobility of labor and capital would be useful. Such things as personal preferences, lack of alternative employment, and risks involved might be considered.

A more adequate knowledge of the limits of resource substitution would be helpful in determining least cost combinations.

Inter-firm comparisons with stratifications based on size of operation would aid in determination of the most profitable size unit to operate.

If a study could be devised which would develop some measure of managerial ability and its influence on elevator operations, this would be of great value to the grain elevator industry. This might be possible through application of certain psychological tests to determine the degree of suitability of individuals for this particular profession. This would be very difficult and maybe impossible.

These represent a few of the possible alternatives that exist for this type of resource productivity appraisal.

ACKNOWLEDGMENTS

Most sincere gratitude is expressed by the author to the following persons for their able assistance and valuable advise in the preparation of this paper: to Dr. Paul L. Kelley, for his suggestion of the problem and willingness to provide guidance whenever needed; to Dr. Milton L. Manuel, for providing data for the analysis and assistance in an understanding of the elevator industry; to Dr. Arlin M. Feyerherm, for guidance in statistical matters; and to other members of the department, namely, Dr. Leonard W. Schruben, Dr. John A. Schnittker, and Prof. Orlo Sorenson, for providing information needed for the study.

LITERATURE CITED

Books

Boulding, Kenneth E., Economic Analysis. Revised Edition. New York: Harper Brothers, 1948.

Bradford, Lawrence A., and Glen L. Johnson, Farm Management Analysis. New York: John Wiley and Sons, 1953.

Halcrow, Harold G., Agricultural Policy in the United States. Second printing. Englewood Cliffs: Prentice-Hall, Inc., 1956.

Heady, Earl O., Economics of Agricultural Production and Resource Use. New York: Prentice-Hall, Inc., 1952.

Heady, Earl O., Glen L. Johnson, and Lowell S. Hardin, Resource Productivity Returns to Scale and Farm Size. Iowa State College Press, 1956.

Periodicals

Heady, Earl O., and Schalk DuToit, "Marginal Resource Productivity for Agriculture in Selected Areas of South Africa and the United States." Journal of Political Economy, December 1954, p. 501.

Plaxico, James S., "Problems of Factor Product Aggregation in Cobb-Douglas Value Productivity Analysis." Journal of Farm Economics, November 1955, 374:664-675.

Government and State Bulletins

Kansas Department of Labor, Kansas Labor and Industrial Bulletin, December 1955.

Kelley, Paul L., John H. McCoy, Henry Tucker, and Virve T. Altau. Resource Returns and Productivity Coefficients in Central and Western Kansas Country Elevators of Modern Construction, Kansas Agriculture Experiment Station Technical Bulletin 88, March 1957.

United States Department of Agriculture, The Demand and Price Structure for Wheat, United States Department of Agriculture Technical Bulletin No. 1136. November 1955.

Miscellaneous

Kansas State Board of Agriculture, Farm Facts 1952. Report of Kansas State Board of Agriculture. September 1953.

Kansas State Board of Agriculture, Farm Facts 1955-56, Reprinted from Kansas Agriculture 1955-56, the thirty-ninth report of the Kansas State Board of Agriculture, 1956.

Kansas State Board of Agriculture, Farm Facts 1956-57, Report of the Kansas State Board of Agriculture, 1957.

Kansas State Board of Agriculture, Summary of Crop and Livestock Information. Kansas State Board of Agriculture Biennial Report and/or Annual Report, 1940-1955.

Manuel, Milton L., Financial Summaries and Analyses for 192 Kansas Grain and 50 Petroleum Cooperatives for 1955-56, Kansas Agricultural Experiment Station Circular No. 361.

U. S. Department of Agriculture, Crop Production, Acreage Yield and Production of Principal Crops. 1955 Annual Summary, United States Department of Agriculture, Washington. December 1955.

U. S. Department of Labor, The Handbook of Basic Economic Statistics, Washington, Economic Statistics Bureau, April 1957.

APPENDIX

Table 10. Minimum and maximum values of range of variables in aggregate and within each area, 191 Kansas cooperative elevator associations, 1955.

Function	Number of elevators	Minimum or maximum values	Added output Y	Salaries and wages X_1	Capital X_2
			(dollars)		
Western	54	Minimum	6,327	4,575	4,127
		Maximum	830,947	177,176	185,981
Central	98	Minimum	4,928	3,024	2,462
		Maximum	695,700	198,747	212,698
Eastern	39	Minimum	5,166	3,620	1,318
		Maximum	201,076	79,681	57,967
Aggregate	191	Minimum	4,928	3,024	1,318
		Maximum	830,947	198,747	212,698

Table 11. Arithmetic and geometric means of input-output variables, 191 Kansas cooperative grain elevator associations, 1955.

Area	No. of associations	Geometric means			Arithmetic means		
		Y	X_1	X_2	Y	X_1	X_2
		(dollars)			(dollars)		
Western	54	73,656	19,030	18,630	123,349	27,882	28,716
Central	98	59,513	17,079	12,394	89,042	25,454	19,377
Eastern	39	37,394	13,911	9,269	55,571	18,653	13,246
Aggregate	191	57,488	16,886	13,087	91,907	24,752	20,766

Y = Value of output added in the production process.

X_1 = Labor service inputs.

X_2 = Capital service inputs.

Table 12. Capital-labor ratios by area and in aggregate, 191 Kansas cooperative grain elevators, 1955.

Function	Number of elevators	Arithmetic ratio[a]
Western	54	1.03
Central	98	.76
Eastern	39	.7102
Aggregate	191	.84

[a] Based on arithmetic means of variables.

Table 13. Percentage total inputs by input category, within areas and in aggregate, 191 Kansas cooperative grain elevator associations, 1955.

Function	Number of elevators	Per cent of total value of input	
		Labor	Capital
Western	54	49.3	50.7
Central	98	56.8	43.2
Eastern	39	58.5	41.5
Aggregate	191	54.4	45.6

Table 14. Residuum of arithmetic mean of value added in the production process over arithmetic mean of all productive resource services by area and in aggregate, 191 Kansas cooperative grain elevators, 1955.

Function	Number of elevators	Residuum (dollars)
Western	54	66,751.13
Central	98	44,210.60
Eastern	39	23,672.15
Aggregate	191	46,389.60

Table 15. Regression coefficients, levels of significance for regression coefficients and multiple correlation coefficient R, and other related statistics, 191 Kansas cooperative grain elevators, 1955.

Type of statistic	Western	Central	Eastern	Aggregate
Value of (a), log form	- .191698	.496224	- .035477	.152123
Value of (a), arithmetic form	.643130	3.134900	.921560	1.419500
Values of (b) elasticities				
Labor services	.637779	.532761	.512432	.553596
Capital services	.545840	.494355	.626435	.550693
Standard error of elasticities				
Labor services	.144386	.076859	.097591	.057934
Capital services	.133040	.069727	.083262	.050808
Sums of elasticities	1.183619	1.027116	1.138867	1.104289
Calculated t-value				
Labor services	4.417180*	6.931667*	5.250812*	9.555632*
Capital services	4.102826*	7.089865*	7.523660*	10.838707*
R, multiple correlation coefficient	.922059*	.916564*	.945798*	.923365*

* Significant at the 1% level.

Table 16. Correlation matrices for input-output variables, 191 Kansas cooperative grain elevator associations, 1955.*

Function	X_1	X_2	Y
Western			
X_1	1.	.874589	.894844
X_2		1.	.890437
Y			1.
Central			
X_1	1.	.803028	.869182
X_2		1.	.871327
Y			1.
Eastern			
X_1	1.	.731470	.853641
X_2		1.	.902088
Y			1.
Aggregate			
X_1	1.	.808684	.872065
X_2		1.	.883751
Y			1.

* Significant at the 1% level in every case.

Table 17. Calculation of K value or weighted average of interest rates paid by Kansas cooperative elevators at the time the study was made. (Rates furnished by the Wichita Bank for Cooperatives.)

Item	Dollars or percentage
Total fixed capital input (Dep. for 1955)	2,118,556.00
Total fluid capital input (1955)	1,847,713.00
Fixed capital at 5 per cent	105,927.80
Fluid capital at 4 3/4 per cent	87,766.37
Total capital input	3,966,269.00
Total interest	193,694.17
Total interest as per cent of total capital input	4.88 *

* Rounded to 4.9 per cent.

RESOURCE PRODUCTIVITY AND RETURNS TO SCALE
IN KANSAS COOPERATIVE ELEVATORS IN 1955

by

CHARLES STREETER

B. S., Kansas State College
of Agriculture and Applied Science, 1941

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Economics and Sociology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1959

Since World War II, factors associated with the problems of the American farmer have had implications affecting the grain elevator industry. Relatively high levels of grain production, declining exports, and government loan programs have caused pressure on grain storage facilities. Government programs were altered to encourage the expansion of storage facilities by providing for accelerated depreciation write-off and occupancy agreements. Consequently, grain storage space increased 228 per cent in Kansas local elevators from 1946 to 1955 while average fixed assets more than doubled in cooperative elevator associations during the 1950 to 1955 period.

Rapidly expanding storage activities indicate that major shifts have taken place in resource use. Because of these shifts, questions arise requiring study of resource productivities. Pertinent questions follow:

1. Is resource productivity greater in the elevator industry than in other industries?
2. Have shifts in resource use proven profitable?
3. In what areas of the state have resource inputs yielded greatest returns?
4. Should grain elevators increase in size and/or in numbers?
5. What other factors are important in future planning?

To solve these problems, certain objectives for the study were specified. These objectives follow: (1) to make available measurements of resource productivity in the elevator industry for purposes of comparison with similar measurements from other industries; (2) to measure and compare resource productivities of these firms among areas of the state; (3) to compare the value marginal product of the resource inputs for each area and in aggregate with their factor costs; and (4) to measure the returns to scale in the elevator industry.

The model considered appropriate for the analysis was assumed to be static with firms operating in pure competition, producing primary products with product prices equal and constant. Both inputs and outputs were expressed in dollar values.

The data were obtained from annual audits of 191 Kansas cooperative elevator associations.

Cobb-Douglas type functions were fitted to the data for each of the area divisions and to an aggregate of the data.

Multiple regression analysis was used to compute elasticity coefficients. The dependent variable in the estimating equations was value added by processing, while the independent variables were value of labor services and value of capital services.

The marginal products of labor and capital service inputs computed at the geometric mean from the aggregate data were $1.88 and $2.42, respectively. The marginal product of labor in eastern Kansas was $1.38, and $2.47 in western Kansas while the marginal products of capital were $2.53 and $2.17, respectively. Central Kansas figures were about midway between the two.

It was found that labor services had not been allocated optimumly between eastern and western Kansas, and that the value marginal products of capital inputs differed significantly from their cost in all functions. The value marginal product of labor inputs differed significantly from their costs in all functions except eastern Kansas.

Increasing returns to scale were evident in all areas except central Kansas where they were about constant.

This study was designed for those who are interested in the average situation in the industry, not for individual firm analysis. This is of vital importance to those who may influence resource flow, or who are interested in the future development of the industry.

Marginal productivity estimates provided by this study can be made available for comparison with other industries.

It appears that profits can be increased by increasing the size of firms in western Kansas with firms using relatively more labor and in eastern Kansas with firms using relatively more capital. In central Kansas it appears that labor and capital should be used in about present proportions but that profits could be increased with an increase in the size of firms. Caution is necessary, however, because changes in government agricultural policy could affect storage revenues materially. An appraisal of the volume necessary to allow profitable expansion should be made, however, mergers of existing firms would aid in avoiding volume limitations.