ECONOMIC EFFICIENCY OF THE EGYPTIAN FARM:
A REVIEW OF THE LITERATURE

by

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The work which has been done in Egypt:

(1) This paper is dealing with economic efficiency in agriculture it measures and compares certain aspects of efficiency in selected agricultural areas.

The main purpose of this study is to analyse the existing combinations of different resources and their services used at different farming regions, to predict the effects of combinations and quantities of resources on the value of product produced, and to suggest the solutions for attaining efficiency. The main statistics at this study are based on random stratified samples of farms in various producing areas in Egypt during the period (1966-1968). These farming producing areas are: Kafr-El-Sheikh, El-Gharbia, El-Kalyubia, Beni-Suef and El-Menia governorates.

Methodology: Cobb-Douglas function was used to derive the pro-Coefficients,

\[ Y = aX_1^b_1 X_2^b_2 X_3^b_3 \]

where,

- \( Y \) refers to the value or quantity of gross output of crops;
- \( X_1 \); refers to the land inputs;
- \( X_2 \); " " " labor ""
\[ X_3 \] refers to the capital input.

Empirical results: (1) Cotton production function: the marginal values of product for land are significantly higher than the land rental value. The marginal return of labour to opportunity cost ratios are less than unity on most cotton farms. The marginal return of capital to opportunity cost ratios are less than unity on most cotton farms, and more than unity on El-Menia cotton farming areas, (2) rice production functions: the marginal return to opportunity cost ratios indicate that little land, more labor and capital services being used, (3) maize production functions: the analysis of the marginal productivities shows many significant findings, and (4) wheat production function: the land inputs in wheat pro are not used according to the economic efficiency conditions. The ratios of MP of labor to opportunity costs only 0.356, 0.162, -1.411, 0.564 and -7.028 in the governorates of Kafr-El-Sheikh, El-Gharbia, El-Kalyubia, Beni Suef and El-Menia respectively. These findings indicate that more capital were used in wheat farming enterprises at Beni Suef, El-Gharbia, and Kafr-El-Sheikh.
(2) The problem of this research that resources of agr. pro. are not efficiently used and that they can be re-arranged to allow for higher total output per unit of input.

The main purpose of this research was to study and analyse the pro. efficiency of the U.A.R. agr. pro. of the main crops at the macro and micro level.

The main statistics of this study are based on the published data of the Ministry of Agr. over the period (1956-1966) and on random sample of farms in Kalubia, El-Gharbia, Beni-Sweif, and Menia governorates in the year (1968-1969).

The researcher used the quantitative and qualitative economic analysis furthermore the trends and estimation the pro. function in the form "Cobb-Douglas" (1)

\[ Y = A X_1^{B_1} X_2^{B_2} X_3^{B_3} \]

for the crops (cotton, maize, wheat, rice, sorghum, beans, sugar-cane, barley, ...).

Efficiency measurements can be applied at the national region and farm level were maximization of profits marginal productivity for each factor of gross output related to total costs, add value, marginal cost add.

(1) \[ Y = AX_1^{B_1} X_2^{B_2} X_3^{B_3} \]
To compare among different agr. regions in the U.A.R. measurements were value add, profitability per feddan were used to cotton and maize crops.

To compare between the different districts of the same governorate, efficiency criteria used were, average productivity, value add, net return, cost of unit, percentage of total costs to gross output, percentage of not return to total cost.

Some of results of this research: (1) the vegetables crops was greater than field crop in the relative profit, (2) Menia & Beni-Sweif were high efficiency in pro. of cotton from other governorate, (3) Kalubia, Menoufia, El-Gharbia, were greater than other governorates in efficiency pro. of summer maize, and (4) Menia & Ausut were greater than others in efficiency pro. of Nile maize.

The problem of this research: the economical and physical input-output relationships at the level of pro. units "farm, pro. regions" in the U.A.R. are not know, many farmers do not realize the economic efficiency in agr. consequently agr. producers may used more or less resource than the optimum level.
The main purpose of this research is to study and analyse the existing combination of different resource to measure the VP of resource and their service used in different farming regions and to predict within the limitations of data and method the effect of varying combination and quantities of resource on the value of products produced.

The research was used "Cobb-Douglas function (1) in estimation the production function for each of the main crops "Cotton, Rice, Maize, Wheat, Beans".

The main statistics of this study are based on random sample of the farms in Kafr-El-Sheikh governorate in the year (1965-1966) that size 152 farms, the sum total production functions which estimated about 74 functions, and used many measurements for test the efficiency in the agr. sectors in the governorate.

Some of results of this research, for cotton: the production elasticity of land was about 0.83, for labor equal zero, for machine animal services 0.003, for worker capital 0.043, the over-all effect of the independent variables explain nearly 93% at the variability of the cotton pro.,

(1) \( Y = A x_1^{B_1} x_2^{B_2} x_3^{B_3} x_4^{B_4} \)
return to scale for cotton was diminishing, for rice was fixed, for maize was fixed, for beans was diminishing, for wheat was diminishing.

(4) The problem of this research: farm capital investments in the U.A.R. is generally believed not to be going in the line with the optimum farm investment plans, the author believes that size of this farm capital investments in the country is not sufficient and are not optimally allocated between the agri. producing units.

This research aims to study and analyse the existing combinations of the different farms of capital as well as the combinations of the capital factor with other factors of pro. in El-Gharbia & Beni-Sweif governorates, one of the objectives of this study is to find out and analyse the optimum planning of resource combinations for "cotton, maize, rice, wheat in the two governorates in order to draw a comparative study between the existing pattern of agr. pro. and the optimum one; to draw policy recommendation on both micro and macro levels in the agr. sector.

This study based on: (1) controlling the farm capital investments inter each district in the two governorates and between this districts and between the villages this districts
and between the two governorates, and (2) measured the value productivity for economic resources.

The main statistics of this study are based on: data collected from random sample in the two governorates, size was 200 farms in the year (1965-1966). The researcher estimates the production function in form "Cobb-Douglas"(1).

Some of results of this research: (1) for cotton, the elasticity of prod. of the land factor is less than one in both governorates (0.66 El-Gharbia, 0.77 Beni-Seweif), for labor were (0.2% & 0.1%), for capital (0.17 & 0.9), (2) for maize: the elasticity of prod. was high in Beni-Seweif governorate and low in El-Gharbia governorate for the land factor, for capital and labor were low in both governorates, and (3) return to scale were (104%, 173%) for cotton, (136%, 159%) for maize, (102%, 109%) for rice.

(5) The problem of this research: the Egyptian structure of agr. is characterised for the multiple fragmented scattered farms, which results in inefficient use of economic resources.

\[(1) \quad Y = A x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4}\]
The aim of this study is to shed light on the deficiencies in using available agr. resources as measured by clear and definite yardsticks of economic efficiency and farm resource productivity, as compared to productive areas of the various farms and to holding categories through estimating certain economic and productive relationships in order to estimate how much agr. economic resource contribute to the productive operation.

The research deals with the study the farms pro., and economic analysis for measurements of efficiency for agr. resources in the "Menoufia" governorate in particular, in the A.R.E. in general, the main statistics of this study are based on the published data of the Ministry of agr. over the period (1954-1971), and on random samples of farms in Menoufia gov.; district of Barkete El-Saba and the data were collected from two villages, the sample represents 336 owned farms, 84 rented, 40 owned by non-resident owners in the year (1972/73) the research employed the pro. function form "Cobb-Douglass" (1) for cotton, maize, wheat.

Some of the results of this research: the rented farms used inputs for technical unit lower than owned farms, value

\[ Y = A x_1^{B_1} x_2^{B_2} x_3^{B_3} x_4^{B_4} \]
of pro\textsubscript{2} (VP) per feddan greater than the owned, VMF for land greater than the rented.

(6) The boundary of this thesis is limited to the sphere of the vertical development which is considered one of the two important parts of comprising the Egyptian agr\textsubscript{2} development to increase agr\textsubscript{2} production and income in the shortest possible time with the minimum costs. The increase in the agr\textsubscript{2} pro\textsubscript{2} in the Egyptian Agr\textsubscript{2} can be realized by increasing the pro\textsubscript{2}ductivity of various agr\textsubscript{2} resources by introducing technology in agr\textsubscript{2} and efficient use of such resources. The main objectives of this study is to find out the degree of agr\textsubscript{2} efficiency achieved in Egyptian Agr\textsubscript{2} and in some producing areas. The result of this study can be of great help to the agr\textsubscript{2} planners and the agr\textsubscript{2} producer. It can serve as a scientific basis in setting up the sound agr\textsubscript{2} policies such analytical tools were used to find out the degree of efficiency on the farm level in each class also rates of MS "marginal substitution" between land and capital were calculated in order to determine the most efficient combination of these two resources. In order to, achieve agr\textsubscript{2} efficiency in Agr\textsubscript{2} sector optimum crop lands should be
setup optimum quantities of various resources per feddan.

Management resource is considered one of the most vital resources in achieving such efficiency. The increasing productivity of land will play an important role in economic development by converting classes two, three and four land to class one on U.A.R. & Menia gov. level will probably increase the value of the total pro. by about 164 million pounds in the U.A.R. and 14 million pounds in Menia assuming that these lands will be cultivated by cotton under normal weather condition present prices and present pro. techniques.

(7)(7) Agriculture has an important role in the economic development of all countries especially at its early stages. Planning of agricultural economic development is considered in most of the countries an important instrument for economic as well as social progress. Agricultural production should increase at higher rate than population growth. In addition agriculture should play an increasing role in the development of other sectors in the national economy. Agricultural economic development has two main channels in the Arab Republic of Egypt. These are horizontal and vertical development. This study in concerned with vertical agricultural economic development in Egypt. It was found that 17 different programs were planned and implanted through the period 60/1961-70/1971
to realize agricultural economic development in the old land in Egypt. The total implemented investments in such programmes amounts to L.E 103.68 millions with an annual average amounted to L.E 9.43 millions, while total planned investments for such programmes amounted to about L.E 119.07 millions with an annual average amounting to about L.E 10.82 millions. The thesis also studies the implications of those agricultural economic development programmes on the productivity of both field crops and vegetables concerning field crops it was found that such development programmes were effective in increasing significantly the productivity of summer maize and summer sorghum wheat flex nilimaize and nilisorghum.

Cross Section data were collected concerning from maize production a random sample consists of 39 Villages. These villages were choosed from the five main producing Governorates of summer maize in Egypt. The data were collected during the 1975-1976 agriculture year. The collected data were fitted through the use of a cob-Doglass production function.

The estimated production elasticities of land input with respect to summer maize production were about 1.601.
1.427, 0.628, 0.508, 0.214 for Dakahlia, Monofeia, Gharbeia, Sharkia, Kaliobia governorates respectively. The study showed that the land input was used in the first stage (increase with increasing rate of production in Dakahlia and Monofeia governorates, while it was used in the second stage of Production (increasing with a decreasing rate) in Sharkia and Kaliobia governorates. Also, the study showed that the Human Labor input had a negative marginal productivity (3rd stage of production in all governorates except the Kaliobia governorate. However, the farm capital input was in the 3rd stage of production in Monofeia and Dakahlia governorates. It was in the 2nd stage (economical stage) in Sharkia, Gharbeia, Kaliobia, Governorate.

The purpose of this study is to indicate the economic situation of Zea Mays production in upper Egypt. This study has been made by using L.S.D. method. The data for this crop has been collected during the period (1963-1973).

It is evident from the results disclosed by current study that if Zea Mays acreage can be expanded among the first class land cultivated by Zea Mays in governorates of Geza, Bani Sweaf, El-Fayoum, El-Menia, Asout, Sbarg,
Qena and Asswan, a certain percentage of land amounting to 14.16%, 16.45%, 6.21%, 1.78%, 10.41%, 27.88% and 3.11% respectively would be released for the cultivation of export crops.

It has been inferred from the current study that there is correlation between soil classification and land productivity as regards to the crop under study in the governorate of upper Egypt.

The aim of this study is to indicate the Economic Situation of Summer Maize Crop in Lower Egypt. This study has been done by using the statistical method L.S.D, the data used in this study collected during the period (1963-1975).

Behara Governorate has been classified into 4 classes according to its productivity the first class contain Shobraheet and Koom hmoda districts; The first class in Garbia Governorate contain Kafer El Ziate, Zefta and Basione; In Kafer el Shake Governorate the first class contain desuke and Kellen; In Dakahlia Governorate the first class contain Mahmodia, Meet Umre, Temy El Amded, Sherbin, and El-Senbelawen districts. The first class in Demiate Governorate contain Faraskoor district only. But in Sharkia
Governorate the first class contain 7 districts, and in Kalubia Governorate about five districts. In Monofia Governorate also five districts.

(11)(11) The statistical Method "the least significant differences has been used in order to classify the different Governorate with respect to the relative profitability importance for summer Maize production. The lower Egypt Governorates has been classified into five productive levels, the first productive zone includes: El-Gharbia and El-Kalubia Governorates, the second productive zone includes: El-Monofia and El-Dakshila Governorates, the third includes: Kafir El-Shiekh, El-Behera and El-Sharkia Governorates, the fourth include Domiat and Ismailia Governorates, Finally the fifth productive zone includes Alexandria Governorate.

Also for the upper Egypt Governorates classification the results of the statistical analysis insist that these Governorates includes five agronomic zones, the first zone consists of Assiout and Shouhag Governorates, the second zone includes El-Hennia Gover., the third zone includes: Banny-Sweef, Giza and El-Faioum governorates, also the fourth and the fifth zones includes, Kenna and Asswan respectively. The second classification with respect to the average productivity show that Egypt can be classified into six agronomic zones, the first includes: Assiout, Shouhag and El-Gharbia Governorate, the second
includes: El-Minnia, Ka-lubia and El-Mounifiia, the third
includes: Dakalalia, Kafr El-Shielh, Behera and El-Sharkia,
the fourth includes: Banny Swif, Giza, and El-Pariound, the
tifth includes El-Ismalia Kenna and Domist, the sixth
includes: Alexandria only, the study showed also that the
planted area can be saved to be in the other agricultural
activities, its can be true if the area planted for summer
maize crop can be extended in the high profitability
regions.

(12) The costs of both the human labor, the animal
effort and the mechanical force which used for the production
per feddan of the important traditional, vegetables and fruits
crops, had been estimated. Also the relative importance of
the contribution of both human, animal and mechanical forces
in the total yield and net yield per feddan for every crop in
Sharkia Governorate.

It was apparent that the highest crops with respect
to using the different human, animal and mechanical forces
were El-Kolkass (118.98 LE), Lemon (60.90 LE) and so on. The
study insist that the human force costs per feddan for
fruits are twice for the similar in traditional and
vegetables productive unit in using both human, animal
and mechanical forces were: rice (27.57 LE), mix manguo
(17.57 €), Lemon (10.55 €) and so on. It was distinguished that relative production costs per unit of human force were higher for fruits crops than the vegetables crops.

The study insist also that the yield per pound in employing both the human and animal and mechanical forces were ordered as follows: Tomatoes (14.01 €), Mix Manguo (9.04 €), Squash (8.03 €), Wine Takesieb (7.03 €) Watermelon (6.74 €), Summer Potatoes (6.35 €) and so on.

It was shown that the net yield per pound for animal force in most fruits crops production were higher than the other for vegetables crops production and lower than the traditional crops production, the study insist also that there are a significant increasing in the net yield per pound in mechanical force which used in vegetables production, rather than fruits production, and lower in the traditional crops production.


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(II): In other countries

(1) The use of a cost function rather than a production function (Cobb-Douglas type) for estimating parameters has several advantages.

The plan of this paper is as follows: (1) a derivation of the Allen partial elasticity of substitution in terms of the cross derivatives of the cost function is presented, (2) the Translog method "linear in logarithms" is used to derive estimates of elasticities of derived demand and of elasticities of substitution for the agricultural sector using U.S. cross-section data of states for the years 1949, 1954, and 1964.

The OLS single equation $R^2$ of the four shares equations with homogeneity imposed on the data are not very high: land 0.68, labour 0.75, machinery 0.45, and fertilizer 0.75. The best substitutes are land and fertilizer which was expected, also machinery is a better substitute: land than for labour.

(2) The concept of technical efficiency differences of different levels of output with identical levels of input is unsatisfactory from a production theoretic point of view. In this paper a model is developed in which differences in non-conventional inputs and especially information obtained by managers may explain productivity differences between firms. Estimation of the underlying production structure (of a sample of California dairy farms 1964) via a modified non-homothetic
Cobb-Douglas pro-function shows the specific impact of information within the neoclassical pro-framework. This is conceptually and analytically superior to the methodology of frontier pro-functions.

(3) The impacts of major exogenous forces on the form sector are measured using a seven equation model. Annual estimates of the parameters of an aggregate Cobb-Douglas pro-function are obtained by using relative market shares. First order conditions for four groups of inputs are derived. Time series and ordinary least squares are used to estimate the supply for farm labor and the demand for farm output. Technological change, exogenous price changes, and population growth are the major exogenous influences. Roughly 50 percent of farm program benefits have accrued to landowners.

(4) A quantitative assessment of the "green revolution" associated with Mexican varieties of wheat in the Indian Punjab is attempted as an alternative to the usual impressionistic assessments. Results indicate that the technical change has been cost-saving and has not been strongly biased in either a labor-saving or a capital-saving direction. Wheat production experienced a favorable cost curve increased by about 25%. Increased capitalized land values lead to inferences about income distribution and constitute a source for reinvestments designed to maintain the momentum of the "green revolution".

\[ y_i = \sum_{j=1}^{n} (X_i j + d_j) \alpha_{ij}, \quad j=0 \]
\[ * Q = \sum_{a}^{A} \sum_{x}^{X} \sum_{y}^{Y} \sum_{z}^{Z} \sum_{s}^{S} \]

\[ y_i = 1 \sum_{j=1}^{n} (X_i j + d_j) \alpha_{ij}, \quad j=0 \]
\[ * Q = \sum_{a}^{A} \sum_{x}^{X} \]
Let the production function for wheat be written in the Cobb-Douglas form as: \( Y = A N^{\alpha_1} L^{\alpha_2} K^{\alpha_3} F^{\alpha_4} \exp (\delta_1 + u) \). The model is applied to farm level cross-sectional data of old and new varieties of wheat for the year 1967/68 from Pervezpur district of Punjab. These data were collected by the Directorate of Economics and Statistics (Ministry of Food & Agri., Government of India) on 150 farms spread over 15 villages.

(5) The relationship between farm size and production costs is examined using current data (1974). The analysis indicates that relatively modest sized farms can achieve a major portion of the possible cost savings associated with size. The sources of efficiency are examined, and it is shown that factors other than labor-saving technology may be important contributors to economic efficiency. The implications of this analysis are developed for the current debate over acreage restrictions in reclamation policy. Strict enforcement of the 160-acre limit could cause a modest overall efficiency loss, but this would be borne by landowners rather than consumers.

(6) There are differences in economic efficiency among groups of farms (say large & small) may result from variations in technical efficiency (larger output with equal

\[ x_\text{Dummy variable} \]
amounts of inputs) and price efficiency (higher profits).

The objectives were: (1) to indicate how agrarian structures affect resource use and thereby of the likelihood of being able to achieve both growth and equity, and (2) to measure and compare performance of farm firms.

In this paper, the Lau-yotopoulos model is used to derive values of technical and price efficiency parameters in order to identify and isolate possible differences between large and small farms. These estimates are based on farm-level data collected from a sample of the farms in the Punjab and Sind provinces of Pakistan. The data were collected in 1974 of farms: in eight irrigated-498 observations for the Punjab and 230 for Sind.

The results: The large farms are more efficient than small by 18% in the Punjab & 51% in Sind. Both large & small farms maximized profit in the Punjab while in Sind, the large farm maximize profit, but small farms pay labor more than its marginal product.

(7) Even if off-farm jobs were available, for older men with educational deficiencies to leave their homes and adjust to new work environments imposes potentially severe psychological stresses.
The objective was to estimate the possible increases in farm incomes by linear programming. A "low income farmer" is defined as a full-time (working fewer than 100 days annually off the farm) operator under 65 years of age whose gross farm sales are less than $5,000. A survey of 342 operators in the four-county area identified 102 (29%) in this category. The enterprises used in this paper, Tobacco, Tobacco on shares, corn, Hog, Cucumbers, peppers, Dairy manufacture milk), Beef cattle, and Swine.

This study shows that the potential for increasing income exists. The possibility of achieving this potential needs to be explored in greater depth, probably through experimental or pilot technical assistance programs. The experience with similar programs aimed at low income farmers in Tennessee, Missouri, Texas, and Virginia could serve as guides (Comer & Wood, West, Strickland & Soliman, and Orden, respectively).

The problem of investigating stochastic aspects of production response is apparently an old one (Fuller, Day, and Anderson).

The purpose of this paper is to examine the implications of traditional econometric production function studies, and to demonstrate some useful generalizations.
The functional forms which are investigated are the Cobb-Douglas
\[ Y_{ti} = AZ_{ti}^\alpha + BZ_{ti}^{B_1} (E_{ti} + W_t), \]
and the translog specifications:
\[ Y_{ti} = AZ_{ti}^{\alpha_1} \exp \left( \frac{1}{2} \alpha_2 \ln^2 Z_{ti} \right) + BZ_{ti}^{B_1} \exp \left( \frac{1}{2} B_2 \ln^2 Z_{ti} \right) (E_{ti} + W_t). \]

An application indicates that fertilizer (Corn & Oats) has a variance-increasing effect on yield; but the marginal variance contribution is much smaller than the standard log-linear disturbance approach would indicate. The data were generated for several crops (corn & Oats) by controlled experiments varying fertilization over several fixed level observations were generated by recording time series of data over a cross-section of plots.

There are differences in general policy focus inherent in the two concepts of small farm (low income & small business). The implied objective is to undertake actions which improve their income (well-being) level, and attention on certain farm establishments.

Data & Methods: a national probability sample of approximately 5,700 farmers, for the year 1975, used description technique in this paper.
Aproximately 52% of all farm families have total family incomes below the median non-metropolitan income for their region in 1975. This low income group is smaller than those families operating a small business establishment; 2-3 (5%) operated farms selling less than $20,000 in farm products; about 4-15 (7%) operated farms selling less than $40,000 in farm products in 1974.

In recent years work has been done on ways in which they gross income of a farm can be estimated from the inputs. This article shows how gross income estimating equations can be presented to farmers. The gross income on a farm is estimated from a single value-productivity equation of the Cobb-Douglas type. The equations discussed in this paper were obtained from 108 farms receiving less than 60% of the gross income from dairy cattle and dairy products, and cash crops, for the year 1950.

Statistical stability of the coefficients of gross income equations can be increased. The Cobb-Douglas function assumes that gross income is a function of the factors of production and that there are no important effects in the opposite direction. Data for different years could be combined by
reduction of prices of factors and products to normal values.

(11)(11) This study dealing with productivity coefficients for specified agricultural products, is designed to help fill this void. Its central objective is to measure the marginal value productivity of resources used in different farming regions and to predict, within the limitations of the data and methods, the effect of different quantities of resources on the value of the product produced.

The main statistics of this study are based on random samples of farms in four areas of U.S. Agr., for the year 1951. The statistics derived in following sections are based on Cobb-Douglas production functions computed by least squares multiple regression.

Mean marginal labor productivity was higher for livestock than for crops in all areas and in practically all cases, the difference is significant. Important differences exist in the mean MP of livestock capital. The coefficients of neither crops nor livestock differ significantly among the four areas. Marginal land productivity was significantly greater than rental rates for all areas in 1950.
Existence of such surpluses points to the need for giving more attention to adjustments in resource use on farms, both to improve incomes of farmers and to make better use of resources from a national point of view (the surplus problem).

This paper is an attempt to indicate what we need to learn before it will be possible to say what kinds of adjustments in farm production will be needed in the next five or six years.

Methodology: it is analytical & descriptive technique use, the data, time series (1947:1953).

The results: Realized net income of all farm operators from farming in 1953 was 7% less than in 1952, and 13% less than in 1951.

"The great increase in the Use of Fertilizer in U.S. agriculture could be largely explained by the decline in the "real" price of fertilizer"

The objectives: (1) I developed a model for testing this hypothesis and applied it to aggregate U.S. for the years 1911-1959, (2) discuss some of the statistical problems more efficiently"
associated with distributed lag models, explore the possible reasons for regional differences in the parameters of the model, and investigated the question whether there is any gain in the explanatory power of the model from disaggregation.

The results indicate the existence of important regional differences in the parameters of the model they do provide additional support for the hypothesis that changes in fertilizer use can be explained by changing relative prices.

(14)(14) This study deals with the demand for a particular resource, fertilizer, by farmers. It is part of a larger study dealing with resource demand and product supply by farmers. It is an aggregative study, based on time series data (1910-56), indicating the variables related to U.S. fertilizer use.

The main objectives: to estimate demand functions for commercial fertilizer and individual nutrients for the U.S. and regions, and to express demand elasticity for fertilizer relative to fertilizer price, crop prices. Also, prediction has been made of demand functions for individual producing regions.

For methodological purposes, we have applied some simultaneous equations and "expectation" models. Also, the main ones being a Cobb-Douglas type, one of first differences in logarithms,

\[ Y = 10.677 - 0.490X + 0.637X + 0.082X + 0.076X \]

\[ (0.201) \quad (0.054) \quad (0.615) \quad (0.022) \]
a linear and a modified quadratic form.

\[ R^2 \text{ is } .988 \text{ for the first equation and } .865 \text{ for the second equation.} \]
(The standard errors of estimate are respectively .028 & .081).

(15) My interest in interregional competition lies in the area of longrun supply response. A primary objective in these studies has been to find the distribution of shipments between surplus and deficit regions that minimize transportation costs.

Methodology deal with the method of trends, correlation analysis, the linear programming technique, and the model building.

(16) The task of this paper: the marriage of foreign surplus disposal and comprehensive supply control has been recorded. The mechanics of this marriage union are sketched in the foregoing paragraphs relating the adjustment of supplies to demand; the logic of the union has been the work of the whole paper.

This paper uses a descriptive approach. Total farm output increased just about 50% between 1940 and 1958.
(17) Variants in tenure forms cause a range of optimal farm sizes in countries of various stages of economic development. Aside from capital restraints, however, modifications can be made in cost functions associated with each tenure form. The optimal use of inputs and farm size then is theoretically the same for individually operated farms. In the case of private, state, and cooperative farms, however, the same resolution is not possible in the short run. If the objective of the cooperative farm is maximum profit per member, this tenure form always has an optimal size smaller than a private or state farm.

(18) This paper presents a technique approximating irrigation response from time-series data on nonirrigated crops and summarizes on empirical application. However, decisions on the economic feasibility of irrigation are hindered because information on irrigation response is not available.

Production data utilized were average county yield per acre for peanuts and corn for 60 counties in the Georgia Coastal Plain for the period 1954-1969.

Methodology & Results: Increase in yield due to technology was estimated by linear trend. Changes in all cultural, nutritional, and management practices were assumed to be represented by trend. Least squares estimates of the annual change in yield due to technology (trend) for farms in the
study area were 80.15 pounds and 11.91 bushels per acre for peanuts and corn, respectively. The estimated average irrigation response in the study area was 326.29 pounds per acre for peanuts and 14.58 bushels for corn.

Empirical observation (1953-1971) and theoretical analysis show that the allocative and forward prop functions of futures markets are more reliable for continuous than for discontinuous inventory markets. This emphasis on the importance of carry-over inventory in affecting day-to-day price spreads is extended to take into account other factors which contribute to pricing efficiency. By examination of the characteristic behavior of the life cycle of a futures contract, a framework is developed to test, analyze, and contrast the performance of futures markets, i.e., how reliable futures quotations are as predictors (linear regressions) of spot (cash) prices. Policy and theoretical implications are given.

The objective of this study was to analyze factors related to the productivity of workers being paid on a piece-work basis for hand harvesting fruit "apples", and vegetable crops in U.S.
There are two problems: (1) difficulty recruiting harvest labor and, (2), difficulty harvesting a crop during the period of peak quality.

Methodology: ordinary least square regression analysis. Data on 560 worker units picking apples by hand on a piece-rate basis in Michigan.

Results: Although the proportion of variation in apples picking rates explained by the regression equation was relatively low, several variables significantly related to worker productivity.

The purpose of this paper is to discuss the problems posed by uncertainty and information as a scarce resource in analyzing the efficiency of existing firms and markets. The limitations of efficiency measures which exclude uncertainty and information are analyzed and the implications for research are briefly discussed.

Efficiency is a widely used concept. If information were not scarce or costly, it would be easy to describe and identify inefficient activities. A meaningful efficiency concept, however, has yet to be defined for a world characterized by uncertainty, imperfect knowledge, and costly information.
A transhipment plant location model is used to determine the number, size, and location of new subterminals, expansions in storage capacity of existing country elevators, the rail network, and the monthly flows of grain from origins to elevators to destinations to maximize joint net revenue of grain producers within a 6½-county region. A grain transportation system having fewer rail lines would increase joint net revenue. Country elevators incapable of loading multiple-car trains would be used as storage facilities and transship much of their grain to market through subterminals. Total net revenue varied by 1% or 2% over a wide range of rail abandonment plans.

The response of a crop to irrigation can be approximated from historical data on the unirrigated crop by assuming that irrigation will result in an increase in yield equal to the difference between actual yield and yield had "ideal" weather obtained.

The results of yield-weather studies of tea in Malawi suggest that irrigation will not generally have the same effect on yield as rainfall or "ideal" weather due to the different associations between rainfall and irrigation and atmospheric environmental variables which affect response to soil moisture conditions. Even the inclusion of independent variables to
reflect the influence of these factors will not be without dangers when the estimation of regression coefficients is based on natural weather-yield data alone.

(24) The Tobit model was applied to cross-sectional data on dairy product consumption. Results show that for three of the four products analyzed, the participation rate adjustment is the most important component of the price and income elasticities. For both price and income changes, entry or exit from the market accounted for more than half of the market response for all products except fluid milk.

(25) Inflation and productivity are most persistent economic problems confronting the U.S. economy. The central thesis of this paper is the dialectical interaction between inflation and productivity.

The hypothesis: (1) What is the impact of inflation on productivity? (2) what is the impact of the decline in productivity on inflation? and (3) how strong is the scientific and technical basis for agricultural productivity growth?
Consider two firms with production functions identical up to a neutral displacement parameter:

\[ V_1 = A_1^1 F(X^1), \quad V_2 = A_2^2 F(X^2), \]

where:

- \( V \) is the output, \( A \) the technical efficiency parameter,
- \( F \) the production function, \( X \) the vector of inputs employed,

and the superscript denotes firm.

Our purpose, therefore, is to measure of economic efficiency.
We compare relative economic efficiency of two firms with varying degrees of technical and price efficiency. For this purpose we compare the actual profit functions of the two firms, at given output and input prices and quantities of measurable fixed inputs.

A Cobb-Douglas production function with decreasing returns in the m variable inputs and with n fixed inputs is given by:

\[ V = A \prod_{j=1}^{m} x_j^{\alpha_j} \prod_{j=1}^{n} z_j^{\beta_j} \]

where:

\[ u = \sum_{j=1}^{m} \alpha_j < 1 \]

The purpose of this paper is to suggest elements of a complete theory of distributive shares by deriving the different concepts of the elasticity of substitution required in different contexts. Section I discusses the model of production and distribution in the multifactor case. Section II analyzes the role of the Samuelson elasticity and the partial elasticities.

The value of \( u < 1 \) is required since constant or increasing returns in the variable inputs are inconsistent with profit maximization.
Section III discusses the direct and shadow elasticities. In addition, other elasticities are introduced to analyze the variety of problems one encounters in real life.

(29) Using cross-sectional agricultural household accounting record data for 1967 and 1968, a linear logarithmic expenditure system, consisting of three commodities - leisure, agricultural commodities, and nonagricultural commodities - is estimated for the Province of Taiwan. The hypothesis of utility maximization, as well as other hypotheses on functional form, are tested. It is found that the empirical evidence is consistent with utility maximization and that household labor supply depends on both the composition and the size of the household as well as the wage rate and prices. The consumption demand, labor supply, and marketed surplus elasticities with respect to prices, income, household composition, and household endowment variables are also reported.

\[ \ln \mathbf{W} = \alpha \mathbf{1} + \sum_{j=1}^{n} \alpha_j \ln p_j + \frac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} B_{jk} \ln p_j \ln p_k \]

where: \( B_{jk} = B_{kj} \), \( \forall j \) and \( k \);

\[ \sum_{j=1}^{n} \alpha_j = 1; \quad \sum_{k=1}^{n} B_{jk} = 0, \forall j. \]

"Note that without loss of generality the matrix \( B_{jk} \) may be assumed to be symmetric."
The household output supply function:

\[ V = V(P, A, q^L, q^A, q^M, q^E, Y, \lambda, \delta, \rho) \]

then:

\[ V = \Pi_\Xi \left( \frac{\partial L}{\partial A}, \frac{\partial A}{\partial A}, \frac{\partial M}{\partial A}, \frac{\partial E}{\partial A}, \gamma_k, \gamma_T, \gamma_L \right) - \sum_{i=1}^{4} \frac{q_i}{\partial A} \frac{\partial \Pi_\Xi}{\partial q_i} \]

where:

\[ \Pi_\Xi \]

is the normalized restricted profit function.

(30) In this paper we report results of an attempt to characterize more completely the structure of technology in U.S. manufacturing, 1947-1971, by providing evidence on the possibilities for substitution between energy and nonenergy inputs. Our principal finding is that technological possibilities for substitution between energy and nonenergy inputs are present, but to a somewhat limited extent.

The data required for B SLS estimation of the KLEM translog cost function in U.S. manuf. 1947-1971 are the prices and cost shares of the four inputs and values for the exogenous variables used in forming the instruments.

The generalized Leontief, generalized Cobb-Douglas, and translog cost functions all are sufficiently flexible (\( \Xi \)).

(\( \Xi \)) The generalized Leontief cost function is discussed by Diewert (1971), the generalized Cobb-Douglas by Diewert (1973a) and the translog by Christensen, Jorgenson, and Lau (1971, 1973).
In this paper we develop an empirical framework for using the translog function to investigate the permissibility of aggregating diverse inputs. We implement this framework to investigate the permissibility of aggregating equipment and structures in U.S. manufacturing 1929-68.

The conditions of Colombia's agrisector seem, at first glance, to suggest the "conflict" version of the relation between output growth and income distribution. If indeed this is the situation, the current inequality of income distribution suggests that policy decisions should be very difficult. An the nature of change over the last decade in the sector suggests that those decisions have essentially favored pro with only sporadic and limited attention given to problems of distribution and quality of employment.

\[ (1) \ln V = \ln \alpha_0 + \alpha_A \ln A + \sum_{i=1}^{n} \alpha_i \ln X_i + \frac{1}{2} \gamma A A (\ln A)^2 \]
\[ + \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \gamma_{ij} \ln X_i \ln X_j + \sum_{i=1}^{n} \gamma_i A \ln X_i \ln A, \]

Elsewhere (Berndt & Christensen, 1973b), we investigate the permissibility of aggregating pro & nonpro labor in U.S. manufacturing 1929-1968.
This study considers that determinants of income distribution and its changes over time, and the relative social efficiency of smaller and larger farms. A best estimate of the personal distribution of income of the agricultural sector in 1960, and the average income level of each decile.

The most plausible explanations of a high or total social factor productivity on small farms are (a) their facing a lower price of labour and a higher price of capital, and (b) the greater incentive associated with low income levels which shows up.

(33) A major objective of this paper is to illustrate the empirical relationship between worker participation, incentive, and productive efficiency for firms. Here, use of researcher of the Cobb-Douglas function in estimation of production function (1), and size of sample were 42 firms (1974-1976).

The organization of productive activity within firms has received increasing attention in recent years, problems of motivation, productivity, and "quality of working life" have become central concerns at both policy and academic levels.

\[
Q = A K^{\lambda_1} L^{\lambda_2} P^{\lambda_3} I^{\lambda_4} u
\]
An empirical result: the most striking differences are that the capital-labour ratio is much higher in the low-participation group, while employment is much greater in the high set. Both differences are statistically significant at the five per cent level.

(34) An estimating form has therefore to be chosen on the basis of which form best describes the data; the basic forms that have been tried in the literature are three: the linear, log-log, and semi-log:

1. Linear \(-Y = a + bA\)
2. Semi-log \(-Y = R/A = a + b \log A\)
3. Log-log \(\log Y = a + b \log A\)

where (2)

\(y = \text{production (or value-added) per acre of land in operation, } A\)

\(R = \text{Production (or value-added) in revenue or physical terms.}\)

(x) A survey of 5,115 households in 1968-69 together data on the type and distribution of income, and the pattern of consumption, savings, and investment of these households. The sample was selected according to a multistage, stratified probability design in order to provide a representative cross-section of the rural Indian population. The survey was repeated in 1969-70 and 1970-71 on the same households and the final version of the data refers to a core sample of 4,118 households.
A = land in operation; usually equal to land owned, but in the case of rentals, equal to land owned + land leased in - land leased out. (For purposes of convenience, A is referred to as land owned in the rest of this appendix).

(35) The Cobb-Douglas production function: $Q = AK^\alpha L^B$

The degree of homogeneity is $\alpha + B$ since

$$F(hK, hL) = A(hK)^\alpha (hL)^B = h^{\alpha + B} AK^\alpha L^B = h^{\alpha + B} Q.$$ 

Hence the Cobb-Douglas has constant returns to scale when $n = \alpha + B = 1.$ (In that case $Q = AK^\alpha$ where $Q = \frac{Q}{L}, K = \frac{K}{L}$.)

The logarithmic form:

$$\log Q = \log A + \alpha \log K + B \log L + U_t.$$ 

The statistical model: we consider cross-section studies first. The parameters $a$ & $B$ are assumed equal for all firms, as are the prices which they face. Disturbance terms are added to account for variations in the data.

$$Q_i = AK^a L^B u_{1i}$$

Most often $u_{1i}$ is held to represent the technical or productive efficiency of the $i^{th}$ entrepreneur.

The Cobb-Douglas production function is slightly generalized to the case of three inputs:

$$Q = A \times_1 x_1^{a_1} x_2^{a_2} x_3^{a_3}$$
The Cobb-Douglas production function (C-D):

\[ Y = AX_1^{b_1} \cdots X_n^{b_n} \]

this form is that it becomes linear in the logarithms of the variables:

\[ \log Y = \log A + b_1 \log X_1 + \cdots + b_n \log X_n \]

The advantages of the C-D function for empirical research: the C-D function has become the workhorse of econometric research. Its simple functional form is computationally economical and yields statistically significant estimates of the coefficients without imposing excessive demands upon data accuracy. Its estimation provides important information that is generally consistent with some a priori notions of economic theory.

Constant elasticity of substitution (CES) production function:

\[ Y = \gamma (sK^{p+} (1-S) L^{p})^{-1/p} \]

where \( \gamma \) is the efficiency parameter, \( S \) is the distribution parameter (0 \( \leq \) S \( < \) 1), and \( p \) is the substitution parameter (-1 \( < \) p \( < \) \( \infty \)).

\[ Y = \gamma (sK^{p+} (1-S) L^{p})^{-r/p} \]

where the special parameter \( r \) measures returns to scale.
This chapter associated with: (1) we deal with some conceptual considerations of economic efficiency "technical & price efficiency"; and we emphasize the implications of this distinction from the point of view of both micro-economic static analysis and dynamic characteristics of the structure of firms and product competition; (2) we present techniques for measuring the technical component of efficiency; and (3) we review the literature on "allocative efficiency".

We can measure technical efficiency by using dummy variables (values of one and zero for the two groups of firms we want to distinguish):

\[ Y_{it} = B_0 + B_1 X_{i1} + \ldots + B_k X_{ik} + \epsilon_{it} \]

The test for allocative efficiency involves not only the purely technological relationship between inputs and output but also an stochastic pro-function:

\[ Y_i = AK_i^a L_i^b U_i \]

\[ \log Y_i = \log A + a \log K_i + b \log L_i + \log U_i \]
In this chapter, we present methods whereby these complicating factors can be handled. Specifically, by introducing the profit function, we can measure relative economic efficiency by identifying separately its technical and price efficiency components in a way that is free of the problems of the more traditional profit function approach.

A test for economic rationality by the estimation of supply elasticities for the variable factors of production. The model consists of the Cobb-Douglas profit function, constant elasticity supply functions for the inputs, and a constant elasticity demand function for the output:

\[
Q_i = \alpha_i (K_i, L_i) = A_i K_i^a L_i^B
\]

(1)

\[
K_i = K_i P_i^1 \quad \text{or} \quad P_{K_i} = (\frac{K_i}{P_i})^{1/n}
\]

(2)

\[
L_i = L_i P_i^1 \quad \text{or} \quad P_{L_i} = (\frac{L_i}{P_i})^{1/E}
\]

(3)

\[
Q_i = q_i P_i^{-\lambda_i} \quad \text{or} \quad P_{Q_i} = (\frac{Q_i}{q_i})^{-1/\lambda_i}
\]

(4)

The formulation of the Cobb-Douglas profit function for the profit function and empirically formulate the test of relative economic efficiency:

\[
V = A \left( \prod_{j=1}^{m} X_j^a \right) \left( \prod_{j=1}^{n} Z_j \right)
\]
were \( Y \) = total yield, \( C \) = yield level in absence of applications of \( X \), the nutrient added;

\[
\text{Log } A = \text{log} (A-Y) = C X
\]

For explain fertilizer response allowing diminishing marginal productivity, Where \( A \) = Total yield when the nutrient, \( X \), is not deficient & \( C \) = a proportionality constant, defining the rate at which marginal yields decline:

\[
Y = (1-10^{-C X}) (10^{C X} - 10^C)
\]

where \( K \) = a "damage factor" due to excessive magnitudes of \( X \).

Spillman's total yield equation is: \( Y = M - A R^X \)

where \( M \) = the maximum total yield attainable by increasing the nutrient input \( X \), \( A \) = a constant defining the maximum response (the sum of marginal yields) attainable from use of \( X \), and \( R \) = the coefficient defining the ratio by which MP of \( X \) declines.

The variable nutrient as \( Y_o = M - A \) while the addition to yield or response is \( Y = A(1-R^X) \) - Based on Bauke's work,

Spillman developed the equation: \( Y = A(1-R^X) (1-R^Z) \)

where \( y \) = output from variable inputs, \( A \) = the maximum increase from use of variable resource, \( R \) = the ratio defining MP's, and \( X \) & \( Z \) = quantities of two variable inputs.
This chapter has concentrated on cases of market imperfections by studying inefficiency in the case of monopolies, and price distortions owing to the imposition of tariffs and quotas. By simulation methods, we have estimated the costs of inefficiency under various alternative assumptions that are likely to hold in many LDCs.

This book deals with agricultural functions. Its purpose is to summarize certain concepts, empirical methods, and quantitative researches which relate to or have been derived for farm functions. It covers both physical functions based on experiments with crops and livestock and firm functions based on cross-sectional or time series samples.

Justus Von Liebig's "law of minimum" was the attempt to define the fundamental relationship between fertilizer of nutrient inputs and crop yields. Bondorff & Plessing interpreted his low as represented by the algebraic form

\[ Y = a X \]

where \( Y = \) yield response, \( X = \) the quantity of the nutrient, \( a = \) the constant or coefficient defining the transformation ratio:

\[ Y = C + AX \]
Briggs suggested the use of the hyperbola function of the general form:

\[ Y = \frac{(x+b)E}{x+B+h} \]

where \( E \) is a maximum yield, \( b \) is the quantity of \( x \) initially in the soil, and \( h \) is the optimal supply of the input.

\[ P = f(a,b,c) \]

\[ p = a^a b^b c^c \quad (a+b+c=1,0) \] Cobb-Douglas

the first formal empirical production function fitted to time series data:

\[ P' = bL^k C^{1-k} \]

where \( P' \) was the predicted index of manufacturing output over the period, \( L \) was the index of employment, and \( C \) was the index of fixed capital.

\[ \dot{p} = bR^{1-K-h} L^K C^h \]

where \( R = (L^2 + C^2)^{0.5} \), and the sum of \( K \) and \( H \) is not forced to unily.

\[ P = a^a L^L \]

where \( L \) and \( x \) are land and labor, \( S \) is the time and \( P \) the rate of pro.

\[ P = bL^k C^j \]

where \( K \) and \( j \) could take any value.

\[ P = a x^a y^a \]

where the production function was the modified Cobb-Douglas type.
(41) The Cobb-Douglas or power function: \( Y = a X^b \), where \( X \) is the variable resource measured, \( Y \) = output, \( a \) = constant, & \( b \) defines the transformation ratio when \( X \) is at different magnitudes. The exponent or \( b \) coefficient is the elasticity of \( X \) and can be used directly. (The equation is estimated in log. form.) This function allows either constant, increasing or decreasing MP, with all other inputs held in fixed magnitude, the MP is expected to decline. This function assumes a constant elasticity of production.

The Spillman function: \( Y = M - AR^X \). The total productive curve of equation is asymptotic to \( M \). The MP curve is asymptotic to the zero axis, never becoming negative as might be the case of fertilizer used in excess.

The simple quadratic equation: \( Y = a + bX - cX^2 \), with a minus before \( c \) to denote diminishing marginal returns, does not impose such strict restraints on the production function as does the Cobb-Douglas or Spillman equation. It allows both declining and negative MP, but not both increasing & decreasing MP's. A maximum TP is defined where \( X = \frac{1}{2}bc \). The elasticity is not constant, but decline with \( X \). The MP's do not bear a fixed ratio to each other as in the Spillman function.
Modifications of the polynomial equation may be used to relax the restraint that MP's decline by a constant amount, $Y=a-bX+cX^5$, this square root equation a simple compromise between the power or exponential equations and the quadratic form. It is allows a diminishing total product but also, indicates, has MP's which decline at a diminishing rate.

Resistance formula: $X=.5C^{-1}b_1(.5c^{-1}P^{-1})P_x$, Sillman

In case n Resources: $Y=ax_2^b_2x_1^b_1+b_2=1$, Sillman-

Mitscherlich response function: $Y=A(1-R^x_x)(1-R^z_z)$,

where $y$ = output resulting from the reso, being varied,
X=the quantity of one factor and Z=quantity of another factor,
$R_x$ indicates the ratio by which MP's of X decline while $R_z$ has the same meaning for Z.

The Quadratic form: $Y=a+b_1x_1+b_2x_2+b_3x_1^2+b_4x_2^2+b_5x_1x_2$

The square root eqn: $Y=a-b_1x_1-b_2x_2x_1^5+b_4x_2^5+b_5x_1x_2^5x_1^5x_2$.

other forms:

$Y=a+b_1x_1+b_2x_2+b_3x_1^5+b_4x_2^5+b_5x_1x_2$

where the $X_1$ are raised to the 1.5 power.

A function combining characteristics of the power and exponential functions is the transcendental function extended to two resources in $Y=ax_1^{b_1}e^c_{x1}x_2^{b_2}e^c_{x2}$

This fun assumes factors are limitational and that $y$ is
zero if either $X_1$ or $X_2$ is zero. It has a maximum point at the single peak where one limitational combination of inputs defines the largest output attainable.

The "resistance" or $B$ almutand type:

$$Y^{-1} = a(b+x_1)^{-1} + d(f+x_2)^{-1} + c$$

This function does not allow negative MP's but provides a surface asymptotic to the maximum yield of $\frac{1}{c}$, "$$\frac{N}{Y} = \frac{a}{X_1} + \frac{b}{X_2} + \frac{c}{X_1X_2} + d$$" modification

where a term has been added to allow factor interaction and the $X_1$ & $X_2$ variables are not summed with another constant.

A advantage is its computational convenience. It can be estimated directly as a linear regression equation in the form $Y^{-1} = ax_1^{-1} + bx_2^{-1} + cx_1x_2 + d$

(42,42) Four over-all equations were fitted to the experimental observations. They are:

1. $G = 0.331 + 48230 + 64155 - 01830^2 - 04978^2 - 02326S$
2. $G = 10_1730 - 23000 - 7755 + 3314\sqrt{G} + 5004\sqrt{S} + 0200\sqrt{GS}$
3. $G = -0_1532 + 27000 - 4512\cdot S^{-1}$
4. $G = -0_9922c + 5537 s^2 3371$
5. $G = 17_908 - 11_442\cdot (9238^6) - 14_343\cdot (9257^8) + 8_323\cdot (9238^6)\cdot (9257^8)$

$G$ refers to gain in pounds per broilers, $C$=pounds of corn per bird, & $S$=pounds of soybean oilmeal per bird.
These functions are based on the 12 pens (2 pens per ration) of rations which were continued from initiation of the experiment up to an average liveweight of 3213 pounds, with 11 to 13 weighings per pen for a total of 146 observations.

(43) The objective of this study was to provide Turkey producers with useful predictions of least-cost rations and most profitable, or optimum, marketing weights for a wide range of price relationships.

The data are based on an experiment in which 600 bronze turkey pouls were fed on alternative rations for a 24-week period. Fewer regression models were applied in this study. The various profit & gain isoquants fitted as regression equations:

(1) Regression equation for 0-3 week interval
   (i) $C = 16716.7413$
   (ii) $C = 16141.5800S + 9727S^2$

(2) Regression equation for the 0-6 week interval
   (iii) $Y = 1.7167S^{0.4422} + 3647$
   (iv) $C = 1.9512S + 7506$
   (v) $C = 0.3915 - 1.6659S + 2668S^2$

(3) Regression equation for the 6-12 week interval
   (vi) $Y = 1.7291C^{0.4998} + 2531$
   (vii) $C = 9.6199 - 3.3851S + 2.5219S^2$
(4) Regression equations for the 12-24 week interval

(vii) \( Y = 100764 + 5108 S - 25.17 \)

(ix) \( Y = 2.8884 + 0.0450C - 0.2966S + 0.9894\sqrt{C + 2.4592\sqrt{S + 1284}} \sqrt{cS} \)

(x) \( Y = 0.0148 + 0.1838C + 0.8637S + 0.0001C^2 - 0.0040S^2 \)

(44) The primary objectives: (1) the rates at which grains and forages substitute under specific technical conditions and (2) the rate at which feeds are transformed into milk for various production levels and rations. The milk production function:

\[ M = f(G, F, X_1, X_2, X_3, X_4, \ldots, X_n) \]

where \( M \) refers to milk production during a specified time period, \( C \) refers to concentrate intake, \( F \) refers to forage intake, \( X_1 \) refers to body size, \( X_2 \) refers to inherent breed qualities of the cow, \( X_3 \) refers to labor used, and \( X_4 \) through \( X_n \) refer to unspecified resources. The Holstein herd at the Iowa State University Dairy Farm was the source of the 36 cows used from March, 1953, to September, 1954.

(45) The objective of this study is to estimate livestock-feed production functions and the feed substitution relationships which can be derived from them.
The data is based on experiments conducted by the Animal Husbandry Department at Iowa State University over a period of 25 years. Data were used employing 272 choice feeder calves and including approximately the same quality and kinds of feeds in each year.

\[ Y = 157492C + 361070P + 112332F - 0.00090147P^2 - 0.0005958F^2 - 0.0003612CF - 0.0000633CF + 0.005144PF + 3.58753 \]

where \( Y \) = total gain in pounds per steer measured from the beginning of the feeding period to weighing date.
Average starting weight of all groups of steers included in the analysis was 400 pounds. Consecutive gain observations were taken at 28-day intervals on a given ration line.

\( C \) = total intake of corn in pounds from the time grain feeding is started to the particular weighing dates.
\( P \) = total intake of protein supplement measured in pounds.
\( F \) = " " " good quality legume hay measured in pounds.

The first observation of corn is from beginning of the experiment to the first weighing date, the second observation is from the beginning of the experiment to the second, etc. Corn silage was converted to corn equivalent.
(46) The purposes of chapter, 14 & 15 are:
(1) the nature of estimated fertilizer response surface,
(2) the nature of isoclines and other relationships derived for various soil and moisture conditions by different algebraic functions, & (3) the optimum quantities and use of fertilizer as specified by particular analysis of response in Iowa in 1952. Experiments which have been completed include those with two of the nutrients N and K$_2$O and P$_2$O$_5$ variable, with all three variable, and with one or more nutrients variable while stand, moisture, or certain other inputs also are variable.

The four process equations estimated for corn are:

(i) $Y = 0.442P - 0.2877 + N - 2877$

(ii) $Y = 7.51 + 0.584N + 0.664P - 0.664P^2 + 0.0016N^2 + 0.0018P^2 + 0.00081NP$

(iii) $Y = -5.68 + 0.316N - 0.417P + 0.63512N^2 + 0.5155P^2 + 0.3410N^2P + 0.5$

(iv) $Y = -13.62 + 0.984N + 1.129P - 0.0500N^2 - 0.0576P^2 + 0.0008NP$

(47) This chapter summarizes several fertilizer process function studies in Iowa. The several sets of predictions are provided to illustrate the types of physical relationships which arise from various functional forms and magnitudes of regression coefficients which appear most efficient in response predictions under various environmental conditions.
The analysis also illustrates the types of empirical studies which often can be made from limited resources for experimentation or from data which already exist. The basic purpose of this study is to estimate crop yield production functions for fertilizer:

\[ Y = 99.223 + 3162K + 0.001812K^2 + 919G^5/2 + 0.04453N \]
\[ Y = 57.97 + 3800K + 0.002711K^2 + 4365K^3 + 0.002552S \]
\[ Y = 77.866 + 3162K + 0.001813K^2 + 919G^5/2 + 0.04453N + 0.02241S \]

where: \( Y \) = predicted total yield in bushels per acre, \( K \) = pounds of \( K_2O \) per acre, \( N \) = pounds of elemental nitrogen per acre, \& \( S \) = stalks per acre.

(48)(48) Simple factor-product relationship:

1. the Spillman, or Mitscherlich, function, \( Y = m - aX \)

"\( aX \) approaches the limit zero and assumes that the elasticity of \( aX \) changes but that the ratio of marginal products where the \( Y \)'s refer to changes in output from each input":

2. The Cobb-Douglas function: \( Y = aX \)

"the elasticity of \( aX \) is constant over all ranges of input, while the MP ratio changes, for an elasticity of less than \( 1 \), is: the curve is asymptotic to a pro\' limit
and the function does not allow diminishing total yields (1). Finally, in observations from physical data or experiments, functions must be fitted to yield observations exceeding those of the check plot (2).

(3) The simple quadratic equation, with a linear and squared term, has greater flexibility than (1) & (2): \[ Y = a + bx - cx^2 \]

(4) The linear and square-root term: \[ Y = a - bx + C \sqrt{x} \]

In case two variable inputs:

(5) The Cobb-Douglas function comes: \[ Y = ax_1^b x_2^c \]

(6) \[ Y = a + bx_1 - cx_1^2 + dx_2 - ex_2^2 + f x_1 x_2 \]

(7) \[ Y = a - bx_1 + c \sqrt{x_1} - d x_2 + e \sqrt{x_2} + f \sqrt{x_1 x_2} \]

Equation (5); (a) the two resources are complementary at some ratio to combination, and (b) the straight lines are “scale lines” indicating increases in the two reducto by same proportions.

Equations (6) & (7) allow the flexibility outlined previously and should be used if observations include diminishing total productivity for one resource increased only, or for all resources increased in scale fashion:

Modified functions:

(8) the Cobb-Douglas & the quadratic function \[ Y = a(x_1 - K_1 x_1^2)^{b_1} (x_2 - K_2 x_2^2)^{b_2} \]

(1) The function does allow diminishing total productivity but it does not allow an increasing and a decreasing total productivity.
(9) alternatively, \( Y = a + b_1(X_1 - K_1X_1^2) + b_2(X_2 - K_2X_2^2) + b_3 X_1X_2 \).

(49) In providing estimations from simultaneous economic equations, many of the steps in the general methodological approach to statistical economic investigations, the steps are following as:

1. Outlining the problem to be investigated;
2. Selecting the relevant economic theory and constructing the economic model describing the sector of the economy under study;
3. Translating the economic model into a statistical model by classifying the variables, setting them forth in explicit symbolic form, and determining the functional form of the equations;
4. Designating the relations between the model and reality in terms of the data available;
5. Examining the implication of the model and the observations available for identification of the equations and the method of estimation;
6. Calculating the estimates, testing the hypotheses and interpreting the results.
(50) $Y = f(X_1, X_2, X_3, \ldots, X_n)$: the exact algebraic form of this response function or production function, this response theory is concerned with the quantity of crop or livestock output achieved in relation to varying input quantities. It is not concerned with growth in terms of the number of members of some biological population.

We suppose the response function is:

$$Y = e^{x_1^{b_1} x_2^{b_2}}$$

(i) $\frac{\partial Y}{\partial X_1} = b_1 X_1^{b_1-1}$ the response function is continuous.

We have:

(ii) $\frac{\partial Y}{\partial X_1^2} = b_1 (b_1-1) \frac{Y}{X_1^{b_1}}$ diminishing returns to the input $X_1$ will prevail so long as $b_1$ is greater than zero and less than one. While (iii) indicates decreasing returns to scale will prevail so long as $\sum b_i$ is less than one.

$$Y = f(x_1, x_2, \ldots, X_n; x_{n+1}, \ldots, X_m)$$ To show that $m-n$ factors are fixed or unimportant, it is only concerned with $n$ inputs are considered as variables.

An algebraic form using in this chapter are:

(1) $Y = f(X_1)$, we can derive 4 quantities:

(i) AP of $X_1$ (ii) MP of $X_1$ (iii) the max. level of $Y$ that can be attained; and (iv) the elasticity of response with respect to $X_1$.

(2) $Y = f(X_1, X_2)$, we can derive 5 quantities:

(i) the family of isoquant equations, (ii) MRS$_{1j}$; (iii) ES$_{1j}$; (iv) the family of isocost equations; and (v) the ridge -line equations.

(3) $Y = f(x_1, x_2, \ldots, X_n)$. 
The purposes of response analysis are:

1. The purely positivistic one of describing the response process. Except for the basic physiological phenomena explaining why response follows a particular pattern, the response process is fully described by the factor-product and factor-factor relations; and
2. The normative one of problem solving.

In this chapter we will confine ourselves to the time less analysis of response efficiency, best operating conditions are specified by the set of input quantities which best achieves the specified goal. Any crop or livestock response process involves gains and losses. The gains are the output produced; losses are the inputs consumed.

1. Single variable input: \( Y = f(X_1) \)
   
   For the unconstrained objective function: \( II = P_y Y - P_1 X_1 \), & taking the first derivative of objective function:
   
   \[ \frac{\partial \Pi}{\partial X_1} = P_y \left( \frac{\partial Y}{\partial X_1} \right) - P_1 \]
   
   The profit maximizing condition: \( \frac{\partial Y}{\partial X_1} = \frac{P_y}{P_1} \).

   Iso-Profit line: \( Y = \frac{P_y}{P_1} X_1 \).

2. \( Y = f(X_1, X_2) \):
   
   The unconstrained objective function: \( II = P_y Y - (P_1 X_1 + P_2 X_2) \) maximization of \( \Pi \) with respect to the 2 variable inputs:
   
   \[ \frac{\partial \Pi}{\partial X_1} = 0, \]
   
   \[ \frac{\partial \Pi}{\partial X_2} = 0. \]
(3) $Y=f(X_1, X_2, \ldots, X_n)$

the unconstrained objective function $\Pi = P_Y Y - \leq P_i X_i$, &

max: of $\Pi$ with respect to the $n$ input variables

implies simultaneous solution of the equations:

$\nabla \Pi / \partial X_i = 0 \quad (i=1, 2, \ldots, n)$

$M P_i = P/Y_i$

(4) multiple response without input control: response function:

$Y=f_k(X_1, X_2, \ldots, X_n) \quad (K=1, 2, \ldots, Y)$

the objective function: $\Pi = P_k Y_k - P_i X_i$, and

subject to the second-condition

(5) multiple response with input control:

$Y_h=f_h(X_{1h}, X_{2h}, \ldots, X_{nh}) \quad (h=1, 2, \ldots, Y)$

where $X_{ih}$ is the quantity of $X_i$ allocated of the

$h$th response process and may be always zero for

some $X_{ih}$'s, and the overall unconstrained objective

function as: $\Pi = \leq \Pi_h$ where $\Pi_h$ the profit from

the $h$th response process:

max $\Pi = \leq (\text{max } \Pi_h)$

(6) Constraints on the objective function:

6.1. Fixed-output constraints: 3 types

(i) single response process, output (Y) fixed;

(ii) $Y$ processes, each with output

$(Y_n)^F$
(iii) response processes, total returns \( \sum P_h Y_h \)
- the iso-revenue locus
- " r-1 product-product relations
- " r-1 factor-factor
- " (n-1)(r-1) factor-product

(52) There are four ways in which time may affect the physical response process: (1) the contribution of fixed inputs may vary with the time-length of the response process so that time directly influences response; (2) the capacity of the set of fixed inputs to accommodate variable inputs may be a function of time and of the mix of variable inputs made available; (3) the time sequence or pattern of either input injections or output harvests may influence yield; and (4) input carryover effects may occur from one period to another if the injection of variable inputs within one period is not completely utilized within that period. As well, time may influence the objective function the rough time influences on prices and profit opportunities.
Several theoretical considerations lead to the expectation that in developing countries large farms will tend toward lower production than small farms, per unit of constant quality land available. A board result is that land goes relatively underused on large farms, while excessive labor is crowded onto small farms.

The differing degree of potential output increased from land redistribution, among different developing countries, is an unexplored subject. The consideration of dynamic factors such as technological changes and savings behavior, need not reverse the policy implications that arise from the static output gains to be achieved from land redistribution and other programs favoring the small-farm sector.

In the analysis of technological change, we distinguish between four basic elements: (1) the technical efficiency of production, (2) the scale of operation of production, (3) the basis of technological change, & (4) the elasticity of substitution.

One approach to measuring technological change is to estimate all the parameters of the production function for different periods of time, or "epochs".
The Johansen method is appropriate for cross-section analysis of interindustry productivity between two time periods. Assume a Cobb-Douglas production function for industry $i$ at time $t$ as

$$Q_{it} = A_{it} K_{it} ^{di} L_{it} ^{Bi}$$

with the assumption of constant returns to scale, that is $B_i = 1$, and constancy of $A_i$ and $B_i$ over time.

For purposes of estimation, we add a constant to the equation $\frac{Q_{it}}{Q_{i1}} = \frac{K_{it}}{K_{i1}} E_i$, and after taking logs, we have

$$\log q_{it} = \log q_{i1} + (\log K) \cdi + \log E_i$$

(55) (55) The production function: $X = \varphi (V_1, \ldots, V_n)$.

The relationship between input and output: in case existence the technical problem of production, we notice that the output of the two products will now depend upon the inputs of a series of variable services rather than upon one alone:

(a) $X = \varphi (x, y_1, \ldots, y_n, y)$

(b) $y = \varphi (y, y_1, \ldots, y_n, x)$

The input of one service will, therefore, depend no longer only upon the quantities of the two products, but will depend also upon the quantities of the other services.
The technical interdependence and the production function: If the input of fixed services is given, the output of one period depends both upon the input of variable services and upon the output of the other period. On analogy with the case of joint mono-periodic production:

\[ x_i = \varphi_{(x_i)} (v_{i_1}, \ldots, v_{i_m}, x_{i_j}) \]

and

\[ x_{i_j} = \varphi_{(x_{i_j})} (v_{i_1}, \ldots, v_{i_m}, x_{i_j}) \]

This chapter analyzes the contribution of agricultural research to the increase in yield in two crops: wheat and maize.

The study covers sixty-four wheat-growing and forty-one maize-growing countries during the 1948-68 period. Average yield increase for these countries were 2% per annum in wheat and 3% in maize, according to the production function:

\[ Q = f(f_b(x_b), f_m(x_m)) \]

where

- Q refers to the output; b the subscript of the biological process; m, the subscript of the technical, mechanical process;
- \(X_b, X_m\) vectors of input.


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