USE AND PRODUCTIVITY OF AGRICULTURAL RESOURCES

JAGUARIUNA COUNTY

SAO PAULO, BRAZIL

A Thesis

Submitted to the Faculty

of

Purdue University

by

Alberto Veiga

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

January 1966

ACKNOWLEDGMENTS

My gratitude to those who helped me in every step of conducting this research is the most sincere. I wish to express my recognition to all of them.

To Dr. D. Woods Thomas. A competent and patient major professor is the main ingredient of a graduate thesis. Dr. Thomas was more than this.

To Dr. G. Edward Schuh who was a permanent contact throughout this research, first guiding my steps on the field work in Brazil and later lending his precious advice in the United States.

To Drs. Earl W. Kehrberg and Rene Manes, members of my advisory committee.

To Boaventura Echeverria, who knew with me every corner of Jaguariuna County in a tireless interviewing work.

To Affonso C. M. e Silva, Alcino da C. Oliveira, Paulo F.C. de Araujo and Olavo Silveira, who made my task theirs in Brazil for the last two years.

To Darcy M. de Souza, extension agent in Jaguariuna, who gave me all the support of his authority and friendship.

To Antonio R. Teixeira Filho, Bruce Cone, and Eliseu A. R. Alves, always ready to discuss my problems.

To the Agency for International Development, for sponsoring my studies at Purdue.

To the Fundacao de Amparo a Pesquisa, of Sao Paulo, which made possible my trip to Brazil, sponsoring this research.

To the Secretaria da Agricultura do Estado de Sao Paulo through Jose Gomes da Silva, Director of the Divisao de Assistencia Tecnica Especialisada, who always gave me moral and material support.

Finally, to my wife, Eleedes, to whom this thesis is dedicated. She has meant to me something too special to be translated into words.

TABLE OF CONTENTS

Table of Contents (continued)

LIST OF TABLES

List of Tables (Continued)

LIST OF APPENDIX TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

Veiga, Alberto, M.S., Purdue University, January, 1966. Use and Productivity of Agricultural Resources - Jaguariuna County - Sao Paulo, Brazil. Major Professor: D. Woods Thomas

This study treated the problem of resource use and productivity, at the farm level, in the County of Jaguariuna, State of Sao Paulo, Brazil. This area was taken as being representative of the "old coffee zones" around the Sao Paulo urban-industrial center that are in transition from traditional to modern commercial agriculture. The study was limited to a single crop year - 1963/64. The primary objectives were to obtain empirical estimates of the relationship between resources used in production and the value of farm output, to determine the optimum level of resource use and to gain insight into probable adjustments in resource use patterns. A secondary objective was to compare the productivity of agricultural resources in the primary study area with the productivity of similar resources in Ituiutaba and Caratinga Counties in the State of Minas Gerais.

The study area was selected from among 33 alternative locations in the State of Sao Paulo. Variables were defined and a questionnaire designed. The population was defined as consisting of all farms in Jaguariuna County that had between 5 and 250 hectares in production in 1963/64. Data were obtained from a stratified random sample consisting of 74 farms. Cobb-Douglas and linear models were estimated. On the basis of economic logic, previous knowledge of the nature of production

relationships and tests of statistical reliability, the following empirical production function was accepted as the best estimate of the true relationship of interest in this study:

$$\hat{Y} = 9.50\, X_1^{.163}\, X_2^{-.136}\, X_3^{.245}\, X_4^{.085}\, X_5^{.044}\, X_6^{.121}\, X_7^{.143}\, X_8^{.237}$$

where: $\hat{Y}$, X_1, X_2, X_3, X_4, X_5, X_6, X_7 and X_8 are, respectively, estimated value of gross farm output, land in crops, land in pasture, labor, capital invested in buildings and improvements, capital invested in equipment, capital invested in productive livestock, capital invested in draft livestock and current operating expenditures.

The production function indicated that, on the average, resources were being used in the rational stage of production (Stage II) with the exception of land in pasture. This was employed in the range of decreasing total returns. The estimated elasticity of production of .90 indicated that this population of farms was characterized by decreasing returns to scale.

The determination of the optimum resource use pattern for farms in this population was obviated by the presence of a negative regression coefficient for one of the resource categories.

Average value products, value marginal products and ratios of value marginal products to input prices were determined for purposes of economic interpretation. Given the factor prices existing in the study area during 1963/64, under ceteris paribus conditions and under the assumption of profit maximization motives, the level of employment of each resource category was examined. This examination indicated that too much land, labor and capital investment in equipment were employed. Investments in buildings, productive livestock, draft livestock and current expenditures, other things equal, were less than optimal.

The comparative analysis of farm populations in Jaguariuna, Ituiutaba and Caratinga showed striking similarities and differences in resource productivity patterns. Cropland was consistently more productive at the margin than land in pasture. Marginal investments in buildings and improvements and in current expenditures were profitable in all areas. On the average, marginal returns to investment in farm equipment were found to be less than marginal costs in all areas although Jaguariuna was close to the optimum use of this input. Marginal investment in draft livestock was found to be highly profitable in Jaguariuna but not profitable in either of the other areas. Use of additional labor was indicated only in Ituiutaba.

In general, it was concluded that both location relative to urban-industrial centers and the historic nature of agriculture in a region influence the pattern of resource productivity and the kind of adjustments in resource use that are occuring and will occur.

CHAPTER I

INTRODUCTION

This study is concerned with the problem of resource use and productivity in agriculture. It attempts to use the economic tools of marginal analysis to arrive at insights into this issue under conditions of economic underdevelopment. The most relevant theoretical questions in this context are treated in the following pages. They include the relationship between production and consumption theories under conditions of perfect competition; the scope of marginal theory and its application in geographic space, and the issues of economic development and their implications in a regional framework. The objective of this preliminary discussion is to show the main theoretical boundaries of the specific case studied. The rest of the chapter describes the particular conditions of the area studied and establishes the objectives of the research.

General Implications of the Resource Productivity Issue

As a first approach to this study, it seems proper to consider the relationship between the production theory upon which it is based and consumption theory. This follows from the fact that the ultimate consumer of goods and services is the end toward which all other economic activity is directed.

Under conditions of perfect competition, a perfectly elastic demand function is faced by the agricultural production unit. As a result, farmers have the single alternative of trying to maximize their short-run objective - widening the distance between total costs and total revenue - by working on the input side of their production function or on the production function itself. This is approached through budgeting, adoption of technological improvements and other maximization procedures in an attempt to equate relevant prices to marginal products and marginal rates of product and factor substitution.

To consider the total cost curve as a reflection of a production function and to take the slope of this curve as a product supply function is another way of looking at this problem. Thus, as farmers try to attain their economic objective they are, at the same time, establishing a supply curve for their product. The long-run supply curve shows the maximum quantities which producers would place on the market at different prices. For the individual producer, in a perfect competition model, this maximum is that production attained under optimum resource allocation conditions.

The consumer with his limited money income tries to maximize utility. Thus, consumer satisfaction is maximized when the additional utility obtained for a dollar's worth of a given commodity is the same as the additional utility for a dollar's worth of any other commodity he might acquire. These objectives are reflected in the relevant demand schedules as sets of quantity and price relationships. A demand curve represents the maximum quantities that will be taken by consumers at different prices. The individual consumer - with his given money income - reaches these quantities in the long run at the point where he maximizes utility.

It is through supply and demand schedules that the objectives of producers and consumers interact - the former trying to maximize efficiency in order to maintain or produce short-run profits and the latter trying to maximize utility. Under the previous assumptions, these are related objectives. As a matter of fact, movements by producers toward the maximization of their efficiency objectives may be translated into lower consumer prices. This is equivalent to an increase in consumer income and, hence, permits gains in utility to be enjoyed by the consumers.

Importance of Value Productivity Estimates

The production function, as the basis of the total and marginal cost curves, is determined by the nature of the whole production process. This process can be looked upon as responding to the elements which influence product and factor choice. They include: a) the nature of the factor and product markets and the expectations of farmers with regard to these markets; b) the structure of aggregate costs as distributed between fixed and variable elements in the short-run; c) the state of technological knowledge as it influences the choice of resource use and determines the range within which a production function might be shifted.

Within the production-consumption framework, the value productivity of resources can be a meaningful index to an evaluation of production efficiency. If a change in consumers' income levels or tastes shifts their preferences for food, the resultant change in demand will be reflected on the production side in a different pattern of output and input choice, and a new production pattern will evolve. This means that resources will be reallocated under the influence of the new value productivity levels.

Regional Implications

As a refinement of the discussion of the production function and as a means of directing attention to a regional framework, a new variable - geographic space - may be introduced. For the present purposes, the spatial approach has two main advantages:

a) Since the set of resources used in production can vary significantly from one area to another, a production function may be disaggregated into a set of more meaningful components. This diminishes an important source of bias in resource productivity studies - the immobility of resources among regions;

b) Location influences production with respect to the intensity of the use of resources, combination of enterprises, size of the production unit and degree of specialization. The spatial relationships among factor and product markets is one of the main reasons for such influences. Here, there is another motive for isolating a region and approaching the problem from this perspective.

There are different ways of defining a region. The most appropriate will depend on the objectives of the analysis. For the purposes of this discussion, a region could be defined as an area in which exists a relatively homogeneous set of fixed productive resources and where resource and product prices are not significantly influenced by location of factor and product markets. In every case, there will exist inter-regional differences in the value productivity of resources.

As a result of such differences, unique production patterns would be expected to characterize each region unless price ratios do not differ in an offsetting manner. The importance of variations in value productivity of resources in explaining consumption trends has been indicated. In the regional framework, it can be seen more explicitly. A change in consumer demand will lead to new patterns of resource allocation and production. These new patterns will differ by regions. A region may be considered as the geographic space in which reactions to these consumption changes are more or less uniform.

The Resource Productivity Issue in Underdeveloped Economies

General Characteristics

At this point, special attention will be given to the particular economic environment where the present work was undertaken. The resource productivity issue, in this context, involves not only the usual questions associated with this type of economic problem but also the unique features of resource productivity in an underdeveloped situation.

The problem of resource productivity in underdeveloped economies is closely related to six general characteristics of poor countries: a) they depend on primary production; b) they face population pressure; c) they have underutilized natural resources; d) they have an economically backward population; e) they are capital deficient; and, f) they are foreign trade-oriented.

The agricultural sector plays a major role in these situations. Poor countries are predominantly producers of agricultural products. Usually, more than 50% of personal income is consumed in the form of food. A large percentage of the population is employed in primary production activities where agriculture, as a rule, has the main share. They face population pressure either in terms of high density or high rates of growth.

Low productivity of the agricultural sector in poor countries is indicated by low ratios of cultivated land per worker. Such low ratios are associated with factors such as: a) defective land tenure patterns; b) small amounts of capital in use; c) inadequate knowledge of production methods; and d) inefficient organization of production.

In every case the problem of resource productivity is evidenced. Very often monoculture is the only way to overcome - through specialization - the barrier of low factor productivity. The land tenure arrangements favor the maintenance of both very large and very small holdings emphasizing the imbalance of resource and income distribution. Deficient communications add imperfections to the marketing channels making producers less responsive to consumer needs in the domestic and in the foreign markets.

To say that a given set of agricultural resources is low in productivity with regard to different combinations does not mean necessarily that they are mal-allocated. Given the traditional levels of technology, reasonably efficient resource allocation patterns are likely to be found in such areas. Therefore, the existence of optimum resource allocation patterns does not mean that a great improvement in output and returns cannot be made through technological innovations and associated factor adjustment.

Developing economies are subject to ever-changing price and consumption patterns of important magnitude. On the production side, these changes are a reason for constant technological adjustments. As a result, most problems of resource use in these economies are related to the process of shifting the production function. Resource use and technology tend to change not as a result of systematic rationalization but as discontinuous economic and technological "pushes". Ways in which this whole process affects a given region is the subject to be treated in the next section.

Regional Imbalance

Sharp regional economic imbalance tends to be one of the main characteristics of developing nations. Some attribute it to the cumulative effects of the circular causation process. Here, the well-known concept of the vicious circle follows a trend. The direction of this trend is given by the extent to which adverse and favorable elements affect an economy.

There are positive and negative economic forces acting in a given geographis space. This means that one region can transmit to or receive from another positive and/or negative influences with corresponding positive and/or negative results on its development. In many cases, a positive effect in a given area may be a negative effect in neighboring areas. A differential in product prices due to locational advantages, for instance, can influence the labor market in another region through the offering of better job and business opportunities to their better-qualified workers and entrepreneurs. Another concept often related to this idea is the regional application of the theory of the deterioration of the terms of trade.

Other theoretical treatments put regional imbalance in a similar but more localized framework. Here, development is related to the existence of locational matrices. These matrices spread around a given industrial-urban complex in process of growth which directs its forces more strongly to areas closer to its center and less strongly to those at the periphery.

Thus, the pace at which development occurs varies widely among regions. These are mainly differences in productive stages characterized by diverse degrees of association between production and consumption. These differences tend to increase over time if an effective balancing policy is not undertaken. Comparative studies of resource productivity among such agricultural regions are needed in order to determine the extent to which differences found to exist are consistent with efficiency of resource allocation and use.

Brazil in the Framework

Brazil belongs to the group of so-called underdeveloped nations. However, its per capita income of U.S $380 in 1962 places it in a relatively high position among them. Both agricultural and industrial production are increasing steadily. During the 1957-61 period, agricultural production rose 4.8 percent per annum, and industry, 12.7 percent. Gross national product expanded as much as 7 percent per year during this period. Tables 1, 2 and 3 show growth in exports, domestic crop production, and livestock population during the period 1950-62. Table 4 gives an idea of industrial growth.

Table 1. Exports of three agricultural products. Brazil, 1950 and 1961

Product	1950	1961	Change 1950-1961
	(million metric tons)		(percent)
Coffee	1,071	2,280	+ 113
Sugar	1,401	3,354	+ 139
Cotton	393	625	+ 59

Source: Celso Furtado, Dialetica do Desenvolvimento, Editora Fundo de Cultura, Brasil.

Table 2. Domestic Production of Six Crops. Brazil, 1950 and 1962

	1950	1962	Change 1950-1962
	(million metric tons)		(percent)
Corn	6,024	9,580	+ 59
Rice	3,218	5,557	+ 73
Beans	1,248	1,709	+ 37
Potatoes	707	1,134	+ 60
Mandioca	12,532	19,843	+ 58
Peanuts	117	648	+ 454

Source: Celso Furtado, Dialetica do Desenvolvimento, Editora Fundo de Cultura, Brasil.

Table 3. Cattle and Hog Population. Brazil, 1950 and 1962

	1950	1962	Change 1950-1962
	(thousand head)		(percent)
Cattle	52,655	79,078	+ 50
Hogs	26,059	52,941	+ 103

Source: Celso Furtado, Dialetica do Desenvolvimento, Editora Fundo de Cultura, Brasil.

Table 4. Indices of Industrial Production. Brazil, 1950 and 1961

	1950	1961	Change 1950-1961
			(percent)
Steel (thousand metric tons)	789	2,493	+ 216
Cement (thousand metric tons)	1,386	4,711	+ 240
Electric Power (millions of kwh)	7,000	24,405	+ 249

Source: Celso Furtado, Dialetica do Desenvolvimento, Editora Fundo de Cultura, Brasil.

Behind this rosy picture there is a great deal of uncertainty. For Brazil is a country on the move. This raises many kinds of reasons for economic disequilibrium and social unrest. One of the principal features of this situation is regional imbalance. In Brazil, one can find some of the poorest regions in the world along side one of the biggest industrial centers of the hemisphere.

As an example of economic imbalance in agriculture the Northeastern and Southern regions of Brazil are compared through the data in Tables 5 and 6. Table 5 records yields, in metric tons/hectare, for six main crops in two different periods of time in both regions. Table 6 gives the percentage of growth in livestock population from 1955 to 1957-59.

Table 5. Average Yields of Six Main Crops. Northeast and South, Brazil, 1953-55 and 1957-58.

	Northeast			South		
	1953-55	1957-58	Changes	1953-55	1957-58	Change
	(metric tons per hectare)		(percent)	(metric tons per hectare)		(percent)
Cotton	0.20	0.36	+ 30	0.41	0.71	+ 73
S. Cane	37.59	38.96	+ 4	40.63	46.81	+ 15
Rice	1.23	1.21	- 2	1.68	1.80	+ 7
Beans	0.47	0.45	- 4	0.83	0.85	+ 2
Corn	0.66	0.67	+ 2	1.36	1.43	+ 5
Potatoes	3.28	2.98	- 9	4.98	5.40	+ 8

Source: Conselho Nacional de Estatistica (IBGE), Anuarios Estatisticos do Brasil.

Table 6. Percentage Growth in Number of Livestock from 1955 to 1957-59. Northeast and South, Brazil

	Northeast	South
Cattle	1.4%	9.9%
Hogs	-2.8%	21.8%

Source: Conselho Nacional de Estatistica (IBGE), Anuarios Estatisticos do Brasil.

Both regions have about the same area. The Northeast (7 states) contains 11.4 percent and the South (4 states) 9.7 percent of the land area of the nation. With regard to population, these percentages are 23.7 and 34.2, for the Northeast and South, respectively.

In regional imbalance is found another important reason for conducting research on the topic of use and productivity of agricultural resources. There is need for cross-sectional and time-series studies on the subject to show the most appropriate path for resource adjustment between poorer and richer areas. Another useful approach is the study of the interaction between the industrial and the agricultural sector on the issue of resource allocation.

The Study Area

The particular study area of this research was a "municipio" (county) in the State of Sao Paulo. This municipio, Jaguariuna, is situated 87 miles northwest of the capital city of Sao Paulo, (4 million inhabitants) and 18.6 miles from Campinas (200,000 inhabitants), the third largest city in the State.

The State of Sao Paulo, (Figure 1) is situated in the Southern region of Brazil and includes 2.9 percent of the area of the country. Of the six main crops, recorded above for purposes of regional comparisons, Sao Paulo is the country's leading producer of three (cotton, rice, and sugar cane), the second in potatoes and the third in beans and corn; in cotton and sugar cane, its production surpasses the total production of the Northeastern region. It has the second largest cattle and swine herds in the nation. Finally, it produces about 55 percent of the country's industrial output.

Figure 1. State of Sao Paulo, Brazil

As indicated above, the main part of this study was restricted to a single county. Even though the county of Jaguariuna is close to a large industrial center its main economic activity is still agriculture.[1/] It covers a small area (57 square miles). About 70 percent of its population is rural.

Partially as a result of its proximity to their large urban area, agriculture in Jaguariuna and neighboring regions is experiencing rapid transformation. This area, under industrial-urban influence is being affected by factors such as (a) the high and growing demand for food, (b) the improvement of marketing channels, (c) a shortage of qualified manpower and (d) the depletion of land. The adjustments being made include a shift from a traditional type of enterprise with emphasis on coffee production to one characterized by (a) more responsive supply, (b) improved technology and mechanization, (c) a trend toward specialization in citrus and cattle production, (d) the entrance of new landowners,[2/] (e) more extensive use of hired labor from nearby urban centers and some tendency toward family farming, and (f) some indication of further expansion of sugar cane production induced by large sugar mills and producers in the surrounding areas.

In spite of its favorable aspects, this transformation emphasizes all defects of traditional agriculture. It suggests the presence of

---

1/ Figure 2, page 48, shows the location of Jaguariuna with respect to the main urban centers of the State of Sao Paulo.

2/ Two types of land-owners can be distinguished: 1) the non-skilled but wealthy people coming from urban centers, developing either week-end farming or large enterprises with emphasis on cattle production, and 2) skilled Dutch and Japanese immigrants trying more difficult and profitable enterprises: tomatoes, high quality citrus, vegetables, thoroughbred livestock, flowers, etc.

widespread resource malajustment cast in the contrasting landscape of a transitional pattern. The distortions introduced by galloping inflation have made much more difficult rational adjustments in resource use framed in a set of stable prices. It is under such premises and conditions that the present study was undertaken.

The preceding pages have been an attempt to point out the main issues involved in the present context both from an economic theory viewpoint and from the perspective of the particular area studies. These issues can be summarized in two aspects of the problem of resource productivity to which particular attention was directed in this study:

a) empirical knowledge of the productivity of various resource categories as guidelines to needed and probable adjustments in resource use patterns within the population of farms studied;

b) empirical knowledge of the relationship between productivity of various resource categories in a given area relative to those in other areas of similar natural resources but different geographic locations relative to industrial-urban centers.

Objectives of the Research

1. To estimate statistically an empirical production function specifying the relationship between the value of gross farm output and resources used in production on a defined population of farms in Jaguariuna County, Sao Paulo, Brazil.

2. To determine the average and marginal productivity of resource categories, marginal rates of factor substitution and the nature of economies to scale in this population.

3. To determine the optimum level of resource use under existing factor and product price situations.

4. To make an economic interpretation of the findings as a means of explaining the present resource allocation pattern and to explore the possibilities of change.

5. To conduct a comparative analysis of resource productivity between this population of farms and farms having a different geographic exposure to the urban-industrial influences.

CHAPTER II

REVIEW OF LITERATURE

Methodological Problems Involved in Agricultural Production Function Studies

A review of literature on the methodological problems related to production function studies is not easy to develop following an author-by-author approach. Contributions to the same point have been made by many. The traditional review approach would result in an endless and tiresome repetition of citations and basic principles. Therefore, the first part of this chapter follows a straight-forward description of the main methodological issues of production function studies.[1]

Many of the methodological problems of estimating and using the production function as a prediction instrument for resource allocation are related to the differences existing between the conditions imposed by production theory and real world situations. Therefore, such problems can be put in terms of the assumptions underlying production function analysis. This set of general assumptions is related to:

a) degree of knowledge

b) time period considered

c) divisibility of product and factors

d) relation of prices to output

e) technological level

1/ Articles and books reviewed are cited in the Bibliography. They are ~~under number 2, 6, 9, 10, 12, 13, 15, 19 and 22.~~ Be 56, Ed 61, Gr 57, Gr 63, He 61, Hi 60, Ke 63, Mu 61, Pl 55.

This set of assumptions means that: a) there is no risk or uncertainty attached to the production concept; perfect knowledge of the input and output markets and of their technological relationships exists; b) all inputs are completely transformed into product during the time period considered; c) both product and factors can be divided in any proportion, in order to provide the best conditions for profit maximization and optimum resource use; d) input price is independent of output price; and e) the technological production level is given.

It is obvious that real-world situations are different. From these assumptions it may be inferred that an estimated production function can only be relied upon when it includes all the inputs involved in the production process, as well as the input and output quantities actually employed. This implies the existence of regression coefficients calculated without error. The exact prices of all factors and products involved are assumed to be known.

These kind of problems are particularly serious when one deals with aggregate, multiple-enterprise production functions. In what follows, some of the main issues common to input and output aggregation are given.

a) Production is essentially a physical phenomenon. This means that the relation between inputs and output is more logically given in physical rather than in value terms. This tends to be relatively easy to do in cases relating one specific kind of input to one specific type of product. But as aggregation increases, the problem of measurement in physical units grows. In practical terms, it is impossible to handle aggregate inputs such as capital investment in construction, improvements, and machinery or like current operating expenditures without using monetary units as a common denominator. Similar problems exist with respect to aggregate output.

The main problem with value measurements is that they do not reflect with fidelity the physical contribution of the inputs to production or the output response to the use of resources. They reflect also the relative scarcity of factors, inflationary overvaluation trends, and the like. Therefore, additional biases may be introduced when monetary value is used to represent inputs.

b) The extent to which different factors are related to production is not easily determined. In this context, resources can be divided into two groups: those that a farmer can control and those that he cannot. In the usual production function analysis, the first group is involved. Here, problems arise out of two questions: 1) Has the whole range of controllable inputs acting on production been considered? 2) Are the actual quantities of each input relevant to the objectives in study known?

With regard to the uncontrollable factors, other important problems may appear. Since most production function studies are of a cross-sectional type, factors such as exceptional climatic conditions or unusual crop or livestock diseases may lend a great deal of uncertainty to predictions based on such abnormal periods. Even though these factors may exist in the whole area studied, it is common to find two different sets of factor-product relationships if two different time periods are considered.

c) In addition to the problem of considering all factors used in production and their actual quantities, there is the problem of allowing for differences in quality. When one aggregatees a bundle of resources it is assumed that they are performing the same kind of services with the same efficiency level in every observation. This is not necessarily true. Differences in input quality will lead to different levels of productivity.

When land is divided into cropland and pastureland components, in a sense, a distinction with regard to quality has been made. Differences in prices found between samples of the same input category may be allowing for quality, also. With respect to the labor input, one may attempt to distinguish quality by attributing different weights according to the age or other particular characteristic of the worker; however, it has been found that the educational level of the farm population can have a meaningful effect in resource productivity. In short, procedures to allow for qualitative differences when either input or output items are aggregated are not well established.

d) Some resources are not measured accurately; others are very often left out partially as a result of the lack of a measurement device. One of these factors, and a very important one, is management. In the absence of its measurement, its effects can be reflected over other input categories, distorting their evaluation. Management is responsible for a great deal of the qualitative difference in input allocation; many of these differences probably could be accounted for if it were possible to introduce the managerial factor into our models.

e) Another outstanding issue is that dealing with the time period involved in cross-section analysis. If any particular year is considered to provide insufficient evidence to permit reliable conclusions from adjusted production curves, longer time spans and average marginal products should be used. But, even so, there would be problems with an aggregate whole-farm production function mainly under conditions of rapid changes as in developing economies. In these cases, technological changes and price instability could introduce prediction errors larger than would results based on shorter time periods.

f) Production function analaysis assumes that farmers have the maximization of profits as their unique goal. This is not always true. It must be recognized that in the real world there is more concern with approximation of the profit motive than with maximization itself. In more cases than one may think, goals probably are put in terms of maximizing family or personal satisfaction. This is usually a constant when one deals with week-end farming or large semi-commercial enterprises. It is possible that this could be generalized to all kinds of absentee ownership, with the exception of rented farms and the share-cropping type of farming. But even in this last case, the landowner and the sharecropper see returns from a different perspective due to the differences in the prices they attach to factors. In multiple-enterprise studies, many kinds of intentionally non-profitable enterprises may appear and it is difficult to identify them or to separate the factor services being allocated to them.

g) Another aggregation problem occurs on the output side. A homogeneous type of farming as well as a homogeneous production technique are generally assumed. In fact, there are no two farms with exactly the same product combination or the same technology. Very often, large farms emphasize cattle production or plantations whereas small farms are on a subsistence level or specialize in intensive, high-value crops. How to identify whether these are different stages of a given production pattern is a problem to be solved.

Studies Performed in Less-Developed Areas

The estimation of production functions in resource use studies has received widespread attention of researchers. From the abundant literature on the subject, attention was directed to those studies most closely related to underdeveloped economies and, particularly, to Brazil. Many of these studies did not aggregate inputs at the level necessary in this study and were concerned with a unique kind of output; but, even so, all of them raise significant points and questions of interest.

Studies Outside Brazil

From studies outside Brazil, two were reviewed: Quintana's[2/] study of types of farming in the Philippines and Aldunate's[3/] research in Chile.

a) Quintana, using data for the crop year 1956-57, studied five types of Philippine farms: rice, corn, tobacco, abaca, and coffee. His objectives were to estimate a production function, determine its implications and the optimum resource combinations for each type. He had a total of 291 observations (about 60 for each farm-type). Five independent variables were used: land (X_1), labor (X_2), animal labor (X_3), capital invested in equipment (X_4) and current operating expenditures (X_5). The dependent variable was gross farm income. A Cobb-Douglas model and the least squares regression technique were employed.

Two equations were tried for rice and corn farms. The first had the

---

2/ Quintana, Emilio U., Resource Productivity Estimates for Five Types of Philippine Farms, Unpublished Ph.D. Thesis, Purdue University, 1960.

3/ Aldunate, Paul, A Comparison of Resource Productivity and Efficiency on Private and Government-Created Farms in the Central Valley of Chile, Unpublished M.S. Thesis, Purdue University, 1965.

variables indicated above. In the second, due to their high correlation with land, X_2 and X_3 were combined and divided into two other variables: man labor, and man-animal labor (operations performed by animal and man together). From the selected equation (the second), X_4 (capital invested in equipment) was excluded because of its non-significant, negative regression coefficient.

Production functions for coffee and tobacco farms were estimated with the original five input variables. The function for abaca farms had only four input variables since animal labor is not used after the establishment of the plantation.

The summation of the regression coefficients (elasticity of production) indicated decreasing returns to scale for tobacco (.85), and coffee (.85) farms; almost constant returns to scale for rice (.93), and abaca farms (1.08); increasing returns to scale (1.36) for corn farms.

The coefficients of determination (R^2) were .65, .76, .60, .75, and .64 for rice, corn, tobacco, abaca, and coffee farms, respectively.

The statistical analysis led to the conclusion that variation in the output of rice farms was associated more with variation in land inputs than with the other inputs. Variation in land and man labor were more important on coffee farms; the same was true for man labor on corn and abaca farms, and man labor and current expenditures on tobacco farms.

An interesting finding was that machinery, tools and equipment did not have a significant influence on the output level on most of the farms studied. This is counter to the generally accepted concept that an increase in this form of capital will lead to important output changes.

b) Aldunate was concerned with resource allocation and productivity on traditional, private farms as compared to that of new production units (dependent farms) created through land reform programs in Chile, in 1962. His objectives were to define the current and optimum levels of resource use and to determine from these findings the differences between the two groups of farms. The period involved was the crop year 1963-64.

Five independent variables were employed: capital investment in buildings, improvements, and machinery (X_1), productive land (X_2), capital investment in productive and draft livestock (X_3), labor (X_4) and current operating expenditures (X_5). The dependent variable was the aggregate production value. The Cobb-Douglas production function was used.

The sample was composed of 53 dependent farms and 67 private farms (farms larger than 10 hectares - with less than 50 percent of their land in orchards and vineyards and more than 80 percent under irrigation - in a given area). For purposes of a better insight, the private farms were divided into crop, livestock, and general farms. In two of these groups (livestock and general farms) the partial correlation coefficients between inputs were quite high, (between .56 and .86), but private farms presented lower partial correlations, (between .34 and .78), although greater than dependent farms (between .01 and .59).

The coefficients of determination were .66 on dependent farms and .84 on private farms. The elasticity of production was .94 for dependent, and 1.05 for private farms.

Value marginal productivities were equated to input prices in order to estimate the optimum resource allocation. Dependent farms were found to be closer to the optimum in the use of capital in buildings, improvements and machinery, capital in livestock, and current operating expenditures; private farms were closer to the optimum in the use of land and labor.

Production Function Studies in Brazil

In Brazil, several studies on resource productivity have been conducted. A good part of them will be reviewed.[4/] The following presentation is chronological.

a) The Food and Agriculture Organization, of the United Nations carried out a study of resource use on 1991 coffee farms in the State of Sao Paulo.[5/] This sample was divided into two groups: one with 486 farms, and the other with 1505. Both groups were then reclassified and stratified according to soil type, variety and age of trees into coffee plantations. In the first group, 825 coffee plantations were included in the final sample. Six independent variables were set: investment in fertilizer (X_2), expenditures in manure or other organic fertilizers (X_3), population of coffee trees per hectare (X_4), capital in land (X_5), labor (X_6)[6/] and the average age of the plantation (X_7). Four other input variables were included depending on their occurrence on the particular observation: two for variety and two for soil type.[7/] Output (X_1),

---

4/ There are indications that other studies have been and are being carried out in Vicosa (State of Minas Gerais), and in the State of Rio Grande do Sul. These were not included.

5/ Organizacao de Alimentacao e Agricultura das Nacoes Unidas. "Analise Estatistica dos Fatores que Afetam os Rendimentos Agricolas do Cafe no Est. de Sao Paulo", Agricultura em Sao Paulo, Secretaria da Agricultura, Sao Paulo, Brasil, June, 1961.

6/ Harvesting labor was not included since it does not add to production but depends on it.

7/ Two variables determined three varieties: Bourbon ($X_9 = 0$, $X_{10} = 0$), Mundo Novo ($X_9 = 0$, $X_{10} = 1$), and Comum ($X_9 = 1$, $X_{10} = 0$). The other two variables determined three soil types: Arenito ($X_{11} = 0$, $X_{12} = 0$), Massape ($X_{11} = 0$, $X_{12} = 1$), and Terra Roxa ($X_{11} = 1$, $X_{12} = 0$).

was production in kg/ha. The period chosen was the crop year 1957-58, but production (X_1) was the average for both years.

The mathematical model devised was a composite one. The variables X_2, X_3, X_4, X_5 and X_6 were put in the Cobb-Douglas form; X_7 in an asymetric parabola ($\log X_1 = k + b_7 \log X_7 + b_8 (\log X_7)^2$); X_9 to X_{12} were a linear function of log X. The resultant function was:

$$\log X_1 = C + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + b_8 (\log X_7)^2 + b_9 X_9 + b_{10} X_{10} + b_{11} X_{11} + b_{12} X_{12} + u$$

The second sample was composed of 1505 farms within which 1921 coffee plantations were found. For these plantations, two variables were not obtained: capital in land, and labor. The others were the same as in the first sample. The model selected was:

$$\log X_1 = K + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 (\log X_5)^2 + b_7 X_7 + b_8 X_8 + b_9 X_9 + u$$

This time, X_2, X_3 and X_4 were the same as before; X_5 was the average age of the plantations; X_7 to X_9 were the variables for variety and soil type.

The analysis of the functions obtained showed that the coefficients of determination were not very meaningful - only 20 to 60 percent of the variation in output was explained. The explanation given was that producers cannot exert influence over more than one-half of the factors influencing production volume. The regression coefficients for labor had a very low statistical significance even though this factor is known as the most important in coffee production. The effect of fertilization proved to be important; marginal productivity was much higher than marginal costs -

Cr$100 invested in chemical fertilizer would yield Cr$650 in production; Cr$100 invested organic fertilizer would give Cr$200 in production. The effect of coffee plantation density (X_4) was found to be low - a 10 percent increase in number of trees would increase production by 8.5 percent.

The other conclusions were quite logical - the new coffee varieties (Mundo Novo) and the best soil types (Terra Roxa) yielded higher return to the use of factors; plantation age as a reason for lower production was more important in the first periods of growth. One interesting observation was that the value of coffee plantations could not be used to measure either soil fertility or capital investment. It seems that after a long period of inflation land values no longer reflect qualitative differences.

b) Junqueira[8/] estimated a production function for tobacco. The crop year concerned was 1961. His objective was to determine the optimum resource allocation for tobacco in the "municipio" (county) of Uba, Minas Gerais. Three "distritos" (townships) were sampled.

The sample consisted of 56 farms. Total population was 759, including non-tobacco growers. A Cobb-Douglas model was employed. The variables were: raw twisted tobacco (Y), land (X_1), chemical fertilizer (X_4) and animal labor (X_6)[9/]; they were measured in "arrobas" (weight unit equal to 15 kilograms), hectares, kilograms (regardless of composition), and animal/days (10 hours), respectively.

8/ Junqueira, Antonio Augusto B., Analise Economica de Uma Funcao de Producao - Fumo em Uba, M.G., 1961, Unpublished Magister Scientiae Thesis, UREMG, Minas Gerais, Brazil, 1962.

9/ X_2 (plant population), X_3 (labor) and X_5 (organic fertilizer) were excluded; the first and second, due to their high correlation with X_1 (.91 and .89, respectively); the third, because it was found in a very small number of observations (13).

The production function obtained was:

$$\hat{Y} = 2.747\ X_1^{.594}\ X_4^{.337}\ X_6^{.069}$$

The regression coefficients for X_1, X_4 and X_6 were significant at the probability levels of .01, .01 and .50, respectively. The coefficient of determination (R^2) was .755. The elasticity of production was 1.000 indicating that constant returns to scale existed.

Optimum levels of land use were determined with respect to different levels of chemical fertilizer, and optimum levels of chemical fertilizer were determined with respect to different levels of land use; in both cases animal labor was considered fixed. Optimum level of use for animal labor was not calculated because of the low statistical significance of its regression coefficient.

Isoquants were also estimated to obtain the different combinations between land and chemical fertilizer to produce specified levels of tobacco.

Finally, the optimum conbinations were introduced on the isoquants to determine the expansion path.

c) For the crop year 1961-62, Tollini[10/] carried out a study in which a production function for milk in the "municipio" (county) of Leopoldina was estimated. His objectives were to estimate a production function, to determine the optimum level of resource use, and its implications.

The population was composed of farms producing between 10,000 and 100,000 liters per year. The stratification was made in six classes of

---

10/ Tollini, Helio, Produtividade Marginal e Uso dos Recursos: Analise da Funcao de Producao de Leite em Leopoldina, M.G., Ano Agricola 1961-62, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, Minas Gerais, Brazil, 1964.

15,000 liters each. The sample consisted of 64 farms.

A Cobb-Douglas production function was used and included the following variables: gross income (Y), capital invested in dairy cattle (X_1), labor (X_2), capital invested in land (X_3), expenditures in feed during the dry season (X_4), capital in constructions (X_5), capital in equipment (X_6), expenditures in medicines and veterinary assistance (X_7).

Only the regression coefficients for X_1 (at .01) and for X_5 (at .05) were statistically significant. The coefficient of determination was .79. Here is the final function:

$$\hat{Y} = 5.280\, X_1^{.708}\, X_2^{-.039}\, X_3^{.057}\, X_4^{.046}\, X_5^{.131}\, X_6^{.036}\, X_7^{-.033}$$

Elasticity of production was .906.

Labor and general expenditures were in the third stage of production whereas the others were in the second. The optimum combination of resources was not calculated since two important variables (land and general expenditures) had negative regression coefficients.

In his conclusions, Tollini points out the problems of the measurement of the land input in value terms. With regard to its price, he recommends the use of rent as a measurement unit. The reason for such advice rests in the inflation problem which distorts to a large extent the results obtained through value computations. Another comment is made on the problem of high correlation between inputs. He suggests that one way of solving it might be the intentional sampling of firms on different points of the scale line.

d) Another study of a particular case of resource productivity was carried out by Jose J. da Silva.[11/] He analyzed beef cattle production

---

11/ Silva, Jose Josi da, Analise da Produtividade Marginal dos Recursos Usados na Producao de Carne Bovina na de Montes Claros, M.G. no Ano Agricola, 1962-63, Unpublished Magister Scientiae Thesis UREMG, Vicosa, Minas Gerais, Brazil, 1964.

in an area of the State of Minas Gerais. His objectives were to estimate a production function for beef cattle, to estimate the optimum resource allocation, and to explore its implications. The period chosen was the crop year 1962-63. The region studied comprised nine "municipios" (counties) and is known as the Montes Claros Zone. It had about 5 percent of the cattle in the State.

The variables used were: gross income from beef cattle sales (Y) value of the weight of cattle purchased (X_1), expenditures on labor (X_2), land in pasture (X_3), expenditures on feed, as a supplement for pasture (X_4), capital in constructions (X_5), capital in equipment (X_6), expenditures on medicines, veterinary, and fuel (X_7). The sample consisted of 80 observations from a population of 273.

Three trials were made to fit the variables to a Cobb-Douglas model. In all three, the only variable showing significance was X_1 (at .01 level). R^2 was .97 in each case. Two additional attempts were made using only 40 farms. The idea was to reduce observations to a number keeping a proportional relationship among inputs. The same results were obtained. Then, a quadratic and a linear model were tried with little success. The quadratic function showed six significant regression coefficients, out of 14; the optimization procedure presented factors with negative signs.

As a result, the first Cobb-Douglas model with seven independent variables was finally used. Elasticity of production was .99. The inputs X_1 to X_6 had positive marginal products and were smaller than their average products (stage II); input X_7 had a negative marginal product (stage III). Higher investments were indicated mainly in X_1 (value of the weight of cattle purchased), X_4 (feed supplementing pasture),

X_5 (constructions) and X_6 (equipment). The optimum conbination was not calculated due to the existence of negative regression coefficients.

e) Teixeira Filho[12/] carried out what may be the first study involving a multiple-enterprise, aggregate production function in Brazil. He analyzed the problem of resource use and productivity for the agriculture of two "municipios" (counties) in the State of Minas Gerais: Ituiutaba and Caratinga. His objectives were to estimate a production function for each of these areas, to determine the optimum resource combination, and to analyze their implications. The period chosen was the crop year 1961-62. The output variable was value of total farm production (Y); the input variables were: land in crops (X_1), land in pasture and forest (X_2), labor (X_3), capital investment in buildings and improvements (X_4), capital investment in equipment (X_5), capital investment in productive livestock (X_6), capital investment in draft livestock (X_7) and current operating expenditures (X_8). The variables Y, X_4, X_5, X_6, X_7 and X_8 were given in Cr$ (cruzeiros); variables X_1 and X_2, in hectares; variable X_3, in man/days. The sampling procedure and results obtained will be reviewed separately for each "municipio".

Ituiutaba - Only farms larger than 5 hectares were sampled. The population (1575 farms) was divided into classes of 200 hectares and 19 farms were drawn from each stratum (from the last one only five farms were taken). The final sample consisted of 100 farms. A Cobb-Douglas model was used.

12/ Teixeira Filho, Antonio Raphael, Analise da Produtividade Marginal dos Recursos Agricolas em Dois Municipios do Estado de Minas Gerais - Ituiutaba e Caratinga - no Ano Agricola 1961-62, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, Minas Gerais, Brazil, 1964.

Four arrangements of the variables were tested. Model I used the eight original input variables. Its coefficient of determination was .81 and all the regression coefficients were positive; three were significant at the .01 probability level (cropland, labor and current expenditures), and one at the .05 level (pastureland). In Model II, without X_5 (equipment), R^2 remained .81 and there were no significative changes in the other coefficients. Model III, without X_7 (draft livestock), presented the same characteristics as the first and second. In Model IV, both equipment and draft livestock were withdrawn; but, even so, there were no modifications in the original trends.

Model I was chosen as the best. It is as follows:

$$\hat{Y} = 1.830\ X_1^{.239}\ X_2^{.171}\ X_3^{.400}\ X_4^{.056}\ X_5^{.006}\ X_6^{.042}\ X_7^{.000}\ X_8^{.187}$$

The highest partial correlations observed were .67 ($r_{1.3}$), and .66 ($r_{3.8}$).

All resources were being used in stage II. Farmers were using excess pastureland, equipment, and productive and traction livestock; on the other hand, there was shortage of labor, constructions and operating expenditures; land in crops was close to the optimum.

According to the profit equation, farms in Ituiutaba had no profit; even at optimum conditions the profit would have been negative (-Cr$317,052). Without considering land and buildings, the returns would have been positive even with the present resource use pattern (Cr$965,067).

Returns to scale were close to constant (1.101). Marginal rates of substitution were calculated to show the possibilities of different resource combinations.

Caratinga - Only farms larger than 5 hectares were sampled. The population (3949 farms) was divided into size intervals of 25 hectares and 10 farms were drawn from each stratum. The final sample consisted of 99 farms. A Cobb-Douglas model was used. Two arrangements were made: in the first all eight input variables were used. The coefficient of determination (R^2) was .90 and the regression coefficients of four variables (labor, equipment, productive livestock and current expenditures) were significant at .01 level; for X_7 (draft livestock) this coefficient was negative.

In the second model, 7 farms were withdrawn from the sample under the assumption that they belonged to a different population. R^2 was .90 again, but three regression coefficients were negative (pastureland, equipment and draft livestock); four were significant at least at .05 probability level: labor, buildings, productive livestock and current expenditures. The second model was selected. It is as follows:

$$\hat{Y} = .890\, X_1^{.049}\, X_2^{-.071}\, X_3^{.371}\, X_4^{.126}\, X_5^{-.086}\, X_6^{.190}\, X_7^{-.014}\, X_8^{.582}$$

The correlation matrix presented som high intercorrelations: .82 ($r_{3.8}$, $r_{4.8}$, and $r_{3.4}$), and .76 ($r_{5.6}$).

Only five inputs were being used in stage II; pastureland, equipment and draft livestock, were in stage III. Inputs X_4 (buildings) and X_8 (operating expenditures) were used in smaller quantities than they should have been. Optimization procedures were not used since there were resources in stage III. The profit equation yielded negative results at the current level of resource allocation (-Cr$1,129,880); without considering land and construction costs, profits would have been positive (Cr$89,510).

Elasticity of production was 1.145. Marginal rates of substitution were also calculated.

f) More recently, a new study on resource productivity was completed. It deals with aggregate production functions for the State of Sao Paulo.13/ The total number of farms in the State was divided into seven strata, the boundaries of which were 3-10-30-100-300-1000-3000-3000 + hectares. In addition, the State was divided into three sectors. For these ten units, production functions were calculated. The time period involved was the crop year 1958-59. The variables used were: total farm production (Y), intermediary consumption, corresponding to operating expenditures (X_1), labor (X_2), and total capital invested in constructions, equipment, productive and draft livestock (X_3). Other variables were tried but were withdrawn as R^2 did not change significantly.

Cobb-Douglas models were employed in all cases. The t-tests performed on the regression coefficients indicated most of them significant at .01 level. Labor proved to be the most important variable in explaining the variability in Y. Negative coefficients appeared twice with variable X_3 (capital), and once with variable X_1 (intermediary consumption). The correlation matrices showed relatively low correlations among the factors; the higher correlations appeared to be between X_1 (intermediary consumption) and X_2 (labor). Returns to scale were close to constant in all cases, but always larger than 1.0 with one exception (.997 for the first stratum). Marginal productivities were also determined.

13/ Schattan, Salomao, Funcoes Agregadas de Producao Agricola no Estado de Sao Paulo, para Tres Regioes e Sete Estratos de Area, Preliminary Draft, Secretaria da Agricultura, Sao Paulo, Brazil, 1965.

Attempts were made to determine a unique production function for the whole State of Sao Paulo. This possibility was studied through comparative statistical treatment of the analyses of variance for each area stratum. It was found that residual variances were statistically different from each other among the strata. This makes unreliable the grouping of the seven strata for purposes of determining a single production function.[9]

CHAPTER III

PRODUCTION FUNCTION MODELS AND HYPOTHESES

The attainment of the objectives of the present study was based on the statistical estimation of a mathematical production function for farms in the defined population. To determine the particular equations to be used, it was necessary to construct a conceptual model. As a second step, two forms of mathematical functions were submitted to statistical treatment. The following sections develop these procedures.

The Conceptual Model

The conceptual model employed consisted of a functional relationship between a dependent variable (Y) and a set of independent variables (X_1, X_2, X_3, ... X_n). It was of the following form:

$$Y = f(X_1, X_2, X_3 \ldots X_n)$$

where: Y = estimated value of gross farm output

$X_1, X_2, X_3 \ldots X_n$ = resource categories as inputs in the production process

Objectively, this relationship is expressed through equations generally called mathematical models.

The Mathematical Models

Two mathematical models were employed in this study. One was a linear equation of the general form:

$$Y = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n$$

where: Y = dependent variable

a = constant

$X_1, X_2, X_3 \ldots X_n$ = independent variables

$b_1, b_2, b_3 \ldots b_n$ = partial regression coefficients

The main characteristics of a linear equation are:1/

(1) Total product increases at a constant rate.

(2) Marginal products remain constant at all output levels

(3) When $a = 0$, marginal product is equal to average product.

(4) Constant returns to scale if Y-intercept is equal to zero.

The second mathematical model employed was one linear in the logarithms. This form is generally known as the Cobb-Douglas function. It is of the following general form:

$$Y = a\, X_1^{b_1}\, X_2^{b_2}\, X_3^{b_3} \ldots X_n^{b_n}$$

where: Y = dependent variable

a = constant

$X_1, X_2, X_3 \ldots X_n$ = independent variables

$b_1, b_2, b_3 \ldots b_n$ = partial regression coefficients

For practical purposes, the Cobb-Douglas equation is most often used in logarithmic form:

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + \ldots + b_n \log X_n$$

The main characteristics of the Cobb-Douglas model are:2/

(1) Diminishing, increasing or constant marginal returns are possible but only one of these may exist for a given variable in a given production function.

1/ Kehrberg, Earl W., Agricultural Production Economics Notes 1963, Agricultural Economics 612, Mimeo, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana.

2/ Kehrberg, Earl W., op. cit. and Heady, Earl O., and Dillon, John L., Agricultural Production Functions, Iowa State University Press, Ames, Iowa.

(2) It does not permit the determination of maximum total products

(3) When any X is equal to zero, Y = 0.

(4) The partial regression coefficients (b_1, b_2, b_3 ... b_n) express the elasticity of production of the corresponding independent variable. The summation of all regression coefficients yields an estimate of the overall elasticity of production and, hence, of the nature of the returns to scale.

(5) It assumes the same elasticity of production at all levels of output and factor employment.

(6) On an isoquant map, the iso-clines are linear, divergent, and go through the origin.

(7) The marginal rate of substitution,

$$\frac{dX_1}{dX_2} = \frac{b_2X_1}{b_1X_2}$$

remains constant at the ratio b_2/b_1 even when the output level changes, if X_1 and X_2 are increased in constant proportions. This is a more realistic assumption for aggregate factors as employed by a firm, than for specific inputs.

(8) The iso-clines are also scale lines.

From the standpoint of economic analysis, the Cobb-Doublas model has several useful properties. The possibility of obtaining diminishing marginal returns, from the use of resources as admitted in the law of diminishing returns and the elasticity of production expressed directly by the regression coefficients are some of these favorable aspects. Even though it has certain disadvantages, it appears to be one of the better models so far devised for purposes of production function studies.

Population Definition

The population studied consisted of all farms in the "Municipio" (County) of Jaguariuna, Sao Paulo, Brazil, having from 5 to 250 productive hectares during the crop year 1963-64.

Definition of Variables

In this study ten variables were used in attempts to establish the desired relationship. These consisted of one dependent variable (Y), and nine independent variables (X_1, X_2, X_3 ... X_9). Definitions of these variables follows:

Y = Value of gross farm output - consists of the value of all final farm products produced during the 1963-64 crop year. This consisted of harvested crops and their livestock, products and by-products, sold or processed for sale or reserved for household consumption. Given in thousands cruzeiros (Cr$1,000).

X_1 = Land in permanent crops[3/] - number of hectares on which permanent crops were grown in the 1963-64 crop year.

X_2 = Land in annual crops - number of hectares on which annual crops were grown in the 1963-64 crop year.

X_3 = Land in pasture - number of hectares on which pasture was produced during the 1963-64 crop year.

X_4 = Labor - number of ten-hour man/days used in intermediate or final productions during the 1963-64 crop year. Included here were four categories of labor-owner's or

3/ The three land categories (X_1, X_2 and X_3) included all land under single management (in the case of owned or rented land) or under single supervision (in the case of sharecropping). In one of the models computed, these variables were measured in value terms (Cr$1,000).

manager's family labor, permanent hired labor, occasional hired labor and sharecroppers' labor.

X_5 = Capital investment in buildings and improvements - replacement value of the total capital invested in any kind of construction or improvement playing a role in intermediate or final production. These were adjusted for actual percentage-use in farming during the 1963-64 crop year. Given in thousands of cruzeiros (Cr$1,000).

X_6 = Capital investment in equipment - current market value of machinery, vehicles, tools or other equipment playing a role in intermediate or final production. These investments were adjusted for percentage-use in farming during the crop year 1963-64. Given in thousands of cruzeiros (Cr$1,000).

X_7 = Capital investment in productive livestock - current market value of the average inventory of productive livestock during the 1963-64 crop year. Average inventory is the simple average of the market value of total productive livestock at the beginning and at the end of the crop year. Given in thousands of cruzeiros (Cr$1,000).

X_8 = Capital investment in draft livestock - current market value of the average inventory of draft livestock during the 1963-64 crop year. These investments were adjusted for percentage-use in farming. Given in thousands of cruzeiros (Cr$1,000).

X_9 = Current operating expenditures - value of the total expenditures for variable inputs pertaining to the flow account of the farm during the 1963-64 crop year. This category included cash expenditures for seeds, plants, fertilizers, pesticides, medicines, veterinary assistance, feeds, fuel and lubricants, machinery rental, minor repairs, and other small items. Given in thousands of cruzeiros (Cr$1,000).

When different aggregation of inputs were used in one or more of the several models fitted statistically to the data, each contained the same elements in different combination.[4/]

Many of the concepts associated with variables of interest in this study are stock rather than flow concepts. Actually, marginal productivity cannot be determined from a stock of capital as the theory underlying this study is conceptually taken. However, a stock may be compared to depreciation if we multiply it by a number representing the average weighted years of life left to the stock. In this sense, no difference will show up as far as the regression equation is concerned. Therefore, stock concepts were used mainly to make the economic interpretation of the statistical findings easier.

Hypotheses

The following general hypotheses constitute the basis of the analysis

---

4/ In Equation V (Chapter V) one additional variable was used. It was X_{10} - capital investment in permanent crops excluding capital invested in land; current market value of permanent plantations during the crop year 1963/64. Given in thousands of cruzeiros (Cr$1,000).

presented in Chapter VI. They are to be taken in light of statements made and information presented in preceding chapters.

The hypotheses are presented in three broad groups:

1) the general pattern of resource use on farms in the study area

2) productivity categories of the several resource categories on farms in the study area

3) relationship between resource productivity in the study area and in other geographic areas.

With respect to the general pattern of resource allocation and utilization of farms in the defined population, it was hypothesized that:

1) agricultural resources utilized on the farms of the defined population were not being used in the most efficient combination.

2) all resource categories were being used within the rational stage of production, i.e., farms were producing in Stage II of production.

The second group of hypotheses dealt with the productivity of individual resource categories. Here, it was hypothesized that the marginal productivity of capital assets would be relatively low as compared to marginal productivities of labor and current expenditures.

A number of factors underly this hypothesis. In the unstable Brazilian economy, inflation is thought to play a major role in resource choice and use. Inflation tends to favor either short-term, highly-profitable investments or the accumulation of long-term assets that will retain their value. In agriculture, the consequences of this phenomenon tend to be quite noticeable as a result of the relatively long time-span of the production process and the low rate of capital turnover. As a result, durable capital assets tend to be preferred by farm investors and greater investment in these items than that actually needed to carry out production is likely to occur. In addition, the two-to three-fold increase in the prices of variable inputs during the 1963/64 crop year together with the unusually dry period observed, led to idleness of a substantial amount of fixed resources and equipment.

With respect to livestock investment, the situation was expected to be somewhat different. Livestock represents a store of value in direct relation to their production capacity either in the form of milk, eggs, meat or labor. Therefore, the productivity of these assets was expected to be higher than that of other capital forms.

Good quality labor in rural areas near urban-industrial centers tends to be scarce. The effort required to hire and retain good quality labor was expected to lead to higher managerial performance in terms of a more skillful allocation of labor. At the same time, improved productive methods tend to put more efficient inputs in the hands of workers. These were the reasons for expecting labor productivity to be relatively high.

Investment in some type of current inputs tends to be highly productive when new, high-payoff technologies are available. The study area is undergoing a transition from traditional to more modern production technology. Hence, relatively high productivity estimates for this resource category were expected.

One of the interests of this study was that of gaining insight into productivity differentials and resource adjustment needs in agricultural areas at different distances from urban-industrial centers. When compared to regions farther from large, urban industrial complexes, multiple-enterprise farm areas tend to show a consistent trend toward a more dynamic production pattern. As a result of the "technological push" and problems related to the factor market already described, there was reason to believe that Jaguariuna farms would tend to be farther from optimum resource allocation than farms located at more distant points.

CHAPTER IV

RESEARCH METHODS AND PROCEDURES

Population Selection

The population of concern in this study consisted of all farms in the "Municipio" (County) of Jaguariuna, Sao Paulo, Brazil, having between 5 and 250 productive hectares during the 1963-64 crop year. This area was chosen following a careful preliminary study of the entire State of Sao Paulo. In the preliminary study, the State was divided into 33 sectors. Six descriptive indices were obtained for each sector.1/ These indices were utilized with an appropriate choice criterion in the selection of the study area. The choice criterion was based on the following set of factors:

a) proximity to areas of high urban population density and industrial concentration;

b) general topographic and climatic conditions similar to those of areas in which other resource productivity studies had been conducted;2/

c) dependence on agriculture as an occupation and income source;

d) level of agricultural technology.

1/ Data on the findings of this preliminary study are given in Appendix A.

2/ These are the studies conducted in the counties of Ituiutaba and Caratinga, Minas Gerais, Brazil, by Teixeira Filho, op. cit. As these two counties differ widely in many respects, it was thought that the area to be chosen for the present study should keep more resemblance to Ituiutaba since this county is under the influence of the Sao Paulo urban-industrial center.

The first factor was used to narrow the choice of study area to a relatively small geographic region. The last three factors were investigated in depth and utilized as choice criteria in the final selection of the "municipio" to be studied.

Table 7 contains data on seven geographic areas near the most densely populated urban area of the State of Sao Paulo.

Table 7. Rural Population, Land in Crops and Average Size of Farm. Seven Geographic Areas, State of Sao Paulo, Brazil, 1963.

Areas	Rural Population	Land in Crops	Average farm size*
	(percent of total)	(percent of total)	(ha)
Sao Paulo	17	17	128
Medio Paraiba	34	7	144
Santos	6	27	183
Ribeira	74	18	80
Paranapiacaba	79	18	69
Braganca	57	29	68
Mantiqueira	55	14	92

* Average of farms larger than 10 hectares

Source: Conselho Nacional de Estatistica (IBGE), Anuario Estatistico do Brasil.

From this and other information, it was apparent that the area of Braganca was appropriate to the objectives of this study. Most of its population (57 percent) depends on the agricultural sector. Agriculture shows a certain degree of intensity in that 29 percent of all land is used in crops and farm size is smaller than in other regions. Furthermore, Santos and Ribeira are on the Atlantic coast. Medio Paraiba, Paranapiacaba and Sao Paulo are immediately inland. All of them present topographic and climatic conditions different from those observed in the interior areas of comparative interest. Mantiqueira is a rather mountainous region that was not appropriate for the comparative purposes of this study.

With regard to the level of agricultural technology, it was assumed that the Braganca zone is in an average level as compared to the others. This was a subjective criterion based on the knowledge the author has of all seven areas.

Jaguariuna is located in the Braganca zone. Descriptive data comparing Jaguariuna with a neighboring county, Americana, are given in Table 8. Following the example of many counties in the same geographic area, Americana has developed its industrial sector and farming has become of secondary importance.

Table 8. Descriptive Statistics, Municipios of Jaguariuna and Americana, Sao Paulo, Brazil, 1960.

	Jaguariuna	Americana
Area (sq. miles)	57	49
Population	8,545	37,856
Urban population		
Number	2,553	32,000
Percent of total	30	84
Rural population		
Number	5,992	5,856
Percent of total	70	16
Inhabitants/sq. mile	150	773
Residences		
Number	1,578	7,443
Inhabitants/residence	5.4	5.1
Rural properties		
Number	316	118
Average size (ha)	47	80
Percent land in crops	39	37
Main crops	Citrus	Sugar cane
	Corn	Cotton
	Rice	Citrus
	Cassava	Coffee
	Sugar cane	Rice
	Coffee	Cassava
	Soybeans	Corn

Source: Conselho Nacional de Estatistica (IBGE), Anuario Estatistico do Brasil.

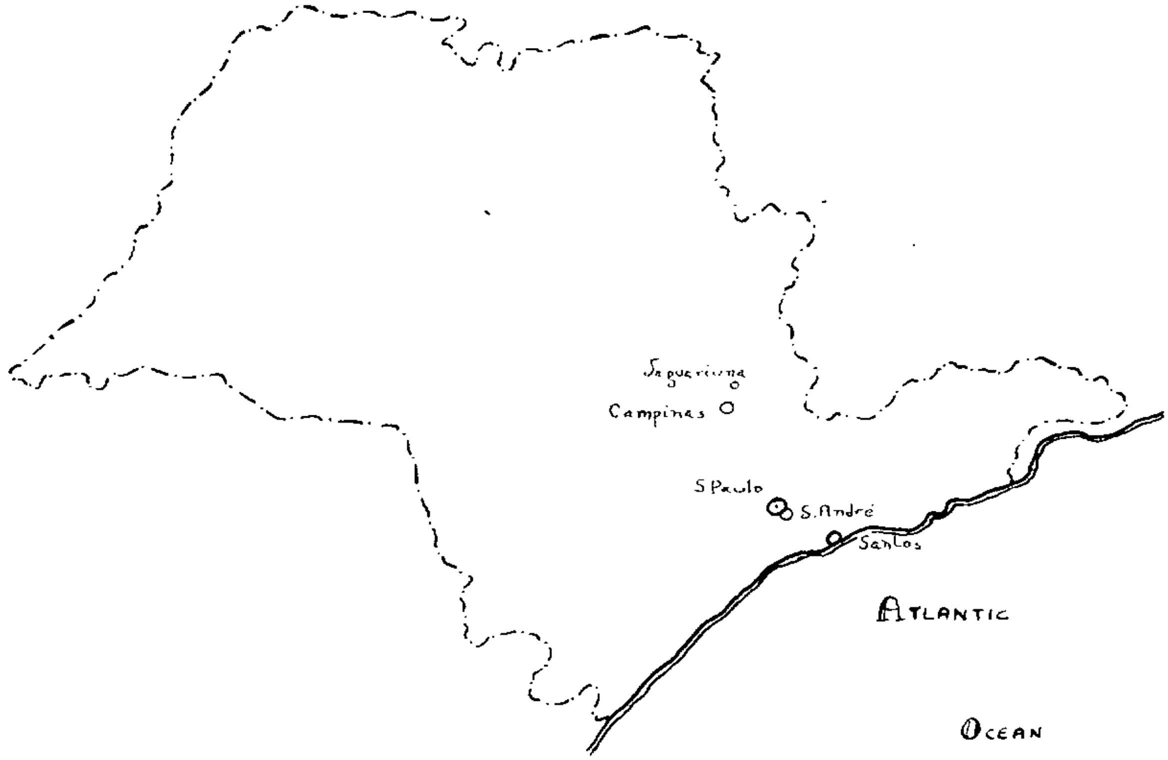

Figure 2. Location of Jaguariuna. State of Sao Paulo, Brazil

With regard to proximity to urban centers, Figure 2 shows Jaguariuna in relation to the four largest urban centers in the State of Sao Paulo. These are the cities of Sao Paulo (4,000,000 inhabitants), Santos (300,000), Campinas (200,000), and Santo Andre (150,000).

For these reasons, Jaguariuna was chosen as the most appropriate area for the purposes of this study.

The population of farms studied ranged from 5 to 250 productive hectares in size. The reason for imposing a lower limit was that most of the land included in properties smaller than 5 hectares was being used for purposes other than farming. It includes dozens of small idle lots and many week-end resorts. The upper limit was taken as 250 hectares because the number of farms above this level was small (11) and scattered over an extended size-range (from 250 to almost 2000 hectares).

Sampling Procedure

The population consisted of 272 farms. The distribution was sharply skewed toward the smaller size strata. To deal with this problem, the population was divided into two groups for sampling purposes. The first group included all farms from 5 to 45 hectares. There were 225 farms in this group. The second group included all farms from 45 to 250 hectares. There were 47 farms in this group.

The total sample consisted of 80 farms. Thirty-three were taken from the first group and 47 (the entire number) from the second group. Table 9 presents data for the total population and the number of farms sampled. The first group (5 to 45 hectares) was divided into four strata in order to show the population and sample distributions throughout the group.

Table 9. Number of Farms (N) and Farms Included in Sample (n) by Size of Farm Strata. Jaguariuna, Sao Paulo, Brazil, 1963.

Strata	Number of farms	Farms Included in Sample	
(ha)	(N)	(n)	(percent)
5 - 15	101	11	10.9
15 - 25	61	7	11.5
25 - 35	36	7	19.4
35 - 45	27	8	29.6
45 - 250	47	41[a]	87.2
Total	272	74	27.2

a/ Six observations had to be excluded for diverse reasons (See Appendix B).

The area of farms included in the sample is presented in Table 10.

Table 10. Total Area in Farms and Area Included in Sample by Size of Farm Strata Jaguariuna, Sao Paulo, Brazil, 1963

Strata	Total area	Sample area	
(ha)	(ha)	(ha)	(percent)
5 - 15	1029	103	10.0
15 - 25	1207	140	11.6
25 - 35	1051	208	19.8
35 - 45	1077	331	30.7
45 - 250	4667	4035	86.5
Total	9031	4817	53.3

Some of the sample farms were eliminated. Reasons for elimination included: a) non-reliable and incomplete information, b) problems in locating farms and c) atypical farms characterized by a high degree of specialization.[3]

With regard to location of farms included in the sample, Figure 3, should be consulted.

Questionnaire Construction and Data Collection[4]

The statistical and economic analyses were based on primary farm data. Data were collected through personal interview of farm operators. An appropriate questionnaire was designed. The questionnaire was based on others used in similar production function studies carried out at the Rural University of Minas Gerais. The questionnaire was field-tested on

3/ A complete list of all farms in the sample and reasons for elimination of some units are given in Appendix B.

4/ See Appendix C for a resume of the questionnaire used in this study. Observations on the questionnaire and suggestions for improvement are included.

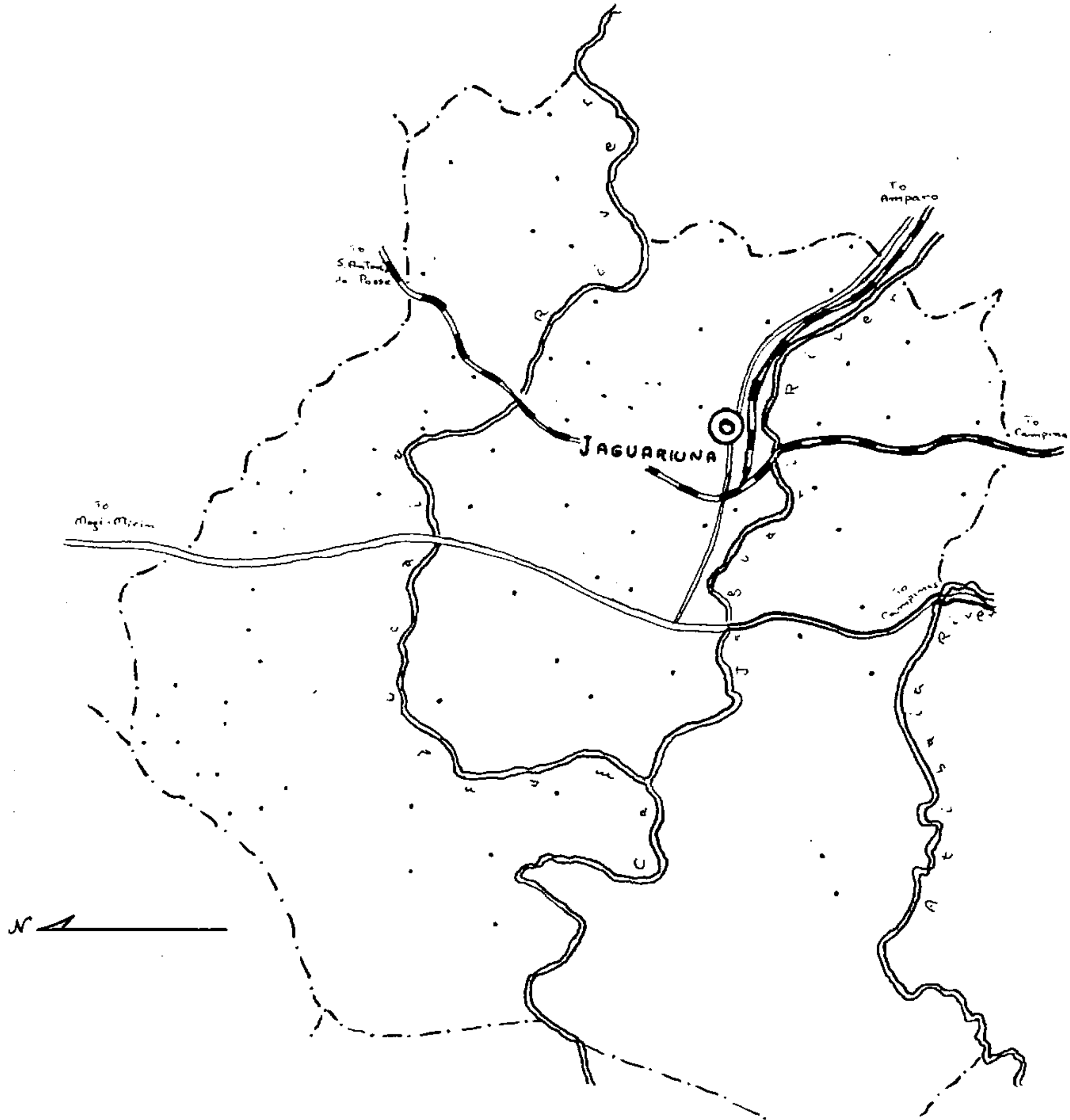

Figure 3. Location of farms included in the sample.
Jaguariuna, State of Sao Paulo, Brazil

three non-sample farms in Jaguariuna. Several revisions and changes were made previous to its use on sample farms.

The questionnaire was designed to obtain systematically all data essential to the attainment of the objectives of the research. These data included:

> <u>Gross Farm Output</u> - quantities and values of all crop and livestock produced on the farm unit.
>
> <u>Land input by enterprise</u> - this included area, physical production, lease arrangements (sharecropping, rental, etc.).
>
> <u>Labor</u> - hours of productive work by the land-owner or manager and his family, workers hired on a monthly or daily basis and sharecroppers.
>
> <u>Capital investment in buildings and improvements</u> - replacement value of all buildings and improvements, type of construction, estimated years of life remaining, depreciation, expenditures on repairs and proportion of use in farming.
>
> <u>Capital investment in equipment</u> - current market value of all vehicles, implements, motors, machinery, tools, and minor items, estimated years of life remaining, depreciation, expenditures on repairs and proportion of use in farming.
>
> <u>Capital investment in productive and draft livestock</u> - physical and value inventory at the beginning and at the end of the year, purchases, sales, births and deaths.

Current operating expenditures - quantity and prices paid for all seeds, plants, fertilizers, pesticides, feeds, veterinary, medicines, fuel, machinery rental and other minor items.

Interviews were conducted by the author and one trained enumerator. Field work was conducted and completed during the months of October, November and December, 1964. Since the crop year begins about August 31st and ends about September 1st, farmers were well aware of the results obtained during the crop year 1963/64. Memory bias is believed to have been minimized through this choice of the interview period.

Managers in charge of the farms were interviewed personally. Questionnaries were checked for completeness and accuracy. Call-backs were made as necessary. All sets of information were supplemented by additional comments and notes.

Upon completion of the field work, each questionnaire was reviewed. Re-interviews were conducted as necessary. The final tabulations as well as statistical analyses were conducted at Purdue University. The regression equations were computed through use of Program 6.0.143 and the IBM 1620 Computer in the Computer Laboratory, Department of Agricultural Economics, Purdue University.

Statistical Methods[5]

The statistical analysis consisted of fitting appropriate mathematical functions to the sample data. Each farm in the final sample was

---

5/ Steel, Robert G.D., and Torrie, James H., Principles and Procedures of Statistics, McGraw-Hill Book Company, Inc., New York, 1960.

taken as a single observation. The least squares regression technique was employed. Significance levels of the regression coefficients were accessed through the use of the t-test. The coefficient of determination (R^2) was tested through the application of analysis of variance (F-test).

Economic analyses performed were based on accepted economic optimization criteria and conditions.[6/]

6/ Kehrberg, Earl W., op. cit.

CHAPTER V

STATISTICAL AND MARGINAL ANALYSES

Statistical Analysis

The attainment of the objectives of this research necessitated the estatistical estimation of an empirical production function that could be accepted as the best estimate of the true production relationship existing between output and inputs on the farm units constituting the defined population. In order to select the most appropriate empirical production function, two mathematical models were fitted to the sample data. These were a Cobb-Douglas and a linear model.

The Cobb-Douglas Model

In the Cobb-Douglas model, six equations using the 74 observations obtained were computed. These equations were:[1/]

Equation I:

$$\log Y = a + b_{1+2+3}\log X_{1+2+3} + b_4\log X_4 + b_5\log X_5 + b_6\log X_6 + b_7\log X_7 + b_8\log X_8 + b_9\log X_9$$

where,

Y = value of gross farm output

X_{1+2+3} = productive land

X_4 = labor

X_5 = capital: buildings and improvements

1/ See Chapter III, pages 38 to 40 for complete definitions of variables.

X_6 = capital: equipment

X_7 = capital: productive livestock

X_8 = capital: draft livestock

X_9 = current operating expenditures

<u>Equation II</u>:

$$\log Y = a + b_{1+2+3}\log X_{1+2+3} + b_4\log X_4 + b_5\log X_5 + b_{6+8}\log X_{6+8} + b_7\log X_7 + b_9\log X_9$$

where,

Y, X_{1+2+3}, X_4, X_5, X_7 and X_9 are the same as in Equation I

X_{6+8} = capital: equipment and draft livestock.

<u>Equation III</u>:

$$\log Y = a + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + b_5\log X_5 + b_6\log X_6 + b_7\log X_7 + b_8\log X_8 + b_9\log X_9$$

where,

Y, X_4, X_5, X_6, X_7, X_8 and X_9 are the same as in Equation I

X_1 = land in permanent crops

X_2 = land in annual crops

X_3 = land in pasture

Equation IV:

$$\log Y = a + b_1\log X_1 + b_2\log X_2 + b_3\log X_3 + b_4\log X_4 + b_5\log X_5 + b_6\log X_6 + b_7\log X_7 + b_8\log X_8 + b_9\log X_9 + b_{10}\log X_{10}$$

where,

Y, X_4, X_5, X_6, X_7, X_8 and X_9 are the same as in Equation I

X_1, X_2 and X_3 are the same as in equation III

X_{10} = capital: permanent crops.

Equation V:

$$\log Y = a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + b_8 \log X_8 + b_9 \log X_9$$

where,

Y, X_4, X_5, X_6, X_7, X_8 and X_9 are the same as in Equation I

X_1 = capital: land in permanent crops + value of permanent crops

X_2 = capital: land in annual crops

X_3 = capital: land in pasture

Equation VI:

$$\log Y = a + b_{1+2} \log X_{1+2} + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + b_8 \log X_8 + b_9 \log X_9$$

where,

Y, X_4, X_5, X_6, X_7, X_8 and X_9 are the same as in Equation I

X_3 is the same as in equation III

X_{1+2} = land in all crops

Results obtained for the constants, partial regression coefficients, elasticities of production and coefficients of determination for each of these equations are given in Table 11.

Equations presented in Table 11 are numbered in order of computation for the Cobb-Douglas model. Equation I was used as a starting point for analysis. It had only three regression coefficients larger than their standard errors. These were labor, productive livestock and current expenditures. The land variable had a negative regression coefficient. Equation II - aggregating capital in equipment with capital in draft livestock - did not add to the significance levels previously observed.

Table 11. Constant, Partial Regression Coefficients, Elasticity of Production and Coefficient of Determination, Equations I, II, III, IV, V and VI.

	Equation I	Equation II	Equation III	Equation IV	Equation V a/	Equation VI
a	9.402	11.430	8.503	8.825	10.100	9.497
X_1			.024	.045	.006	
X_2			.022	.018	-.020	
X_3			-.122	-.129	.008	-.136*
X_4	.375**	.376**	.302+	.302+	.365	.245+
X_5	.060	.055	.083+	.087+	.048	.085+
X_6	.014		.047	.050	.011	.044
X_7	.079*	.082*	.112*	.113*	.075*	.121*
X_8	.083		.148+	.153+	.082	.143+
X_9	.302**	.292**	.257**	.258**	.315**	.237**
X_{10}				-.019		
X_{1+2}						.163+
X_{1+2+3}	-.027	-.000				
X_{6+8}		.043				
Σb_i	.886	.848	.873	.878	.890	.902
R^2	.76	.76	.77	.77	.76	.78

X_1 = permanent cropland
X_2 = annual cropland
X_3 = pastureland
X_4 = labor
X_5 = capital: buildings
X_6 = capital: equipment
X_7 = capital: productive livestock
X_8 = capital: draft livestock
X_9 = current operating expenditures
X_{10} = capital: permanent crops

a/ In equation V, X_1 = capital: land in permanent crops + value of permanent crops; X_2 = capital: land in annual crops; X_3 = capital: land in pasture.

** = significant at .01 level
* = significant at .05 level
\+ = coefficient larger than its standard error but t-value found less than t at .05 level.

Degrees of freedom:
Equation I = 66
Equation II = 67
Equation III = 64
Equation IV = 63
Equation V = 64
Equation VI = 65

Further aggregation was not made since the models obtained would provide less and less information on the variables relevant to the production process. Therefore, in the other equations, the number of variables was increased through disaggregation.

In Equation III the land variable was divided into three components. These were land in permanent crops, land in annual crops and pastureland. This "model" appeared to offer a better explanation of the phenomenon. The negative forces associated with the sign of the regression coefficient for the land variable in Equation I were concentrated in the pastureland variable. Use of this model, resulted in the regression coefficients of six variables (pastureland, labor, buildings and improvements, productive livestock, draft livestock and current expenditures) being larger than their standard errors.

In Equation IV, a new variable, capital invested in permanent crops, was introduced. Its coefficient was negative. The other regression coefficients were almost the same as those observed in Equation III.

Equation V had the same number of variables as Equation III, but in this model the land variable was measured in monetary units (cruzeiros). Value of permanent crops was added to the value of permanent cropland. The significance of the regression coefficients was not satisfactory compared to those obtained for Equation I and II.

The last equation - Equation VI - yielded better results in so far as the significance of the regression coefficients is concerned. In this equation, permanent cropland and annual cropland were aggregated. The regression coefficient for this variable was larger than its standard error. The other regression coefficients improved only slightly in comparison to other equations.

The correlation matrix obtained for Equation IV is given in Table 13. It includes all partial correlations for Equation III and part of the partial correlations of the other equations. Table 13 records the partial correlation coefficients of Equations I, II, V and VI not included in Table 12.

The Linear Model

For purposes of comparison, two linear regression equations were fitted to the data prior to the selection of the final model. These equations were:

Equation VII:

$$Y = a + b_{1+2+3}X_{1+2+3} + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9$$

where, the variables are the same as for Equation I.

Equation VIII:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9$$

where, the variables are the same as for Equation III.

Results obtained for the constant, partial regression coefficients and coefficient of determination of these equations are presented in Table 14.[2/]

2/ Correlation matrices are presented in Appendix D.

Table 12. Partial Correlation Coefficients: Equation IV [a/]

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	Y
X_1	1.000	.116	.121	.648	.359	.482	.115	.275	.808	.309	.432
X_2		1.000	.129	.512	.256	.373	.272	.376	.073	.568	.529
X_3			1.000	.366	.403	.369	.616	.588	-.017	.047	.230
X_4				1.000	.650	.730	.423	.502	.562	.631	.757
X_5					1.000	.627	.405	.354	.395	.530	.620
X_6						1.000	.319	.326	.471	.675	.680
X_7							1.000	.443	.065	.257	.465
X_8								1.000	.200	.230	.415
X_9									1.000	.353	.783
X_{10}										1.000	.418
Y											1.000

X_1 = permanent cropland
X_2 = annual cropland
X_3 = pastureland
X_4 = labor
X_5 = capital: buildings
X_6 = capital: equipment
X_7 = capital: productive livestock
X_8 = capital: draft livestock
X_9 = current operating expenditures
X_{10} = capital: permanent crops
Y = gross farm output

a/ Correlation matrix for Equation I excludes variables X_1, X_2, X_3 and X_{10}, and adds X_{1+2+3} (Table 13)
Correlation matrix for Equation II excludes variables X_1, X_2, X_3, X_6, X_8 and X_{10}, and adds X_{1+2+3} and X_{6+8} (Table 13)
Correlation matrix for Equation III excludes variable X_{10}.
Correlation matrix for Equation V excludes X_1, X_2, X_3 and X_{10}, and adds X_1, X_2 and X_3 (Table 13).
Correlation matrix for Equation VI excludes X_1, X_2, X_3 and X_{10}, and adds X_{1+2} (Table 13).

Table 13. Partial Correlation Coefficients of Equation I, II, V and VI not included in Table 12.

	X_{1+2+3}	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y
Equations I and II: X_{1+2+3}					.691	.566	.582	.584	.666	.440	.591
Equation II: X_{6+8}	.683				.758	.623		.390		.643	.699
Equation V:[a/] X_1			-.020	-.016	.548	.383	.456	.088	.219	.314	.392
X_2				.012	.388	.184	.343	.207	.349	.445	.371
X_3					.338	.385	.287	.423	.502	.631	.288
Equation VI: X_{1+2}				.248	.698	.463	.588	.235	.382	.582	.655

X_{1+2+3} = productive land ($X_1 + X_2 + X_3$)

X_{6+8} = capital: equipment and draft livestock ($X_6 + X_8$)

X_{1+2} = land in all crops ($X_1 + X_2$)

X_1 to X_9 and Y are the same as in Table 12

a/ In Equation V, X_1 = capital: land in permanent crops + value of permanent crops
X_2 = capital: land in annual crops
X_3 = capital: land in pasture

Table 14. Constant, Partial Regression Coefficients and Coefficient of Determination, Equations VII and VIII

	Equation VII	Equation VIII
a	-378.444	-196.025
X_1		60.483**
X_2		-28.591$^+$
X_3		-5.569
X_4	1.119**	.392
X_5	-.053	-.029
X_6	.258**	.248**
X_7	-.059	-.085*
X_8	2.898	3.772*
X_9	2.044**	2.204**
X_{1+2+3}	.864	
R^2	.82	.85

X_1 = permanent cropland
X_2 = annual cropland
X_3 = pastureland
X_4 = labor
X_5 = capital: buildings
X_6 = capital: equipment
X_7 = capital: productive livestock
X_8 = capital: draft livestock
X_9 = current operating expenditures

** = significant at .01 level
* = significant at .05 level
\+ = coefficient larger than its standard error but t-value found less than t at .05 level.

Degrees of freedom: Equation VII = 66
Equation VIII = 64

From these results it can be said that a linear relationship between product and some factors is very likely. But the lack of diminishing returns in the linear equation can lead to meaningful economic estimates only to a very limited extent. This was one of the reasons for the final selection of an equation of the Cobb-Douglas model.

The selection of the final model was based on the following criteria:

1) consistency with the theoretical nature of the production relationships essential to the attainment of the objectives of this study.

2) statistical reliability

The first criterion necessitated the use of a model consistant with general economic principles. In this case the theoretical concept of diminishing returns argued for the use of a model such as the Cobb-Douglas instead of a linear equation. Another point, within the same criterion, was the desirability of choosing a number of independent variables comprising the whole range of resources under the managerial control of farm operators. At the same time, it was considered desirable to have these variables sufficiently disaggregated to permit investigation of fairly specific economic phenomena.

This set of reasons directed the statistical criterion toward equations III, IV, V and VI. As a result of the low significance level of its regression coefficients, Equation V was abandoned. The other three equations (III, IV and VI) were given more careful consideration. The coefficients of determination for equations III and IV were the same (.77), and the t-tests of the regression coefficients presented similar results. But the new variable introduced in Equation IV - capital in permanent crops - had a very high correlation with the land in permanent crops variable ($r_{1.10}$ = .81). This high association between factors did not permit the establishment of a meaningful division of the services provided by each. Thus, the influence of the variable capital in permanent crops could be accounted for in the interpretation of the variable land in permanent crops. Hence, there was no reason for using Equation IV.

Finally, the comparison between equations III and VI was favorable to the latter. In this equation, the aggregation of the land in permanent crops variable with land in annual crops yielded a more significant regression coefficient. At the same time, the levels of significance of the regression coefficients for the variables pastureland and productive livestock were also improved. The coefficient of determination (.78) was higher than in other equations. The partial correlations for the new variable (X_{1+2}) were not much higher than those for X_1 and X_2 in Equation IV (see Tables 12 and 13).

For the above reasons, Equation VI was chosen as the best empirical estimate of the true relationships between output and the set of inputs on farms in the defined population.

Other Computations

As a complement to the above procedure, three other equations (IX, X, XI) were computed in order to search more deeply into the problem of resource use in Jaguariuna. This consisted of taking 10 observations out of the original sample. These observations were from a Dutch colony established in the region about 15 years ago. The type of farming in

Table 15. Constant, Partial Regression Coefficients, Elasticity of Production and Coefficient of Determination, Equations IX, X and XI

	Equation IX	Equation X	Equation XI
a	9.109	12.531	12.160
X_1		.139	
X_2		-.063	
X_3		-.091+	-.131+
X_4	.438**	.278+	.297*
X_5	.018	.017	.038
X_6	.039	.047	.062+
X_7	.119**	.161**	.166**
X_8	.137+	.204*	.165+
X_9	.162**	.142**	.113+
X_{1+2+3}	-.067		
X_{1+2}			.146+
b_i	.846	.835	.855
R^2	.75	.78	.77

X_1 = permanent cropland
X_2 = annual cropland
X_3 = pastureland
X_4 = labor
X_5 = capital: buildings
X_6 = capital: equipment
X_7 = capital: productive livestock
X_8 = capital: draft livestock
X_9 = current operating expenditure

** = significant at .01 level
* = significant at .05 level
\+ = coefficient larger than its standard error but t-value found less than t at .05 level

Degrees of freedom:
Equation IX = 66
Equation X = 64
Equation XI = 65

this colony is not much different than that in the rest of the county. However, the Dutch farmers tend to be on a higher technological plane than many farmers in the rest of the area.

Three functions of the Cobb-Douglas form were computed. They correspond to equations I, III and VI (7, 8 and 9 independent variables) already described. Results obtained for the constant, partial regression coefficients, elasticity of production and coefficient of determination for each of these equations are presented in Table 15.[3/]

Selected Production Function

The mathematical production function selected was:

$$\hat{Y} = 9.497\, X_1^{.163}\, X_2^{-.136}\, X_3^{.245}\, X_4^{.085}\, X_5^{.044}\, X_6^{.121}\, X_7^{.143}\, X_8^{.237}$$

where, $\hat{Y}$ = estimated value of gross farm output (Cr$1,000)

X_1 = land in crops (ha)

X_2 = land in pasture (ha)

X_3 = labor (man/days)

X_4 = capital investment in buildings and improvements (Cr$1,000)

X_5 = capital investment in equipment (Cr$1,000)

X_6 = capital investment in productive livestock (Cr$1,000)

X_7 = capital investment in draft livestock (Cr$1,000)

X_8 = current operating expenditures (Cr$1,000)

In the next sections, the main statistical and economic implications of this function will be discussed.

Statistical Findings

The independent variables included in the selected production function

3/ Correlation matrices are presented in Appendix D.

explained 78 percent of the variations in production. The main statistical inferences relative to its predictive qualities are presented below.[4/]

Correlation Matrix - The complete correlation matrix has already been presented. In Table 16, variables with partial correlations greater than .50 are indicated.

Table 16. Partial Correlation Coefficients larger than .50, Equation VI

$r_{i.j}$	Values	$r_{i.j}$	Values
$r_{1.3}$	.70	$r_{3.5}$	.73
$r_{1.5}$	.59	$r_{3.8}$	.63
$r_{1.8}$	.58	$r_{4.5}$	.63
$r_{2.6}$	.62	$r_{4.8}$	.53
$r_{2.7}$	.59	$r_{5.8}$	.67
$r_{3.4}$	.65		

In comparison with other production function studies reviewed in Chapter II, these correlations are not unusually high. As pointed out in that Chapter, correlations larger than .70 or .80 were often found and the variables involved still considered in further analytical work. However, it is important to be aware of the existence of high correlations when interpreting the effect of a particular variable.

Partial Regression Coefficients - The significance level of each regression coefficient together with standard errors and results of the

4/ See Appendix D for an additional statistical analysis of this function.

t-tests for Equation VI are given in Table 17.

Table 17. Partial Regression Coefficients, Standard Errors, T-Test and Significance Levels, Equation VI.

	Regression Coefficients	Standard Errors (s_b)	T-Test[a]	Significance Levels
b_1	.163	.096	1.708	.10
b_2	-.136	.070	-1.929	.05
b_3	.245	.143	1.711	.10
b_4	.085	.063	1.342	.20
b_5	.044	.058	.753	.45
b_6	.121	.039	3.070	.01
b_7	.143	.104	1.373	.20
b_8	.237	.057	4.145	.001

a/ $\frac{b_i - \beta}{s_b}$, where β is hypothesized equal to zero.

It will be noticed, Table 17, that seven out of the eight coefficients are greater (in absolute numbers) than their standard errors. However, only three of them are significant at .05 or less probability level. The regression coefficient of variable X_5 (capital in equipment) was significant only at the .45 level. Even so, all variables were considered for purposes of economic interpretation since they offer important contributions to the understanding of the production process.

Analysis of Variance - Here, it was hypothesized that the variation introduced in the regression through the effects of the independent variables was not due to chance variations. For this purpose, the total variation (as a sum of squares) was divided into two parts: one due to the regression itself and the other due to chance (residual).

This can be done by using the fact that the coefficient of determination ($R^2 = .78$) is equal to the ratio of the sum of squares due to regression to the total sum of squares.

$$R^2 = \frac{\Sigma \hat{y}^2}{\Sigma y^2}$$

y and y can be determined by making:

$$.78 = \frac{\Sigma \hat{y}^2}{\Sigma y^2}.$$

and $\Sigma y^2 - \Sigma \hat{y}^2 = 3.498$ 5/

The results are:

$\Sigma y^2 = 16.046$ and $\Sigma \hat{y}^2 = 12.548$

The remaining procedure is summarized below, where the F-test is performed.

Source	d.f.	S.S.	M.S.	F
Regression	8	12.548	1.569	29.056**
Residual	65	3.498	.054	
Total	73	16.046		

The value for F with 8 and 65 degrees of freedom, at the .01 probability level, is 2.83. From this one concludes, with a .99 probability, that in the total sum of squares of the dependent variable the share due to the combined effect of the independent variables is not the result of chance variation.

5/ The sum of squares residual - $\Sigma(Y - \hat{Y})^2 = 3.498$ - is given in the printout from Program 6.0.143.

Marginal Analysis

Estimation of Value Marginal Productivities

The Value marginal productivity (VMP) for any input is given by:

$$VMP_{X_i} = AVP_{X_i} \cdot b_i = P_y \frac{\bar{Y}}{\bar{X}} b_i = P_y \frac{\bar{Y}}{X_i} \cdot \frac{X_i}{\bar{Y}} \cdot \frac{\Delta Y}{\Delta X} = P_y \frac{\Delta Y}{\Delta X}$$

where,

AVP_{X_i} = average value product of X_i.

b_i = elasticity of production of the factor of "i" order.

$\bar{Y}$ = geometric mean of the dependent variable.

$\bar{X}_i$ = geometric mean of input X_i.

P_y = output price.

Table 18 presents the average value products and value marginal products obtained.

Table 18. Average Value Products and Value Marginal Product, Equation VI

Variables	Average Value Product	b_i	Value Marginal Product
	(Cr$1,000)		(Cr$1,000)
Cropland (ha)	116.9	.163	19.05
Pastureland (ha)	249.4	-.136	-33.92
Labor (man/days)	3.1	.245	.76
Buildings (Cr$1,000)	2.8	.085	.24
Equipment (Cr$1,000)	3.3	.044	.15
Prod. Livestock (Cr$1,000)	4.5	.121	.54
Draft Livestock (Cr$1,000)	11.9	.143	1.70
Curr. Expenditures (Cr$1,000)	7.9	.237	1.87

These results indicate that all resources were being used in Stage II or III since the value marginal products are smaller than the average value products. There was one resource being used in StageIII: pastureland.

The value marginal productivity of an input is interpreted as the change in the value of output that accompanies a one unit change in the input. It cannot be said that a given output change is large or small unless a basis for comparison of this change exists. This measurement is given by the cost (price) of the use of the input. If the ratio VMP_{X_i}/P_{X_i} is larger than one (other factors constant), then the quantity of X_i used may be increased; if the ratio is smaller than one, too much of X_i is being used.

Table 19. Ratios of Value Marginal Products to Input Prices 6/

Variables	VMP_{X_i} (1)	P_{X_i} (2)	(1)/(2)
	(Cr$1,000)	(Cr$1,000)	
Cropland	19.05	28.8	.661
Pastureland	-33.92	28.8	-1.178
Labor	.76	1.11	.685
Buildings	.24	.12	2.000
Equipment	.15	.18	.833
Prod. Livestock	.54	.10	5.400
Draft Livestock	1.70	.08	21.250
Curr. Expenditures	1.87	1.15	1.626

6/ For information on the determination of input prices, see Appendix E.

Under the assumptions that the objective of the producing firms is one of maximizing profit and that other inputs remain constant at their geometric mean, the data in Table 19 indicate on the average that:

a) the use of buildings, productive livestock, draft livestock and current expenditures could be increased

b) pastureland, cropland, labor and equipment were employed in excessive amounts during the study year.

Since the pastureland variable had a negative regression coefficient, it was not possible to calculate the optimum resource use pattern for all variables simultaneously.

From the knowledge obtained on the preceding pages about the inputs studied, the following statements can be made:

Cropland: The regression coefficient (.163) expresses the elasticity of production of this input. It indicates that an increase of 10 percent in the use of cropland would have increased the value of output by 1.6 percent. The average value product of one hectare of cropland was Cr$116,900. At the margin, this input had a value productivity of Cr$19,050. Maintaining the other inputs constant, a decrease in the amount of cropland used would have increased net farm income.

This input was an aggregate of land in permanent crops and land in annual crops. The value marginal productivities of these two components were also estimated separately.[7/] Land in permanent crops had a VMP of 8.98, and VMP for land in annual crops was 6.40. VMP/P's were .31 and .22, respectively. If these results are compared to those obtained for the cropland variable (VMP=19.05 and VMP/P = .66) a question could be

---

7/ These results were obtained from Equation III, Chapter IV.

raised with regard to the possible overestimation of the latter. It is possible that the grouping of two factors into one variable might have introduced the effects of other elements in the estimate.

Pastureland: A 10 percent increase in the use of pastureland would have decreased production by 1.4 percent. The average value product of one hectare of pastureland was Cr$249,400; at the margin, this input had a value productivity of -Cr$33,920. Other factors constant, a decrease in the quantity of pastureland used would have increased net farm income.

Labor: A 10 percent increase in the number of man/days of labor would have increased production by 2.4 percent. The average value product of one man/day of labor was Cr$3,100; at the margin, this input had a value productivity of Cr$760. Other factors constant, a decrease in the use of labor would have increased net farm income.

Buildings and Improvements: A 10 percent increase in the capital invested in buildings and improvements would have increased production by 0.8 percent. The average value product of Cr$1,000 of capital in buildings and improvements was Cr$2,800; at the margin, this input had a value productivity of Cr$240. Other factors constant, an increase in the use of buildings and improvements would have increased net farm income.

Equipment: A 10 percent increase in the capital invested in equipment would have increased production by 0.4 percent. The average value product of Cr$1,000 of capital in equipment was Cr$3,300; at the margin, this input had a value productivity of Cr$150. This factor was very close to its optimum use level.

Productive Livestock: A 10 percent increase in the capital invested in productive livestock would have increased production by 1.2 percent.

The average value product of Cr$1,000 of capital invested in productive livestock was Cr$4,500; at the margin, this input had a value productivity of Cr$540. Other factors constant, an increase in the use of productive livestock would have increased net farm income.

Draft Livestock: A 10 percent increase in the capital invested in draft livestock would have increased production by 1.4 percent. The average value product of Cr$1,000 of capital invested in draft livestock was Cr$11,900; at the margin, this input had a value productivity of Cr$1,700. Other factors constant, an increase in the use of draft livestock would have increased net farm income.

Current Operating Expenditures: A 10 percent increase in current operating expenditures would have increased production by 2.4 percent. The average value product of Cr$1,000 of current expenditures was Cr$7,900; at the margin, this input had a value productivity of Cr$1,870. Other factors constant, an increase of current expenditures would have increased net farm income.

Overall, the use of agricultural resources was yielding decreasing returns to scale. If all resources had been increased by the same proportion (say, 100 percent), farm production would have increased at a lower rate (90 percent).

Marginal Rates of Substitution

Marginal rates of substitution between inputs indicate the change in a factor which corresponds to a change in another factor, with a constant output level. They are given by:

$$-\frac{\Delta X_i}{\Delta X_j} = \frac{b_j \; X_i}{b_i \; X_j} = \frac{VMP_{X_j}}{VMP_{X_i}}$$

where b_j and b_i are the elasticities of production (change in output relative to the change in input) of resources X_j and X_i, respectively.

Through the marginal rate of substitution the least cost combination of two resources can be calculated by making:

$$-\frac{\Delta X_i}{\Delta X_j} = \frac{P_{X_j}}{P_{X_i}}$$

At the same time, such procedure could indicate the kind of change in resource combination which correspond to a given change in input prices.

Table 20 presents the marginal rates of substitution calculated from the selected equation.

Table 20. Marginal Rates of Substitution Between Inputs ($-\Delta X_i/\Delta X_j$)

X_i	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1.00	-1.79	.04	.01	.01	.03	.09	.10
X_2	-.56	1.00	-.02	-.01	-.00[a/]	-.02	-.05	-.06
X_3	25.07	-44.63	1.00	.32	.20	.71	2.27	2.44
X_4	79.38	-141.33	3.17	1.00	.62	2.27	7.14	7.69
X_5	127.00	-226.13	5.07	1.60	1.00	3.57	11.11	12.50
X_6	35.28	-62.81	1.41	.44	.28	1.00	3.23	3.45
X_7	11.08	-19.72	.44	.14	.09	.31	1.00	1.09
X_8	10.19	-18.14	.41	.13	.08	.29	.92	1.00

a/ Negative and larger than -.005.

Table 21 presents the P_{X_i}/P_{X_j} for all inputs. Comparing it with Table 20, it is clear that if $|-\Delta X_i/\Delta X_j| > |P_{X_j}/P_{X_i}|$, X_i should be decreased and X_j should be increased - other resources fixed - if a least cost combination of these resources is to be attained.

Table 21. Input Price Ratios (P_{X_j}/P_{X_i})

	P_{X_1}	P_{X_2}	P_{X_3}	P_{X_4}	P_{X_5}	P_{X_6}	P_{X_7}	P_{X_8}
P_{X_1}	1.00	1.00	.04	.00[a]	.01	.00[a]	.00[a]	.04
P_{X_2}	1.00	1.00	.04	.00[a]	.01	.00[a]	.00[a]	.04
P_{X_3}	25.95	25.95	1.00	.11	.16	.09	.07	1.04
P_{X_4}	240.00	240.00	9.25	1.00	1.50	.83	.67	9.58
P_{X_5}	160.00	160.00	6.17	.67	1.00	.56	.44	6.39
P_{X_6}	288.00	288.00	11.10	1.20	1.80	1.00	.80	11.50
P_{X_7}	360.00	360.00	13.88	1.50	2.25	1.25	1.00	14.38
P_{X_8}	25.04	25.04	.97	.10	.16	.09	.07	1.00

a/ Positive, but smaller than .005.

Comparisons with Ituiutaba and Caratinga

In Table 22, results of the present study are compared with those obtained in the "Municipios" of Ituiutaba and Caratinga, Minas Gerais.[7]

In Ituiutaba, all resources were being used in the rational stage of production (Stage II) whereas pastureland in Jaguariuna, and pastureland, equipment and draft livestock, in Caratinga, were in Stage III. Ratios of value marginal products to input prices show that in Jaguariuna four factors (current expenditures, buildings, productive livestock and draft livestock) were yielding returns larger than their prices; in Ituiutaba five inputs (cropland, pastureland, labor, buildings and current

7/ Teixeira Filho, A. R., op. cit.

Table 22. Regression Coefficients, Value Marginal Products and VMP/P_X obtained in the "Municipios" of Jaguariuna, Itulutaba and Caratinga, Brazil, Crop Year, 1963-64.

	Jaguariuma			Ituiutaba a/			Caratinga a/		
	Regr. Coeff.	VMP (Cr$1,000)	$\frac{VMP}{P_X}$	Regr. Coeff.	VMP (Cr$1,000)	$\frac{VMP}{P_X}$	Regr. Coeff.	VMP (Cr$1,000)	$\frac{VMP}{P_X}$
Cropland	.163+	19.05	.661	.239**	25.12	10.928	.049	1.25	.493
Pastureland	-.136*	-33.92	-1.178	.171*	1.47	1.079	-.071+	.62	-.453
Labor	.245+	.76	.685	.400**	.59	2.204	.371**	.14	.987
Buildings	.085+	.24	2.000	.056+	2.70	2.500	.126+	2.80	2.593
Equipment	.044	.15	.833	.006	.40	.364	-.086*	-20.50	-18.636
Productive Livestock	.121**	.54	5.400	.042+	.10	.091	.190**	.60	.545
Draft Livestock	.143+	1.70	21.250	.000	.00	.000	-.014	-2.20	-2.037
Current Expenditures	.237**	1.87	1.626	.187**	2.70	2.348	.582**	13.00	11.304
Returns to scale	.900			1.101			1.147		

** Significant at .01 level.

* Significant at .05 level.

\+ Coefficient larger than its standard error but t-value found less than t at .05 level.

a/ Teixeira Filho, A.R., op. cit.

expenditures), and in Caratinga two inputs (buildings and current expenditures) were doing the same.

A closer look at the figures shows some similarity with respect to the relative situation of resources productivities. Value marginal product for cropland was consistently greater than for pastureland in the three cases. Similarly, in all counties value marginal productivity of investment in current expenditures and buildings were found to be higher than their prices.

Striking differences can also be observed. This is the case of the high value marginal product of cropland and labor in Ituiutaba as compared to the others. In Jaguariuna, investments in draft and productive livestock were yielding high returns relative to costs whereas the opposite was happening in Ituiutaba and Caratinga. Returns to cost, at the margin, for current expenditures in Caratinga were much higher than those observed in the other counties.

Interpretation of these similarities and differences are given in Chapter VI.

CHAPTER VI

ECONOMIC INTERPRETATION AND IMPLICATIONS

The present chapter is dedicated to an exposition of the economic implications of the findings of this study. The empirical results will be examined in light of the hypotheses established in Chapter III. At the same time, additional insights into related issues of resource productivity in the study area will be sought.

Historical Background

Knowledge of the historical background of the development of agriculture in the geographic area of which Jaguariuna is a part, is important to an understanding of the results of this study. At the present time, the average Jaguariuna farm has a very low degree of specialization. There is some tendency for smaller farms to emphasize crop enterprises whereas the larger ones give some preference to dairy cattle. But, in general, they are quite diversified. Evidence to this effect is given in Tables 23 and 24.

Given the agricultural development trends in the State of Sao Paulo during the last 50 years, it is not difficult to understand the reasons for such diversification.[1/] The coffee plantation, characteristic of the early growth of Brazilian agriculture, found its way into Sao Paulo

---

1/ For additional information on the development pattern of Brazilian agriculture, see Furtado, Célso, Economic Growth of Brazil, University of California Press, Berkeley, Cal., 1963.

Table 23. Percentages of Land Used for Different Purposes by Size Strata, 74 Farms, Jaguariuna County, Sao Paulo, Brazil 1963/64

Size of Farm (ha)	Crops Permanent (%)	Crops Annual (%)	Pasture (%)	Non-Productive (%)
5 - 15	48.0	29.0	19.0	4.0
15 - 25	27.7	40.3	26.8	5.2
25 - 35	18.6	40.0	35.2	6.2
35 - 45	26.6	36.0	31.9	5.5
45 - 55	19.6	42.0	26.2	12.2
55 - 100	20.3	23.5	37.1	19.1
100 - 250	24.7	17.4	45.7	12.2

Table 24. Land Use Distribution by Size Strata, 74 Farms, Jaguariuna County, Sao Paulo, Brazil, 1963/64

Size of Farm (ha)	Crops Permanent (ha)	Crops Annual (ha)	Pasture (ha)	Non-Productive (ha)	Total (ha)
5 - 15	4.4	2.7	1.8	.4	9.4
15 - 25	5.6	8.1	5.3	1.0	20.0
25 - 35	5.5	11.9	10.5	1.8	29.7
35 - 45	11.0	14.9	13.2	2.3	41.4
45 - 55	10.0	21.3	13.2	6.2	50.7
55 - 100	13.8	15.9	25.1	12.9	67.7
100 - 250	40.8	28.7	75.4	20.1	165.0

State by spreading from the States of Rio de Janeiro and Minas Gerais to the so-called "old coffee zones" - the Paraiba Valley and, later, the Campinas, Braganca and Ribeirao Preto Zones. In the last 20-30 years, the coffee plantations have followed the opening of the western agricultural frontier and advanced toward the Sao Jose do Rio Preto, Bauru and Marilia Zones and to the north of the State of Parana. As a result of the poor competitive position of the "old zones" relative to the new coffee areas, coffed has gradually lost its importance. This unfavorable competitive position is generally considered to have its foundation partly in land exhaustion, partly in resistance to the adoption of new production methods and partly in the growth of progressive urban centers which have attracted the rural labor force - one of the main inputs into coffee production.

These "old regions" have experienced and are experiencing a transition period. This transition is characterized by the division of large holdings, subsistence agriculture, stagnation and labor migration. Areas with better production conditions, mainly in terms of land, tended to be transformed more quickly and entered into commercialized agriculture based on more intensive and advanced methods. The other areas, generally quite mountainous, have remained in subsistence farming or been diverted to extensive beef and dairy cattle production which are, in many cases, the only types of commercialized agriculture in these parts of the "old zones".

However, it is not likely that agriculture in such privileged locations will develop into specialized cattle producing areas. It is more likely that this is an intermediate step toward more profitable types of farming which are appearing as a result of the comparative advantages of more intensive and technologically improved enterprises.

Jaguariuna is typical of these transition areas. Subsistence and commercial farming are intermingled. By subsistence farming is meant the food-producing type of agriculture, generally consisting of annual crops such as corn, rice, beans and cassava, grown in relatively small plots and produced primarily for home consumption rather than for the commercial market. Small livestock enterprises are included in this category. Commercial farms in Jaguariuna produce annual crops, permanent crops (citrus, other fruits or coffee) and livestock (dairy cattle, hogs or chickens) for market purposes.

One interesting feature of the production pattern in Jaguariuna is shown in Table 25.

Table 25. Income distribution, land use between crop and livestock enterprises and farm income per hectare by size of farm. 74 farms. Jaguariuna County, Sao Paulo, Brazil, 1963/64.

Size of farm a/ (ha)	Crops b/ % of total income	Crops b/ % of land used	Livestock % of total income	Livestock % of land used	All enterprises Income/ha (Cr$1,000)
5 - 15	64.7	78.6	35.3	21.4	140
15 - 25	70.0	73.8	30.0	26.2	100
25 - 35	61.6	61.8	38.4	38.2	90
35 - 45	56.2	67.6	43.8	32.4	178
45 - 55	79.5	60.0	20.5	40.0	67
55 - 100	43.0	41.8	57.0	58.2	77
100 - 250	64.4	49.0	35.6	51.0	70

a/ Hectares of productive land

b/ Includes commercial forests.

Resources have been allocated in a manner such that the proportion of land used in crop production tends to have approximately a one to one relationship to the proportion of income from crop production. Similarly, for livestock production. The only qualification is that part of the cropland is used for producing livestock feed whereas the income considered does not include the value of intermediate production. Hence, the amount of land used for livestock is underestimated and that used for crops is overestimated.

As farm size increases, there is a tendency to dedicate relatively more resources to extensive cattle production and commercial plantations. This results in an increase in the proportion of income from crop enterprises relative to that from livestock. It also results in lower farm income per hectare. This is indicated by data in the last column of Table 25.

Another important influence in this area is that of foreign immigrants. We are not concerned here with the large share of the Brazilian farmers who are descendants of Italian families that arrived in Brazil more than 50 or 60 years ago. These have been completely absorbed. The main immigrant influence in the particular case of Jaguariuna is exerted by Dutch and Japanese immigrants of recent origin. These farmers usually work cooperatively and brought with them advanced techniques and the dedication to work which tends to characterize new people in foreign land. Their example appears to have had an influence on other farmers, even though they still constitute a distinct group - socially and economically.

Commercial agriculture has reached Jaguariuna through a process of spreading from other "old areas" that overcame the transition period. The introduction of citrus and sugar cane is the main example of this influence. The present trend is toward the development of farming on a more business-like basis.

One important purpose of the present study is to provide insights into the kinds of adjustment in resource allocation and use needed to transform agriculture from the traditional pattern, described above, to more profitable commercial agricultural production units. The rest of this chapter will be directed to the particular problems of resource allocation and efficiency.

The General Hypotheses

One of the several dimensions of the hypotheses formulated in Chapter III treated the general behavior of the production function. It stated that resources on farms in the Jaguariuna area were not optimally allocated. It was further hypothesized that all resources were being used within the rational stage of production.

This general hypothesis was supported, in part, and in part rejected. Even though it was not possible to determine the optimum resource allocation pattern, it appeared that individual resource categories were not being utilized in an economically optimum manner, other things equal. This is supported by the relationships found to exist between value marginal productivities and input prices for the several resource categories.[2/]

It was also found that one of the factors was not being used in the rational stage of production. Land in pasture, on the average, yielded negative marginal returns. Since the particular influences of other elements on this variable were not studied in the present context, it can only be said that pastureland was being used in a manner such that its productivity, at the margin, was far below that of the other resource categories.

From this evidence, it may be concluded that, on the average, Jaguariuna farms should decrease production costs and increase profit through a general adjustment in the pattern of resource use. Even though

2/ See Table 19, Chapter V.

the amount of the adjustments needed were not determined, the directions that should be followed may be indicated.

The Resource Productivity Issue

As already pointed out, the scope of an interpretation of the results obtained is limited by the difficulty of obtaining meaningful estimates of prices for the use of capital and by the fact that the production function obtained did not permit the determination of a general optimum resource use pattern. These two aspects restrict the usefulness of this study and makes it difficult to test satisfactorily some aspects of the hypotheses.

The 1963/64 crop year was unusually adverse for agriculture in Brazil. In the particular area of concern in this study, eight months of almost complete drought contributed to low crop yields and associated low farm income.3/ While it might be assumed that the relative productivity position of the several resource categories would not differ as a result of adverse climatic conditions, it is almost certain that the estimates of average and marginal products are lower than they would have been under more favorable weather conditions.

Taking into account these problems, the following discussion is conditioned by the fact that the results cannot be applied directly to the individual farm. They are useful in the regional scene and perhaps within a broader framework. Therefore, interpretation of the findings is given as a contribution to the knowledge of general economic problems and should not be taken with regard to problems below that of a generalized

---

3/ This is evidenced by the fact that the crop year 1964/65, in Brazil, had a total output 20 percent higher than that obtained in 1963/64.

policy level.

The Profit Equation

For the average Jaguariuna farm, net revenue was estimated to be Cr$21.100. In this, all inputs and output were taken at the geometric means.[4] It is quite likely that the particular adverse weather conditions of the crop year 1963/64 contributed significantly to this result by depressing total output.

Net revenue was also calculated for 64 observations.[5] This excluded 10 observations taken in a Dutch colony characterized by use of more advanced production technology.[6] This yielded an average net revenue of -Cr$234.800 - worse than the result found for 74 observations.

One striking conclusion from these results is that farming in the Dutch colony, during 1963/64, was profitable in spite of the bad weather conditions. This suggested that the adoption of more efficient technological and managerial methods resulted in meaningful material gains. If this reasoning is generalized, it could be inferred that commercial agriculture employing modern techniques has real possibilities of development in Jaguariuna.

Present Resource Allocation

With regard to the expected behavior of the marginal productivity

---

4/ This calculation was made through the formula $\pi = \bar{Y}P_Y - \bar{X}_i P_{X_i}$. It can be found in Appendix E together with the prices and geometric means of the inputs used.

5/ This corresponds to Equation XI, Chapter V. The calculation of the profit equation is described in Appendix E.

6/ The following data can evidence this statement.

	74 farms	10 Dutch farms
Production/hectare (Cr$1,000)	59	269
Days man/hectare	20	29
Current Expenditures/hectare (Cr$1,000)	10	96
Equipment/hectare (Cr$1,000)	53	114
Average farm size (ha)	57	49

estimates, the results did not confirm the hypotheses formulated in several important points. It was suggested that the marginal productivity estimates would reflect heavily the effects of inflation. Thus, it was expected that farmers would have tended to overinvest in land, buildings and machinery as a means of maintaining the value of their assets. Such overinvestment was expected to drive marginal productivities of these items to low levels relative to the other inputs, when equated to their prices. On the other hand, it was anticipated that increasing and relatively high cost of variable items such as fertilizer, feed, insecticides and fuel, would have caused farmers to restrict their consumption, resulting in relatively high marginal productivities for current expenditures. It was thought that the productivity of labor and capital invested in livestock would remain at an intermediate level.

Table 26, contains the same data previously given in Table 20, Chapter V, together with the corresponding results for 64 sample farms excluding those in the Dutch colony. The first and third columns can be compared to the trends suggested in the hypotheses.

The results given in Table 26 do not support in many ways the hypotheses formulated. Land (specially pastureland) and equipment were characterized by low returns to their use; but capital invested in buildings and improvements turned out to be the opposite. The two livestock variables had high returns, but returns from draft livestock were much higher than those from productive livestock. Marginal returns from current expenditures were at an intermediate level. Labor productivity was below the optimum.

Table 26. Value Marginal Productivities and Ratios of Value Marginal Products to Input Prices for Two Sample Sizes, Jaguariuna County, Sao Paulo, Brazil, 1963/64

	Value Marginal Product a/	Value Marginal Product b/	VMP_X/P_X a/	VMP_X/P_X b/
	(Cr$1000)	(Cr$1000)		
Cropland (hectare)	19.05	15.33	.66	.53
Pastureland (hectare)	-33.92	-23.51	-1.18	-.82
Labor (man/days)	.76	.80	.68	.72
Buildings (Cr$1000)	.24	.10	2.00	.83
Equipment (Cr$1000)	.15	.19	.83	1.06
Prod. Livestock (Cr$1000)	.54	.58	5.40	5.80
Draft Livestock (Cr$1000)	1.70	1.57	21.25	19.62
Curr. Expenditures (Cr$1000)	1.87	1.08	1.63	.93

a/ 74 observations

b/ 64 observations

Cropland and Pastureland: Other inputs constant and given the factor prices used, a decrease in the use of these two factors would be recommended and would be expected to occur since, at the margin, they yielded returns lower than their unit cost. However, this conclusion must be interpreted most carefully in that part of the low marginal productivity of these factors might be attributable to the following phenomena:

a) bad weather conditions during the study year resulting in low farm output.

b) the influence of inflation on land prices. In an inflationary situation, reliable price differentials for different qualities of land tend to be difficult to establish. All types of land in a given area, especially in areas close to large urban centers, tend to be priced similarly. This follows from the fact that they are appraised not only for their production potential but also as a store of value and for nonagricultural uses. This tends to depress the VMP/P ratios with greater effects on the pastureland variable since it tends to consist of lower quality land.

c) the estimates of cropland productivity might be reflecting the influence of other factors.[7]

As pointed out in the hypotheses, low land productivity might be a result of overinvestment. But the difference between the value marginal products for cropland and pastureland deserves special mention.

This difference possibly could be explained by two elements - differences in quality of land and interaction between land and other factors influencing production. Both would tend to result in the value marginal productivity of cropland being high relative to that of pastureland. There are technological reasons for this. Even though both crops and pasture can utilize good quality land, less intensive cattle production is more easily adaptable to poorer grades of land. As a consequence, expenditures on current inputs such as fertilizers and pesticides tend to be greater per hectare of cropland than are expenditures on feed, medicines and other variable inputs per hectare of pasturelend.

Furthermore, economic reasons can be found to explain this difference. Capital invested in cattle is one of the more liquid forms of capital in that it can be converted into cash at any time during the year. Consequently, it may be considered to be less risky than capital invested in annual or permanent crops which are subject to weather and disease hazards before yielding any production. As a means of reducing such risk, additional inputs may have been directed to the crop enterprises helping to increase, through interaction, the productivity of cropland.

7/ See observations in Chapter V, page 73 .

An additional reason for the productivity differences between cropland and pastureland might be found in the fact that the lack of good quality labor and the increasing costs of variable inputs tended to reduce the crop area in favor of pastureland. Farmers tend to consider all land not used for crops as pastureland.

Finally, this phenomenon might have been related to output prices. If prices received by farmers from livestock production were relatively low with respect to prices received from crop production, another source of the differences in value productivity would exist.[8]

Labor: As a consequence of better transportation and population growth leading to greater urban-rural interchange, the competitive position of farmers in the labor market has been weakened. In Jaguariuna, man-power shortages have been found. But these problems seem to be more of a qualitative than of a quantitative nature. The low value marginal productivity estimate obtained for the labor variable indicates that too much of this resource was being employed. As a matter of fact, many of the farmers in the Jaguariuna population had occupations other than farming or were part-time farmers. But, on the other hand, a substantial amount of farm work on larger farms was performed by workers hired on a daily basis from the town of Jaguariuna or from other towns in the neighborhood.[9] However, there was a general complaint about the quality of the work performed by hired workers and sharecroppers and against the relatively high wage rates in existence.[10]

8/ Even though this might not be true for milk and hog production, several cases were found where prices paid for eggs and chickens were below the cost of producing them.

9/ This originated as resistance of farmers to comply with Brazilian minimum wages law. The VMP/P rates for this variable could be higher if informants were not inclined to declare labor prices in terms of the minimum wages they are supposed to pay.

10/ In several cases the survey revealed the existence of landowners and their families working on other farms rather than cultivating their own land.

Nearly 40 percent of all farm work was carried out by the manager and his family. On the smaller farms (comprising about 70 percent of the population) more than 50 percent of the farm work was of this type. Workers hired on a monthly basis were responsible for only about 20 per cent of all man-days of work performed. The rest was provided by sharecroppers and workers hired on a daily basis.

The fact that labor inputs were being used, on the average, to the point where their marginal value product was less than the going wage rate may not indicate irrational employment. This follows from a) the possibility that farmers were willing to accept a lower return for family labor, b) the possibility of a difference between wages actually paid and those reported, c) willingness of sharecroppers to accept a lower return to their labor and d) the difference between expectations and realized events resulting from adverse weather conditions in the study year.

Buildings and Improvements: The estimates suggest that, on the average, investment in this factor should be increased if returns are to be equal to cost at the margin. With respect to other factors, the marginal return to buildings and improvements ranked third, below those of draft and productive livestock. This phenomenon might be partly explained by the following:

a) Farm buildings have not really been taken as a guaranty against inflation. This might be in view of the fact that in the current real estate market farms are appraised primarily as a function of location and less in terms of buildings and improvements. In other words, buyers would not weigh the value of buildings as heavily as they weigh location and land. In Jaguariuna, many cases were found where land value was considered the same regardless of its use. This is also a consequence of inflation which tends to make prices less sensible to qualitative variations.

b) Five main types of construction were found in Jaguariuna farms:

1) Cheaply constructed wooden buildings, rapidly depreciated, made out of material produced on the farm. This was a very common type of construction on the subsistence type of farm.

2) Old brick buildings with short remaining life. In some cases, old houses offering poor security conditions were in this group. This type was found on small and average subsistence and semi-commercial farms.

3) Old, solidly constructed brick and wood buildings with long remaining life. Usually, these were found on large, traditional farms. Very often, these constructions were built above the specifications of functional buildings. x

4) Modern, well constructed brick and wood buildings with long remaining life. Usually, these were on large or week-end farms. These tended to be expensive constructions above common functional standards.

5) Modern, functional brick and wood buildings with an average remaining life. Usually, these were found on commercial and semi-commercial farms.

About one-fourth of all capital invested in this input consisted of construction types 3 and 4, above. The negative effect of such buildings was more than balanced by the functional or very cheap constructions. Additional evidence of this fact is given in Table 26, where one may observe x that the value marginal productivity declined from .24 to .10 when ten farms, highly ranked as commercial enterprises, were excluded from the sample.

c) Materials used in construction were relatively cheap in the area studied. Brick kilns were found in several places during the field work. Some wood was available in every farm for emergency repairs. The availability of new materials at reasonable prices tended to depress the value of used materials on which were based the replacement values.

Equipment: This input on the average yielded marginal returns lower than its price. Even so, its employment was not far from the optimum level. This can be observed more clearly in the result obtained for VMP/P (1.06) for 64 observations, Table 26. This same result also suggests that more mechanized farms were using capital in equipment at relatively low productivity levels. In a sense, this might be taken as evidence that some overinvestment in equipment existed. Forty-three trucks and smaller vehicles and 33 tractors were found on the sample farms.[11] Even discounting the time that they were not in service on the farms, it is probable that they represented some idle capital which would tend to depress the marginal productivity of this input. But, in general, farmers were using equipment in a quite rational manner.

It should be noted for future reference that this input was being employed at near optimum level, other inputs constant, and its marginal value product/price relationship was below that for draft livestock and relatively close to that for labor.

Productive Livestock: Returns from capital invested in this factor, at the margin, were much greater than its cost. Investment in productive

11/ Self-propelled equipment and implements represented about 75 percent of all the capital invested in equipment.

livestock was relatively low on the average Jaguariuna farm. This input consisted mostly of dairy cattle, hogs and chickens. The investment in dairy cattle comprised 83.7 percent of the total investment in livestock.[12/] Therefore, the productivity estimate for this input pertains principally to dairy cattle production.[13/]

One of the possible results of this could be that any growth of investment in productive livestock would emphasize dairy cattle. Comparing these findings with the low productivity of the pastureland variable (Table 26), intensification of the existing methods of dairy cattle production appears advisable.

Draft Livestock: The high marginal productivity of draft animals was an important finding of this study. The marginal product/input price relationship suggests that more of this input could have been employed profitably. It appears to be useful to compare this input with equipment and labor (Table 26) since any increase in investment in draft livestock is closely related to changes in these inputs. Two possibilities exist:

a) to increase the use of draft animals without increasing investments in equipment and labor. This could be done through a qualitative change in the use of factors. Capital in equipment and labor might be allocated so as to provide an increase in the use of draft animals. Another type of adjustment would be to intensify the use of labor and equipment in order to permit an increase in the use of draft animals. To reduce the

---

12/ Dairy cattle, hogs and chickens constituted 96.5 percent of the total capital invested in productive livestock. Dairy cattle made up 83.7 percent, hogs 7.0 percent and chickens 5.8 percent.

13/ It could be added that chicken production was not in good situation with respect to returns during the crop year 1963/64. Several cases were found where feed cost was above production value.

area in cropland or in pastureland, for example, would make labor and equipment available for other purposes. Better management is a main condition for this type of change.

b) since capital in equipment is often hard to be deinvested or qualitatively changed without incurring substantial loss, an increase in the investment in equipment might be advisable if the objective is to take advantage of the high returns to investment in draft animals.

Current Operating Expenditures: An increase in the use of this resource category would be expected to increase farm income. Table XV shows that an important aspect of the high productivity of current expenditures was in the quality of its components. When the group of farmers using better technology was excluded from the sample, the value marginal productivity of this variable decreased sharply, from 1.87 to 1.08. The explanation might be in the fact that the ten better-producing farmers used fertilizers, pesticides, better seeds and feed in larger quantities. The remaining group, trying to keep out-of-pocket expenditures at a low level, in many cases, did not apply fertilizers or pesticides, used seeds from past crops and used only natural pasture to feed cattle. This difference indicates that a qualitative change in current expenditures could increase noticeably its productivity.

Resource Productivity Comparisons

The final broad hypothesis of this study stated that the farms in Jaguariuna were expected to be farther from the optimum resource allocation pattern than were farms in areas such as Ituiutaba and Caratinga in the State of Minas Gerais, Figure 4. Since the production function obtained for the population of Jaguariuna farms was such that a general optimum

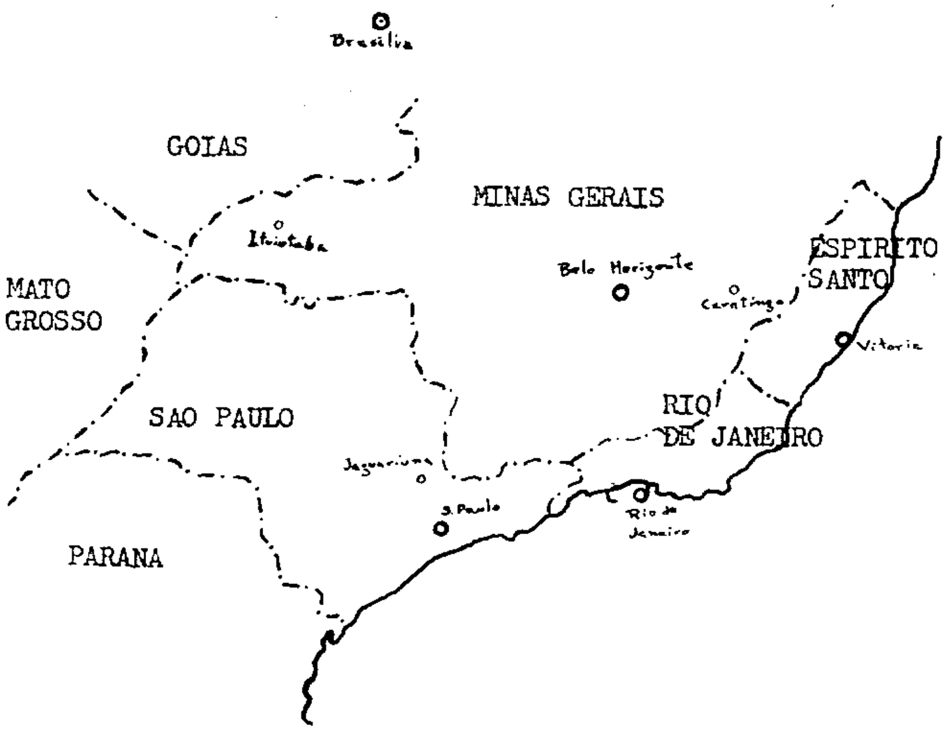

Figure 4. Location of Jaguariuna, Ituiutaba and Caratinga Counties relative to main urban-industrial centers. Brazil, 1963/64.

pattern of resource use could not be obtained, it was impossible to test this hypothesis in its entirety. However, useful insights into the question of regional differences in resource productivity, allocation and use may be obtained through comparisons of the relative productivity of the several resource categories in the several regions.

A comparison of resource productivity estimates and, particularly, the relationship between value marginal products and factor prices in the study area and in the Municipios of Ituiutaba and Caratinga, Minas Gerais, provides a set of striking similarities and differences, Table 27.

Table 27. Value Marginal Products and Value Marginal Product/Input Price Ratios, Jaguariuna, Ituiutaba and Caratinga, Brazil, 1963/64

	Jaguariuna		Ituiutaba		Caratinga	
	VMP (Cr$1000)	VMP/P	VMP (Cr$1000)	VMP/P	VMP (Cr$1000)	VMP/P
Cropland (ha)	19.05	.66	25.12	10.93	1.25	.49
Pastureland (ha)	-33.92	-1.18	1.47	1.08	-.62	-.45
Labor (man/days)	.76	.68	.59	2.20	.14	.99
Buildings (Cr$1000)	.24	2.00	2.70	2.50	2.80	2.59
Equipment (Cr$1000)	.15	.83	.40	.36	-20.50	-18.64
Prod. Livestock (Cr$1000)	.54	5.40	.10	.09	.60	.54
Draft Livestock (Cr$1000)	1.70	21.25	.00[a]	.00[a]	-2.20	-2.04
C. Expenditures (Cr$1000)	1.87	1.63	2.70	2.35	13.00	11.30

a/ Positive, but smaller than .005.

In Ituiutaba, all resource categories were positively associated with output. Not so in the study area nor in Caratinga. In the former, land in pasture had, on the average, a negative marginal effect on output; in the latter, not only land in pasture but also capital invested in equipment and in draft livestock were being employed in Stage III of production.

In addition, Ituiutaba had five inputs (cropland, pastureland, labor, buildings and current expenditures) yielding returns greater than their prices. Buildings, productive livestock, draft livestock and current expenditures in Jaguariuna and buildings and current expenditures in Caratinga were in the same situation.

A general conclusion from these findings is that, given the existing patterns of resource productivity and use in these counties, Ituiutaba and Jaguariuna appear to possess better conditions for growth and investment in the agricultural sector than does Caratinga. However, each area has rather different and unique economic forces that suggest different types of change.

In Ituiutaba, the higher returns to cropland relative to returns to pastureland and productive livestock suggest a change toward a relative increase in crop production. In Caratinga, a decrease in most input categories should be expected. The result might be stagnation in the short run or a substantial transformation in the production pattern in order to change the existing factor relationships. In Jaguariuna forces giving impetus to these broad changes are not so evident. In the previous analysis, certain trends in resource use were suggested, several alternatives were discussed but no important fundamental changes could be clearly seen as imminent.

Reasons for differences in the probable changes in regional patterns of resource use may be suggested. First, Ituiutaba and Caratinga may be considered to be newly-settled areas relative to Jaguariuna. One of the fundamental reasons that makes people move from old to new agricultural areas is the relatively higher resource productivity that can be obtained through the use of previously unused or scarcely used natural resources. This higher productivity and low land costs more-than-offset the disadvantages of higher prices of labor and variable inputs.

Ituiutaba shows one facet of this phenomenon. Traditionally, it was a beef cattle producing area. The favorable topographic conditions and the good quality land, tied to the existing production pattern, presented sound reasons for rapid and stable growth through time as soon as the main problems of communication with consumption centers were solved. With the growing importance of crop relative to livestock production, a move toward new enterprises was not difficult. This might also suggest a long run shift of extensive cattle production to more distant areas in the interior.

In Caratinga, a different trend was followed. It developed as a crop region and was settled by people used to a itinerant type of subsistence agriculture. Furthermore, this is a quite mountainous area where land resources may be rapidly depleted through intensive cultivation. The result of this process might be translated into the low levels of resource productivity presented in Table 27.

As previously indicated, Jaguariuna is a typical representative of the slow transition of the "old coffee zones" toward the more technical and specialized types of agriculture that are increasing around the Sao Paulo urban-industrial center. Farmers have been there for a longer period of time than in Ituiutaba or Caratinga. Even though technological innovations are not difficult to introduce, type of farming tends to change at a slow rate. These slow changes are conditioned by a set of marketing relationships established through time. From the analysis conducted in previous sections, the most important probable changes foreseeable were those of intensification of dairy cattle production and an increase in the use of draft animals.

It might be inferred from these findings, that production patterns changes of a broader nature might be suggested for Ituiutaba and Caratinga than for Jaguariuna.

Some other useful remarks may be made with respect to the relative position of the productivity of the different resource categories among the three counties. The value marginal productivity of cropland was greater than that of pastureland in all three cases. The explanations previously presented for Jaguariuna might be given for the others: land quality, more extensive use of pastureland and more intensive use of other factors in crop production.

Similarly, in all cases, capital invested in current expenditures enjoyed high returns at the margin. In Caratinga, these returns were about six times higher than in Ituiutaba, and seven times higher than in Jaguariuna. The reason for this difference might rest in the very nature of resource use in Caratinga. The itinerant type of agriculture that Caratinga farmers practiced excludes almost completely the use of more expensive, although highly productive, variable resources. It may be that these estimates reflect the very sharp increases in output often associated with relatively small inputs of such things as fertilizer, improved seed, etc. In a sense, thus, the high productivity of this input might be considered to be a consequence of the cultural background of Caratinga farmers.

Capital invested in buildings and improvements was another highly productive factor in all three counties. Marginal returns relative to factor were similar. This illustrates the tendency of Brazilian farmers to make low investments in this input. Explanations might be diverse. In Caratinga, it might be due primarily to the lack of capital; in Ituiutaba, low-cost construction for extensive cattle production and the growth of annual crop production using small building investment; in Jaguariuna, growth of commercial production on relatively small farms. Regardless of the specific reasons, this tendency exited in all regions.

In Ituiutaba, labor was scarce as compared to Caratinga and Jaguariuna. One possible reason for this might be the land tenure patterns characterizing each area. The average farm in Ituiutaba is several times greater than that in Jaguariuna or Caratinga. This means that the share of hired labor must be important in the total man-power invested in Ituiutaba. Silva[14/] pointed out two aspects that illustrate the labor shortage in Ituiutaba. First, the salaries paid for agricultural labor in this county were among the highest in the whole Triangulo Mineiro Zone. Second, Ituiutaba farmers "import" man-power even from the Northeast of Brazil, several thousand miles away, to keep up with their needs for labor.

Investments in productive and draft livestock were many times more productive in Jaguariuna than in Ituiutaba and Caratinga. In productive livestock, a fundamental difference exists: dairy cattle predominates in Jaguariuna whereas beef cattle is the main product in Ituiutaba.[15/] Hence,

---

14/ Silva, Jose Zeferino da, Analise da Estrutura e Formacao de Capital nos Municipios de Ituiutaba (Triangulo Mineiro) e Caratinga (Vale do Rio Doce), Minas Gerais, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, M.G., Brazil.

15/ The composition of the capital invested in productive livestock in Caratinga was not available.

they can be considered as different enterprises. However, returns to investment in draft livestock and equipment constitutes one of the main advantages of Jaguariuna with respect to the other areas. Ituiutaba and Caratinga were using too much of these inputs, and capital in equipment, once acquired, is not easy to be desinvested without a loss in the short run. In Jaguariuna, investment in equipment is close to optimum, and draft livestock could be advantageously substituted for it.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The primary objective of this study was to contribute to knowledge and understanding of agricultural resource use and productivity in Jaguariuna County, Sao Paulo, Brazil. Secondarily, the study was designed to enhance understanding of differentials in resource allocation and use in selected geographic areas in Brazil.

Every aspect of the agricultural resource efficiency problem, once identified, calls for solution. Such will depend on both public and private initiative and action. Empirical knowledge about the present status of resource use and indicated adjustments should be helpful to both public and private decision-makers.

The productivity of the various resources employed on farms in Jaguariuna varied quite widely. This was associated with a number of specific economic forces that undoubtedly are influencing agricultural production and resource use not only in this area but also in the whole region of which Jaguariuna is a part. Jaguariuna is close to the important urban-industrial center represented by Sao Paulo and neighboring cities. The economic forces affecting farms in this area are conditioned by a number of important phenomena. Among these are:

1) the increasing demand for food resulting from a high rate of population growth and increasing per capita income.

2) improvement in the means of communication, educational facilities and opportunities for technical and financial assistance.

3) the gradual depletion of land resources and diminished availability of good-quality labor.

4) the sharp inflationary trends of the Brazilian economy with their impact on factor and product markets through price instability and uncertainty.

5) a gradual change in the land tenure pattern as a result of the division of old, large farms and the entrance of foreign migrants - Italians, Japanese and Dutch.

All these forces, and others, influence factor-product and factor-factor relationships. As a result, Jaguariuna is believed to be in a transition period between the old coffee-producing era and one of modern, commercialized farming. The diversification of production and resource use suggests such transition. Hence, special attention must be given to the changes suggested by the pattern of resource use and productivity and to means of facilitating and improving the climate for these technological, organizational and economic changes.

The general approach to the attainment of the objectives of this study was one of obtaining statistical estimates of a mathematical production function that expressed the relationship between resource inputs and product outputs on farms in the study area. A conceptual model was designed. Alternative mathematical models consistent with the conceptual model were devised. This included the definition of output and input variables. The study area was chosen following a preliminary study of the characteristics of 33 geographic areas in the State of Sao Paulo. A questionnaire was designed, field-tested and revised. Data were collected from a stratified random sample of 74 farms during the last months of 1964. Statistical analyses consisted of routine tabulation, the fitting of regression equations to the data by least-squares techniques and the performance of appropriate statistical tests.

Eleven regression equations were fitted to the empirical input-output data from the sample of Jaguariuna farms. A Cobb-Douglas-type model was accepted as the best estimate of the true production relationship between the value of output and inputs of several categories of resources. The model accepted was:

$$\hat{Y} = 9.497\, X_1^{.163}\, X_2^{-.136}\, X_3^{.245}\, X_4^{.085}\, X_5^{.044}\, X_6^{.121}\, X_7^{.143}\, X_8^{.237}$$

where,

$\hat{Y}$ = value of gross farm output (Cr$1000)

X_1 = land in crops (hectares)

X_2 = land in pasture (hectares)

X_3 = labor (man-days)

X_4 = capital investment in buildings and improvements (Cr$1000)

X_5 = capital investment in equipment (Cr$1000)

X_6 = capital investment in productive livestock (Cr$1000)

X_7 = capital investment in draft livestock (Cr$1000)

X_8 = current operating expenditures (Cr$1000)

All resources were being used in the rational stage of production (Stage II) with the exception of pastureland which was being used in the stage of decreasing total returns (Stage III).

The variation in value of gross farm output was associated more closely with the use of X_3 (labor) and X_8 (current operating expenditures) than with the other inputs. Their regression coefficients can be interpreted as indicating that a 10 percent increase in the use of these inputs, would have, on the average, increased production by 2.45 and 2.37 per cent, respectively. The other resources in decreasing order of relative contribution to production were: land in crops, draft livestock, productive livestock, buildings and improvements, equipment and land in pasture. A 100 percent proportional increase in the use of all inputs would have increased production by 90.2 percent. Thus, the production function indicated that diminishing returns to scale characterized farms in the defined population.

At the level resources were being used, their average value products, value marginal products and ratios of value marginal products to input prices were as given in Table 28.

Table 28. Average Value Product, Value Marginal Product and VMP_{X_i}/P_{X_i}, 74 farms, Jaguariuna County, Sao Paulo, Brazil, 1963/64

Variables	Average value product*a/	Value marginal product**b/	VMP_{X_i}/P_{X_i} ***c/
	(Cr$1000)	(Cr$1000)	
Cropland (ha)	116.9	19.05	.661
Pastureland (ha)	249.4	-33.92	-1.178
Labor (man/days)	3.1	.76	.685
Buildings (Cr$1000)	2.8	.24	2.000
Equipment (Cr$1000)	3.3	.15	.833
Prod. Livestock (Cr$1000)	4.5	.54	5.400
Draft Livestock (Cr$1000)	11.9	1.70	21.250
Curr. Expenditures (Cr$1000)	7.9	1.87	1.626

*a/ Average value product indicates the average return per unit of input used.

**b/ Value marginal product indicates the return per unit of input added to the production process.

***c/ Indicates the relative productivity of inputs with regard to each other and their position with regard to their optimum allocation level (where VMP/P = 1).

Resources were not being used in optimum combination. This was indicated by the fact that the factors' marginal products were substantially different from their prices. One variable (pastureland) was being used in Stage III of production. Considering each input individually with other inputs constant, too much land, man-labor and equipment were being used in production. The use of current expenditures, buildings, productive livestock and draft livestock could have been expanded profitably. It is clear that a general adjustment in resource combination is called for within the population of Jaguariuna farms studied.

Under the hypotheses formulated[1/], land, buildings and equipment were expected to be characterized by low value productivity at the margin relative to factor costs. This was true of land and equipment. Marginal returns relative to marginal costs of current expenditures were expected to be at a higher level than those for either livestock or labor. The empirical results indicated that returns to marginal investments in livestock were higher than to current expenditures. The labor input was at a lower level.

The low marginal productivity of land might have been the result of inflation-inspired overinvestment in this factor. The higher marginal productivity of cropland as compared to pastureland might have been due to higher quality of the former and less intensive use of the latter. In addition, farmers might have concentrated application of other resources on cropland as a means of offsetting risk associated with the crop enterprises. Other things constant, a reduction in both pastureland and

1/ See Chapter III.

cropland was indicated. It is probable that greater adjustments in the quantity of pastureland would be required than in the case of cropland.

Too much man-labor was being employed. On the average, about 40 percent of the labor input was provided by the farm manager and his family. The rest was provided by workers hired on a monthly or daily basis and by sharecroppers. Given the poor competitive position of farmers in the labor market relative to labor alternatives in urban centers, problems with low quality labor and high wages were recognized by farmers in the sample. Hence, the possible explanations of the low return relative to price yielded by the labor input at the margin consist of the following:

a) less-skilled farm families and sharecroppers lacking more profitable alternatives might have been willing to accept, in the short run, returns lower than the current wage rate.

b) measurement error in the labor input resulting from systematic informant bias in applying the comparative standards used to appraise labor capacity. This could have been important in view of the large share of hired and family labor that was provided by boys, women, old people and less-skilled men.

c) inefficient labor management resulting from absentee ownership and the more-skilled land owners having been attracted by better employment opportunities.

d) labor cost estimates might have been erroneously high as a result of a possible tendency of farmers to make such estimates in terms of the minimum wages they are supposed to pay under Brazilian law.

The absence of overinvestment in buildings and improvements could be partly attributed to the fact that investment in this input might not have been used as an inflation hedge. Furthermore, most buildings were constructed of cheap materials readily available in the area.

Capital investment in equipment was close to the optimum other factors constant. At the margin, returns were found to be only slightly below cost. This indicates that the farmers tended to be quite rational in decisions about the purchase of self-propelled equipment and implements since these items constituted about 75 percent of the total capital invested in this resource category.

An increase in the capital invested in productive livestock would have increased net farm income. High marginal returns relative to the cost of this input were associated mainly with dairy cattle since this type of livestock comprised 83.7 percent of the total capital invested in productive livestock. This, in conjunction with the low marginal productivity of pastureland, suggests the intensification of the dairy cattle enterprise.

The marginal return to capital invested in draft livestock relative to its cost was greater than that of any other capital input catagory. This implies opportunities for the profitable expansion of their factor. Also, taking into account the low return relative to price yielded, at the margin, by man-labor and equipment, the possibility of substituting draft animals for these inputs appears to offer potential for increased profit.

On the average, marginal returns relative to cost were favorable for current operating expenditures. Wide variation in investment in current expenditures among farms in the original sample existed. The VMP/P ratio for current expenditures decreased from 1.63 to .93 when 10 farms were excluded. The[5e] farms tended to employ chemical fertilizers, pesticides, feed and selected seeds in larger amounts and more frequently than did the other units. This finding might lead to the conclusion that return to investment in current expenditures larger than its price would be attained if these investments are made in terms of increasing use of fertilizers, pesticides, feed and selected seeds.

Jaguariuna is about 60 miles from the Sao Paulo urban-industrial center. Ituiutaba and Caratinga are in the State of Minas Gerais. Ituiutaba tends to be under the influence of the Sao Paulo complex area. It is about 350 miles from that center.[2/] Caratinga tends to be influenced by a different set of effects represented by its location relative to the cities of Rio de Janeiro and Belo Horizonte. Resource productivity comparisons among Jaguariuna, Ituiutaba and Caratings suggests that geographic location has a definite influence on production and resource use patterns. As a consequence, the kinds of change suggested in Jaguariuna, Ituiutaba and Caratinga differ.

Ituiutaba and Jaguariuna appeared to offer better prospects for growth and investment in the agricultural sector than did Caratinga. In Ituiutaba, all resources categories were being used in the rational stage of production. Five categories yielded marginal returns greater than marginal costs. In Jaguariuna, pastureland was irrationally employed but four input categories were characterized by highly profitable marginal returns. On the other hand, the sample of farms in Caratinga had three resource categories employed in the irrational stage with only two yielding.

2/ All distances taken on straight lines between points considered.

advantageous returns.

In all three cases, the marginal value productivity of cropland was greater than that of pastureland. Higher quality and more intensive use of other resources on cropland might be the reason. Current expenditures and investments in buildings and improvements had high value marginal productivity/price ratios on farms in the three counties. Low capital investment in buildings tends to be characteristic of subsistence farming and in situations where production patterns are changing based on low capacity to invest. The high productivity of current expenditures was the consequence, in all probability, of the use of newer, high-payoff technologies. In Caratinga, current expenditures tended to be relatively more profitable at the margin. This could have been because farmers in this area have been more resistant to technological change than in the other areas and the use of these inputs was at an early stage.

Capital investments in productive livestock were not profitable, at the margin, in Ituiutaba and Caratinga. Such additional investments were profitable in Jaguariuna. This might be a reflection of the fact that dairy cattle predominated in Jaguariuna and beef cattle in Ituiutaba.

The results obtained for Jaguariuna and Ituiutaba were closely associated with the development pattern conditioned by the influence of the Sao Paulo urban-industrial center. Jaguariuna is a representative of an agricultural region in transition between the coffee producing era of the 1800's and modern commercial agriculture. Ituiutaba, on the other hand, represents a region in transition between traditional patterns of beef cattle production and more intensive systems of crop production. It is a relatively new region in so far as trade with important consumption centers is concerned. This in all probability has exposed this area to strong economic forces leading to resource and production adjustments.

It is clear that significant adjustments in resource use patterns are called for and probably will occur in all three regions. It is also clear that the nature of the needed adjustments varies among regions. This study did not provide clear-cut evidence to support the hypothesis that needed adjustments in agricultural resource use patterns tend to be less in areas more distant from the influence of large urban-industrial centers.

BIBLIOGRAPHY

Aldunate, Paul, A Comparison of Resource Productivity and Efficiency on Private and Government-Created Farms in the Central Valley of Chile, Unpublished M.S. Thesis, Purdue University, 1965.

Beringer, Christopher, "Problems in Finding a Method to Estimate Marginal Value Productivities for Input and Investment Categories on Multiple-Enterprise Farms", Resource Productivity, Returns to Scale, and Farm Size, Iowa State College Press, Ames, Iowa, 1956.

Bradford, Lawrence A., and Johnson, Glenn L., Farm Management Analysis, John Wiley & Sons, Inc., New York, 1953.

Conselho Nacional de Estatistica (IBGE), Anuario Estatistico do Brasil - 1956, Servico Grafico do IBGE, Rio de Janeiro, Brasil.

__________, Anuario Estatistico do Brasil - 1960, Servico Grafico do IBGE, Rio de Janeiro, Brasil.

Edwards, Clark, "Demand Elasticity in the Factor Market as Implied by Cobb-Douglas Production Functions", Journal of Farm Economics, February 1961.

Furtado, Celso, Dialetica do Desenvolvimento, Fundo de Cultura, Brazil, 1964.

__________, Economic Growth of Brazil, University of California Press, Berkeley, Cal., 1963.

Griliches, Zvi, "Specification Bias in Estimates of Production Functions", Journal of Farm Economics, February, 1957

__________ "Estimates of the Aggregate Agricultural Production Function from Cross-Sectional Data", Journal of Farm Economics, May, 1963.

Heady, Earl O., Economics of Agricultural Production and Resource Use, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1953.

__________, and Dillon, John L., Agricultural Production Functions, Iowa State University Press, Ames, Iowa, 1961.

BIBLIOGRAPHY

Hildebrand, John R., "Some Difficulties with Empirical Results from Whole-Farm Cobb-Douglas-Type Production Functions", Journal of Farm Economics, November, 1960.

Junqueira, Antonio Augusto B., Analise Economica de Uma Funcao de Producao - Fumo em Uba, M.G., 1961, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, M.G., Brazil, 1962.

Kehrberg, Earl W., Agricultural Production Economics Notes - 1963, Agricultural Economics 612, Mimeo, Department of Agricultural Economics, Purdue University.

Leftwich, Richard H., The Price System and Resource Allocation, Holt, Rinehart and Winston, New York, 1955.

Liebhafsky, H.H., The Nature of Price Theory, The Dorsey Press, Inc., Homewood, Ill., 1963.

Meier, Gerald M., and Baldwin, Robert E., Economic Development, John Wiley & Sons, Inc., New York, 1957.

Mundlak, Y., "Empirical Production Function Free of Management Bias", Journal of Farm Economics, 1961.

Myrdal, Gunnar, Economic Theory and Underdeveloped Regions, G. Duckworth, London, England, 1957.

Organizacao de Alimentacao e Agricultura das Nacoes Unidas, "Analise Estatistica dos Fatores que Afetam os Rendimentos Agricolas do Cafe no Est. de Sao Paulo", Agricultura em Sao Paulo, Secretaria da Agricultura, Sao Paulo, Brazil, June, 1961.

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

Quintana, Emilio U., Resource Productivity Estimates for Five Types of Philippine Farms, Unpublished Ph.D. Thesis, Purdue University, 1960.

Schattan, Salomao, Funcoes Agregadas de Producao Agricola no Estado de Sao Paulo, para Tres Regioes e Sete Estratos de Area, Preliminary Draft, Secretaria da Agricultura, Sao Paulo, Brazil, 1965.

Schultz, Theodore W., The Economic Organization of Agriculture, McGraw-Hill Book Company, Inc., New York, 1953.

____________________, Transforming Traditional Agriculture, Yale University Press, New Haven, 1964.

Silva, Jose Josi da, Analise da Produtividade Marginal dos Recursos Usados na Producao de Carne Bovina na Zona de Montes Claros, M.G., no Ano Agricola 1962/63, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, M.G., Brazil, 1964.

Silva, Jose Zeferino da, Analise da Estrutura e Formacao de Capital nos Municipios de Ituiutaba (Triangulo Mineiro) e Caratinga (Vale do Rio Doce), Minas Gerais, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, M.G., Brazil, 1963.

Steel, Robert G.D., and Torrie, James H., Principles and Procedures of Statistics, McGraw-Hill Book Company, Inc., New York, 1960.

Teixeira Filho, Antonio Raphael, Analise da Produtividade Marginal dos Recursos Agricolas em Dois Municipios do Estado de Minas Gerais - Ituiutaba e Caratinga - no Ano Agricola 1961-1962, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, M.G., Brazil, 1964.

Tollini, Helio, Produtividade Marginal e Uso dos Recursos: Analise da Funcao de Producao de Leite em Leopoldina, M.G., Ano Agricola 1961-1962, Unpublished Magister Scientiae Thesis, UREMG, Vicosa, M.G., Brazil, 1964.

APPENDIX A

INDICES FOR THE 33 ZONES OF THE STATE OF SAO PAULO

APPENDIX A

INDICES FOR THE 33 ZONES OF THE STATE OF SAO PAULO

Table 1A. Six Indices for 33 zones, State of Sao Paulo, Brazil, 1963

Regions	% Rural Population / Total Population	% Land in crops / Total land	Average Farm* Size (ha)	Ha/ Tractor	Ha/ Plow	Cattle (head/ha)
1. S. Sebastiao	56	11	140	173	234	0.016
2. Medio Paraiba	34	7	144	56	23	0.445
3. Alto Paraiba	82	7	85	609	42	0.447
4. Mantiqueira	55	14	92	636	82	0.271
5. Santos	6	27	183	878	1437	0.014
6. Ribeira	74	18	80	552	215	0.037
7. S. Jose* do Rio Pardo	54	29	106	225	26	0.389
8. Braganca	57	29	68	145	27	0.342
9. S. Paulo	17	17	128	57	14	0.161
10. Paranapiacaba	79	18	69	79	12	0.075
11. Alto Ribeira	81	12	85	896	36	0.026
12. Pirassununga	46	22	117	109	19	0.363
13. Rio Claro	30	36	103	103	24	0.253
14. Piracicaba	43	33	103	193	19	0.267
15. Campos Gerais	55	15	137	190	12	0.200
16. Itaporanga	78	31	65	414	12	0.177
17. Franca	51	22	134	238	77	0.325
18. Ribeirao Preto	41	24	213	186	54	0.282
19. Araraquara	42	31	134	136	29	0.303
20. S. Carlos e Jau	44	27	152	178	28	0.272

Continued next page.

Regions	% Rural Population / Total Population	% Land in crops / Total land	Average Farm* Size (ha)	Ha/ Tractor	Ha/ Plow	Cattle (head/ha)
21. Botucatu	48	15	233	180	29	0.190
22. Piraju	64	41	115	334	56	0.210
23. Barretos	57	31	150	146	38	0.367
24. Rio Preto	58	24	99	265	12	0.496
25. Catanduva	61	28	113	241	22	0.357
26. Bauru	49	25	137	201	24	0.391
27. Aracatuba	60	25	119	170	11	0.708
28. Marilia	63	46	71	265	13	0.424
29. Assis	60	24	100	189	21	0.417
30. Presidente Prudente	61	33	75	335	6	0.558
31. Pereira Barreto	76	28	91	239	10	0.527
32. Andradina	61	26	104	474	16	0.594
33. Presidente Wenceslau	54	15	239	171	15	0.443
TOTAL	37	25	112	177	17	0.356

* Average of farms larger than 10 hectares.
Source: Conselho Nacional de Estatistica (IBGE), Anuario Estatistico do Brasil.

APPENDIX B

LIST OF OBSERVATIONS AND REASONS FOR EXCLUDING SAMPLE FARMS

APPENDIX B

LIST OF OBSERVATIONS AND REASONS FOR EXCLUDING SAMPLE FARMS

Below, a list of the observations included in the final sample is presented:

Number	Land Owner	Farm area (Productive ha)
1	Alescio Gandolfi	5
2	Vitorio Refundini	5
3	J.A. Aaldering	6
4	Jose Gaona e irmaos	6
5	Geraldo Zanelato	7
6	Eliseo Siqueira Penteado	9
7	Joao Rebelato	11
8	Herminio Tonini	11
9	Odorico Ursini	12
10	Ulisses R. Cavalcanti F.	12
11	Agostinho Bruno	15
12	Antonio Scaion	17
13	Augusto Lana	17
14	Dante Panini	18
15	A. van Bruggen	18
16	Espolio Joao Canizella	20
17	Orlando Santos	21
18	G. Oude Groeniger	22
19	Santo Serafim e irmao	24
20	Ercilia A. Mussato e filhos	26

Number	Land Owner	Farm Area (Productive ha)
21	Joao Pinheiro Alves	27
22	Carlos Rebelato	27
23	Jurandir C. Raggio	28
24	Johannes G. Palmes	31
25	Pedro Celestino dos Santos	33
26	Celso P. Pedroso	33
27	Wilhelmus T.S. Schreurs	33
28	Th. Meulman	35
29	Zelindo Baldo	36
30	Luiz Baldassin e irmaos	36
31	Wilhelmus Jeuken	40
32	Yu S. Hang e Yu C.Pu	40
33	Antonio Zoia e irmaos	40
34	Pedro Rebelato	42
35	W. Visser	42
36	Primo e Santo Zaparolli	44
37	Mario e Lino Sisti	44
38	Frieda Messerli	45
39	Narciso Marion e irmaos	46
40	Jose Panini	47
41	Fazenda Barreiro	47
42	Aparicio de Almeida	48
43	Franklin T.Piza F.	48
44	Guerino Rebelato	48
45	Jose Dal'Bo e irmaos	48

Number	Land Owner	Farm Area (Productive ha)
46	Attila Ribeiro Ponciano	50
47	Jose Parnaiba da Silva	51
48	Nelson Testa e irmaos	52
49	Darcy M.de Souza	53
50	Primo e Silvio Dal'Bo	54
51	Eugenio Dal'Bo e irmaos	54
52	Valdir Tombolato	55
53	Fiacao Excelsior	56
54	Amadeu Bruno e irmaos	57
55	Th. J. Klein-Gunnewieck	64
56	Joaquim P. da Silva	65
57	Natalino Finotelli	67
58	Antonio S. Carvalhal	67
59	Rita V. A. Lima	71
60	Antonio M. Pinto	77
61	Espolio Jose Murer	96
62	Alejandro Tinkler	100
63	J. T. de Wit	103
64	Ferrucio e Emilio Testa	103
65	Alfredo Farhat	111
66	Dante e Manoel Carazolli	126
67	Fiorindo Granghelli	133
68	Antonio P. Catao	138

Number	Land Owner	Farm Area (Productive ha)
69	Benedito A. Santos e irmaos	150
70	Barbara G. Salembier	165
71	Celso A. Moraes	191
72	Antonio A. Assumcao	198
73	Pedro Granghelli	198
74	Edgard Jafet	218

Obs.: The names above are in the same order as the data presented in Appendix F.

Reasons for Excluding Sample Farms

Farms or landowners not located	5
Farms included in larger out-of-population holdings	4
Atypical farms with highly specialized enterprises	4
Refused to give information	2
Unreliable information	3
Incomplete information	2
Farms not in production	2
Other reasons	3
TOTAL	25

APPENDIX C

RESUME OF QUESTIONNAIRE, COMMENTS AND SUGGESTIONS ON THE DESIGN OF THE SURVEY

APPENDIX C

RESUME OF THE QUESTIONNAIRE, COMMENTS AND SUGGESTIONS ON THE DESIGN OF THE SURVEY

The translated questionnaire is presented herein in resume form:

PAGE 1 1/

- Questionnaire no......; (Title of the study); Crop year 1963/64; Date:....; Starting time:.....; Ending time:.....; Enterviewer: .....; Landowner:.....; Informer:.....; Farm area:.....; Farm name:.....; County:.....; Township:.....; Road or place:.....; Revised by.....; Date:......

PAGE 2 2/

- Land: Use and Production
- Area (Unit of the farmer; Hectares). Total Production (Unit of the farmer; Unit of the research). Yield. Owned or Rented (Area; Production).
- Permanent crops (Coffee; Citrus; Banana;....). Annual crops (Corn; Cassava; Cotton; Sugar cane; Rice;....). Pastureland. Forests. Natural forests. Land out of use.

PAGES 3 and 4 (cont. of page 2)

- The same as in page 2.
- Land under sharecropping (Area; Production). Land under sharecropping (Area; Production). Land under sharecropping (Area; Production).

1/ The different paragraphs are separated by semicolons. Dotted lines mean blanks of variable width.

2/ From page 2 on, the following conventions are being used: the first paragraph is the heading; the second paragraph is the pannel with the column heads; the third is the stub with its entries - colon lines, and caption lines.

- The same as in page 2.

PAGE 5

- Capital: Permanent crops.
- Value of the plantation including land (1). Land value (2).

  (1) - (2). Land type.
- Coffee. Oranges. Banana. Sugar cane. Forests. Others. Total.

PAGES 6 and 7

- Capital: Constructions and Improvements.
- Material of construction. Dimensions. Replacement value. Probable future lasting. Depreciation. Value of repairs. First total. Percentage use in farming. Total.
- In the stub there is a list of the most common types of constructions and improvements with blanks for additions, if needed.

PAGES 8, 9, and 10

- Capital: Equipment.
- Type. Replacement value. Probable future lasting. Depreciation. Value of repairs. First Total. Percentage use in farming. Total.
- In the stub are listed the most common vehicles, machines, tools, and general equipment with blanks for additions, if needed.

PAGE 11

- Capital: Productive livestock.
- End of the year: 30/8/64 (Quantity; Unit price; Total value).

  Born. Purchases. Consumed. Sold. Dead. Beginning of the year: 1/9/63 (Quantity; Unit price; Total value).

- Cattle (Cows; Bulls; Calves;.....). Hogs (Sows;.....).
  Other kinds (......). Total.

PAGE 12 (cont. of page 11)

- The same as page 11.
- End of the year: 30/8/64 (Quantity; Unit price; Total value).
  Consumed. Sold. Purchased. Beginning of the year: 1/9/63
  (Quantity; Unit price; Total value).
- Chickens. (.....). Total.

PAGE 13

- Capital: Draft livestock.
- End of the year: 30/8/64 (Quantity; Unit value; Total value).
  Purchased. Born. Sold. Dead. Percentage use in farming. Beginning
  of the year: 1/9/63 (Quantity; Unit price; Total value).
- Horses. Donkeys. Oxen. (.....). Total.

PAGE 14

- Labor: Manager and his family
- Age. Days/week. Months/year. Days/year. Conversion factor. Man/days.
- Manager. Wife. Sons (.....). Total.

PAGE 15

- Labor: Permanent workers.
- Age. Days/week. Months/year. Days/year. Conversion factor. Man/days.
  Payment without board. Observations.
- In the stub there is a list of the names given to the most usual
  occupations in farming.

PAGE 16

- Labor: Occasional workers.
- Expenditures in the operation. Daily payment. Man/days. Observations.
- In the stub there is a long list of the most common tasks performed in farming.

PAGE 17

- Labor: Sharecroppers.
- In the panel there is a list of the most common cropping operations.
- In the stub there is a list of the main crops: corn, peanuts, beans, rice, etc.

PAGE 18

- Production: Crops.
- Production. Sale. Unit price. Total value.
- Corn. Beans. Rice. Sugar cane. Coffee. Citrus (.....). Total.

PAGE 19

- Production: Milk (Sale).
- Liters/day (1). Lasting of the period (Months (2); Days (3)). (1) x (3).

  Unit price. Total value.
- Wet season. Dry season. Total.

PAGE 20

- Production: Milk (Consumption).
- The same as page 19.

- Landowner family. Landowner sons. Employees. (.....). Total.

PAGE 21

- Production: Milk (Transformation)
- Wet season (Conversion; Quantity; Unit price; Total value). Dry season (Conversion; Quantity; Unit price; Total value). Whole year (Conversion; Quantity; Unit price; Total value).
- Cream. Cheese. Butter. (.....). Total.

PAGE 22

- Production: Eggs (Sale and Consumption).
- Sale (Dozens/day; Dozens/month). Consumption (Dozens/day; Dozens/month). Total (Dozens/day; Dozens/month). ✓
- January. February...................December. Total.

PAGE 23

- Production: Manufactures.
- Quantity. Unit price. Total value.
- In the stub there is a list of the most common products extracted from sugar cane, cassava, and corn.

PAGE 24

- Production: Others.
- Sale. Consumption. Total (Quantity; Unit price; Total value).
- Vegetables. Honey. Leather. Manure. Others (.....). Total.

PAGE 25

- Current expenditures: Crops.
- Seeds and Plants (Quantity; Unit price; Total value). Fertilizers

(Quantity; Unit price; Total value). Pesticides (Quantity; Unit price; Total value). Others (Quantity; Unit price; Total value).

- Corn. Rice. Cotton. Beans. Coffee. Citrus. Sugar cane. (.....). Total.

PAGE 26

- Current expenditures: Livestock.
- Medicines. Veterinary. Salt. Feeds.
- Cattle (.....). Hogs (.....). Draft livestock (.....). Chickens (.....). Total.

PAGE 27 (first table)

- Current expenditures: General
- Quantity. Unit price. First total. Percentage use in farming. Total.
- Gasoline. Oil. Lubricant. Rent paid (Land; Machinery). Telephone. Electricity. Shipments. (.....). Total.

PAGE 27 (second table)

- No heading.
- Value
- Taxes (Land; Vehicles; Roads). Insurance. Interests. Rents. Cooperatives. Total.

Comments and Suggestions on the Design of the Survey

In addition to the general comments in Chapter II on the methodological problems related to production function estimates, this Appendix was reserved to deal with some of them in a more specific way as well as to develop some suggestions with regard to the questionnaire, using the experience accumulated during more than 90 interviews. Since particular emphasis is given to the second topic, the following comments will be made in terms of the variables involved.

Land - The problem of sharecropping should be carefully weighed for each observation. When only one family of sharecropper carries on all the farm work, there is no difference between this and any other observation. However, there are many cases where farming is carried on a) by more than one family working as completely isolated units, b) by more than one family working separately but performing tasks on the whole farm (in the case of permanent plantations); c) by one or more family of sharecroppers, besides the landowner.

These situations may lead to cases where distinct production units are taken as a unique observation. In such cases one of the following alternatives should be taken: a) to consider the farm as a set of observations equal to the number of production units included; b) to take at random only one of the units included in the farm, or c) to exclude the whole farm, since it does not comply with the stratum where it was included.

In any case, it seems in error to consider the entire complex unit as a single observation; this is only justifiable when the activities performed are so closely related that it is possible to say that the sharecroppers are cooperating and producing together. Otherwise, a group of small units qualitatively difference would be considered as belonging to a single observation.

The questionnaire should not divide the land variable among the different sharecropping families, unless very special and not common cases are being considered.

Capital in general - Probably the best procedure for handling any item of the capital variables would be the evaluation of the main capital holdings in terms of their "new" price (during the year considered) and their probable endurance under normal use conditions. It is not difficult to obtain good data on these points from commercial sources, and with people acquainted with agriculture in the area considered. This procedure, in addition to being more accurate, would save a good deal of interviewing time, and would make the final computations easier. But the main advantage is that it would not submit the informant to tiresome mental exercise which, very often, lead to rough guesses.

Obviously, this procedure could not be followed for all capital items. Some information would still have to be given by the informant. But a least the most common capital items might be so appraised. If this were followed, the questionnaire tables would remain the same but the work would be simplified and the results improved.

In the following, suggestions on each capital item are given,

Permanent crops - A better heading would be:

Value of Land (ha)	Value of plantation (ha)

since farms can easily appraise plantations separately; value of land could be previously determined. Quality of land, as influencing price, is only taken into account in large multi-enterprise farms, and in situations where inflation has not distorted the price patterns.

A further comment in permanent crops is related to its introduction in the model as a variable. This could be done in two forms: a) by measuring land in money terms and adding to it the plantation value; b) by including value of plantations (without land) as an additional input.

Constructions and Equipment - There are two ways of using the item "repairs": one is by adding it to the depreciation; this is done whenever it is known or assumed that the amount paid for repairs was not included in the replacement value. The other is by leaving it out whenever it is known or assumed that it was included in the replacement value. The decision criterion is simple: either the interviewee is asked whether his declaration has included the repair value, or it is added to the depreciation any repair value which is lower than a given arbitrary percentage of the replacement value.

Productive and draft livestock - Prices of most kinds of livestock could be previously determined. In this case, the only remaining problem would be to get good estimates of the inventory changes. It must be recalled that, very often, the same livestock is bought and sold within the crop year. There must be a criterion to handle this problem.

Labor - This is probably the most difficult item to handle through tables. This is the reason why detailed explanations are presented with the suggestions below.

Hours/day (1)	Days/week (2)	Days/year (2) x 52 (3)	Holidays (4)	Sickness, travels, etc (5)	......	Conversion Factor (6)	Hours/year (7) (3)-(4)-(5)x x(6)x(1)	Man/days (7)/n (8)

Columns (1) and (2) are easily obtained and give a good idea of the work performed in a usual day or week of labor.

Columns (3), (7), and (8) are calculated at the office.

Column (4) will give the number of holidays generally taken by the entire work force and may be known previously. On the other hand, column (5) is a record of particular cases.

The conversion factor (column 6) can be calculated by the interviewer with the help of the farmer; it depends on personal judgement. Only if no information of this kind can be obtained, standardized conversion coefficients may be used.

Column (8) is to be calculated at the office; n is the number of hours of daily work being considered in the study.

The above heading may be used for all the permanent workers on the farm, including sharecroppers. It will work even better if the suggestions on the item "land" are taken into account.

In the case of occasional labor, the informant usually knows approximately the number of persons and the number of days of hired occasional labor. If the service was performed as a task without control, the informant knows the cost of the operation. Both cases can be solved by using two small tables:

1)

Hours/day (1)	No. of days (2)	No. of persons (3)	Total hours (4) (1)x(2)x(3)	Man/days (5) (4)/n

Columns (4) and (5) are to be calculated at the office.

2)

Cost of operation (1)	Usual daily payment (2)	Man/days (1)/(2) (3)

If the usual daily payment corresponds to the number of daily working hours used in the study, column (3) will give directly the number of man/days. Otherwise, adjustments will be needed between columns (2) and (3).

Production - Here, again, previous data with regard to prices should be obtained. The number of middle-men is not large and prices are usually fairly stable during the production months. The advantages of this procedure are the same as those previously mentioned.

Crops - Here is a suggestion for a new table:

	Production (1)	Consumption in the farm * (2)	(1) - (2) (3)	Unit Price+ (4)	Total Value (3)x(4)
Corn					
Beans					
Rice					
.....					
Total					

* Includes all production used as intermediary consumption in the farm.
\+ Prices previously known.

Milk: Sale and Consumption

	Liters/day* (1)	Liters/year (1)x182,5 (2)	Unit Price+ (3)	Total Value (2)x(3)
Wet season				
Dry season				
Total				

* Discounting milk given to calves and used for transformation in butter, cheese, etc.
\+ Prices previously known.

This last table would replace the tables on pages 19 and 20 of the questionnaire.

Milk: Transformation - In areas where dairy cattle is not a primary activity the following table is recommended:

	Weight Unit (1)	Quantity Per Month (2)	Per Year (3)	(1) x (3) (4)	Price* (5)	Total Value (4) x (5)
Butter						
Cheese						
......						
Total						

* Prices previously known.

This table would replace page 20 of the questionnaire.

Eggs - For small domestic hen flocks this table heading would be useful:

Average Dozens/day (1)	Dozens/year (1)x365 (2)	Unit Price (3)	Total Value (2)x(3)

For commercial flocks:

	Dozens/day												Total	Unit Price	Total Value
	J	F	M	A	M	J	J	A	S	O	N	D			
Chickens															
Turkeys															
....															
Total															

These tables would replace those on page 21 of the questionnaire.

Current Operating Expenditures - Previous determination of prices paid during the crop year considered is again essential.

APPENDIX D

FURTHER STATISTICAL ANALYSIS

Table 1D. Partial Correlation Coefficients: Equations VII and VIII

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y
X_1	1.000	.258	.254	.772	.366	.678	.455	.219	.314	.576
X_2		1.000	.014	.400	-.012	.449	.011	.184	.548	.539
X_3			1.000	.306	.637	.381	.411	.481	-.033	.087
X_4				1.000	.477	.693	.460	.300	.457	.645
X_5					1.000	.481	.702	.292	.305	.318
X_6						1.000	.589	.175	.463	.637
X_7							1.000	.197	.314	.318
X_8								1.000	-.013	.168
X_9									1.000	.833
Y										1.000
X_{1+2+3}				.669	.594	.699	.480	.489	.291	.480

X_1 = permanent cropland
X_2 = annual cropland
X_3 = pastureland
X_4 = labor
X_5 = capital: buildings
X_6 = capital: equipment
X_7 = capital: productive livestock
X_8 = capital: draft livestock
X_9 = current operating expenditures
X_{1+2+3} = productive land ($X_1 + X_2 + X_3$)
Y = gross farm output

Table 2D. Partial Correlation Coefficients: Equations IX, X and XI

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	Y
X_1	1.000	.220	.073	.676	.403	.528	.239	.239	.517	.633
X_2		1.000	.250	.514	.176	.324	.383	.469	.452	.415
X_3			1.000	.416	.482	.439	.725	.578	.222	.418
X_4				1.000	.635	.717	.544	.519	.681	.801
X_5					1.000	.608	.498	.354	.493	.585
X_6						1.000	.422	.352	.709	.674
X_7							1.000	.531	.376	.631
X_8								1.000	.343	.544
X_9									1.000	.704
Y										1.000
X_{1+2+3}				.678	.571	.578	.725	.677	.505	.660
X_{1+2}			.309	.676	.425	.559	.337	.410	.568	.643

X_1 = permanent cropland
X_2 = annual cropland
X_3 = pastureland
X_4 = labor
X_5 = capital: buildings
X_6 = capital: equipment
X_7 = capital: productive livestock
X_8 = capital: draft livestock
X_9 = current operating expenditures
X_{1+2+3} = productive land ($X_1+X_2+X_3$)
X_{1+2} = land in all crops (X_1+X_2)
Y = gross farm output

Further Statistical Analysis, Equation VI.

Geometric Means

$\bar{X}_1 = 22.4$	$\bar{X}_4 = 942.9$	$\bar{X}_7 = 219.2$
$\bar{X}_2 = 10.5$	$\bar{X}_5 = 800.0$	$\bar{X}_8 = 332.9$
$\bar{X}_3 = 841.8$	$\bar{X}_6 = 586.8$	$\bar{Y} = 1619.1$

Standard Errors of the Partial Regression Coefficients (s_b)

$b_1 \pm .0957$	$b_4 \pm .0630$	$b_7 \mp .1038$
$b_2 \pm .0702$	$b_5 \pm .0579$	$b_8 \mp .0571$
$b_3 \pm .1430$	$b_6 \pm .0393$	

F-test for the Effect of the Independent Variables on R^2

In order to know whether the independent variables are contributing significantly to explain the coefficient of determination, an F-test can be performed based on the expression:

$$F = \frac{R_2^2 - R_1^2}{1 - R_2^2} (n - k - 1)$$ with 1 and n-k-1 degrees of freedom

where,

R_2^2 = coefficient of determination after the addition of the variable considered.

R_1^2 = coefficient of determination before the addition of the variable.

n = total number of observations

k = number of independent variables up to the most recent addition.

Here are the successive coefficients of determination after the addition of each variable:

Variable introduced	Coefficient of determination
X_8	.6133
X_3	.7282
X_6	.7554
X_1	.7644
X_2	.7684
X_4	.7747
X_7	.7800
X_5	.7819

Applying the preceding formula one gets the following F's:

Variable introduced	F	
X_8	170.64**	(with 1 and 72 d.f.)
X_3	30.32**	(with 1 and 71 d.f.)
X_6	7.71*	(with 1 and 70 d.f.).
X_1	2.63	(with 1 and 69 d.f.)
X_2	1.17	(with 1 and 68 d.f.)
X_4	2.08	(with 1 and 67 d.f.)
X_7	1.50	(with 1 and 66 d.f.)
X_5	.60	(with 1 and 65 d.f.)

** significant at .01 level

* significant at .05 level

\+ significant at .10 level

Conclusion: There is a .90 probability that X_8, X_3, and X_6 have added a significant share to the coefficient of determination.

APPENDIX E

THE INPUT PRICES AND THE PROFIT EQUATION

APPENDIX E

THE INPUT PRICES AND THE PROFIT EQUATION

Calculation of the Input Prices

All input and output prices were taken from the questionnaire. But for the variables given in monetary terms, the price of its use had to be computed. This price was equal to the opportunity cost (Cr\$1000) plus an interest rate correspondent to an alternative use of the capital in the case of current operating expenditures. The price for capital investment in buildings, and equipment was at the usual bank interest rate.

In the present case, the same interest rates calculated by Teixeira Filho[1] were used: constructions - .08; equipment - .10; productive livestock - .10; draft livestock - .08; and current operating expenditures - .15. The price of land - Cr\$28,800 - is equal to 8% of the average price of one hectare - Cr\$360,000. For labor, the average price of one working day (10 hours) was used - Cr\$1,110.

The Profit Equation

The general equation employed was:

$$\pi = \bar{Y}P_Y - (\bar{X}_1P_{X_1} + \bar{X}_2P_{X_2} + \ldots\ldots.+ \bar{X}_8P_{X_8})$$

For the 74-observations equation these were the results:

$\bar{Y}P_Y$ = 2619.1 = total farm revenue, during 1963/64, in Cr\$1000.

$\bar{X}_1P_{X_1}$ = (22.4)(360)(.08) = 645.1

22.4 = number of hectares in cropland used during 1963/64 (geometric mean)

1/ Teixeira Filho, A.R., op. cit.

360 = price of one hectare of land, in Cr$1000 (average from sample)

.08 = interest rate (the same used for constructions)

$\overline{X}_2 P_{X_2}$ = (10.5)(360)(.08) = 302.4

10.5 = number of hectares in pastureland used during 1963/64. (geometric mean)

360 = price of one hectare of land, in Cr$1000 (average from sample)

.08 = interest rate

$\overline{X}_3 P_{X_3}$ = (841.8)(1.11) = 934.4

841.8 = number of man/days (10 hours) of labor employed in 1963/64 (geometric mean).

1.11 = price of one man/day of labor, in Cr$1000 (average from sample).

$\overline{X}_4 P_{X_4}$ = (942.9)(.12) = 113.1

942.9 = capital investment in constructions, in Cr$1000 (geometric mean).

.12 = interest rate (.08) + depreciation (.04)

$\overline{X}_5 P_{X_5}$ = (800.0)(.18) = 144.0

800.0 = capital investment in equipment, in Cr$1000 (geometric mean).

.18 = interest rate (.10) + depreciation (.08)

$\overline{X}_6 P_{X_6}$ = (586.8)(.10) = 58.7

586.8 = capital investment in productive livestock, in Cr$1000 (geometric mean).

.10 = interest rate.

$\overline{X}_7 P_{X_7}$ = (219.2)(.08) = 17.5

219.2 = capital investment in draft livestock, in Cr$1000 (geometric mean).

.08 = interest rate.

$\overline{X}_8 P_{X_8}$ = (332.9)(1.15) = 382.8

304.4 = current operating expenditures, in 1963/64, in Cr$1000 (geometric mean).

1.15 = opportunity cost (Cr$1000) plus interest rate

Substituting in the profit equation:

π = 2619.1 - (645.1 + 302.4 + 934.4 + 113.1 + 144.0 + 58.7 + 17.5 + 382.8 =
2619.1 - 2598.0 = 21.1

π = 21.1

A similar procedure was followed for the 64-observation equation (Equation XI) with these results:

π = 2172.5 - [(20.7)(360)(.08) + (12.1)(360)(.08) + (808.4)(1.11) +
(833.9)(.12) + (690.1)(.18) + (615.0)(.10) + (227.6)(.08) +
(227.2)(1.15)] = 2172.5 - (596.2 + 348.5 + 897.3 + 100.1 + 124.2 +
61.5 + 18.2 + 261.3) = 2172.5 - 2407.3 = -234.8

π = -234.8

APPENDIX F

SAMPLE DATA AS USED IN THE SELECTED REGRESSION EQUATION

Table 1F. Sample data as used on the regression equation*

Observation	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
	(ha)	(ha)	(man/days)	(Cr$1000)	(Cr$1000)	(Cr$1000)	(Cr$1000)	(Cr$1000)	(Cr$1000)
1	3	2	200	1082	97	24	30	5	242
2	4	1	318	169	28	151	70	25	714
3	5	1	377	219	1046	121	30	496	953
4	5	1	422	93	40	10	65	183	1131
5	6	1	564	472	227	47	29	127	1007
6	7	2	263	143	52	60	40	86	1027
7	10	1	211	27	857	0 (1)	260	174	644
8	7	4	211	582	68	0 (1)	130	16	444
9	11	1	396	320	88	160	155	109	1711
10	6	6	794	2496	2222	1704	350	742	3860
11	14	1	554	753	1590	0 (1)	160	505	846
12	13	4	661	640	440	730	160	72	1230
13	8	9	211	270	57	425	50	1	594
14	14	4	528	450	422	277	153	223	1583
15	15	3	521	3268	209	1460	280	2632	4693
16	16	4	528	230	337	895	580	34	2170
17	11	10	208	240	45	625	80	128	824
18	20	2	364	150	109	10	70	841	2126
19	18	6	1872	278	606	430	270	137	3054
20	7	19	345	329	142	444	110	153	960
21	4	23	421	120	42	1455	340	40	876
22	15	12	317	152	939	1606	120	215	635
23	21	7	513	1869	550	300	660	93	1654
24	29	2	763	439	1060	239	95	2858	3898
25	9	24	264	135	45	420	230	9	325
26	32	1	734	1671	1888	388	110	403	1301
27	30	3	1130	2366	2833	2138	100	5942	11732
28	31	4	957	2367	4866	5250	130	2504	12267
29	29	7	1079	1361	6941	427	150	912	6731

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
30	24	12	1056	427	1345	972	160	283	4327
31	34	6	1066	2273	9274	2969	174	3098	13149
32	37	3	1764	2781	201	806	279	397	5398
33	16	24	1976	4320	~~3087~~ 3807	2420	160	831	2589
34	18	24	493	910	224	1283	200	341	3111
35	32	10	747	1978	1938	2402	225	5286	13245
36	19	25	713	2420	2588	1387	380	410	2333
37	14	31	461	332	5172	1714	130	274	2172
38	40	5	1471	1165	249	527	580	1292	3271
39	36	10	1426	1125	2200	930	260	296	2286
40	24	22	814	2077	2035	477	340	507	1723
41	6	41	234	2090	182	1058	160	117	1190
42	24	24	856	120	215	223	307	368	809
43	42	6	660	1845	194	162	70	269	1679
44	9	39	413	661	39	2120	320	137	1678
45	36	12	2458	2745	2493	1300	870	600	8318
46	47	3	683	965	373	2412	240	2431	4426
47	13	38	609	314	371	4790	430	63	2892
48	46	6	2614	583	256	1015	450	52	8163
49	48	5	1594	212	472	1315	475	637	4838
50	20	34	1315	1380	4493	240	250	658	2591
51	39	15	1478	578	2013	752	264	831	3245
52	54	1	492	225	43	98	118	121	519
53	22	34	1830	3320	2543	2459	540	544	968
54	50	7	1114	2840	5967	542	230	1294	7715
55	60	4	1834	4674	798	9070	222	10690	23667
56	5	60	248	208	69	2505	320	24	1214
57	11	56	595	180	104	1734	710	29	1058
58	33	34	1981	910	12045	1595	240	446	2415
59	47	24	1248	956	263	1935	800	181	2442
60	10	67	2030	17025	2406	4398	700	445	6271

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y
61	22	74	1872	858	1383	1169	320	545	1410
62	90	10	2282	11885	13954	0 (1)	380	6178	13460
63	98	5	4566	4406	20714	93	290	6926	33116
64	91	12	4316	3000	3324	580	303	893	4569
65	14	97	1738	14300	10310	780	210	60	1972
66	31	95	624	962	8701	~~3180~~ 3280	1010	584	3385
67	39	94	1440	2720	5175	3573	150	432	4300
68	58	80	3086	1996	9605	2310	245	646	7144
69	26	124	610	1432	160	1466	665	91	2335
70	119	46	4224	6212	10597	10005	320	3723	11034
71	123	68	1922	2750	10617	6500	700	978	18785
72	24	174	1685	~~36670~~ 33670	2630	9500	620	1280	5809
73	143	55	2621	497	27571	4970	340	2841	12936
74	95	123	4857	38550	31083	~~10488~~ 104888	560	5178	16740

X_1 = cropland

X_2 = pastureland

X_3 = labor

X_4 = capital investment in buildings and improvements

X_5 = capital investment in equipment

X_6 = capital investment in productive livestock

X_7 = capital investment in draft livestock

X_8 = current operating expenditures

Y = gross farm output

* Equations IX, X and XI (64 observations) excluded the following observations: 15,18,24,27,28,31,35,55,62 and 63.