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RESOURCE ACCUMULATION AND ECONOMIES OF SCALE IN AGRICULTURE THE CASE OF SAO PAULO, BRAZIL

DISSERTATION

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By

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CHAPTER I

INTRODUCTION

The Problem

During the past two decades, most public decision makers throughout the world have been preoccupied with economic development. This is especially apparent in the under-developed nations where economic development is a paramount political issue. The earlier attempts to put backward countries onto the road of development were based on fast industrialization, usually without regard to the development of the agricultural sector as a necessary part of the overall growth effort.

In the late forties, when the underdeveloped nations of the world set out to increase their rate of economic growth, they looked upon the rich nations as their basic example and in so doing, defined economic development as the continuous increase in gross national product. The setting of an increasing gross national product as the primary objective of development led to a series of policy decisions, that at the time, not only seemed logical but were proclaimed as rational by academicians and politicians alike. Among these were the decisions to pursue import substitution industrialization, to drastically reduce international trade, and to maintain low prices for agricultural products in order to reduce wage costs in the industrial sector. These decisions on the whole, were very detrimental to the development of the agricultural sector.

In a large number of countries this approach to development lasted until recently. During the past decade however, a growing awareness of the inadequacy of these policies has brought about some change in the direction of the economic policies. The case of Brazil is very illustrative. Until the early sixties, the country was pursuing a developmental strategy based exclusively on import substitution industrialization. Recently, while still giving incentives to industry, the central government has strongly supported increases in exports, productivity, and production in all sectors of the economy. This more balanced approach to development has benefited agriculture somewhat. The goal of development, however, still remains the same; increased gross national product.

When the objective of development is defined as increased gross national product, questions such as equity, income distribution, and opportunities for the lower income classes are usually put aside. Furthermore, in agriculture this objective usually results in policies oriented toward the commercial sector of agriculture. This sector in the underdeveloped world usually consists of the large plantations or large livestock farms. The underlying reason for this orientation is the assumption of existing economies of scale or size on these farms.

In Brazil this approach to economic policy has resulted in a series of policy options and a changing focus for policy over the past twenty years. The policy options selected appear to be benefiting almost exclusively larger farms.[1] Examples of these policy tools are numerous: highly subsidized credit for "modern inputs" minimum prices considerably above world prices for certain crops (especially wheat); and highly favorable financing arrangements for the acquisition of machinery and for pasture improvement.

While Brazilian agricultural policy during the past twenty years has emphasized the above policy tools the focus of this policy has been geared generally to the solution of a series of supply crises that plagued Brazil

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[1] J. J. C. Engler, "Alternative Enterprise Combinations Under Various Price Policies on Wheat and Cattle Farms in Southern Brazil," unpublished Ph.D. dissertation, Department of Agricultural Economics and Rural Sociology, The Ohio State University, 1971. B. P. Rao, "The Economics of Credit Use in Southern Brazil," unpublished Ph.D. dissertation, Department of Agricultural Economics and Rural Sociology, The Ohio State University, 1970. W. C. Nelson, "An Economic Analysis of Fertilizer Utilization in Southern Brazil," unpublished Ph.D. dissertation, Department of Agricultural Economics and Rural Sociology, The Ohio State University, 1971. Norman Rask, R. L. Meyer, and F. C. Peres, "Credito Agricola e Subsidios a Producao como Instrumentos para o Desenvolvemento da Agricultura Brasileira." Revista Brasileira de Economia, No. 1/73.

during the fifties and early sixties.[2] Whenever there was a supply crisis in the agricultural sector which interfered with the industrialization process the government acted to resolve the crisis, by definition a short run difficulty. To resolve crisis it is necessary to operate mechanisms that react quickly. To a large extent that was the reason for the use of market incentives. Policies that operate through the market (i.e., price, credit, tax incentives, marketing policies) have rapid reactions as contrasted with policies that change the structure of agriculture (i.e., infrastructure, land reform, research, education).

Recently, the government has changed the direction of the general economic policy to one of expansion of production, productivity and exports. The expansion of production requires increases in capital, better technology and widespread access to low cost modern inputs. In an attempt to accomplish these changes heavy reliance is again being put on market incentives although there is considerably more emphasis on the structural aspects specifically education, research, and extension.

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[2]D. W. Adams, "Agricultural Development Strategies in Brazil, 1950-1970," Economics and Sociology Occasional Paper, Department of Agricultural Economics and Rural Sociology, The Ohio State University, September, 1970. G. E. Schuch, The Agricultural Development of Brazil, New York Praeger Press, 1970. G. W. Smith, "Brazilian Agricultural Policy," in the Economy of Brazil, H. Ellis (Ed.), University of California Press, 1969.

Now, as earlier, it is apparent that the rationale for heavy reliance on market incentives is based on an implicit assumption of economies of scale in Brazilian agriculture, that is, it is assumed that large farms are in general more efficient than small farms. A striking example of this assumption is the recent policy decision to finance, again at very favorable rates of interest, the amalgamation of sugar cane farms so that the smaller farms can achieve an "economic scale of operation."

A close look at the meaning of economies of scale as defined by Brazilian policymakers would seem to indicate a confusion between economies of size, as defined by the economies resulting from the increase of one factor of production, namely land, and economies of scale as defined by the economies resulting from the proportional increase of all factors of production.

While these policies which implicitly assume economies of scale have been in operation now for several years, little research has been undertaken to verify the assumptions on which they are based or to test the consequences of their use. For example, information is needed on which types of capital items have been accumulated recently on farms in response to these policies. Has this varied by farm size and enterprise? Second, if the accumulation occurred primarily on the larger farms, was it due to agricultural policies or to the fact that the larger farms are more efficient? Third, are there economies of scale in Brazilian agriculture? If so, in which farm types? This study is primarily concerned with these questions, since improvement in the formulation of future policy criteria can only be achieved through better information and knowledge about the current agricultural structure and the consequences of alternative actions. The analysis will focus on resource allocation and accumulation under the given policy matrix; on the effects of policies on the productivity and economic efficiency of production inputs; and on the determination of the extent of economies of scale on farms of a given region of Brazil.

Objectives

The objectives of this study are twofold:

(1) to analyze the process of capital growth at the farm level in the state of Sao Paulo during the past eleven years (1960-1970) including:
   - interaction of government policies and growth
   - which farms have been more directly affected by these policies
   - an assessment of the probable effects of the continuation of these policies on the farm structure of the study area

(2) to determine if economies of scale exist within

the farm enterprise and size structure of the sample region.

The second objective will focus on the scale impact of agricultural policies on farm resource organization. An optimal farm organization[3] will be determined and the deviations from this optimum will then be compared with the eleven year capital growth analysis. This integrated approach will permit an evaluation of agricultural policies in relation to farm growth, productivity and resource adjustments.

The Area and its Agriculture[4]

The area chosen for this study is situated in the north central part of the state of Sao Paulo, Brazil. The major urban center of the area is Ribeirao Preto, a city with a population of over 200,000 people. The city houses the headquarters of the regional extension office having

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[3]Optimal farm organization is here defined as being that farm organization that given constant factor prices and the existing technology, produces at the minimum point of the average cost curve.

[4]A more complete and detailed description can be found in Perroco, et. al, Aspectos Economicos da Agricultura na Regiodo de Ribeirao Preto, Ano Agricola, 1969-70, ESAL/USP, Piracicaba, November, 1971. And K. L. Wessel and W. C. Nelson, Methodology and General Data Description: Farm Level Capital Formation in Sao Paulo, Brazil, Department of Agricultural Economics and Rural Sociology, Occasional Paper No. 47, The Ohio State University.

responsibility over eighty "municipios."[5] These municipios comprise an agricultural extension administrative region officially known as "Divisao Regional Agricola de Ribeirao Preto" (DIRA).

Three main factors were decisive in choosing this area for the present study. First, there existed sufficient farm diversity to represent policy impact on various resources and enterprise situations; second, the area is representative of the major agricultural systems in the state of Sao Paulo and third, it is a rapidly growing agricultural production area.

The region chosen has approximately 14 percent of the total area in farming in the state of Sao Paulo and about 10 percent of the total number of farms. The range of farm sizes in the region is similar to that of the entire state of Sao Paulo. (Table 1) The area is also representative of the major agricultural enterprises of Sao Paulo (Table 2).

There are 21 soil types in the region. Five of the most important types, however, are found on 86 percent of the total land area. Of these, the soil known locally as "Terra Roxa Legitima" makes up 47 percent of the area. This soil is highly fertile and extremely favorable for

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[5]Municipio is a political subdivision equivalent to a county.

Table 1

Comparison of the Distribution of Rural Properties in the State of Sao Paulo, The DIRA of Ribeirao Preto and the Sample Farms According to Size - 1969[a]

Hectares	Properties Number	Properties Percent	Area Hectares	Area Percent
		(Estate of Sao Paulo)		
-30	186,005	63	1,991,763	9
31-200	89,777	30	650,377	29
200-	20,186	7	13,919,594	62
Total	295,968	100	22,561,456	100
		(DIRA - Ribeirao Preto)		
-30	12,162	45	166,806	5
31-200	11,403	42	901,666	27
200-	3,719	13	2,260,766	68
Total	27,284	100	3,329,248	100
		(Sample Farms)		
-30	69	18	1,372.4	2
31-200	180	47	15,494.1	19
200-	183	35	62,899.4	79
Total	382	100	79,765.9	100

Source: Anuario Estatistico, Sec. de Economia e Planejamento, Sao Paulo, 1969, page 43 and preliminary analysis of field data, 1970.

[a]1970 for the sample farms.

Table 2

Area and Production of Selected Agricultural Products in the State of Sao Paulo and Ribeirao Preto Region, 1970

Crops	Sao Paulo			Ribeirao Preto Area		
	Area (Ha.)	Production (Tons)	Rank Within Brazil in Area[a]	Area (Ha.)	Production (Tons)	Rank Within Sao Paulo in Area[b]
Beans	230,933	128,237	7	16,238	5,820	4
Coffee	762,325	732,000	2	64,400	33,000	3
Corn	1,317,595	2,114,931	3	271,863	390,000	2
Cotton	469,767	551,493	1	76,690	115,050	1
Lemons	1,930[c]	2,570[d]		638	963,000[d]	6
Peanuts	479,193	565,772	1	33,928	40,700	3
Oranges	82,996	6,305,544	1	13,954[c]	585,320	1
Rice	709,017	774,097	4	181,330	132,000	2
Soybeans	47,121	61,010	3	42,471	54,600	1
Sugarcane	495,704	25,887,374	1	197,327	9,354,000	1
Tomatoes	18,400	381,000	1	9,183	126,500	1

[a]There are 22 states within Brazil.

[b]There are nine regions within the state.

[c]1,000 plants/hectare.

[d]Boxes of 40 kg.

Source: (1) Anuario Estatistico Do Brasil, Instituto Brasileiro de Estatistico, (IBGE), Rio de Janeiro, 1970, and (2) Anuario Estatistico De Sao Paulo, Secretaria de Economia e Planejamento, Departmento de Estatistico, Sao Paulo, 1970.

the production of crops such as coffee, cotton, sugar cane, rice, and corn. The remaining soils are somewhat less fertile and are devoted to the production of crops such as citrus, pineapple, peanuts, and bananas.

The topography of the region is generally favorable for agricultural production with gently rolling hills and altitudes varying from 300 to 1,000 meters.

About 60 percent of the region is classified as having a moderate climate with dry winters. The average temperature ranges from 18°C to 22°C, and rainfall varies from 1,100 to 1,700 millimeters annually, falling below 30 millimeters in the driest month. About 30 percent of the area is considered to have a tropical humid climate with rainfall ranging from 1,000 to 1,300 millimeters and with temperatures about 22°C in the warmest months. The remaining 10 percent of the region has a moderate climate with temperatures ranging from 16.5°C to 22°C with a rainfall from 1,300 to 1,700 millimeters.

Nine municipios were selected as being representative of the region. The choice was made on the basis of available agricultural data information and knowledge of local extension personnel. Within the region, sub-areas represent specialization in perennial crops, annual crops, livestock and general farms.

The municipios of Sertaozinho, Pontal, and Batatais were chosen because of their specialization in perennial crops (the first two being in sugar cane and the third in coffee). Guaira, Jardinopolis, Sales de Oliveira, and Altinopolis were chosen because of their specialization in annual crops and Barretos and Colombia because of their specialization in beef production.

Mechanical technology is intensively used throughout this region; the larger farms using mainly power equipment and the smaller farms using mostly animal equipment. In both cases the mechanical technology is restricted to land preparation and tilling, with little harvesting equipment being used. Chemical technology is common with respect to fertilizers and pesticides. Herbicides are rarely used. Modern management methods including cost accounting is restricted to a few of the very large farms.

The overall agricultural policies of Brazil are in full effect in this region. These are minimum prices for practically all crops grown, and subsidized credit for machinery, pasture improvement and "modern inputs" especially fertilizer. Also, specific crop policies are in effect for crops such as coffee and sugar cane. In the case of coffee these policies include highly subsidized and long term credit for new planting and minimum prices closely related to world prices.

For sugar cane they include production quota allotments, minimum prices calculated on a cost plus profit basis[6], and subsidized credit for farm consolidation.

Source of Data

The basic farm data were obtained through a farm survey carried out in the study areas during the month of July, 1970. The questionnaire used included questions on cash flow, inventories, production, production practices, use and types of credit, labor force, family size, educational situation, family consumption, use of family and non-family labor, use of machinery, levels of technology as well as questions on the history of acquisition of land, machinery, livestock, buildings and land and building improvements.

From the land records of IBRA (Brazilian Agarian Reform Institute) sample farms and alternates were randomly chosen. The final choice of individual sample farms was subject to the following criteria: (1) more than 50 percent of the land owned was operated; (2) more than 50 percent of the land operated was devoted to one of the principal enterprises in the region and (3) more than 50 percent of the land was owner operated. Based on these sampling criteria, 382 interviews were carried out during July, 1970.

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[6] Pedroso, I. A. and D. K. Freebairn, "Food Crops vs. Monocultural Cane - The Case of Piracicaba, Sao Paulo, Brazil," Cornell Agricultural Bulletin, No. 13, September 1969, Cornell University, Ithaca, N. Y.

Based on a prior knowledge of agriculture in the area, the sample farms were divided into four size groups as follows:

Group	Hectares	
I	0.1 - 19.9	(small)
II	20.0 - 49.9	(medium)
III	50.0 - 199.9	(large)
IV	200 -	(very large)

With the exception of the municipio of Altinopolis, farms in all four groups in each of the municipios had an average of more land operated than owned. This would indicate a net renting-in of land.

Approximately one-half of the 382 farms in the sample were owner operated. The small farms were almost all operated by their owner. The large farms were operated under various arrangements such as partnerships, owner-operator, and other forms.

Enterprise classification within the sample was determined on the basis of land use ratio and the relative importance of various farm types measured in terms of income share. The land use ratio equals the quotient of cultivated land divided by total land used (cultivated land plus natural pasture land). Based on these quotients four farm types were defined. First, livestock farms, land use ratio smaller than .25; second, mixed farms, land use ratio greater than or equal to .25 and more than 50 percent of the income is generated by livestock sales; annual crop farms, land use ratio equal to or greater than .25, and more than 50 percent of income generated by the sales of annual crops; perennial crop farms, land use ratio equal to or greater than .25, and more than 50 percent of income generated by the sales of perennial crops (sugar cane and coffee).

The distribution of the sample farms according to size and enterprise specialization is shown in Table 3.

Table 3

Stratification of Sample Observations by Farm Size and Type
DIRA - Ribeirao Preto - Brazil, 1970

Enterprise Specialization[a]	Farm Size - (hectares per farm)[b]				
	-19.9	20.0-49.9	50-199.9	200-	Total
Livestock	-	2	9	1	12
Mixed	2	7	32	35	46
Annual	27	43	82	63	215
Perennial	16	23	27	13	79
Total	45	75	150	112	382

Source: DIRA - Ribeirao Preto - survey 1970.

[a]See text page 13 for explanation of criteria used to determine farm type.

[b]Farm size is measured in hectares actually used for crops or pasture.

Analytical Procedures

Two methods of analysis are utilized in studying the growth impact of policies on the farm capital structure of this region. The first is an historical descriptive analysis that traces the changes in capital use and acquisition over the past eleven years, including land, machinery, and improvements. Simple comparisons are made between farm types and sizes on the timing and intensity of capital acquisition and the source from which the capital was financed (i.e. savings, credit).

The second methodology is utilized to determine the existence of varying returns to scale for the farms of the region. Initially, a Cobb-Douglas Production Function is fitted to three types of farms; perennial crops, annual crops, mixed and livestock farms, and the results are utilized to determine if different production techniques and different sub-regions for production exist within the specified region. Secondly, a test is made to define the existence of variant economies of scale for two types of farm activities, annual crops and perennial crops.

The economies of scale analysis is done with the aid of generalized production functions. These functions permit the identification of variant returns to scale within a production function and the identification of the optimum resource combination.

Once the farms with optimal resource organization are identified they are compared with the farm organizations outside the optimum range. The resource constraints that must be relaxed to allow these farms to move to an optimum organization are then identified.

A comparison of the economies of scale analysis with the resource accumulation analysis permits a critique of the general agricultural policies of the country in the last eleven years. It indicates if the policies are geared towards making possible the expansion of control of resources that are limiting the achievement of economies of scale, or if they are in fact making it more difficult for farms to reach an optimum scale organization.

CHAPTER II

ANALYTICAL FRAMEWORK

This chapter presents the two basic methodologies used in the analysis. The discussion begins with a brief literature review followed by a statement of the hypothesis to be tested. Next, the methodology used in the historical description of the capital growth process on the farms is presented. Thirdly, the methodology used in the economies of scale and productivity analysis is developed including both the theoretical aspects and the rationale behind the choice of this particular methodology. Finally, some theoretical background for tests of differences in production functions and a brief description of the variables and economic and statistical models used is given.

Review of Literature

This section reviews briefly some of the major works dealing with returns to scale and input productivity.

Specific studies dealing with variant returns to scale in Brazilian agriculture are not available. However, a considerable number of studies for individual crops using a Cobb-Douglas production function with invariant returns to scale exists. Of these, the most comprehensive is Cline's work.[1] Cline uses an extensive sample of farms from the major agricultural areas of Brazil and analyzes returns to scale for some of the major crops produced in the country. Except for two crops in specific locations, coffee in the state of Sao Paulo and sugar cane in the state of Alagoas, the production functions show constant returns to scale (the sum of the coefficients is equal to one).

Cline analyzes returns to scale as a means of projecting possible consequences of land distribution in Brazil. Finding constant returns to scale in most of the crops analyzed Cline concludes by indicating that significant increases in production would occur if land were distributed in farms of a family size, because the smaller farms use land more intensively. Employment also would increase, since the family farms use labor more intensively.

Cline's methodology however may not be entirely appropriate since it is not valid to arrive at conclusions regarding the degree of returns to scale with an invariant returns to scale production function model. This issue is discussed in more detail later.

A number of less extensive works for individual crops

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[1] Cline, W. R., Economic Consequences of a Land Reform in Brazil, North Holland Publishing Company, Amsterdam 1970.

and/or individual regions are also available for Brazilian agriculture. But as a rule they are either preoccupied with cost of production or input productivity and do not analyze economies of scale.

Cost of production studies are usually done by state or regional institutions as the basis for government supported minimum price programs. Examples of this type of work can be found in the periodical "Agricultura em Sao Paulo"[2] for various years and for several crops. These studies arrive at a different cost per hectare for different farm sizes and different technologies of production using simple cost accounting. In many cases conclusions regarding efficiency of production as measured by per unit cost of output are derived. In general these studies conclude that larger operations using mechanical and chemical technology are producing at lower costs. In all cases these studies use market prices and assume them to be equal for all farm sizes which may cause biased results.

The studies pertaining to factor productivity are also fairly numerous and they always use a Cobb-Douglas production function with invariant returns to scale. As an

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[2]A bulletin published monthly by the Secretaria da Agricultura de Sao Paulo, Brazil.

example, Bizerra's[3] thesis, which analyzes input-output relationship for corn production in Guaira and Jardinopolis, two of the municipios included in this work, is an interesting case. Utilizing a Cobb-Douglas production function Bizerra finds constant returns to scale for the production of corn and variables such as cultivated land and operating expenses explain most of the variation in production. The highest values for marginal products are for cultivated land, improved seed and operating expenses.

In other parts of the world, several analyses dealing with the subject exist. In general however, they deal with economies of size through use of either cost accounting or simulation models. Raup[4] reports briefly on several of the studies for the U.S. Citing a work by Madden,[5] Raup quotes, "In most of the studies, all of the economies of size could be obtained by modern and fully mechanized 1-man or 2-man farms."

The acre size involved in these studies covered a wide range. Based on the conclusions summarized by Madden, Raup indicates:

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[3]Bizerra, J. V., "Analise de Relacoes Factor - Produto na Cultura de Milho em Jardinopolis e Guaira, Estado de Sao Paulo, ano Agricola 1969-1970." M.S. Thesis, ESALO/USP, Piracicaba 1971.

[4]Raup, Philip, "Economies and Diseconomies of Scale of Large Scale Agriculture," American Journal of Agricultural Economics, Vol. 51, No. 5, December 1969.

[5]Madden, J. Patrick, "Economies of Size in Farming," USDA/AER Report 107, February 1967.

In California cling peach production, lowest average costs were achieved by orchards of 90 to 110 acres, if mechanized. In market vegetable crops, farms of 640 acres were almost as efficient as farms up to 2,400 acres and above, if use could be made of custom work for field operations.

In other California field crops, lowest average costs were attained by farms in the 600 to 800 acre range, producing some combination of sugar beets, tomatoes, milo, barley, alfalfa, and safflower. Average costs began to rise slightly for farms of this type above 1,400 acres in size, and (in another location) for farms above 3,000 acres in size, when cotton was included as one of the crop alternatives. For irrigated farms specializing in cotton, the most efficient California farms required four men and 700 to 1,400 acres (depending on soil type). In contrast, Texas irrigated cotton farms achieved lowest average costs with one-man operation on 440 acres. For wheat in Oregon, the one-man unit with 1,600 acres was also as efficient as larger farms.

Van Arsdall and Elder in Illinois used a simulation technique and linear programming to explore economies of size for cash grain and hog-producing farms over a size range requiring one to six men, with various combinations of four-, six-, and eight-row equipment.[6] Total acres ranged from 574 to 3,937 in the cash grain area and 355 to 2,104 in the hog area. Gross income ranged from $54,000 to $438,000.

In cash grain production (corn and soybeans) the efficiency reached by an optimally organized two-man farm, using eight-row equipment on 1,641 acres, was as great as that achieved by larger farms of up to 4,000 acres. In hog production, lowest average cost was achieved by a two-man farm using six-row equipment on 716 acres. Farms of up to 2,000 acres requiring a capital investment of almost one million dollars were

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[6] Van Arsdall, R. N. and W. Elder, Economies of Size of Illinois Cash, Grain, and Hog Farms, Illinois Agricultural Experimental Station Bulletin 933, February 1969.

> included in the model.
> In both cash grain and hog production, the efficiency achieved by one-man farms using eight-row equipment was almost as great as that computed for two-man farms, leading Van Arsdall and Elder to conclude that "...any size of farm considered in this study can compete effectively with the optimal two- or three-man units."[7]
> Although research methods and procedures differ above a two-man scale of operation, the studies show no significant economies or diseconomies of size throughout the size ranges studied.[8]

There are several studies dealing with economies of scale in industry. A monograph edited by Marc Nerlove,[9] for example, discusses returns to scale in electricity generation in the U.S.

For agriculture the only work known to the author, using the same methodology as the present study, is the work of Salkin. Salkin[10] analyzes returns to scale and finds them to vary. Also he calculates a minimum average cost per unit of output for rice production in South Vietnam to indicate the optimum farm size for an agrarian reform program. The details of the methodology used by Salkin are discussed later in this chapter.

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[7]Van Arsdall, R. N., and W. Elder, op. cit.

[8]Raup, P., op. cit. page 1274.

[9]Nerlove, Marc, Estimation and Identification of Cobb-Douglas Production Functions, Rand MacNally & Company, Chicago, 1965.

[10]Salkin, Gary, "Optimal Scale in Rice Production in South Vietnam," Second World Congress of Econometricians, Cambridge, England 1970 (mimeo).

The Hypothesis

This study is concerned with three closely interrelated aspects of agricultural production. First - how has capital been accumulated? On what farms and in what forms? Second - do the production activities of different sizes and types of farms utilize different technologies; i.e. do they have different production functions? Third - if they do, are there different (variant) returns to scale within each class of production technique?

These questions and their interrelationship follow directly from the anticipated impact of agricultural policies to be analyzed in this study.

The specific hypotheses are the following:

(1) It is hypothesized that policies have favored specific farm size and type in the accumulation of resources. Specifically the large farms (as measured by size of land area) and the farms specialized in certain crops (sugar cane and coffee) have had more opportunity to increase resource control than have small farms and those specialized in annual crops.

(2) The second hypothesis is that the input-output relationships are different for different regions, types and sizes of farms.

(3) The third hypothesis is that there are invariant returns to scale within the same production function.

However, if the third hypothesis is rejected, then the returns to scale vary within the same production function and there is an optimum input matrix which may be reached either by relaxing the constraints of resources or by constraining the use of resources to pull back to the optimum. In either case, the analysis will attempt to identify the existence of variant returns to scale. If they exist, an optimum output level will be determined. If the returns to scale are invariant then there is either constant returns to scale in which case any output is optimum or diseconomies occur in which case the smallest output is optimum.

This last aspect is of considerable importance to policy analysis. As already indicated the implicit assumption behind Brazilian agricultural developmental policies is the existence of economies of scale or size in Brazilian agriculture and thus, the largest farm possible should be the optimum farm organization. These assumptions apparently have biased policies to favor large farms and certain types of agricultural activities.

The analysis of Chapter III will describe the resource accumulation process for a period of eleven years for the sample farms. The analysis of Chapter IV will identify different technologies for each class of farm activities and different regions. Subsequently, a test will be made of the hypothesis of invariant returns to scale within each of the different classes of farm activities.

The Methodologies

The methodology utilized in the documentation and comparison of the capital growth process (Chapter III) is descriptive and tabular trend analysis. Tabular presentations indicating machinery and livestock investment, operating expenses, farm receipts and credit use on a per farm and per hectare basis are utilized for comparison across farm sizes and types on the intensity of use of capital, both fixed and variable, and land.

Graphical analysis is utilized to depict the path on a per hectare basis of major types of investments over an eleven year period. Investment credit use is also analyzed through the use of graphs over the eleven year period. Finally, changes in land ownership and control are plotted for the eleven year period.

The methodology employed in Chapter IV is an econometric micro analysis of production. Both classical Cobb-Douglas and generalized production functions are utilized in the analysis.

Generalized production functions are used to test the hypothesis of production relationships occurring with invariant returns to scale. Classical Cobb-Douglas are used for the constant returns to scale analysis. This is due to the form of the Cobb-Douglas production function implicitly assuming constant elasticities of production and of factor substitution.

For example, if a Cobb-Douglas function is fitted to data derived from a sample of farms and the coefficients of elasticities of production add to more or less than one, there are imperfections in the markets and the Cobb-Douglas is not the function that best describes the production function for the particular sample.

Having, by definition, constant elasticities of factor substitution, the Cobb-Douglas production function assumes perfect market conditions for both the factor and product markets and thus implicitly assumes that all farms are operating at the minimum average cost per unit of output.[11] Also assuming profit maximizing behavior the returns to scale and the elasticity of factor substitution must be equal to one.

To overcome the rigidities imposed by invariant returns to scale and unitary elasticity of substitution, recent efforts by several authors have resulted in various forms of more general production functions. Among these are the constant elasticity of substitution function, the

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[11] For a complete description of the Cobb-Douglas characteristics and limitations in the case of agriculture see: Yotopoulos, P. A. : Allocative Efficiency in Economic Development, Center of Planning and Economic Research, Athens, 1967.

class of homothetic isoquant production function, transcendental production function, the variable elasticity of substitution production function, the generalized power production function[12] and the modified Cobb-Douglas production function.[13] All of these functions allow flexibility primarily in the elasticity of substitution but do little to relax the other rigidities imposed on the input-output relationship, an aspect of primary concern to this study.

From a policy point of view one of the most important questions is: are the returns to scale invariant? Further, if they are invariant, do they represent decreasing, constant or increasing returns to scale?

If, on the other hand, the production functions exhibit varying returns to scale that is, some farms are experiencing decreasing returns, others experiencing

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[12] K. T. Arrow, H. B. Chenery, B. S. Minhas and R. M. Solow, "Capital-Labor Substitution and Economic Efficiency," in Arnold Zellner, Economic Statistics and Econometrics (ed.) Little, Brown and Company, Boston 1968. S. Clemhout "The Class of Homothetic Isoquant Production Function," Review of Economic Studies, 35:91, January 1968; A. N. Halter, H. O. Carter and J. B. Hocking, "A Note of the Transcendental Production Function," Journal of Farm Economics, Vol. 39, November 1957.

[13] E. F. Ulveling and L. B. Fletcher, "A Cobb-Douglas Production Function with Variable Returns to Scale," American Journal of Agricultural Economics, Vol. 52, May 1970, and also: A. De Janvry, "The Generalized Power Production Function," in American Journal of Agricultural Economics, Vol. 54, No. 2, May 1972.

constant returns and some increasing, the most relevant question then becomes which ones are operating at the optimum level of output or in other words, at the point of minimum average cost. If however, the production function exhibits constant returns to scale for a group of farms, one must still determine if all have the same level of average cost per unit of output or different levels exist although as a group they show constant returns. These questions cannot be answered by the formulations discussed above but can be answered (within certain limitations imposed by methodological constraints) with production functions that allow for variable returns to scale.

Such functions can be generated by first specifying a returns to scale function. Salkin[14] based on the work of Zellner and Ravenkar[15] specifies a returns to scale function as:

$$A(Y) = Af(1-Y/K)$$

A (Y) is the degree of returns to scale of the conventional production function (if the conventional production function assumes the Cobb-Douglas form, Af is the sum of the exponents of the variable inputs). K is

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[14]Salkin, J. S., "Optimal Scale in Rice Production in South Vietnam," (mimeo) paper presented at the Second World Congress of Econometicians, Cambridge, England, December 1970.

[15]Zellner, A. and Ravenkar, N. S., "Generalized Production Functions," Review of Economic Studies, Vol. 36, April 1969.

an unknown parameter that sets a ceiling on output. As output increases the degree of returns to scale monotonically decreases.

Letting the production function take the Cobb-Douglas form, for i = 1....k inputs X, and Y equal to output, then $A(\prod^{i} X_{ij}^{b_i})^{1/A_j}$ is an index of total cost where A is the returns to scale parameter. Average total cost can be expressed as Z/Y where $Z = A(\prod^{i} X_{ij}^{b_i})^{1/A_j}$ and is constant if Af = 1. Optimum output is indeterminate. If the production function exhibits some returns to scale function, e.g. A(Y) = Af(1-Y/K), K an unknown parameter, then average total cost becomes $Z/Y = (Y/(K-Y))^{1/Af}$, and optimum output is determined by setting $d(Z/Y)/dY = (K^{1/Af}-1)/(K-1)=0$ and solving for optimum $Y^* = K(Af-1)/Af$ if $Af > 1$ and $K > 1$.

Given the above returns to scale function the generalized production function can be derived as[16]

$$\log (Y/(K-Y)) = \log A_o + \sum_{i=1}^{n} b_i \log X_{ij}$$

A_o is the scaling on technical efficiency parameter and the b_i are the elasticities of Y/(K-Y) with respect to the X_i.

A second model used to investigate the possibility of varying degrees of returns to scale is derived from

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[16]Zellner, op. cit.

the returns to scale function:

$$A(Y) = Af/(1+ZY)$$

where $Af = \sum_{i=1}^{n} b_i$, and Z is an unknown parameter. If $Z > 0$ it is easy to verify that A(Y) is a decreasing function of Y. However, Z is not restricted as long as $Z < -1/Y$, i.e., the degree of returns to scale Y cannot be undefined or negative. If the invariant returns to scale production function assumes a Cobb-Douglas form, the Generalized Production Function takes the following formula:[17]

$$Y_{\theta}^{ZY} = A_o X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} \ldots X_n^{b_n}$$

Note that if $Z < 0$, marginal products may increase, if $Z = 0$ the production function reduces to the Cobb-Douglas form.

For this model the minimum average cost level of output is calculated from:

$$Y^* = (Yf-1)/Z$$

Test for Different Production Functions

Commonly, when analyzing production with the aid of production functions, different enterprises and types of farms are used as a single sample. If, however, these farms are producing on different production functions the

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[17] Ramsey, J. B. and P. Zarembka, "Alternative Functional Forms and The Aggregate Production Function," Econometric Workshop Paper No. 6705, Michigan State University, November 1967.

estimates of the elasticities of production coefficients will be biased. It is advisable, consequently to test for different production functions for different type and size enterprises. One test, for checking the equality of the full set of elasticity of production coefficients for two regression models, can be formed by taking the ratio of the sum of residuals of the two subsamples.

In the case of Cobb-Douglas production function in the logarithm form:

$$\log Y_j = \log A + \sum_{i=1}^{b} b_i \log X_{ij}$$

let λ_1 be a column vector $\lambda_1 = \begin{bmatrix} \log A_1 \\ b_{11} \\ b_{21} \\ \cdot \\ \cdot \\ \cdot \\ b_{k1} \end{bmatrix}$

where subscript (1) indicates subsample (1), and

$$\lambda_2 = \begin{bmatrix} \log A_2 \\ b_{12} \\ b_{22} \\ \cdot \\ \cdot \\ \cdot \\ b_{k2} \end{bmatrix}$$

where subscript (2) indicates subsample (2) then the null hypothesis to be tested is H_0: $\lambda_1 = \lambda_2$ against the alternative hypothesis H_A: $\lambda_1 \neq \lambda_2$.

If the null hypothesis is not rejected, the two functions can be written as:

$$\log Y_1 = \log X_1(\quad_1) + E_1$$

$$\log Y_2 = \log X_2(\quad_2) + E_2$$

where X_1 is a (nxk) matrix, with (n) number of observations and X_2 is a (mxk) matrix, with (m) number of observations.

Af ratio is formed

$$F = \frac{\frac{A - B - C}{k}}{\frac{B + C}{(m + n - 2k)}}$$

and tested against the critical value of F(k, m+n-2k,), where,

A - is the sum of squares of the residuals of the pooled samples with (m+n) observations.

B - is the sum of squares of residuals of the first subsample with (m) observations.

C - is the sum of residuals of the second subsample with (n) observations.

K - is the number of independent variables in each subsample including the constant term.[18]

The Variables

The analytical work that follows is based on seven

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[18]For a detailed information see G. C. Chow, "Tests of Equality Between Subsets of Coefficients in Two Linear Regressions," Econometrica, 28, 1960, pp. 591-605.

variables. The dependent variable (Y) is gross output and is defined as the sum of the values of crop sales, livestock product sales, family farm privileges, hired labor privileges, livestock inventory changes, and rental payments made in kind minus livestock purchases.

The independent variables are six in number and are defined as follows:[19]

X_1 - hectares of cultivated land

X_2 - hectares of natural pasture land

X_3 - man month equivalent of family labor utilized in production

X_4 - man month equivalent of hired labor (both temporary and permanent)

X_5 - a 12 percent service flow of capital inputs (machinery, buildings and livestock, both production and work livestock)

X_6 - operating expenses.

The Models

Economic Models

Three economic models are used in this work. The first is a production function of the Cobb-Douglas

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[19]For a complete description of the variables see Appendix B.

formula:

$$Y_j = AX_{1j}^{b_1} X_{2j}^{b_2} X_{3j}^{b_3} X_{4j}^{b_4} X_{5j}^{b_5} X_{6j}^{b_6}$$

Where Y is the output; X_1, cultivated land; X_2, natural pasture land; X_3, total family labor; X_4, total hired labor; X_5, flow of capital input; and X_6, operating expenses.

The second economic model is composed of the returns to scale function:

$$A(Y) = Af(1-Y/K)$$

where A(Y) is the degree of returns to scale at some level of output, Y. Af is scale of the given neoclassical production function, K is an unknown parameter that sets a ceiling in output. From this function a generalized production function can be derived:[20]

$$Y/(K-Y) = AX_{1j}^{b_1} X_{2j}^{b_2} X_{3j}^{b_3} X_{4j}^{b_4} X_{5j}^{b_5} X_{6j}^{b_6}$$

Where A is the scaling or technical efficiency parameter, and the b_i are the elasticities of Y/(K-Y) with respect to cultivated land, natural pasture land, total family labor, total hired labor, flow of capital input and operating expenses.

The third economic model is composed of the return to scale function:

$$A(Y) = Af/(1+ZY)$$

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[20] Salkin, J., op. cit.

where, as for the previous model, $Af = \sum_{i=1}^{6} b_i$. From this scale function the following generalized production function is derived:[21]

$$Y_e^{ZY} = A\ X_{1j}^{b_1}\ X_{2j}^{b_2}\ X_{3j}^{b_3}\ X_{4j}^{b_4}\ X_{5j}^{b_5}\ X_{6j}^{b_6}$$

where the X's are defined as for the previous model.

Statistical Models

For the first model the estimation requires the specification of a statistical model of the following formula:

$$\log Y = \log A + b_1 \log X_{1j} + b_2 \log X_{2j} + b_3 \log X_{3j} + b_4 \log X_{4j} + b_5 \log X_{5j} + b_6 \log X_{6j} + u_j$$

This statistical model can be estimated through the use of ordinary least squares provided that the error term is normally distributed with mean equal to zero and variance equal to $\sigma^2 I$. Assuming farmers are maximizing expected profits and that the inputs are determined exogenously as do Zellner, Kmenta, and Dreze[22] it is possible to estimate the production function by ordinary least squares.

The estimation of the second and third model requires the use of maximum likelihood estimates techniques due to

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[21] Zellner, A. and N. S. Ravenkar, op. cit.

[22] Zellner, A., J. Kmenta and J. Dreze, "Specification and Estimation of Cobb-Douglas Production Function Models," Econometrica, Vol. 34, October 1965.

the fact that the models are nonlinear.

For the second model the statistical estimation procedures require a logarithmic transformation and the specification of an error structure, which yield the following equation:[23]

$$\log \left(Y_j/(K-Y_j)\right) = \log A + \sum_{i=1}^{6} b_i X_{ij} + u_j$$

The error term is assumed independent with mean equal to zero and variance equal to σ^2. By assuming that all farms maximize expected profits, and perfect market conditions, it is possible to show that the input variables are distributed independently of the production function's disturbance term. Thus single equation techniques will yield consistent and assyntotically unbiased estimates of the production function parameters.[24]

The maximized log likelihood function is:[25]

$$\log \max (K) = \text{const.} + N\log K - N\log (K-Y_j) - (N/2)\log \hat{\sigma}^2$$

Via an interactive procedure various arbitrarious values of K are inserted in the generalized production function and then the same K and the respectives $\hat{\sigma}^2$ of the generalized production function are inserted in the maximized log likelihood function. The K that maximizes

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[23]Salkin, J., op. cit.

[24]Zellner, A., J. Kmenta and J. Dreze, op. cit.

[25]Salkin, J., op. cit.

the log likelihood function is the maximum likelihood estimate of K. At this point the parameters of the generalized production function are also the maximum likelihood estimates of the function's parameters.

Plotting on a graph the values of the maximized log likelihood function against the K values it is possible to depict the path of the maximized log likelihood function and though the following formula:

$$\log \max (\hat{K}) - \log \max (K) < \tfrac{1}{2} \chi^2 (.05) = 1.92$$

determine an approximate five percent confidence interval for K.

If the confidence interval for K bounds K in the positive range the null hypothesis that the degree of returns to scale are invariant can be rejected.

For the third model the statistical estimation requires first a logarithmic transformation and the specification of an error structure similar and with the same characteristics of the previous model. The logarithmic transformation yields the following statistical model:[26]

$$\log (Y_j^{\theta Z Y_j}) = \log A + \sum_{i=1}^{6} b_i \log X_{ij} + u_j$$

In a manner analogous to that employed in the previous model, various values of Z are inserted into the above

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[26]Ramsey, J. B., and P. Zarembka, "Alternative Functional Forms and the Agregate Production Form," Econometrics Workshop Paper No. 6705, Michigan State University, November 1967.

regression model and the equations parameters are estimated. The Z and the sum of squared residuals resulting from the various estimates of the above equation are inserted in the following maximized log likelihood function:[27]

Plotting the values of the maximized log likelihood function the maximum likelihood estimate of Z, $\hat{Z}$ is obtained. At that point the parameters of the function are also the maximum likelihood estimates of the function's parameters.[28] In the same manner described previously a 95 percent confidence interval for Z can be obtained. If the confidence interval bounds Z in the positive range the null hypothesis which implies that the production function has invariant returns to scale can be rejected.

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[27]Salkin, J., op. cit.

[28]Box, G. E. P. and D. R. Cox, "An Analysis of Transformations," Journal of the Royal Statistical Society, Series B, Vol. 26, 1964.

CHAPTER III

FORM AND INTENSITY OF RESOURCE ACCUMULATION

This chapter reports on the changes in capital use and acquisition during an eleven year period.

Comparisons between farm types and sizes on the timing and intensity of major capital acquisitions (land, machinery and improvements) permit an appraisal of farm growth and policy impacts on agricultural resource accumulation.

First, a background statement is presented which treats some theoretical and empirical studies relating agricultural structure and policy to farm growth.

A series of studies has shown that all farmers (especially small farmers) have not shared equally in the significant growth that has occurred recently in many countries.[1] The reasons for unequal growth are many. For example, economic growth at the farm level usually occurs in an environment that is formed by the interaction of three basic factors; the nature of technology, the institutional system and public policy. The agricultural

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[1]Adams, D. W. and E. W. Coward Jr., "Small Farmer Development Strategies: A Seminar Report," The Agricultural Development Council, July, 1972.

institutional system has a significant influence upon the nature of technological change and in the speed of its adoption. Public policies that alter price relationships, both for factor and products or alter capital constraints will influence also the direction and speed of the growth process.[2]

The impact of the interaction of these factors on the growth of farms can be different also. In general, small family farms do not take advantage of the on going growth. This is especially true in situations where both small and large farms are operating within a given region. Programs for speeding development are usually more complex in these bimodal rural societies than in unimodal societies.[3] In general, this is true due to the fact that policies designed for development are based on the assumptions of modern economic theory, and these assumptions are not necessarily valid for areas characterized by a very heterogeneous agricultural sector (heterogeneous is here defined in terms of significant size and technology

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[2]Rask, N., "The Differential Impact of Growth Policy on the Small Farmer of Southern Brazil," Purdue Workshop on Empirical Studies of Small Farm Agriculture in Developing Nations, Purdue University, West Lafayette, Indiana, November 13-15, 1972.

[3]The term unimodal is used here in the sense defined by Rask (op.cit.) as characterizing a system in which farm size was uniform and institutional services and technology were evenly distributed. Bimodal represents a skewed distribution of land holding with economic and political power concentrated in the hands of large land owners.

differences among farms).

As suggested by Gotsch,[4] small farms should be studied within the context of the policy and economical environment in which they exist. Gotsch hypothesizes that on the basis of combinations of different technology, farm sizes and policy framework, comparative studies will reveal a number of distinct types of development situations. The policy environment in Brazil, according to Rask,[5] can be classified as one using the "filter down approach" to policy. This approach is the one that used national agricultural development policy tools with essentially no specific programs for the small farms.

The area in which this farm survey was taken can be characterized as a bimodal area (see Table 1), and thus is ideal for the analysis of the different impacts of a given policy matrix on farms of different sizes employing different technologies. This analysis will illuminate some aspects of the differential impact of policies on the growth of these farms.

The Bimodal Farming System

From the original sample described in Chapter I,

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[4] Gotsch, C. H., "Technical Change and the Distribution of Income in Rural Areas," American Journal of Agricultural Economics, Vol. 54, No. 2, May, 1972.

[5] Rask, N., op. cit.

eleven sub-samples were defined based on a division by size and activity. The activities and sizes used are those defined in Chapter I. However, two groups of activities, pasture livestock and mixed farms did not have enough observations within each specific size group to permit a division by farm size. Thus, pasture livestock is analyzed as one group and mixed farms are divided into two groups by size; large and very large. The annual crop farms and perennial crop farms are divided in four groups by size; small, medium, large, and very large.

Modern technology is available in many forms in the region. Pesticides, herbicides, fertilizer and mechanical technology are commonly used. However, mechanical technology has been developed in the form of large size equipment and power sources. Thus, the smaller farms find it more difficult to own machinery and must rely on custom hiring. Lack of significant economic response by existing varieties to additional fertilizer use has been reported for the area in a detailed study by Nelson.[6]

As mentioned earlier, agricultural policy affecting the study area can be considered a filter down approach. Briefly, this approach is composed of an expanded supply of low interest rate credit, special credit terms for the

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[6]Nelson, W., op. cit.

acquisition of machinery, minimum prices and in the case of sugar cane and coffee some specific policies as already indicated.

In this framework several of the factors suggested by Gotsch[7] can be identified as contributing to differential rates of growth. An interaction of mechanical technology which includes economies of scale, special credit services and more economically efficient service institutions could result in lower costs and easier access to technological inputs. Lower interest rates should stimulate demand for credit by all farmers, while on the supply side, cost of service, supply of funds, repayment guarantees and bankers preferences should determine whether equitable distribution occurs.[8]

In the next section, farm data is presented to show the differences in use of inputs, levels of output and use of credit, and to observe the investments made in capital items (land, buildings, improvements, and machinery over an eleven year period).

Capital Composition and Use

Farm data on investment expenses and gross income measures are presented in Table 4. To permit capital use

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[7] Gotsch, C. H., op. cit.

[8] Rask, N., op. cit.

Table 4

Selected Characteristics of Sample Farms by Farm Size and Type - 382 Farms - DIRA - Ribeirao Preto - 1970

Characteristic[a]	Pasture Livestock Farms	Large Mixed Farms	Very Large Mixed Farms	Small Annual Farms	Medium Annual Farms	Large Annual Farms	Very Large Annual Farms	Small Perennial Farms	Medium Perennial Farms	Large Perennial Farms	Very Large Perennial Farms
Number of observations	12	32	35	27	43	82	63	16	23	27	13
Land Use (ha)						(Average per Farm)					
Total hectares Operated	133.00	178.00	798.00	20.00	38.00	136.00	596.00	16.00	42.00	109.00	408.00
Agricultural Land	120.00	121.00	701.00	13.00	32.00	113.00	544.00	15.00	37.00	102.00	371.00
Cultivated	17.00	85.00	623.00	13.00	29.00	92.00	436.00	13.00	35.00	82.00	317.00
Pasture	103.00	36.00	78.00	0.00	3.00	20.00	108.00	2.00	2.00	20.00	53.00
Livestock & Machinery Investment (cruzeiros)											
Machinery	10,615.00	15,094.00	174,254.00	2,620.00	11,413.00	50,979.00	131,097.00	4,905.00	15,807.00	74,214.00	86,192.00
Livestock	22,227.00	42,810.00	273,360.00	5,984.00	8,107.00	22,765.00	75,484.00	4,179.00	7,559.00	13,672.00	26,483.00
Operating Expenses (cruzeiros)											
Crop	1,629.00	1,736.00	13,471.00	1,054.00	3,263.00	9,724.00	43,728.00	1,242.00	3,171.00	8,123.00	31,012.00
Custom Hire	539.00	686.00	1,778.00	365.00	902.00	1,227.00	2,466.00	204.00	622.00	2,272.00	1,461.00
Machinery	807.00	2,582.00	7,178.00	185.00	1,903.00	6,000.00	20,748.00	917.00	3,926.00	6,450.00	28,477.00
Livestock	2,505.00	2,208.00	8,693.00	14.00	425.00	1,703.00	5,203.00	117.00	245.00	883.00	1,724.00
Other	388.00	1,157.00	4,581.00	194.00	710.00	1,800.00	12,083.00	349.00	1,195.00	1,979.00	10,072.00
Total Operating	5,818.00	8,019.00	35,702.00	1,812.00	7,203.00	20,454.00	84,223.00	2,828.00	9,159.00	19,707.00	72,747.00
Farm Receipts	15,758.00	26,673.00	135,698.00	4,977.37	14,400.37	50,886.00	167,407.50	8,946.00	20,796.00	41,109.00	237,711.00
Int. Expenses	32.00	368.00	1,168.00	74.00	262.00	1,200.00	6,042.00	90.00	63.00	554.00	695.00

Source: DIRA - Ribeirao Preto - survey - 1970.

[a]See appendix for definition of characteristics.

intensity comparison, the same data are presented on a per hectare of agricultural land basis (pasture plus cultivated land) in Table 5.

Five basic trends are apparent from the information in Table 5. First, crop, livestock and "other" operating expenses per hectare do not vary significantly across types except for pasture livestock and mixed farms. Second, custom hire expense is high for the annual farms of all sizes when compared with all other types except for the large perennial crop-farms. Third, although machinery expense does not show a clear trend, intensity of machinery expense is greater on annual and perennial medium size farms. Fourth, machinery investment does not vary significantly for the very large farms across farm types, but both the large annual farms and the large perennial farms have invested considerably more in machinery than any other type or size. Fifth, livestock investment is considerably larger on the smaller farms, both perennial and annual and the small farms show the largest per hectare investment in livestock of all types and sizes analyzed. Sixth, farm receipts per hectare decline as size of farms increases for all types.

Some preliminary conclusions can be drawn from this analysis. The machinery investment per hectare would indicate that on the whole access to machinery acquisition is not limited by type or even size of farms. Also it is

Table 5

Investment, Expenses and Farm Receipts Per Agricultural Hectare by Farm Size and Type - 382 Sample Farms - DIRA - Ribeirao Preto-1970

Farm Type and Size	Investments		Operating Expenses					Farm Receipts	Int. Expenses
	Machinery	Livestock	Crop	Custom Hire	Machinery	Livestock	Other		
Pasture Livestock	88.00	184.00	13.00	4.00	7.00	21.00	3.00	131.00	.24
Mixed									
Large	125.00	354.00	15.00	6.00	21.00	18.00	9.00	220.00	3.00
Very Large	249.00	390.00	19.00	2.50	10.00	12.00	6.50	194.00	2.00
Annual									
Small	196.00	449.00	79.00	27.00	14.00	1.00	15.00	375.00	6.00
Medium	357.00	254.00	102.00	28.00	60.00	13.00	22.00	451.00	8.00
Large	452.00	202.00	86.00	11.00	53.00	15.00	16.00	451.00	11.00
Very Large	241.00	139.00	80.00	4.50	38.00	9.50	22.00	307.00	11.00
Perennial									
Small	333.00	284.00	84.00	14.00	62.00	8.00	24.00	607.00	6.00
Medium	428.00	209.00	86.00	17.00	106.00	7.00	32.00	563.00	2.00
Large	728.00	134.00	79.00	22.00	63.00	9.00	17.00	402.00	5.00
Very Large	233.00	71.00	76.00	4.00	77.00	5.00	27.00	144.00	2.00

Source: Table 4.

conceivable that the "large" farms are at a size limit in which mechanization becomes quite attractive since both the large annual and perennial farms not only have the highest machinery investment per hectare, but also the large perennial has the highest value for custom hiring. One could also assume that the heavier reliance on custom hiring on the part of all annual farms is indicative of a less critical timing problem for the performance of production tasks. On the other hand, all perennial crop farms have the same basic crops, sugar cane and coffee. Thus, timing of critical tasks such as planting and harvesting occur at about the same time. The annual crop farms with different enterprises (cotton, rice, corn, soybeans) have greater timing flexibility and consequently rely more on custom hiring.

Farm receipts increase from the small to large annual crop farms and seem to stabilize for the very large annual crop farms. The perennial crop farms present a similar pattern but at higher values, except for the very large perennial crop farms where receipts are not only lower than for the large perennial, but also lower than for the very large annual crop farms. This result may indicate that size has an effect on efficiency, an aspect to be analyzed in the second part of the study.

In view of the substantial differences in operating expenses across sizes it is interesting to note the differential use of credit as measured by interest expense per hectare. It rises from 2.00 cruzeiros per hectare for the small farms to 11.00 cruzeiros for the very large farms and the difference between the large and very large farms is not significant. These figures indicate that credit is a considerable part of the financing of operating expenses.

For the perennial crops the results are more inconclusive, since there is no real consistency. However, it is apparent that the perennial crop farms rely less on credit than do the annual crop farmers. The analysis of the next section seems to confirm this observation.

Major Investments and Source of Finance (1960-1970)

Four major categories of investment are analyzed for the eleven year period 1960-1970. They are land improvements, building improvements, including new buildings, machinery purchase and land purchases. Land rentals are also analyzed as a form of increasing control over land resources. The year by year investment for machinery, land improvements and building improvements are analyzed on a cruzeiros per hectare basis to permit a direct comparison across farm sizes. Also, in order to reduce extreme variation on a year to year basis, a three year moving average which eliminates the first and last year from the analysis is used. Land purchase and rental are examined as a percentage of land owned in 1960. This permits a direct comparison across sizes.

The source of finance is divided into savings (own financial resources) and credit (both formal and informal) and is measured as a percentage of the total value invested for each category of investment for the eleven year period.

The pattern of investment for machinery, land improvement and building improvement is presented in Figures 1 through 3.

Three major trends are clearly indicated in this analysis. They are:

(1) Levels of investment are much greater on crop farms than on livestock farms.

(2) Among the capital items, machinery accounts for the greatest investment outlay, especially on the crop farms.

(3) A definite sequence of machinery acquisition is apparent by farm size.

The livestock and mixed farms maintained a very low and stable pattern of investment for all three items analyzed. Apparently, these farms are simply maintaining their capital stock and do not show significant increasing trends.

The perennial crop farms show considerably higher levels of investment when compared with the annual farms. On the whole, the small farms make their major machinery investment seven to nine years later than do the very large

FIGURE I

Major Capital Investments Per Hectare on Pasture Livestock and Mixed Crops and Livestock Farms. DIRA-Ribeirao Preto 1960-1970

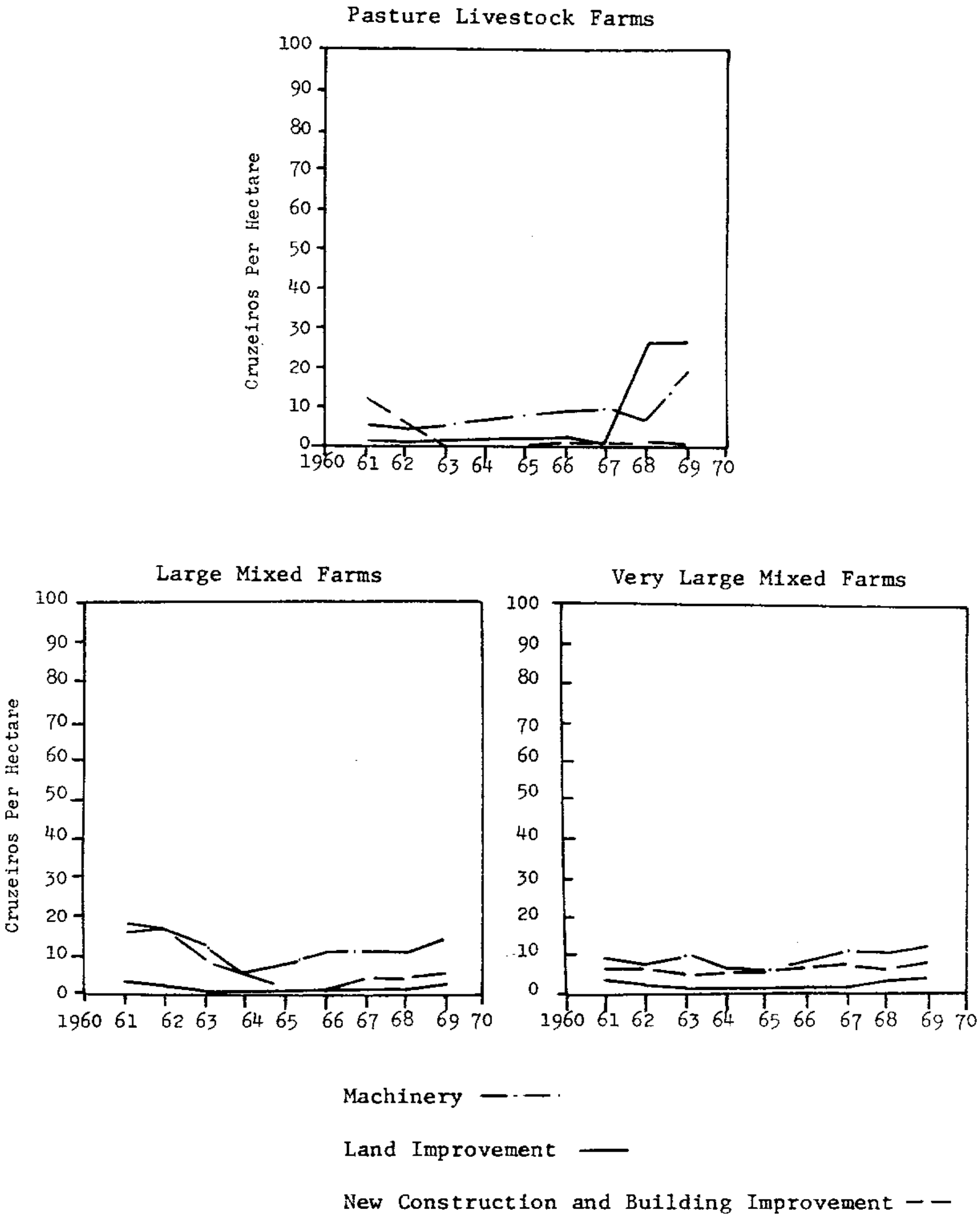
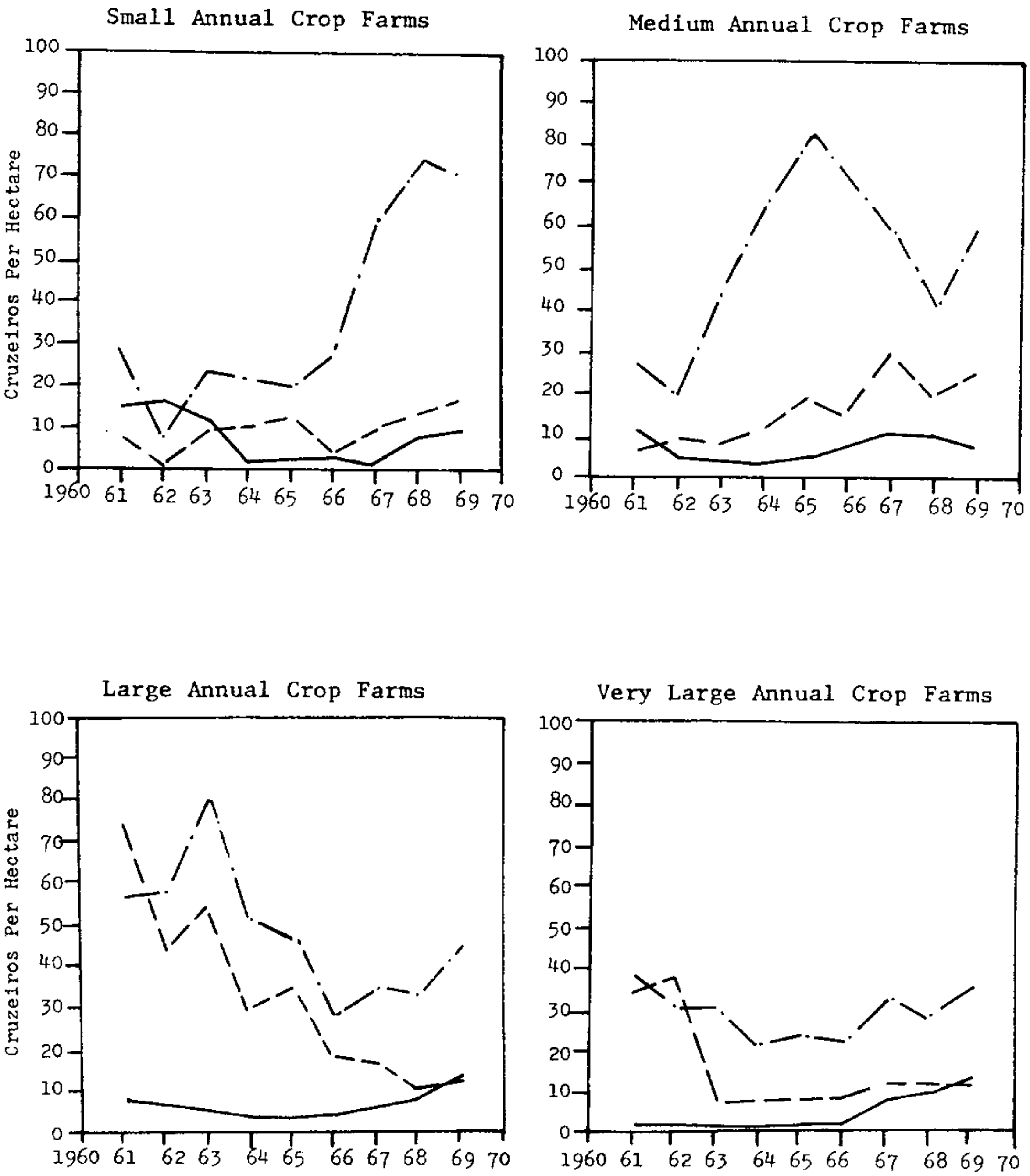


FIGURE II

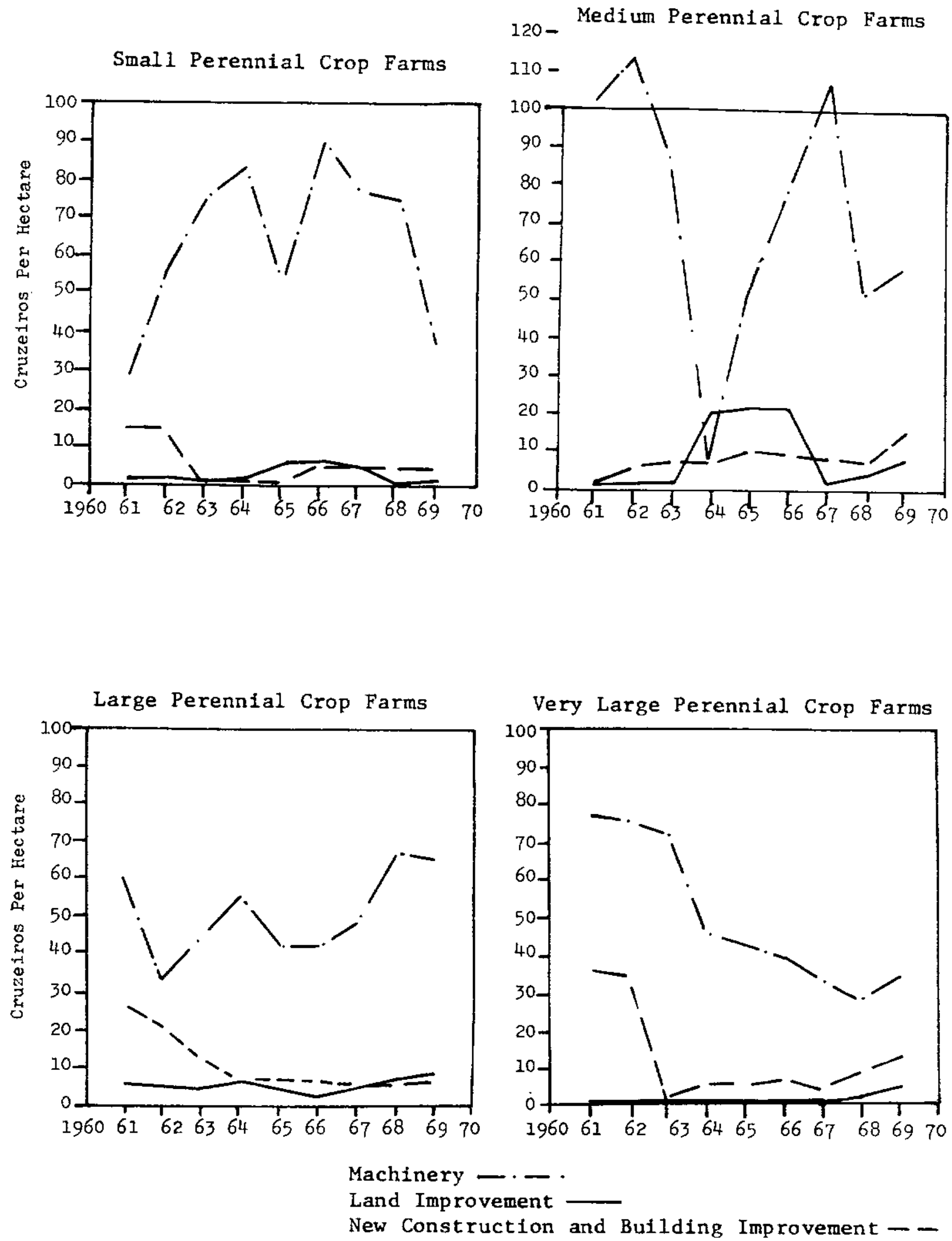
Major Capital Investments Per Hectare on Annual Crop Farms - DIRA-Ribeirao Preto 1960-1970



Machinery —·—·
Land Improvement ——
New Construction and Building Improvement — —

FIGURE III

Major Capital Investment Per Hectare on Perennial Crop Farms
DIRA-Ribeirao Preto 1960-1970



farms. The medium farms make their major machinery investment two to three years after the large farms.

The very large perennial farms have a high rate of investment at 1960-1961 and the rate declines continuously afterwards.

Another form of capital that has been acquired by many farms during this period is additional land. Rental of land increased control of this resource as well.

Land acquisitions and rentals for the sample farms are shown in Figures 4 to 6. As in the previous analysis the pasture livestock and mixed farms are fairly stable in their land control, except for the very large mixed farms that show a slight increase in land rented in at the end of the period analyzed.

The annual crop farms show a significant increase in land operated for all sizes, with the small farms having the largest percentage increase, doubling the land operated during the eleven year period.

The small and medium perennial crop farms have their land basis reduced in size during the eleven year period while the large and very large increased their land basis.

Figure 7 indicates the sources of financing for the types of investments analyzed.

On the whole, the annual crop farms are the heavier users of credit, while the perennial crop farms use the least. The majority of the investment credit for all farms

FIGURE IV

Land Owned and Operated as Percentage of Land Owned in 1960-
Pasture Livestock Farms and Mixed Crop and Livestock Farms-
DIRA-Ribeirao Preto 1960-1970

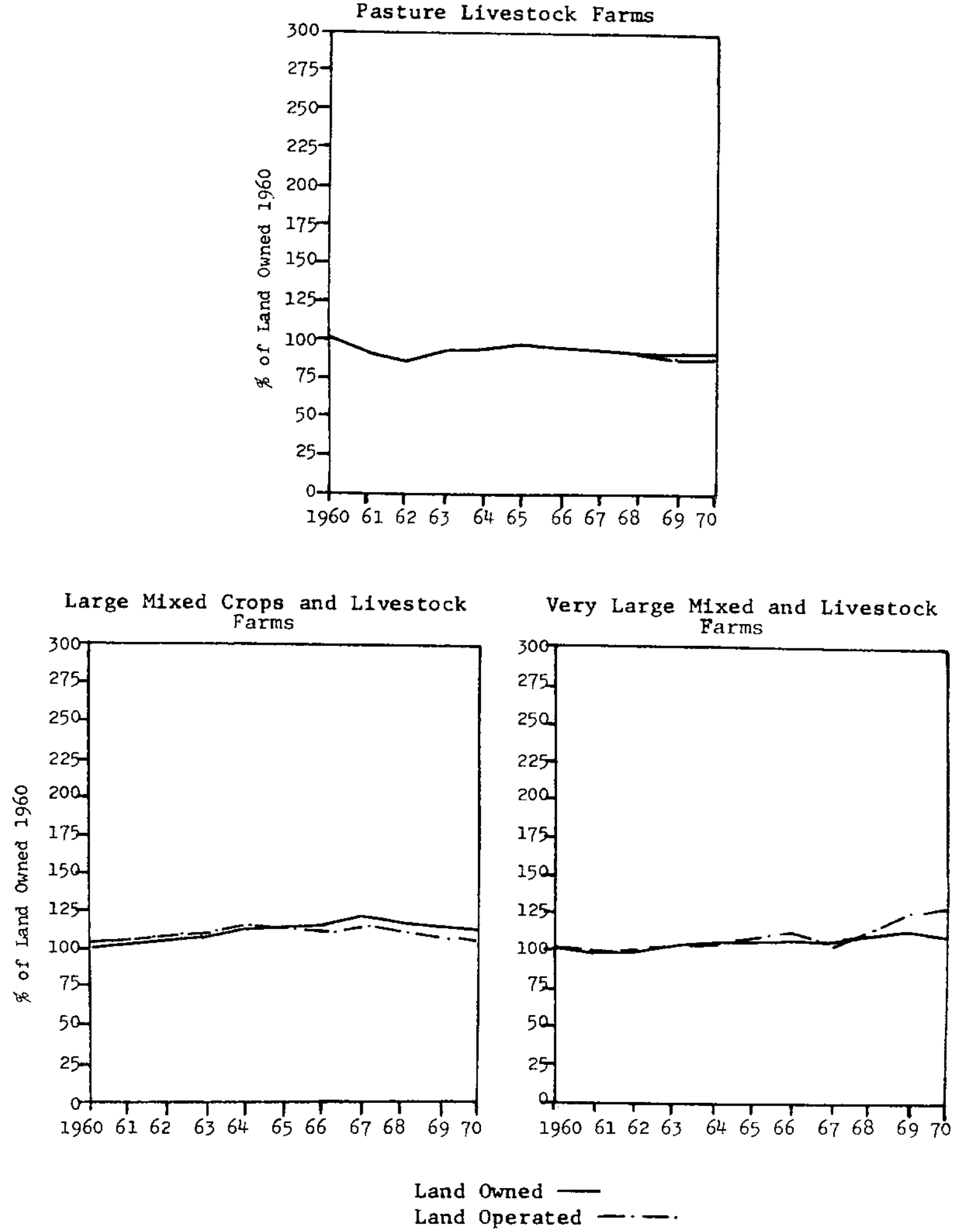


FIGURE V
Land Owned and Operated as Percentage of Land Owned in 1960 on Annual Crop Farms - DIRA-Ribeirao Preto 1960-1970

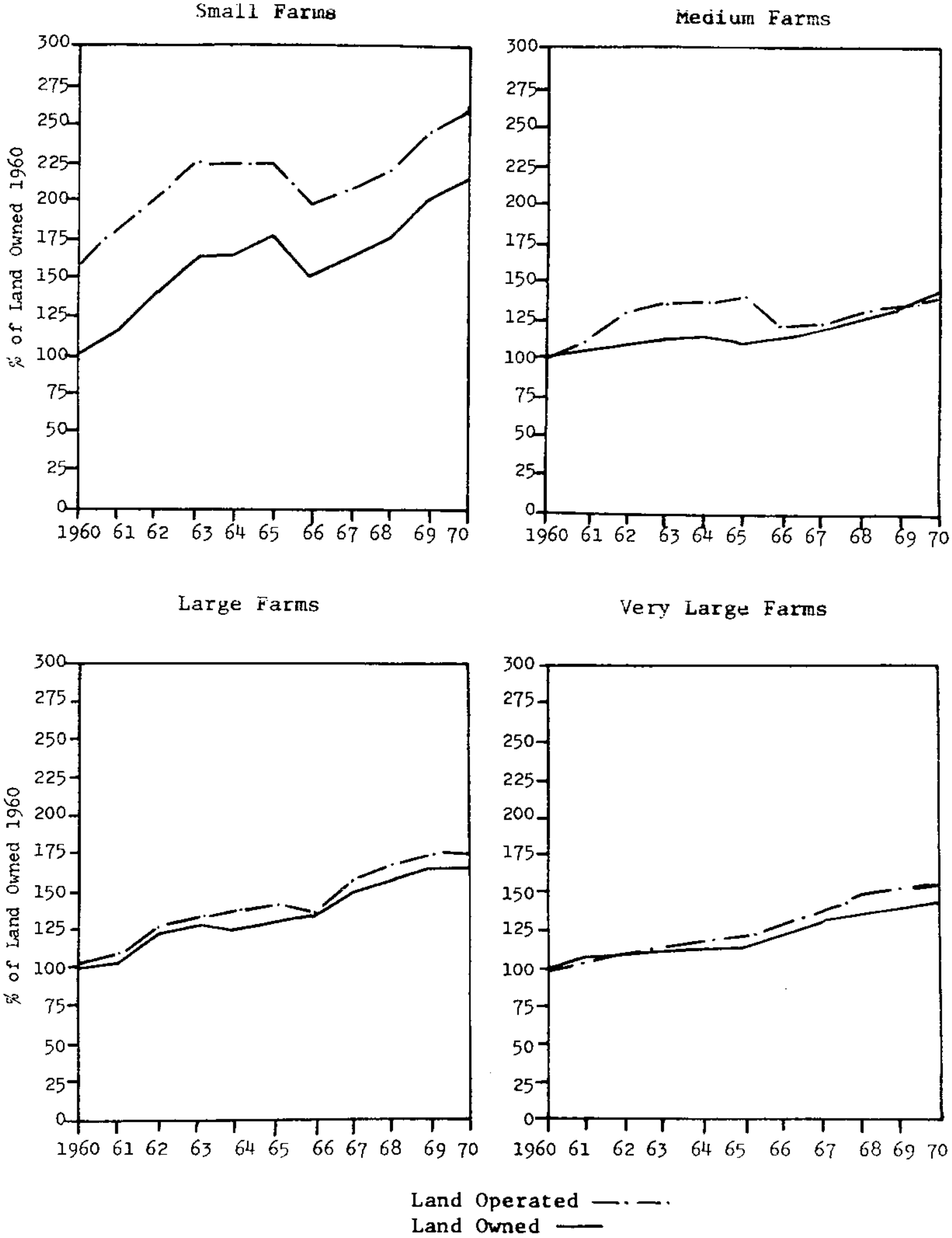


FIGURE VI

Land Owned and Operated as Percentage of Land Owned in 1960 on Perennial Crop Farms - DIRA-Ribeirao Preto 1960-1970

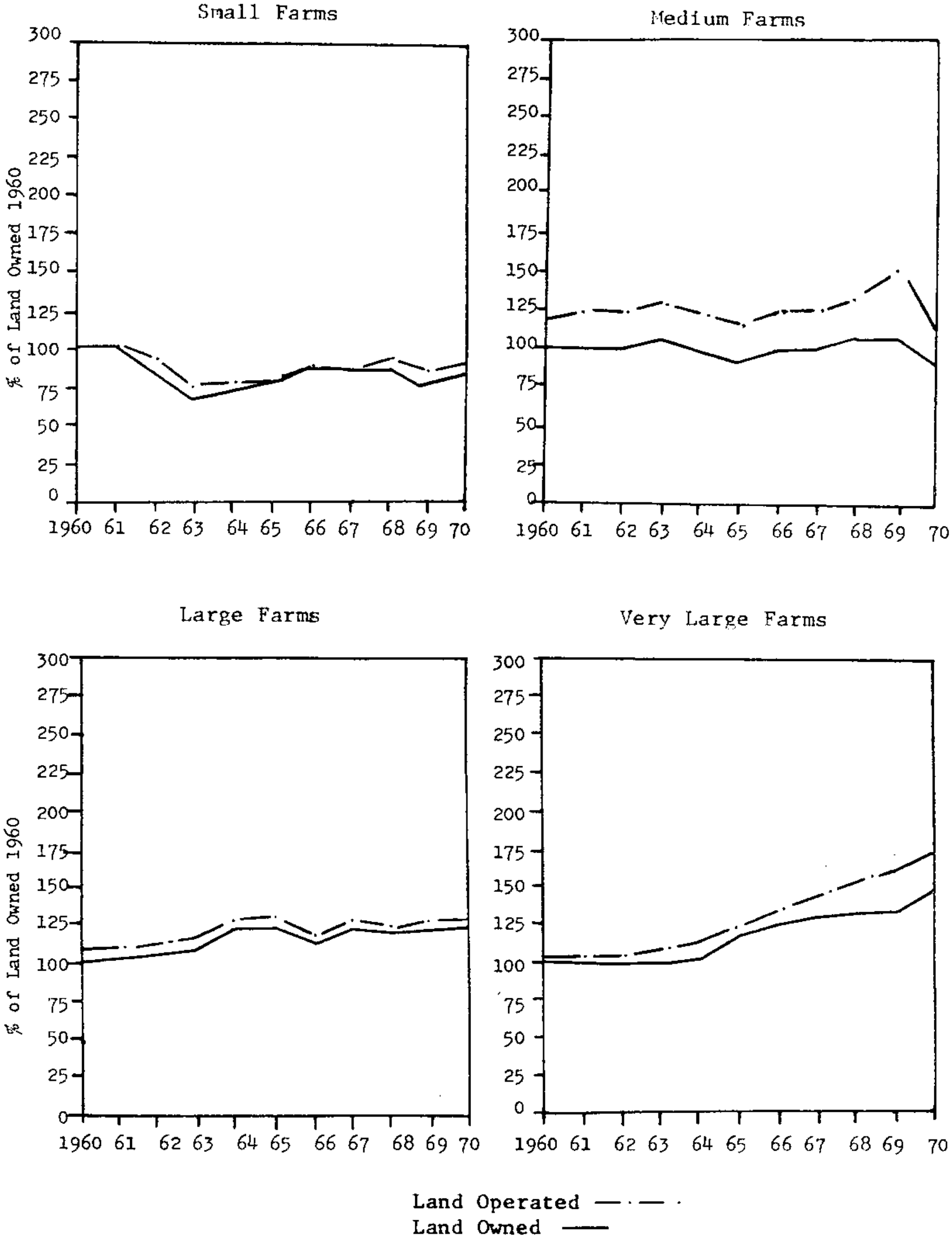


FIGURE VII

Source of Funds for Major Capital Investments as Percentage of Total Capital Investments - DIRA-Ribeirao Preto 1960-1970

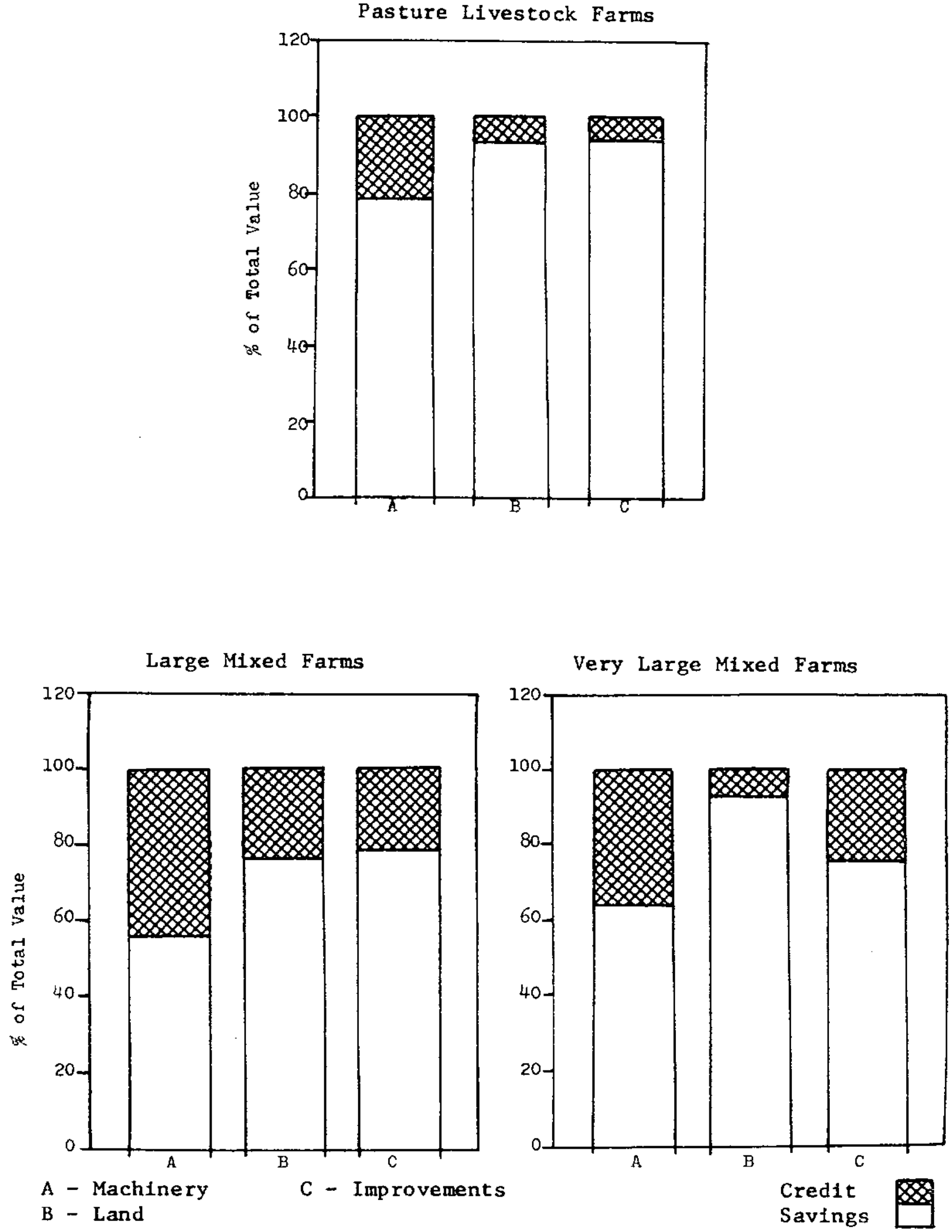


FIGURE VII (continued)
Source of Funds for Major Capital Investments as Percentage of Total Capital Investments - DIRA-Ribeirao Preto 1960-1970

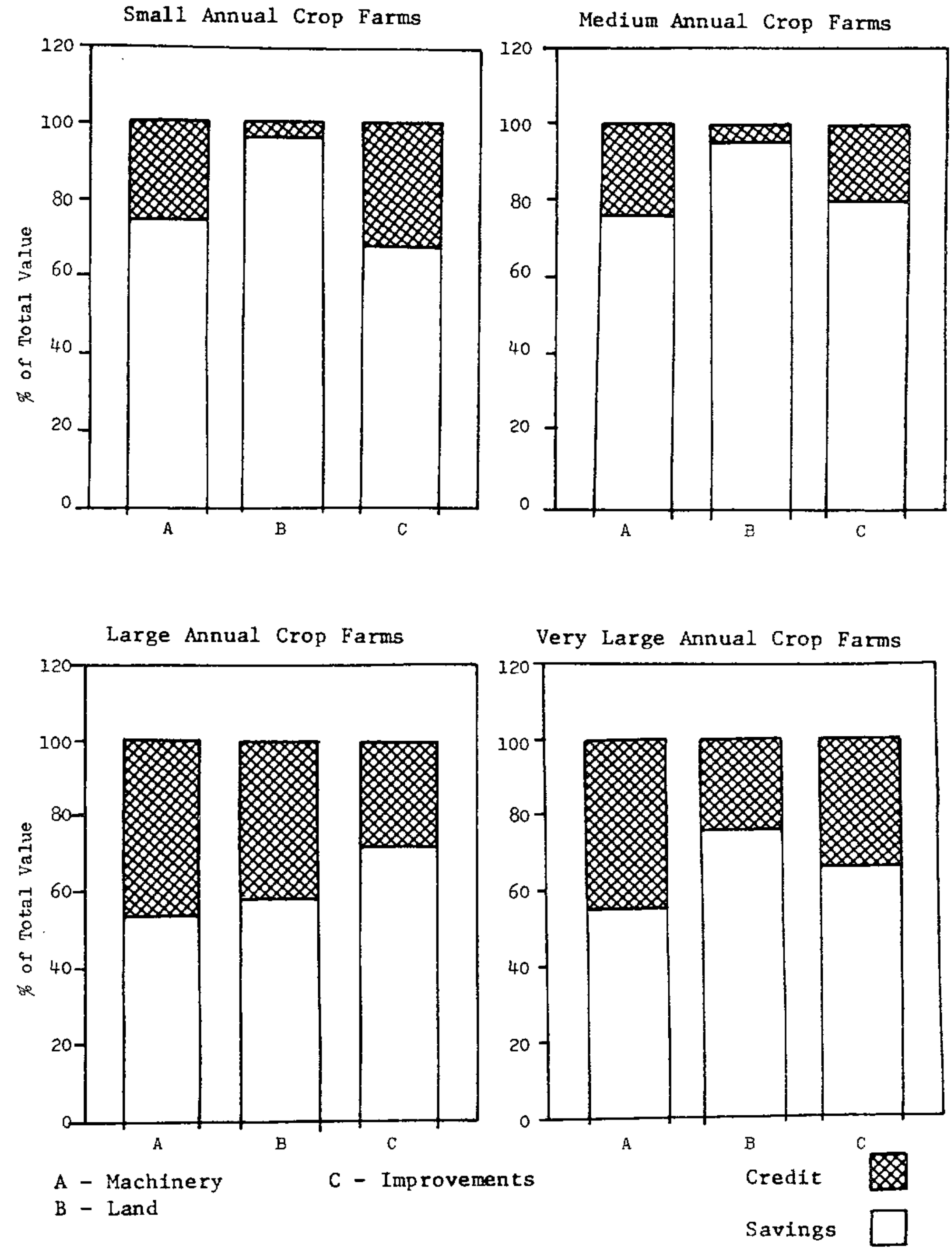
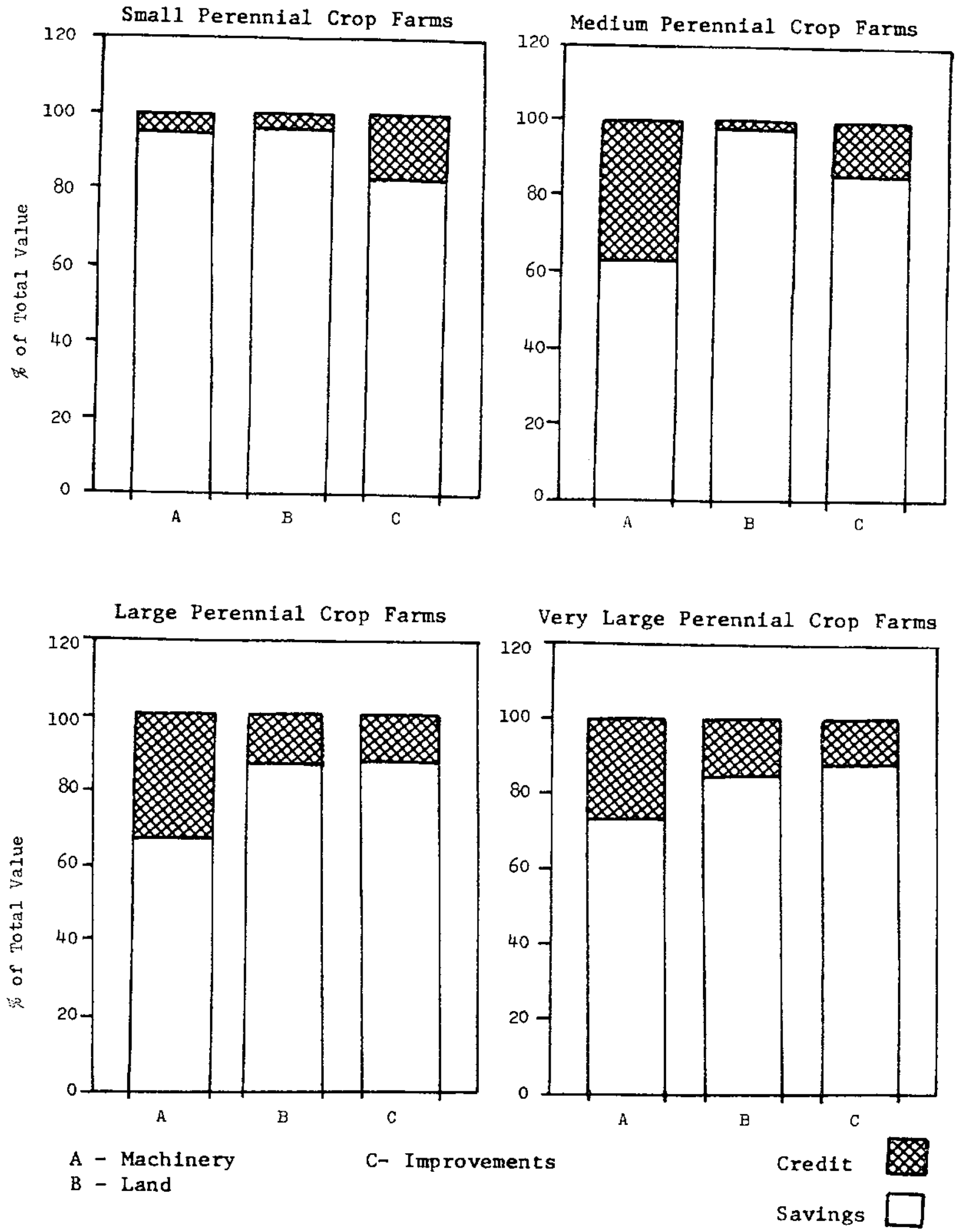


FIGURE VII (continued)
Source of Funds for Major Capital Investments as Percentage of Total Capital Investments - DIRA-Ribeirao Preto 1960-1970



for the eleven years analysis went to machinery acquisitions, the remaining distributed between improvements and land purchases, with the least amount used for the latter.

Conclusions

Four distinct general patterns emerge from the overall analysis. First, machinery investment is a major investment item for all the farms considered. In the cases of annual and perennial farms, there is a lag of two to four years in machinery investment from the smaller to the larger farm sizes. Thus, the very large farms appear to begin mechanizing seven to nine years before the small farms. Second, for the annual farms of all sizes, land is an important resource and it is available. In fact, the heavy increase in land operated by the small annual farms seem to indicate that land is a scale neutral resource for annual crop production which in turn would indicate constant return to land size and also a very active land market in the area. Third, the decline in land size of the small perennial farms and the increase in size of the large and very large perennial farms would indicate either a significant increase in efficiency as perennial farms increase their land basis, or, agricultural policies that on the whole, are favoring the large perennial farms. This will be tested in the scale analysis. Fourth, reasonable amounts of credit are apparently available for machinery. Considerable less is available for land and improvements. It would seem that operating expenses are adequately financed. This lack of credit for land, coupled with the significant increase in land operated shown by most farmers is indicative of imperfections in the credit market, (by design) which could cause significant distortion in factor prices resulting in imperfect resource allocation.

The same general conclusions are valid for the mixed farms analyzed. It is not possible to arrive at more definitive conclusions for the pasture livestock farms because of the very small number of observations, which does not permit a size comparison. However, the slight decline in land operated on these farms, coupled with the relatively low levels of investment in machinery, land and building improvements, (plus the fact the total sample only showed twelve livestock farms) is indicative that pasture livestock is not an attractive alternative, given the present economic conditions in the region. Crops such as sugar cane and soybeans, which only recently became important in the area studied are sufficiently profitable (helped along by favorable policies) that they compete successfully with the more traditional activities.

From this analysis the hypothesis that national policies have different impacts upon different farms can be substantiated. First, it is obvious that on the whole, the small farms both annual and perennial are using considerable amounts of both mechanical and chemical technology as indicated by the crop expenses. However, the larger farms are using them more intensively. Also, as is apparent from the land accumulation analysis, the small annual crop farms have made significant progress in increasing their land control, while on the other hand, it is quite obvious that the small perennial crops are reducing their land basis, although slowly.

While some differences are noted between farm sizes, striking differences appear between farm types - indicating the commodity orientation of agricultural policies. For example, in the present case the perennial crop farms are specialized in coffee or sugar cane but the sample is primarily of sugar cane farms. Sugar cane in Brazil is produced under very strict controls. Quota allotments are distributed to farms surrounding a sugar mill and prices are established by government on a cost plus profit basis.[9] The quota allotment is linked to the land, since it has to be location specific so as to guarantee adequate supply to the sugar mills.

Such policies are effectively adding an extra and significant value to land and as a consequence land has to be very productive so as to make possible the equalization of the value of its marginal product to its price. To raise

[9]Pedroso, I. A. and Donald K. Freebairn, op. cit.

land productivity, significant investments in management, machinery and fertilizer have to be made. It is conceivable that small farms are not able to compete for these resources with the larger farms and are being driven out of farming and their land incorporated into the larger farms. Also, the significant increase in land operated due to land renting occuring in the very large perennial farms, may indicate that small farms are finding it more efficient to rent than to operate their lands.

Assuming that the above analysis is valid it is possible that on one hand, the general agricultural policies of the country are not discriminating against small farms, at least as far as land resources are concerned, but on the other hand, the specific crop or technology policies, in this case sugar cane production, marketing and mechanization policies are hindering the growth of the small farms.

CHAPTER IV

ECONOMIES OF SCALE AND PRODUCTIVITY ANALYSIS

This chapter begins by defining homogeneous production sub-regions within the region studied. This definition is made through the use of the Cobb-Douglas model described previously and with the F Test also described previously. Subsequently, a test is made to identify different production activities (different production functions) within each of the sub-regions defined. The methodology is the same as described for the previous test.

Once the sub-regions and production activities are defined, the analysis proceeds by testing the null hypothesis: invariant returns to scale occur in all production functions defined. Failing to reject the above hypothesis the analysis proceeds by defining production functions within different farm sizes for the different production activities.

Rejecting the hypothesis that the production activities are the same for the different farm sizes the analysis then proceeds to examine values of marginal products for the different farm sizes and finishes by discussing the implications of these results.

Comparison of Production Regions

As stated in Chapter I, page 7, the region was chosen because of its specialization in various activities of importance for the agriculture of the state. It was expected that the municipios of Sertaozinho, Pontal, Ribeirao Preto and Batatais would be producers primarily of perennial crops. The municipios of Barretos and Colombia were expected to be composed of farms having mixed activities, both livestock and crops. The remaining municipios were expected to specialize in annual crop production.

For the purpose of the analysis of economies of scale the sample was then divided into three sub-samples representing each of the above specializations. Thus, the municipios of Guaira, Salles de Oliveira, Jardinopolis and Altinopolis were defined as the annual crop sub-region or sub-region I, the municipios of Sertaozinho, Pontal, Ribeirao Preto and Batatais as the perennial crop sub-region or sub-region II, and the municipios of Barretos and Colombia as the mixed farming sub-region or sub-region III.

Each sub-sample was further divided into blocks of farms by size and type. Table 6 indicates the results of this division.

Table 6

Distribution of Farms, by Size and Type of Sub-Region - DIRA - Ribeirao Preto, 1970[a]

Sub-Region \ Type	Annual Crop Farms	Perennial Crop Farms	Mixed Farms	Total
Annual Crops Sub-Region				
Small	23	3	1	27
Medium	35	4	4	43
Large	59	4	5	68
Very Large	40	2	7	49
Sub-Total	157	13	17	187
Perennial Crops Sub-Region				
Small	4	13	1	18
Medium	8	19	-	27
Large	14	23	6	43
Very Large	13	11	6	30
Sub-Total	39	66	13	118
Mixed Sub-Region				
Small	-	-	-	-
Medium	-	-	3	3
Large	9	-	21	30
Very Large	10	-	22	32
Sub-Total	19	-	46	65
Total	215	79	76	370

Source: Ribeirao Preto Survey - 1970.

[a]The 12 farms classified as pasture livestock in the original sample, were scattered through the three regions and were eliminated in this analysis.

Although the different farm types are distributed throughout the sub-regions, the majority of the farms within each specialization falls within its defined region. Thus, of the 215 farms specialized in annual crops, 157 are in sub-region I; of the 79 perennial crops, 66 are in sub-region II; and of the 76 farms defined as mixed, 46 are in sub-region III.

The next step was to determine the existence of regional differences in production functions. The regional production functions were tested pair-wise.

The model utilized was a Cobb-Douglas production function with the following logarithmic formula:

$$\log Y = \log A + b_1 \log X_1 \; b_2 \log X_2 + b_3 \log X_4 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6$$

in which Y = Gross Output

X_1= Cultivated land

X_2= natural pasture land

X_3= total family labor

X_4= total hired labor

X_5= service flow of fixed capital

X_6= operating expenses

The first test was between annual crops in the sub-region I (annual crop region) and annual crops in sub-region II (perennial crop region). The coefficients and related statistics for the production functions are shown in Table 7.

Table 7

Summary Statistics for Production Function (Cobb-Douglas) - Annual Crop Farms
Sub-Region I, II and Pooled - DIRA - Ribeirao Preto - 1970

Variables	Sub-Region I		Sub-Region II		Pooled	
	Elasticity Coefficients	T-Test for B=0	Elasticity Coefficients	T-Test for B=0	Elasticity Coefficients	T-Test for B=0
Log A	.9638	3.6988*	.5187	2.3962*	.6973	4.2519*
Cultivated Land	.0342	0.3646	.0374	.2500	.0245	.3401
Natural Pasture Land	.0058	0.6024	-.0147	.7492	.6024	.2911
Total Family Labor	.0236	0.8519	-.0342	.4817	.0161	.6274
Total Hired Labor	.0464	2.0534**	.0024	.0631	.0223	1.2550
Capital Services	.1728	2.7856*	.4495	3.6792*	.2516	4.6935*
Operating Expenses	.6757	7.4913*	.5498	5.3384*	.6754	10.9254*
Correlation (Adjusted R^2) =	.8482		.9232		.8716	
F ratio	146.2589		75.0996		220.4358	
D.F.	150		31		138	

*Significant at 1 percent.

**Significant at 2.5 percent.

To test for differences of production functions between the two regions an F Test for the sum of squared residuals of the two models is formed. In this case:

$$F = \frac{\dfrac{11.7502 - 1.9975 - 9.2165}{7}}{\dfrac{1.9975 + 9.2165}{157 + 39 - 14}} = .124$$

The critical level F for 7/182 degrees of freedom at 5 percent level is 2.05. Thus, the null hypothesis is accepted, i.e., $H_o: \lambda_1 = \lambda_2$ in which λ_1 is the column vector $\begin{bmatrix} \text{Log } A_1 \\ b_{11} \\ b_{21} \\ b_{31} \\ b_{41} \\ b_{51} \\ b_{61} \end{bmatrix}$ for the production function for sub-region I and λ_2 is the column vector $\begin{bmatrix} \text{Log } A_2 \\ b_{12} \\ b_{22} \\ b_{32} \\ b_{42} \\ b_{52} \\ b_{62} \end{bmatrix}$ for the production function for the sub-region II.

Failing to reject the null hypothesis implies accepting no difference in the production functions for the two sub-regions, consequently accenting the equality of the technology of production for annual crops between sub-regions. In the remainder of the analysis, therefore, annual crop farms are pooled for the two sub-regions.

Comparison of Production Activities

The next step is to test for differences among enterprises. Since the annual crop farms production functions do not differ across regions, the test for different production activities is done through the test of a production function for all annual crop farms versus a production function for the perennial crop farms in region II.

The next table presents the summary statistics for the perennial crop farms of sub-region II and the pooled model, in this case comprised of all annual crop farms plus the perennial crop farms.

A similar F Test is done for testing the differences in the production function of all annual crops versus the perennial crops. The test results are shown below:

$$F = \frac{\dfrac{15.9267 - 11.7502 - 2.9694}{7}}{\dfrac{11.7502 + 2.9694}{196 + 66 - 14}} = 2.92$$

Table 8

Summary Statistics for Production Function (Cobb-Douglas) - Perennial Crop Farms in Sub-Region II, and Pooled DIRA - Ribeirao Preto 1970

Variables	Sub-Region II		Pooled	
	Elasticity Coefficients	T Test for B=0	Elasticity Coefficients	T Test for B=0
Log A	2.9356	8.1780*	1.5593	8.2529*
Cultivated Land	.9132	6.3584*	.2543	3.7713*
Natural Pasture Land	.0131	.8829	.0093	1.2326
Total Family Labor	.0696	1.2366	.0365	1.5516
Total Hired Labor	.0295	.9868	.0526	3.1647*
Capital Services	- .0834	.8756	.1434	2.9444*
Operating Expenses	.0565	.4278	.4619	7.4246*
Correlation (Adjusted R)		.8144		.8229
F Ratio		47.6222		68.7227
D. F.		59		254

*Significant at 1 percent.

This F Test for the null hypothesis $H_o: \lambda_1 = \lambda_2$ in which λ_1 is a column vector $\begin{bmatrix} \text{Log } A_1 \\ b_{11} \\ b_{21} \\ b_{31} \\ b_{41} \\ b_{51} \\ b_{61} \end{bmatrix}$ for the annual crops production function in both sub-region and λ_2 is a column vector $\begin{bmatrix} \text{Log } A_2 \\ b_{12} \\ b_{22} \\ b_{32} \\ b_{42} \\ b_{52} \\ b_{62} \end{bmatrix}$ for the perennial crops production function in sub-region II, is significant at the 5 percent level and 7/248 D.F. which implies rejection of the null hypothesis and acceptance of the alternative hypothesis i.e., the production functions for different activities within regions are different.

The last step in testing for different production functions between enterprises and between regions is to test for differences between enterprises and across regions.

Using similar models an F Test was derived and the result follows:

$$F = \frac{\dfrac{14.4990 - 9.2165 - 2.9694}{7}}{\dfrac{9.2165 + 2.9694}{157 + 66 - 14}} = 10.5657$$

The F Test for the null hypothesis $H_o = \lambda_1 = \lambda_2$ in which λ_1 is a column vector $\begin{bmatrix} \text{Log } A_1 \\ b_{11} \\ b_{21} \\ b_{31} \\ b_{41} \\ b_{51} \\ b_{61} \end{bmatrix}$ for the annual crops production function in sub-region I and λ_2 is as column vector $\begin{bmatrix} \text{Log } A_2 \\ b_{12} \\ b_{22} \\ b_{32} \\ b_{42} \\ b_{52} \\ b_{62} \end{bmatrix}$ for the perennial crops production function in sub-region II, is significant at the 5 percent level and 7/203 degrees of freedom. This implies rejection of the null hypothesis and acceptance of the difference between production functionsfor the two activities, but not between the two regions. In other words, the production function for the annual crops is different from the production function for the perennial crops. However, the location of the annual crop farms within the two regions is not a consideration.

Subsequently, an F Test was calculated for the annual crop sub-region (sub-region I) versus the mixed farm sub-region (sub-region III). Using the same econometric model a production function for the mixed farm sub-region was derived and with the residual sum of squares the F Test was calculated. The result was not significant which implies the acceptance of the null hypothesis, or the existence of no difference between the two production functions for the two sub-regions. Further testing for differences between the two regions was impaired by the lack of enough observations and therefore, it was decided that no further analysis was to be done with the mixed farms.

The analysis proceeded with the production functions which were found to be different in the previous tests, i.e. the annual crops production function encompassing observations from both the perennial and annual crop sub-regions and the perennial crops production function encompassing the perennial crop farms in the perennial crop sub-region or sub-region II. Thus, from the total initial sample, two sub-samples are defined. One consists of 196 observations all defined as annual crop farms from sub-regions I and II and the other constituted of 66 farms defined as perennial crop farms all located in the sub-region II.

Annual Crops - Analysis of Economies of Scale

The invariant returns to scale model on which the scale economies for the annual crops is based is the Cobb-Douglas production function model with the characteristics described in the Table 7 (pooled model).

The model shows a well behaved function with constant invariant returns to scale ($\sum_{i=1}^{6} b_i$ not statistically signficantly different from 1) and the elasticity coefficients for service flow of capital, operating expenses and the intercept are significantly different from zero and the function has high explanatory power as indicated by the coefficient of determination, R^2 equals .8716.

However, the model restricts the returns to scale to be invariant for all levels of output. To test the hypothesis of variant returns to scale a generalized production function has to be derived. Given that for the present model the sum of elasticities of production is smaller than one, in absolute value, the statistical model for the estimation of the Generalized Production Function takes the following form:

$$\log (Y_j^{ZY_j}) = \log A_0 + \sum_{i=1}^{6} b_i \log X_{ij} + u_j$$

The above model is estimated for various arbitrary values of z and the sum of the squared residuals for the various equations estimated and the respective z values are inserted in maximized log likelihood function given below:

$$L \max (z) = \text{const.} + N \overline{\log (1+ZY_j)} - N/z \log \sigma^2$$

The values of the maximized log likelihood function are plotted against the respective values of z and the maximum estimate of z can be found. The next figure depicts the path of maximized log likelihood function and shows that the function reaches a maximum, within the positive range of z, when z is equal to zero.

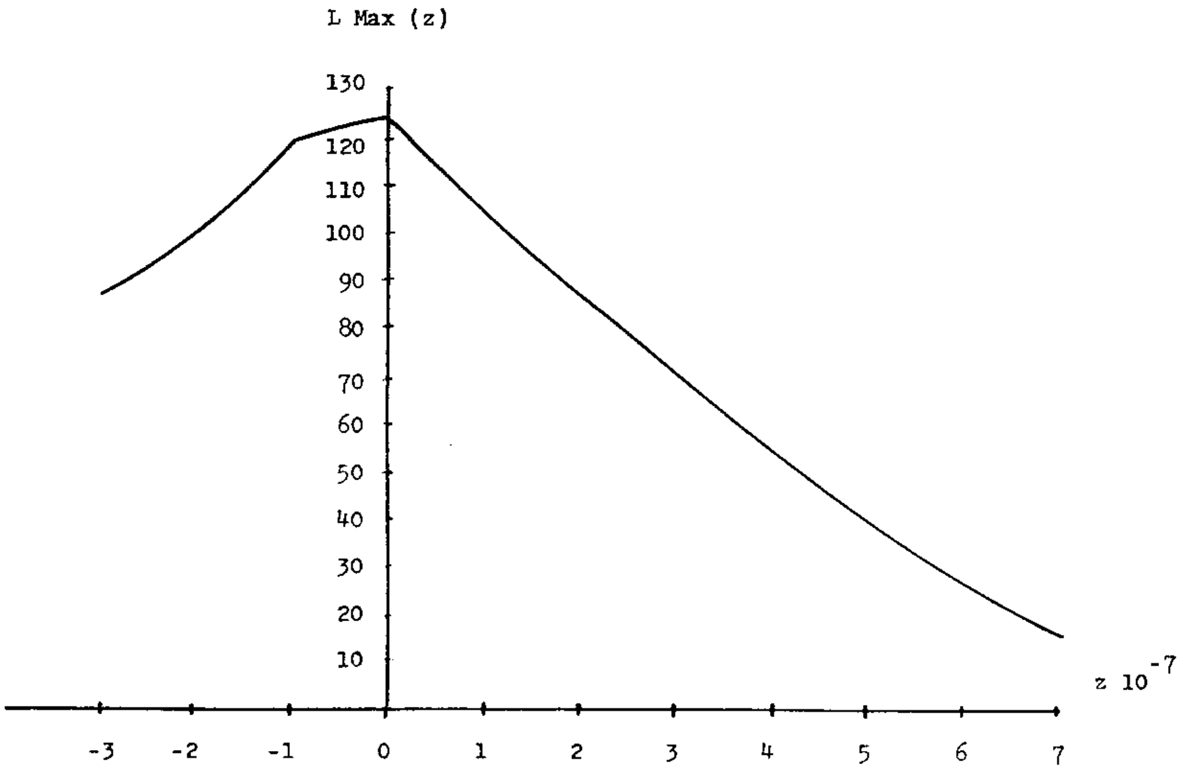
In light of these results the hypothesis of invariant returns to scale production function for the annual crop farms can be accepted.

Perennial Crop Farms - Analysis of Economies of Scale

The invariant returns to scale model on which the analysis of economies of scale for the perennial crop farms is based, is the Perennial Sub-Region II model. Its statistics are presented in Table 8. The equation has a high explanatory power as indicated by an R^2 of .8114.

FIGURE VIII

Maximum Log Likelihood Function Annual Crop Farms
(Returns to Scale Function: A (Y) = Af/(1 + zY)



However, the coefficients for labor, both family and hired, capital flow and operating expenses are not significantly different from zero. Cultivated land, however, is highly significant and explains most of the variation in output (it has a beta weight of 0.85).

Given that the coefficients of production elasticity for the model specified add up to more than one (1.0185), the Generalized Production Function assumes the following form:

$$Y_j^{(K)} = \log (Y_j/K-Y_j) = \log A_o + \sum_{i=1}^{6} b_i \log A_{ij} + u_j$$

Various arbitrary values of K are inserted in the model and the residual sums of squares of the model and the respective K's are inserted in the maximized log likelihood function below:

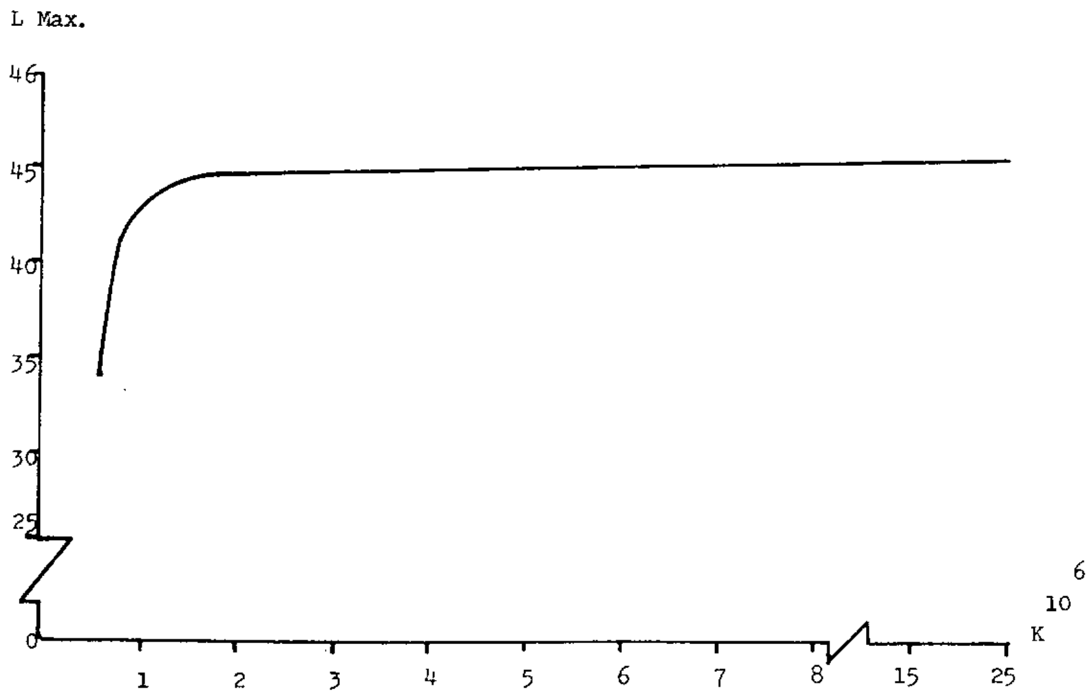
$$L \max (K) = \text{const.} + N \log K - N \overline{\log (K-Y_j)} - N/z \log \sigma^2$$

The results of the Maximized Log Likelihood Function are plotted against the K values and the path of the function is determined. From this path the maximum K can be determined and at the maximum K the likelihood estimates of the production function coefficients are also determined. The next figure depicts the path of maximum Log Likelihood Function.

From the figure it can be established that the function does not reach a maximum and thus the hypothesis

FIGURE IX

Maximum Log Likelihood Function Perennial Crop Farms
(Returns to Scale Function: A (Y) = Af (1-Y/K)



of invariant returns to scale for the perennial crop farms can be accepted.

Productivity Analysis by Size

Given that the input-output relationship exhibits invariant returns to scale for the agregate sample, a further analysis was attempted to study the possibility of having annual crop and perennial crop farms of different sizes operating at different levels and with different factor productivities.

Annual Crop Farms

The sample of annual crop farms was divided into two groups by size, one composed of the small and medium annual crop farms (up to 49.9 hectares) and the other composed of the large and very large annual crop farms (from 50 and more hectares).

The same Cobb-Douglas production function, utilized in the previous analysis was fitted to the two samples of farms. Table 9 gives the summary statistics of the two functions and Table 10 gives the values of the marginal products for the various inputs. An F Test for different production functions was performed and the results indicate that the functions are statistically different.

Table 9

Summary Statistics for Production Function (Cobb-Douglas) - Small-Medium Annual Crop Farms and Large-Very Large Annual Crop Farms - DIRA - Ribeirao Preto - 1970

Variables	Small-Medium Farms		Large-Very Large Farms	
	Elasticity Coefficients	T Test for B=0	Elasticity Coefficients	T Test for B=0
Log A	.4267	1.7825*	.9843	3.8525*
Cultivated Land	.0421	.1540	.0199	.2432
Natural Pasture Land	.0034	.1639	.0005	.0583
Total Family Labor	-.0918	1.6099**	.0558	2.0813*
Total Hired Labor	-.0319	1.2415	.1241	4.3287*
Capital Services	.2774	2.8721*	.1992	3.0987*
Operating Expenses	.7249	5.8500*	.6384	8.6298*
Correlation (Adjusted R^2)		.7968		.7800
F Ratio		45.4480		74.8838
D. F.		62		119

*Significant at 5 percent.

**Significant at 10 percent.

Table 10

Geometric Mean and Value of Marginal Product for Variable Factor Inputs - Annual Crop Farms - DIRA-Ribeirao Preto 1970

Variables	Small - Medium Farms		Large - Very Large Farms	
	Geometric Mean	Value of Marginal Product	Geometric Mean	Value of Marginal Product
Gross Output	6,590.00	---	59,100.00	---
Cultivated Land	19.00	0	149.00	0
Natural Pasture Land	.52	0	.45	0
Total Family Labor	1.30	-465.00 Cr$/m.e.[a]	1.13	2,905.00 Cr$/m.e.
Total Hired Labor	.01	0	5.16	1,394.00 Cr$/m.e.
Capital Services	1,305.00	1.40 Cr$/1Cr$	12,260.00	.92 Cr$/1Cr$
Operating Expenses	2,900.00	1.60 Cr$/1Cr$	27,800.00	1.40 Cr$/1Cr$

[a]The elasticity of production coefficient is significant at the 10 percent level.

Perennial Crop Farms

The perennial crop farm sample was divided into small and medium size farms and large and very large farms, according to the same size limits defined for the annual crop farms.

An econometric model similar to the previous models was fitted to each of the two sets of data and the summary statistics can be found in Table 11. The values of the marginal products for the different inputs can be found in Table 12.

An F Test for the difference between the two production functions was carried out and the result was lower than the critical level, indicating that the functions are not different. However, a test on a sub-set of coefficients indicated that some coefficients are different when compared with each other. Consequently, the functions have the same overall profile, but certain coefficients are different.

Conclusions

The first objective of the preceding analysis was to establish whether varying or invariant returns to scale are exhibited by the production functions. The results indicate that the returns to scale are invariant, that is, the returns to scale do not vary with output. In both cases, (perennial and annual crop farms) any size operates

Table 11

Summary Statistics for Production Function (Cobb-Douglas) Small-Medium Perennial Crop and Large-Very Large Perennial Crop Farms
DIRA-Ribeirao Preto-1970

Variables	Small-Medium Farms		Large-Very Large Farms	
	Elasticity Coefficients	T Test for B=0	Elasticity Coefficients	T Test for B=0
Log A	3.7401	8.1395*	1.4364	1.8559**
Cultivated Land	.7898	3.7841*	.8045	2.9910*
Natural Pasture Land	.0305	1.4200	-.0041	.1940
Total Family Labor	.1007	.7622	.0550	.8324
Total Hired Labor	.0562	1.7816**	.0740	.4654
Capital Services	-.1095	.9333	-.0258	.1758
Operating Expenses	-.0828	.5591	.3794	1.5391**
Correlation (Adjusted R^2)		.4918		.7177
F Ratio		6.0007		14.9833
D. F.		25		27

*Significant at 5 percent.

**Significant at 10 percent.

Table 12

Geometric Mean and Value of Marginal Product for Variable Factor Inputs - Perennial Crop Farms - DIRA - Ribeirao Preto 1970

Variables	Small - Medium Farms		Large - Very Large Farms	
	Geometric Mean	Value of Marginal Product	Geometric Mean	Value of Marginal Product
Gross Output	11,280.00	---	60,900.00	---
Cultivated Land	20.84	428.00 Cr$/ha.	124.80	392.00 Cr$/ha.
Natural Pasture	.046	0	.29	0
Total Family Labor	1.86	0	1.41	0
Total Hired Labor	.85	742.00 Cr$/m.e.	9.47	0
Capital Services	1,868.00	0	11,300.00	0
Operating Expenses	3,348.00	0	27,370.00	.76 Cr$/1Cr$

with similar average cost, therefore any size is optimum. Obviously, the results are only valid within the limitations of the sample and of the implicit assumptions of the methodology.

No conclusions, for example, can be drawn for farms outside the range included by the sample. Thus, it is conceivable that farms which were not included in the sample may have either increasing or decreasing returns to scale. Second, the methodology implies constant factor and output prices and constant elasticity of substitution for factor inputs. One of the theoretical reasons that returns to scale increase as farms increase output size is a reduction in costs as the purchase and handling of large quantities of inputs increase. In a like manner, handling and transportation cost of products decreases as output increases. It is conceivable that at least the very large farms may benefit from these cost reductions, although it is not necessarily certain that such reductions occur.

Another restrictive aspect of the analysis is the fact that the methodology employed assumes constant partial elasticities of substitution between inputs. It is possible that as farms increase in size the elasticity of substitution for the different factors changes and this change could bias the parameters of the estimated function.

However, the relatively good results shown by the model employed demonstrate that at least within the limits of the sample the production relationship can be explained fairly satisfactorily with the model used.

The analysis of the results of the model for the small-medium annual farms indicates that these farms have a lower production profile than the profile of large and very large annual farms as indicated by the coefficient for the intercept. However, the response of output to capital services and operating expenses on the small-medium farms is slightly higher than for the large farms.

All annual crop farms, both small and large, have an estimated elasticity of production for land, both cultivated and natural pasture which is equal to zero. Capital services and operating expenses on the smaller farms are the largest coefficients and explain most of the variation in production. Values of marginal products for these two coefficients are greater than one indicating that increased net return could be obtained by the expansion of the two factors. The larger annual crop farms have labor coefficients (both family and hired) considerably larger than the same coefficients for the smaller farms, indicating that the productivity of labor increases as farms increase the land size.

For the small farms the elasticity of production is negative and significant at the ten percent level. There is some measurement error in the data and the coefficient could be considered actually equal to zero. Given the data for family labor, it is hard to explain how much of the problem results from real labor redundancy on the farms and how much results from statistical problem. Hired labor is equal to zero in the smaller farms indicating the insignificance of hired labor employment on the smaller farms (note that the geometric mean of hired labor in the smaller farms is equal to .01 man equivalents - Table 10).

Capital service and operating expense productivities decrease as farms increase land size. The value of marginal product for capital services on the larger farms indicates a very low potential for increased returns by expanding the use of capital services. On the other hand, the value of marginal product for operating expenses on the larger farms indicates some potential for increased investment in operating expenses.

A relatively poor fit (R^2 = .49) was obtained by the model when applied to the production data of the small-medium perennial farms. The coefficients however, are consistent. Cultivated land is by far the most important coefficient (beta weight = .709)[1] followed by total hired labor (beta weight = .301). The production function for the large-very large perennial farms indicates a relatively good fit (R^2 = .72) and consistent coefficients. Land again is the most important coefficient (beta weight = .58) followed by the coefficient of operating expenses (beta weight = .27).

The small-medium perennial farm size has an intercept considerably larger than the large-very large farms indicating that for these farms the fixed inputs are proportionally larger than for the large-very large farms. (See Table 11) In other words, the fixed inputs are of a size that permits more flexibility in production organization for the large farms than for the smaller farms. This aspect should explain the near zero value of marginal product of capital flow for the small perennial farms at the same time that the value of marginal product for hired labor is positive and fairly large. Having fixed capital inputs available at only certain sizes (trucks and machinery for example) obligates these farmers to over-invest in those items, thus increasing labor productivity. On the other hand, the heavy investment in operating expenses is driving marginal productivity of cultivated land to higher

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[1]The beta weight is the production elasticity coefficient normalized by its variance. It is free of the influence of the measurement values of the variables.

levels.

The large-very large farms show a value of marginal product for cultivated land that is lower than that for the small-medium farms, and value of marginal product for operating expenses that is less than one.

The near zero value of marginal product for the capital services variable in the large-very large perennial farms also indicates a large investment in capital items which may be due to the easy access to highly subsidized credit available to these farms as was indicated previously. The low values of marginal product for operating expenses on both farm sizes indicates high levels of use of operating expense which may be responsible for the relatively large values of marginal returns for land.

CHAPTER V

CONCLUSIONS AND POLICY IMPLICATIONS

The principal purpose of this study has been to document the impact of agricultural policy on farm resource accumulation and adjustment possibilities for an agricultural region of the state of Sao Paulo in Brazil. Much of Brazilian agricultural policy has assumed that large farms are more efficient than small farms, i.e. small farms do not employ inputs at their optimum use and that economies of scale exist in Brazilian agriculture. Policies favoring mechanization, farm consolidation and increased production of crops produced principally on large farms have resulted. Less attention has been paid to the generation of yield increasing technology or the improvement of the inputs used on both small and large farms.

In view of this approach to increasing agricultural production this study has attempted to evaluate both the impact and economic desirability of these policies in terms of farm level development and capital growth. First, an analysis of the form, source and sequence of capital growth for an eleven year period on farms of various types and sizes in the study area was conducted. This analysis verified that capital growth was strongly affected by policies. Machinery was the main form of capital investment. Increases in land ownership and control were also evident. Capital investments were much greater on crop than on livestock farms, and finally large farms formed capital earlier and more intensively than small farms. Credit was a major source of capital growth especially for machinery purchases and again used much more intensively by large farms.

This level of analysis then verified the assumption that agricultural policies can be a powerful determinant of the direction, speed, and distribution of capital growth in agriculture. This leads to the second objective of the study. In question form this is: do large farms have the greater economic efficiency in converting inputs into agricultural output? and do returns to scale vary as output increases mainly by increasing the land base? These questions were addressed through a micro analysis of production.

First an analysis of returns to scale was made on several sub-sets of data. Perennial and annual crop farms in two size categories were examined. The general conclusion from this analysis was that in each farm type, the returns to scale are invariant and in fact constant. All farms of a given type operate at a constant level of average cost per unit of output, consequently there is no unique optimum size. However, within each farm type there are different production functions for the two sizes analyzed. The specific conclusions, as they relate to farm type and size and the policy implications are described below.

Annual Crop Farms

For the annual crop farms, the productivity (elasticity of production) of various inputs changes when the farm size changes. An examination of the production elasticities for inputs on both farm sizes indicates that capital services and operating expense productivities decline as farms get larger. On the other hand, labor productivity is much higher on the larger farms. These results indicate that output on the smaller farms increases more in response to changes in the use of both capital services and operating expenses but not to labor.

Part of the reason for such differences lies in the fact that the larger farms use less labor per unit of other inputs-they are less labor intensive. The estimates may also be indicating that both family and hired labor are critical inputs in certain phases of the production process.

The value of marginal product for inputs on the smaller farms is very low with the exception of the two capital inputs. These results indicate that very little potential for expansion of production exists for the smaller farms if land or labor use is increased, since additional expenditure on these resources will result in very low returns. However, capital use could be increased some as indicated by the marginal return. The capital is really in the form of mechanization suited to larger land bases however.

Several policy implications are evident. First both sizes of farms would receive little increased return from the use of more land. This result indicates that increases in land, with the other inputs held constant, will not increase production significantly. For the annual crop farms then the resource constraint is not land, but other production factors.[1] For the smaller farms it may be capital services and operating expenses. For the larger farms it may be labor. The large value of marginal return to labor on larger farms indicates the potential these farms have to increase output by becoming more labor intensive. The fact that the value of marginal product for capital services on the farms is quite low indicates

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[1]The significant increase in land observed during the sixties as indicated by Figure VI, Chapter 3 further supports this conclusion.

substitution of capital for labor has taken place. In this case, capital would take the form of machinery. The historical capital accumulation analysis supports this conclusion. For example, the larger farms have a greater per hectare investment in machinery than the smaller farms. Also, the larger farms used proportionally more credit to acquire machinery than did the smaller farms. Thus, it is apparent that due to the credit policies the larger farms not only have greater access to cheaper credit for machinery, but the ease with which machinery is acquired has resulted in a substitution of machinery for labor that has detracted from a potential increase in production through a more labor intensive organization, or at least an undistorted labor-land-capital organization of production.

Concluding, it can be said that the smaller annual farms are more efficient in the use of capital services and operating expenses, i.e., in terms of response of output to changing levels of capital use, but are considerably less efficient in relation to labor use. Land does not seem to be a constraining resource for the smaller annual farms in the region analyzed. Very little returns can be obtained from increases in land input. Machinery services however, have a greater return as indicated by the value of marginal product for capital service. Thus, as smaller farms mechanize they have to increase land base since it is apparent that the machinery component is such that it is only viable in combination with an increased land area. At that point land may become a resource constraint.

For these farms it is apparent that increasing land size coupled with mechanization has resulted in higher labor productivity but lower capital productivity. The easy access to machinery is apparently raising labor productivity but not the productivity of other factors, especially land. Increases in production, at the margin, are low as are the returns to increases in most factors. These findings indicate that the production functions for both farm sizes are low and policies should be directed toward pushing the production frontier outward through an increase in average productivity for all production factors, particularly land.

Perennial Crop Farms

As in the case of the annual crop farms the analysis of returns to scale for perennial crops indicates that invariant and constant returns exist, thus any size of farm operation can be considered optimum when the sample is analyzed in the aggregate. The production analysis by size, however, indicates that production elasticities are quite different. The larger farms have greater elasticities of production for land and operating expense inputs. The value of marginal product for operating expenses is also higher on the larger farms. On the other hand, the values of marginal product for land and hired labor are larger on the smaller farms.

Apparently the smaller farms rely substantially on family labor (geometric mean for family labor is relatively high) and by so doing are increasing average land productivity thus raising the value of marginal product of land. Also, operating expenses are being used to the point at which further investments in operating expenses will no longer expand production and thus may have contributed to raising the average productivity of land to its upper limit.

As indicated previously, the production function for the smaller perennial farms has a higher intercept when compared to that of the larger farms, but smaller values for most of the production elasticities. This aspect may be due to the indivisibility of certain fixed factor inputs. Thus, the only alternative left for the small perennial farms is to increase their land base which would allow a more flexible combination of resources. The analysis however, clearly indicates that the smaller perennial farms have reduced their land base. Although the production function indicates a higher potential on the part of these farms to expand output by expanding land, some other factor apparently not only inhibits their possibility to increase their land base, but actually leads them to reduce the size of their operations.

A possible reason is the specific sugar cane policies. Sugar cane is produced under strict controls. The most important feature of this policy, in relation to the present analysis, is the quota allotment. The production quotas are allocated by means of a process in which the sugar mill that acquires the sugar cane has some control over the quota distribution. This control stems from the fact that a quota is granted to a given farm after the farm has sold sugar cane for three consecutive years to a given sugar mill. After three years, the farmer is granted a quota (attached to his farm) equivalent to the arithmetic average of his sales for the three years. For the sugar mills however, fewer independent suppliers are preferred, since the administrative costs of supply control are reduced, as well as a guarantee of a steady supply is increased if it buys sugar cane from a smaller number of larger suppliers. Therefore the most rational attitude is to direct the mill's supply policy efforts to have the smallest number of suppliers consistent with supply needs. This attitude may explain the apparent discrimination of sugar mill managers against the small sugar cane growers.

Also, the quota increases land values, since it represents the elimination of economic risk. Participation in the program therefore would be capitalized in land values. Under such conditions, it is not surprizing that small farmers in an area of sugar cane production may be forced out of agriculture and their lands incorporated into the larger farms. The historical analysis suggests that this situation may be occuring.

Final Comments

The results of the productivity analysis and historical investment patterns indicate that the present agricultural policies of Brazil are hindering the expansion of smaller farms, especially the perennial crop farms in the area studied. Also, it is clear that the expansion of the larger farms has been facilitated. If the objective of agricultural policies is to expand output per farm only, the policies are operating in the right direction since returns to scale are constant but detracting from increasing output per unit of land or other resources. The increase comes at the extensive margin. To handle such an increase, mechanization suitable to large land base operation has to take place along with the farm size increases.

Highly subsidized credit, especially for machinery and operating expenses, usually is more accessible to the larger farms. Having the possibility to acquire financial resources for operating expenses and machinery, these farmers can use their own resources to invest in land, thus the pattern; more land, more machinery, larger farms, more output. The levels of marginal productivity however, are low for most of the inputs. For example, with average machinery investment, larger farms have reached very low levels of marginal returns for capital services.

The production elasticity for operating expenses for all farms analyzed (except for the small-medium perennial crop farms) is relatively high. These results when analyzed in conjunction with the production elasticities of land and capital services further illustrates the resource constraints faced by the smaller farms. Crop and machinery expenses for example are the main components of operating expenses. Thus, increases in land and machinery for further production expansion would require an expansion of machinery and crop expenses or in other words the increase in use of biological and mechanical technology. As indicated previously, it is apparent that smaller farms are hindered by present policies in their attempt to attain higher levels of use of these inputs without expansion of the land base.

From the above discussion it is quite apparent that the agricultural policies of Brazil assume that size, especially when measured in terms of land area, is the primary reason for economic efficiency in farming. In a few instances Brazilian policy makers acknowledge explicitly this assumption. In general however, one can only perceive such assumption by carefully reviewing the overall policies of the country. Credit is subsidized for machinery acquisition, pasture improvement, fertilizer and farm consolidation. Each of these are really more accessible to larger farms. Substantial tax incentives are given for the opening of extensive cattle ranches in the Amazon region. In the Northeast of Brazil, one of the most impoverished areas of this hemisphere, fruit tree plantation type farms have been formed through generous tax incentives. All of these incentives are accessible only to individuals or firms of considerable financial and managerial capability.

The preceding analysis suggests that size (or scale of operation) alone may not be the main reason for economic efficiency. The larger farms are more efficient in relation to some factors but not in relation to others. The larger perennial crop farms are more efficient in relation to land and operating expenses and the larger annual crop farms are more efficient in relation to labor both family and hired. It is apparent that the higher level of efficiency for these factors can be traced to agricultural policies that by assuming that larger farms are more efficient favors them and discriminates against the smaller farms. One may also speculate that smaller farms face a less favorable price situation in addition to the productivity differences noted.

The larger perennial farms are more productive in relation to labor and to operating expenses, apparently due to sugar cane policies that discriminate against smaller sugar cane farms. Further, a general problem of relatively low absolute levels of productivity for all farms in this area, one of the most economically advanced of Brazil, raises questions about the development of appropriate forms of agricultural technology.

According to the 1960 census, Brazil had about 3,300,000 farms of which 2,400,000 farms had less than 50 hectares.[2] By operating on the assumption of efficiency being directly correlated with land size, the government may be alienating a tremendous growth potential on all farms, a potential that can only be realized fully through the development and introduction of technology to increase output per unit of input.

Future Research

Two aspects of additional research are indicated. First, the results of the present analysis lead to tentative conclusions that challenge the direction of current agricultural policy. These results must be investigated and tested more thoroughly under a wider range of farm situations. Also, in this regard, there is a need to more fully

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[2]Fundacao IBGE-Inst. Brasileiro de Estatistica, Brasil-Series Estatisticas Retrospectivas, 1970.

understand relationships between factors of production and how they change between farm types and sizes.

For example, the increase in land operated which apparently would result from the continuation of present policies would also cause an increase in the intensity of use of capital services and operating expenses. The same would occur if production were to increase through increases of factor productivities. It is quite certain that in both cases present factor-factor relationships would change. An analysis of factor-factor relationships would indicate first,the efficiency in resource allocation for the different farm resource organizations and second, the factor substitution that would occur as one type of production organization changes to another, either because the farm expands the use of inputs or because policies alter factor productivities. This analysis would be best carried out with the use of a generalized production function and with price data on factor inputs for different farm groups.

The estimation of a generalized production function with an unrestricted factor-factor relation for the two farm sizes utilized in this study could allow a comparison of the production functions and a definition of which type of function best explains the results, given that returns to scale are invariant. Once the production function is defined, the most efficient resource allocation, that is, the point where the ratio of value of marginal product over price of input equals one, could be determined.

Also, the factor-factor ratios particularly the capital-labor ratio could be determined and an analysis of labor substitution as a consequence of farm size increases and technological changes could be done.

The second area of future research is dependent on verification of the tentative results of the present study. If the results are confirmed, they indicate the need for a fundamental reordering of agricultural policy priorities in favor of increased productivity of all inputs, especially land. This can only be accomplished through emphasis on technological research. Land productivity increase for example, is a scale neutral technological change and all farms although probably large more than small, can benefit from it. To achieve significant increases in land and other input productivity a substantial program of research on bio-chemical technology must be mounted.

In addition, the results of this study point to the need for research on two special topics. Research should be directed toward the development of appropriate programs for small farms, especially for land acquisition and technological change. This program should be structured so as to bring the small farm into a competitive position with the large farms as far as technological innovations and access to modern inputs are concerned. First however, research (as noted above) is needed to indicate the magnitude of the price differentials that exist between small and large farms.

A careful analysis is also recommended for the sugar cane farms. Research following the lines of the present study should be developed with sugar cane farms only. In this research sugar cane farms should be more precisely defined (more homogeneous in the production of sugar cane). Also, a broader size range should be included so that some of the very large farms can be analyzed in the sample, and if possible different price ratios for the different farm sizes should be included.

APPENDIX A

Description of "Characteristics" for Tables 4 and 5

Land

Cultivated land: land planted with crops of any kind (including improved pasture) measured in hectares.

Pasture Land: natural pasture measured in hectares.

Machinery and Livestock Investment

Machinery: the sum of the actual value of all machinery on the farm at the time of the survey.

Livestock: the sum of the actual value of all types of livestock on the farm at the time of the survey.

Operating Expenses

Crop: includes fertilizer, lime, herbicides, pesticides, and seed expenses.

Custom Hire: actual value paid for hiring machinery services.

Machinery: actual value of maintenance and fuel expended on the operator's own machinery.

Livestock: actual value of expenses on animal health, feed and breeding.

Other: crop and machinery insurance, taxes on land and machinery and other incidental expenses not included in any of the above categories.

Farm Receipts

The sum of crop, livestock and livestock product sales.

Interest Expenses

The value paid during 1970 for interest on loans.

APPENDIX B

Independent Variables for Regression Models[1]

Cultivated Land

Land cultivated provides a hectare measure of the total amount of land under cultivation. Land cultivated includes both irrigated and non-irrigated crop land as well as the amount of improved pasture under operation. Improved pasture is commonly replanted each year.

Natural Pasture

Natural pasture land provides a hectare measure of the amount of unimproved pasture land operated. Land classified as natural pasture may have received some minor improvements but excludes any land which has been reseeded or actively tilled.

Total Family Labor

This figure expresses the entire family (household) labor contribution to the productive process during the year in terms of man-equivalents. The sum of adult and child family labor expressed in man-equivalents equals the total family labor force.

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[1]This appendix draws heavily on Richert, Allan, "Capital Formation Project: Summary Data," Ohio State University, (mimeo) 1972.

Total Hired Labor

Total hired labor is the sum of permanent and temporary hired labor. This figure, expressed in man-equivalents, indicates the contribution that all forms of hired labor made to the productivity process during the production year.

Capital Services

This figure is calculated as a 12 percent service flow of all fixed capital items. Initially the total value of fixed capital is derived by adding the actual values of buildings, machinery and workstock. Second, a 12 percent depreciation on the value of all fixed assets is assumed (actually the 12 percent represents a weighted average of different depreciation rates). This figure constitutes the capital service variable used in the analysis.

Several assumptions are involved in this calculation. First, it is assumed that the monetary value of capital items is a good substitute for the use value of the capital items themselves. Second, the available figures in the data are for capital stock and not for capital flow, thus a linear relationship between capital stock and capital flow is assumed. Third, the depreciation rates are assumed to be linear.

This measurement of capital flow has obvious limitations. However, the data restrictions were such that this approach was the only viable one.

The theoretical rationale for the use of the above approach is described in detail by Yotopoulos.[2]

Operating Expenses

Operating expenses is the sum of actual market cost of fertilizer, lime, seeds, herbicides, pesticides, machinery rental, machinery maintenance and fuel, all taxes and insurance and animal expenses during the production period.

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[2]Yotopoulos, Pan A., op. cit.

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RESOURCE ACCUMULATION AND ECONOMIES

OF SCALE IN AGRICULTURE

The Case of Sao Paulo, Brazil

By

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The Ohio State University, 1973

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The general objective of this study was to analyze the impact of agricultural policies on resource accumulation and economic efficiency of crop farms in the state of Sao Paulo, Brazil. An assumption of economies of scale in agriculture is inherent in the selection of many policy options for Brazilian agriculture and therefore became a central hypothesis for this study.

The data source for the analysis consisted of a cross section sample of 382 farms from the Ribeirao Preto area of northeast Sao Paulo. The sample farms displayed considerable size variability and enterprise specialization in the production of either livestock, annual or perennial crops. Data were collected during July 1970.

Two analytical techniques were utilized. An historical descriptive analysis traced capital investment patterns

on the sample farms during the decade of the 1960's including the form, sequence and source of various capital investments. The findings of this level of analysis, indicated that farms specialized in crops accumulated more capital than livestock farms. Annual crop farms augmented their land base considerably through acquiring or renting additional land. The smaller perennial crop farms reduced their land base slightly while the larger perennial crop farms increased it considerably. Machinery investment was the most important item of formed capital and in general the larger farms began mechanizing six to nine years before the smaller farms. Credit was an important source of financing capital resources especially for machinery.

The second analytical technique, production function analysis, was used to test for economies of scale and the productivity of inputs. Different production functions were defined for small (under 50 hectares) and large annual and perennial crop farms. A generalized Cobb-Douglas production function was fitted for each size and type to assess returns to scale. With the aid of a maximum log likelihood estimation technique, invariant and constant returns to scale were found in all cases.

An analysis of production elasticity coefficients and values of marginal products indicated that the larger farms are more productive than the smaller farms for some factor inputs, but not for others. The indications are that land, capital services and operating expenses are the major resource constraints for the smaller farms.

The history of resource accumulation however, indicates that the smaller farms are apparently unable to acquire these resources, at least on the same basis as do the larger farms. Agricultural policies operating on the assumption that larger farms are more efficient become a self fulfilling prophecy as they allow larger farms easier access to resources, especially credit. It is also apparent that the present policies detract from the major problem which is input productivity. For all farms, levels of input productivity are very low and little potential exists to increase values of marginal product. Expansion of production thus, under current technology is largely confined to expansion at the extensive margin.