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A STUDY OF ALLOCATIVE EFFICIENCY AT THE FARM LEVEL IN SOUTHERN BRAZIL

DISSERTATION

A dissertation submitted in partial fulfillment of requirements
for the degree of Doctor of Philosophy
at the University of Kentucky

By

Jose F. Noronha

Abaete, M.G., Brazil

Director: Dr. Fred E. Justus, Jr., Professor of Agricultural Economics

Lexington, Kentucky

1973

DISSERTATION

Jose F. Noronha, M.E.

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A STUDY OF ALLOCATIVE EFFICIENCY AT THE FARM LEVEL IN SOUTHERN BRAZIL

This is a study of the economics of resource allocation. The specific objectives of this study are: (1) To determine possible differences between production functions of three farm types in the region: beef cattle, mechanized wheat farms and mixed farms; (2) To determine differences in productivity levels as means to appraise resource allocative efficiency, and (3) To determine possible effects of the current price policy on the pattern of resource use and the potential for capital formation at the farm level.

Cobb-Douglas production functions were estimated using cross-section data. The data were collected by directly interviewing a sample of 169 farmers in Sao Borja, Rio Grande do Sul, in 1969-70. A research team from The Ohio State University and the Universidade Federal do Rio Grande do Sul conducted the survey.

The empirical results reveal that significant differences exist between the three farm types. These differences are reflected by the shape of the production functions and production elasticities of individual inputs.

The main factors explaining such differences between production functions are the capital structure of each farm type, technological level and market incentives.

Economic inefficiency is observed in all farm types. Cattle farms have the lowest, while wheat farms have the highest average and marginal productivity levels in the region. Cattle farmers are using land, labor and operating expenses very extensively. These farmers are usually owner-operators and rely mostly on family labor.

Mixed farms use too little capital and labor, while land is being used beyond the most profitable point at present levels of labor and capital use. This farm group includes both intensive as well as extensive users of land and other inputs. They are potential users of additional labor. This is the only farm group with underinvestment in labor, in the region.

Wheat farmers are using labor efficiently, but they use too little land and capital. This farm type presents a rare case of high productivity of land. In a developing economy land use is usually very extensive. High land productivity in wheat production in this case appears to be due to the use of modern inputs and possibly a better quality of land on wheat farms. Intensive use of land is also explained by the fact that wheat farmers usually rent most of their land they operate.

The most productive input for all farm types is capital. Working assets is the only input which has consistently presented very high MVP as well as AVP across the board. This result is strong evidence of generally favorable conditions for capital formation at the farm level irrespective of farm type.

This general high return to capital investment in the region throws suspicion on the efficiency of the capital market in responding to a high demand for capital. There seems to exist a shortage of capital in the region. Increases in capital investment either by internal savings and/or exogenous sources of capital would have significant impact on agricultural production, under current technological conditions.

A comparative analysis of these farm types shows that cattle farmers are in a disadvantageous position, mostly because of the current wheat price subsidy policy and the level of technology. Under present conditions it is logical to expect that resources will be transferred from beef production into mixed and wheat production, which offer higher returns to investment. If the wheat price subsidy is eliminated it is conceivable that the MVP of resources used in wheat production will decrease making this transfer of resources less attractive. It may even result in reverting the process, transferring modern inputs currently used in wheat production to mixed farming and cattle production, hence increasing their productivity levels. However, as long as the relative prices of the inputs (and outputs) used do not change substantially, the competitive position of the beef cattle business in Southern Brazil will continue to depend on major changes in production technology.

Jose F. Noronha

Jose F. Noronha

August 27, 1973

Date

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CHAPTER I

INTRODUCTION

Brazil has had surprisingly high rates of economic growth in recent years, both in the industrial and the agricultural sectors (Baer, 1972). But a major and very important difference exists between the two sectors. The industrial sector's growth is supported by government policies intended to protect and modernize the domestic industry and hence increase capital formation. Inflow of foreign capital as well as technological changes and export incentives play a very important role in this process (Baklanoff, 1970; p. 198).

On the other hand, agricultural output grows almost entirely by increasing cultivated area, except for some effort to increase productivity in the Central-South region. Since income per capita is increasing, demand for agricultural products is rising.

The implication of this contrast between the two sectors is that, as some economists predict, agricultural production may fail to meet domestic consumption needs and food importation will be necessary. Hence, the industrial sector may have to support the agricultural sector instead of the other way around, as usually advocated in development theory. Consequently, the development process may be seriously disturbed, if not completely stopped. This prediction arises out of the fact that (a) a very large proportion of the Brazilian population still depends on the agricultural sector; (b) agriculture is characterized by traditional methods of production and low productivity levels, and (c) both population, and urbanization are increasing at high rates.

Recent policies providing incentives for exports of agricultural products will certainly add to the burden imposed on the agricultural sector. These new policies which favor more diversified exports can be expected to have a major impact on the reallocation of resources at the farm level. Under full employment, increases in agricultural production would have to take place through shifts outward in the production possibility curve of this sector. However, full employment is not the case, so production can increase by either (or both) moving along the existing production functions, or shifting them upward via technological changes. Adams (1970, p. 20) predicted that "A major part of future agricultural growth will likely be determined by creating and adapting, through research, new technologies appropriate for Brazil."

Moving along the production function surface, toward or away from the point of maximum economic efficiency, is the subject of allocative efficiency. Thus, it becomes important to identify and estimate production functions in order to assess how well producers have been allocating their resources to achieve the assumed goal of individual profit maximization.

Several studies in Brazil have focused on resource productivity. This type of research is very useful for policy makers, mainly where resources are mobile, as capital and labor within a region or country. Development policies can be more effective when accurate predictive measures exist concerning the outcome of alternative decisions.

Predicting resource allocation among farms in any region and/or among regions requires empirical estimates of the production functions of these farms. Several levels of aggregation can be considered in estimating production functions, from the farm-level micro studies to the macro-models of the whole sector. The present study is of the first type. It is an attempt to estimate production functions for different farm types. It is a study of the production unit in isolation. Yet, the complex interrelations between production and consumption decisions inherent to the farm business is recognized.

Objectives

The general objective is to identify and analyze differences in resource productivities at the farm level in Southern Brazil. Such a study should shed some light on questions of resource allocation and capital formation in the agricultural sector of a developing economy.

Specific objectives are (1) To determine possible differences between production functions of three different types of farms in the region: beef cattle, mechanized wheat farms and "mixed" farms; (2) To determine differences in productivity levels, as measured by the production function estimates, as a means to appraise resource allocative efficiency. It is also hoped that the current dynamic move away from beef cattle and toward wheat production in this region can be at least partially evaluated by this analysis; (3) To determine possible effects of the current price policy on the pattern of resource use in the region and the potential for capital formation at the farm level.

Review of Literature

Brazil has a very short history of agricultural economic research. The agricultural economic discipline barely existed in the early 1960s; but significant progress has been made in this first decade of research. Nevertheless, the total amount of high quality research still leaves much to be desired considering the needs of the country (Schuh, 1970).

A number of production function studies have been done, usually at the farm level, taking a municipio[1] as the geographic population. The usual procedure is to fit Cobb-Douglas type production functions to cross-sectional

[1]Municipio is a Brazilian political administrative division that falls in between the U.S. county and township as far as function and jurisdiction is concerned.

data gathered from a survey of farm operators. Other techniques such as linear programming have been used, but less frequently.

The following paragraphs briefly review recent research in Brazil relating to the present study. Special attention is given to studies done in the South of Brazil, thereby permitting some comparisons of results. Other studies will be mentioned throughout the discussion of procedures and analysis.

Engler's (1971) linear programming study of the wheat and cattle farms in Rio Grande do Sul is of special interest. His main objective was "to analyze alternative enterprise combinations for farms specialized in wheat and beef cattle production in Southern Brazil, to provide an evaluation of price policies directed toward these farm enterprises and information and orientation for future policies" (p. 89). Sao Borja was one of the three municipios included in the area surveyed in building his typical farm for programming.

One of the main conclusions of his simulated wheat and beef cattle price changes was that these will have significantly different effects, depending on the level of technology and length of time of alternative policies. For instance, under a "medium" level of productivity beef prices have to be increased by 150 percent in order to compete with wheat and soybeans (p. 97). These two crops, he pointed out, are complementary activities and represent the "two most common crops in the region" (p. 92).

Beef cattle become more profitable than the wheat-soybean combination, only at a higher level of technology and with a substantial increase (60 percent over the 1970/71 levels) in beef prices (p. 97). This result raises an empirical question, which will be investigated here concerning the differences between production functions of beef cattle farms, and mechanized wheat farms as they currently exist.

Drummond (1972) fitted Cobb-Douglas production functions to cross-section data from two regions of Minas Gerais, Brazil. His objective was "to measure the effect of different levels of enterprise diversification on the economic efficiency of the firm and to analyze those factors felt to contribute to the firm's degree of diversification" (p. 6). He used an index of diversification which included both "the number of activities and relative importance of each activity" (p. 168).

The two regions studied, in his words, are "felt to be polar opposites in their fundamental characteristics" (p. 41). One region represents traditional farming in Brazil where soil fertility has been exhausted since colonial times. Small farms predominate in this region. The other region is endowed with productive and relatively unexploited soil. Farms are larger and highly mechanized, by Brazilian standards. The latter region is much more adaptable to mechanization than the former.

Some of the conclusions of Drummond's study will be used to support part of the procedure used in this study (Chapter III). It should be pointed out, however, that his comparison of these two regions led to the conclusion that "the agriculture of Muriae," the traditional region, "is neither more nor less efficient in the use of available resources than in the commercially oriented region of Capinopolis" (p. 151). This result supports the position taken by many development economists today that traditional agriculture is not necessarily inefficient.

Rao (1970) also used Cobb-Douglas production functions. His objective was "to examine the economics of agricultural credit use in the context of agricultural development" (p. 1). His sample of 451 farms was subdivided into two groups; one representing transitional technology and the other traditional agriculture. The first one was represented by the mechanized crop farms in a region where the transition from livestock to crop production is considered almost complete. The second group was represented by range livestock farms from a different area. His study included municipios in the States of Santa Catarina and Rio Grande do Sul, Brazil.

He found significant differences in both the elasticities of production and marginal productivities among sub-groups of farms. "This indicates diversity between farm types and (therefore) pooling of sample farms for the purpose of analysis may not be valid" (p. 127).

One of the conclusions regarding capital use was that "there is considerable under-utilization of capital on small farms and the scope to meet additional investment needs from their internal resources is very limited"

(p. 150). Another interesting conclusion for policy purposes was Rao's observation that "diversity in the structure of Brazilian agriculture is the rule and homogeneity the exception. Farms differ in terms of existing capital structure and enterprise combinations, input mix and production possibilities available to them." This implies that "generalizations regarding psychological propensities of farmers or investment opportunities in agriculture in general are likely to mislead in the formulation of credit policies" (p. 150).

Richter (1971) studied beef cattle production under current and new technology in the Southwest part of Rio Grande do Sul. His main objective was to determine the best beef cattle production alternatives based on contribution to the development of meat production in that State (p. 7). He tested two hypotheses of direct interest in the study of beef cattle productivity. The first asserts that "the total number of animal units is a function of the farm size measured in hectares." And the second, that "the farmers are relatively traditional and homogeneous in terms of the variability of important characteristics, such as, animal units per hectare, age of sale of animals, methods of handling the herd, and pasture management" (p. 7). He concluded, from statistical tests, that these two hypotheses could not be rejected. The farm size was found to be "the factor of primordial influence in cattle production" (p. 16). He estimated that "for an increase of one hectare in farm size there will be an increase of .75 animal-units," and that this linear relationship was independent of farm size.

For the second hypothesis he found that "except for the period of sales and the species of cultivated pasture, the majority of cattlemen (ranchers) are relatively traditional and homogeneous in their system of production of cattle" (p. 137).

Steitieh (1971) also studied resource productivity in Southern Brazil. His main objective was to estimate and compare the productivity of resources used by three different groups of crop farmers: "those that use their own machinery, those that rent machinery, and those that use no mechanized equipment on their crop enterprise" (p. 7). He also studied productivity change between the years 1965 and 1969, and estimated the elasticity of substitution of labor for other inputs. A Cobb-Douglas production function was used to estimate input productivity and a CES production function was used to study elasticities of substitution of labor for other inputs. Cross-sectional data were used in both cases.

Steitieh found, among other things, that land was being used near the optimum economic level by the custom-operator farmers. Further, farmers in the custom-operator group were better managers, and used the available resources more efficiently than the others. Because of these findings, he suggests: "Good management and better utilization of resources should go hand in hand with farm mechanization to insure higher crop production" (p. 91). No response was found, however, to fertilizer. He seems to suggest that this lack of response was due to misuse of fertilizer and its complements (insecticides, lime and seeds) in production.

No difference in resource productivity between 1965 and 1969 was found. He suggests that it may have been due to the lack of proper use of modern inputs during the period. "These results indicate that more expenditure on these inputs should be encouraged. At the same time, more information on time and amount of application and soil conditions should be supplied to the farmers to increase crop output" (p. 95). No conclusion was reached about the elasticity of substitution of capital for labor.

Most of these productivity studies failed to specify management as one of the independent variables. The reason for consistently neglecting management was the lack of a measure of its contribution to the production process.

Sorenson (1968) tried to estimate the effect of management. His population consisted of small farmers in Southern Brazil. His objective was "to estimate the marginal value productivities of capital inputs and to assess the effect of management performance on capital productivity.." (p. 1). Cobb-Douglas production functions were fitted to cross-section data to estimate the marginal value product of inputs, mainly of capital items. He presented an extensive review of the literature dealing with the specification (or lack of specification) of management and developed his own management index. "The purpose of developing the index is to include some composite factors which, while not entirely independent of other input categories does serve as a measure indicative of management performance on the swine farms studied" (p. 54).

Sorenson concluded that "The management index when included as an independent variable in the production function did not add measurably to the explanatory value of the function. However, managerial performance was demonstrated to have a cumulative effect on gross farm output as the use of a greater number of recommended practices was accompanied by increases in the crop and swine production components of the management index" (p. 2).

Thesis Organization

Chapter II is a concise presentation of the relevant economic and econometric models used here. Chapter III describes the setting of the study, and the overall procedures used. The statistical formulas used to test specific hypotheses are also presented in Chapter III. Chapter IV contains an overall analysis of the empirical results, and Chapter V presents a summary and the main conclusions of the study.

CHAPTER II

THEORETICAL MODELS

Economic Model

Production function analysis is the basic economic model used in this study. It constitutes, one might say, the foundation of the neoclassical theory of production.

At the theoretical level a production function is no more than a useful construct. It asserts that a process takes place in which an inflow of factor services (inputs) is transformed into an outflow of products produced (output). The number of inputs and outputs in a given process is theoretically unlimited. However, only a limited number of inputs and usually one or two products are analyzed.

The theory is an oversimplification of the real world. It assumes instantaneous transformation. This transformation takes place under internal and external constraints. The internal constraints are summarized by "the state of the arts," or the shape and level of the production function. External constraints are dictated by factor and product market conditions. Further simplifications are achieved by assuming perfectly competitive input and output markets as well as perfect foresight. Risks, uncertainties, and technological changes, are ignored. This is equivalent to saying that the available technology is promptly adopted. The expected output thus obtained from each combination of the limited available resources is a maximum. Hence, the production function can be represented by a single-valued functional relation between inputs and output. Theoretically, the entrepreneur has in mind an objective to be attained when a production process is undertaken. The most widely accepted objective is profit maximization.

Given the assumptions and a well-defined objective function, it is a matter of using logical reasoning (deductive process) to derive the necessary and sufficient conditions for profit maximization. That is, a set of principles can be derived from the theoretical framework. Properly applied these principles predict the most profitable use of resources. The derivation of such principles will not be presented here since they are presented in most economic textbooks.

A necessary condition for profit maximization is that inputs be combined so as to minimize the cost of any level of output produced. That is to say, any increase in production must be obtained along the firm's expansion path. Furthermore, profit will be maximized if, and only if, production is expanded up to the point where marginal cost of production equals output price or marginal revenue.

From the point of view of resource use and allocative efficiency analysis, however, it is more comprehensive to state the above equilibrium conditions in terms of input productivities. It can be easily shown that the best resource allocation within the firm is obtained when (a) for each input employed its marginal value product (MVP) equals its marginal factor cost (MFC); and (b) the input combination must be such that the last dollar's worth of each input is equally productive. Similarly, efficient resource allocation among firms is attained when the marginal value product of a given input is the same for all firms employing that input. This result follows from the assumption that all firms face the same input prices set by a perfectly competitive market. If any of these equilibrium conditions are not met, then resources are said to be misallocated and Pareto optimality is not attained. Consequently, there is room for change in resource use through policy incentives and/or the free play of market forces.

This model serves to explain resource allocation since it is possible to empirically estimate the marginal value products of the inputs using statistical techniques. Given the static nature of this model, the analysis has to be restricted to an equivalently static situation. In spite of this restriction, policy implications can be derived from this model by using comparative static analysis.

Econometric Model

A Cobb-Douglas production function was used to fit the sample data. There is empirical evidence, that this functional form well serves the objective of analyzing resource allocation (Heady and Dillon, 1961). In addition, it is widely used as an estimator of the population parameters of farm level production functions, has convenient analytical properties, and is relatively simple to work with.

A stochastic model must be considered in order to estimate the parameters of the production function. This research uses a modified form of the Zellner et al. (1966) stochastic model. The principal assumption of this model is that the entrepreneur's objective is to maximize the mathematical expectation of the profit function. This in turn implicitly assumes that there exists two types of error in the process of profit maximization; (a) in the production function itself, and (b) in the decision functions. Errors in the production function are due to factors such as weather, diseases, and machine performance, while errors in the decision functions are attributed to the human agent. Both types of error lead to inefficiencies which will be reflected by the size of the residual term of the model.

The assumption that quantity produced is uncertain (due to errors in the production function alone) is indeed appropriate when biological processes are part of the production function. This implies that in agricultural production function analysis a deterministic profit function could not exist even if all quantities and prices of the inputs used were known with certainty.

In order to employ inputs so as to equate marginal value productivities with input prices, farmers have to form expectations with respect to input-output price ratios. According to Zellner et al. (1966) errors in the decision functions are generated by the farmers' inability to predict such price ratios. Therefore, additional assumptions are needed to account for the interrelationship among all these different types of errors. The following assumptions are made: (a) for each farm in the sample input and output prices are assumed to have finite expected values and be "either known with certainty or statistically independent of the production function disturbance" (p. 787); (b) the differences between expected and observed prices are also "randomly distributed over firms" (p. 788); and finally (c) the correlation coefficient between the error term of the production function and each of the error terms of the decision functions are zero.

The general form of the model used here is:

$$Y = A\ D^{B_i}\ L^{B_2}\ K^{B_3}\ e^{u_o}$$

where Y = flow of output produced; D = land input services; L = labor input services; K = capital input services; A = constant term which reflects the level of the function; B_i (for i = 1, 2, 3) = production coefficients; and e^{u_o} = stochastic term of the model that accounts for both controllable and noncontrollable imperfections in the production process. It is assumed that u_o is normally distributed with mean zero and variance σ^2. Hence, e^{u_o} has a lognormal distribution.

The most interesting feature of this model is that single equation estimation of the linearized form of the production function, using ordinary least squares (OLS), leads to consistent and unbiased estimators (Zellner et al. 1966: 786-790). That is to say, the OLS estimates of the parameters of the Cobb-Douglas function are free from the simultaneity bias between input and output usually present in cross-section studies of production function.[1]

Two additional problems not specific to this model may still exist in this estimation procedure. The most frequent is specification bias, which results from a failure to include all the relevant variables of the model, either because some of them are not specified and/or cannot be numerically measured. This last case is best exemplified by management, which is usually left out of the model for lack of measurement (Griliches, 1957). The other estimation problem is multicollinearity. This results from the violation of the assumption of non-linearity between regressors. High coefficients of simple correlation between inputs are usually taken as indicators of multicollinearity. If

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[1]De Janvre (1972) has generalized this result. He has proven that under the Zellner et al. maximization of expected profit assumption, "direct estimation of the production function from cross-section data on firms is always free from simultaneous equation bias, whatever the functional form specified."

multicollinearity occurs, the variance of the regression coefficients will be overestimated. Consequently, the reliability of the statistical tests regarding these coefficients is diminished. In statistical jargon, the probability of committing a type II error increases with the degree of multicollinearity.

The estimates presented in Chapter IV are subject to these two types of statistical problems. Specification bias may be present due to the non-specification of the management factor. On the other hand, multicollinearity is not a matter of being present or not; rather, it is a matter of degree (Kmenta, 1971). Even though the importance of these problems for empirical research can hardly be overemphasized, it is not within the scope of this study to extend the analysis at this point.

CHAPTER III

RESEARCH PROCEDURE

Data Source

The data used for estimating the models constitute only a small part of the information gathered by the Capital Formation Project (CFP) team in 1969-70. The CFP is a research project being carried out by the Ohio State University's Department of Agricultural Economics and Rural Sociology. The general objective of the CFP is to study capital formation at the farm level, technological changes and agricultural output growth in less developed countries (Rask, 1972).

In the Brazilian part of the project, a large cross-section of farmers was interviewed directly using a fairly detailed questionnaire schedule. The main purpose was to obtain a range of primary information wide enough to allow the study of the different aspects of the farm business-household complex. Furthermore, the general procedure of the project included the preparation of a centralized "data bank" at the Department of Agricultural Economics and Rural Sociology, Ohio State University, from which individual research efforts could be conducted. Thus, this study takes advantage of concessions made by the CFP team regarding the use of their data, computer facilities and valuable technical cooperation.

The basic population studied, in most cases, included the farm-household units located within the geographic area of a municipio. This study focuses upon the municipio of Sao Borja in the State of Rio Grande do Sul.

A preliminary report regarding the Sao Borja survey has been published in Portuguese by Souza et al. (1972). Hence, the description of the region and sampling procedure presented here are taken largely from that report.

The Region

Sao Borja city is located in the State of Rio Grande do Sul about 495 km West of Porto Alegre, the state capital (see Figure 1). The municipio of Sao Borja is separated from Argentina by the Uruguay River on the West. The estimated area of the municipio is about 5000 km^2 and the population was about 30,000 people in 1970. More than 60 percent of the people live in the rural area. The topography is gently rolling and adaptable to mechanization.

In 1969 the estimated number of farms in the municipio was 2,015. Most of the area (about 70 percent) is used for livestock production. The main agricultural crops are wheat, rice, flax, corn, soybeans and mandioca. Sao Borja ranks as the leading municipio in wheat production in the country, and

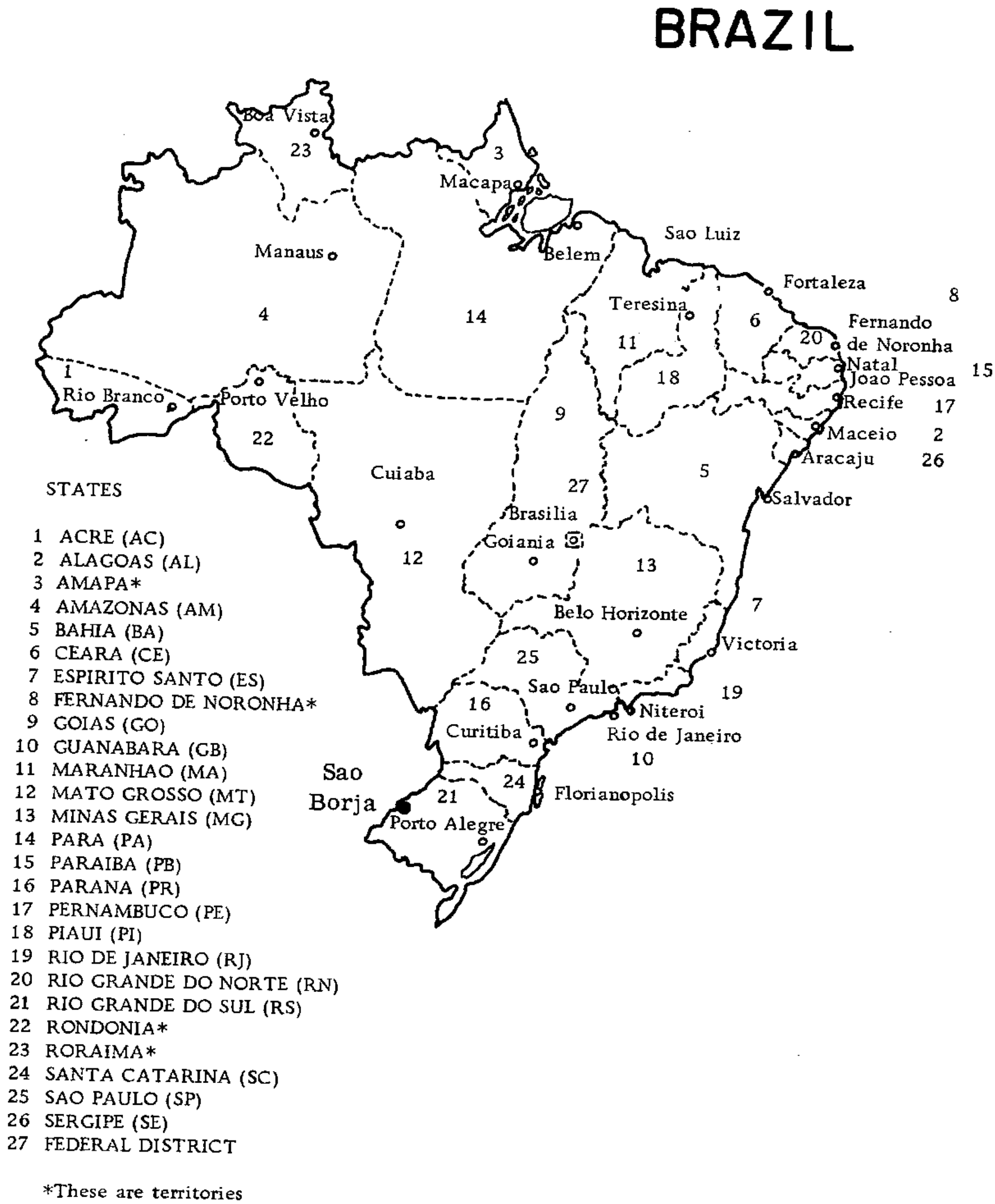

Figure 1.--Sao Borja, Rio Grande do Sul, Brazil

has a cattle herd which is the 9th largest in the state. There are more than 200 municipios in the state of Rio Grande do Sul.

Wheat production more than doubled between 1968 and 1970 due to increases in both land devoted to the crop and higher crop yield. Production went up from 47,000 to 110,000 tons due to a 100 percent increase in acreage and about a 15 percent increase in yield. Soybean acreage also has been expanding. On the other hand, the livestock herd is increasing in size, even though there is evidence that increasing acreages of wheat and soybeans have reduced the acreage of pasture land. Therefore, either cattle farms must be using their pasture more intensively, or previously idle land is being incorporated as pasture, or both.

The preliminary study of the region seems to indicate that livestock farms are more traditional than the others. Wheat farms are highly mechanized and essentially market oriented, whereas mixed farming is a transitional phase between livestock and wheat farming. The empirical estimates of the production function should reflect these differences if they actually exist.

Sampling

The general objectives of the CFP included collecting data on both economic and sociological factors, so the survey had to cover a wide range of farm types. The only information available prior to the survey about all the 2,015 farms in Sao Borja was total area (in hectares). A decision was made to use the available list of farms, the research team's observations, and secondary data to sample this population.

The population of interest consisted of 653 farms within the area interval of 100 and 5,000 ha. These farms represented 33 percent of the total number of farms and included 79 percent of the municipio's total area.[1] A simple random sample of 130 farmers taken from this population was judged to be satisfactory. To compensate for nonrespondents the study team started with a list of 200 farmers to be interviewed. The final number of usable questionnaires obtained, after completion and checks, was 169. The fact that the final sample was larger than planned can only benefit the quality of the estimates, thus all 169 observations were used.

Computation

In order to attain the specific objectives of this research, the sample was divided into three sub-samples composed of 67 cattle farms, 42 mechanized wheat farms, and 60 mixed farms, hereafter called "cattle," "wheat," and "mixed" farms, for simplicity.

In order to separate cattle from wheat farms, the relative importance of the product in the total farm income was used. "Cattle farms" were defined as those in which "60 percent or more of the annual income from the sale of

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[1] Farms with less than 100 ha presented insignificant economic importance, and only 6 are larger than 5,000 ha.

crops and livestock (including livestock products) is from the sale of cattle." Mechanized wheat farms were defined as those in which "60 percent or more of the annual income from the sale of crops and livestock (including livestock products) is from the sale of wheat and each farm has at least one tractor" (Reichert, 1972). The third group, the mixed farms, includes all farms in the sample which fail to be classified as either cattle or wheat farms by definition; it is a residual group. The 60 percent cutoff point is an arbitrary one. It was chosen mainly because it indicates a fairly high degree of specialization and still preserves acceptable sub-sample sizes for estimation purposes.

The idea was to estimate and study the production function of each farm type separately. Such an approach would allow inferences to be drawn with respect to resource productivity by the type of farm business and within the total region. The information available did not permit a discrimination of the different inputs (and outputs) between different enterprises of a given farm. Therefore, it was necessary to study farms which have a certain level of specialization, and consider a sub-sample of each farm type as having a single product production function. The group of mixed farms can be looked upon as a control group in this experiment.

This procedure may have theoretical implications if the degree of specialization per se implies different levels of technology. If so, any differences between these farm types must be attributed to the classification procedure, and not to actual differences in resource combination. However, Drummond (1972) studying Brazilian farms found that "The efficiency of the firm in production is not related to the level of diversification as measured by the index used. ." (p. 145). He also contends that the level of diversification and farm size are not associated "in either a theoretical or empirical framework" (p. 146). His results support the classification criterion used here.

Description of the Specified Input and Output Variables

Input Variables

The three classical factors of production have been specified, i.e., land, labor and capital. The definitions and criteria used here are based on those of the Capital Formation Project (Reichert, 1972). This same reference contains the definitions of the output items.

Land input is measured in terms of the total land operated, not necessarily total land owned (in hectare). Total land operated includes cultivated land, natural pasture, and other land. Cultivated land includes irrigated and non-irrigated crop land, as well as improved pasture land. Natural pasture may have received minor improvements but excludes any land which has been reseeded or actively tilled. And "other land" includes that land which is only indirectly used for agricultural purposes such as forest areas, irrigation facilities, and building areas.

Labor input is measured by the number of man-equivalents of family and hired labor utilized, during the year studied. A man-equivalent is defined as a "standard labor unit" working 300 days per year. A standard labor unit is a male between 18 and 59 years of age. Percentage weights were assigned to workers who did not fall within this age interval. Thus, a homogeneous unit was defined in terms of total utilized labor.

Capital was divided into two main categories: working assets and operating expenses. Working assets represent the sum of the value of buildings, mechanized equipment, trucks, non-mechanized equipment, production livestock and work livestock. Operating expenses represent the sum of total annual crop, livestock, machinery and general expenses used up in the production process. All these capital items were measured in cruzeiros. The value of land is not included in the capital input for it has been measured as a separate input (in hectares).

From Stock to Flow Variables

It is well known that inputs and output are usually specified in terms of flows during a production period. The production period in this case is the agricultural year which goes from July 1, 1969 to June 30, 1970. All the data refer to this annual length of time. However, not all of the input variables can be measured in flow terms directly. For some input data are available only in terms of their stock value at the time of the interview. This is the case with the so-called working assets. These factors of production have a life span which covers many production periods. Therefore, the question of transforming stock values into flows must be considered.

Measurement of the contribution of working assets for the production process in a given period always presents problems for the researcher. The transformation of stock into flow variables must consider that, in a given year, some factors of production depreciate while others appreciate in real value. Also, some of them supply a fairly constant flow of services during their life span while others present a flow of services which varies with the age of the productive agent. In either case, the problem is to compute the input's individual contribution to the production process during that specific period.

Accurate input measurement requires detailed analysis of each input individually on a fairly disaggregated basis.[2]

The approach used here to transform stock into flow variables is only a gross approximation of the more precise measurement procedure, since data were not available to permit a more elaborate analysis. This approach charges a rental rate against the stock value of the input, by using conversion ratios "chosen to reflect the opportunity costs of capital in off-farm investment of similar nature" (Drummond, 1972, p. 167). Drummond's conversion ratios were used here. These ratios were developed for Brazilian farmers somewhat similar to the ones under concern, and hence, considered reasonable estimates. The actual values of the ratios were: 6 percent for livestock, 4 percent for

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[2]A detailed treatment of the theory of input measurement and the transformation from stock into flows can be found in Yotopoulos (1967).

permanent structure, 12 percent for machinery and equipment, and 100 percent for operating expenses in general.

Output Variable

Total gross output is defined as the sum of crop and livestock sales, family privileges, hired labor privileges, changes in the value of the livestock inventory, value of abnormal livestock losses, value of rent payment made in kind minus the value of livestock purchases.

Most of the items included in this working definition are self-explanatory. However, two of them deserve special attention: (a) the value of livestock purchases and (b) the value of abnormal losses. Both (a) and (b) are corrections for possible bias in the measurement of actual farm-produced output. The value of livestock purchases positively affects the livestock inventory change and/or livestock sales. Therefore, it had to be subtracted from the sum of the other output items since it was not the result of the farmer's production. The value of abnormal livestock losses also reflects on changes in livestock inventory. When the level of losses is significantly large (i.e. when abnormal losses occur) the observed change in livestock inventory is biased downward. Consequently, total gross output is also biased in the same direction. Therefore, the value of abnormal losses was added to the other production items as a corrective measure. Abnormal livestock losses was defined by the difference between observed livestock losses and a statistically determined level of normal livestock losses.[3]

Estimation

On the basis of the theoretical justification discussed in Chapter II, single equation models were set up. Several models were initially specified, starting from very disaggregated models to more aggregated ones. The OLS statistical technique was used to fit the linearized form of the model to the sample data.[4] It was found that more disaggregated models did not fit the data well. This may have resulted from lack of good measures of some specific items such as family labor, expenses on non-mechanized equipment, and/or from specification errors.

The most disaggregated models divided land into cultivated and pasture land; labor was divided into hired and family labor; capital was divided into working assets and operating expenses. Working assets were further sub-divided into two variables: value of production and work livestock as one variable and value of machinery and equipment as another. Operating expenses were also sub-divided into two variables. One was composed of crop and

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[3]For a detailed explanation of how abnormal losses was computed, see Reichert, (1972), Appendix B.

[4]OSU-Economic Regression Program, by Dr. John Cunnyngham, and computer facilities were utilized for this purpose.

machinery expenses, and the other of livestock and general expenses. Four other models were derived by aggregating some of the independent variables into different combinations of inputs. The most aggregated model included only land, labor and capital.

Another modification used in this specification procedure was in the type of aggregation. Whenever two (or more) variables were aggregated into one, two different aggregation methods were tried. Thus, in reality, two models were developed: one where the aggregation was arithmetic (i.e. variables were simply added together) and the other where the aggregation was geometric (i.e., the logarithms of the variables were added up). This procedure implies that a different set of assumptions have to be used in each case.

Employing two methods of aggregation was done as a scanning device to better specify the final model. It was not intended to test the validity or superiority of one method over the other. The analysis of the estimates, however, indicated that the geometric aggregation had to be rejected from the point of view of statistical "goodness of fit." This conclusion, however, should not leave the false impression that geometric aggregation of inputs should never be done. One of the difficulties was that similar models (in terms of number of regressors) had to be specified for the three different types of farm, given the objectives pursued. This created problems in that the relationships between inputs are not necessarily the same for different types of farms.

For instance, two inputs which apparently were complements in cattle production would not be so in wheat production. Thus, geometric aggregation of these two production function inputs did not work. Arithmetic aggregation, consequently, was used in all final models, for all three farm types.

Two different models were selected for final consideration. The results of these two models are presented in Chapter IV.

Statistical Tests

In order to answer relevant economic questions, a number of statistical hypotheses have been formulated and tested. This section is devoted to a simple but detailed description of these tests. No proof of the formulas will be presented since it is outside of the purposes of this study.

A statistical hypothesis is a statement about the distribution of a random variable. A test of the hypothesis is simply a decision rule which, on the basis of the observed sample results, indicates whether the null hypothesis is to be rejected or not (Hogg and Craig, 1972).

Failure to reject the null hypothesis, however, does not imply that it is true. It simply indicates that the available sample observations are not strong enough evidence for rejection. In either case a probability of making the wrong decision can usually be computed; the researcher's objective is to minimize such probability as far as hypothesis testing is concerned. The probability of rejecting a true hypothesis (α) is usually set in advance by the investigator. The so-called coefficient of confidence of the test is given by $1 - \alpha$. In most agricultural economic studies, this level of significance (α) is either 10 or 5 percent, and even 1 percent.

With these concepts quickly reviewed, the following tests will be presented, leaving the discussion of the empirical results for the next chapter.

The Regression Equations

Once each production function is fitted to the data, the first test performed is that of the validity of the regression of output on the input variables. The F-statistic is estimated directly by the regression program. At the same time, each parameter of the equation is tested by the t - statistic estimate. These tests are well known and need no further discussion of the specific procedure, since they are incorporated directly in the regression programs.

The null hypothesis in this case is that all regression coefficients are equal to zero (in the F-test), while the alternative hypothesis is that at least one of the regression coefficients is different from zero. Rejection of the null hypothesis, when the F - estimate falls into the critical region of the test, means that it is very unlikely that the estimated equation is generated by a model in which no relationship exists between the regressor and the independent variables. But it should be pointed out that each coefficient need not be statistically significantly different from zero when the null hypothesis is rejected. Therefore, the t-test is used for individual inputs. The null hypothesis is then, that the regression coefficient being tested is equal to zero. The alternative is that it is not zero.

Since in the case of a Cobb-Douglas production function these regression coefficients are the elasticities of production of the respective inputs, these elasticities are being tested for statistical significance. Non-rejection of the null hypothesis for a given input suggests that there is a positive response to the use of that input.

Several other hypotheses are also of major interest for economic analysis, but are not tested directly from the computer results. They require additional computation to estimate the relevant statistic, and to test the null hypotheses. They are discussed in the following sections.

Returns to Scale

The sum of the elasticities of production gives the returns to scale in a Cobb-Douglas production function. The relevant hypothesis here is whether this sum is equal to unity or not. That is, whether constant returns to scale prevail or not. So the hypotheses are:

$$Ho: \sum_{i=1}^{k} \beta_i = 1$$

$$Ha: \sum_{i=1}^{k} \beta_i \neq 1$$

The T-statistic is used, and can be computed as follows:

$$t = \frac{E - \sum^{k} b_i}{\sqrt{Var\ (E)}}$$

where t is distributed with 1 and n-k-1 degrees of freedom. E = 1 is postulated, and $E = \sum_{i=1}^{k} b_i$ is obtained from the regression estimates. So all that is needed is to compute the standard error of the returns to scale. That is,

$$Var\ (E) = \sum_{i=1}^{k} Var\ (B_i) + 2 \sum_{i,j}^{k} Cov\ (B_i, B_j),\ i < j$$

and $S.D._E = \sqrt{Var\ (E)}$

The variance-covariance matrix of the regression program and the estimates of the coefficients supply all the information necessary for this test.

<u>Comparing the Marginal Value Products (MVP)</u>

The relevant test here is whether there is any difference between the marginal value product of each input and the input price. This would answer questions related to economic efficiency of resource use, as was discussed in the economic model (Chapter II). In the present study, unfortunately, input prices were not obtained directly from the farmers interviewed. This necessitated computing average regional input prices from secondary data, which means no measure of price variability is available. Further, there is no guarantee that this regional average price is an accurate proxy for the price actually paid by farmers for inputs. But this was the only information available, so it was used as an approximation, at least, of prices farmers paid.

These prices can be compared to the confidence intervals computed for the MVPs. If the computed confidence interval overlaps the proxy for input price, then there is at least some indication of efficient use of that input. If the C.I. does not overlap the input price, then either too little or too much of the input is being used. These same confidence intervals can also be used to compare the MVPs of each input when used by different farm types.

If the C.I. of the estimated MVP of a given input for cattle, for instance, does not overlap the C.I. of this same input used in wheat production, then it is necessary to reject the hypothesis that they are equal. This conclusion would lead to inferences regarding possible direction, in which each input should be moving. That is, the input should be moving from less productive to more productive uses, other things being constant.

A $1 - \alpha$ confidence interval for the MVP of a given input is computed as follows:

$$MVP \pm t_{1-\alpha}\sqrt{Var\,(MVP)}$$

where the MVP is computed at the geometric mean of the inputs and output.

Since $MVP = b\,\frac{\bar{Y}}{\bar{\bar{X}}}$ when output is measured in value terms, a simple and approximate estimate of its variance is given by

$$\text{Var (MVP)} = \left[\frac{\bar{Y}}{\bar{X}}\right]^2 \quad \text{Var (b)}$$

where $\bar{Y}$ and $\bar{X}$ are assumed constant. This, of course, is only an approximation, because $\bar{Y}$ is estimated as a function of the regression coefficients (b) so it actually is not constant.

Carter and Hartley (1958: 306-313) developed a formula for the precise estimate of Var (MPP) when $\bar{Y}$ is not assumed constant. They show that the two alternative estimates are quite different when the MPP is computed at values of the inputs other than their geometric mean. But, if the MPP's are estimated "near the geometric mean of the independent variable" (Carter and Hartley, 1958), then the error made using the approximate formula is usually small. Thus, all the confidence intervals computed here take advantage of the simplicity of this approximation formula. The MPP's have been computed at the geometric means, so no major problem should arise. It must be pointed out also, that their formula gives the variance of the MPP, and not the variance of the MVP. But the fact that the output is being measured in value terms, gives the latter directly, instead of the first. It obviously could be applied more rigorously to compute Var (MVP) = Var (P.MPP) where P = product price. But the product here is a composite of several crop and animal products whose price is almost impossible to compute with reasonable accuracy. Therefore, using the formula for Var (MPP) as a proxy for the Var(MVP) seems more reasonable an alternative than trying to come up with a price for the composite product.

Comparing Production Functions

The Chow (1960) test was used to test for differences between the three production functions. Firstly, it was hypothesized that there was no difference among the three production functions, i.e. cattle, wheat, and mixed. This hypothesis, if not rejected, would imply that the subdivision of the sample by farm types is probably an artificial one. The alternative hypothesis was that the three production functions were not equal, i.e. it made sense to estimate three different equations.

Chow's F-test is based on the sum of squares of the residual of the sample estimates. The F- statistic is distributed with K and $\sum_{i=1}^{t} n_i - t.k$ degrees of freedom. It is computed as follows:

$$F = \frac{\dfrac{SSE_p - \sum_{i=1}^{t} SSE_i}{k}}{\dfrac{\sum_{i=1}^{t} SSE_i}{\sum_{i=1}^{t} n_i - t.k}}$$

where SSE_p = the sum of squares of the residuals when a given model is fitted to the pooled sample (i.e., the 169 observations in the present case); SSE_i = the sum of squares of the residual when the same model is fitted to each of the ith sub-sample of size n_i; thus, $\sum_{i=1}^{t} n_i = n$ is the size of the pooled sample, and t = the number of sub samples; k = the number of parameters being estimated by the model, including the constant term. In this study t = 3 when all three production functions are tested.

The test of equality among the three production functions is inconclusive with respect to any pair of them. So the same formula was used to compare all possible combinations of these three farm types two at a time. The only change to notice in the formula, though, is that t = 2, when two samples are compared.

Comparing Elasticities of Production

The hypothesis that there is no difference between the elasticities of production of a given input used in two different farm types was also tested. Either the t-test or the F-test can be used for this purpose. The F-statistic (Hill and Takayama, 1971) is distributed with 1 and $(n_1 + n_2) - 2k$ degrees of freedom.

$$F = \frac{\dfrac{(b_{i1} - b_{i2})^2}{(c_{ii,1} + c_{ii,2})}}{\dfrac{SSE_1 + SSE_2}{n_1 + n_2 - 2k}}$$

where b_{i1} and b_{i2} are the elasticities of production (estimated) of the ith input, when a given Cobb-Douglas model is fitted to samples 1 and 2, respectively. Sample 1 has n_1 and sample 2 has n_2 observations, and k is the number of estimated parameters, including the constant term. The sum of squares of the residuals are SSE_1 and SSE_2, obtained when the same model is fitted to samples 1 and 2, respectively; $c_{ii,1}$ and $c_{ii,2}$ are the diagonal elements of the inverse matrix of samples 1 and 2, equivalent to the ith input. These elements may not be directly provided by the computer results of a specific program, but they can be estimated by simply recalling that $c_{ii} = Var(b_i)/MSE$. The mean square of the errors (MSE) and Var (b_i) are given directly by the regression results.

CHAPTER IV

EMPIRICAL RESULTS AND ANALYSIS

The Three Types of Farms - A Comparison

Beef cattle farms, mechanized wheat farms and "mixed" farms, as defined in this study, are considerably different when compared on the basis of the arithmetic mean values of selected variables. This discussion aims at examining such differences since they help in understanding the statistical results to be analyzed later in the chapter.

In terms of size (measured in hectares) cattle farms are the largest group, with an average of 539.26 ha of operated land. The next largest group is mechanized wheat farms with 189.37 has and the smallest group is the mixed farms with 145.04 ha (Table 1).

With respect to land use, the data show that cattle farmers cultivate only 2 percent of their operated land, 89 percent is used as natural pasture and 9 percent is "other land" i.e., land not usable directly in the production process. Considering that cultivated land includes improved pasture and that these farmers usually devote some land to crop production, it must be inferred that cattle farmers in this region have an insignificant proportion of their land in improved pasture.

TABLE 1.--Input Use and Output Level by Farm Type - Sample Arithmetic Means and Coefficient of Variation[1]

	Cattle Farms			Mixed Farms			Wheat Farms		
	Unit	Percent	C. V.	Unit	Percent	C. V.	Unit	Percent	C. V.
LAND:	(Ha)			(Ha)			(Ha)		
Cultivated	12.35	2	226	44.60	31	190	104.70	55	162
Natural Pasture	476.69	89	150	89.05	61	126	74.73	40	231
Other Land	50.22	9	219	11.39	8	149	9.94	5	352
Operated	539.26	100	151	145.04	100	96	189.37	100	172
LABOR:	(m. e.)			(m. e.)			(m. e.)		
Family Labor	1.43	56	66	1.57	26	84	1.65	32	61
Hired Labor	1.11	44	140	4.43	74	152	3.56	68	108
Utilized	2.54	100	59	6.00	100	114	5.21	100	73
CAPITAL:	(Cr$)			(Cr$)			(Cr$)		
Buildings	33,274.78	24	178	39,415.00	21	167	31,498.57	15	140
Mach. & Equipment	9,153.09	7	142	86,951.03	46	146	125,809.12	60	67
Livestock	95,801.49	69	121	62,391.20	33	229	51,066.12	25	163
		100			100			100	
W. Assets	138,229.36	(96)	123	188,757.23	(82)	145	208,373.81	(77)	74
Crop Expenses	412.87	8	319	16,899.80	40	149	32,713.05	54	92
Mach. Expenses	1,297.51	26	183	20,576.72	49	147	25,037.24	41	100
Livestock Expenses	1,655.07	33	157	1,545.47	4	230	1,353.67	2	172
General Expenses	1,639.10	33	186	2,756.88	7	184	1,707.48	3	139
		100			100			100	
O. Expenses	5,004.55	(4)	161	41,778.87	(18)	139	60,811.44	(23)	85
Total Capital	143,233.91	100	(123)	230,536.10	(100)	138	269,185.25	(100)	70
OUTPUT	23,429.42		114	122,753.67		156	162,762.12		78

[1]Note: $C.V. = \frac{s.d.}{\bar{x}}$ where s.d. is the standard deviation and $\bar{x}$ the arithmetic mean of each variable.

On mixed farms 61 percent of the operated land is in pasture, 31 percent is cultivated land and 8 percent is other land. On wheat farms 55 percent of the operated land is ultivated, 40 percent is used for pasture, and 5 percent is other land. This large proportion of the wheat farms land in natural pasture is a bit surprising, as will be seen later in this analysis. It seems to indicate that wheat farmers have considerable flexibility in the use of the land input for wheat production.

Differences are also noticeable among farm types with respect to labor use. The mean amount (in man-equivalents) of labor used on cattle farms is 2.54 m.e., while mixed farms and wheat farms use 6.00 m.e. and 5.21 m.e., respectively. Cattle farmers rely mostly on family labor (56 percent of the total amount used), whereas mixed farmers and wheat farmers rely on family labor for only 26 and 32 percent of their total labor.

The most significant differences among these farm types is found in their capital structure, particularly between cattle and wheat farms. The average value of investments excluding the value of land on the wheat farms is almost twice as large as that of the cattle farms. Considering the stock value of working assets and operating expenses separately, the capital composition is as follows:

(a) Cattle farms have 96 percent of their capital in working assets (mostly in the form of livestock and buildings) and only 4 percent as operating expenses;

(b) Mixed farms have 82 percent in working assets and 18 percent in operating expenses, and

(c) Wheat farms have only 77 percent of the total capital as working assets and 23 percent in operating expenses.

These figures indicate that wheat farmers concentrate heavily on mechanized equipment in both absolute and relative terms with respect to the other farm types. Machinery and equipment account for 60 percent of the wheat farms' working assets. Moreover, 95 percent of the operating expense is accounted for by machinery (41 percent) and crops (54 percent) expenses.

Table 1 also contains the coefficient of variation (C.V.) of each variable considered. The coefficient of variation is larger than 100 percent for most of the variables. Family labor is the only variable with a C.V. consistelt below 100 percent for all three types of farms. Hired labor's C.V. is also less than 100 percent for mixed and wheat farms. This special characteristic (low variability) of the labor input seems to indicate that farming is primarily a family business in this region, even on the mechanized wheat farms.

Another important characteristic which differentiates the farm types is land tenure. The sample data indicate that cattle farmers are mostly owner-operators (Table 2). Rather than rent land from others, they often rent part of their land to others. Wheat farmers usually rent at least part of their land. Approximately 33 percent of them rent all the land they operate, and only 5

TABLE 2.--Frequency Distribution of the Farms in the Sample According to Land Tenure and Farm Type

Tenure Class[1]	Frequency					
	Cattle		Mixed		Wheat	
	No.	Percent	No.	Percent	No.	Percent
A	15	23	7	12	2	5
B	3	5	7	12	17	40
C	41	61	21	35	2	5
D	0	0	17	28	14	33
E	8	11	8	13	7	17
Sample	67	100	60	100	42	100

A = Does not rent land to or from others

B = Operates own land and rents from others (may rent more than 50 percent), but does not rent to others

C = Operates part of his land and rents the rest to others

D = Rents all the area operated

E = Other systems

percent own all the land they operate. Again, mixed farms constitute an intermediate stage with percentage figures falling in between cattle and wheat farms for most items. These differences in land ownership partially explain the observed differences in capital structure and land use discussed previously.

In general, there are considerable differences among these farm types, as shown by this preliminary analysis. Such differences should be borne in mind since they will serve to explain some of the empirical results discussed in the following sections.

Empirical Estimates

Several different models were fitted to the data. Two were selected for the comparative analysis. The criteria used in selecting these two models were (a) statistical best fit indicators and (b) usefulness for economic analysis.

Some of the statistical estimates are similar for all farm types and models. For example, all three functions present an adjusted coefficient of multiple determination (R^2 -adj.) varying from 0.80 to 0.86, and a high level of significance of the regression estimate according to the ANOVA test. Other similarities among the estimates are related to returns to scale and multicollinearity.

Returns to Scale

The sum of the Cobb-Douglas production elasticity estimates is usually taken as a measure of returns to scale. In this sense the results presented in Table 3 indicate constant returns to scale in Southern Brazil. The sum of the production elasticities (for each farm type) is not significantly different from unity, at the 1 percent probability level.[1] Similar results have been found for several other countries (Heady and Dillon, 1961; Yotopoulos, 1967).

Specification Bias

Since management was not specified in this case, the estimated production elasticities (and hence, the returns to scale) are subject to specification bias. The direction of the bias depends on the association between the specified inputs and management. "There are *a priori* theoretical reasons to believe that constant returns to scale must prevail if all inputs are included. Indeed, the exclusion of the management factor would lead to an underestimation of the returns to scale, if we assume that the omitted factor varies less than proportionately with changes in the included factors over the range of the sample observations" (Yotopoulos, 1967; p. 182).

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[1]These results must be interpreted cautiously, because management was not specified. Attempts made to avoid specification bias by specifying management in other research work have not been successful due to a lack of measurement of the effect of management on production (Sorenson, 1968).

TABLE 3.--Characteristics of the Empirical Production Functions, by Farm Type

Model and Characteristic	Farm Type		
	Cattle	Mixed	Wheat
Model I:			
R^2 (adj)	0.8183	0.8593	0.8588
F - ratio[a]	75.3010	91.0864	63.3334
$S^2_{y.x}$	0.0434	0.2856	0.1457
d.f.	62	55	37
Return to Scale[b]	1.0600	1.0318	1.0826
(S.D.)	(0.0970)	(0.1048)	(0.0903)
Model II:			
R^2 (adj)	0.7987	0.8641	0.8570
F - ratio[a]	85.1348	126.0580	82.9344
$S^2_{y.x}$	0.0495	0.2807	0.1466
d.f.	63	56	38
Return to Scale[b]	1.0126	1.0316	1.0951
(S.D.)	(0.1012)	(0.1021)	(0.0755)

[a]All F - values are statistically significant at the 1 percent level.

[b]No return to scale is significantly different from unity, at the 1 percent probability level.

The implication of excluding management in a Cobb-Douglas production function analysis is that the inferences must be based on the average firm. It is implicitly assumed thereby that the estimation of the function is based on the average level of management in the sample (Mundlak, 1961).

Multicollinearity

Whenever explanatory variables are correlated with each other in regression analysis multicollinearity is present. "Of particular interest are cases of high degree of multicollinearity, which arise whenever one explanatory variable is highly correlated with another explanatory variable or with a linear combination of other explanatory variables" (Kmenta, 1971; p. 380). The author points out that the problem "is a question of degree and not of kind." Since it relates to the non-stochastic variables of the model, multicollinearity is a feature of the sample and not of the population."

The most serious consequence of high degree of multicollinearity is the large value of the standard deviations of the regression coefficients. This implies that the probability of making a type II error is increased considerably. Or alternatively, the t-test of the individual regression coefficients fails to reject the null hypothesis (when it should) more frequently than would be the case if no serious multicollinearity problem existed.

The simple correlation coefficients between pairs of explanatory variables are usually considered indicators of multicollinearity. In this study, it is most likely that high levels of correlation between working assets and operating expenses is causing a multicollinearity problem (Table 4). Model II, in which these two variables are aggregated into total capital, aims at reducing the degree of multicollinearity. But total capital and labor are also highly correlated in both the mixed farms and wheat farms samples.

The empirical results reveal that the multicollinearity problem did not affect the test of the production elasticities very much, but variances of the marginal value products of the inputs were seriously affected. Consequently, the confidence intervals initially placed on the MVP were seriously overestimated.

Beef Cattle Production Function

The traditional factors of production, land, labor, and capital explain about 82 percent of the variation in beef cattle production (Table 5). The elasticity of production of working assets is 0.81, which denotes a very high response in production to changes in this input. The elasticity of production of operating expenses, on the other hand, is not significantly different from zero, even at the 25 percent level of probability. In addition, this elasticity carries a negative rather than the expected positive sign.

The elasticity of production of land and labor are significantly different from zero at the 25 and 5 percent probability levels, respectively. But they indicate that production response is much smaller to changes in these inputs than to changes in working assets.

TABLE 4.--Matrix of the Correlation Coefficients by Farm Type in the Sample

Variable and Farm Type	Variable					
	X_1	X_5	X_9	X_{27}	X_{30}	X_{41}
X_1 = Output						
Cattle	1.00					
Mixed	1.00					
Wheat	1.00					
X_5 = Land						
Cattle	0.55	1.00				
Mixed	0.10	1.00				
Wheat	0.60	1.00				
X_9 = Labor						
Cattle	0.52	0.31	1.00			
Mixed	0.80	0.17	1.00			
Wheat	0.70	0.44	1.00			
X_{27} = Working Assets						
Cattle	0.90	0.57	0.48	1.00		
Mixed	0.89	0.25	0.79	1.00		
Wheat	0.87	0.59	0.77	1.00		
X_{30} = Operating Expenses						
Cattle	0.79	0.48	0.49	0.87	1.00	
Mixed	0.90	0.06	0.76	0.87	1.00	
Wheat	0.87	0.40	0.64	0.79	1.00	
X_{41} = Total Capital						
Cattle	0.89	0.55	0.49	0.98	0.94	1.00
Mixed	0.93	0.13	0.80	0.95	0.98	1.00
Wheat	0.91	0.47	0.70	0.88	0.98	1.00

TABLE 5.--Regression Coefficients, Average and Marginal Value Products, Geometric Means and R^2 (adj.), as Estimated by Models I and II, for Cattle Farms

Model, Input and Output	Regression Coefficient (S.D.)	Average Value Product	Marginal Value Product	Goemetric Mean
MODEL I ($\bar{R}^2$ = 0.82):				
Intercept	0.9656[a] (0.2107)	-	-	-
Land (ha)	0.0448[e] (0.0569)	53.28	(2.39)	246.00
Labor (m.e.)	0.2007[b] (0.1072)	6,182.54	1,240.84	2.12
W. Assets (Cr$)	0.8148[a] (0.1116)	2.88	2.35	4,544.00
O. Expenses (Cr$)	-0.0003 (0.0828)	6.56	(-0.00)	1,997.00
MODEL II ($\bar{R}^2$ = 0.80):				
Intercept	1.0337[a] (0.2185)	-	-	-
Land (ha)	0.0769[d] (0.0598)	6,182.54	(4.10)	2.12
Labor (m.e.)	0.1969[b] (0.1138)	2.88	1,217.34	4,544.00
Capital (Cr$)	0.7388[a] (0.0687)	1.90	1.41	6,890.00
OUTPUT (Cr$)	-	-	-	13,107.00

Notes: (1) a, b, c, d, and e indicate statistical significance at 1, 5, 10, 12.5, and 25 percent probability levels, respectively.
(2) $\bar{R}^2$ (adj.) = adjusted R-squared.
(3) All the MVPs were computed at the geometric mean values of the inputs and output. MVPs in parentheses were computed with production elasticities nonsignificantly different from zero at the 10 percent probability level.

Working assets seem to behave as a dominant variable in both models. It explains most of the variation in output produced. Little is explained by the other inputs. Rao and Miller (1971; p. 40) point out that this type of estimation problem frequently occurs in empirical research when the dependent variable is somehow functionally related to an independent variable in relatively fixed proportion. They also point out that "Whether a variable is truly superfluous" (as operating expenses seem to be in this case) "or is a consequence of the presence of a dominant variable" cannot be determined on a priori grounds. In the present case, two factors seem to explain the dominant effect of working assets on output: (a) the low level of technology and (b) the extensive use of land in cattle production. Under traditional methods of production, it is logical to expect production to depend mostly on the animal stock. As observed previously, 96 percent of the capital investment on these farms (other than that invested in land) is in working assets. And the value of the livestock accounts for 69 percent of this capital item.

In terms of resource allocation, the MVPs (Table 5) indicate that land and operating expenses are being used to (or near) the point of zero marginal value product. Unless the opportunity costs of land is zero, economic inefficiency is evident. Decreasing the amount of land can be expected to increase total profit, ceteris paribus.

The estimate of the MVP of labor is Cr $1,241.00 per man-equivalent (m.e.). The average regional wage rate was Cr$1,725.00 per m.e. at the time of the survey, according to the research team. This result also suggests that too much labor is being used by cattle farmers for existing size of beef herd, in spite of the low absolute amount of labor employed (2.12 m.e. on the average) per farm.[2]

The estimate of the MVP of working assets is 2.35 cruzeiros worth of output per additional cruzeiro used up in the production process (Model I). If total capital is considered (Model II), the general conclusions still hold with respect to the overall inefficient use of resources, but the return per additional cruzeiro invested in capital items is reduced to 1.41. This result still indicates that there is a gross margin of 41 percent on capital investment.

The aggregation of the capital input variables slightly affects the elasticity of production of land. It increases from 0.04 to 0.08 and becomes significantly different from zero at the 10 percent probability level. No major change occurs on the MVP of land.

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[2]Unfortunately a statistical test of the equality between the MVP and the market price of each input was precluded by the fact that input prices were not collected directly from those interviewed. Average regional input prices from secondary sources were used by the researchers whenever necessary. An alternative method was tried here to perform this test. Confidence intervals were placed on the MVPs so that they could be compared to the average input price. As it turned out, however, these C.I. (even at the 90 percent level for the coefficient of confidence) were not reliable. High multicollinearity affecting the variance of the MVPs seems to have been the cause of the serious overestimation of the confidence intervals.

Mixed Farms Production Function

Land, labor and capital changes explain about 86 percent of the variation in output in this case. The production elasticities of all inputs but land are significantly different from zero at the 5 percent probability level (Table 6). Land's production elasticity, besides being non-significant, carries a negative sign. A plausible explanation for the negative sign in this case may be sought in the composition of the sub-sample of the mixed farms group. Since this group includes farms with intensive land use as well as those with very extensive land use, the net composite effect of changes in land operated may well be neutral and carry the negative sign. Increases in operated land by some farmers in the sample may have occurred by renting land from other farmers in the same group thereby neutralizing the average effect of changes in the land input on total gross output. This result is more likely to occur in very heterogeneous groups of farms (such as the mixed farms, as defined here) but it does not have to be true for any group of diversified farms. Positive and significant land production elasticities have been found for production functions of diversified farming areas (Drummond, 1972; p. 72).

With respect to resource allocation the MVPs again indicate the presence of economic inefficiencies. Land is being used in much larger proportion than would be most profitable (Table 6). Labor's MVP (Cr$2,447.45) is fairly high as compared to the regional average wage rate. This indicates

TABLE 6.--Regression Coefficients, Average and Marginal Value Products, Geometric Means and $\bar{R}^2$ (adj.), as Estimated by Models I and II for Mixed Farms

Model, Input and Output	Regression Coefficient (S.D.)	Average Value Product	Marginal Value Product	Geometric Mean
MODEL I: ($\bar{R}^2$ = 0.86)				
Intercept	1.2109[a] (0.3467)	-	-	-
Land (ha)	-0.0758 (0.0856)	384.25	(-29.09)	89.10
Labor (m.e.)	0.2512[b] (0.1315)	9,743.02	2,447.45	3.51
W. Assets (Cr$)	0.4775[a] (0.1482)	5.18	2.47	6,607.00
O. Expenses (Cr$)	0.3789[a] (0.0908)	3.54	1.34	9,661.00
MODEL II: $\bar{R}^2$ = 0.86				
Intercept	0.9275[a] (0.3363)	-	-	-
Land (ha)	-0.0532 (0.0779)	384.25	(-20.42)	3.51
Labor (m.e.)	0.2481[b] (0.1287)	9,743.02	2,417.24	6,607.00
Capital (Cr$)	0.8367[a] (0.0825)	1.82	1.52	18,763.00
OUTPUT	-	-	-	34,198.00

Notes: (1) a, b, c, d, and e indicate statistical significance at 1, 5, 10, 12.5, and 25 percent probability levels, respectively.
(2) $\bar{R}^2$ (adj.) = adjusted R-squared.
(3) All the MVPs were computed at the geometric mean values of the inputs and output. MVPs in parentheses were computed with production elasticities nonsignificantly different from zero at the 10 percent probability level.

that there is room for higher levels of employment in mixed farming. The MVP of capital variables (both in Model I and Model II) also indicate under-utilization of capital on these farms. A gross margin of return on investment exists. This margin is about 34 percent on operating expenses and about 147 percent on working assets investment. As an aggregate (Model II) the capital input offers a return of 52 percent at the margin.

In short, capital and labor investments are too low while there is an overinvestment in land on these farms. Consequently, resources are not being allocated in the most efficient way considering the norms of neoclassical marginal productivity theory. Mixed farming in this region is a potential user of more labor and capital. The results suggest that this group of farmers can increase profits by releasing land for rent, hiring more labor, and increasing the use of capital.

Wheat Farms Production Function

Variations in the specified inputs explain 86 percent of the output produced by mechanized wheat farms. The production elasticity of labor, in this farm type is not significantly different from zero at the 5 percent probability level, even though it carries the expected positive sign (Table 7). When working assets and operating expenses are aggregated into total capital (Model II), labor's production elasticity increases from 0.05 to 0.10 and becomes significantly different from zero at the 25 percent probability level.

TABLE 7.--Regression Coefficients, Average and Marginal Value Products Geometric Means, and R^2 (adj.), as Estimated by Models I and II for Wheat Farms

Model, R^2 (adj.) Input and Output	Regression Coefficient (S.D.)	Average Value Product	Marginal Value Product	Geometric Mean
MODEL I: $R^2 = 0.82$				
Intercept	0.7471[b] (0.4137)	-	-	-
Land (ha)	0.1235[a] (0.0498)	1,564.00	193.26	74.96
Labor (m.e.)	0.0491 (0.1119)	28,750.00	(1,413.01)	4.08
W. Assets (Cr$)	0.3599[a] (0.1435)	7.86	2.83	14,928.00
O. Expenses (Cr$)	0.5501[a] (0.1033)	2.62	1.44	44,751.00
MODEL II: $R^2 = 0.80$				
Intercept	0.6331[c] (0.4116)	-	-	-
Land (ha)	0.1393[a] (0.0463)	1,564.00	217.98	74.96
Labor (m.e.)	0.0959[d] (0.1018)	28,750.00	(2,759.83)	4.08
Capital (Cr$)	0.8599[a]	1.92	1.65	61,249.00
OUTPUT	-	-	-	117,300.00

Notes: (1) a, b, c, d, and e indicate statistical significance at the 1, 5, 10, 12.5 and 25 percent probability levels, respectively.
(2) $\bar{R}^2$ (adj.) = adjusted R-squared.
(3) All the MVPs were computed at the geometric mean values of the inputs and output. MVPs in parentheses were computed with production elasticities nonsignificantly different from zero at the 10 percent probability level.

Hence, the aggregation of these two capital variables (which are highly correlated) improves the estimate and the significance level of labor's production elasticity. This is an additional sign of a multicollinearity problem in the sample. Better measurement of the flow of services from the capital variables is very likely to improve the estimates of all elasticity coefficients. Further improvement could undoubtedly be obtained by accounting for land and labor quality, if measures of quality were available.

Land and capital inputs present highly significant elasticities of production. This result reflects an intensive use of both land and capital. Operating expenses' production elasticity is particularly high (0.55) as compared to the other inputs' production elasticities. High response to changes in operating expenses associated with intensive use of land is consistent with the fact that most of the wheat farmers rent part or all of their land operated (Table 7).

The MVP of labor as measured by Model I does not inspire much confidence given that labor's production elasticity is not significantly different from zero even at the 25 percent level of probability. However, in Model II it becomes significant at that level. Therefore, it seems to indicate that there is some response in wheat production to the use of additional labor. The MVP is below the regional average wage rate as estimated by Model I and above that average when estimated by Model II. It seems reasonable to argue, nevertheless, that wheat production requires higher quality labor given its relatively high level of mechanization. Hence, actual wage rates, on the average, may be larger or at least near the MVP estimated by Model II. Therefore, wheat farmers are hiring the right quantity of labor (or very near that quantity) necessary to maximize economically efficient use of this input.

Underinvestment in land is evidenced by comparing the MVP of land to its opportunity cost. The opportunity cost of land in wheat production, as measured by the interest on capital invested, is Cr$12.48 per hectare in Rio Grande do Sul (Noskosky, 1971; p. 89). Since the MVP of land is Cr $193.00 (Model I), considerable increases in profits would be obtained by renting additional land, if the opportunity cost quoted is actually a reasonable proxy for the rent rate as reflected by the market for cultivated land in this region.

Capital is also being used at less than the optimum levels in wheat production. Working assets and operating expenses yield returns of 2.83 and 1.44 cruzeiros worth of output, respectively, per additional cruzeiro used up in wheat production (Model I). A margin of return of 65 percent exists when considering total capital in the farm business (Table 7, Model II).

In summary, it is quite clear that capital and land are highly productive while labor is being used to the optimal point in wheat production. It should be emphasized that this farm type is the only one which presents a highly productive land input. This is an exceptional case in a developing country such as

Brazil where land is usually very extensively used. The comparative analysis which follows will indicate that land tenure and market incentives have much to do with the intensive use of land by wheat producers.

Comparative Analysis

The foregoing analysis of the individual production functions shows that resources are not being allocated in the most profitable manner within each farm type. These farms are all located in a given and fairly homogeneous region. Moreover, there is reason to believe that the market imperfections which may exist are not strong enough to impede resource mobility within the region. Therefore, it becomes imperative to look at the allocation of resources among these farm types and attempt to identify possible patterns of resource use and sources of inefficiencies.

The preliminary description of the three farm types has shown that they differ significantly in many aspects. A comparative analysis of their production functions should not only reflect those differences but also bring new insights regarding allocative efficiency in the region.

The first question to ask at this point is whether there are any real differences among the production functions of the farm types under consideration. If the evidence available does not show significant differences among them, then it is not worth undertaking a comparative analysis. The three production functions would have to be considered as simply alternative estimates of a unique unknown production function. Consequently, the use of the pooled sample would have probably yielded much better estimates of the parameters of the function than the three sub-samples used here.

However, the result of the Chow test indicates that the null hypothesis stating strict equality among all three production functions must be rejected at the 5 percent or lower probability level (Table 8). This same test was applied to compare all possible combinations of these functions taken two at a time. In general the results indicate that studying individual farm types leads to better quality estimates than pooling different farm types together for the purpose of estimating production functions in the region.

The sample results indicate that the hypothesized equality between cattle and wheat farm production functions must be rejected at the 5 percent probability level (Models I and II). Model I yields this same result when cattle and mixed farm production functions are compared. However, the sample data do not provide evidence for rejecting the same hypothesis regarding cattle and mixed farms when Model II is fitted.

Neither Model I nor Model II lead to the rejection of the null hypothesis (at the same level of significance) when wheat and mixed farm production functions are compared for equality.

These statistical results support the original conjecture that cattle and wheat farms are the two extremes of a continum with mixed farms as a

TABLE 8.--Comparison of the Production Functions Between Farm Types (The Chow Test)

Farm Types	Model I		Model II	
	F - estimate	d.f.	F - estimate	d.f.
Cattle vs. Wheat	9.35[a]	(5;99)	3.44[b]	(4;101)
Cattle vs. Mixed	3.14[b]	(5;122)	0.71	(4;124)
Wheat vs. Mixed	1.37	(5;92)	1.62	(4;94)
All three types	4.35[a]	(8;161)	2.07[b]	(6;163)

Note: a,b and c indicate statistical significance at the 1, 5, and 10 percent probability levels, respectively.

transitional stage. The static nature of the whole procedure used here does not allow for any stronger inferences than this "feeling" of a dynamic process taking place in the region. The estimates presented and discussed may well be thought of as a "snapshot" of the process showing the three stages cross-sectionally. Stronger statements concerning this relationship among farm types have to be pursued using dynamic models.

In order to perform a more detailed analysis of the differences between farm types, the Chow test was also used to compare individual production elasticities of different production functions. Only Model I was used for this purpose and the results are presented in Table 9.

TABLE 9.--Estimates of the F-Statistic Used to Test the Difference Between Elasticities of Production of Individual Inputs - Model I

Input	Cattle vs. Mixed	Mixed vs. Wheat	Cattle vs. Wheat
Intercept	0.71	2.35	0.62
Land	2.48	16.19[a]	1.94
Labor	0.14	4.86[b]	1.87
Working Assets	5.30[b]	1.10	13.66[a]
Op. Expenses	13.03[a]	5.01[b]	37.13[a]
d.f.	(1;122)	(1;92)	(1;99)

Note: a,b, and c indicate statistical significance at the 1, 5, and 10 percent probability levels, respectively.

Statistically significant differences are revealed by the Chow test between the elasticities of production of capital when cattle and mixed (as well as cattle and wheat) farms are compared.

When mixed and wheat farms are compared, the null hypothesis of equal production elasticities for labor, land and operating expenses must be rejected at the 5 percent level of probability. Only working assets presents a non-significant statistical difference in this case.

With respect to the intercept, when any two farm types are compared, the sample data do not lead to the rejection of equality hypothesis at the 5 percent probability level between the intercepts of the functions. This result has relevant implications depending upon the interpretation given to this term in the function.

One possible assumption regarding the constant term is that it is "a multiplicative index attached to the Cobb-Douglas function" implying that "better managers (in this index sense) must use more of each input" (Timmer, 1970; p. 119). If this heroic assumption is made then the statistical result just presented indicates that no significant differences regarding management quality exist between any two of the three groups of farmers being compared. Differences in resource use have to be explained by technological differences and/or input market imperfections.

Another possible assumption usually made is that the multiplicative term of the Cobb-Douglas function reflects technical change of the neutral type (Steitieh, 1971; p. 34). In this sense, the non-significance of the statistical test comparing differences between the intercepts leads to the suspicion of non-existence of technical change (of the neutral type) between any of the farm groups considered.

Neither of these assumptions seems very plausible in the present case. Major differences in the use of modern inputs and the quality of management among farm types seem to be indicated by the analysis of the production function elasticities and the capital structure of each farm type.

The overall results of this comparative analysis show that a general state of resource misallocation prevails in the region.

Land is extensively used by cattle and mixed farmers while under-investment in land is observed on wheat farms. Labor is adequately used only by wheat farmers. Mixed farms use too little and cattle farms too much labor. Capital investment is too low across the board, with the exception of cattle operating expenses. In the comparative analysis, it was found that average and marginal productivities are lower in beef cattle production than in the other two farm types. Wheat producers have the highest productivity levels (except for labor which is higher in mixed farming) in the region. One of the reasons for higher productivity levels in wheat production is undoubtedly the use of modern inputs. Another very important reason is the wheat price subsidy currently in use.

Economic efficiency in the region could be substantially increased by simply reallocating the existing resources. The excess of labor and land currently being used by cattle farmers would increase efficiency if shifted to mixed and wheat farms. Mixed farms could also rent additional land to wheat farmers thereby contributing to an increase in economic efficiency. However, the results suggest that capital is a limiting resource. There are high returns to capital investment in the region, principally in working assets.[3] This result throws suspicion of the efficiency of the capital market in responding to a high demand for capital.[4] Rao (1970, p. 128) found that "farm types representing small scale agriculture, appear to be facing credit rationing" whereas large mechanized crop farmers "appear to be relatively free from capital constraints." Capital rationing may well be the case here even though none of the three farm types can be considered small agriculture in absolute terms.

Reallocation of resources can also be attained through economic policy. If the price subsidy for wheat were eliminated, considerable changes would take place in the region. Heavy mechanized equipment and fertilizer currently used in wheat production would most likely be shifted to mixed farms and cattle production.[5] Consequently, higher productivity levels would be attained by

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[3]This high level of productivity of capital is evidence of favorable conditions for capital formation at the farm level regardless of farm type.

[4]It may also be a case of self-rationing caused by risks and uncertainties.

[5]Some of the machinery and equipment used in wheat production cannot be adapted to the production of other crops (and livestock) in the short run. Others cannot be adapted (and hence transferred) at all. Therefore, such shift to mixed and livestock would be a slow process.

these two farm types, improving their competitive position. However, as long as the subsidy policy is maintained, it is likely that resources will shift from cattle production to mixed and wheat farms which offer higher returns to resource use.[6]

Wheat and soybeans (which are complementary products), and beef are under increasing world demand. Hence, the relative prices of these products may not change significantly in the short run. Therefore, the competitive position of the beef cattle business in Southern Brazil will continue to depend on major changes in the technology of beef cattle production.

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[6]Engler (1971) shows that the cattle farmers best economic alternative in this region is to move from beef cattle production to a combination of wheat and soybean, unless beef prices and production technology increase substantially.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This is a study of the economics of resource allocation in Southern Brazil. The specific objectives pursued are:

(1) To determine possible differences between production functions of three different types of farms in the region: beef cattle, mechanized wheat farms and "mixed" farms.

(2) To determine differences in productivity levels, as measured by the production function estimates, as a means to appraise resource allocative efficiency. It is also hoped that the current dynamic move away from beef cattle and toward wheat production in this region can be at least partially evaluated by this analysis.

(3) To determine possible effects of the current price policy on the pattern of resource use in the region and the potential for capital formation at the farm level.

The methodological approach used is traditional marginal analysis according to the norms of neoclassical marginal productivity theory.

The procedure involves estimation of Cobb-Douglas production function using cross-sectional data. A modified form of the Zellner et al. (1966) stochastic model was used. This model's fundamental assumption is that the entrepreneur's objective is to maximize the mathematical expectation of his profit function.

The data utilized for empirical estimation were collected by directly interviewing a sample of 169 farmers in Sao Borja, Rio Grande do Sul, in 1969-70. A research team composed of staff members and students from the Ohio State University and the Universidade Federal do Rio Grande do Sul conducted the survey. This study became possible because of the generous concessions made by the research team regarding the use of their data and valuable technical cooperation.

The original sample was sub-divided into three groups of farms for the purpose of this research based on the relative importance of beef cattle and wheat production in the farm business. Farms on which "60 percent or more of the annual income from the sale of crops and livestock (including livestock products) is from the sale of cattle" were classified as cattle farms. Those on which "60 percent or more of the annual income from the sale of crops and livestock (including livestock products) is from the sale of wheat and each farm has at least one tractor" were classified as mechanized wheat farms (Reichert, 1972). The remaining farms in the sample were classified as "mixed" farms. There are 67 cattle farms, 42 wheat farms and 60 mixed farms in the sample.

A tabular analysis of the data led to the formulation of hypotheses regarding significant differences among these three farm types. Differences in the capital structure, land and labor use, and in land tenure indicated that major differences in production functions and resource use could be expected among the farm types.

Conclusions

At least 80 percent of the variation in output is explained by variations in land, labor and capital, for all farm types and models analyzed. In general, the other features of the statistical estimates were very much as expected, except for the presence of multicollinearity. This problem has apparently resulted from a high degree of linear correlation between the two capital variables, i.e., working assets and operating expenses. Despite some shortcomings imposed on the analysis by the multicollinearity problem, it did not significantly diminish the quality of the estimates. The results seem very much in line with other research findings and reveal much about resource allocation in the region.

Significant differences were found between the three farm types. These differences are reflected by the shape of the production functions and by differences among the elasticities of production of individual inputs. These differences indicate that estimating production functions by farm type may yield more accurate results than using the original random sample to estimate only one production function for the region. The main factors explaining such differences in the production process are the capital structure of each farm type, technological level and market incentives.

Economic inefficiency, as measured by disequality between the MVP and the opportunity cost of the inputs, is observed in all farm types.

Cattle farms have relatively low average and marginal productivities as compared to the mixed and wheat farms. Wheat farms have the highest productivity levels. The mixed farms group has an intermediate level of average and marginal productivity. This result supports the hypothesis that mixed farming is a transitional stage between the other two farm types. That is to say, mixed farming is a logical stage in the process of transforming the traditional production methods prevailing on cattle farms into the mechanized wheat production in the region. Public policy designed to provide financial incentive for either wheat production, beef cattle production or a mixed farming situation should be aware of such differences among the production functions of these farm groups; otherwise such policy is bound to have ineffective results.

Cattle farmers are using land, labor and operating expenses very extensively. The MVPs of land and operating expenses are practically zero, and the MVP of labor is very low. These farmers are usually owner-operators and rely mostly on family labor. They can increase profits by simply increasing the proportion of working assets to other inputs. Additional gains due to an increase in the size of the cattle herd, for instance, are substantially high. The production elasticity of working assets (and high MVP of this input) are evidence of such potential gains.

Mixed farms, on the other hand, use too little capital and labor, while land is being used beyond the most profitable point. This farm group, as defined here, is very heterogeneous since it includes both intensive as well as extensive users of land and other inputs. The results indicate that these farms are potential users of additional labor. They are the only ones in the region with underinvestment in labor.

Wheat farmers have attained the highest productivity levels in the region. There is evidence of adequate use of labor by these farmers with underinvestment in land and capital. This farm type presents a rare case of high productivity of land. In a developing economy land use is usually very extensive. The explanation, however, for high land productivity appears to be the use of modern inputs and possibly a better quality of land on wheat farms. Intensive use of land is also explained by the fact that wheat farmers usually rent most of their land from others. Furthermore, these farmers invest heavily on mechanized equipment and operating expenses.

Looking at individual inputs, the most productive one is capital. Working assets represent the only input which has consistently presented very high

MVP as well as AVP across all farm types. This result is strong evidence of generally favorable conditions for capital formation at the farm level irrespective of farm types. Increases in capital formation would certainly increase the MVP of other inputs as well.

This general high return to capital investment in the region throws suspicion on the efficiency of the capital market in responding to a high demand for capital. Evidence of imperfections in the capital market have been pointed out by Rao (1970, p. 128) who stated that large mechanized crop farmers "appear to be relatively free from capital constraints while all other types representing small agriculture appear to be facing credit rationing."

In any event, a shortage of capital seems evident in face of current demand. Whether higher levels of capital investment will come from increased internal savings or from sources exogenous to the region is an empirical question which cannot be answered here. But the important point to bear in mind is that agricultural production in this region is very responsive to the use of capital inputs, under the current "state of the arts." Therefore, a well formulated credit policy will result in substantial increases in agricultural production.

A comparative analysis of the situation shows that cattle farmers are in a disadvantageous position, because of the current wheat price subsidy policy and the level of technology. Productivity differences indicate that economic efficiency will be increased if resources are driven out of less productive activities to more productive ones, until each input attains equal marginal productivity level across farm types. Therefore, it is logical to expect resources to be transferred from beef cattle production into mixed farming and wheat production, respectively, under the present situation. If the wheat price subsidy is eliminated, it is conceivable that the MVP of resources used in wheat production will decrease making this transfer less attractive. It may even result in reverting the process, transferring modern inputs currently used in wheat production to mixed farming and cattle production hence increasing their productivity levels. Nevertheless, this change in policy is very unlikely to occur, at least in the short run. Any adjustments to be made in resource allocation are probably going to be left subject to the effectiveness of the market forces.

Given that beef, wheat and soybeans are similarly under increasing demand in the world market, it is very likely that their relative prices will not change significantly in the near future. Therefore, the competitive position of the beef cattle business in Southern Brazil will continue to depend on substantial changes in production technology.

BIBLIOGRAPHY

Adams, Dale W. 1970. "Agricultural Development Strategies in Brazil 1950-70." The Ohio State University, Columbus, Ohio. (Mimeo.), 37 pp.

Baer, Werner. 1972. "The Brazilian Economic Miracle." A Public Lecture presented at The Ohio State University, Columbus, Ohio. Office of International Programs.

Baklanoff, Eric N. 1971. "Brazilian Development and the International Economy," IN, Modern Brazil, edited by John Saunders. Gainesville, University of Florida Press, 350 pp.

Carter, H. O. and H. O. Hartley. 1958. A Variance Formula for Marginal Productivity Estimates Using the Cobb-Douglas Function. Econometrica 26 ( ) 306-313.

Chow, Gregory C. 1960. Tests of Equality Between Sets of Coefficients in Two Linear Regressions. Econometrica 28 (3) 591-605.

Cunnyngham, Jon. 1969. "OSU/Econ Regression Program Operating Instructions." The Ohio State University, Columbus, Ohio (Mimeo.) 22 pp.

De Janvry, Alain, 1972. "The Generalized Power Production Function" Journal of Agricultural Economics, 54 (2): 234-237.

Drummond, Harold Evan. 1972. "An Economic Analysis of the Farm Enterprise Diversification and Associated Factors in Two Regions of Minas Gerais-Brazil." Purdue University (Unpublished Ph.D. Dissertation), 189 pp.

Engler, Joaquim Jose de Camargo, 1971. Alternative Enterprise Combinations under Various Price Policies on Wheat and Cattle Farms in Southern Brazil. The Ohio State University - DAERS - (Unpublished Ph.D. Dissertation), 221 pp.

Griliches, Zvi, 1957. "Specification Bias in Estimation of Production Functions." Journal of Farm Economics, 39: 8-20.

Heady, Earl O. and John L. Dillon, 1961. Agricultural Productions Functions. Ames, Iowa, Iowa State University Press. 667 pp.

Hill, Lowell and Takashi Takayama, 1971. "Statistical Tests for Comparing Means Variances, and Regression Coefficients." University of Illinois, Urbana-Champaign.

Hogg, Robert V. and Allen T. Craig, 1972. "Introduction to Mathematical Statistics." Third Ed., New York, The MacMillan Company. 415 pp.

Kmenta, Jan. 1971. Elements of Econometrics. New York, The MacMillan Company, 655 pp.

Mundlak, Y. 1961. Empirical Production Functions Free of Management Bias. Journal of Farm Economics, 43: 44-56.

Noskoski, Carlos. 1971. Analise Economica do Uso de Corretivos na Cultura do Trigo, Safra 1969 - Ibiruba - RS. UFRS - FCE - IEPE - Porto Alegre, (Tese de M.S.) 91 pp.

Rao, Bodepudi Presada. 1970. The Economics of Agricultural Credit - Use in Southern Brazil. The Ohio State University - DAERS - (Unpublished Ph.D. Dissertation), 161 pp.

Rao, P. and R. LeRoy Miller, 1971. "Applied Econometrics" Belmont, California, Wadsworth Pub. Company, Inc., 235 pp.

Rask, Norman and Richard L. Meyer. 1972. Analysis of Capital Formation and Technological Innovation at the Farm Level in LDC's. The Ohio State University - DAERS - Agr. Econ. Res. Series. 47 pp.

Reichert, Allen. 1972. Capital Formation Project. Summary data Set: Coding Format, Variable Description and Source Location. The Ohio State University - DAERS - 36 pp.

Richter, Humberto Vendelino, 1971. "Analise Economica do Sistema Produtivo e Uso de Nova Tecnologia na Exploracao de Gado de Corte - Bage-Rio Grande do Sul." Porto Alegre (IEPE-UFRGS), 142 pp.

Schuh, G. Edward. 1970. Research on Agricultural Development in Brazil. New York, The Agricultural Development Council, Inc. 302 pp.

Sorenson, Donal M. 1968. Capital Productivity and Management Performance in Small Farm Agriculture in Southern Brazil. The Ohio State University - DAERS - (Unpublished Ph.D. Dissertation), 164 pp.

Souza, Eli de Moraes, et al. 1972. "Formacao de Capital e Mudancas Tecnologicas ao Nivel de empresas Rurais - Sao Borja - RS." Porto Alegre UFRS (IEPE), Estudos e Trabalhos Mimiografados No. 20, 51 pp.

Steitieh, Akram Justafa. 1971. Input Productivity and Productivity Change of the Crop Enterprise in Southern Brazil. The Ohio State University (Unpublished Ph.D. Dissertation), 103 pp.

Timmer, C. Peter, 1970. "On Measuring Technical Efficiency" Stanford University, Food Research Institute Studies, Vol. IX, No. 2, pp. 99-171.

Yotopoulos, Pan A. 1967. "Allocative Efficiency in Economic Development." Athens: CPER, 313 pp.

Zellner, A., J. Kmenta and J. Dreze. 1966. Specification and Estimation of Cobb-Douglas Production Function Models. Econometrica 34 (4): 784-795.

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The author was born on a farm in the municipio of Abaete, M.G., Brazil, on September 8, 1940. He attended secondary school in the State of Rio de Janeiro from 1954 to 1960. In 1961 he entered the UREMG in the State of Minas Gerais (Current Universidade Federal de Vicosa) where he received a degree in Agronomy in 1964 and a Master's degree in Agricultural Economics in 1966.

From 1967 to 1968 he worked as a researcher-consultant for the Secretaria da Agricultura-Ford Foundation Project in Belo Horizonte, M.G. Since June, 1968, he has been an employee of the Instituto de Economia Agricola da Secretaria da Agricultura do Estado de Sao Paulo. His program in the U.S. started in the fall of 1969 at North Carolina State University where he was awarded a Master's degree in Economics in August, 1971. In the fall of 1971 the author transferred to the University of Kentucky where he has been working toward a Doctor of Philosophy degree in Agricultural Economics.

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