AN ECONOMIC EVALUATION OF THE IMPACT OF AN EXTENSION PROGRAM, MINAS GERAIS, BRAZIL

A Thesis

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Eliseu Roberto de Andrade Alves

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ABSTRACT

Alves, Eliseu Roberto de Andrade. M.S., Purdue University, January 1968. An Economic Evaluation of the Impact of An Extension Program, Minas Gerais, Brazil. Major Professor: G. Edward Schuh.

An increase in the productivity of the resources in agriculture can make a substantial contribution to the growth of developing countries, since these countries have a major portion of their resources in agriculture. Recognizing this fact, the Extension Service of Minas Gerais State has, as one of its goals, the increase of the productivity of agriculture in the State. As one consequence of its educational work, it is hoped that farmers make two kinds of adjustments which will increase the productivity of their enterprise: (1) adopt a higher level of technology and (2) chose the optimal mix of inputs.

The basic goal of this research is to attempt to measure these two types of adjustments, following a procedure suggested by Nerlove. The specific objectives of the study are: a) To develop a frame of analysis to evaluate the impact of an extension service on the productivity of resources in agriculture; b) to use this frame of analysis to evaluate the impact of ACAR in selected municipio; c) to derive policy conclusions and recommendations from the

empirical analysis made; d) to evaluate the suitability of the proposed frame of reference for further evaluation of extension type educational programs.

The conceptual model is based upon the traditional theory of the firm, allowing, however, for firms to be operating at a level different from the optimum. Therefore, the profit of a firm will be a function of the level of technology chosen, environmental factors (described by the prices of inputs and output) and the degree of technical efficiency at which the firm chooses to operate. Based upon this model, Nerlove constructed a measure of economic efficiency that has two components: a) price efficiency -- which measures the relative ability of the firm to maximize profit; and b) technical efficiency -- which measures the relative ability of the firm to select the most appropriate technology within its environment.

If the production process can be described by a production function of the Cobb-Douglas type, it is possible, under certain assumptions, to estimate these two components and, consequently, the overall measure of economic efficiency. This research attempted to obtain these estimates from a sample of farmers worked by ACAR, taken from the municipio of Senador Firmino and a sample of farmers not assisted by ACAR, drawn from the municipio of Presidente Bernardes. This last sample is the basis for comparison.

Based upon the characteristics of the ACAR's work, two

hypotheses were formulated and tested: a) that those firms receiving technical assistance from an extension program would have a higher level of technical efficiency than those not receiving such an assistance; b) that those receiving technical assistance would have a lower level of price efficiency.

The results of the analysis appears to have rejected these hypotheses. As a matter of fact, the opposite seems to have occurred. The farmers from Presidente Bernardes have a higher level of technical efficiency and a lower level of price efficiency. Consequently, if one accepts the results as being a valid measure of the impact of ACAR in Senador Firmino, the conclusion one reaches is that the ACAR program is not effective, or even worse, that is, is having a deleterious effect on the level of efficiency.

However, these results may in part be due to economic environment in Brazil and the characteristics of the program. For example, a) Presidente Bernardes might not have been a valid basis for comparison; b) the inability to measure differences in managerial ability may have influenced the results (farmers from Presidente Bernardes might have had a higher managerial ability); c) as a consequence of the very high rate of inflation, it is possible that the goal of the farmers is to maximize their assets and not income; d) Many farmers of the sample have a very low degree of education. They keep few records and are quite dependent on memory recall

to answer the questionnaire. Consequently, substantial measurement errors may be present in the study, and they might have benefited more the Presidente Bernardes' sample.

The results do suggest guidelines for the extension service in further developing their program. One important part of this would be an increased emphasis on the economic aspects of their recommendations, and some attempt to define appropriate program goals.

It appears that the model used in the analysis has considerable utility in analyzing similar educational programs. Suggestions for increasing its effectiveness are made in the thesis.

CHAPTER I

INTRODUCTION

Development economists for many years tended to ignore the contributions of agriculture to economic development. Agriculture was considered to be synonymous with poverty and industry with wealth. Rapid industrialization was considered to be the appropriate solution for the problem of economic development.

In recent years, however, economists have given much more attention to the role of agriculture in economic development. The principal reasons for this shift of emphasis are:[1/]

(1) rapid increases in population,

(2) increasing urban unrest as internal prices of food have moved upward,

(3) widening foreign exchange gaps that result from reduced farm exports, which in turn are the result of increasing domestic consumption, and

(4) failure to obtain sustained rates of economic growth through programs which concentrate on industrialization to the neglect of the agricultural sector.

1/ A more detailed discussion of this point may be found in a paper by Schuh, G.E., and Tollini, Helio, "Agriculture and Economic Development," Instituto de Economia Rural, URENG, Vicosa, Brazil, 1964, pp. 1-7. See also Witt, Lawrence W., "Role of Agriculture in Economic Development," Journal of Farm Economics, Vol. 47, No. 1 (Feb. 1965), pp. 120-131.

Now it is recognized that agriculture can make a substantial contribution to economic development. This contribution is generally recognized to take place in at least five ways:[2/]

(1) the release of labor to the nonfarm sector,

(2) as a source of savings or capital formation for the total economy,

(3) a rise in the real income of all members of society by supplying food at lower prices, which also has strong income distribution effects,

(4) enlarging the market for products produced in the nonfarm sector, and

(5) as a source of foreign exchange earnings.

The potential contribution of the agriculture sector in these various ways is generally quite large. Underdeveloped countries tend to have more than 50 percent of their labor force in agriculture, as well as a large fraction of other resources. The farm population is generally a large potential market if its purchasing power can be increased. And finally, agricultural products tend to be an important source of exchange earnings.

The important problem, then, becomes one of how to develop the agricultural sector, or how to raise income levels and productivity in the rural sector. The traditional answer to this question was to recommend an increase in the amount of capital in its traditional forms -- machinery, equipment,

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2/ Cf., op. cit., Schuh and Tolbert, pp. 1-3.

dams, and roads. This recommendation relies upon the well-known fact that man is more productive if he has more capital or more of other resources to work with him. However, this is a rather superficial view of the problem, since it neglects the fact that man is responsible for making capital more productive, and not the inverse. Or, as Galbraith has said, "Literate people will see the need for getting machines. It is not so clear that machines will see the need for getting literate people."[3/]

Thinking on this subject is now changing. It is being recognized that capital formation also takes place in non-traditional forms: education, improved health, the creation of new knowledge, and informal training programs. And research has indicated that the returns to society from investments in these non-traditional forms are indeed quite high. This position is perhaps most systematically treated in Schultz's book, Transforming Traditional Agriculture,[4/] where references to relevant empirical work can also be found.

The Problem

A logical consequence of this stream of thought has been an increasing tendency to give a high priority in development planning to programs that improve the human agent. These include formal education, ranging from primary level education

3/ Galbraith, J.K., Economic Development, (Boston: Houghton Mifflin Company, 1964) p. 42.

4/ See for instance: Schultz, T.W. Transforming Traditional Agriculture, New Haven and London: Yale University Press, 1964, pp. 15-23.

to graduate training, and informal education such as extension programs and on-the-job training.

However, the fact that the program is intended to improve the human agent does not necessarily mean that it will do so, or that it is the best one that could be chosen. Even though a program may be well conceived, it may not do what it is intended to do, either for reasons internal to it or for reasons over which it has no control.

The resources that most developing countries have for financing their economic development are very limited in amount. Hence, it becomes crucial that these resources be applied in activities that will be effective in attaining intended goals. This suggests that research which evaluates the effectiveness of development activities can make a substantial contribution to improving the productivity of development resources.

It is in this area that the present research attempts to make a contribution. One of the programs implanted in many developing countries to aid in the development of the agricultural sector is an extension service. Extension programs are oriented to the human agent and tend to be very similar to educational programs. Generally, their ultimate objective is to increase production or raise productivity in the agricultural sector, through the transmittal of "know-how" or new knowledge to farm people.

The extension service in the state of Minas Gerais,

Brazil, is no exception. Known as ACAR (Associacão de Credito e Assistencia Rural), it was patterned originally after the Farm Home Administration of the United States. As such it addressed itself primarily to small farms and was a combination of a supervised credit program and technical assistance. Later, it shifted away from these rather narrow objectives and began to work with the full range of farm sizes, with less emphasis given to the supervised credit part of the program.[5/] Throughout its history, however, its purpose has been to help rural people raise their standard of living through an educational program for adults and young people.

As with almost all educational programs, the problem of evaluating the effectiveness of an extension program is rather complex. The effects of educational programs tend to be diffuse -- sometimes with rather large spill-over effects.[6/] Some aspects of the programs take a considerable time to have an effect. And in some cases their effect takes place in non-measurable forms.

Many different devices can be and have been used to evaluate such programs.[7/] But an obvious criterion of such

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5/ See Appendix A for a more detailed discussion of the history, program, and organization of ACAR. Other descriptions in English can be found in Mosher and Wharton, (reference to their work is in Appendix B).

6/ Weisbrod, Burton A., External Benefits of Public Education, Princeton University, 1964, Princeton, New Jersey, p. 143.

7/ For a summary of previous attempts to measure the effectiveness or impact of ACAR, see Appendix B.

with which resources are combined.[9/]

Objectives of the Study

This study is in part methodological in that it attempts to apply a new tool to the evaluation of an extension service. The specific objectives of the research are:

1. To develop a frame of analysis whereby the impact of an extension service can be evaluated in terms of its effect on the economic and technical efficiency of firms with which it works.
2. To assess the impact of the ACAR system on a sample of farms through the use of a production function and estimating procedures which permit differences among farms in both the production function they use and the degree of optimization in the use of resources.
3. To derive policy conclusions and recommendations from the empirical analysis made.
4. To evaluate the suitability of the proposed tool for further evaluation of extension-type educational programs.

Procedures

M.J. Farrell[10/] has defined measures of economic efficiency which permit comparisons among firms within an industry

9/ See below, Chapter II, for more detail on this.

10/ Farrell, M.J., "The Measurement of Productive Efficiency," Journal of the Royal Statistical Society, Series A (General), Vol. 120, 1957, pp. 253-81.

in the degree of technical efficiency, economic efficiency, and over-all efficiency.[11] These measures are based on rather restrictive assumptions and do not account for the fact that individual firms may be facing more or less rigorous environments.[12]

Nerlove[13] has generalized Farrell's work in such a way that the restrictive assumptions are not necessary and so that differences in economic environment faced by the firms can be taken into consideration. This model will be used to develop a framework in which the impact of an extension service can be analyzed. Specific hypotheses about the impact of the extension service will be derived.

Nerlove's measure of economic efficiency owes its inspiration to the unique properties of the Cobb-Douglas production function. He then shows, following a procedure suggested by Klein,[14] how the production function can be estimated in such a way as to provide measures of relative economic efficiency.

The impact of ACAR will be evaluated in this study by using two samples of data to fit a Cobb-Douglas production function in the manner suggested by Klein and Nerlove. One sample of farms will consist of a group that have been

[11] See below, Chapter II, for precise definitions of these concepts.

[12] See Nerlove, Marc, Estimation and Identification of Cobb-Douglas Production Functions, Chicago: Rand McNally & Company, 1965, p. 90.

[13] Nerlove, Ibid., pp. 96-99.

[14] Klein, L.R., A Textbook of Econometrics. Evanston: Row, Peterson & Co., 1953, pp. 238-239.

receiving the services of ACAR for a number of years. The other sample will be drawn from a universe of farms which have not received the services of ACAR. The farms will be ranked in terms of their respective economic efficiency, and these rankings will be used to test the hypotheses about the impact of the extension service. This testing will implicitly involve an evaluation of the effect of ACAR on the farms working with it.

The empirical data generated in this process will then be used as a basis for policy recommendations. It should also provide insights into the applicability and limitations of the procedure as a tool for evaluating similar education or extension-type programs.

Organization of the Thesis

In Chapter II conceptual and statistical models will be presented, together with computational procedures for obtaining the indices of efficiency and a discussion of the data used in the analysis. Chapter III will provide background data on the two areas of study, drawn from both primary and secondary sources, which will provide a basis for interpreting and evaluating the results. Chapter IV will present the findings from estimating the production function and a general analysis of them. Chapter V will discuss policy implications and present suggestions for future research. Supplementary material such as more detailed information on ACAR, the review of previous studies, and details of the sampling procedures are presented in appendices.

CHAPTER II

CONCEPTUAL AND STATISTICAL MODELS

This chapter is divided into five parts. The first part discusses the concepts of technical and economic efficiency. The second part discusses the hypothesized influence that an extension-type educational organization might have on efficiency. The third part discusses some measures of relative economic efficiency that have been proposed. The fourth part presents a specific statistical model and estimation and computational procedures that provide indices of relative economic efficiency. And the fifth and final part discusses the data used in the empirical work.

The Concept of Relative Economic Efficiency

The notion of efficiency comes up quite naturally from the fact that some firms are able to produce more than others under similar conditions and with the same quantity of resources. We might say that those firms that produce more are more efficient. In this context, the idea of efficiency is a relative one, and the firms in an industry, for example, could be said to vary in their efficiency.

Farrell[1/] has attempted to define a measure of efficiency

1/ Farrell, M.J. op. cit., pp. 253-81

in this sense which permits a comparison among firms. This measure is discussed here since it is useful in clarifying the issue and is useful for discussing the impact that an extension service such as ACAR might have on efficiency.

His measure may be divided into two components. The first, technical efficiency, relates to the choice of production function among those actually in use by firms in the industry. The second, price efficiency, refers to the proper (or improper) choice of input combinations.

The distinction between the two components and an understanding of Farrell's definition may be obtained from Figure 1. If there are constant returns to scale, and a single output and two factors of production, the production function can be characterized by a single isoquant II'. Let DD' be the price line. Then Q' is the optimum combination level of inputs X_1 and X_2.

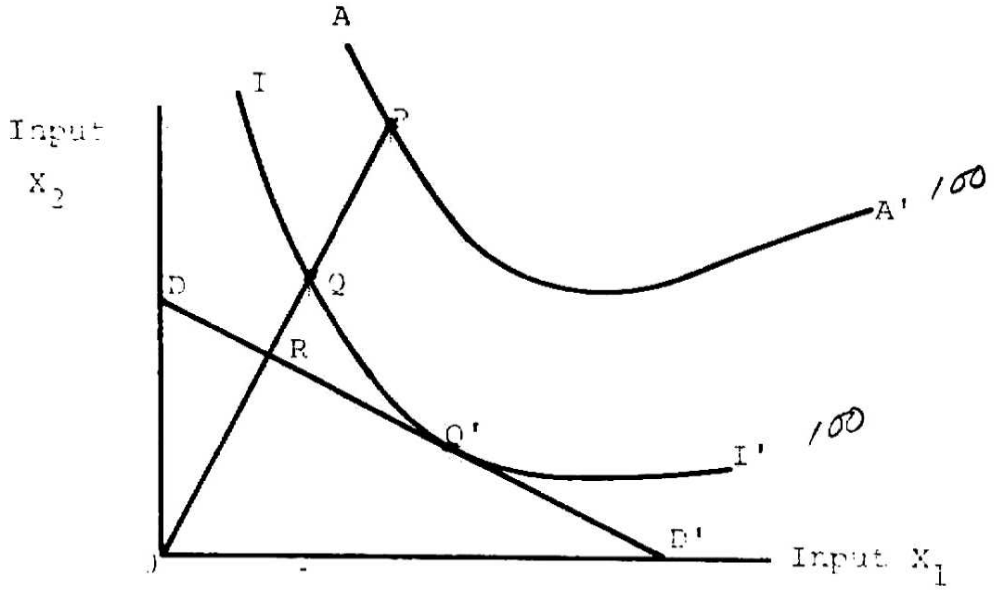

Figure 1. Farrell's Definition of Relative Efficiency and Its Components.

However, a firm may produce at P rather than at Q', where P represents the same level of output as in isoquant II'.[2/] The distance OP relative to OQ measures the extent to which the same amount of output could be produced with fewer inputs used in the same proportion, or what Farrell calls "technical efficiency." The distance OR relative to OQ measures the fraction of costs for which the output could be produced if the relative use of inputs were altered. Farrell calls OR/OQ "price efficiency." A measure of the "over-all efficiency" is given by

$$\frac{OR}{OQ} \cdot \frac{OQ}{OP} = \frac{OR}{OP}$$

This is the "over-all efficiency" for the production of a unit of output by means of the input combination P rather than the combination Q'.

The Influence of an Extension Service on Economic Efficiency

With this as background, we can now indicate the effect of an extension program. Assume once again that a homogenous product is being produced with two inputs and that there are constant returns to scale.[3/] In this case, the production function can again be represented by a single line such as AA' in Figure 2. In this case the line AA' represents the

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2/ The isoquant AA' represents a different production function than that represented by II'. In this case it characterizes a production function with a lower level of technical efficiency.

3/ The assumption of constant returns is made only to facilitate the graphical exposition. As will be shown below, measure of economic efficiency can be obtained when this assumption is relaxed.

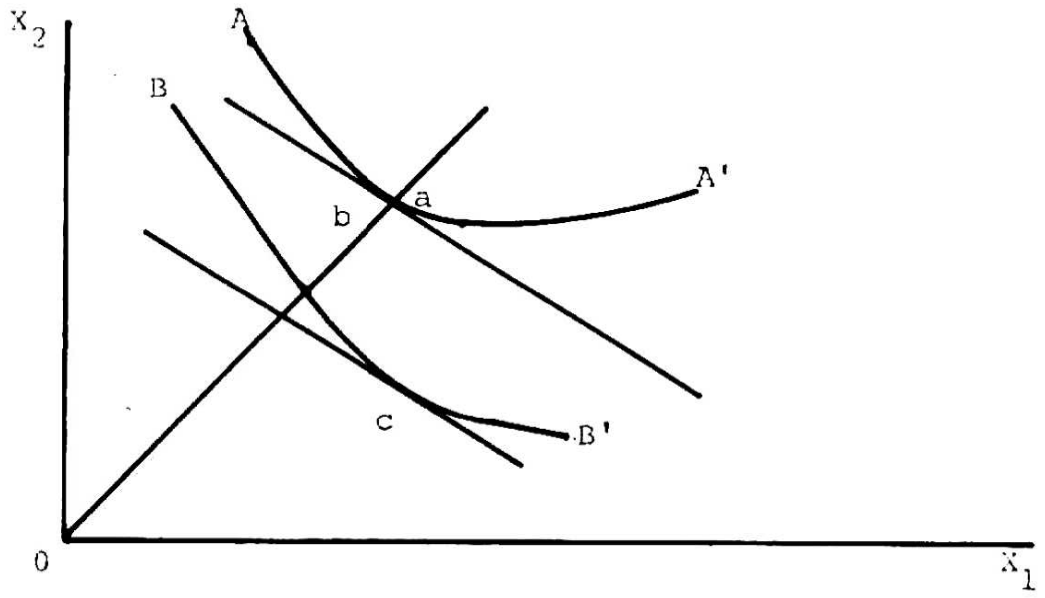

Figure 2. Effect of Extension Program on Economic Efficiency.

production function for the situation before the work of the extension service began. The optimum combination of resources is given by a, where the price line is tangent to the isoquant.

Now, assume that the extension service is in operation for a period of time, with the primary objective of introducing new technology to the farm operators. The result of such a program, if it were successful, would be to implant the production function represented by the isoquant BB'. This isoquant, which represents the same amount of output as AA', indicates that the same amount of output is being produced with fewer inputs. It has purposely been drawn, however, to indicate that the technical change was not neutral. That is,

it has been assumed that the marginal rate of substitution among the inputs has been changed.

Now, let's assume that the farmers adjust to the new technology in the following way. Assume that the combination of inputs indicated by a is a result of a stable equilibrium that has been in existence over a long period of time. If so, the use of inputs in this proportion will be rather strongly ingrained among the firms.

When adopting the new technology, therefore, the farmer maintains these same proportions, indicated by the point b, which is defined as the intersection of a ray extending from the origin to point a with the isoquant BB'. The consequence of this is that the firm has moved to a point that is more efficient, technically speaking, but that is less efficient from the standpoint of price efficiency.

With the passage of time, however, as the firm gains experience with the new production function, it learns that the basic shape of the production function is different and adjusts accordingly. As a result, it will eventually move to the point c, a point of both price and technical efficiency so long as the relative factor prices have not changed.

Viewing the adoption of technology as a process in this way leads to two hypotheses. First, it is expected that those firms receiving technical assistance from an extension program would have a higher level of technical efficiency than those not receiving such assistance. And second, those

receiving technical assistance would have a lower level of price efficiency."

These are two hypothesis which will be tested in the present research. The first is rather straightforward, and is based on the avowed intent of an extension program. The second is not as straightforward, however, and is more designed to learn something about the process of technical change.

Various writers have argued that the introduction of technical change does create an economic disequilibrium. By postulating this as a hypothesis to be tested, we can possibly throw some light on the subject. The hypothesis is dependent, however, on the technical change being non-neutral. If the new technology does not change the marginal rate of substitution among inputs, the hypothesis will be rejected, but without throwing any light on the process at hand. The methodological problem, of course, is that under the circumstances of the present research, it is not possible to say a priori whether the technical change is neutral or non-neutral.

Further plausability is given to this hypothesis when it is recognized that ACAR does not give a great deal of attention to the economic aspects of innovations it recommends. This is a reflection of the general lack of economic research being conducted in Brazil.

A final point has to do with the nature of the technology being implanted and with the process of adoption of

this technology among a sample of farms. First, it should be recognized that ACAR operates in such a way that it is attempting to implant a bundle of new technologies, rather than one discrete innovation. Individual farmers may adopt part or all of these technologies. If he should adopt all, conceivably he would be along some line such as BB'. If he has only adopted part of them, however, he may be at some point between AA' and BB'.

Hence, when one examines a sample of farms working with the extension service, he would expect them to be distributed in this area, especially if they have not been working with the extension service for a long period of time. However, it is to be expected that as a group, those working with the extension service would be more technically efficient than those not working with it. This consideration is important when developing testing procedures, a subject to be treated below.

Alternative Measures of Relative Economic Efficiency

Farrell develops measures of these various concepts of relative economic efficiency. Since he does not know the true production function, he estimates it by fitting an envelope to the scatter of points in the input plane. From this, one is able to compute empirically the various measures of efficiency.

Nerlove[4] has pointed out that Farrell's approach assumes: (1) constant returns to scale,[5] (2) perfect competition in the sense that level of output does not affect either factor or product prices, and (3) no difference in environmental conditions in which the firms are operating. The measure is ambiguous if any one of these three conditions is relaxed.

Point (3) is an important consideration in any measure of efficiency. Clearly it does not make sense to consider a firm with a smaller output as less efficient if this firm faces a more difficult environment.

Nerlove[6] has developed a measure of economic efficiency which is, in theory, free from all of the three assumptions given above. He recognizes that differences among firms can be summarized under three headings:

1. Ability to maximize short-run profits, given a particular production function and in a given environment.
2. The production function itself which summarizes the state of technical knowledge and the possession of fixed factors.
3. The environment.

He proceeds by supposing there to be three vectors of parameters associated with each firm i and corresponding to

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4/ Nerlove, Marc, op. cit., pp. 88-90.

5/ Actually, a production function homogeneous of degree n is sufficient.

6/ Nerlove, Marc, op. cit., pp. 96-100.

each of the categories of factors causing differences among firms. Hence:

1. Profit maximizing factors: u_f
2. Production functions: v_f
3. Environmental factors: w_f

The components of these vectors are assumed to be real numbers and belong to the closed and bounded sets U, V, and W respectively. Firm f is included in the industry or set of firms F.

Given its production function, ability to maximize profits, and its environment, each firm will realize a certain net revenue or profit, π_f. Hence, π can be regarded as a function of the parameters u, v, and w:

$$\pi = \pi(u_f, v_f, w_f)$$

Moreover, it is assumed that π is a continuous function of all these parameters.

Since U is closed and bounded, it follows that for each f, π has a maximum with respect to variations in u.

$$\hat{\pi}(v_f, w_f) = \underset{u \text{ in } U}{\text{Max}}\ \pi(u, v_f, w_f)$$

That is, there is some combination of inputs and outputs that would lead to maximum profits for firm f. The symbols v_f and w_f indicate that the production function and environmental factors are being held constant at the level of the firm.

The analysis can be extended by noting that for any environment w_f, $\hat{\pi}$ may be regarded as a function of v, the

characteristics of the production function. Since V is closed and bounded, the value

$$\lambda(f) = \max_{v \text{ in } V} \hat{\pi}(v, w_f)$$

must exist.[7/] (Note that since π is continuous on the cartesian product U X V X W, $\hat{\pi}$ is continuous in V X W; hence, $\hat{\pi}$ is also uniformly continuous.)

Now the way that we have defined $\pi(u_f, v_f, w_f)$, $\hat{\pi}(v_f, w_f)$ and $\lambda(f)$ implies that:

$$\pi(u_f, v_f, w_f) \leq \hat{\pi}(v_f, w_f) \leq \lambda(f)$$

where:

$\pi(u_f, v_f, w_f)$ = the profit obtained by firm f,

$\hat{\pi}(v_f, w_f)$ = the profit that firm f would obtain if it were a perfect maximizer, and

$\lambda(f)$ = the maximum profit possible, given that the firms are profit maximizers and select the best production function, but given the environment.

If it is not possible that $\lambda(\cdot)$ be zero, then the measure of economic efficiency for firm f can be defined as:

$$h(\cdot) = \frac{\pi(u_f, v_f, w_f)}{\lambda(f)} = \frac{\pi(u_f, v_f, w_f)}{\hat{\pi}(v_f, w_f)} \cdot \frac{\hat{\pi}(v_f, w_f)}{\lambda(f)}$$

where:

$\frac{\pi(u_f, v_f, w_f)}{\hat{\pi}(v_f, w_f)}$ measures relative price efficiency, or the relative ability to maximize profit within a given environment, under the production function chosen,

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7/ This, of course, is an example of stepwise maximization.

$\frac{\hat{\pi}(v_f, w_f)}{\lambda(f)}$ measures relative technical efficiency, or loosely speaking, the ability to pick out the right production function, and

$E(f)$ is the over-all measure of relative economic efficiency.8/

If no firms in the industry incur losses, then $E(f)$ and its components are numbers between zero and one. The closer to one they become, the greater the relative efficiency.

It should be noted that this is also a cardinal measure and, hence, is not subject to variations when we, say, double all prices. The effect of a doubling of prices would cancel itself out since prices would appear in both the numerator and denominator of any of the ratios.

One problem with the definition above is that $\lambda(f)$ could quite conceivably be zero or negative in the short-run. Since $E(f)$ is defined as a ratio, certain difficulties may arise. This problem can be circumvented by taking as a measure the following:

$$E_1(f) = \pi(a_f, v_f, w_f) - \lambda(f)$$

$$= [\pi(a_f, v_f, w_f) - \pi(v_f, w_f)] + [\pi(v_f, w_f) - \lambda(f)]$$

This measure of efficiency will be a non-positive real number, and the closer it is to zero, the relatively more efficient is f. In addition, it can be divided into two components which, as before, reflect price and technical efficiencies, respectively. (Within the successive brackets.)

8/ These can be shown to be similar to those of Farrell.

But this measure also has a serious shortcoming. Assume a competitive industry. If price changes do not affect either u or v, $\pi(u,v,w)$ and $\pi(v,w)$ are homogeneous of degree one in prices. That is, if we double all prices, $E_1(f)$ would be doubled also. Hence, $E_1(f)$ is not a cardinal measure, since it is not invariant under the indicated price changes.

It should be noted, however, that the relative position of any two firms does not change with this change of prices. Because of this, it is possible to use $E_1(f)$ to rank the firms, assigning 1 to the most efficient, and so forth.

Both measures of efficiency, $E_1(f)$ and $E(f)$, are clearly subject to sample error when computed from a sample. Nerlove has shown that the sample rank, $\hat{E}_1(f)$, tends uniformly, in probability, to the true rank as the sample size increases without limit.[9] In other words, $\hat{E}_1(f)$ is consistent.

A Statistical Model and Estimation Procedures

Suppose that the production process can be described by a Cobb-Douglas type equation

$$X_{of} = \alpha X_{1f}^{\alpha_1} X_{2f}^{\alpha_2} \cdots X_{nf}^{\alpha_n} v_{of}$$

where:

X_o = output

X_i = inputs (i=1...n)

α = the intercept

α_i = the production elasticities (i=1...n)

9/ Nerlove, op. cit., pp. 95-96.

and v_{of} is interpreted as representing differences in the production function among firms.[10/] This is interpreted as if we permit the production function to vary from farm to farm up to a factor of proportionality. It is assumed that $\log v_{of}$ is normally distributed,[11/] with mean equal to zero and a finite variance.

We assume that profits or net income is a function of the three vector variables, u, v, and w:

π = profit or net income

u = profit maximizing factors

v = production functions

w = environment, which will here be defined as the prices of the products and factors.

For firm f, $\pi = g(u_f, v_f, w_f)$. It is desired that the statistical model permit these considerations.

In terms of the usual static theory, one would postulate a profit equation:

$$\pi_f = P_{of}X_{of} - \sum_{i=1}^{n} P_{if}X_{if}$$

and proceed to maximize it, subject to the constraint implied by the production function, in order to determine the

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10/ The subscript i defines the function for a given firm.

11/ In the usual estimation case, v_{of} is assumed to represent a larger number of relatively unimportant variables that have been omitted from the model. In this case the Central Limit Theorem provides a rational for the normal distribution. In the present case v_{of} is assumed to represent the level of technology. To the extent that the level of technology is made up of a relatively large number of variables such as the qualitative dimensions of the various inputs and the omitted variable management, the same rational applies.

conditions for an equilibrium. The first order conditions for a maximum would imply

$$X_{of} = \alpha X_{1f}^{\alpha_1} X_{2f}^{\alpha_2} \ldots X_{nf}^{\alpha_n}$$

and

$$\alpha_i = \frac{P_{if} X_{if}}{P_{of} X_{of}} \text{ for } i=1,2\ldots n$$

as conditions of equilibrium, and as sufficient to determine the level of resource use and output, given the prices and perfect competition. The latter condition is frequently used to estimate the parameters of the production function, if equilibrium can be assumed.[12/]

The second order conditions state that α_i must be greater than zero and less than one and that the sum of the α_i must be less than one. The latter implies that perfect competition and profit maximization are inconsistent if $\sum_{i=1}^{n} \alpha_i > 1$.

The variation among firms that we are after can be introduced in a number of ways. Differences in the production function have already been indicated by the variable v_{of} which was added to the initial production function. This assumes that production functions differ among firms in a rather specific way -- such that given percentage increases in inputs would result in the same percentage increases in output for all firms, but firms with the same level of inputs

12/ This property is unique to the Cobb-Douglas production function.

will not all produce the same output.[13/]

Alternatively, or in addition to, in the same manner a random term can be introduced into the equilibrium conditions to indicate that the firm may not be a perfect profit maximizer. In this case the equilibrium conditions become

$$a_i u_{if} = \frac{P_{if}X_{if}}{P_{of}X_{of}} \quad \text{for } i=1,2...n$$

where $\log u_{if}$ is a random variable with a normal distribution,[14/] a mean equal to zero, and a finite variance, σ_i^2, and once again is given an economic interpretation.

Taking the stochasticized production function and equilibrium conditions as our model,[15/] Klein[16/] suggests that estimates of the coefficients of the production function be obtained as follows:

$$\log \hat{a}_i = \frac{1}{F}\sum_{f=1}^{F} \log \frac{P_{if}X_{if}}{P_{of}X_{of}}$$

$$\log \hat{A} = \frac{1}{F}\sum_{f=1}^{F}\left[\log X_{of} - \sum_{i=1}^{n} \hat{a}_i \log X_{if}\right]$$

where F is the total number of firms in the sample. Taking anti-logarithms will provide the parameter estimates $\hat{a}_i$ and $\hat{A}$:

13/ In essence, an economic meaning is being given to the usual error term of the estimating equation.

14/ In this case the u_{if} is assumed to represent a large number of relatively unimportant variables that account for the firm not attaining an economic optimum.

15/ Assuming the production function to be transformed logarithmically into its linear form.

16/ Klein, L.R., op. cit., pp. 226-236. For a derivation see Appendix C.

$\hat{\alpha}_i$ = antilog (log α_i) (i=1...n)

$\hat{\alpha}$ = antilog (log α)

Thus, the α_i are obtained as the geometric means of the shares of the respective inputs to the total value of output for individual firms. The intercept, $\log \hat{a}$, is obtained by inserting these estimates into the equation of the production function and obtaining the mean difference.

Nerlove proves that the estimates of log α_i are unbiased and consistent regardless of the interpretation of v_{of} in the original production function.[17/] The estimates, $\hat{\alpha}_i$, however, are biased, although they can be shown to be consistent. $\log \hat{\alpha}_i$, on the other hand, is biased and in general inconsistent.

Under the assumption of normality and independence,

$$s^2 = \frac{1}{F} \sum_{f=1}^{F} (\log X_{if} - \log X_{of} - \log \alpha_i)^2$$

$$\text{Var} \log \hat{\alpha}_i = \frac{s^2}{F}$$

Log α_i is normally distributed with variance $\frac{\sigma^2}{F}$ and mean log α_i. These facts can be used to construct a 95 percent confidence interval for log α_i:

$$\log \hat{\alpha}_i - \frac{s_i}{\sqrt{F}} t \leq \log \alpha_i \leq \log \hat{\alpha}_i + \frac{s_i}{\sqrt{F}} t$$

$$\text{Antilog} (\log \hat{\alpha}_i - \frac{s_i}{\sqrt{F}} t) \leq \alpha_i \leq \text{antilog}(\log \hat{\alpha}_i + \frac{s_i}{\sqrt{F}} t) \text{ where}$$

α_i = antilog (log α_i)

17/ Nerlove, op. cit., pp. 65-66.

Solving the original model, which consists of the production function and the equilibrium conditions, for the levels of output and input in terms of the α's and the v's, and substituting the results in the profit equation results in:[18]

$$\pi_f = (1 - \sum_{i=1}^{n} \alpha_i u_{if}) \left[\alpha v_{of} P_{of} \prod_{i=1}^{n} \left(\frac{\alpha_i u_{if}}{P_{if}} \right)^{\alpha_i} \right]^{\frac{1}{1 - \sum \alpha_i}}$$

To obtain π for any firm f in a sample of firms F, we substitute $u_{if} = 1$ for i = 1...n. $\lambda(f)$ is then found as the maximum of π in the sample.

$$E_1(f) = \pi_f - \lambda(f) = (\pi_f - \hat{\pi}_f) + (\hat{\pi}_f - \lambda(f))$$

where $\pi_f - \hat{\pi}_f$ measures price efficiency,

$\hat{\pi}_f - \lambda(f)$ measures technological efficiency, and

$E_1(f)$ measures overall economic efficiency.

These computational procedures can be summarized as follows:

1. Estimate α and α_i (i=1...n) as indicated above.
2. Compute $\hat{v}_{of} = \dfrac{X_{of}}{\alpha X_{1f}^{\alpha_1} \cdots X_{nf}^{\alpha_n}}$ for f=1....F
3. Compute for each firm f the set of values u_{if} for i=1...n.
4. Compute for each firm f the values $\alpha_i u_{if}$ for i=1...n.

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[18] This equation differs from that suggested by Nerlove, op. cit., p. 97. Computation along the lines suggested by Nerlove resulted in infinite values for profits or net income. Appendix D shows the derivation which resulted in the following equation. It is based on the procedures suggested by Nerlove.

5. Introduce these values in the above profit equation for each firm, f=1 ... F.

6. Compute r_f for f=1....F.

7. Make $u_{if} = 1$, i=1...n, in the production function,

8. Compute π_f for f=1...F.

9. Select the maximum value of π. This is $\lambda(f)$.

10. Compute the various measures of efficiency by the use of the formulas above.

11. Use these values to rank the firms.

The Data

The basic model to be fit is a Cobb-Douglas equation of the type

$$X_o = aX_1^{\alpha_1} X_2^{\alpha_2} \ldots X_n^{\alpha_n}$$

which is stochasticized as indicated in the previous section. The dependent variable refers to output and the independent variables refer to inputs. The intercept, a, generally reflects the level of technology and other omitted variables. The α_i are production elasticities.

The model as initially specified had six independent variables: land, buildings, labor, machinery and equipment, animals, and operating expenses. Preliminary runs with the model resulted in sums of the exponents which were greater than one, which violates the second order conditions for equilibrium with a Cobb-Douglas. For this reason, two of the variables were dropped -- land and buildings -- with the result being a short run production model. The effects of

these variables are, of course, reflected in the constant term of the production function. Since the production elasticities are estimated by factor shares, this approach does not lead to specification bias of the production elasticities, as it might have done had something like ordinary least squares estimation procedures been used.

The model used in the analysis below is specified as:[19]

X_0 = gross income of the farm, measured in cruzeiros

X_2 = labor services, measured in cruzeiros

X_4 = machinery and equipment, measured in cruzeiros

X_5 = animal services, measured in cruzeiros

X_6 = other expenses, measured in cruzeiros

All variables are measured as a flow, as contrast to a stock. However, the conversion of stocks to flow presents serious problems in an inflationary environment such as in Brazil. Nominal or monetary rates of interest are quite high--as much as 40-60 percent a year, or higher. Real rates of interest are much lower, but it is very difficult to know what this rate is.

Even if it were possible to have a market determined real rate of interest, it is not clear that one should use it in converting stocks into flows for estimating the production function. The reason for this is that capital gains are quite large when rates of inflation are high and this is an important determinant of resource use and resource holdings.

19/ The definition and measurement of the variables can be found in Appendix E.

Farmers purchase land and animals not only as a productive resource, but also as a store of value or a hedge against inflation. Since the conventional theory of the firm treats only the flow account, to the neglect of the asset account, there is no way of taking these different factors into account.

The procedure followed here was to measure the variables in both ways and let the results of the estimation procedure suggest which was the better model. Hence, one model was estimated with assumed real rates of interest of 10-15 percent (depending on the variable) while another was estimated with nominal rates of interest of 42-54 percent (again depending on the variable). The latter model gave the better statistical results (R^2 of around .60 as contrast to .40) and hence was used in further analysis.

Lest it be felt that these rates are prohibitively high, it should be remembered that this will depend on the decision model which farmers actually use. If they make their production decisions based on the market rates of interest, of course, the approach taken here is valid. On the other hand, if they are able to think in "real" terms, our results will be biased.

An additional factor that bears on this issue is that the capital markets which farm people face is very imperfect. Funds are not available in many cases even at the going rate of interest. And because of the rapid inflation, loans typically have to be paid back within two to three years -- even for the purchase of land.

The data themselves were taken from farm interviews in two municipios (counties) of the state of Minas Gerais. In one municipio ACAR had been working for 10 years, and the data were taken from the universe of farms cooperating with them. The second municipio was chosen so that it would be as similar as possible to the ACAR municipio, with the exception that ACAR had not worked there. In this municipio, a random sample of farms was drawn, but within size intervals similar to those for the ACAR municipio so that the size distribution would be similar. Sixty questionnaires were taken in each municipio.[20/]

20/ For more detail on the sampling procedures see Appendix F.

CHAPTER III

BACKGROUND AND DESCRIPTIVE DATA

The purpose of this chapter is to give a description of the two municipios. This will serve to characterize the setting from which the samples were drawn and to compare various characteristics of the sample units in order to indicate to what extent the two samples were in fact similar. The descriptions of the two municipios, Senador Firmino and Presidente Bernardes, will be based on data obtained from the IBGE, the Federal institution in charge of collecting data in Brazil. Sample data could not be used for this purpose since neither sample was drawn for this purpose.

Statistical tests will not be made to verify whether there is a statistically significant difference in measurements of any attribute of the two samples. The reason for this is that statistical differences or similarities between the two samples in the characteristics considered in this chapter do not really bear on the basic analysis to be made. Hence, even though it would be interesting to know whether the samples came from the same population, it was not deemed of sufficient value to merit the considerable computational expense involved.

Presidente Bernardes

Presidente Bernardes is the name of a town that is situated in the Zona de Mata of Minas Gerais. It is also the name of the municipio of which the town is the administrative and political center. According to the 1960 Census of Population, the population of the municipio was 8,450, of which only 814 (9.7 percent) lived in town.

The rainfall period in the municipio extends from October to April, and the average annual rainfall is 1313.1 mm. The temperature ranges from 14° C. (average of the minimum) to 25.8° C. (average of the maximum) with an average of 19.2°C.

Presidente Bernardes has been a town since December, 1938, when a State law raised the village of the same name to the category of a town. But its history goes back to the first years of the eighteenth century, when a group of Portuguese and Brazilians began to settle in the region. They cleared the forest and established in its place farms that produced cattle and crops.

With the advent of the coffee cycle in Brazil, this crop became the most profitable and important crop of Presidente Bernardes. It reached almost all parts of its area, including lands inappropriate for its cultivation, such as very steep hills.

Since no care was taken to preserve soil fertility, the yield of the crop began to decrease in a short time. This problem has recently been aggravated by discriminatory prices

imposed by the government against the coffee of regions that are not considered appropriated for its cultivation.[1/] These adverse conditions -- a decrease in yield and relatively lower prices -- brought about a gradual, but steady decrease in the coffee production. At the present time, it is no longer an economically significant crop for the municipio.

The coffee was replaced by corn, rice, and beans in those areas where the fertility of the soil made it possible. The steep hills and poor land formerly in coffee is now in pasture or is being transformed into pasture.

These pastures are of very low productivity, since almost nothing was done to raise the level of fertility of the land. The process of pasture formation was and continues to be primitive. It consists only in allowing the land in coffee to be invaded by grasses, with very little interference on the part of man. As time goes by the trees die and are eliminated either by fire or by natural processes. Ultimately, a time comes when there are no coffee trees standing and the area is then completely in grasses.

Agriculture is the main occupation of the municipio. About 50 percent of the labor force is engaged in agricultural activities.

Actually, only a small portion of the area of the municipio (213 km²) is appropriate for crop production, since the

1/ In Presidente Bernardes it costs much more to produce an exportable type of coffee than in other regions of the State. The original plantings were not of a type suitable for exporting.

topography is very irregular. Moreover, the area currently in crops -- 15.3 percent of the total area -- is greater than would be recommended if the cannons of soil conservation were followed. The rest of the area is in pasture, forest (a small part), or in non-farm uses.

The majority of the farms are very small, and some of them under the current level of technology probably do not afford even a subsistence pattern of living to the farmers. The size distribution of the land holdings is very asymetric, with the approximately 10 percent of the farms over 100.0 hectares[2/] accounting for about 48.8 percent of the total land in farms (Table 1). On the other end of the distribution, some 47 percent of the farms are less than 10 hectares in size and cover only 6.2 percent of the total area in farms.

Table 1. Size Distribution of Farms, Presidente Bernardes, Measured in Hectares, 1960.

Size of Farm (hectares)	Number of Farms	Percent of Total	Area Included in Farms (hectares)	Percent of Total
Less than 10	186	47.2	900	6.2
From 10 to less than 100	170	43.2	6471	45.0
From 100 to less than 1000	38	9.6	7018	48.8
Total	394	100.0	14389	100.0

Source: I.B.G.E. - Sinopse Preliminar do Censo Agricola de Minas Gerais, 1960.

[2/] A hectare is equal to 2.2 acres.

According to 1964 data, corn was the most important crop of the municipio, followed by rice, beans, and coffee. The yield of these crops is very low as can be seen in Table 2. The limited use of fertilizers and improved seeds, plus inappropriate stands are possible reasons for the low level of productivity.

Table 2. Crop Production and Yield Data, Presidente Bernardes, 1964.

Crops	Area (hectare)	Production (long tons)	Yield per hectare (kilos)	Value of Production (Cr$1000)	Percent of Total
Coffee	230	211	917	21,105	7.8
Corn	2027	2369	1169	118,440	43.4
Rice	822	752	915	56,389	20.7
Beans	964	586	608	58,620	21.5
Sugar Cane	570	11150	19561	6,690	2.5
Others*	57	--	--	11,263	4.1
Total	4670 --	--	--	272,507	100.0

*This category includes: oranges, bananas, tobacco, manioc, garlic, pineapple, onions, peanuts, sweet potatoes, potatoes, tomatoes, etc.

Source: Servico de Estatistica da Producao do Estado de Minas Gerais, - S.E.P.

Data on the flow of animal products from the livestock sector are more difficult to obtain. The value of livestock products is given in Table 3. However, data on the livestock itself refer only to the stock on hand. No data are available on sales. However, if the yield from the cattle and

Table 3. Production of Animal Products, Presidente Bernardes, 1964.

Products	Unit of Measure	Production	Value of Production (Cr$1000)	Percent of Total
Milk	ton	855.0	68,400	53.4
Cheese	ton	2.9	2,340	1.8
Eggs	dozen	93,100.0	18,640	14.6
Cream	ton	47.6	38,080	29.8
Honey and bee wax	-	-	508	0.4
Total			127,968	-

Source: Servico de Estatistica da Producao do Estado de Minas Gerais, - S.E.P.

swine herds is assumed to be 10 percent,[3/] the value of crop production is still above the value of annual production. This can be seen from the data presented in Tables 2, 3, and 4.

Cattle and hogs are the principle livestock on farms, as measured by value (Table 4). Cattle breeding is not specialized either for beef or for milk production, and the size of the operation is in general very small. On the average there are 18 head of cattle per farm (adult and nonadult cattle). Farms do not specialize in hog production either. The main purpose of the hog enterprise is to satisfy family needs, with the excess being sold as a cash product. The level of

3/ A direct measure of the yield of the cattle and hog herds is not available for the municipio. The 10 percent rate is the average for the state as a whole and is probably not too far off the mark.

Table 4. Stock of Animals, Presidente Bernardes, 1964.

Category	Number	Value (Cr$1000)	Percent of Total
Cattle	7,190	480,000	43.6
Horses	3,055	61,100	5.6
Swine	11,409	382,000	34.7
Mules	3,140	141,300	12.8
Fowl	51,050	33,758	3.1
Sheep	440	1,320	0.1
Goats	600	1,200	0.1
Total	XXX	1,100,678	100.0

Source: Servico de Estatistica da Produção do Estado de Minas Gerais - S.E.P.

technology involved in both enterprises is very primitive, and practically all the investments are in land or in animals. Hogs are fed with corn only, and cattle get almost all the nutrients they receive from pasture.

Educational facilities in the municipio are very poor both in amount and quality.[4/] The elementary schools are not sufficient for the needs of the population, and the quality of their teaching is far below that provided by the state supported elementary schools. Unfortunately, the state schools are in general placed in larger towns or cities and, hence, benefit only that part of the rural population that lives near them.

4/ Reference is made here to the schools that are supported by the municipio.

and was cultivated in almost every part of the municipio, regardless of the adversity of the natural conditions. For the same reasons, the production of coffee decreased and now has practically no economic importance for the municipio. Corn, beans, rice, and pasture were the replacements for coffee. The process of pasture formation was not greatly different from Presidente Bernardes.

The municipio differs in two respects from that of Presidente Bernardes. Crops contribute a relatively larger amount to the total value of production than in Presidente Bernardes, (Tables 5, 6, and 7) and among the crops, corn is really the only one that is important (Table 5). Hence, this municipio is much more specialized in corn production than is Presidente Bernardes. As was the case in Presidente Bernardes, the production per hectare is low for every crop. However, the yield for corn, the principal crop for both municipios, is higher in Senador Firmino. This might be an indication of a higher level of technology, although it can also be due to other factors such as a higher level of soil fertility.

Cattle production is also important for Senador Firmino (Table 7). Although not yet specialized in beef or milk production, the tendency is to move rapidly toward milk production due to the proximity of a very large consumer center --Rio de Janeiro. Hog production is another important agricultural activity of the municipio, although, to a great

Table 5. Crop Production and Yield Data, Senador Firmino, 1964.

Crops	Area (hectare)	Production (long tons)	Yield per Hectare (quite)	Value of Production (Cr$1000)	Percent of Total Value
Coffee	155	52	335	19,250	4.0
Corn	4,050	6,000	1,481	400,000	84.1
Rice	260	600	2,307	36,000	7.6
Beans	240	72	300	8,550	1.8
Tobacco	15	13	866	9,000	1.9
Others*	22	-		2,887	0.6
Total	4742			475,687	100.0

*Includes garlic, manioc, sugar cane, sweet potatoes, and onions.

Source: Servico de Estatistica da Producao do Estado de Minas Gerais (S.E.P.).

Table 6. Production of Animal Products, Senador Firmino, 1964.

Products	Unit of Measure	Production	Value of Production (Cr$1000)	Percent of Total
Milk	Ton	1,000.0	68,000	75.9
Butter	Ton	20.0	11,400	12.7
Cheese	Ton	1.2	600	0.7
Eggs	Dozen	51,000.0	9,690	10.8
Total			89,690	100.0

Source: Servico de Estatistica da Producao do Estado de Minas Gerais, (S.E.P.).

Table 7. Stock of Animals, Senador Firmino, 1964.

Category	Number	Value (Cr$1000)	Percent of Total
Cattle	9,000	556,000	88.3
Horses	600	12,000	1.9
Swine	1,400	35,400	5.6
Mule	170	4,760	0.8
Fowl	25,200	20,230	3.2
Sheep	90	400	0.1
Goats	100	500	0.1
Total		629,290	100.0

Source: Servico de Estatistica da Producão do Estado de Minas Gerais, (S.E.P.)

extent, its main objective is to meet the needs of the family.

The great majority of the farms are less than 100.0 hectare, and about half of all farms are less than 10.0 hectares in size (Table 8). The size distribution of farms is very asymetric also, since the farms with area over 100 hectares (7.5 percent of total number of farms) enclose 44.3 percent of the total area in farms. Presently, about 13 percent of the area in farms is in crops, of which corn is the most important.

The educational facilities, as far as elementary school is concerned, are slightly better in Senador Firmino than in Presidente Bernardes, although the same problems are found in relation to high school education.

Table 8. Size Distribution of Farms, Senador Firmino, Measured in Hectares.

Size of Farm (hectares)	Number of of Farms	Percent of Total	Area Included in Farms	Percent of Total
Less than 10	225	48.2	958	7.2
From 10 less than 100	207	44.3	6,440	48.5
From 100 to less than 1,000	35	7.5	5,871	44.3
Total	467	100.0	13,269	100.0

Source: Servico de Estatistica da Producão do Estado de Minas Gerais - S.E.P., Year 1960.

An Analysis of the Sample Characteristics

Sample data were taken from two municipios: Senador Firmino, where ACAR had been working for more than 10 years, and Presidente Bernardes, which was chosen as the basis for comparison. At the time the data were collected, there were 67 farmers, each one operating a farm, who were receiving ACAR's assistance under supervised credit activities. Their farms are the sample units for Senador Firmino. Hence, this is a purposive sample. The farms were not selected at random, but by the fact that they were ACAR borrowers. As a result they were assumed to have received a much more intensive assistance from ACAR.

For Presidente Bernardes the only characteristic of the farms known at the time the sample was taken was the farm size. Using this characteristic, the sample was drawn from Presidente Bernardes in such way that the distribution of the size of the sampled farms would be very similar to that

of the 60 farms from Senador Firmino.[5/] It was hoped that other characteristics of the farms and farmers were correlated with the size of farms, except for those which ACAR might have influenced. Unfortunately, it turned out that this "hypothesis" was not always true. Although the average size of the farm and the size distributions of the samples are much the same, a wide range of variation was found for other characteristics for which ACAR was not supposed to interfere.

Farm Size and Land Use (Table 9). The size distributions of farms in the samples are very different from the distributions based on secondary data. For example, in the samples there are no farms with an area less than 12.00 hectares, whereas the secondary data indicated that the number of farms below 10.0 hectares was around 50 percent for both municipios. Hence, the samples are not representative of either municipio.

The size distributions of the sampled farms, however, appear to be very similar (Table 9). The average size of the sample farms from Presidente Bernardes is a little larger than it is in Senador Firmino, but this difference is very small when the wide variation of this characteristic is considered.

In Senador Firmino, on the average 17.9 percent of the farm area is for crops, 71.3 percent for pastures and 10.4 percent is in forests. For Presidente Bernardes these

[5/] For more details see Appendix F.

Table . Size Distribution of Farms, Measured in Hectares, and Land Usage, Sample Data from Senador Firmino and Presidente Bernardes.

Class	Division (Hectares)	Municipality	Number of Farms	Crop	Pastures	Forests	Other	Total
I	14.00-[illegible]	S.F.[a]	16	6.20	17.39	3.90	.70	28.29
		P.B.[b]	19	6.92	12.82	3.71	.10	23.45
II	[illegible].00-54.99	S.F.	17	7.11	32.78	4.08	.92	44.89
		P.B.	16	3.19	27.98	8.35	.26	44.68
III	55.00-97.99	S.F.	17	14.49	44.36	9.85	--	68.70
		P.B.	11	16.06	48.52	8.41	1.18	74.17
IV	98.00-139.99	S.F.	6	17.79	89.27	11.67	1.14	119.83
		P.B.	8	17.94	69.50	20.68	.47	108.59
V	140.00-183.99	S.F.	1	34.10	107.90	18.00	--	160.00
		P.B.	1	45.00	42.75	62.25	--	150.00
VI	184.00-226.99	S.F.	1	31.00	164.00	15.00	--	210.00
		P.B.	3	33.21	140.97	22.40	.03	196.67
VII	227.00-269.99	S.F.	2	26.55	223.50	3.25	.50	253.80
		P.B.	2	26.16	208.34	21.00	--	255.50
	Average	S.F.	60	11.52	46.87	6.84	.31	65.54
		P.B.	60	13.30	44.39	10.19	.39	68.27
	Percent Difference*		*	-15.4	+5.2	48.9	--	-4.2

* = $\frac{\text{Senador Firmino} - \text{Presidente Bernardes}}{\text{Senador Firmino}} \times 100$

Source: Samples.
a/ S.F. = Senador Firmino
b/ P.B. = Presidente Bernardes

figures are: crops - 19.5 percent, pastures - 65.0 percent, and forests - 14.9 percent. Hence, the differences are not large.

When considered by strata, Presidente Bernardes appears almost consistently with a larger area in crops, and smaller areas in pastures, although the differences are not very large. The only exception is for the class 140.00 - 183.99, where there is a large difference in the area in pasture, favoring Presidente Bernardes.

The percentage of the area in crops for the Presidente Bernardes sample, 19.5 percent, is a little larger than the same percentage for the municipio, 15.3 percent. For Senador Firmino the sample difference is about the same: 17.6 percent for the sample against 13.3 percent for the municipio.

Sources of Gross Income (Table 10). Animals are responsible for a larger part of the income in both samples. However, the sample from Presidente Bernardes has a larger part of its income coming from animals. This is somewhat in disagreement with what is presented in Table 1, where the farms from this municipio almost always have a smaller part in pasture. No obvious explanation can be given for this, other than to observe that the differences are not large enough to make it improbable that the means would not have come from the same population. The variation of this characteristic is wide.

Table 19. Sources of Gross Income, Measured in Percentage of the Gross Income, Sample Data from Senador Firmino and Presidente Bernardes.

Class	Municipio	Crops		Animals		Total	
		Family Consumption	Sales and Change in Inventory	Family Consumption	Sales and Change in Inventory	Crops	Animals
I	S.F.	16.1	22.7	13.0	48.4	38.8	61.4
	P.B.	9.7	30.4	10.0	50.1	39.9	60.1
II	S.F.	11.0	37.0	15.4	36.6	48.0	52.0
	P.B.	20.0	28.9	13.2	37.9	48.9	51.1
III	S.F.	7.2	38.5	9.0	45.3	45.7	54.3
	P.B.	6.9	32.8	10.2	50.1	39.7	60.3
IV	S.F.	6.8	34.2	8.2	50.8	41.0	59.0
	P.B.	5.5	27.3	7.2	60.0	32.8	67.2
V	S.F.	1.4	44.9	6.0	47.7	46.3	53.7
	P.B.	2.3	52.8	4.5	40.4	55.1	44.9
VI	S.F.	4.9	34.4	9.7	51.0	39.3	60.7
	P.B.	17.1	29.8	19.1	34.3	46.6	53.4
VII	S.F.	3.5	49.4	9.6	37.5	52.9	47.1
	P.B.	3.9	28.3	14.5	53.3	32.2	67.8
Average	S.F.	8.2	36.4	11.4	43.0	44.6	55.4
	P.B.	9.4	30.6	10.2	49.8	40.0	60.0

Source: Samples.

It should be noted that there are substantial differences between the two regions for individual cells of the table. However, the number of observations on which the means for each cell is based is quite small.

The part of production consumed by the family is, on the average, about the same for both samples: 20.6 percent for Senador Firmino and 19.6 percent for Presidente Bernardes. In both samples there is a tendency for the part of the production consumed by the family to decrease as the size of the farm increases.[6/]

The similarity in sample means for the fraction of production consumed by the family could be taken as evidence of the failure of the extension service, since we might expect a greater specialization of the farms as a consequence of its action. This would be expected to decrease the fraction of the production that is consumed by the family.

However, two things should be kept in mind:

1) As will be indicated below, the majority of the farmers have been receiving assistance from ACAR for three or less years, and this period is not enough to bring about substantial specialization.

2) This change if it occurs, would presuppose the development of a market where the farm could buy the food they need, and as far as Senador Firmino, President Bernardes, and nearby cities are concerned, this is far from being true.

Farm Inputs (Table 11). The data presented in Table 11

6/ For almost all of these farmers, the major fraction of the food comes from the farm. They buy only sugar, salt, macaroni, and a few other things.

Table 1. Average Farm Capital Values per Class of Farm Size. Sample Data from Senador Firmino and Presidente Bernardes.

Class	Municipio	Land	Labor	Buildings	Machinery	Animals	Other	Gross Income
I	S.F.	3036	3778	1249	393	1248	2942	7968
	P.B.	1987	2867	734	1097	1048	2407	10314
II	S.F.	4418	4499	1931	474	2234	3969	12369
	P.B.	3230	3046	1274	394	1180	2710	9809
III	S.F.	7273	7221	2033	1306	3538	5166	20934
	P.B.	4666	3964	2367	1327	2379	3182	18552
IV	S.F.	11271	7839	2390	1549	4671	7843	22836
	P.B.	8471	7139	2623	899	4301	4733	33088
V	S.F.	35929	10896	3430	2751	2326	16687	62815
	P.B.	22743	8469	2308	10454	3802	11579	48371
VI	S.F.	29703	13732	7371	6943	5069	6486	32329
	P.B.	9977	6322	3165	5050	3641	9224	22097
VII	S.F.	18636	9712	5911	4086	10041	22165	61402
	P.B.	24830	6848	6280	793	3429	9946	29110
General Average	S.F.	6962	5844	2063	1062	2910	5266	17477
	P.B.	5173	4084	1763	1269	1997	3661	16579
Percent of Difference *		+25.7	+37.2	+14.3	-19.5	+31.4	+30.5	+5.1

* Percent difference = $\frac{\text{Senador Firmino} - \text{Presidente Bernardes}}{\text{Senador Firmino}} \times 100$

Source: Sample Data.

represents the flow of services and were calculated as indicated in Appendix E. Excépt for machinery, Senador Firmino used more inputs in production than Presidente Bernardes, and in all cases the differences exceed 14 percent. However, the gross income of the sample of Senador Firmino is only 5.1 percent greater than the sample from Presidente Bernardes, which suggests that the average output per unit of input in Presidente Bernardes is greater than that of Senador Firmino.

As Table 12 indicates, this is true for all inputs except machinery. The differences, against Senador Firmino are: land, 27.3 percent; labor, 35.8 percent; buildings, 10.6 percent; animals, 38.8 percent. No statistical tests were performed to determine whether the differences are significant or not. However, they are large enough to merit further analysis. It was expected that Senador Firmino would show higher levels of productivity, since these farmers have been receiving assistance from ACAR. These preliminary results suggest that the level of technical efficiency is higher in Presidente Bernardes.

Additional productivity data is presented in Table 13, where the average output per hectare is given for the two municipios. It is interesting to note that when measured in this way, the difference in productivity is substantially less, and in favor of Senador Firmino--the municipio in which ACAR has been working. It is doubtful, however, whether this difference would be statistically significant, given the rather large sample variability.

Table 11. Average Output per Unit of Input by Resource Category. Sample Data from Senador Firmino and Presidente Bernardes.

Class	Variable	Land	Labor	Buildings	Machinery	Animals	Others	Total
I	S.F.	[illegible]	1.11	4.38	20.23	6.38	2.71	.63
	P.B.	1.13	3.66	13.66	9.40	9.84	4.28	1.01
II	S.F.	2.73	2.72	6.40	26.10	3.29	3.12	.70
	P.B.	2.97	3.28	7.69	24.91	8.31	3.62	.82
III	S.F.	2.97	2.00	8.89	16.02	5.91	4.03	.78
	P.B.	3.99	4.68	7.84	13.98	8.14	5.83	1.04
IV	S.F.	2.03	2.91	9.55	14.74	4.89	3.11	.63
	P.B.	4.00	4.63	12.61	36.81	7.69	6.92	1.18
V	S.F.	1.73	3.81	43.92	22.83	27.02	3.38	.87
	P.B.	1.14	5.73	21.04	4.64	12.77	4.19	.82
IV	S.F.	1.09	2.35	4.39	4.66	6.38	4.98	.47
	P.B.	2.21	3.49	6.98	4.38	6.07	2.40	.59
VII	S.F.	3.29	6.32	15.70	15.04	6.12	2.77	.89
	P.B.	1.17	4.25	4.64	38.73	8.49	3.22	.57
General Average	S.F.	2.51	2.09	8.47	16.45	6.00	3.32	.72
	P.B.	3.20	4.06	9.37	17.06	8.30	4.53	.92
Percent of Difference*		-27.1	-55.8	-10.6	+20.6	-38.3	-36.4	-27.8

* $\frac{\text{Senador Firmino} - \text{Presidente Bernardes}}{\text{Senador Firmino}} \times 100$

Source: Sample Data.

Table 13. Average Output per Hectare of Land, Measured Cr$100. Sample Data From Senador Firmino and Presidente Bernardes.

Class	Municipio	Average Hectares	Gross Income/hectare (Measured in Cr$100)
I	S.F.	25.29	315.06
	P.B.	23.45	439.83
II	S.F.	44.89	275.54
	P.B.	44.68	219.54
III	S.F.	68.70	304.72
	P.B.	74.17	250.13
IV	S.F.	119.83	190.57
	P.B.	108.59	30.47
V	S.F.	160.00	392.59
	P.B.	150.00	323.81
VI	S.F.	210.00	153.95
	P.B.	196.67	112.36
VII	S.F.	253.80	241.93
	P.B.	255.50	113.93
Average	S.F.	85.84	266.67
	P.B.	68.27	242.84
Percent of Difference*		-4.2	+8.9

* $\frac{\text{Senador Firmino} - \text{Presidente Bernardes}}{\text{Senador Firmino}} \times 100$

Source: Sample Data.

An additional point should be noted from both Tables 12 and 13. No discernible relationship exists between the various measures of partial productivity and the size of farm as measured by hectares. This is the case for both municipios and suggests[7] that within the range of the data, there is no relationship between efficiency and farm size.

7 The word "suggests" is used here because of the inherent limitations of indexes of partial productivity.

Composition of the Labor Force (Table 14). Family labor is the largest source of labor in both municipios. It contributes 48.6 percent of the total labor force in Senador Firmino and 42.6 percent in Presidente Bernardes. Permanent labor is the second most important source of labor in both municipios, with temporary labor and share crop labor[9/] being relatively less important.

The farms in Senador Firmino tend to use a little more labor (9.4 percent), although this is probably not statistically significant. The differences in the individual components are substantially greater. The farms in Senador Firmino use more family and permanent labor, whereas those in Presidente Bernardes use more temporary and share crop labor.

In both municipios there is a tendency for the fraction of labor coming from the family to decline as farm size increases. The difference comes from each of the other sources of labor as farm size increases.

The productivity of labor measured on physical units of labor indicate, as with the previous indices of partial productivity, that there is no relation between size of farm and labor productivity. On the average, labor appears to be slightly less productive in Senador Firmino--the ACAR

9/ It is common for the farmer (in our case the owner of the land) to provide a tract of land for the permanent worker (and sometimes temporary workers) to operate. The types of agreements vary. But in general the farmer pays expenses related to the preparation of the land and fertilizers. The share cropper is responsible for all other inputs. They share the production according to some agreed upon rate.

Table 14. Source of Labor Worked on Farms, Measured in Man Equivalents, and the Average Output per Man Equivalent, Measured in Cr$100. Sample Data From Senador Firmino and Presidente Bernardes.

Class	Municipio	Family Labor	Permanent Labor	Temporary Labor	Share Crop Labor	Total	Gross Income/ Man Equivalent (Measured Cr$100)
I	S.F.	586	328	42	46	1002	7.95
	P.B.	484	309	74	62	929	11.10
II	S.F.	842	125	73	120	1160	10.66
	P.B.	486	315	60	103	964	10.17
III	S.F.	613	701	88	254	1656	12.64
	P.B.	559	281	191	257	1288	14.40
IV	S.F.	826	655	38	380	1899	12.02
	P.B.	830	689	293	346	2158	15.33
V	S.F.	312	312	85	1767	2476	25.37
	P.B.	312	338	397	1820	2867	16.94
VI	S.F.	1093	1872	---	---	2965	10.90
	P.B.	789	208	164	909	2070	10.67
VII	S.F.	702	1196	186	650	2734	22.46
	P.B.	559	169	448	1048	2224	13.09
Average	S.F.	698	463	68	207	1436	12.17
	P.B.	559	347	144	251	1301	12.74
Percent Difference*		+19.9	+25.0	-111.8	-21.2	+9.40	-4.7

*Percent Difference = $\frac{\text{Senador Firmino - Presidente Bernardes}}{\text{Senador Firmino}}$

Source: Sample Data.

municipio--than in Presidente Bernardes. The difference is small, however.

Measurement problems are always serious for labor, especially when such a large fraction comes from family labor. The tendency is for the interviewee to overstate the time actually worked when the question is asked after the fact. An attempt was made to circumvent this by asking the question in terms of the number of days not worked and then subtracting this from the total number of days in the year. No evidence is available to indicate whether this improves the estimates or not. Presumably, however, any bias would be the same in both samples.

Pricing of the labor input also has difficulties, since a large part of it comes from unpaid family labor. Family labor was priced at the wage paid for permanent labor, which is to assume that they have similar levels of productivity. If there should be a systematic bias in this, distortion could be introduced in the results below, since Senador Firmino does use relatively more family labor than Presidente Bernardes.

Prices at the Farm Level (Table 15). The prices presented in Table 15 are weighted average prices computed from sample data. There is little that one can say about systematic differences in prices between the regions. Substantial differences exist,[9/] but as we shall see, they go in

9/ Both factor and product markets are quite inefficient in Brazil. Substantial differences in prices exist within relatively small areas. (See periodic reports of the Secretary of Agriculture, Minas Gerais.)

Table 15. Weighted Average Prices, Sample Data From Senador Firmino and Presidente Bernardes, Measured in Cr$.

Items	Unit	Senador Firmino	Presidente Bernardes
Crops:			
Corn	60 kg.	3,607	3,831
Rice	"	4,824	5,342
Bean	"	9,042	7,641
Tobacco	"	8,178	15,152
Sugar Cane	Ton*	5,452	6,304
Coffee	60 kg.	6,795	20,876
Work Animals:			
Oxen	1	64,922	52,380
Horse	1	23,171	23,105
Burro	1	41,185	39,210
Mare	1	18,424	16,545
Cattle:			
Dairy cattle	1	62,179	50,882
Yearling bull	1	54,000	30,625
Cows	1	54,687	48,007
Young stock-male	1	29,064	23,667
Young stock-female	1	19,601	23,208
Calves-male	1	9,144	9,126
Calves-female	1	9,418	9,434
Hogs:			
Boars	1	22,957	18,755
Sows	1	22,606	21,432
Piglets	1	4,930	3,192
Hogs for fattening	1	12,807	9,923
Fattening Hogs	1	28,623	31,345
Labor (man equivalent)	1	400	300
Land	Hectare	87,740	141,035

* 60 kg. corresponds to a bag and one ton corresponds to 1000 kilos.

Source: Sample Data.

one direction for one comparison, but in another direction for another. The effect of this on the measures of efficiency to be constructed below will be discussed at a later point.

Among the crops, corn, rice, and beans are the principal products in the two municipios. Of these, corn is the relatively more important. For this crop, the price is some 6 percent higher in Presidente Bernardes than in Senador Firmino. The price of rice is also higher in Presidente Bernardes, but the price of beans is higher in Senador Firmino.

Work animals tend to be higher priced in Senador Firmino, although the price of horses is practically the same in the two municipios. The price of cattle, another major output, tends to be higher in Senador Firmino, although heifers, for example, have a higher value in Presidente Bernardes. The various categories of hogs also have price differentials that go both directions.

This diversity in differentials carries over to land and labor, the two major inputs. The price of labor is some 30 percent higher in Senador Firmino, but the price of land is almost twice as high in Presidente Bernardes. This latter is probably the most surprising and perplexing price differential, since there is no obvious explanation for it. It was expected that land quality was not greatly different and that if there was a locational advantage, it would be in favor of Senador Firmino.

Demographic Characteristics (Tables 16 and 17). There is a rather large difference both in the age distribution of the two samples and in the sample means. The farmers working with ACAR (Senador Firmino) are much younger. This could have been expected, and for two reasons: 1) They are farmers who are borrowers, and it is ACAR policy that the local office should make the concession of credit to persons over 55 more difficult. 2) Younger farmers are more prone to take risk. This becomes a selective factor in farmers working with ACAR.

In Presidente Bernardes there are 19 farmers out of 60 that are 60 years old or over -- a strong tendency toward the aged. This may not be as important as it appears on the surface, however. Although the old man is considered to be the head of the farm, the person that really makes the decisions may be a son, if the father is not in good condition to be the manager. No question was placed on the questionnaire to identify the decision maker, however, since this problem was not foreseen.

Table 16. Age Distribution of the Head of the Farms. Sample Data From Senador Firmino and President Bernardes.

Age Classes (Year)	Senador Firmino		Presidente Bernardes	
	Number	Cumulative Percentage	Number	Cumulative Percentage
20 - 29	7	11.7	4	6.7
30 - 39	18	41.7	12	26.7
40 - 49	25	83.4	14	50.0
50 - 59	8	96.7	11	68.3
60 and over	2	100.0	19	100.0
Median	41.8		48.3	

Source: Sample Data.

On the other hand, it is not clear whether age is an important factor influencing economic efficiency as measured later in the study. There might be a presupposition that younger people would adopt new ideas and new innovations more quickly. On the other hand, younger people may not have the resources to adopt a new technology, if the latter involves substantial resources. In any case, the younger population is associated with the ACAR program -- a fact which should be kept in mind in the later analysis.

Data on the amount of schooling by the head of the farm is given in Table 17. There is little difference between the two samples on this characteristic, with the medians being identical and the distributions being essentially the same. The only difference between the two samples is that Presidente Bernardes has a larger fraction of illiterates.

Table 17. Distribution of Number of Years of School of the Head of the Farm. Sample Data from Senador Firmino and Presidente Bernardes.

Number of Years	Senador Firmino		Presidente Bernardes	
	Number	Cumulative Percentage	Number	Cumulative Percentage
Illiterates	4	6.7	9	15.0
1 - 2	22	43.4	18	45.0
3 - 4	32	96.7	31	96.7
5 and over	2	100.0	2	100.0
Median	3.1	X	3.1	X

Source: Sample Data.

Number of Years with ACAR Assistance. Data on the number of years that the farmers in Senador Firmino have received assistance from ACAR is given in Table 18. A number of points are to be noted from this table. First, some 20 percent of the sample had been working with ACAR only a year or less at the time pertinent to the data. On the other hand, 33 percent of the sample have had assistance for three years, and some 40 percent have had assistance for 4 years or more, with some going up to as much as 14 years.

Although it is not known how much time is necessary for an extension-type program to have an effect, it does not appear that the average of 3.6 years should be sufficient time to obtain measurable results.[10/] Sixteen, or slightly over 47 percent of the sample, have had assistance for periods of from 8 - 14 years, which should counter-balance the effect of the 20 who have received assistance for a year or less.

One alternative would have been to work only with those who had received ACAR assistance for two years or more. This reduces the size of the sample substantially, however, and in view of the rather large sample variability, it was decided to use all of the data available.

10/ Wharton found an effect in the first year of cooperation with ACAR. See Appendix B.

Table 18. Distribution of Number of Years of ACAR Assistance With the Farmers of Senador Firmino.

Number of Years	Number	Cumulative Percentage
Less than 1	2	3.3
1	10	19.9
2	5	28.2
3	20	61.5
4	1	63.2
5	3	68.2
6	3	73.2
7	0	73.2
8	3	78.2
9	3	83.2
10	0	83.2
11	4	89.9
12	1	91.6
13	1	93.3
14	4	100.0
Total	60	X
Mean	3.6	X
Median	2.8	

Source: Sample Data.

Table 19. Statistical Results--Comparison of Klein's Procedure with Least Squares Estimates.

	Klein's Procedure				Least Square		
Variables	Coeffi-cient	Low Coef-ficient	Standard Error Low Coefficient	Confidence interval Low Coefficient	Coeffi-cient	Standard Error	t
Intercept	24.0597				49.31		
X_2 (labor)	.33951	-1.42917	.0494	-1.5260 to -1.3324	.22675	.10084	2.24850*
X_4 (machinery)	.09414	-2.36295	.0848	-2.5229 to -2.1967	.11826	.04360	2.271231*
X_5 (animals)	.34317	-1.06954	.0366	-1.1413 to - .9978	.51367	.060774	7.58227*
X_6 (others)	.13869	-1.60763	.0595	-1.7842 to -1.5510	-.05610	.07085	-.79181
R^2		.64				.65	

* Significant at 95% level of probability.

obtained by taking the anti-logarithm of the estimated coefficient.

It is interesting to note that the explanatory power of the two models, as measured by the R^2, is virtually the same. The statistical reliability of the least squares model, as measured by the significance of the individual coefficients, is also quite good, with three of the four estimated production elasticities being significantly different from zero at the 5 percent level.

Two of the variables (labor and machinery) have estimated coefficients that are very similar in magnitude. The remaining two, however, are rather different. The coefficient for animal services is larger than estimated by ordinary least squares (.51 against .34), and the coefficient for other purchased inputs is negative when estimated by ordinary least squares, but positive when estimated by Klein's procedures. The negative coefficient is not significantly different from zero, however.

The relative size of the coefficients, or the ordinal ranking, tends to be the same for both procedures. The coefficient for animal services is largest, and of the three coefficients with a positive sign (and significant coefficient in the least squares estimation) machinery services is smallest.

In the least squares equation, the partial coefficient of animal services is approximately .60, indicating that it

explains about 60 percent of the variation in gross output. This is larger than would be expected from the descriptive data presented in the previous chapter. This is probably a reflection of specification bias in the least squares estimates of this coefficient. Livestock tend to be correlated with land, and since land has been omitted from the model, the animal services variable is probably picking up its effect, with an overestimate of the coefficient of animal services being the result. The estimate of this coefficient using Klein's procedures avoids this problem, and hence results in a lower coefficient value.

The sum of the production elasticities or the returns to scale is not greatly different between the two estimation procedures. Klein's procedures result in an estimated returns to scale of .86, while the estimate from least squares is .90.

In order for the second order conditions for a maximum to be met, the individual production elasticities must be between zero and one. Statistically testing this with the Klein estimates would be difficult since it would require the derivation of the density function for the convex transformation presented in Chapter II.

The testing here was restricted to setting confidence intervals on the logarithmic coefficients[1/] (See Table 19).

1/ This is because of the desire to test the multiple null hypotheses that $a_i = 1$ and $a_i = 0$.

These suggest that the coefficients are in fact different from both zero and one.

When short-run profits[2] are calculated for each firm, it is found that 47 out of the 120 farms have negative profits. This restricts the index of efficiency which has to be used.[3] However, the finding of such a large number of firms with negative profits is not surprising in view of the chronic inflation Brazil has experienced. As Nicholls[4] has pointed out, negative profits is a sign of sophisticated decision making if it reflects a concern with the asset account of the firm as contrast to the flow account. However, this does suggest that a criterion of efficiency defined only in terms of the flow account may not be appropriate.

The Indices of Efficiency

The next step in the analysis was to use the production function estimated by Klein's procedure to compute the three measures of economic efficiency indicated in Chapter II. Because of the existence of negative profits among the sample firms, it was necessary to use as a measure of efficiency those indices that would provide only an ordinal ranking and not a cardinal measure of efficiency.

Testing procedures for testing the basic hypotheses of

2/ Gross income minus the expenditure on the four studied inputs.

3/ See Chapter II.

4/ Nicholls, William H. and Paiva, Ruy Miller, "The Structure and Productivity of Brazilian Agriculture," (J. Farm Econ., May, 1963), pp. 360-61.

the study have to be developed accordingly. It will be remembered that these were twofold:

1. That the farms from Senador Firmino would be more technically efficient, because of their work with ACAR.
2. That the farms from Presidente Bernardes would have a higher level of price efficiency, since they would be essentially undisturbed from a position of long-run or traditional equilibrium.

Because of these differing effects, it was not possible to hypothesize which group would have the highest overall efficiency.

The null hypothesis specified was that the sample came from the same population. The null hypothesis was then tested by means of the rank test, also known as the U-test, the Mann-Whitney test, and the Wilcoxan test. This test procedure leads to the computation of a U statistic, which for sample sizes greater than 8 is distributed approximately normally. Hence, by computing a Z-statistic, the normal distribution can be used for testing the null hypotheses.[1/]

The distribution of rankings for the various measures of efficiency are presented in Tables 20, 21, and 22, together with their respective means and medians and the value of the Z-statistic. The index of efficiency is a negative number, and the closer it is to zero, the more efficient is

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1/ See Appendix G for details.

the firm. Hence, in ranking the firms, high rankings (1, 2, 3, etc.) are assigned to the firms with small negative values for the index of efficiency.

For price efficiency (Table 20), Z was equal to 1.75, indicating that the difference between the two samples was not significant at the 5 percent level.[6/] Hence, the null hypothesis that the two samples came from the same population cannot be rejected if $\alpha = .05$ is taken as the level of significance. If $\alpha = .10$ were used, the null hypothesis would be rejected ($/Z/ \geq 1.64$ for this level), however.

Table 20. Distribution of Rankings and Related Statistics, Price Efficiency, Senador Firmino and Presidente Bernardes.

Class of Ranks	Presidente Bernardes No. of Farms	Senador Firmino No. of Farms
1 - 10	3	7
11 - 20	6	4
21 - 30	4	6
31 - 40	4	6
41 - 50	5	5
51 - 60	5	5
61 - 70	5	5
71 - 80	3	7
81 - 90	5	5
91 - 100	5	5
101 - 110	9	1
111 - 120	6	4
Average	66	55
Median	66	54
Z	1.75	

Source: Sample data.

6/ For $\alpha = .05$, if $/Z/ \geq 1.96$, reject the null hypothesis of no difference between the samples.

The interesting thing is that the difference between the two samples is different than was hypothesized. Both the mean and median of the index is smaller in Senador Firmino than in Presidente Bernardes, indicating that the farmers in the ACAR sample (Senador Firmino) have a higher level of price efficiency than those in the other.

This can also be seen by examining the tails of the distribution. In the first class, Senador Firmino has 7 farms, as against 3 for Presidente Bernardes, while in the last class, Senador Firmino has only 5, as against 15 for Presidente Bernardes.

For technical efficiency (Table 21), χ^2 was equal to 2.95, indicating that the difference between the two samples was statistically significant. Hence, the null hypothesis that the two samples came from the same population is rejected at the 5 percent level of significance.

However, the direction of the difference is different than was postulated. The farmers of Presidente Bernardes have a higher level of technical efficiency than those from the ACAR sample--Senador Firmino. The differences in the means and medians are both fairly large. And once again, the differences between the two samples are fairly large in the tails.

For overall economic efficiency (Table 22), the difference between the two samples was again statistically significant at the 5 percent level.

Table 21. Distribution of Rankings and Related Statistics, Technical Efficiency, Senador Firmino and Presidente Bernardes.

Classes of Ranks	Presidente Bernardes No. of Farms	Senador Firmino No. of Farms
1 - 10	6	4
11 - 20	9	1
21 - 30	5	5
31 - 40	7	3
41 - 50	7	3
51 - 60	4	6
61 - 70	2	8
71 - 80	3	7
81 - 90	6	4
91 - 100	7	3
101 - 110	2	8
111 - 120	2	8
Average	51	70
Median	44	70
Z	2.95*	

* Significant at the 1% level of probability.

Source: Sample data.

Table 22. Distribution of Rankings and Related Statistics, Overall Economic Efficiency, Senador Firmino and Presidente Bernardes.

Classes of Ranks	Presidente Bernardes No. of Farms	Senador Firmino No. of Farms
1 - 10	5	5
11 - 20	6	4
21 - 30	8	2
31 - 40	8	2
41 - 50	5	5
51 - 60	6	4
61 - 70	2	8
71 - 80	5	5
81 - 90	5	5
91 - 100	4	6
101 - 110	3	7
111 - 120	3	7
Average	53	68
Median	46	70
t	2.32*	

* Significant at 5% level of probability.

Source: Sample data.

The statistic $\bar{z}$ was equal to 2.32, indicating a rejection of the null hypothesis that the samples came from the same population. The farmers in Presidente Bernardes have the highest overall efficiency, indicating that the higher technical efficiency of these farmers over-weighs the higher price efficiency of the farmers in Senador Firmino.

A striking fact about all of the measures of economic efficiency was their very wide dispersion. This suggests that the farms vary a great deal in the production function on which they operate, and also in the extent to which they are profit maximizers.

This was to be expected in the case of Senador Firmino but not in Presidente Bernardes. In fact, in a traditional setting such as the latter, where shocks introduced from outside have supposedly been at a minimum, one could have argued that the indices of both price and technical efficiency would tend to be grouped, since there would not be a dynamic process of change. The fact that these indices were as widely dispersed as in Senador Firmino suggests either that a disturbance had been introduced into the traditional setting in the form of new ideas or knowledge, or that the managerial capacity of the farms varied a great deal.

Of the three indices, those for technical and overall efficiency had the greatest amplitude. That for economic efficiency was much less. The arithmetical reason for this was that two of the farmers had very large profits as

calculated from the equation. Their profits were so large, in fact, that it would take the GNP of several municipios to be equivalent to them.

Back of this was the fact that these farms had a high level of technical efficiency in relation to the others, which resulted in a high calculated constant term for their production function. Since this enters multiplicatively in the profit equation, their calculated profits become very large.

In order to avoid this, the third ranking farm was taken as the basis for computing the efficiency indices. This was done to facilitate the computational problem. It changes nothing in the analysis, however, since the testing is based on the rankings and not on the numerical values of the indices.[7/]

7/ See Appendix II for the indices of efficiency.

CHAPTER V

EVALUATION AND SUGGESTIONS FOR FUTURE RESEARCH

If one accepts the results as being a valid measure of the impact of the ACAR extension service, the conclusion one reaches is that the ACAR program is not effective, or worse, that is, is having a deleterious effect on the level of efficiency. Although we will see below that this is entirely possible, given the program and the economic environment in Brazil, the limitations of the study should be kept in mind.

Limitations of the Study

1. The lack of a valid ex ante comparison between the two municipios. A basic premise of the study was that the level of both technical and price efficiency in Senador Firmino was the same before ACAR started working there as it was in Presidente Bernardes at the time of the study. The basis for this, of course, is that Presidente Bernardes is very traditional and has not been subject to change. Moreover, the two municipios were selected in such a way as to be as similar as possible in other respects.

   Despite these considerations, it is very possible that the level of efficiency in Senador Firmino was much

below that of Presidente Bernardes prior to the introduction of ACAR to the farmers. If that is the case, the extension program could have had a substantial impact and still not have brought the farms up to the level of Presidente Bernardes. No data are available to evaluate this possibility.

2. The inability to measure differences in managerial ability. Management appears as an omitted variable in the equations. Because of this, any systematic differences in the level of managerial ability between the two municipios would tend to show up as differences in technical efficiency. Of course it was recognized that differences in managerial ability would exist--this is a basic premise of the analytical model used. But it was assumed that any differences in efficiency would reflect the management services provided by ACAR and not those inherent in the farm decision makers in the respective municipios.

However, let's suppose that Presidente Bernardes, for whatever reason, had a greater original endowment of managerial talent. If this were the case, then once again the extension service, through its introduction of new technology, would be only introducing something to bring the firms closer to those with superior managerial talent. Given the limitations in the amount of new technology available to distribute, this could be a

fairly unsuccessful program. That is, there may not be enough new knowledge available to bring the Senador Firmino farms to a level which would compensate for the managerial advantages that the other municipio would have.

3. The possibility of an inappropriate criterion. The primary criterion used to evaluate the impact of ACAR has been its impact on technical efficiency, with consideration given to its effect on price efficiency as a side issue. The basis for selecting this criterion is that an extension service is basically in the business of distributing new knowledge and the impact of this should be to raise the level of technical efficiency. These considerations, of course, come from a frame of reference in which the basic motive of farmers is assumed to be the maximization of profits or net income on current account.

However, in an inflationary environment, the maximization of profits on current account may not be an appropriate optimizing criterion for firms. The point is that firms have both an asset account and a flow account. From the standpoint of the welfare of the individual, what he does on his asset account may be much more important than what he does on his flow account. This has been recognized in the American literature by

numerous writers,[1] and in previous studies of Brazil by Nicholls.[2]

In an inflationary situation such as in Brazil, larger gains and losses are to be had by the appropriate or inappropriate investments in assets. The purchase of land as a hedge against inflation is much more important than its use as a factor of production.

Yet, the theory that one traditionally uses completely ignores the asset account. The conceptual problems of integrating the asset and flow accounts to provide overall optimizing behavior have not been worked out.

The consequence of this to the present study is that technical efficiency may be a relatively unimportant goal of farm people. The capital gains that they obtain from their asset account may dwarf the increases in income to be obtained from a higher level of technical efficiency. Moreover, if farmers are sufficiently sophisticated to recognize this, the "better" farmers may have very low levels of efficiency simply because they are concerned only with the accumulation of assets. That is, the output produced in relation to the inputs owned by the firm may be quite low.

1/ See for example, Glenn L. Johnson, "Supply Functions - Some Facts and Notions," in Heady, Earl O., et al., Agricultural Adjustment Problems in a Growing Economy, Ames, Iowa: The Iowa State College Press, 1965, pp. 74-93.

2/ Op. cit., pp. 360-1.

It is interesting to note that one part of the ACAR program could actually be contributing to this. The loan program, which is restricted by law to a limit of 12 percent as the rate of interest, actually results in a considerable subsidy to the acquisition of real assets.[4/] The rate of inflation in Brazil, which has been chronically high for a long period of time, was around 80 percent a year at the time of this study. A monetary rate of 6 percent becomes a rather large negative rate of interest under these conditions, and essentially means that the farmer is actually paid to take the loan.

If such funds are used for resource acquisition, without having a technical innovation which increases output substantially associated with it, then the index of technical efficiency will actually be lower. In this sense ACAR may inadvertently be lowering technical efficiency rather than increasing it.

4. The problem of measurement error. Many of the farmers in the sample are illiterate. They keep very few records and are quite dependent on memory recall when responding to questions from the questionnaire. This problem is complicated by the fact that the inflation rate has been high, which places a greater demand on the memory.

Undoubtedly, substantial measurement errors are present in this study. However, there is no obvious

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4/ The rate of interest generally charged for the loans ranged from 6-8 percent for ACAR's borrowers.

evidence that these have been such as to bias the results one direction or another. That is, there is nothing to suggest that they might have been greater in one sample than in another, and the ability to obtain a least squares estimate of the production function with reasonably stable coefficients suggests that large random errors have not been so prevalent as to wash out any systematic relationship among the variables.

5. The short period of time which many of the farmers had been working with ACAR may have led to an underestimate of its impact. Little is known about the length of time necessary to obtain changes with extension programs, although Wharton's[5/] results indicate a substantial payoff in the first year. Since the short-time cooperators were counter-balanced by some who had worked for long periods of time in our sample it would appear that basically the period of time was adequate. It may not have been, however.

Some Suggestions for ACAR

The results of the present research suggest, both directly and indirectly, some guidelines which ACAR might want to follow.

A Greater Attempt at the Dispersal of Knowledge. The results presented above indicate a very wide range in the

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5/ See Appendix B.

level of technical efficiency among farms. This suggests that a great deal could be learned from the highly efficient farmers that could be transferred to the less efficient. It may be that a great deal of transferrable knowledge can be obtained without the use of expensive research programs. Surveys which attempt to identify what the better farmers are doing may provide a great deal of information that can be carried out in extension programs.

Greater Attention to the Economic Aspects of its Recommendations. Two considerations are important here. The first is that very little economic research of any kind is available in Brazil. A consequence of this is that innovations are recommended by the extension service without sufficient cognizance being taken of the economics of the innovation or new technology. For example, the application of fertilizer may be recommended when it is not rational. Product switches may be recommended when they are not rational from the point of view of the individual farmer. As a result, either the recommendations are ignored, or as was discussed earlier, price efficiency declines at the same time that technical efficiency increases.

The second consideration concerns the immediate program objectives of the extension service. If their concern is with the well being of farm people, the nature of their program may need to be quite different from what it currently is. Program activities may better be directed toward teaching

farm people how to manage their asset account, and more generally, the teaching of economic principles, than in teaching them the use of newer, more productive inputs or practices. This, however, will require a great deal more economic research.

At the same time it should be recognized that program goals potentially may be conflicting. From a national standpoint, the program goals might be to increase total food production or the efficiency with which the food is produced. From the standpoint of the individual farmer, however, the appropriate goal may be to increase his welfare through the appropriate management of his asset account. These may well be in conflict, which points up the need for a clear statement of program goals, and a careful economic analysis of how they might best be obtained.

A Reconsideration of the Role that Credit Plays in the Program. The original idea behind the credit program had two bases. It was felt that the provision of credit at low interest rates would stimulate the adoption of new practices and new technology. In addition, it was a carryover from the FHA program and related to the concern with small farms. Since it was recognized that small farmers would neither have the resources nor the access to credit markets which might be necessary in order to adopt certain practices, the credit was provided as an integral part of the program.

If as the above analysis suggests is entirely possible,

this program is actually lowering economic efficiency, then this program needs to be reexamined. The program may have a rather high cost to society, without at the same time attaining its specified program goals.

Suggestions for Future Research

The suggestions for future research are concerned primarily with considerations for use of the basic analytical framework in future studies. Although subject to rather serious limitations in the present case, it does appear that considerable potential exists for the use of the approach used herein in further analyses, especially if certain conditions can be met.

1. In general the method should be restricted to situations in which inflation is relatively low, unless the model itself can be extended.

   The criteria used in this analysis may not be valid if the inflation rate is high, since this gives greater emphasis to the asset account. On the other hand, decision models which integrate the asset and the flow account may provide a basis for extending the applicability of the method.

2. An attempt should be made to select the samples in such a way that the control group actually was similar to the "treatment" group before the treatment was applied. This can be done by a more detailed study and collection of data before the sample areas are actually chosen.

3. An attempt should be made to verify the level of managerial capacity between the two groups. This is important because management appears in the constant term of the equation and is measured as technical efficiency. Although the author is not optimistic that instruments will soon be developed which will measure management, it is important that an attempt be made to control this variable.
4. Sufficient time should be allowed that the extension program can have an effect. Additional research may be necessary to verify what this is, but this should be an important consideration in selecting a study group.

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APPENDIX A

THE RURAL EXTENSION SERVICE

OF MINAS GERAIS STATE

APPENDIX A

THE RURAL EXTENSION SERVICE OF MINAS GERAIS STATE

ACAR is the Extension Service of the State of Minas Gerais. Its purpose is to help rural people raise their standard of living through an education program for adults and young people. Its history and the way it operates will be discussed in this Appendix.

Origin and Evolution

ACAR was created on December 6, 1948, by an agreement between the Minas Gerais state government and the American International Association, a non-profit corporation of the Rockefeller family. Minas Gerais is located in the central part of Brazil and is a pivotal state between the more well-developed South and the less-developed Northeast. It has an area of about 224,000 square miles, and its population is about 12 million. The main agricultural activities are dairy cattle, corn, beef cattle, hogs, rice, beans, and sugar cane. There is a predominance of small farms in the relatively heavy populated areas to the south.

Supervised credit and extension work were practically unknown in Brazil when ACAR was founded. Assistance programs for agriculture were based on the classical view of capital.

Brazilian leaders believed that what farmers needed to produce more was only tangible capital -- machinery, equipment, and buildings. Programs based on this approach tended to benefit more the larger farmers, and, consequently, to widen the income distribution within agriculture. They were also subject to substantial political influence and unable to work on the basis of a sound program.

On the side of the farmers the situation was: (a) a very low level of productivity and (b) an almost complete ignorance of any modern techniques of production. Most work was done with hand tools, and farmers had practically no confidence in the work and knowledge of agronomists.

This was the situation encountered by Nelson Rockefeller in 1948 when, together with the state governor, he decided to establish ACAR. They had two principal obstacles to cope with: (a) the lack of confidence on the part of the farmers in any technical work and (b) a prevalent mentality in favor of programs which subsidized tangible forms of capital.

The principle on which the financial arrangements between the state and the American International Association was based was to increase the state contribution over time and to decrease the foreign contribution as ACAR was accepted by the leaders and the people of the state. In keeping with this, the last contribution of the American International Association was made in 1961. At the present time ACAR's funds come from the State and ABCAR, the federal extension

service. ABCAR gets its funds from both the federal government and from international agencies.

The original objective of ACAR was to operate a supervised credit program fashioned after the Farm Home Administration and designed to benefit small farmers. But from the very beginning it was recognized that such a program was not an appropriate program for Brazil. Consequently, ACAR was never a pure supervised credit program.

A few years after the program was put into action it was realized that it would be better to transform it into an Extension Service, based primarily on informal education. Gradually such a transformation took place. But in the first step there were two programs acting side by side: one of Rural Supervised Credit and the other of Rural Extension. There was no formal coordination between them.

A formal coordination did characterize the second step. The tool for implementing this was a program worked out every year by the local office supervisors and similar to the County Extension Program now in use.

But the absorption of the earlier Rural Supervised Program was not yet clear, for the activities of credit were kept separated from those of Extension.[1/] This absorption began in 1953 and was finally completed in 1956, when ACAR

1/ This point is made clear in Wharton, op. cit., 46-49, where he discussed the supervised credit program as a program with its own goals, independent of the extension goals. At the present time, there is so such rural credit program but only an extension program that uses educational credit as a tool.

entered the third phase of its evolution.

All decisions taken since then have aimed at consolidating the idea that ACAR is an Extension Service. Among these the following are worth mentioning:

a) The establishment of both individual and group work only in strategically selected parts of the municipio. Prior to this program activities were spread out all over the municipio. Since the local office teams did not generally have the capacity to work with all farmers, some selection took place, but without a reasonable principle to guide it. From year to year some parts were abandoned and others included, with the result that continuity of action, so necessary for an educational program, was not always present.

It was estimated that the local team would be able to handle between 600 to 800 farms. It was recommended that the municipio be divided into several parts, with program activities to be carried out only in some of them. The parts to be selected were to be those that offered better conditions for the development of the work. Preferably they were to be located in different points of the municipio so that the new ideas introduced would be spread out by indirect influence, and, hence, ultimately reach all farmers in the unattended parts of the municipio. Obviously the mass media are not restricted to the selected parts, and its contribution to the

diffusion of new ideas in the entire municipio is considered to be important.

b) The establishment of Rural Extension Committees. These were introduced in 1961. Their aim is to enlarge the number of people participating in all ACAR program activities. Their members are supposed to represent all important areas of interest of the rural people. They are to help the Extension Agents in making decisions about the problems that will be faced by the program, about the recommended solutions, and about the program objectives. Important responsibilities are also given to them in connection with carrying out the program and evaluating it.

c) A change in the role of rural supervised credit (and other types introduced later), 4-S clubs, and leadership, and adult groups in the local office programs. These activities came to be considered as tools for organizing rural people in such a way that the extension service program could be more effectively carried out and more in accordance with the principles of extension. Prior to this, these activities were not viewed as having this as a primary function. They were viewed more as activities in themselves, with their own specific objectives, and with little or no relation to the goals of the total program. Because of this, it was common, in a region where the program objectives were related to dairy cattle, for example, to have a great deal of loans for annual crops.

At the present time, the loans are in close correspondence with the program goals, and the same is true for group work, 4-S clubs, and leader training activities.

Expansion Over Brazil

The ACAR example, as a way to improve the life of rural people, began to expand to other Brazilian states in 1954. It is now being followed by 16 of the 22 Brazilian states.

A national organization -- "Associacao Brasileira de Credito e Assistencia Rural" (ABCAR) was established in June, 1956, for coordinating the work of the various state organizations. It receives both federal and foreign resources and distributes them to the state organizations according to a plan for this purpose. It also maintains a corps of specialists for handling the technical necessities of the State Extension Services.

Administrative Organization

The ACAR administration is composed of:

a) A Board of Directors. -- This is composed of two representatives from the state government and representatives from the cooperative organizations that provide substantial financial contributions. ABCAR also participates in the Board of Directors. The AIA has not participated since the end of 1961, when it ceased to contribute to ACAR. The principal functions of the Board of Directors are: (1) to approve the plan of work; (2) to select the municipios for local offices; (3) to approve the annual

budget; (4) to grant authorization to establish agreements with other institutions; and (5) to elect the President, the Secretary, and the General Supervisor.

b) The Presidency. -- It is composed of the President and has the following functions: (1) to preside at the meetings of the Board of Directors and to be responsible for carrying out the decisions approved; (2) to give investiture to the Secretary and the General Supervisor; and (3) to represent ACAR at Courts of Justice, to sign agreements, and to call for meetings of the Board of Directors and other meetings.

c) Executive Director. -- A general Supervisor is in charge. Its functions are: (1) to execute the plans formulated by ACAR, to receive financial contributions, to submit the annual budget to the Board of Directors, and to develop the annual plan; (2) to audit, to promote, to transfer and to fire personnel according to the rules approved by the Board of Directors; to determine salaries, expenses, and work conditions, and (3) to represent ACAR in activities that do not pertain to the President.

d) Departments.-- They are four in number. The head of each department is responsible for its management. They are made up of a certain number of divisions and specialists. A detailed description of their function can be found in Ribeiro.[2/]

2/ Ribeiro, José Paulo -"Aspectos Institucionais do Crédito Rural Supervisionado no Brasil," Belo Horizonte, ACAR's Information Division, 1964 , pp. 5-51.

e) Training Coordination.-- This group is responsible for the training of all ACAR personnel.

f) State Supervisors.-- They are responsible for the work of the Regional Supervisors and are directly connected with the Executive Directory.

g) Regional Offices.-- They are responsible for the program in a given region of the state. Each regional office has from eight to ten local offices under its responsibility. They have three members: (1) a regional supervisor, who is in general an agronomist (can also be a veterinarian); (2) a regional home supervisor; and (3) a clerk.

Criteria for the selection of the first two members are: (1) to have had some years of experience as a local office agent and (2) to have demonstrated a capacity for extension work and to have shown ability to lead their colleagues in work programs.

h) Local Offices.-- They are in charge of working with the rural families. The team is composed of three persons: (1) County agent. This agent may be an agronomist, a veterinarian, or a person from practical schools of agriculture. The great majority of county agents (agronomists and veterinarians) enter ACAR soon after they have received the B.S. degree. Since Rural Extension was only very recently introduced as a discipline in the curricula of some agricultural schools, the recently graduated

students are not well enough prepared for extension work. They need to be trained in theoretical and practical aspects of extension work, and ACAR provides a course for this purpose each year. In general the course lasts for three months. (2) Home Management Agent. A few of them come from Schools of Home Economics. The great majority, however, have only a high school diploma. Consequently, in their pre-service period of training, it is necessary for them to study Rural Extension principles and to receive special training on those aspects of home economics that are important for their work. The period of their pre-service training is three months also. (3) A Clerk.

i) Origin of Funds.-- In the beginning the contributions for maintaining ACAR came from the AIA and the state of Minas Gerais. Additional funds have been obtained from the federal government and from international agencies.

At the present time the direct financial support for ACAR comes from only two sources: the state of Minas Gerais and ABCAR. About 60 percent of the funds are from federal sources and 40 percent from the state.

Work Organization at the Local Office Level

First, it is necessary to select the parts of the "municipio" where the program activities will be implanted. Since there is a concentration of the educational activities in these selected parts, it is expected that a relatively

rapid development will occur, which will be expanded to the unattended parts by indirect influence.

Second, it is necessary to choose the people that will be involved in program activities. It is known that a small group of farmers can be a key to the adoption of new ideas, with the rate of adoption increasing rapidly after they have accepted the new idea. Hence, a larger number of educational opportunities are given to them. In fact, they are invited to be borrowers (if they need a loan), to participate in the adult work groups, and in leadership training activities. In general the members of the Committees are selected from among them, also.

Up until now these farmers have been selected by a trial and error process. Hence, it was necessary to work with a large number of them in order to be able to select those that were instrumental in the adoption of new ideas.

This work procedure does not imply that other farmers do not have the right to receive ACAR assistance. They do. If they want to participate in any ACAR activity, they are permitted to.

Another important feature of the local office work organization is the extension program for the Municipio. This is developed by the Committees and Extension agents. The number of years covered by the program (from the study of the situation to the establishment of the educational objectives) is from three to five years. So, a new Program is worked out

each three to five years. An annual Work Plan is elaborated each year to plan the action that will be carried out in order to attain program goals.

Funds for Educational Credit

Education credit embodies the earlier rural supervised credit and other types of rural credit introduced later. These types are: oriented credit, a credit appropriate for 4-S members, and a credit for building houses. Currently, the emphasis is placed upon oriented credit, for it is much simpler to be implemented. The specific goal of education credit is to give financial resources to the leaders so that they can adopt the recommended practices in a shorter period of time.

To obtain the funds for the loans, two agreements were made by ACAR: one with the Caixa Economica do Estado de Minas Gerais (a bank of the state of Minas Gerais) in 1949, and the other with the Banco do Brasil (a federal bank) in 1954. They have been renewed since then.

However, since 1962 the emphasis has been placed on the work with the Caixa Economica de Minas Gerais. In 1963, as a consequence of an agreement of this institution with the Inter American Bank for Development, the resources for educational credit were appreciably enlarged. Now, there are funds available so that each local office may have up to 100 families benefiting from this educational activity.

APPENDIX B

REVIEW OF LITERATURE

APPENDIX B

REVIEW OF LITERATURE

The purpose of this appendix is to review previous studies that have attempted to evaluate the extension program in Brazil. In general the approaches taken have been quite different from those proposed here. To the best of our knowledge, all the studies conducted so far in Brazil have dealt with ACAR.

Mosher's study[1/]

The major goal of this study was to evaluate the supervised credit activity, which at that time embodied almost all of the ACAR program.

Productivity indexes such as net income and production per hectare were constructed, and then confronted with data on the size and type of loan in order to appraise the influence that supervised credit might have had on the increase of productivity of the farmers with whom ACAR was operating. The results were somewhat inconclusive, but they suggested the potentialities of the program.

The study relied upon a selected sample of ACAR's

1/ Mosher, Arthur T., "Case Study of the Agricultural Program of ACAR in Brazil," Washington, D.C., Technical Cooperation in Latin America, National Planning Association, 1955.

borrowers, which was visited and interviewed by the author. Additional information was obtained from farm plans that had been worked out to justify the loans that the sampled farmers obtained. The productivity indexes were constructed on the basis of this information.

Wharton's Study[2/]

As the author indicated, this study had the following objectives:

1. To describe the agriculture of an undeveloped region and to analyze its problems. Particular emphasis was given to the total Brazilian setting in which the agricultural development of Minas Gerais had proceeded, and to specifying the problems of capital and technology in Minas Gerais.
2. To describe the operation of the ACAR Supervised Credit program.
3. To attempt to evaluate the success of the ACAR Supervised Credit based on the actual experience of a sample of participating farms. Three local offices were chosen for the analyses, although one of them was later eliminated. The remaining local offices were in Curvelo and Uba. In Curvelo all families were selected who participated in the supervised credit program for one year or

2/ Wharton, Clifton R., Jr., "A Case Study of the Economic Impact of Technical Assistance, Capital and Technology in the Agricultural Development of Minas Gerais, Brazil," Unpublished Ph.D. thesis, Department of Economics, The University of Chicago, Chicago, Illinois, 1958.

more, regardless of the number of years of participation from 1949 through 1954. In Uba only those families who participated for two years or more were selected.

To measure the impact of the ACAR Supervised Credit Program, the procedure followed was as follows:

1. Output and input indexes were constructed for the total agricultural sector, for Minas Gerais and for the ACAR samples.
2. Simple linear regressions of the output indexes on time were estimated for Brazil, Minas Gerais, Curvelo, and Uba. The form of the regression was $I = a + bt$, where I was the output index and t refers to year or time. The trends in output (b coefficients) for the Curvelo and Uba samples were tested against the general trends for Brazil and Minas Gerais. The results showed up favorable only for Curvelo.
3. Output/input indexes were used to estimate the relative efficiency of Supervised Credit activities. Simple linear regressions of the output/input indexes on time were estimated for Brazil, Minas Gerais, Curvelo, and Uba. The slopes for Curvelo and Uba were tested against the trends for Brazil and Minas Gerais. The results were somewhat less impressive than for the output trends.
4. Some attempts were made to study the costs and returns of the ACAR program. It was assumed that the variation not explained (the residuals) was due to the introduction

of new technological practices. In Curvelo each Cr$ 1 invested in the addition to the average Curvelo farmer's stock of technological knowledge brought a return on the average of Cr$ 6.5 output in the first year. In the second year Cr$ 1 resulted in a return of Cr$ 2.5. This suggests that the program did have a strong impact in the first year.

Brandao's Study[3/]

Brandao's study used basically two approaches:

a) Productivity indexes were constructed for a sample of ACAR cooperators and for a sample of non-cooperators, and the results were compared. As was the case in Mosher's study, the results were not always conclusive. For some indexes, the ACAR farmers were found to have higher productivity. For others, the difference among the index (ACAR and non-ACAR) was not significant. The results also varied from one local office analyzed to the other.

b) An attempt was made to measure the number of practices adopted by each group. A chi-square test was performed to test the hypothesis of association between adoption of practices and the classification of the farmers. The results were quite favorable to ACAR.

3/ Brandao, Erly Dias, "Principios de Administracao Rural que Interessam a um Programa de Extensao E Credito Supervisionado," (tese de concurso para provimento efetivo de catedra de Contabilidade d Administracao Rural de Escola Superior de Agricultura da Universidade Rural do Estado de Minas Gerais) Unpublished thesis, 1958, UREMG, Vicosa, Minas Gerais, Brazil.

The study was carried out in seven local offices, each one representing an ACAR region. The "cooperating" and "non-cooperating" samples were both drawn from the same municipio. Since the "non-cooperating" farmers were living in the same area as the cooperators, it is highly probable that they received ACAR influence also. In this case they do not represent an ideal basis for comparison.

The study covered the crop year 1956-57. As a by-product of the study, an interesting method was developed to evaluate the efficiency of enterprises in such a way that weaknesses could be identified.

Sociological Studies

Several studies have been made by sociologists and using a sociological framework. They have attempted to evaluate the role of ACAR as a source of information and as a change agency.

Different approaches have been followed, and some of them were concerned with a more general problem than to evaluate the impact of ACAR. The basis for comparison was always farmers who did not work with ACAR. As these farmers were usually located in the same municipio, or nearby municipios, it is possible that the results were biased to some extent because the non-ACAR farmers may also have benefited from ACAR's work through indirect contact.

Basically, these studies have concluded that ACAR has played an important role as a change agent, and that ACAR is

practically the only organization in Minas Gerais that is recognized by the farmers as benefiting them. They have concluded also that the farmers view ACAR more as a credit agency than as an Extension Service. They tend to suggest that ACAR's influence could be enlarged if it were to improve the methodology (Extension Methods) it has been using and rely more on mass-media.[4/]

4/ Alves, Eliseu Roberto A., "Adocao de Praticas: Area Atingida Pelo Escritorio Local de Vicosa," ("Adoption of New Ideas in the Area that is worked by the Local Office of Vicosa"), Belo Horizonte; Divisao de Informacao da ACAR, 1962.

_____, "Desenvolvimento do Projeto Gado Leiteiro em Itauna," ("Evaluation of the Dairy Cattle Project: Itauna Local Office"), Belo Horizonte, Divisao de Informacao da ACAR, 1963.

_____, "Desenvolvimento do Projeto Gado de Leite em Esmeraldas," ("Evaluation of the Dairy Cattle Project: Esmeraldas Local Office"), Belo Horizonte; Divisao de Informacao da ACAR, 1963.

_____, "Desenvolvimento do Projeto Gado de Leite em Para de Minas," ("Evaluation of the Dairy Cattle Project: Para de Minas Local Office"), Belo Horizonte; Divisao de Informacao da ACAR, 1964.

Fonseca, Luiz, "Information Patterns and Practice Adoption Among Brazilian Farmers, unpublished Ph.D. thesis, University of Wisconsin, Madison, Wisconsin, 1966.

Lopes, Renate Simplicio, "Information Seeking Behavior of County Extension Agents in Minas Gerais, Brazil," Unpublished M.S. thesis, University of Wisconsin, Madison, Wisconsin, 1966.

Rocha, Fernando A.S., "Ligacoes Entre os Sistemas Sociais; Zueira, Municipio de Uba, 1962," ("Link Among Social Systems - Zueira, Municipio de Uba, 1962"), Tese apresentada a Escola de Especializacao de UREMG, Vicosa, Minas, Brazil, 1964 (unpublished M.S. thesis, UREMG, Vicosa, Brazil, 1964).

Michigan University Study: (forthcoming) its scope is very broad. The study in Minas Gerais is part of a project that is being carried out in other parts of the world.

APPENDIX C

DERIVATION OF THE MAXIMUM LIKELIHOOD ESTIMATES OF THE PRODUCTION ELASTICITY COEFFICIENTS AND OF THEIR VARIANCES

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DERIVATION OF THE MAXIMUM LIKELIHOOD ESTIMATES OF THE PRODUCTION ELASTICITY COEFFICIENTS AND OF THEIR VARIANCES

According to the formulation of Chapter II, $\alpha_i (i=1,2...n)$ is to be estimated from the equation:

$$\alpha_i u_{if} = \frac{P_{if}X_{if}}{P_{of}X_{of}},$$

where $\log u_{if}$ is assumed to be normally distributed with mean zero and finite variance σ_i^2. The log form of the above equation is

$$\log u_{if} = \log \frac{P_{if}X_{if}}{P_{of}X_{of}} - \log \alpha_i, \text{ since } \frac{\partial(\log u_{if})}{\partial(\log X_{of})} = 1, \text{ then}$$

the likelihood function is:

$$f\left[\log\left(\frac{P_{i1}X_{i1}}{P_{o1}X_{o1}}\right), \ldots\ldots \log\left(\frac{P_{iF}X_{iF}}{P_{oF}X_{oF}}\right); \log \alpha_i\right]$$

$$= \left(\frac{1}{2\pi\sigma_i^2}\right)^{\frac{F}{2}} \exp\left[\frac{-1}{2\sigma_i^2} \sum_{1}^{F} (\log\frac{P_{if}X_{if}}{P_{of}X_{of}} - \log \alpha_i)^2\right]$$

Obtaining the log transformation of this function, and taking the derivatives with respect to $\log \alpha_i$ and σ_i^2 and equating them to zero, one obtains:

$$-\frac{1}{\sigma_i^2}\sum_{1}^{F}\left(\log\frac{P_{if}X_{if}}{P_{of}X_{of}}-\log\alpha_i\right)=0$$

$$\frac{\sum_{1}^{F}\left(\log\frac{P_{if}X_{if}}{P_{of}X_{of}}-\log\alpha_i\right)^2}{2(\sigma_i^2)^2}-\frac{F}{2\sigma_i^2}=0,$$

therefore

$$\log\hat{\alpha}_i=\frac{1}{F}\sum_{1}^{F}\log\frac{P_{if}X_{if}}{P_{of}X_{of}}$$

$$S_i^2=\frac{1}{F}\sum_{1}^{F}\left(\log\frac{P_{if}X_{if}}{P_{of}X_{of}}-\log\hat{\alpha}_i\right)^2$$

APPENDIX D

DERIVATION OF THE PROFIT EQUATION

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DERIVATION OF THE PROFIT EQUATION

The purpose of this appendix is to provide a derivation of the profit equation. This is necessary because the equation obtained is quite different from the one given by Nerlove.[1/]

From considerations presented in Chapter II, we have the following system of equations:

$$\pi_f = P_o X_{of} - P_1 X_{1f} - P_2 X_{2f} \quad \text{(Profit function)} \tag{1}$$

$$\alpha_1 u_{1f} = \frac{P_1 X_{1f}}{P_o X_{of}} \tag{2}$$

$$P_1 X_{1f} = \alpha_1 u_{1f} P_o X_{of} \tag{2a}$$

$$P_2 X_{2f} = \alpha_2 u_{2f} P_o X_{of} \tag{2b}$$

$$\alpha_2 u_{2f} = \frac{P_2 X_{2f}}{P_o X_{of}} \tag{3}$$

$$X_{of} = \alpha V_{of} X_{1f}^{\alpha_1} X_{2f}^{\alpha_2} \tag{4}$$

We want to obtain π_f as a function of P's, u_f's, and V_f's. Substituting (2a) and (2b) in (1):

$$\pi_f = P_o X_{of} (1 - \alpha_1 u_{1f} - \alpha_2 u_{2f}) \tag{5}$$

Equations (2) and (3) yields:

$$X_{1f} = \frac{P_2}{P_1} \frac{\alpha_1 u_{1f}}{\alpha_2 u_{2f}} X_{2f} \tag{6}$$

1/ Nerlove, Marc, op. cit., p. 97.

Substituting this value of X_{1f} in Equation (2) and using equation (4):

$$X_{2f} = \left[(\alpha V_{of})(\alpha_2 u_2)^{1-\alpha_1} \frac{P_o}{P_2} \left(\frac{P_2}{P_1}\right)^{1-\alpha_1} (\alpha_1 u_1)^{\alpha_1}\right]^{\frac{1}{1-\alpha_1-\alpha_2}} \quad (7)$$

Substituting X_{2f} in equation (6),

$$X_{1f} = \left[(\alpha V_{of})(\alpha_1 u_{1f})^{1-\alpha_2}(\alpha_2 u_{2f})^{\alpha_2} \frac{P_o}{P_2}\left(\frac{P_2}{P_1}\right)^{1-\alpha_2}\right]^{\frac{1}{1-\alpha_1-\alpha_2}} \quad (8)$$

Substituting (7) and (8) in (5):

$$V_f = (1-\alpha_1 u_{1f}-\alpha_2 u_{2f})\left[P_o \alpha V_o (\alpha_1 u_{if})^{\alpha_1}(\alpha_2 u_{2f})^{\alpha_2} P_1^{\alpha_1} P_2^{\alpha_2}\right]^{\frac{1}{1-\alpha_1-\alpha_2}}$$

APPENDIX E

MEASUREMENT OF THE VARIABLES

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MEASUREMENT OF THE VARIABLES

Output: X_o

Output is measured in cruzeiros. It includes total sales, plus or minus inventory changes in livestock or in crops, home consumption, and the value of the sharers crop production.[1/]

The production was priced in the following way:

a) Crop production

Whenever the farm had sold some quantity of a product, the price used to evaluate home consumption and sharer crop production of this product was the sale price. If no sale of the product was made by a farmer, then the price of the product was given by:

$$P_i = \sum_{i=1}^{n} P_{ij}Q_{ij} \Big/ \sum_{j=1}^{n} Q_{ij}$$

where:

P_i = price for the product i (weighted mean)

1/ In Minas Gerais, it is common for farmers to allow their employees to cultivate a tract of land under their own management. The farmers are responsible for expenses with fertilizers, seeds and plowing, and the employees are responsible for labor expenses. The production is shared according to a given proportion. (The value of the total production was included in the output.)

P_{ij} = price that farmer j obtained in the sale of product i

Q_{ij} = quantity of i sold by farmer j.

These weighted prices were calculated for each product and for each municipio (Senador Firmino and Presidente Bernardes).

To calculate the change in the value of stocks (changes in inventory) these weighted prices were also used whenever no sale of a product was effectuated by a farmer.

b) Animals

There were no share arrangements for livestock. The prices of the animals consumed by the family were given by the farmers.

The change in inventory was defined as the inventory at the end of the year - (value of the animals bought within the year + inventory at the beginning of the year).

c) Animal products

(1) Milk and eggs: the questionnaire specified the part sold, consumed by the family and transformed into products like cheese, butter, candy, etc. on a monthly basis. There was always some sales, and the sale prices were used to evaluate home consumption.

(2) Transformed Products (cheese, butter, etc.): the questionnaire gave the total production and the part of it that was sold, consumed by the family, or stored on a quarterly basis. There was always some sale within the period, and, hence, the sale prices could be used to evaluate home consumption.

Inputs

a) Land (X_1) was measured in cruzeiros and in terms of a flow.

The land was divided into four categories: crop, brushwood, pasture, and permanent crops. For the first three categories, the farmers indicated the acreage and price of a hectare.[2/]

In the case of permanent crops (in general coffee) we tried to obtain separated estimates of the values of land and of the trees. The trees were depreciated linearly, admitting as 8 years the remaining average life. The interest rate used was 42 percent. Hence, by multiplying the value of the trees by .545, the correspondent flow was obtained, which was aggregated to the flow obtained for the land (42 percent of the value of the land) in which the trees were located. This value was aggregated to the flow obtained for the other three categories of land (42 percent of their value). The result is the measure of the input land, in cruzeiros, and in terms of flows.

Labor (X_5) was measured in cruzeiros. The total man-equivalent used in the farm during the year was estimated. This total includes hired labor, family labor, and share crop labor. Whenever there was hired labor, the price of the hired labor was used to evaluate family and share-crop

2/ The price was obtained as an answer to the following question: "How much would you pay for land like this if you were to buy it?"

labor. If a farm did not have any hired men working there during the year, a weighted price, obtained by a formula similar to the one used for output, was used to evaluate family and share crop labor. The work of an adult man (from 14 to 60 years old) was considered as the standard for measurement. The following factors were used to make the necessary transformations:

Woman - 3/4 (equivalent to 3/4 of the standard)

Youngsters - 1/2 (equivalent to 1/2 of the standard)

Old man (greater than 60) - 1/2 (equivalent to 1/2 of the standard)

Buildings (X_2) were measured in cruzeiros and in terms of flow. The interest rate used was 42 percent. The depreciations were calculated on the basis of:

$$d = \frac{\text{value if built now}}{\text{remaining years of life}}$$

The value if built now is the quantity of money that would be spent if the farm were to construct one that is equal to the given building.

Machinery and equipment (X_3) were measured in cruzeiros and in terms of flow. The interest rate used was 54 percent. The depreciation was calculated on the basis of:

$$d = \frac{\text{value if purchased now}}{\text{remaining years of life}}$$

The value if purchased now was the price that the farmer would pay for a unit equal to the given one, if he were to buy one.

Whenever a machinery or equipment was used for nonfarm activities, the percentage of time in this form of work was obtained from the farmer. Only that part of the time used in farm activities was used in the calculation of the flow.

Animals (X_4) were measured in cruzeiros and in terms of a flow. The flow for productive animals and for work animals was calculated separately and then aggregated.

(1) Productive animals - This category includes dairy cattle, hogs, hens, sheep, and kids.

The interest rate was 54 percent. The depreciation coefficients were:

Bulls and cows - .163

Hog breeding stock - .250

Hens and fowls - 1.000

Sheep and kids - .250

(2) Work animals - This category includes oxen, horses, azinines, and mares. The interest rate used was 54 percent. The depreciation coefficients were:

Ox - .125

Azinines - .067

Horse and mare - .100

Other inputs (X_6) were measured in cruzeiros. This category includes expenses with seeds, fertilizers, pasture supplements, gasoline, oil, electricity, taxes on property, interest paid, rent expenses, etc. In other words, it includes everything that is not one of the previous inputs.

The prices of inputs in calculating an equilibrium are as follows:

Land - Cr$142

Buildings - Cr$142

Machinery and equipment - Cr$154

Animals - Cr$154

Labor:

Senador Firmino = Cr$400/man equivalent

Presidente Bernardes = Cr$300/man equivalent[3/]

Other inputs - Cr$154

The interest rates used in our calculations were obtained from information provided by commercial banks and by the large Brazilian investment company, Crescinco. No better way to estimate them was available since there was no other information available. It is possible that they misrepresent the real situation in both directions, i.e., they may over or underestimate the true monetary interest rate.

3/ The price was calculated by the following formula on the basis of information given by farmers that used hired and permanent labor.

$$P = \frac{\sum_{j=1}^{n} P_j Q_j}{\sum_{j=1}^{n} Q_j}$$

where Q_j = the quantity of hired and permanent labor for farm j, measured in man-equivalent units, and P_j = the price paid by the farmer j.

APPENDIX F

THE SAMPLE AND THE DATA COLLECTION PROCEDURES

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THE SAMPLE AND THE DATA COLLECTION PROCEDURES

At the time data were collected for this study, ACAR was operating in 185 municipios that were spread out over a large part of the state of Minas Gerais. These municipios were benefiting from the work of 128 local offices whose ages varied from less than 1 year to 16 years of age. About half of them were less than 5 years old.

The disparity of ages of the local offices, and the wide range of variation there is among the municipios where ACAR is working, make the problem of designing a representative sample of local offices for ACAR very complicated. This problem is further complicated by the lack of statistical information that is necessary for this purpose.

Previous studies have relied on some kind of purposive sample in which the local offices were always nonrandomly selected.[1/] Clearly, one might question the validity of any generalization for ACAR as a whole from such studies. However, one can, to a certain degree, justify some generalization on the grounds that any local office of ACAR can be as efficient as those sampled--if enough inservice training and

1/ Appendix A.

supervision are provided for their personnel. Although there is some empirical evidence that would bolster this conclusion, one might always doubt its validity, on the basis that in-service training and supervision do not suppress differences in efficiency that arise from differences in ability that people have, even though they might reduce the effect of such differences. Hence, there is always a basis for not accepting the validity of the generalization.

It is not assumed in the present study that the sample will be representative for the total ACAR system. It may represent only those offices that are similar to Senador Firmino in relation to efficiency of the local team of extensionists and to environmental conditions. It is recognized that this transfers the problem of generalization to the problem of discovering which local offices are similar to Senador Firmino--and it may be that there is no such local office. But even if that is the case, the study may be useful in evaluating ACAR's work in Senador Firmino and in testing the appropriateness of an evaluation tool. If the evaluation tool proves useful, then it can possibly be extended to a more general evaluation of the ACAR system.

The Population and Sample

In this study the concept of a population has to be built on the basis of the sample. (This is a procedure used in the design of experiments, where the population is

conceptually thought of as being obtained by repeating the experiment under the same conditions.) Hence, we have to explain how we obtained our sample. The process used in selecting this sample will be discussed first, followed by an indication of the population that can be conceptually generated by the sample.

The sampling procedure took place in two steps. The first stage was the selection of the local office and municipio that was going to be the basis for comparison. The local office chosen was Senador Firmino, located in the Zona da Mata of the State of Minas Gerais. The reasons for the choice were:

1. This local office had been in operation for more than 10 years.
2. The turnover of personnel had been relatively small.
3. This local office was considered by the administration of ACAR to rank high among all local offices of ACAR as far as their efficiency of work was concerned.

The municipio of Presidente Bernardes was selected as a basis of comparison to measure the efficiency of ACAR. This municipio was very similar to the first one in relation to the type of farming, the quality of land, and topography. In addition, as near as could be determined, it had not been under ACAR's indirect influence.[2/] Nor had it been subject

2/ This was informally verified by asking the leaders of the municipio whether they considered the farmers of the municipio to be under ACAR's influence or not.

to the direct influence of any other agency. Hence, it may be possible that its farmers are quite close to the stage that farmers of Senador Firmino were when ACAR started operating with them, although this is impossible to evaluate.

The second stage of the sampling process was the selection of the farm families that were to be interviewed for the purpose of data collection. At the time of the study there were 60 farm families working with ACAR very intensively. They received technical assistance plus the financial support necessary to put ACAR's recommendations into practice. These 60 farm families (each family operates its own farm) were chosen as a basis for the evaluation of ACAR's work in Senador Firmino. Hence, the selection of the farm units in Senador Firmino was not at random.

In Presidente Bernardes the sample units were randomly selected within well-defined strata. The procedure used was as follows:

1. A list of all the farms in the municipio and their size (measured in hectares) was obtained.

2. The 60 farms from Senador Firmino were classified according to their size in hectares into 6 classes, each containing 10 farms.

3. The same intervals were chosen for Presidente Bernardes. This resulted in 8 classes since there were some farms smaller than the smallest farm and larger than the largest farm of Senador Firmino.

4. In each of the six correspondent classes, 13 farms were randomly selected. The last three were to be interviewed if and only if one or more of the first 10 units failed to cooperate with the interviewer. The rates at which the respective samples were taken from their underlying populations can be seen in Table F-1.

These procedures lead to two conceptual populations. One is made up of all farms that can be conceived as being similar to the 60 farms selected from Senador Firmino. The other is made up of those farms that can be conceived to be similar to the 60 interviewed farms from Presidente Bernardes. These two populations will be treated as if they were infinite.

Table F-1. Distribution of the Sample Farms from Presidente Bernardes and Senador Firmino in Accordance with the Size of Farms, Measured in Hectares.

Farm Size (hectares)	Presidente Bernardes		Senador Firmino	
	Population	Sample	Number of Borrowers	Sample
00 - 17.99	954	-	-	-
18.00 - 28.26	51	10	10	10
28.27 - 33.00	16	10	10	10
33.01 - 48.00	36	10	10	10
48.01 - 62.73	27	10	10	10
62.74 - 97.52	28	10	10	10
97.53 -194.50	20	10	10	10
194.51 and over	16	-	-	-
Total	1,148	60	60	60

Data Collection

Four interviewers collected the data. They received special training for the work, and their work was supervised several times in order to check the way they were interviewing the farmers.

The completed questionnaires were thoroughly checked, and only after that were they accepted. Several questionnaires were returned to the interviewers for corrections, since some information was found to be incomplete or incompatible with information collected on other parts of the questionnaire.

Some questionnaires were completely rejected.[3/] There were basically two reasons for this:

1. The size of the farm was outside the range previously specified as acceptable. This occurred because the list of farmers used was not completely up to date.

2. The quality of the answers were poor, and it was not possible to improve them because the farmer refused to cooperate.

In the end, 120 questionnaires were obtained--60 for each municipio. The data collection period extended from September to December of 1964. The information collected covered the 1963-64 crop year--from July to June.

3/ There were no refusals in Senador Firmino.

The Questionnaire

The questionnaire was made up of a set of tables to be filled out during the interview. In general, only one table was placed on each page. Information collected included:

a) Size of the farm and land use--pasture, crops, brushwood--and the price of land by category.

b) Types of crops, acreage, production, production sold and value, production consumed by the family, employees, and animals.

c) Numbers of animals on hand by category, prices at the beginning and end of year, animals bought and sold, and the corresponding prices.

d) Numbers of work animals by category, prices at the beginning and end of year, work animals bought and sold, and prices.

e) Monthly production of milk and eggs, the part of the production sold and its price, the part consumed by the family and employees, and the part transformed into products like cheese, butter, etc.

f) The production of other products such as butter, cheese, sweets, brown sugar, "cachaca" (crude rum), and so forth; production sold and price; and production consumed by the family and employees.

g) Family labor: Information about sex, age, and days of work for the enterprise.

h) Hired permanent labor: Information about sex, age, days of work, and salaries.

APPENDIX H

STATISTICAL TABLES

i) Temporary labor--by kind of exploration: Number of days worked and money paid.

j) Share crops--by crop: Acreage, and number of days necessary to cultivate a hectare, phase by phase of the crop.

k) Fertilizers, seed, feeds, chemical products, and other similar operating inputs purchased; price and quantity for each category.

l) Fuel, oil, grease: quantity consumed, price, and percentage used for farm purposes.

m) Equipment and machinery: type, remaining years of life, value if purchased at time of interview, maintenance expenses, and percentage of use for farm purposes.

n) Buildings: type, year of construction, value if built at time of interview, remaining years of life, and maintenance expenses.

o) Taxes on property, interest paid, rent expenses, and transportation expenses.

To determine the price of a stock item the question formulated was of this form: "What price would you pay for a tractor like this if you needed to buy one?"

APPENDIX G

THE U TEST FOR RANKS

APPENDIX G

THE U TEST FOR RANKS

The rationale of the U-test is as follows:[1/]

1. There are two samples A and B, that yielded the measurements:

$$A: \quad X_1 \; X_2 \; \ldots \; X_m, \qquad B: \quad Y_1 \; Y_2 \; \ldots \; Y_n$$

2. Arrange the values jointly (as if they were one sample) in an increasing order of magnitudes (or decreasing) and assign them, in this order, the ranks 1, 2 ... m+n. If there is a sizeable difference between the means of the two populations from which the samples were drawn, most of the lower ranks will be occupied by the values of one sample and the higher ranks will be occupied mostly by those of the other sample.

3. The statistic $U = (N_A) \times (N_B) + \frac{N_A \cdot (N_A + 1)}{2} - R_A$ is computed, where N_A and N_B are the sizes of the respective samples (in our case $N_A = N_B = 60$) and R_A is the sum of the ranks for Sample A.

4. When N_A and N_B are greater than 8 the normal distribution is a good approximation for the distribution of U.

1/ Freund, John E., Mathematical Statistics, Englewood Cliffs, N.J.: Prentice Hall Inc., 1964, pp. 290-292.

5. Hence, compute $\not{Z} = \frac{U - E(U)}{\sqrt{var\ (U)}}$, where

$$E(U) = \frac{N_A N_B}{2}$$

$$var(U) = \frac{N_A N_B\ (N_A + N_B + 1}{12}$$

6. With $\alpha = .05$, if $/\not{Z}/ \geq 1.96$, reject the null hypothesis.

HUMAN CAPITAL FORMATION AND RETURN ON INVESTMENT FROM TRAINING IN EMBRAPA

ABSTRACT

The main objective of this study is to evaluate the returns froin both graduate and continuous trainng programs developed and carried out since 1974 by EMBRAPA, the Brazilian Agricultural Research Corporation.

The evaluation of these training programs followed the standard social rate of return approach. However, the particular feature of the paper is that only the economic benefits related to increases in farmer's income were considered. Therefore, only net benefits resulting from adoption of new technologies by farmers were taken into account.

The internal rate of return was 22.2 percent assuming that the 1982 level of net benefits will the maintained during the 1983-96 period. If the expected benefits were calculated at the 1982-86 average for the 1987-96 period the internal rate of return would increase to 28.7 percent. When the benefits for this period were assumed to remain at the estimated 1986, level the internal rate of return further increased to 30.3 percent.

Results of othen studies show, in general, that the rate of return on investments decreases at more advanced levels of education. Nevertheless, the rates of return obtained in this study are higher than the rates calculated for college education in many countries, including Brazil. These high rates of return support the proposition that training of human capital by EMBRAPA has produced large benefits for Brazilian society.

LA FORMATION DU CAPITAL HUMAIN ET LA RENTABILITÉ DES INVESTISSEMENTS DANS L'ENTRAÎNEMENT AU NIVEAU DE L'EMBRAPA

RÉSUMÉ

Le principal objectif de ce travail c'est l'évaluation de la rentabilité des investissements de l'EMBRAPA - Entreprise Brésilienne de Recherche Agronomique dans la formation de son capital humain, en particulier, à travers les programmess d'entraînement de chercheurs au niveau post-universitaire, mis à exécution depuis 1974.

L'évaluation réalisée emploie les mêmes procédures des analyses traditionelles de la rentabilité sociale d'investissements, sauf ce qui concerne le calcul des bénéfices sociaux dus aux programmes d'entraînement. Ces bénéfices on été estimés au niveau des producteurs agricoles et basés sur l'utilisation des innovations techniques développées aux Centres de Recherche de l'EMBRAPA.

Le taux interne de rentabilité des investissements a été estimé commeétant 22,2%, basé sur l'hypothèse de que durant la période 1981/86 les bénéfices nets seront égau à ceux de l'année 1982. Si l' on utilise des hypothèses plus optimistes comme prévision des bénéfices nets de l'entraînement pour les prochaines, années, les taux internes de rentabilité obtenus seront plus élevés, 28,7% et 30,3%, respectivement.

Les résultats obtenus par d'autres études montrent en général une diminution du taux de rentabilité à mesure que s'accroît le niveau de formation. Cependant, les taux de rentabilité des programmes d'entraînement se situent au-dessus de ceux obtenus au niveau universitaire dans beaucoup de pays, y compris le Brésil. Ces résultats montrent donc assez clairement que les programmes de l'EMBRAPA en ce qui concerne la formation du personnel au niveau de la recherche agronomique sont en train d'apporter de grands bénéfices à la société brésilienne.

APPENDIX H

STATISTICAL TABLES

Table H-1. Values of the Measure of Price Efficiency ($\pi_f - \pi_f$) for Presidente Bernardes and Senador Firmino.

Number of the Farm	$\pi_f - \pi_f$	Municipios SF=Senador Firmino PB=Presidente Bernardes
105	-11.6831E+02	S.F.
117	-23.7851E+03	S.F.
7	-54.0010E+03	P.B.
11	-57.3488E+03	P.B.
84	-66.7095E+03	S.F.
17	-82.2902E+03	P.B.
78	-85.5105E+03	S.F.
97	-93.0761E+03	S.F.
91	-93.4763E+03	S.F.
75	-96.3517E+03	S.F.
93	-98.5478E+03	S.F.
21	-99.5724E+03	P.B.
60	-10.5610E+04	P.B.
106	-10.7246E+04	S.F.
92	-11.9319E+04	S.F.
53	-12.5950E+04	P.B.
47	-12.7001E+04	P.B.
107	-12.7424E+04	S.F.
18	-13.1802E+04	P.B.
26	-14.1245E+04	P.B.
110	-14.7906E+04	S.F.
74	-14.8805E+04	S.F.
13	-15.4745E+04	P.B.
109	-15.7834E+04	S.F.
65	-15.8851E+04	S.F.
112	-17.7258E+04	S.F.
24	-18.3670E+04	P.B.
1	-19.3560E+04	P.B.
95	-19.5981E+04	S.F.
9	-20.2473E+04	P.B.
4	-21.7317E+04	P.B.
44	-25.3544E+04	P.B.
61	-26.3734E+04	S.F.
79	-26.4148E+04	S.F.
111	-27.3777E+04	S.F.
98	-28.5924E+04	S.F.
80	-31.0084E+04	S.F.
32	-31.2042E+04	P.B.
77	-32.7633E+04	S.F.
25	-35.0354E+04	P.B.

Table H-1. (continued)

Number of the Farm	$\pi_f - \hat{\pi}_f$	Municipios SF=Senador Firmino PB=Presidente Bernardes
12	-35.9177E+04	P.B.
37	-37.9074E+04	P.B.
57	-40.9585E+04	P.B.
114	-41.6483E+04	S.F.
67	-43.2183E+04	S.F.
90	-43.3374E+04	S.F.
100	-43.5178E+04	S.F.
73	-43.9405E+04	S.F.
15	-46.4561E+04	P.B.
28	-47.8190E+04	P.B.
50	-49.9485E+04	P.B.
45	-50.5707E+04	P.B.
10	-52.4637E+04	P.B.
108	-54.7086E+04	S.F.
43	-56.3171E+04	P.B.
88	-56.6809E+04	S.F.
99	-57.1233E+04	S.F.
103	-57.5241E+04	S.F.
58	-58.1833E+04	P.B.
119	-60.1297E+04	S.F.
22	-60.4368E+04	P.B.
33	-61.4359E+04	P.B.
62	-65.3108E+04	S.F.
96	-66.9491E+04	S.F.
5	-67.0073E+04	P.B.
64	-70.1593E+04	S.F.
104	-71.7564E+04	S.F.
59	-73.8804E+04	P.B.
85	-74.2189E+04	S.F.
19	-81.3640E+04	P.B.
72	-93.6032E+04	S.F.
27	-96.2738E+04	P.B.
76	-10.1003E+05	S.F.
6	-10.3759E+05	P.B.
87	-10.3898E+05	S.F.
63	-10.9551E+05	S.F.
94	-11.3335E+05	S.F.
118	-12.3711E+05	S.F.
82	-13.5204E+05	S.F.
41	-14.1169E+05	P.B.

Table H-1. (continued)

Number of the Farm	$\pi_f - \hat{\pi}_f$	Municipios SF=Senador Firmino PB=Presidente Bernardes
20	-14.4377E+05	P.B.
89	-15.7478E+05	S.F.
120	-15.7664E+05	S.F.
2	-16.0654E+05	P.B.
81	-16.6687E+05	S.F.
116	-16.9953E+05	S.F.
102	-17.2578E+05	S.F.
8	-18.0610E+05	P.B.
29	-18.2080E+05	P.B.
48	-18.4251E+05	P.B.
71	-19.1004E+05	S.F.
30	-19.4252E+05	P.B.
86	-20.7832E+05	S.F.
34	-22.4162E+05	P.B.
52	-24.1664E+05	P.B.
66	-27.3435E+05	S.F.
68	-27.5995E+05	S.F.
3	-29.0179E+05	P.B.
113	-33.2028E+05	S.F.
35	-38.5171E+05	P.B.
42	-41.6303E+05	P.B.
16	-46.7553E+05	P.B.
46	-48.2458E+05	P.B.
23	-55.3992E+05	P.B.
83	-56.1179E+05	S.F.
36	-58.3652E+05	P.B.
39	-69.1497E+05	P.B.
55	-12.6760E+06	P.B.
56	-13.7439E+06	P.B.
49	-13.9466E+06	P.B.
38	-15.4288E+06	P.B.
54	-17.1832E+06	P.B.
115	-19.2319E+06	S.F.
69	-19.3044E+06	S.F.
70	-23.5834E+06	S.F.
101	-30.9122E+06	S.F.
14	-46.2687E+06	P.B.
51	-12.8392E+07	P.B.
40	-57.4203E+07	P.B.
31	-13.3132E+09	P.B.

Source: Sample Data

Table H-2. Values of the Measure of Technical Efficiency ($\pi_f - \lambda(g)$ for Presidente Bernardes and Senador Firmino.

Number of the Farm	$\pi_f - \lambda(g)$	Municipios SF = Senador Firmino PB=Presidente Bernardes
40	00.0000E-99	P.B.
31	00.0000E-99	P.B.
51	-45.1473E+07	P.B.
14	-53.3949E+07	P.B.
101	-54.8074E+07	S.F.
70	-55.5976E+07	S.F.
115	-55.9018E+07	S.F.
69	-55.9326E+07	S.F.
54	-56.2628E+07	P.B.
56	-56.4258E+07	P.B.
38	-56.4836E+07	P.B.
49	-56.6134E+07	P.B.
55	-56.6731E+07	P.B.
39	-57.3561E+07	P.B.
36	-57.3536E+07	P.B.
83	-57.8628E+07	S.F.
23	-57.5057E+07	P.B.
46	-57.5299E+07	P.B.
16	-57.5591E+07	P.B.
3	-57.5865E+07	P.B.
35	-57.6199E+07	P.B.
68	-57.7360E+07	S.F.
102	-57.7497E+07	S.F.
52	-57.7563E+07	P.B.
48	-57.8049E+07	P.B.
71	-57.8097E+07	S.F.
120	-57.8172E+07	S.F.
34	-57.8411E+07	P.B.
30	-57.8543E+07	P.B.
89	-57.8571E+07	S.F.
2	-57.8614E+07	P.B.
20	-57.8917E+07	P.B.
27	-57.9457E+07	P.B.
114	-57.9467E+07	S.F.
59	-57.9703E+07	P.B.
96	-57.9805E+07	S.F.
33	-57.9847E+07	P.B.
5	-57.9895E+07	P.B.
25	-57.9913E+07	P.B.
119	-57.9922E+07	S.F.

Table H-2. (continued)

Number of the Farm	$\pi_f - \lambda(g)$	Municipios SF = Senador Firmino PB=Presidente Bernardes
57	-57.9923E+07	P.B.
8	-57.9865E+07	P.B.
58	-57.8968E+07	P.B.
44	-57.9988E+07	P.B.
67	-57.9995E+07	S.F.
43	-57.9996E+07	P.B.
86	-58.0015E+07	S.F.
12	-58.0094E+07	P.B.
37	-58.0155E+07	P.B.
77	-58.0192E+07	S.F.
98	-58.0265E+07	S.F.
79	-58.0284E+07	S.F.
24	-58.0389E+07	P.B.
60	-58.0390E+07	P.B.
9	-58.0438E+07	P.B.
112	-58.0457E+07	S.F.
91	-58.0496E+07	S.F.
109	-58.0515E+07	S.F.
7	-58.0526E+07	P.B.
117	-58.0539E+07	S.F.
111	-58.0543E+07	S.F.
21	-58.0550E+07	P.B.
65	-58.0552E+07	S.F.
6	-58.0571E+07	P.B.
75	-58.0603E+07	S.F.
85	-58.0619E+07	S.F.
110	-58.0635E+07	S.F.
74	-58.0680E+07	S.F.
80	-58.0692E+07	S.F.
92	-58.0707E+07	S.F.
105	-58.0737E+07	S.F.
118	-58.0741E+07	S.F.
17	-58.0760E+07	P.B.
97	-58.0776E+07	S.F.
99	-58.0776E+07	S.F.
107	-58.0779E+07	S.F.
4	-58.0779E+07	P.B.
84	-58.0793E+07	S.F.
28	-58.0808E+07	P.B.
113	-58.0811E+07	S.F.

Table H-2. (continued)

Number of the Farm	$\frac{1}{f} - \frac{1}{A}$ (g)	Municipios SF=Senador Firmino PB=Presidente Bernardes
47	-58.0813E+07	P.B.
106	-58.0813E+07	S.F.
61	-58.0825E+07	S.F.
53	-58.0825E+07	P.B.
11	-58.0826E+07	P.B.
26	-58.0831E+07	P.B.
19	-58.0833E+07	P.B.
93	-58.0840E+07	S.F.
95	-58.0847E+07	S.F.
42	-58.0850E+07	P.B.
66	-58.0851E+07	S.F.
18	-58.0857E+07	P.B.
15	-58.0860E+07	P.B.
78	-58.0860E+07	S.F.
10	-58.0863E+07	P.B.
82	-58.0864E+07	S.F.
13	-58.0864E+07	P.B.
50	-58.0864E+07	P.B.
1	-58.0865E+07	P.B.
22	-58.0865E+07	P.B.
62	-58.0866E+07	S.F.
73	-58.0870E+07	S.F.
100	-58.0871E+07	S.F.
81	-58.0871E+07	S.F.
41	-58.0873E+07	P.B.
88	-58.0873E+07	S.F.
87	-58.0874E+07	S.F.
64	-58.0874E+07	S.F.
104	-58.0875E+07	S.F.
45	-58.0876E+07	P.B.
63	-58.0876E+07	S.F.
108	-58.0876E+07	S.F.
103	-58.0876E+07	S.F.
72	-58.0877E+07	S.F.
90	-58.0877E+07	S.F.
32	-58.0878E+07	P.B.
116	-58.0878E+07	S.F.
76	-58.0878E+07	S.F.
94	-58.0878E+07	S.F.
29	-58.0879E+07	P.B.

Table H-3. Values of the Overall Measure of Economic Efficiency for Presidente Bernardes and Senador Firmino.

Number of the Farm	$\pi_f - \lambda(g)$	Municipios SF=Senador Firmino PB=Presidente Bernardes
40	-57.4203E+07	P.B.
56	-57.8002E+07	P.B.
115	-57.8250E+07	S.F.
31	-57.8465E+07	P.B.
69	-57.8631E+07	S.F.
3	-57.8766E+07	P.B.
101	-57.8986E+07	S.F.
102	-57.9222E+07	S.F.
83	-57.9240E+07	S.F.
36	-57.9373E+07	P.B.
55	-57.9407E+07	P.B.
39	-57.9476E+07	P.B.
70	-57.9560E+07	S.F.
120	-57.9748E+07	S.F.
54	-57.9811E+07	P.B.
51	-57.9866E+07	P.B.
114	-57.9883E+07	S.F.
48	-57.9891E+07	P.B.
52	-57.9980E+07	P.B.
71	-58.0007E+07	S.F.
35	-58.0051E+07	P.B.
49	-58.0081E+07	P.B.
68	-58.0120E+07	S.F.
46	-58.0123E+07	P.B.
89	-58.0145E+07	S.F.
14	-58.0218E+07	P.B.
2	-58.0221E+07	P.B.
44	-58.0241E+07	P.B.
25	-58.0263E+07	P.B.
38	-58.0265E+07	P.B.
16	-58.0267E+07	P.B.
57	-58.0333E+07	P.B.
20	-58.0361E+07	P.B.
27	-58.0419E+07	P.B.
67	-58.0427E+07	S.F.
59	-58.0442E+07	P.B.
12	-58.0453E+07	P.B.
33	-58.0461E+07	P.B.
96	-58.0475E+07	S.F.
30	-58.0485E+07	P.B.

Table H-3. (continued)

Number of the Farm	$\pi_f - \lambda(g)$	Municipios SF=Senador Firmino PB=Presidente Bernardes
60	-58.0495E+07	P.B.
77	-58.0520E+07	S.F.
119	-58.0523E+07	S.F.
37	-58.0535E+07	P.B.
79	-58.0548E+07	S.F.
58	-58.0550E+07	P.B.
98	-58.0551E+07	S.F.
43	-58.0559E+07	P.B.
117	-58.0563E+07	S.F.
5	-58.0565E+07	P.B.
24	-58.0572E+07	P.B.
7	-58.0580E+07	P.B.
91	-58.0589E+07	S.F.
23	-58.0597E+07	P.B.
112	-58.0634E+07	S.F.
9	-58.0640E+07	P.B.
21	-58.0649E+07	P.B.
34	-58.0652E+07	P.B.
109	-58.0673E+07	S.F.
75	-58.0699E+07	S.F.
65	-58.0711E+07	S.F.
105	-58.0739E+07	S.F.
110	-58.0783E+07	S.F.
111	-58.0817E+07	S.F.
92	-58.0827E+07	S.F.
74	-58.0829E+07	S.F.
17	-58.0842E+07	P.B.
84	-58.0860E+07	S.F.
97	-58.0869E+07	S.F.
11	-58.0884E+07	P.B.
107	-58.0906E+07	S.F.
106	-58.0920E+07	S.F.
93	-58.0939E+07	S.F.
47	-58.0940E+07	P.B.
78	-58.0946E+07	S.F.
53	-58.0951E+07	P.B.
26	-58.0972E+07	P.B.
18	-58.0988E+07	P.B.
4	-58.0996E+07	P.B.
80	-58.1002E+07	S.F.

Table H-3. (continued)

Number of the Farm	$\pi_f - \lambda(g)$	Municipios SF=Senador Firmino PB=Presidente Bernardes
13	-58.1019E+07	P.B.
95	-58.1043E+07	S.F.
1	-58.1059E+07	P.B.
61	-58.1089E+07	S.F.
32	-58.1190E+07	P.B.
28	-58.1286E+07	P.B.
100	-58.1306E+07	S.F.
73	-58.1309E+07	S.F.
90	-58.1311E+07	S.F.
15	-58.1325E+07	P.B.
99	-58.1347E+07	S.F.
85	-58.1361E+07	S.F.
50	-58.1363E+07	P.B.
45	-58.1382E+07	P.B.
10	-58.1388E+07	P.B.
108	-58.1423E+07	S.F.
88	-58.1439E+07	S.F.
103	-58.1452E+07	S.F.
22	-58.1470E+07	P.B.
62	-58.1519E+07	S.F.
64	-58.1576E+07	S.F.
104	-58.1592E+07	S.F.
6	-58.1609E+07	P.B.
19	-58.1646E+07	P.B.
8	-58.1771E+07	P.B.
72	-58.1813E+07	S.F.
76	-58.1888E+07	S.F.
87	-58.1913E+07	S.F.
63	-58.1972E+07	S.F.
118	-58.1978E+07	S.F.
94	-58.2012E+07	S.F.
86	-58.2093E+07	S.F.
82	-58.2217E+07	S.F.
41	-58.2283E+07	P.B.
81	-58.2537E+07	S.F.
116	-58.2577E+07	S.F.
29	-58.2699E+07	P.B.
66	-58.3586E+07	S.F.
113	-58.4131E+07	S.F.
42	-58.5013E+07	P.B.

Source: Sample data.

Table H-4. Values of the Inputs and Gross Income Used to Fit the Production Function, Senador Firmino, 1964.

Number of the Farm	Labor Services Measured in Cr$100 X_2	Machinery and Equipment Measured in Cr$100 X_4	Animal Services Measured in Cr$100 X_5	Other Expenses Measured in Cr$100 X_6	Gross Income Measured in Cr$100 X_0
61	- 7640	1766	6545	3344	17189
62	6886	1345	6770	7032	15625
63	9192	3635	7122	5151	14169
64	6968	2089	6541	3721	12344
65	8012	3559	18175	9843	41266
66	11150	13774	23420	26500	47773
67	2916	1137	5917	1625	16110
68	4386	840	3917	1955	18688
69	6332	2216	8659	4958	44644
70	1622	672	7530	4780	27793
71	8368	1873	17559	2082	38597
72	5946	1496	7235	6150	11482
73	4356	1352	4813	4977	11194
74	8252	4309	9425	7590	30069
75	6504	889	5587	2297	17072
76	5196	1323	6608	4907	7936
77	3552	526	3284	2791	13737
78	1248	330	1854	2155	4913
79	4653	388	7141	4302	19788
80	9232	3114	17571	10319	39004
81	7532	11956	6880	10158	19937
82	7274	2199	20320	9778	26191
83	6580	1253	11579	4973	40773
84	1284	1439	3910	992	7814
85	8572	4376	23448	2032	33605
86	6822	32107	12974	9516	49270
87	7374	1933	12256	5668	16886
88	4224	896	6070	5644	11226
89	3844	1775	4044	2625	19620
90	4262	1543	2686	1178	5347
91	8474	5274	14326	5020	35989
92	4288	695	7467	5426	18395
93	3355	682	1816	757	6006
94	6272	3076	5267	2933	6215
95	5200	1305	3617	1635	10109
96	1401	1157	5661	2075	14334
97	3406	866	3329	4377	12073
98	1792	578	4021	2035	11705
99	6252	5834	18554	6577	32528
100	3432	1255	6667	3968	11049

Table H-4. (continued)

Number of the Farm	Labor Services Measured in Cr$100 X_2	Machinery and Equipment Measured in Cr$100 X_4	Animal Services Measured in Cr$100 X_5	Other Expenses Measured in Cr$100 X_6	Gross Income Measured in Cr$100 X_0
101	3436	1269	6606	4715	34952
102	8612	5597	36214	19480	86465
103	4616	1365	3735	4320	8304
104	3848	660	3756	7972	9099
105	2891	1025	3805	2163	11284
106	3978	1488	2712	1849	10113
107	3578	1716	7557	1532	14106
108	2636	1797	3365	5214	7564
109	3586	3521	10908	2862	22936
110	6048	2054	14773	4724	28555
111	7863	1251	16392	3421	29542
112	2974	313	5445	2427	13605
113	10812	28244	28679	26013	61219
114	12016	2938	14694	5174	44775
115	10806	11784	8542	18554	75967
116	6696	5972	12676	6093	14448
117	5596	1815	8742	3290	22603
118	13732	16909	18591	13630	51866
119	6136	430	5096	7009	22228
120	6754	2567	14532	3288	38442

Source: Sample Data

Table H-5. Values of the Inputs of Gross Income Used to Fit the Production Function, Presidente Bernardes, 1964.

Number of the Farm	Labor Services Measured in Cr$100 X_2	Machinery and Equipment Measured in Cr$100 X_4	Animal Services Measured in Cr$100 X_5	Other Expenses Measured in Cr$100 X_6	Gross Income Measured in Cr$100 X_0
1	1648	1255	1040	2776	4917
2	6268	10943	6856	6617	37260
3	8980	4107	18402	10615	63225
4	4278	2008	7056	7550	19714
5	1302	1043	3737	824	10042
6	7803	15451	4556	3987	24496
7	3315	1224	4034	2460	14016
8	8469	30078	13441	9182	52248
9	2112	2137	7894	1966	16493
10	3744	891	3639	7862	11043
11	1554	133	481	444	2560
12	3882	1847	3298	3713	16997
13	1304	54	3197	1298	4450
14	2808	178	1230	773	11598
15	1423	4662	4982	3309	9913
16	1505	368	3168	1852	13010
17	2110	704	6540	2392	12107
18	1800	246	1622	2807	5377
19	4511	1480	16300	9914	24527
20	2840	1436	2365	3773	15589
21	2864	741	2431	2174	10501
22	2886	704	10837	4549	13066
23	1635	139	603	1191	6387
24	6716	956	13696	6871	31302
25	4581	1234	7511	5675	25157
26	1784	2290	4812	2460	10413
27	2010	1752	2704	2334	13391
28	6651	1393	13937	7731	25633
29	4716	679	11767	4802	3756
30	1564	163	2608	1393	9659
31	861	270	2978	1474	29719
32	2340	222	1355	1648	2446
33	3521	750	4837	1125	14407
34	4234	7150	3068	1092	17807
35	4038	1164	7620	1124	22221
36	10013	850	12594	3560	42077
37	4094	1161	3936	1075	13706
38	2271	610	1422	745	11183
39	7009	1796	21637	2312	46784
40	8880	3262	19951	4852	103700

Table H-5. (continued)

Number of the Farm	Labor Services Measured in Cr$100 X_2	Machinery and Equipment Measured in Cr$100 X_4	Animal Services Measured in Cr$100 X_5	Other Expenses Measured in Cr$100 X_6	Gross Income Measured in Cr$100 X_0
41	3464	10824	258	3737	4225
42	3302	44783	6838	6671	20246
43	3389	1480	3338	748	12149
44	5616	2372	9386	3242	26987
45	1929	1585	6310	3193	7986
46	2350	1286	4088	1189	16467
47	2652	1883	6878	2597	13399
48	6847	965	15502	3581	36766
49	4305	4264	2823	893	20263
50	6534	3166	4255	4086	13194
51	3620	697	1464	665	16576
52	4111	1238	6090	2315	22742
53	3420	1429	6532	2358	13014
54	5461	22390	16922	2502	57947
55	2875	1352	11209	3024	33174
56	11090	3678	14158	6240	63932
57	4400	1359	5512	2279	19005
58	7479	11473	10424	4643	37302
59	3042	430	4216	1531	13583
60	4846	1233	7195	2436	19543

Source: Sample Data

APPENDIX I

CORRELATION MATRIX

APPENDIX I

CORRELATION MATRIX

Table I-1. Correlation Matrix of the Variables.

X_i	X_o	X_2	X_4	X_5	X_6
X_o	1	.65846	.56332	.77548	.53246
X_2		1	.59630	.66566	.62017
X_4			1	.49387	.54582
X_5				1	.62734
X_6					1