THE ECONOMIC EVALUATION OF THE IMPACT OF EXTENSION PROGRAMS: A SUGGESTED METHODOLOGY AND AN APPLICATION TO ACAR IN MINAS GERAIS, BRAZIL[1]

Eliseu Roberto de Andrade Alves
G. Edward Schuh

Agricultural development efforts quite frequently involve programs designed to extend knowledge to farm people through various kinds of extension programs. Yet, the basic methodology for evaluating such programs is not very well developed. The typical approach is to evaluate the impact of the extension service on various measures of physical productivity, or on other characteristics of technical change. This may involve the calculation of indices of partial and total productivity, and/or the collection of data on rates of adoption of new modern inputs or the use of new farm practices.

One objective of the present paper is to suggest the application of a methodology which appears to have promise as a means of evaluating the impact of extension programs on a broader base. In addition the results of applying the methodology in a limited evaluation of the extension program of (ACAR), the extension agency for the State of Minas Gerais in Brazil, are also presented, as is a discussion of the implications of the results obtained.

The proposed methodology makes a distribution between technical efficiency and price efficiency, and provides a means whereby the effect of the extension program on these two components of total efficiency can be assessed. The meth-

---

[1] This paper was written in 1968 when Eliseu R. de Andrade Alves was with ACAR (State Agricultural Credit and Extention Service) Minas Gerais, and G. Edward Schuh was professor of agricultural economics, Purdue University and Program Advisor in Agriculture to the Ford Foundation, Brazil.

odology is implemented by estimating a farm-level production function with cross-sectional data in such a way that it is neither assumed that all farms are on the same production function, or that they are economic optimizers.

The suggested procedures which we propose are not new[2]. However, to the best of our knowledge their application to the evaluation of extension programs is new. Although the present application is of rather limited scope, the results obtained do seem to provide insights into the impact of the ACAR extension program in dimensions which would not be possible with more conventional means of evaluation.

EVALUATING THE IMPACT OF EXTENSION PROGRAMS

Most extension, or farm-level technical assistance programs, have as a basic objective an increase in the efficiency of the farming enterprise through the production of a larger output from given resources. For the most part it is expected that the increase in efficiency will be one means of raising incomes and the level of living of farm families who manage the firm.

The concept of efficiency as developed in economic literature, has two basic dimensions. Price efficiency has to do with the extent to which resources are combined in an optimum manner, given relevant factor and product prices. Technical efficiency, on the other hand, has to do with the choice of an appropriate production function.

In principle, an extension program could attempt to change either or both aspects of efficiency. That is, it could attempt to increase the output form given resources by advising farm firms to move from non-optimum (economic) positions to ones of optimality, and/or it could attempt to move these firms from one production function to another. In practice, however, extension programs seem to give more attention to the latter type of change, presumably because the gains from such changes are expected to be larger.

It seems important in evaluating extension programs to consider both concepts of efficiency. It may be, for example, that the immediate potential from an extension program is in improving price efficiency. As a case in point, suppose

---

[2] The basic methodology has been proposed by Nerlove (1965) in a different context. It draws on earlier work by Farrell (1957) and Klein (1953).

that the extension program is carried out in an economic environment in which there are substantial changes in relative prices — which demand sizeable adjustments in resources proportions and levels — but in which there is little or no new knowledge available to introduce into the production process[3]. Under these conditions, one alternative for the extension agency is to attempt to improve the price efficiency of the farms. However, evaluation of the effectiveness of the extension agency with measures, which attempt to identify its impact on the level of technical efficiency, will miss the point in this case, and perhaps erroneously indicate that the extension program is ineffective.

Alternatively, it may be that the adoption of new technology[4] so changes the production function, or the resource mix, that a decline in price efficiency results when the new inputs or new practices are adopted[5]. That is, the change in technology may increase technical efficiency, but at the same time lower price efficiency. In this case, measures which assess only technical efficiency will tend to over-estimate the net contribution of the extension program.

PROCEDURES

Farrell (1957) has defined measures of economic efficiency which permit comparisons among farms within an industry in the degree of technical efficiency, economic efficiency, and over-all efficiency. The distribution among these concepts and an understanding of Farrell's definitions can be obtained from Figure 1.

Assume constant returns to scale, a single output, and two factors of production. The production function can then be characterized by a single isoquant, II'. Let DD' be the price line. Then Q' is the optimum combination of inputs X_1 and X_2. However, a farm may produce at P rather than at Q', where P represents

---

3 This combination of circumstances is not too wide of the mark in many rapidly developing countries such as Brazil.

4 New technology is used here as a proxy for all manner of new skills and new materials, be they "improvements" in previously used inputs, such as the change from open pollinated corn to hybrid corn, or the adoption of a "new" input such as fertilizer or insecticides.

5 For example, the adoption of fertilizer may so change the marginal productivity of other inputs, such as labor, that the ex post utilization of this input is non-optimum given the prevailing price rations. This problem may be especially important if the new input should have large output effects which lead to declines in the price of the product.

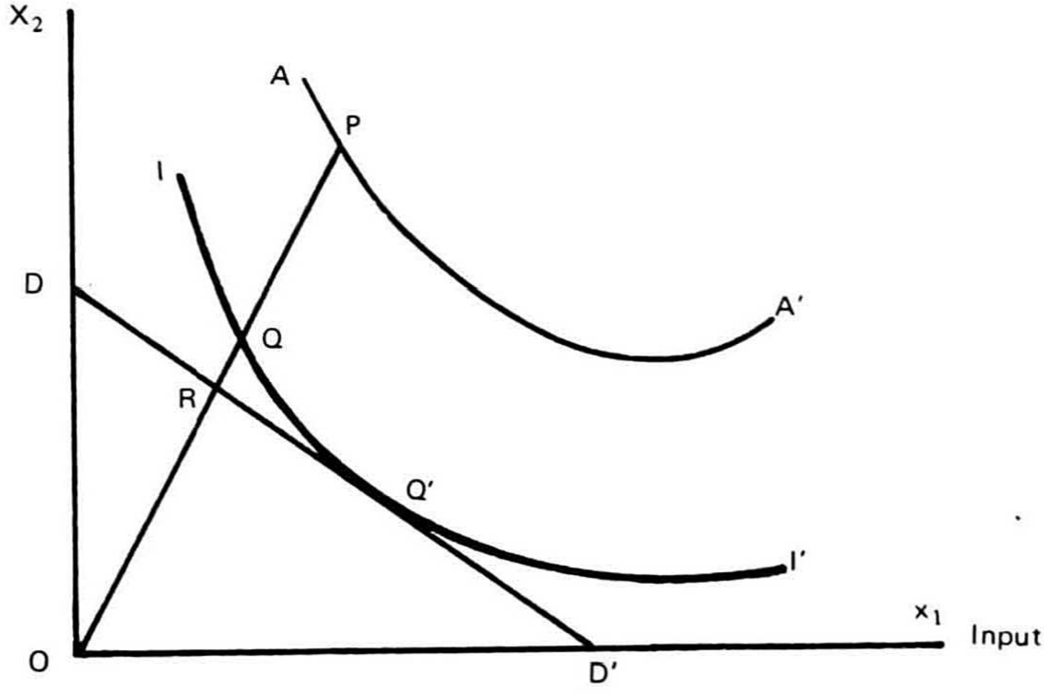

FIG. 1. Farrell's definition of relative efficiency and its components.

the same level of output as on isoquant II'. That is, the isoquant AA' represents a different production function[6], with a lower level of technical efficiency than that represented by II'. The distance OP relative to OQ measures the extent to which the same output could be produced with fewer conventional or measured inputs used in the same proportion, or what Farrell calls "technical efficiency". The distance OR relative to OQ measures the portion of costs for which the output could be produced if the relative use of conventional inputs were altered. Farrell calls this "price efficiency". A measure of the "over-all efficiency" is given by $\frac{OR}{OO} \cdot \frac{OQ}{OP} \; \frac{OR -}{OP}$. 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'.

---

[6] This difference in production functions must ultimately trace back to the absence of an input in AA' that occurs in II'. We are immediately faced with the question of "What is technical change?" The exposition and analysis in this article assumes technology to be the conventional unexplained residual that arises from accounting problems. This can be seen in the following way. Suppose the original production function were AA' and involved only the two inputs X_1 and X_2, the essence of technical change is the introduction of a "new" input, say X_3, into the production process. Complete specification of the production function would then require three dimensions and the accounting procedures would have to consider X_3. However, most empirical work on measuring technical change only deals with the X_1 and X_2 dimension, and therefore attributes the difference between AA' and II' to "technical change". Our empirical work is done in this same framework.

Farrell (1957) used these concepts in empirical work. Since he did not know the true production function, he estimated it by fitting an envelope to the scatter of points in the input plane. Nerlove (1965) has pointed out that Farrell's approach assumes: (1) constant returns to scale, (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 (relative prices) in which the farm is operating. The measures are ambiguous if any one of these three conditions is relaxed.

Nerlove (1965) then develops a measure of economic efficiency, which in principle, is free of all three of these restrictive assumptions. He recognizes that individual differences among a set of farm firms may be the result of differences in factors which can be classified under three headings:

1. The ability to maximize short-run profits, given a particular production function and a given environment;

2. The production function, which summarizes the state of technical knowledge and the possession of fixed factors; and

3. The environment which here is defined as the prices of the products and factors.

Then he assumes there to be three vectors of parameters associated with each farm f and corresponding to each of the categories of factors causing differences among firms. Hence: profit maximizing factors, u_f; production functions, v_f; and 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. Farm f is included in the industry or set of firms F.

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

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

Stepwise maximization of this function implies

(2) $\Pi \ (u_f, v_f, w_f) \leqslant \hat{\eta} \ (v_f, w_f) \leqslant \lambda \ (f)$

where:

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

$\hat{\eta}\ (v_f, w_f)$ = 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 "highest" level production function, but given the environment.

Measures of efficiency that are comparable to those of Farrell can be obtained by taking ratios of the terms in the equality above. Although these are cardinal measures, they have the disadvantage of not being useful in empirical work if short-run realized profits should be zero or negative. To circumvent this, Nerlove (1965) suggests that the following measures can be used:

(3) $E_1\ (f) = \eta\ (u_f, v_f, w_f) - \lambda\ (f)$

(4) $E_1\ (f) = [\Pi\ (u_f, v_f, w_f) - \hat{\eta}\ (v_f, w_f)] + [\hat{\eta}\ (v_f, w_f) - \lambda\ (f)]$

where E_1 (f) is the **overall** measure of relative economic efficiency of the firm, the first expression in brackets is the measure of **price efficiency,** or the relative ability of the firm to maximize profit within a given environment and with the production function chosen, and the second expression in brackets measures technical efficiency or, loosely speaking, the ability to choose the correct production function.

This measure of efficiency, E_1 (f), will be a non-positive real number, and the closer it is to zero, the relatively more efficient is firm f. This measure has problems associated with it also. If price changes do not affect either u or v (i.e., profit maximization **behavior,** or the choice of the production function), then Π (u, v, w) and $\hat{\eta}$ (v, w) are homogenous of degree one in prices.

It should be noted, however, that the relative position of any two firms does not change with a change of prices. As a result, it is possible to use E_1 (f) to rank the firms. And Nerlove (1965) has shown that the sample rank, E_1 (f), tends uniformly, in probability, to the true rank as the sample size increases without limit. That is $\hat{E}_1$ (f) is consistent.

In order to compute these measures of efficiency, one has to have knowledge of the production function. Hence, the estimation problem is one of obtaining this knowledge. But the problem is more complex than in the conventional case, since it is desired to permit the production function to vary among firms and to impose no assumption about equilibrium among firms. This can be handled if one is willing to assume that the underlying production function is of the Cobb-Douglas type, and is willing to given an economic interpretation to the usual error term — a restriction which incidentally will solve the identification problem.

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

(5) $X_{of} = \alpha X_{1f}^{\alpha_1} X_{2f}^{\alpha_2} \; .... \; X_{nf}^{\alpha n} \; v_{of}$

where:

X_o = output,

X_i = conventional inputs (i = 1 ... n), such as land, labor, capital, and operating expenses,

α = the intercept,

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

v_{of} = a random, normally distributed variable with mean equal to one and a finite variance, and the subscript f defines the function for a given firm.

In the conventional estimation problem for a function of this kind, v_{of} is assumed to represent a large number of relatively unimportant variables that have been omitted from the model. In that case, the Central Limit Theorem provides a rationale for the assumption of normality.

Alternatively, assume for our purposes that v_{of} represents differences in the production function among firms[7]. This is interpreted as if the specified production function were permitted to vary from farm to farm up to a factor of proportio-

---

[7] For details, see Alves (1968) where references to the pertinent literature may also be found.

nality[8]. 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, then the same rationale about the normality of v_{of} applies.

With this assumption it is possible to specify a production function for estimational purposes which will permit the level of technology to vary among the farms in the sample. What about the possibility of differences in profit maximizing ability? Is it possible to specify a model which will permit estimation of the production function in the absence of an equilibrium assumption?

We know that if we can postulate equilibrium, then the parameters of the production function can be estimated by the factor shares, given that certain other assumptions such as constant returns to scale hold. That is,

$$(6) \quad \alpha_i = \frac{P_{if} X_{if}}{P_{of} X_{of}} \quad \text{for } i = 1, 2, \ldots n$$

where the P_i refers to factor prices and P_o is the product price. But we would like to avoid making the assumption of equilibrium. How can we proceed?

Suppose a random term is introduced into the equilibrium conditions of the firm to indicate that the firm may not be a perfect profit maximizer. In this case the equilibrium conditions become

$$(7) \quad \alpha_i u_{if} = \frac{P_{if} X_{if}}{P_{of} X_{of}} \quad \text{for } i = 1, 2, \ldots n$$

where u_{if} is a random variable with a normal distribution, a mean equal to one, and a finite variance. The random error terms, u_{if}, is once again given an economic interpretation by assuming that it represents a large number of relatively unimportant variables that account for the firm not attaining an economic optimum.

Klein (1953) suggests that under these conditions — a stochasticized pro-

[8] Differences, of course, which show up because of unmeasurable or unmeasured inputs, which have been omitted from the functions, or because of unmeasured or unmeasurable quality differences in the inputs. That is, the specified production function is assumed to differ among firms in a rather specific way. Given percentage increases in inputs are assumed to result in the same percentage increases in output for all firms, but firms with the same level of inputs will not all produce the same output.

duction function and stochasticized equilibrium conditions – the estimates of the coefficients of the production function can be obtained as follows:

$$(8)\quad \log \hat{\alpha}_i = \frac{1}{F} \sum_{f=1}^{F} \log \frac{P_{if} X_{if}}{P_{of} X_{of}}$$

$$(9)\quad \log \hat{\alpha} = \frac{1}{F} \sum_{f=1}^{F} [\log X_{of} - \sum_{i=1}^{n} \hat{\alpha}_i \log X_{if}]$$

where F is the total number of firms in the sample. Taking anti-logs will provide the parameter estimates $\hat{\alpha}_i$ and $\hat{\alpha}$. Thus, the log $\hat{\alpha}_i$ is obtained as the geometric means of the shares of the respective inputs in the total value of output for individual firms. The intercept, log $\hat{\alpha}$, is obtained by inserting these estimates into the equation of the production function and obtaining the mean difference[9].

With knowledge of the production function, the measures of efficiency can be calculated. This can be seen in the following way. Solve the original model consisting of the production function and the equilibrium conditions for the levels of output and input in terms of the 's and the v's. Substitute the results into the profit equation to obtain[10]:

$$(10)\quad \eta_f = (1 - \sum_{i=1}^{n} \alpha_i u_{if}) [\alpha v_{of} P_{of} \prod_{i=1}^{n} \frac{\alpha_i u_{if}}{P_{if}} - \alpha_i]^{\frac{1}{1 - \Sigma \alpha_i}}$$

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

---

[9] Nerlove (1965) proves that the estimates of log α_i are unbiased and consistent regardless of the interpretation of v_{of} in the original production function. The estimates α_i, however, are biased, although they can be shown to be consistent. Log $\hat{\alpha}$, on the other hand, is biased and in general inconsistent. Estimates of $\hat{\alpha}^2$ can be obtained and can be used to set confidence intervals on the log $\hat{\alpha}_i$.

[10] This equation differs from that suggested by Nerlove (1965). Computation along the lines suggested by him resulted in infinite values for profits or net income. For the derivation which resulted in the equation above, see (Alves 1968, Appendix D).

Then,

$$(11)\quad E_1\ (f) = \Pi_f - \lambda\ (f) = (\Pi_f - \hat{\eta}_f) + (\hat{\Pi}_f - \lambda\ (f)\ )$$

where:

$\Pi_f - \hat{\Pi}_f$ measures price efficiency,

$\hat{\eta}_f - \lambda$ (f) measures technical efficiency, and

E_1 (f) measures overall economic efficiency.

The complete computational procedures can be summarized as follows:

1. Estimate an "average", or aggregate production function for the sample by estimating α and α_i (i = 1 ... n) as indicated in equations (8) and (9).

2. Use this "average" function to calculate the proportional technology shifter for each firm:

$$\hat{v}_{of} = \frac{X_{of}}{\alpha X_{1f}^{\alpha_1} \ldots X_{nf}^{\alpha n}} \quad \text{for } f = 1 \ldots F$$

3. Compute for each firm f the set of values $\hat{u}_{if}$ for i = 1 ... n. These are the stochastic elements on the equilibrium conditions, and indicate the degree to which the firm does not maximize profits. The $\hat{u}_{if}$ can be calculated using equation (7). The factor shares were already used to estimate the α_i, so the elements are already at hand.

4. Compute for each firm f the values $\hat{\alpha} i\ \hat{u}_{if}$ for i = 1 ... n. The $\hat{\alpha}_i$ are constants for the sample and were obtained in step (1).

5. Develop a profit equation for each firm by inserting the parameters α, α_i, $\hat{v}_{of}$, and $\hat{\alpha}_i\ \hat{u}_{if}$ into equation (10) for each firm, f = 1 ... F.

6. Compute π_f, realized profit, for f = 1 ... F by inserting the observations on P_{of} and P_{if} into the equations obtained in step 5.

7. Compute $\hat{\pi}_f$, estimated profit it the firm were perfect profit maximizer, by setting u_{if} = 1, i = 1 ... n in the production function.

8. Select the maximum value of $\hat{\pi}$ as λ (f).

9. Compute the various measures of efficiency by the use of the formulas in (11) above:

   a. $\pi_f - \hat{\pi}_f$ measures price efficiency for the firm since it is the difference between its realized profits, π_f, and what it could have received had it maximized profits, $\hat{\pi}_f$.

   b. $\hat{\pi}_f - \lambda$ (f) measures technical efficiency, since it is the difference between what the firm could have received in profits had it been a perfect profit maximizer and what was possible had it been a perfect profit maximizer and selected the highest level production at the same time.

   c. The sum of price efficiency and technical efficiency provides a measure of overall economic efficiency.

10. Use the values obtained in (9) to rank the firms.

THE DATA

This model was applied to a limited evaluation of the ACAR extension service in Minas Gerais, Brazil[11]. The ACAR (Associação de Crédito e Assistência Rural) was created in 1948 as a rural development program. It was to operate mainly through supervised credit and extension-education activities, with the focus on the small disadvantaged farmer.

Over time, the nature of the program has changed a great deal in response to changing conditions, careful internal evaluation, and the accumulation of knowledge as to what will work and what will not work. However, the elements of subsidized credit[12] and educational activities have been key ingredients, although their form

---

[11] For an excellent description and evaluation of the ACAR program, together with references to reviews of previous studies of the system, see Ribeiro & Wharton Junior (1969). For data on how the ACAR model has been expanded to other states, and the organization of the national system, ABCAR, see Schuh & Alves (1970).

[12] The subsidized credit was not necessarily by design. The interest rate charged on ACAR loans ranges from 6 to 8 percent and there is a legal ceiling of 12 percent per year. With rates of inflation ranging from 12-120 percent per year in the post-war period, interest rates such as these constitute a substantial subsidy (Ribeiro & Wharton Junior (1969).

and relative proportions have changed from time to time. The ACAR program has been generally recognized as a successful approach to the problem of rural development. It has been widely copied by other states in Brazil, and has been expanded into what in essence constitutes a nation-wide extension service, ABCAR.

Since our interests were primarily methodological at this stage, we proceeded with a paired comparison of two **municípios** (counties) in the state of Minas Gerais. In one **município**, Senador Firmino, ACAR had been working for 10 years. The data were collected (in direct farm interviews) from the universe of farms cooperating with ACAR at the time of the survey. The second **município**, Presidente Bernardes, was chosen so that it would be as similar as possible to the ACAR **município**, but in which ACAR had not worked nor had an office nearby. In this **município**, a random sample of farms was drawn, but within size intervals which corresponded to those for the ACAR **município** (at the time of the survey) so that the size distribution would be similar. Sixty questionnaires were taken in each **município**. The period of data collection extended from September to December, 1964, and the information collected refer to the 1963-64 crop year: July, 1963 through June, 1964.

It should be clear from this description that the samples are not necessarily representative of either **município** – nor were they intended to be. In one case, a universe of firms was used; in the other, the objective of the sampling procedure was to obtain a group of farms that would be similar to this universe, although the only data available for guiding the sampling process was general descriptive data on the **municípios** and information on the size distribution of farms. It was hoped that other characteristics of the farms and farmers would be correlated with the size of farms.

Given this rather crude sampling procedure, the two groups were broadly similar[13]. This applies to size distributions, sources of gross income, yields, and basic resource endowment. However, the farms in the ACAR sample tended to have more resources – measured as a flow, with the exception of machinery. Gross income per farm was not greatly different – 5% on the average. The level of schooling of those with formal education was quite similar, although the ACAR sample had a somewhat lower incidence of illiteracy – 6.7 per cent as contrast to 15.0 per cent for the non-ACAR sample. One of the more significant differences was that the ACAR sample tended to be younger than the non-ACAR sample.

---

[13] See (Alves 1968, Appendix F) for more detail.

Eighty-three per cent of the farm operators in Senador Firmino were 49 year old or less while in Presidente Bernardes the corresponding percentage was 50 per cent.

The average length of time that ACAR had been working with the farms sampled was 3.6 years. Some 20 per cent of the sample had been working only a year or less, although 33 per cent had received assistance for three years and some 40 per cent had received assistance for four years or more, with some going up to as much as 14 years.

In order to compute the factor shares for estimating the production function, all variables were measured as a flow[14], with the flow of inputs for capital inputs estimated by the application of an interest rate to capital values. This conversion of stocks to flows presents serious problems in an inflationary environment such as Brazil, however, nominal or monetary rates of interest are quite high – as much as 40 - 60 per cent a year. Real rates of interest are much lower, of course, but it is very difficult to know what these rates are.

The procedure followed was to measure the variables using both current nominal rates of interest (42 - 54 per cent, depending on the variable) and assumed real rates of interest (10-15 per cent, again depending on the variable). The results of the estimation procedure were then used to determine which procedure interpreted the data better[15] The model using nominal rates of interest gave the better statistical results – an R^2 of around 0.60 in contrast to 0.40 – and hence was used in further analysis.

STATISTICAL RESULTS AND THE EFFICIENCY INDICES

The basic production function (assumed to be Cobb-Douglas) on which the analysis is to be based is estimated by pooling the data from the two samples. The estimation procedure allows for the fact that the farms may not all be on the same production function, but assumes that the individual farm functions differ only by a factor of proportionality. The production elasticities are assumed to be the same for each farm.

---

[14] The basic data and more detailed discussion of sampling procedures and data processing can be found in reference (Alves 1968) or in mimeographed form from the authors.

[15] This evaluation was made with a least squares estimation of the production function, rather than the more burdensome factor shares procedure.

The analysis was carried out with a short-run production model. Production elasticities were estimated for labor, machinery and equipment, animals, and other purchased inputs. Buildings and land are reflected in the constant term of the production function. Although this procedure might lead to bias in least squares estimates of the production function, it need not in Klein's factor shares approach, since the production elasticity is estimated as the ratio of the expenditure on the input (or the flow of services, as the case may be) and the value of output. It has the disadvantage, however, that quality of land and buildings may be compounded with technical efficiency. If there should be a significant difference in the quality of land between the two samples, the measure of technical efficiency would be biased[16].

The results of estimating the short-run equation are presented in Table 1. Results from using both Klein's factor shares procedures and ordinary least squares are included as a basis of comparison. 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 per cent level.

The coefficients for labor and machinery are similar in size when comparing the two procedures. The coefficient for animal services is much higher when estimated by ordinary least squares, and the coefficient for other purchased inputs differs in sign. The orginal ranking of the sign of the coefficient for livestock services with the least squares estimate probably reflects specification bias, since animal services tend to be correlated with land — an omitted variable. The reason for the negative coefficient for other inputs is not so obvious.

The sum of the production elasticities is not greatly different between the two estimation procedures. In order for the second order conditions for a maximum to be met, the production elasticities must be between zero and one. Statistically testing this for the Klein estimates would be difficult, since it would require the derivation of the density function. Therefore, the evaluation was restricted to setting confidence intervals on the logarithmic coefficients. These suggest that the coefficients are, in fact, different from both zero and one.

[16] The same argument applies to other inputs that are omitted from the production function, such as managerial ability. This problem arises in all procedures which attempt to use the intercept of the production function as a measure of technical efficiency.

TABLE 1. Statistical Results – Comparison of Klein's Procedure with Least Squares Estimates.

	Klein's Procedure				Least Squares		
Variables	Coefficient	Log Coefficient	Standard Error Log Coefficient	Confidence Interval Log Coefficient	Coefficient	Standard Error	t
Intercept	25.06				49.31		
X_2 (labor)	.24	-1.43	.05	-1.53 to -1.33	.23	.10	2.25*
X_4 (machinery)	.09	-2.36	.08	-2.52 to -2.20	.12	.04	2.27*
X_5 (animals)	-.34	-1.07	.04	-1.14 to -1.00	.51	.06	7.58*
X_6 (others)	.19	-1.67	.06	-1.78 to -1.55	-.06	.07	-.79
R^2		.64			.65		

* Significant at the 5% level or better.
Source: Sample data Alves 1968.

When short-run profits (calculated as the net return to the fixed factors of land, buildings, and management) were calculated for each firm using equation 10, it was found that 47 out of the 120 farms had negative profits. This finding is not surprising in a chronic inflationary milieu such as in Brazil[17], but it does force the computation of efficiency indices as ordinal measures rather than cardinal measures, and complicates somewhat the testing procedures to be used in comparing the samples.

Rankings on the three measures of economic efficiency are summarized in Table 2, together with the appropriate test statistics. Testing was based on two basic hypothesis which were specified **ex ante**:

1. That the farms from Senador Firmino would have a higher level of technical efficiency because of the work of ACAR.

2. That the farms from Presidente Bernardes would have a higher level of price efficiency. The basis for this hypothesis was two-fold. First, it was expected that the farms in this **município** would be essentially undisturbed from a position of longrun or traditional equilibrium. And second, that the adoption of new technology in Senador Firmino would have disturbed the equilibrium by changing both the underlying production function and the resource proportions. An improvement in price efficiency was not expected since ACAR gives little explicit attention to the economic dimension in its technical assistance program.

The null hypothesis specified was that the samples came from the same population. This null hypothesis was tested by means of the rank test, which is also known as the U-test; the Mann-Whitney test, and the Wilcoxen test[18].

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

---

17 As Nicholls & Paiva (1965) have pointed out, negative short-run profits are an indication of sophisticated decision-making, if it reflects a concern with the asset account of the firm as contrast to the flow account.

18 For detail, see (Freund 1964). This test procedure leads to the computation of a U statistic, which for sample sizes greater than eight is distributed approximately normally. Hence, by computing a Z- statistic, the normal distribution can be used for testing the null hypothesis.

TABLE 2. Distribution of rankings — Indices of efficiency, and related statistics, Senador Firmino and President Bernardes[a/].

Class of Ranks	Price Efficiency		Technical Efficiency		Overall Efficiency	
	President Bernardes	Senador Firmino	President Bernardes	Senador Firmino	President Bernardes	Senador Firmino
	(No. of farms)		(No. of farms)		(No. of farms)	
1-10	3	7	6	4	5	5
11-20	6	4	9	1	6	4
21-30	4	6	5	5	8	2
31-40	4	6	7	3	8	2
41-50	5	5	7	3	5	5
51-60	5	5	4	6	6	4
61-70	5	5	2	8	2	8
71-80	3	7	3	7	5	5
81-90	5	5	6	4	5	5
91-100	5	5	7	3	4	6
101-110	9	1	2	8	3	7
111-120	6	4	2	8	3	7
Average	66	55	51	70	53	68
Median	66	54	44	70	46	70
Z	1.75		2.95*		2.52*	

* Significant at 5 per cent level of probability.

Source: Sample data (Alves 1968, Appendix H).

a/ High ranking reflect small negative values for the measures of efficiency.

maximizers on the flow account. Of the three indices, those for technical efficiency and overall efficiency had the greatest dispersion, with variation in economic efficiency being much less.

Part of the reason for the wide dispersion in the indices was the fact that two of the farmers had very large profits as calculated through equation 10. In back of this, was the fact that these farms had very high levels of technical efficiency in relation to the others, which resulted in a high calculated constant term for their production function. Since this term enters multiplicatively in the profit equation, their calculated (as contrast to realized) profits were very large.

In order to avoid working with very large numbers, the third ranking farm was chosen as the basis for computing the efficiency indices. This changes nothing in the analysis, however, since the testing is based on the rankings and not on the numerical values of the indices.

For price efficiency, Z was equal to 1.75, which indicates that the difference between the two samples was not significant at the 5 percent level[19]. If $\alpha = .10$ is used, however, the null hypothesis would be rejected (1.21 > 1.64 for this level). The interesting thing is that the difference between the two samples is different than was hypothesized. Both the mean and median of the rankings are smaller in Senador Firmino than in President Bernardes, indicating that the farmers in the ACAR sample have a higher level of price efficiency than those in the other.

For technical efficiency, Z was equal to 2.95, indicating that the difference between the two samples was statistically significant. However, the direction of the difference is once again 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 mean and median rankings are both fairly large.

For overall economic efficiency, the difference between the two samples was again statistically significant at the 5 percent level. The farmers in President 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 the ACAR sample.

[19] For $\alpha = .05$, if $/Z/ > 1.96$, reject the null hypothesis of no difference between the samples.

INTERPRETATION AND EVALUATION

The above comparison can by no means be taken as a complete evaluation of the ACAR program. After all, ACAR had 120 local offices serving 152 **municípios** in 1964, reaching more than 3 million people a year through its various activities and projects. Although the particular **município** chosen for study was believed to be representative of the ACAR program, the sample is clearly too restricted to offer much by way of results applying to general conditions.

Our interest was primarily methodological, and we were especially interested in determining whether the suggested methodology could be successfully implemented, and whether it might provide insights which more traditional procedures do not offer. Hence, in this section, we will concentrate on interpretation and evaluation in a methodological context, although we believe there are some insights of value to the ACAR program itself. These will be brought out at the appropriate time.

The empirical part of the study is subject to limitations that are characteristic of studies of this gender. In the first place, there may be substantial 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 on the questionnaire. This problem is complicated by the fact that the inflation rate has been high, which places a greater burden on the memory. Despite these restrictions, however, there is nothing to suggest that measurement errors might have been greater in one sample than in the other. Moreover, 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.

What is more serious is the difficulty in making an **ex ante** comparison between the two **municípios**, or between the sets of sampled farms. A basic premise of the study is that the two **municípios** were similar in every respect except for the "treatment effect" of the ACAR program. But the choice had to be made on the basis of incomplete data and the judgement of the researchers. The possibility of error is great. There may be substantial differences in such basic factors as the quality of land and managerial talent. It is very difficult even with the data in hand to completely evaluate these factors. Such factors, as we were able to consider, do not indicate substantial differences between the two **municípios**, but in the final analysis, this has to remain an unanswered question.

Finally, there is a question of whether the comparison of the two municípios at a given point in time is a valid comparison. Presumably, if the extension program is effective, the growth paths over time of the firms which cooperate with ACAR should be quite different than those which don't. In this sense, the sample base should be established at the time the ACAR program starts, rather than after it has been operating for some period of time. Needless to say, this kind of data is extremely difficult to come by ex-post, and we had to settle for the less desirable, although in our judgement still useful procedure of comparing a set of farms that had been working with ACAR for some time with a set that was broadly similar except that it had no ACAR "treatment".

The methodology does lend itself to longitudinal analysis, and the authors hope to be able to follow up with a survey of the farms in Senador Firmino in the near future. In this way we should be able to discover whether the presence of ACAR leads to changes in price and technical efficiency over time.

With these limitations caveats aside, we now turn to a consideration of what we consider to be some of the lessons or insights provided by the study. An interpretation of the results obtained suggest additional factors which might be considered in using the methodology.

Although the results obtained were different than hypothesized at the beginning of the study, they do have a plausible explanation.

In an inflationary environment, the maximization of profits on current account may not be an appropriate optimizing criterion for firms. From the standpoint of the welfare of the individual, what the firm does on its asset account may be much more important than what it does on its flow account[20]. For example, the purchase of land as a hedge against inflation may be much more important than its use as a factor of production. If this is the case, then technical efficiency may be a relatively unimportant goal of farm people, and in turn, an inappropriate criterion by which to evaluate the extension program. If the consequence of the educational program is to make the farmers more aware and alert, then they may have lower levels of efficiency simply because they have (correctly) become more concerned with the accumulation of assets. In fact, this may explain the results we obtained.

---

[20] This has been recognized in both the American literature and by writers on Brazil. For example, see Johnson 1965 and Nicholls & Paiva 1965.

It is interesting to note that the credit program of ACAR may actually be contributing to this problem. The high subsidy implicit in the low nominal rates of interest facilitates the acquisition of resources. If the stock of new knowledge is rather limited – as it is in Brazil – technical efficiency may actually decline if output increases do not match the resource acquisitions.

This finding, if it is valid, has program implications for ACAR, and suggests additional considerations for improving the methodology of the ACAR program. From a programmatic standpoint, it suggests that the role that credit plays in the extension program might well be re-examined. It appears to initially have had two bases: (1) to stimulate the farmer to adopt new practices, and (2) a concern that small farmers (the primary focus of the program in its initial stages) would have neither the resources nor the access to capital markets which would enable them to grow internally. If the credit program is actually lowering economic efficiency, as the above analysis suggests, then it needs to be re-examined. The program has a rather high cost to society, and may not be attaining its intended objectives.

In a somewhat more general context, the above observations suggest other changes which might be made in the ACAR extension program. To date, it has concentrated on introducing changes in production technology, with very little attention given to the economic dimension of its recommendations, or to the economics of program goals or farm organization more generally. We submit that: greater attention to the economic dimension, both in program development and in the kind of knowledge extended to the farmer, could improve the efficiency of the organization. This seems especially important in the light of the limited capacity for biological-technical research in Brazil, and the corresponding lack of new technical knowledge to distribute to the farmer.

In terms of evaluating the impact of an extension program, the results, and our interpretation of those results, support the attempt to separate price efficiency and technical efficiency, and also suggest ways in which the model might be extended. If one accepts the results on face value, they suggest that the ACAR program improved price efficiency and reduced technical efficiency. An improvement in price efficiency is plausible, since the credit program may have alleviated internal and external capital rationing. This is a positive gain which might have gone unnoticed in the more conventional evaluations which have concentrated on changes in technical efficiency.

At the same time, however, it may be appropriate to extend the economic dimension, especially if inflation is an important characteristic of the economic environment. Under these conditions an evaluation in terms of the flow account of the firm, is not sufficient, and an attempt should be made to integrate both the flow and asset accounts to provide criteria for overall optimizing behavior.

SOME CONCLUDING COMMENTS

Previous studies of the ACAR and other extension programs have focused primarily on assessing their impact on technical efficiency or technical change. In this article we suggest that evaluations should have a broader base, and should consider the impact on both price and technical efficiency. Although our particular empirical application is subject to rather serious limitations, we believe that it demonstrates the feasibility of the approach, as well as the kind of additional insights that can come from taking a broader approach to the evaluation.

At the same time, however, additional research is needed not only to improve our understanding of the impact of extension programs, but also to strengthen the conceptual frame of reference on which such analyses are based. For example, the ultimate test of ACAR-type programs will rest on knowing their impact on a specific set of farms over a period of time. The framework used herein lends itself to this kind of analysis, but longitudinal data will be necessary. This kind of data is, of course, expensive to collect, but the payoff may merit the expenditure.

The discussion herein has concentrated on the economic and technical impacts of extension programs. Clearly, such programs have motivational and educational goals that cannot be assessed with the economic tools proposed. However, improvements in the methodology for measuring what is clearly economic may assist in making a more general evaluation of such programs.

REFERENCES

ALVES, R.A. **An economic evaluation of the impact of an extension program, Minas Gerais Brazil.** Purdue University, 1968. Unpublished Master's thesis.

FARRELL, M.J. The measurement of productivity efficiency. **J. Royal Stat. Soc., 120**:253-81, 1957.

FREUND, J.E. **Mathematical statistics**, Englewood Cliffs, New Jersey, Prentice Hall, Inc., 1964. p.290-2.

JOHNSON, G.L. Supply functions – some facts and notions. In: HEADY, E.O. et alii. **Agricultural adjustment problems in a growing economy.** Ames, Iowa, The Iowa State Press, 1965. p.74-93.

KLEIN, L.R. **A Textbook of econometrics.** Evanston, Row, Peterson and Company, 1953.

NERLOVE, M. **Estimation and identification of Cobb-Douglas production functions.** Chicago, Rand McNally and Company, 1965.

NICHOLLS, W.H. & PAIVA, R.M. The structure and productivity of brazilian agriculture. **J. Farm Econ., 47**: 360-1, May 1965.

RIBEIRO, J.P. & WHARTON JUNIOR, C.R. The ACAR program in Minas Gerais, Brazil. In: WHARTON JUNIOR, C.R., ed. **Subsistence agriculture and economic development.** Chicago, Illinois, Aldine Publishing Company, 1969. 424-37.

SCHUH, G.E. & ALVES, E.R. **The agricultural development of Brazil.** New York, Frederick A. Praeger Publishers, Ind., 1970.

WHARTON JUNIOR, C.R. **A case study of the economic impact of technical assistance, capital and technology in the agricultural development of Minas Gerais, Brazil.** Chicago, Illinois, University of Chicago, 1958. Unpublished Ph.D. thesis.