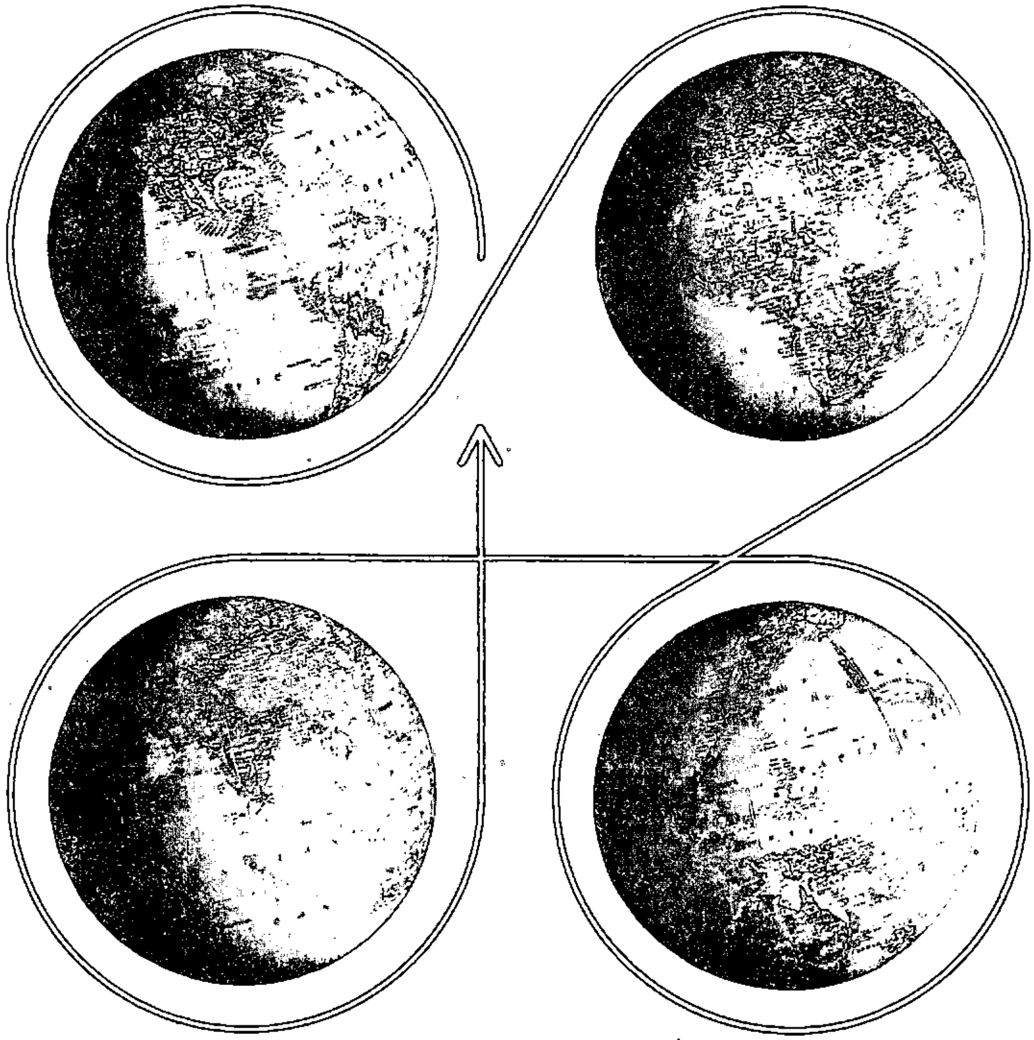
CORNELL INTERNATIONAL AGRICULTURE MIMEOGRAPH 84



APPLYING EFFICIENCY ANALYSIS TO SMALL FARMS IN LOW INCOME COUNTRIES: SOME THEORETICAL AND EMPIRICAL CONSIDERATIONS

Douglas Pachico

DEPARTMENT OF AGRICULTURAL ECONOMICS
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York

November 1980

THE Program in International Agriculture publishes manuscripts resulting from international research and other activities of faculty and graduate students in the College of Agriculture and Life Sciences at Cornell University. A Bulletin Series and a Mimeograph Series include comprehensive and definitive topics relating to international agricultural and rural development. An annual Dissertation Abstract Series summarizes the Cornell Ph.D. theses concerned with agricultural and rural development abroad.

A list of topics published in these series may be obtained from the Program in International Agriculture, 252 Roberts Hall, Cornell University, Ithaca, New York 14853. Upon written request, educational, research and other public and private organizations will be placed on a mailing list to obtain future publications.

Single Copy Free
Additional Copies 25¢ Each

4/81 CU 1.2M

APPLYING EFFICIENCY ANALYSIS TO SMALL FARMS IN LOW INCOME COUNTRIES: SOME THEORETICAL AND EMPIRICAL CONSIDERATIONS

by

Douglas Pachico

Department of Agricultural Economics

New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York

November 1980

Applying Efficiency Analysis to Small Farms in Low Income Countries: Some Theoretical and Empirical Considerations

Douglas Pachico*

The success of policies for raising agricultural productivity and improving the welfare in low income countries may often depend very substantially upon the quality of decision making by farmers. For example, both the rate of diffusion and the magnitude of the benefits derived from new agricultural technologies may be significantly related to farmer decision skills. The better farmers are able to evaluate the advantages and disadvantages of new technologies and the sooner farmers learn to use new technologies, the faster will be the spread of profitable new technologies. Likewise, as farmers become more highly skilled in managing new technologies, they will realize the full potential benefits of new techniques.

Efficiency is the main concept with which economists have analyzed the quality of farmer decision making. Efficiency refers to the degree to which producers are achieving the greatest possible output given available resources and techniques. It is a particularly important consideration for most low income countries for a variety of reason's. Since endowments of productive resources are frequently relatively low in developing countries, it is an especially urgent concern to produce as much as possible with those scarce resources.

Furthermore, the efficiency of farmer decision making can influence the design of development strategy. If farmers are inefficient in their management of resources, then agricultural production can be raised by simply improving the allocation of resources without having to develop new technolo-. gies. On the other hand, if new highly productive technologies are developed, inefficient decision making reduces the gains from these technologies, both to farmers and to society as a whole. In either case, policy makers may want to know what can be done to reduce inefficiency where it exits. An important tool for increasing the ability of farmers to make efficient decisions may be investment in the human capital of farmers through education.

This paper discusses several issues that affect the suitability of efficiency analysis for the assessment of the rationality of resource management in the agricultural sector of low income countries, particularly in the case of traditional peasant farmers. The two major components of overall economic efficiency—allocative efficiency and technical efficiency—will be defined; various approaches to their estimation will be described; and some empirical results from studies of farmer efficiency in low income countries will be

*Research Associate, Centro Internacional De Agricultura Tropical (CIAT), Call, Colombia.

reported. Next, the appropriateness of the efficiency criterion as a guide to public policy will be critically explored. Finally, some problems of measurement and specification which can complicate the interpretation of the results of empirical estimates of efficiency analysis will be examined. Throughout this paper the impact on efficiency of investments in the human capital skills of farmers will receive special attention because there exists a range of policies which may be effective in promoting agricultural productivity by improving farmer efficiency.

Allocative Efficiency

In microeconomic theory it is typically assumed that firms attempt to maximize profits. That is, they try to obtain the highest possible value of production net of the costs of producing. Given competitive markets, certainty, and no input constraints, profits will be maximized where the levels of inputs are set such that the marginal value products of variable inputs are equated with the marginal cost of variable inputs. If the cost of a resource is less than its marginal value product, profits are at less than a maximum because an additional unit of input would give a greater return than its. costs. Conversely, if the cost of a resource is greater than its marginal value product, profits are also at less than a maximum. Allocative inefficiency, which occurs when the marginal value product of a resource is not equated with its cost, represents resource wastage. Inefficient farmers earn reduced profits from their resources and have, as a result, a decreased income and welfare.

The allocative efficiency of farms can be investigated through production function models. In such analysis output is a function of the levels of inputs. The marginal value products of inputs can be computed from an estimated production function and these can be compared with the prices of inputs in order to determine the degree of allocative efficiency. Where farmers are found to have marginal value products not statistically different from the marginal costs of resources, they are allocatively efficient and net incomes are at a maximum given the technology and prevailing prices.

Several studies have utilized production functions to appraise the allocative efficiency to peasant farmers in low income countries. Despite some problems associated with testing for farmer efficiency, discussed in the final section of this paper, the general consensus of opinion today is that small peasant farmers are generally efficient in their use of resources.

Sidhu (1974) discovered no evidence of inefficiency among wheat farmers in the Indian Punjab. Welsch (1965) used production functions to estimate the marginal productivity of resources for a sample of Nigerian farms, then computed the regression coefficient that would be necessary to equate the marginal value product of a resource with its cost. He then tested for efficiency by seeing whether this optimal regression coefficient was statistically different from the actual estimated coefficient. Welsch's results indicated that the Nigerian farmers in his sample were efficient in allocating most resources on most crops. This methodology was also used by Chennareddy (1967) for a sample of South Indian farms and by Pachico (1980) for a sample of Nepalese hill farms. Both found that farmers were usually allocatively efficient. Farmers are also reported to be allocatively efficient in studies by Sahota (1968) and Hopper (1965).

The thrust of the above empirical evidence suggests that traditional farmers are frequently allocatively efficient. This in turn implies that new technology is required to achieve greater agricultural productivity since there are no gains to be made from increasing allocative efficiency among traditional farmers. Once the productivity augmenting process of technical change is initiated, however, farmers move out of a traditional system where the characteristics of the technology are fully understood and where allocational efficiency prevails.

Schultz (1.975) has argued that traditional farmers are in an efficient long run equilibrium because through generations of trial and error farmers have come to an understanding of their production processes that approaches the neo-classical assumption of perfect information about production possibilities. When traditional technologies are supplanted by new, farmers face a more complex and dynamic environment where optimal farm strategies can no longer be identified from the fully known traditional wisdom. The penetration of new technology into traditional farm systems results, therefore, in a tendency for it to be far more difficult for farmers to be allocationally efficient. Even though productivity typically cannot be raised in traditional farm systems by means of improving farmer efficiency, as soon as new productivity enhancing technology is introduced, efficiency reemerges as a concern.

Improved ability of farmers to make allocational decisions can reduce inefficiency and increase incomes and productivity. Since investments in the human capital of farm managers through, for example; schooling or extension, may raise the ability of farmers to make allocational decisions, such investments may be of particular importance once a process of technical change has begun. Schultz (1975) maintains that as disequilibrating technical change proceeds, the returns from human capital increase since a large part of the contribution of human capital may lie in its effects on the ability to manage resources in an optimal fashion. Increases in human capital may not serve so much to extend the boundaries of the firm's production possibility surface as would be the case for other more conventional inputs, but rather human capital may improve upon the decision maker's ability to reach an optimal point on that surface.

Welch (1970) has elaborated an extension of microeconomic theory which systematizes a conception of how decision skills or human capital can contribute to allocative efficiency. This allocative effect of human capital can be derived from a net revenue function.

$$(1)\quad Q_n = pq(X,Z) - P_x X$$

where:

Q_n = net revenue

X = variable inputs

Z = fixed inputs

P_x = prices of variable inputs.

In equation (1) an important distinction is drawn between the variable inputs, X, and the fixed inputs, Z. While the fixed inputs are exogenous, the levels of the variable inputs are determined by the decision maker. For a profit maximizing firm the levels of the variable inputs should be chosen such that the marginal value of each input equals its cost. Thus, human capital may have an allocative effect of enabling managers to select levels of variable inputs so that marginal products of variable inputs equal marginal costs. The allocative effect of human capital can be expressed as:

$$(2) \quad \frac{dQ_n}{dX} - P_x \frac{dX.}{dE}$$

Welch suggests that an estimate of this allocative effect of human capital on productivity can be obtained by regressing net revenue on fixed inputs and human capital since the variable inputs, X, ". . . can be excluded as an explicit variable and education included, in which case the marginal product of education reflects comovement between X and E with any resulting allocative gains or losses." (Welch, p.44)

Technical Efficiency

The discussion of efficiency has thus far concentrated on the allocational decisions of firm managers. Although this is a key component of economic efficiency, which until Liebenstein's (1966) seminal article, was considered practically synonymous with efficiency, current theory views efficiency as comprised of allocative and technical efficiency. Technical efficiency refers to whether firms obtain the maximum amount of output given the inputs of production. That is, a technically efficient firm is on the boundary of its production possibility surface while a firm that is also allocatively efficient is on that point on the boundary which is tangent to the ratio of input prices.

Traditionally economic theory had treated technical efficiency as an engineering problem and assumed that economic analysis applies to improving: allocational efficiency. "The production function differs from the technology in that it presupposes technical efficiency and states the maximum output obtainable from every possible input combination. The best utilization of any particular input combination is a technical, not an economic, problem," (Henderson and Quandt. 1971, p. 54). It is now believed, however, that, technical inefficiencies may result in even greater wastage of resources than allocative inefficiency (Timmer 1970). To assume that firms produce the maximum possible output given a set of inputs now appears to assume away an important question.

Differences among firms in their abilities to be technically efficient are essentially differences in management. Technical inefficiency results from firms not fully understanding their underlying production functions. The "best practice" firms which do fully understand the available technology produce more output from their resources than other firms in the same industry. The major sources of technical inefficiency are the complexity of the given technology and the rate of change of the technology. Clearly, where the production process is highly complex, it is more difficult for a firm to organize its internal operations to achieve the maximum possible output. It might be expected, though, that should the technology be static, over time all or most firms would be able to achieve technical efficiency.

With the introduction of technological change, however, technical efficiency becomes far more elusive. Where the technology is changing rapidly the best managed firms will be able to more quickly adapt to new processes and to utilize them to their maximum benefit. As with allocative efficiency, once technical change becomes important, inefficiency becomes a greater problem. Likewise, as with allocative efficiency, it is reasonable to expect that the human capital of firm managers may improve their ability to attain technical efficiency. Therefore, in a strategy of agricultural development focusing on the introduction of new, more productive technology, technical inefficiency is likely to emerge as a major concern and investments in the human capital of farmers may be an important policy tool for increasing output by reducing inefficiency.

Several methodologies have been developed in order to empirically implement the concept of technical efficiency. Perhaps the most common approach has been to compare the behavior of best practice firms with other firms. This typically entails the use of linear programming to estimate a "frontier production function" of the most productive firms (Farrell 1957, Aigner and Chu 1968). The relative technical efficiency of other firms can then be measured by comparing their performance to that of the best practice firms.

Some taxing problems are associated with this approach, the most prominent of which may be the reliance on outliers for the computation of the frontier function. Not only are the data for the vast majority of firms not utilized in the computation of the frontier function, but the estimation may be highly sensitive to extreme values. Even if they do. not reflect measurement error in the observed variables, always a danger among outliers, they may represent "an unusual endowment of some fixed factor of production, such as entrepreneurship, or luck ... or of noise in the universe, and as such it can imply nothing systematic about efficiency" (Yotopoulos 1974). Moreover, since the estimated frontier relationships are efficient only relative to observed firms, not to any actual, underlying production relationship, whether <u>any</u> firms are truly technically efficient cannot be answered from this approach (Carlson 1976).

An alternative method for measuring differences in technical efficiency which utilizes data from controlled experiments to estimate the frontier, production function has been recently developed. (Herdt and Mandac, forthcoming). Data gathered by IRRI agronomists from experiments conducted on farmers' fields were used to estimate a frontier or technically efficient production function. The degree of technical inefficiency of farmers can then be calculated from the difference between actual yields and the yields that technically efficient producers are estimated to get from the same levels of resources as the farmer used. Both technical and allocative efficiency of the 56 sample farms were estimated and only 25 percent of the farmers were found to be less than 20 percent from the technically efficient output level while 41 percent of the farms were less than 20 percent from the allocative optimum. Of the difference between actual and maximum possible yields, 63 percent of the gap was due to technical inefficiency and only 31 percent due to allocative inefficiency.

Although Herdt and Mandac (forthcoming) (see also Mandac and Herdt 1978) have developed an interesting approach which provides some tentative indication of the relative importance of technical and allocative efficiency in rice production in the Philippines, two problems qualify the wider application of this methodology. First, it is not clear whether the experimental data does in fact lie in the production possibility set that the farmer actually faces. Production by agronomists in a controlled experimental framework may be sufficiently different from production by farmers that agronomists and farmers simply have different production possibility sets. Therefore, the level of farmer technical inefficiency in terms of the difference between actual farm yields and what could be produced in farm conditions may be overstated by comparing farmer yields with the experimental result. A second difficulty with the methodology is that it requires both farm survey and experimental data. While this is neither impossible nor unreasonable, such combinations of data sets are neither widely available at present nor inexpensive to obtain.

A third approach to estimating technical and allocative efficiency utilizes profit function models (Lau and Yotopoulos 1971, Yotopoulos and Lau 1973). This method depends upon the theoretical duality between production functions' and profit functions. For every production function there exists a corresponding profit function where profits are a function of input prices and fixed inputs. Differences in technical efficiency between groups of firms can be observed through neutral shift parameters, that is, differences in the constant term between estimated profit functions for two groups of firms. This methodology, besides being of questionable use in a multiproduct situation since profit is expressed as unit-output-profit, only permits the examination of relative technical efficiency between groups and can say nothing about the absolute level of technical efficiency. Furthermore, this methodology is usable only where there are differences in the prices of resources and output among farmers.

Having defined technical efficency and briefly reviewed some approaches to its estimation, it is important to consider the causes of differences in technical inefficiency among firms. Herdt and Mandac (forthcoming) hypothesize that technically inefficient farmers are older, less educated, lacking in technical knowledge, devoting more time to non-farm activities and cultivating larger areas. Shapiro and Muller (1977) find that differences in technical efficiency are related to scores on composite modernization indices derived from factor analysis. Items included in the factor analysis scale include knowledge of new technology, knowledge of factor and product prices, knowledge of local agricultural officials and various proxies for wealth. Timmer (1970) hypothesized that older arid less educated farmers would be less technically efficient, but his results from the United States did not support this hypothesis. The approach taken in all these studies is to first estimate a technically efficient production function, and then to regress the firm by firm deviations from the technically efficient function on a set of hypothetically relevant explanatory variables.

Some economists evince a substantial skepticism about such procedures and about the very validity of the concept of technical efficiency (Yotopoulos 1974, Muller 1974). It is argued that differences in observed technical efficiency are likely to represent differences either in technology or in unmeasured inputs. Muller suggests that there are three types of explanations of why not all firms lie on a single isoquant as one might expect from optimal behavior of firms and the theory of production: differences in technology, random effects, and actual differences in technical efficiency.

If production technology differs among firms, then there is no basis for comparing efficiency since firms are on different production surfaces. Alternatively all firms may face the same production surface, but different outputs are obtained due to stochastic disturbances. In this case there are no systematic differences in technical efficiency. Consequently, when a production function is estimated by ordinary least squares, the whole question of technical efficiency drops into the residual error term. This view, though, does not seem completely adequate because the residual error can be conceptually partitioned both into a stochastic component and into "real" differences in technical efficiency.

The empirical problem of measuring the technical efficiency; of individual firms then becomes how to discriminate between stochastic elements and actual differences in technical efficiency as components of the residual error term. Given any firm that is producing an output other than that predicted by the estimated production function, the crucial methodological question for estimating technical efficiency is: what part of that firm's deviation from the predicted output is the result of true differences in technical efficiency and what part is due to random processes?

If the true efficiency differences could be separated from the stochastic elements, then the relative technical efficiency of individual firms could be detected by examining the residual error terms from an estimated average production function. A positive residual error term for a firm would indicate above average efficiency since farms with above average efficiency will be producing more output from their resources than would be predicted by the model of production. Conversely, technically inefficient firms would be producing less from their resources than predicted by the production function.

An interesting problem is posed by the fact that there are observed differences in efficiency given the same levels of inputs. One explanation is that the levels of inputs are not the same because some inputs are not measured. Technical inefficiency in this view is merely a form of specification error. For example, knowledge of the underlying production process is as much a part of the appropriate specification of a production function as are measures of conventional inputs and outputs.

Likewise, there may be differences in such inputs as entrepreneurship or varieties of seed (Yotopoulos 1974). Thus, a large part of differences in technical efficiency may be accounted for by differences in unmeasured inputs, in particular, knowledge or technology. "Firms at the industry frontier have available some additional inputs which make them seem more efficient" (Muller 1974, p. 737). In this view production functions are best estimated through the standard regression framework although additional care is required to specify all the relevant inputs to production.

Timmer (1970), who uses a frontier production function analysis, would essentially agree with much of the above position. In this view technical change and the process of the diffusion of innovation over time, along with management factors account for cross sectional differences in the observed technical efficiency of best practice and average firms. Hence, the very usefulness of frontier production function analysis is to identify first, the best practice firms, and secondly what characterizes them as a group. Such analysis can provide a utilitarian understanding of what, at a given point in time, is limiting productivity. Although in the context of neo-classical assumptions, like the instantaneous adoption of profitable technology, there may be no place for technical efficiency, the estimation of technical efficiency may be useful "as a first step to identify the additional inputs which cause the efficiency differences" (Muller 1974, p. 737).

Nevertheless, it is clear that there is a substantial body of opinion that views management, information, or to use the umbrella term, human capital, as a key factor in differences in technical efficiency is. adumbrated in Welch (1970). One of Welch's allocative effects of human capital might best be called a "techno-allocative" effect, since "producers are mistaken about the true values of certain parameters of the production function" (Heibert 1974, p. 766).

Welch's techno-allocative contribution of human capital to productivity can be derived from an equation for the value of gross output for a multi-product firm, in the example in equation (3) a two product firm.

$$(3) \quad Q_s = p_1 q_1 \,(X_1) + p_2 q_2 \,(X_2)$$

$$(4) \quad X_1{}^i + X_2{}^i = X^i$$

where:

Q_s = gross value of output

q_1, q_2 = outputs

p_1, p_2 = prices

X_1, X_2 = inputs used in producing q_1, q_2

X^i = total of input i available for production of either q_1 or q_2

The total inputs available for production, X^i, is fixed and exogenous to the decision maker, but the levels of the inputs allocated to producing each of the products of the firm are not predetermined. The variables $X_1{}^i$ and $X_2{}^i$ are the decision variables of the firm. For a profit maximizing firm facing competitive markets equation (5) holds in equilibrium.

$$(5) \quad p_1 \frac{dq_1}{dX_1{}^i} - p_2 \frac{dq_2}{dX_2{}^i} = 0.$$

That is, the marginal value product of any input i is equal in alternative uses. Although efficient profit maximizing firms should be operating in this equilibrium condition, Schultz (1975) has pointed out that where production relations are highly complex or rapidly changing, firm managers may have an imperfect understanding of the production function which they face and thus they may not be able to equate marginal value products of resources across alternative uses. Since human capital may improve the ability to allocate resources efficiently, the techno-allocative effect of human capital can be expressed

$$(6)\quad \frac{dQ_s}{dE} \left(p_1 \frac{dq_i}{dX_1^{\,i}} - p_2 \frac{dq_2}{dX_2^{\,i}}\right) \frac{dX_1^{\,i}}{dE}.$$

Welch suggests that an estimate of this techno-allocative effect of human capital can be obtained by comparing the marginal products of human capital from the engineering function with that obtained from a gross sales function since the estimated coefficient of a human capital variable in a gross sales equation includes both the worker effect and the techno-allocative effect.

Thus far the definitions and empirical approaches to technical and allocative efficiency have been discussed. Some empirical results have been alluded to and the theoretical bases of these studies have been briefly reviewed. Efficiency has been shown to be a concept which focuses attention on the wastage of resources, and is therefore, of particular relevance in the context of agriculture in low income countries. It has been argued that efficiency is of relatively less importance in a traditional agriculture though both allocative and technical efficiency are likely to become issues of greater concern once the process of technical change has been introduced into a heretofore traditional environment.

It has been pointed out that many economists view human capital—a general term for education, communications and information—as an important factor in reducing both technical and allocative inefficiency, thus leading to greater farm incomes and welfare as well as greater output from the agricultural sector. This focus on the importance of efficiency and the potential impact of investment in human capital on reducing inefficiency, must be tempered by a recognition of some difficulties both in the empirical implementation of the efficiency criterion as well as shortcomings of the criterion as a guide to sound social policy.

Efficiency as a Criterion

In examining the usefulness of efficiency as a criterion to evaluate policy, it is important to note that efficiency is an indicator not of welfare, but of rational utilization of resources. Small farmers, for example, may be very efficient but still have low per capita incomes or still operate farms where the productivity of resources is low. If farmer objectives are taken to be obtaining the highest possible ncome with given resources, then efficiency directly corresponds to the achievement of this objective. If, on the other hand, farmer objectives are taken to be attainment of a specific standard of welfare or income, then efficient decision making does not necessarily lead to the achievement of objectives when resources are limited.

For the attainment of the maximum income with a particular endowment of resources, efficiency is a necessary and a sufficient condition. For the attainment of a given level of income, efficiency is neither a sufficient nor a necessary condition. Individuals with substantial resources may get high incomes despite being inefficient while individuals with few resources may obtain low incomes despite being efficient.

Although efficiency denotes the individual rationality of farms in terms of achieving farm level objectives, such as profit maximization, in the aggregate the collective behavior of numerous individuals acting efficiently and rationally in pursuit of their own private interests may be disastrously irrational and inefficient from the wider perspective of collective or social interests. For instance, farmers may very efficiently use public pastures or forests, deriving maximum current benefit from grazing livestock and obtaining firewood at minimum cost to insure the objectives of short term survival and maintenance of the standard of living of the farm family. Nevertheless, the total impact of many farmers efficiently exploiting pastures and jungles may be to deplete and irremediably degrade the natural resource base and thus undermine the long run survival prospects of the entire community. Such problems, it may be emphasized, are no less common in high income industrialized societies than in peasant communities.

It is essential to affirm that efficiency characterizes the quality of decisions taken in the context of fulfilling some pre-specified goal. If individual objectives are incompatible with collective welfare, then individual efficiency in the attainment of objectives may be something less than a social good. The efficiency criterion takes objectives as exogenously given and on the basis of efficiency considerations it is impossible to evaluate the desirability of alternative objectives. Efficiency has a fairly clear, if limited, meaning and it may certainly be an important criterion of individual or social behavior. Nonetheless, efficiency is applicable only within the context of achieving predetermined goals while the structure of social and individual goals frequently may be of far more importance.

In part because the efficiency criterion takes objectives as given, it tends to be embodied in a particular social context, that of a free market exchange society. This may make judgments based on efficiency somewhat misleading when applied in a different social setting. Where competitive markets prevail with profit maximizing individuals, prices in theory reflect directly the underlying preferences of individuals. In this sense, prices may be taken as fit indicators of social value.

Where markets are imperfect or public goods or externalities exist, prevailing prices bear no necessary relation to general equilibrium social value. Even with perfect markets and no public goods or externalities, perhaps a somewhat unlikely state of affairs, prices may not be appropriate indicators of social value because they are determined, in part, by the distribution of resources in society. A different distribution of resources would result in a different composition of effective demand and hence a different set of market prices.

Thus it could be of questionable desirability for farmers, for example, to respond efficiently to a set of prices that in some sense does not correspond to consensual social value. Such concerns underly the dependency theory literature on terms of trade between agriculture and industry, the center and the periphery, and unequal exchange. These approaches dismiss efficiency as a major concern, focusing instead on the process whereby the prices which are used to judge efficiency are generated (de Janvry 1975).

It is also important to note that efficiency of all farms does not imply that total agricultural output is maximized given currently available technology, but instead it only indicates that total output is maximized given a particular distribution of resources. Changing the distribution of resources may in some circumstances lead to an increase in total production. Hence, even where all farms are efficient, there may be scope for increasing output given a constant technology. An extensive literature on the relative productivity of small versus large farmers attempts to address this problem (see, for example, Lau and Yotopoulos 1971). Associated with this concern is an extensive literature on land tenure systems and their effects on productivity (Griffin 1974, Dorner 1972). In this view, then, even where farms are efficient, output may be increased through changes in land tenure systems and the redistribution of resources.

Under some rather uncommon conditions, efficient behavior by all individuals and firms would theoretically lead to a type of general social efficiency, Pareto Optimality. A social state is efficient or Pareto Optimal, if, given the initial distribution of resources among individuals in society, neither production nor distribution can be reorganized to improve the welfare of any member of society.

A necessary condition for Pareto Optimality is that all individual firms be technically and allocatively efficient. The dependence of this general state of social efficiency on the allocative and technical efficiency of individual firms gives somewhat greater force to the importance of firm efficiency. It is not merely a question of maximizing income or welfare of certain individuals or maximizing output in a particular sector, but individual efficiency is linked through the concept of Pareto Optimality to a general, though theoretical, state of greatest welfare for all.

This general social efficiency is somewhat parallel to a state of efficiency for a firm where more profits cannot be made in any enterprise without reducing profits in another. This state of Pareto Optimality, however, may not only be unlikely to be attained, but it may not be a fully adequate measure of social welfare and thus the significance of individual firm efficiency as it contributes to the achievement of Pareto Optimality is thereby lessened.

Efficiency may not be a universally acceptable social criterion, first because it does not admit the discussion of the social desirability of the initial distribution of resources which results in a particular distribution of welfare that may, indeed, be efficient though perhaps highly unequal. Second, the collective efficiency or Pareto criterion rules out the possibility of policies that, for example, substantially increase the welfare of a large number of the least well off members of society at the expense of even a small sacrifice on the part of even a few of the most well off members of the community.

Third, for any given initial distribution of resources there exists, in general, not one, but a multitude of Pareto Optimal states, each of which implies a different distribution of welfare among members of society. Efficiency, then, does not usually lead to a uniquely preferable social state but rather leads to the specification of a number of efficient states each of which has different consequences for individual welfare. Since it is not possible to choose from among these potential efficient states by means of the efficiency criterion, the criterion is both vague and indeterminate.

To summarize this discussion of the applicability of the efficiency criterion, efficiency is of clear importance in that it directs attention to problems of resource wastage. It is, however, in many respects a limited criterion and efficiency alone may be a poor guide to policy. Farmers may be efficient but nonetheless poor and of low productivity. Individual farms may be efficient and thus rational while at the same time the collective behavior of all efficient farmers may be disastrously irrational. Efficiency is of relevance only with respect to given objectives although the specification of objectives may upon occasion be of great importance. Efficiency tends to be. expressed in terms of prevailing prices which may not be sound indicators of social value. Even if all farms are efficient, less than the maximum total output that is feasible with given technology may be produced depending on the distribution of resources. Individual firm efficiency is a necessary condition for a universal social efficiency or Pareto Optimality and is of particular concern in consequence. Pareto Optimality may not be a universally acceptable criterion both because it does not incorporate distributional considerations and also because it is indeterminate.

Problems of Interpretation of Efficiency Analysis

Even if efficiency is accepted as a reasonably valid criterion despite the above noted theoretical issues, difficulties can occur in measuring costs and profits as well as in correctly specifying the objective function of the firm. Either of these problems may lead to inefficiency being apparently observed even where it does not actually exist. These problems will now be briefly addressed in turn.

To measure profits, metrics for both cost of inputs and the value of output are required. For the case of a firm purchasing its inputs and marketing its produce, market prices are generally agreed to be an appropriate numeraire for the analysis of firm level behavior, even though market prices may not be. wholly acceptable indicators of social value. Many farms in low income countries, however, are primarily subsistence operations which buy few inputs and sell only a small portion of output. Consequently, for such farms market prices may not be a relevant concern.

Unpurchased inputs to production on the subsistence farm, for example, land or family labor, might be valued at market prices with prices measuring the cost of resources as an opportunity cost; that is, what the resource could have earned in the most remunerative alternate use. This may be difficult to implement where markets or prices for inputs are not established, for example, for cattle dung or child labor herding goats. Furthermore, even where prices exist, they may not realistically represent a return which could have actually been obtained from a resource. Wages do not reflect the opportunity cost of family labor if there is no real chance of obtaining employment. It is common in village economies for there to be few available employment vacancies. In this situation, wages may offer a poor guide to the opportunity cost of family labor. Similar conditions often exist with respect to land.

In a subsistence setting trading in farm products may be uncommon and prices to value output may be lacking. Where farm production is primarily for subsistence consumption, and where alternative supplies of food are not reliably available, it is not clear that farmers will value output at some equivalent of market prices in their own decision calculus. When market prices are imputed for resources and output on subsistence farms, it is not uncommon to find subsistence farmers producing at an imputed loss inferring a possibly undeserved economic irrationality on the part of farmers who may be quite successfully providing for their family's subsistence needs (Sen 1966, Paglin 1966).

These problems of valuing resources and output for subsistence farms can complicate the empirical examination of allocative and technical efficiency. Among commercialized farmers for whom market prices are realistic measures of costs and returns, the estimation of allocative and technical efficiency can proceed without difficulty. Analysis of the behavior of subsistence farmers can be more problematic. If subsistence farmers cost inputs and value outputs on some subjective basis other than market prices, then it can be misleading to measure allocative efficiency of these farmers using estimates of marginal cost and marginal value product of resources derived from market prices. Apparently inefficient behavior can be observed simply because subsistence farmers are not responding to market valuations.

When considering technical efficiency, the use of market prices again seems appropriate for commercialized farmers but it is more questionable when applied to the situation of subsistence farmers. If inputs and output can be measured in physical terms, for example; days of labor or kilograms of output, then the estimation of technical efficiency is straightforward. Generally, inputs can be measured in physical units but when multiple products prevail, physical units may not be suitable measures of output. For instance, it makes little sense to add kilograms of rice and soybeans.

For commercialized farmers both technical and allocative efficiency can be measured using market prices. For subsistence farms, estimating allocative efficiency through market prices may not represent the actual decisions that the farmers are making. On the other hand, the technical efficiency of subsistence farmers can be estimated in a straight forward manner by using physical measures except in the case of multiple outputs.

For empirical estimates of efficiency to be meaningful, not only must costs and returns be measured in a suitable fashion, the objective function hypothesized for farmers in the analysis must correspond to the actual objective function of farmers. Since allocative and technical efficiency measure resource wastage incurred in the process of attempting to achieve a specified goal, it is clearly desirable to examine the quality of farmers' resource use in terras of how well it leads to the attainment of actual farmer, objectives. If farmers are pursuing aims other than those hypothesized for them in the analysis, then observed inefficiency may give a misleading portrayal of the quality of farmer decision making.

Although this discussion of efficiency has so far made the usual micro-economic assumption of the profit maximizing behavior of farmers, in fact farmers may pursue objectives other than profit maximization. If farmers are not attempting to maximize profits, the applicability of efficiency analysis may be somewhat dubious. The presence of risk or uncertainty, for example, can vitiate the usefulness of production function estimates of allocative efficiency as a measure of the quality of farmer decision making although it does not affect estimates of technical efficiency except as a component of the error term. With respect to allocative efficiency, when risk or uncertainty is present, the optimal condition for a decision maker may be one where mar-; ginal cost is not equated with marginal value product. Hence, a farmer who, is observed to be not equating marginal costs and returns, may be facing risk rather than wasting resources through inefficiency.

Theory suggests that with risk, the optimal input level occurs when marginal factor cost is equated with marginal expected value product <u>minus a</u> marginal risk deduction which depends on the utility function of the decision maker and the marginal variance or revenue. Only in the cases when the decision maker is risk neutral or the variance of output is not affected by the level of the decision variable will decision making under uncertainty be equivalent to decision making with certainty (Anderson et al. 1977). In general, the marginal value products of resources may be expected to be less than their marginal factor costs under conditions of risk, and farmers facing, risk may appear to be inefficient even when actually making optimal decisions.

While the consideration of risk may serve to undermine the suitability of the standard tools of efficiency analysis as indicators of rational decision making, the existence of risk may actually reinforce the importance of human capital as a factor in improving the ability to manage production. Risk may., be defined as the subjective probability of the distribution of outcomes of an act (Roumasset 1976). If human capital can increase the knowledge that a decision maker has about the consequences of alternative actions., it effectively reduces risk. The ability of farmers to obtain and interpret information may not only promote technical and allocative efficiency as discussed* above, but it may also lessen risk.

Because in one sense risk simply represents a lack of complete information, every decision maker may be efficient given the amount of information available. "In a world where every individual is asserted to behave consistently with constrained maximization, economic inefficiency presents a contradiction in terms. Even outright mistakes are traceable to constraints of some type" (Cheung 1974).

This view suggests that all decision makers may be efficient in terms of selecting the preferred alternative given the circumstances. If information is as much a factor of production as capital or labor, and if a producer could have obtained more output only by having had additional information, then it makes as little sense to characterize decisions made in this environment as inefficient as it would be to call a farmer inefficient because more could have been produced had there been additional capital. Efficiency, it ought to be repeated, refers to the quality of decision making relative to resources on hand.

> To conclude that firms or markets are inefficient because of imperfect knowledge or uncertainty is to say little more than that decision makers would select other choices if uncertainty and imperfect knowledge were not facts of life. Since information is scarce and cannot be obtained at zero cost, firms and markets operating under real world conditions will yield different outcomes than those implied by the perfect market norm. (Pasour and Bullock 1975).

Such a perspective in essence suggests that in a world of uncertainty information is a factor of production that leads to greater output by reducing risk. It adds weight to the possible importance of human capital in contributing to increased productivity while at the same time casting doubt on the usefulness of the concept of efficiency as a criterion of rational decision making.

Summary and Conclusions

Because it may be important to maximize the productivity of available scarce resources, especially in low income countries, the analysis of farmer efficiency may be an important focus of research even though efficiency alone is not a completely suitable criterion to guide public policy. This paper has considered some aspects of the utility of efficiency analysis to appraise the quality of decision making by farmers in low income countries. The theoretical distinctions between allocative efficiency and technical efficiency as components of overall economic efficiency have been discussed.

Allocative efficiency essentially pertains to the ability of producers to select profit maximizing levels of variable inputs while technical efficiency consists of obtaining the maximum output that is possible with available resources. Both technical and allocative efficiency can be particularly difficult for farmers to attain when there is technological change. Thus, while traditional farmers may be expected to be efficient in the more dynamic setting which characterizes most low income countries today, inefficiency may be a problem. The human capital skills of farmers can contribute significantly to the ability of farmers to achieve efficiency. Investments in schooling or extension may thus be a useful policy for promoting efficiency and raising agricultural output.

Some of the main empirical approaches to the analysis of allocative and technical efficiency have been reviewed. Problems of measuring costs and returns as well as of specifying the appropriate objective functions of farmers can make it difficult to interpret the results of empirical studies of efficiency. Nevertheless, there is an emerging consensus of opinion, based on the findings of a number of empirical studies, that the behavior of farmers in low income countries generally appears to be allocatively efficient. Since there may be few gains realized by improving the current aliocation of resources, technical efficiency may be a relatively more important concern.

The examination of technical efficiency is in some senses problematic. Differences in technical efficiency are detected largely through observed differences in resource productivity. Failure to measure all resources, especially information and technology, may be a significant source of apparent differences in technical efficiency. In order to avoid the generation, of misleading results it is necessary to conduct careful studies of farm production systems in low income countries. Detailed micro-studies of the sources of differences in productivity among farmers may, therefore, be as fruitful an area of research as the estimation of either frontier or average production functions.

References

Aigner, D. J. and S. F. Chu. "On Estimating the Industry Production Function." American Economic Review, 1968.

Anderson, J. R. and J. B. Hardecker. "Economic Analysis in Design of New Technologies For Small Farmers." In G. M. Scobie, A. Valdes, and J. L. Dillon, Economic Analysis in the Design of New Technology For Small Farmers. Ames: Iowa State University Press, 1979.

Carlson, D. Calculating Frontier Multi-Product, Multi-Factor Production and Cost Relationship. Berkeley, California: Giannini Foundation of Agricultural Economics, 1976.

Chennareddy, V. "Production Efficiency in South Indian Agriculture." Journal of Farm Economics 49, No. 4, 1967.

Cheung, S. N. G. "A Theory of Price Control." Journal of Law and Economics 17, 1974.

Dorner, P. Land Reform and Economic Development. Hammondsworth, England: Penquin, 1972.

Farrell, M. J. "The Measurement of Productive Efficiency." Journal of the Royal Statistical Society Series A (General), Vol. 120, Part 3, 1957.

Griffin, K. B. The Political Economy of Agrarian Change. New York: Macmillan, 1974.

Heibert, L. D. "Risk, Learning, and the Adoption of Fertilizer Responsive Seed Varieties." American Journal of Agricultural Economics 56, No. 4, 1974.

Henderson, J. M. and R. E. Quandt. Microeconomic Theory. New York: McGraw-Hill, 1971.

Herdt, R. W. and A. M. Mandac, "Modern Technolgy and Economic Efficiency of Philippine Rice Farmers" Economic Development and Cultural Change (forthcoming).

Hopper, W. D. "Allocation Efficiency in a traditional Indian Village." Journal of Farm Economics 47, No. 3, 1965.

de Janvry, A. "The Political Economy of Rural Development in Latin America: An Interpretation." American Journal of Agricultural Economics 57, No. 3, 1975.

Lau, L. J. and P. A. Yotopoulos. "A test for Relative Efficiency and Application to Indian Agriculture." American Economic Review 61, No. 1, 1971.

Liebenstein, H. "Allocative Efficiency vs. 'X-Efficiency." American Economic Review 56, 1966.

Mandac, A. M. and R. W. Herdt. Economic Inefficiency as a Constraint to Rice Yields in Nueva Ecija, Philippines. International Rice Research Institute, Los Banos, Philippines, 1978.

Pachico, D. "Small Farmer Decision Making: An Economic Analysis of Three Farming Systems in the Hills of Nepal." Unpublished Ph.D. dissertation, Cornell University, 1980.

Paglin, M. "Surplus Agricultural Labor and Development: Facts and Theories." American Economic Review 55, 1965.

Pasour, E. C. and J. B. Bullock. "Implications of Uncertainty for the Measurement of Efficiency." American Journal of Agricultural Economics 57, No. 2, 1975. '

Roumasset, J. A. Rice and Risk. , North Holland, Amsterdam, 197.6.

Sahota, G. S. "Efficiency of Resource Allocation In Indian Agriculture." American Journal of Agricultural Economics 50, 1978.

Schultz, T. W. "The Economic Value of the Ability to Deal with Disequilibria." Journal of. Economic Literature 13., No. 3, 1.975.•

Sen, A. K. "Peasants and Dualism with and without Surplus Labor." Journal of Political.Economy. 1966.

Shapiro, K. H. and J. Muller. "Sources of Technical Efficiency: The Roles of Modernization and Information." Economic Development and Cultural Change 25, 1977.

Sidhu, S. S. "Relative Efficiency in Wheat Production in the Indian Punjab." , American Economic. Review 64, 1974.

Timmer, C. P. "On Measuring Technical Efficiency." Food Research Institute Studies 9, No. 2, 1970.

Welch, F. "Education in Production." Journal of Political Economy 78, 1970.

Welsch, D.. E. "Response to Economic Incentive by Abakali Rice Farmers in Eastern Nigeria." Journal of Farm Economics 47, No. 4, 1965.

Yotopoulos, P. A. "Relatively, Efficiency and Organizational Behavior: Through the Production Function Darkly." Food Research Institute Studies 63, No. 3, 1974.

_______________ and L. J. Lau. "A Test for Relative Economic Efficiency: Some Further Results." American Economic Review No. 1, 1973.

CORNELL UNIVERSITY Founded by Ezra Cornell

STATE UNIVERSITY OF NEW YORK — 1948 —
TO LEARN — TO SEARCH — TO SERVE