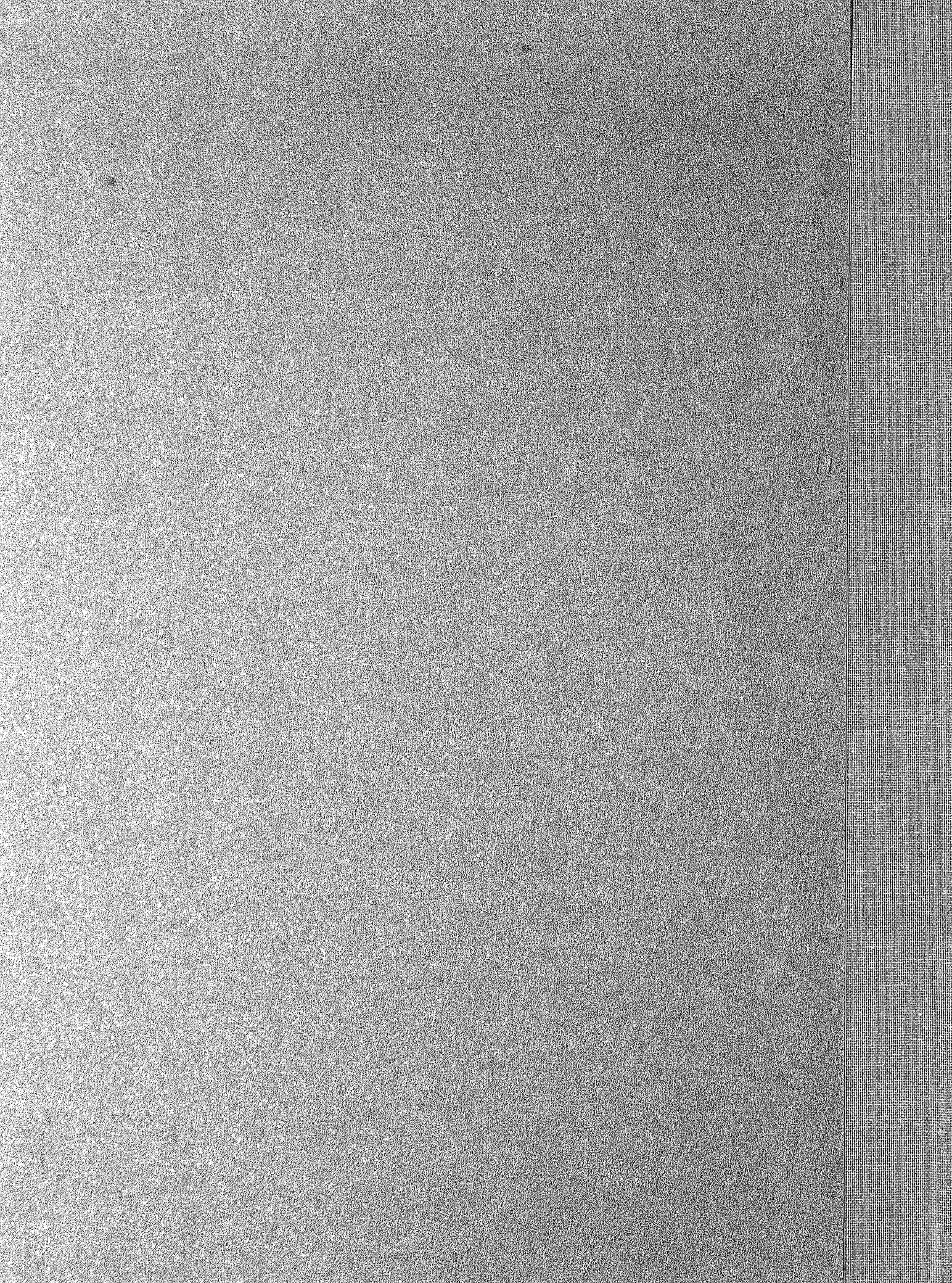


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Efficiency Differentials in Peasant Agriculture
and Their Implications for Development Policies

by

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ABSTRACT

Efficiency Differentials in Peasant Agriculture
and Their Implications for Development Policies¹

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This paper reviews the theoretical and empirical work on allocative efficiency in traditional agriculture and presents a new study of technical efficiency among Tanzanian cotton farmers. The theoretical arguments are shown to apply primarily in a competitive context that differs significantly from that in which peasant farms operate. Reanalysis of earlier empirical studies shows that, on average, the marginal value products of inputs differ by more than 40 percent from the marginal factor costs to which they should be equated under allocative efficiency. Our own study among Tanzanian cotton farmers in Geita District reveals that output could be increased by 51 percent if all farmers achieved those levels of technical efficiency that were in fact achieved by the best farmers in the sample using the same inputs and technologies that the less efficient used. These results indicate that the efficiency hypothesis may not be applicable to much of peasant agriculture and that development policies might fruitfully place more emphasis on raising large numbers of farmers closer to the relatively high efficiency levels achieved by some of their neighbors.

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Ce document passe en revue la recherche théorique et pratique sur l'efficacité d'affectation des ressources dans l'agriculture traditionnelle et présente une nouvelle étude de l'efficacité technique chez les producteurs cotonniers de Tanzanie. Les raisonnements théoriques exposés sont applicables principalement dans un contexte de concurrence qui diffère de façon importante de celui dans lequel les exploitations paysannes fonctionnent. Une nouvelle appréciation des études empiriques antérieures montre que, en moyenne, les produits marginaux en valeur des facteurs de production diffèrent de plus de 40 pour cent des coûts marginaux des facteurs qu'ils devraient évaluer dans l'hypothèse d'une affectation efficace. Notre propre étude parmi les producteurs de coton de Tanzanie dans le district de Geita révèle que la production pourrait être augmentée de 51 pour cent si tous les producteurs atteignaient les niveaux d'efficacité technique qui sont en fait obtenus par les meilleurs du groupe étudié, utilisant les mêmes facteurs de production et les mêmes techniques que les autres. Les résultats indiquent que l'hypothèse de l'efficacité ne s'applique peut-être pas à une grande partie de l'agriculture paysanne et que les politiques de développement pourraient fructueusement attacher plus d'importance à amener un grand nombre de producteurs plus près des niveaux relativement élevés d'efficacité atteints par certains de leurs voisins.

¹Ce document sera présenté à la 16^e Conférence Internationale des Economistes Agricoles à Nairobi, du 26 juillet au 4 août 1976.

Introduction

Decisions about development strategies are in part guided by policy makers' conceptions of farm-level performance. An important aspect of that performance, relative economic efficiency, has been the focus of numerous studies since the early 1960s. The majority of that empirical work is commonly viewed as supporting the hypothesis that traditional agriculture is highly efficient given the available inputs and technologies. Acceptance of that hypothesis by policy makers has led to increasing emphasis on new investments and technologies rather than extension and education efforts aimed at less efficient farmers. If the efficiency hypothesis does not in fact apply to much of peasant agriculture, development policy makers may be overlooking opportunities for relatively inexpensive gains in production.¹

This paper reviews the theoretical and empirical work on allocative efficiency in traditional agriculture and presents a new study of technical efficiency among Tanzanian cotton farmers. The theoretical arguments are shown to apply primarily in a competitive context that differs significantly from that in which peasant farms operate. Reanalysis of earlier empirical studies shows that, on average, the marginal value products of inputs differ by more than 40 per cent from the marginal factor costs to which they should be equated under allocative efficiency. Our own study among Tanzanian cotton farmers in Geita District reveals that output could be increased by 51 per cent if all farmers achieved those levels of technical efficiency that were in fact achieved by the best farmers in the sample using the same inputs and technologies that the less efficient used. These results indicate that the efficiency hypothesis may not be applicable to much of peasant agriculture and that development policies might fruitfully place more emphasis on raising large numbers of farmers closer to the relatively high efficiency levels achieved by some of their neighbors.

The first section of the paper introduces the concepts of allocative and technical efficiency and reviews their theoretical bases. Section two reconsiders the empirical support for the hypothesis that traditional farmers are allocatively efficient. The third section presents new evidence of technical efficiency differentials among Tanzanian cotton farmers.

¹See Jones [1976] for a related analysis.

1. The Efficiency Hypothesis and its Theoretical Basis

In 1964 Theodore Schultz formulated the following hypothesis which has since been accepted and installed as a basic tenet in the field of agricultural development [Schultz, 1964, p. 37]:

"There are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture."¹

Although Schultz explicitly mentions only allocative efficiency (the equivalence of marginal value product and marginal factor cost for each factor) it is clear that he also posits perfect technical efficiency (all farmers operating on the outer bound production function given the available technology). Whereas allocative efficiency is usually considered and measured in terms of the amounts of inputs combined in production, technical efficiency refers to the manner in which the inputs are used. And Schultz specifically refers to the manner in which inputs are used when he states that one implication of his "efficient but poor hypothesis" is

"that the combination of crops grown, the number of times and depth of cultivation, the time of planting, watering, and harvesting, the combination of hand tools, ditches to carry water to the fields, draft animals and simple equipment -- are all made with a fine regard for marginal costs." [Schultz, 1964, p. 39, emphasis added.]

Schultz refers to studies by Tax [1953] and Hopper [1957] and concludes that they support his hypothesis. Following publication of Transforming Traditional Agriculture several economists replicated Hopper's study and reported similar results. However, as shown in section 2, a close examination of the data presented by Hopper and others reveals that the empirical evidence does not support Schultz's poor but efficient hypothesis. In fact, this is not surprising since the main a priori reasons for expecting efficiency apply primarily to modern, competitive situations and not to most peasant agricultural communities.

One of the major a priori arguments for expecting allocative (and technical) efficiency is that competition will force less efficient firms to become more efficient or go out of business. Firms remaining in a competitive industry may thus come to approximate levels of maximum efficiency.

¹See Yengoyan [1966] for a critique of the concept of traditional agriculture with constant state of the arts.

In much of peasant agriculture the same argument does not apply. Farms that are mainly subsistence oriented are largely outside the arena of competition. The environment does place some constraints on farming practices, but these are unlikely to be in a narrow band at maximum efficiency. Even if a farmer incurs a food and cash deficit in one year, his neighbors are more likely to help him than to drive him out of business.¹

Another argument for allocative efficiency builds on assumptions about rationality and the maximizing of satisfactions. However, Scitovsky [1943] has shown that the maximization of satisfaction and profits² are likely to coincide only when entrepreneurs display nondiminishing marginal utility of money income. We do not expect that behavior pattern in modern economies and, perhaps more so, not in peasant economies. Monetary profits obviously take their place alongside leisure, social obligations, status, and other elements in comprising satisfaction.³

In a different vein we have Friedman's [1953] "as if" formulation. Here the question of how and why peasants act is secondary to the outcome of their actions. If that outcome is consistent with profit maximization assumptions, then such assumptions are considered useful. Of course, as Nagel [1963] has noted, the "as if" school does not deal in explanation since several assumptions may satisfy the consistency criterion. Additional information is required.

If we do not hold the profit maximization formulation to the task of explaining peasant behavior, can we nonetheless accept it as useful on Friedman's terms? That is, is the formulation consistent with empirical evidence? The following section attempts to show that, contrary to prevailing opinion, the empirical evidence does not support Schultz's "efficient but poor" hypothesis.

¹Even in cash crop production peasants' use of land and labor may be subject only to indirect market pressures if the farmer owns the land and if his family provides the labor. These indirect pressures might be in the form of rich, cash-oriented farmers bidding for these inputs, but this is quite different from and weaker than the inexorable force of the market assumed in survival theories of efficiency.

²And it is of course profit maximization that yields the marginal equivalences to which allocative efficiency refers.

³See Wharton [1971] and Lipton [1968] for related discussions.

2. Empirical Evidence Regarding Allocative Efficiency

The hypothesis that peasant farmers are allocatively efficient is said to be supported by the empirical work of Hopper and of several researchers who replicated his tests. The essence of that body of work is estimation of Cobb-Douglas production functions, derivation of average estimated marginal productivities (MP) from those functions,¹ and comparison of those averages (transformed to money units and called marginal value products or MVP) with relevant marginal factor costs (MFC, assumed to equal observed unit costs and generally assumed to be constant over the sample).²

Most researchers who have performed this production function test for allocative efficiency have concluded that their work supports Schultz's hypothesis. The following are examples of such conclusions:

"There is no evidence that an improvement in economic output could be obtained by altering the present allocations as long as the village [Senapur in India] relies on traditional resources and technology." [Hopper, 1965, p. 620.]

"With the exception of seed, reallocating the present factors does not appear to be a fruitful means of increasing productivity. The present factors are allocated about as efficiently as they can be [in Eastern Nigeria]." [Welsch, 1965, p. 907.]

"My investigations support the opinion of Schultz and the empirical evidence of both Hopper and Welsch that in a traditional and technologically stagnant agriculture [in South India] farmers are aware of efficient use of traditional inputs." [Chenareddy, 1967, pp. 819-820.]

"Other than [the]...relatively few exceptions, the bulk of the evidence provided by this study [of Indian farming] appears to support the hypothesis that the resources available to farmers in India have, by and large, been efficiently allocated." [Sahota, 1968, p. 604.]

¹The Cobb-Douglas function may be written as:

$$X_o = A_o \prod_{i=1}^n X_i^{a_i}$$

where X_o = output of a certain crop;

X_i = factors of production;

A_o, a_i = coefficients to be estimated.

$$\hat{MP}_{X_1} = \frac{\partial X_o}{\partial X_1} = \hat{a}_1 \frac{X_o}{X_1}; \quad \overline{MVP}_{X_1} = p_o \hat{a}_1 \frac{\overline{X_o}}{\overline{X_1}}$$

where p_o is the observed price of X_o , and where the superscript symbols $\hat{\quad}$ and $\overline{\quad}$ indicate estimated and average values respectively.

²Lau and Yotopoulos [1971] drop the latter assumption.

It is interesting to examine the results upon which the above conclusions are based. Table 1 presents the ratios of $\hat{MVP}:MFC$ found in those studies. A ratio of 1.0 is accepted by the above authors as evidence of allocative efficiency. The interpretation of Table 1 is not at all straightforward. Approximately one-third of the ratios differ significantly from 1.0 and hence

Table 1. -- Ratios of $\hat{MVP}:MFC$

Study	Factors							
	Land	Animal Power	Labor	Water	Seed	Capital	Misc.	Fertilizer
Hopper	2.29 ^{2/}	<u>1/</u>	1.25 ^{2/}	<u>1/</u>				
Welsch	1.7 ^{4/}		0.4 ^{3/}		4.8 ^{3/}			
			1.0 ^{4/}		1.8 ^{3/}			
			1.0 ^{4/}		1.0 ^{4/}			
Chennareddy	1.54 ^{5/}		0.83 ^{4/}			0.01 ^{4/}	1.21 ^{4/}	
	0.91 ^{4/}		1.03 ^{4/}			1.74 ^{4/}	1.71 ^{4/}	
	1.52 ^{6/}		0.89 ^{4/}			0.01 ^{4/}	1.40 ^{5/}	
Sahota		.74 ^{4/}			<u>7/</u>	1.38 ^{4/}		
		<u>7/</u>	0.55 ^{5/}					
		<u>7/</u>	1.11 ^{4/}			.99 ^{4/7/}		3.61 ^{4/7/}
		<u>7/</u>			0.77 ^{4/7/}	.39 ^{5/7/}		
		<u>7/</u>	0.92 ^{4/}			.97 ^{4/}		
		2.30 ^{5/}	<u>7/</u>		<u>7/</u>	.66 ^{4/7/}		
			0.44 ^{5/}			.59 ^{4/}		

^{1/}No estimate available of MFC.
^{2/}No significance test reported.
^{3/}Significantly different from 1.0. No significance level reported.
^{4/}Not significantly different from 1.0. No significance level reported.
^{5/}Significantly different from 1.0 at the 10% level.
^{6/}Significantly different from 1.0 at the 5.0% level.
^{7/}Regression coefficient not significantly different from zero.

contradict the efficiency hypothesis. The remaining ratios range from 0.59 to 3.61 but all are accepted as not significantly different from 1.0.¹ As these ratios indicate and as is discussed below, the usual t test employed in earlier studies is not a very powerful tool for verifying the equality conditions of allocative efficiency. Holding this point in abeyance for the moment, we may gain some insight from the ratios themselves since it is true that they are formed from the best estimates of \widehat{MVP} and from observations of MFC.

The reported ratio (R) provides information on the extent to which farmers, on average, should change the relevant MVP through resource reallocation in order to arrive at the equality of MVP and MFC. That information can be obtained as follows:

$$\widehat{MVP} \div MFC = R$$

$$\left| \frac{\widehat{MVP} - MFC}{\widehat{MVP}} \right| = \left| 1 - \frac{MFC}{\widehat{MVP}} \right| = \left| 1 - \frac{1}{R} \right| = D$$

where D is the relative change in \widehat{MVP} that is required in order to obtain the desired equality.

Table 2 presents the D values² for all ratios in Table 1. The average D is .41 if we exclude the two extremes of 99.0. (Inclusion of those extremes would raise the average to 6.05.) An average of .41 means that, on average, farmers should have reallocated resources so as to cause a 41% change in their marginal value products. This may indicate major deviations from allocative efficiency, and yet all the above authors conclude that their tests confirm Schultz's "poor but efficient" hypothesis. Such conclusions and their general acceptance in the profession are indeed puzzling. Perhaps they may be attributed in part to inappropriate interpretations of t tests.

The difficulty lies in the inability of t tests to provide assurances that two statistics are equal. That is, a t test cannot provide information

¹The complete range of ratios in Table 1 is from .01 to 4.8. In Transforming Traditional Agriculture, Schultz refers to Indian farming data cited by Heady [1960] showing a range of ratios from -.85 to 6.97 (.03 to 3.60 for variables other than capital) and Schultz comments as follows [Schultz, 1964, pp. 51-52]:

"It is noteworthy that no logical explanation of the extreme ranges in the estimates cited for the six sets of farming in India is offered. Had one been attempted, the untenable nature of the results would have become apparent.

²In percentage terms.

Table 2
Percentage Change Required in MVP to Equate MVP to MFC

<u>Study</u>	<u>Factors</u>							
	Land	Animal Power	Labor	Water	Seed	Capital	Misc.	Fertilizer
Hopper	56		20					
Welsch	41		150		79			
			0		44			
			0		0			
Chennareddy	35		20			9900	17	
	10		3			43	42	
	34		14			9900	29	
Sahota		35				28		
			82					
			10			1		72
					30	156		
			9			3		
		57				52		
			127			69		

on the probability of a type II error, such as accepting $H_0: \overline{MVP} = MFC$ when that hypothesis is false. The t test provides probabilities of error only for findings that \overline{MVP} is different from MFC. When a computed t (t_c) is numerically greater than $t_{\alpha/2}$ the result is clear: if \overline{MVP} and MFC were actually equal, such a t_c would occur by chance only $\leq \alpha\%$ of the time. That is, we have no more than an $\alpha\%$ probability of rejecting the true hypothesis that $\overline{MVP} = MFC$, a Type I error. However, if $t_c < t_{\alpha/2}$ (numerically), the test does not indicate the probability of such a result occurring when \overline{MVP} actually does not equal MFC. That is, we do not know the probability of accepting the false hypothesis that $\overline{MVP} = MFC$, a Type II error. Thus, for example, even though Chennareddy assures us that the \overline{MVP} and MFC for land are not significantly different from each other at the 10% level, we have no indication of how confident to be that the two statistics actually are equal. Lacking such confidence measures, one must re-examine Chennareddy's data, which in this case reveal that \widehat{MVP} is 54% greater than MFC. This seems to be a very large discrepancy and the t test cannot give us any assurances that, in spite of such a divergence, the two statistics really are equal.

Even if the data did show close correspondence between \widehat{MVP} 's and MFC's (which they do not) such results could not be cited as strong support for the efficiency hypothesis because of the nature of average MVP. As stated earlier, \widehat{MP}_i is the product of: 1) the estimated \hat{a}_i , which is assumed to be the same for all farms in the sample, and 2) the average output:input ratio, \bar{X}_o/\bar{X}_i . This calculation reflects the assumption that all farms operate on the same Cobb-Douglas production function (at least up to a neutral shift parameter), but that input and output levels and ratios vary over farms. Indeed, this latter variability is a prerequisite for estimation. However, it is this variability of output:input ratios that vitiates the conclusions of earlier researchers.¹

For the individual farm, $\widehat{MVP}_j = \hat{a}_i X_{oj} P_o / X_{ij}$, where j indexes farms. If all farms in a sample face the same prices, as is often true and as seems to be assumed by the aforementioned writers, then variation in the output:input ratio (X_o/X_i) assures variation in \widehat{MVP}_i which assures variation in levels of allocative efficiency. Only one output:input ratio will yield equality of MVP and MFC. All others will yield inequality and hence inefficiency.

¹See Massell and Johnson, 1968, for a similar argument.

It may be true that $\widehat{MVP} = MFC$, but while this implies 100% allocative efficiency for a mythical average farm, it says nothing about the average of the actual individual farms' efficiency levels. This latter average must be less than 100% since, as noted above, an estimable production function implies variation in individual efficiency levels and that variation can only be downward from 100%.¹

3. Empirical Evidence Regarding Technical Efficiency²

As with allocative efficiency, if not more so, policy makers' conceptions of technical efficiency in peasant agriculture may influence the shape of development strategies. If most farmers obtain the best output/input ratios possible with the available inputs and technologies, then new investment streams may be critical for any development. However, if some farmers perform much better than most of their neighbors with the same inputs and technologies, there may be considerable scope for increasing output without major new investments in the near or intermediate future.

Our measurement of technical efficiency among Tanzanian cotton farmers in Geita District relies on an outerbound Cobb-Douglas production function derived with a linear programming methodology developed by Aigner and Chu [1968] and Timmer [1970].³ The outerbound, maximum-efficiency function obtained for our sample, after allowance for possible outliers, is

$$\hat{y}_j = 5.3430 + .8025l_j + .05048k_j \quad (1)$$

Where, for farm j :

\hat{y}_j = log of predicted earnings in Tanzanian cents;

l_j = log of manhours labor used in cotton field-work;

k_j = log of acres planted to cotton.

A farmer's actual output⁴ (Y_j), given his actual inputs, would equal predicted output (\hat{Y}_j) only if he operated on the outerbound production function. Otherwise, actual output would be less than predicted. Each farmer

¹If \widehat{MVP} did equal MFC this would probably indicate a balance between farmers using too much of an input and those using too little. By reallocating that input among farmers, all of them would come closer to allocative efficiency and, hence, net output in the area would increase.

²See Leibenstein, 1976, for discussion of the relationship between technical efficiency and x-efficiency.

³This recent work is based largely on the earlier work of Farrell [1957].

⁴Capital Y represents the raw variable, not its log.

was assigned a technical efficiency score equal to the ratio of his actual to predicted output (Y_j/\hat{Y}_j).

It is worth emphasizing that this methodology sets maximum efficiency in accord with the best practices found in the sample. It is also worth emphasizing that in this sample all farmers relied on the hand hoe for all their land preparation and weeding, and on hand picking for harvesting. Furthermore, almost none of the farmers used fertilizer or insecticide in effective ways. Nine used artificial fertilizer, four manure, and eleven insecticide. Of the eleven insecticide users, only two sprayed more than twice. The recommendation is for six sprayings, and it is believed that two sprayings are worse than none because of damage done to the natural enemies of cotton-destroying pests. In sum, we are arguing that technical efficiency differentials do not reflect differences in types of inputs but rather differences in how traditional inputs are used.

The distribution of efficiency scores is shown in Table 3. The average level of technical efficiency in the sample was .663. Thus if all farmers were to modify their operations so as to operate on the outer-bound production function, output would increase by 51% for the sample as a whole. This change would not require new inputs and would not require introduction of new technologies. That is, this increased output could be obtained while adhering to Schultz's [1964, p. 39] rules for testing his efficient but poor hypothesis:

"...in testing this hypothesis it is not permissible to alter the technical properties of the factors of production at the disposal of the community. Nor is it permissible to provide new useful knowledge about superior factors that exist in other communities...."

The aforementioned technical efficiency differentials indicate that output may indeed be increased without changing the technology, inputs and knowledge now available to the community.

Table 3. -- Distribution of Technical Efficiency Scores Among Tanzanian Cotton Farms

<u>Technical Efficiency Scores</u>	<u>Number of Farms</u>
.231 - .385	3
.385 - .539	12
.539 - .693	6
.693 - .847	6
.847 -1.000	10

4. Conclusion

The data presented and reviewed above do not provide support for the hypothesis that peasant agriculture is highly efficient (allocatively and technically) and that, hence, important gains in production must rely solely on the infusion of new inputs and technologies. On the contrary, the data reveal sizable deviations from optimal resource allocations and from the highest output/input ratios possible given the available inputs and technologies. Thus our major conclusion is that decision makers might fruitfully increase efforts such as extension and education which are aimed at improving the allocation and use of available resources so that more farmers come to operate closer to the efficiency ideals now achieved by only a few. This conclusion is not intended to downplay the overwhelming importance of new inputs and technologies for developing agriculture, especially in the longer run; rather the intention is to point out that there are observable efficiency differentials in peasant agriculture which may imply the potential for relatively inexpensive, shorter run gains in output that do not depend on major new investments or research programs.

One important implication of our conclusion is that we need more research into the causes of efficiency differentials. Is education of major importance, as Mook [1973] found in Kenya and as Schultz [1975] argues generally? Is modernization a key element as we found in Tanzania [Shapiro and Mueller, 1974]? Do Leibenstein's [1976] arguments about motivation apply to peasant agriculture? Or do efficiency differentials spring from imperfect market structures that inhibit optimal allocations across farms? Do legal and social constraints prevent some farmers from attaining the appropriate combinations of inputs? Answers to such questions would help policy makers focus on those key variables which might be altered to help yield relatively inexpensive gains in output.¹

¹On the other hand, such answers might also reveal that the causes of efficiency differentials are so intractable that policies aimed at improving efficiency levels have a low probability of success or will prove to be very expensive.

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