Vol XXXIV
No. 2

APRIL-
JUNE
1979

ISSN 0019-5014

# INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

# NATURE AND MEASUREMENT OF ECONOMIC EFFICIENCY IN INDIAN AGRICULTURE

R.K. Sampath*

## I

### TRADITIONAL APPROACH

*Economic Efficiency*

Economics is in many ways a science of efficiency. But the concept of "Economic efficiency is an elusive one in which the economist, the engineer and the policy maker all have great stakes. The policy implications of economic efficiency permeate both the micro and macro-economic level. Suppose, for example, that we can measure the efficiency of small and large farms. We can then determine by how much a given set of farms could be expected to increase its output through appropriate reorganization without absorbing additional resources in the aggregate. We can also draw policy recommendations in connection with land ceilings, land redistribution and land groupings under co-operative farming and other forms of agrarian organizations"(13)†.

*Two Components of Economic Efficiency*

Farrell (7) divided the measure of economic efficiency into two components, namely, 'Technical Efficiency' and 'Price Efficiency'. Technical efficiency refers to the proper choice of production function among all those actively in use by firms (farms) in the industry (agriculture). Price efficiency refers to the proper choice of input combinations. Economic Efficiency combines both technical and price efficiency.[1]

*Measurement of Technical Efficiency*

Farrell estimates his production function by fitting an envelope. But Farrell's approach has the following drawbacks:

* Project Specialist, The Ford Foundation, New Delhi.

The author would like to thank Professor Peter P. Rogers of Harvard University and the two referees for very helpful comments and suggestions and Mr. K. R. Raghunathan for excellent secretarial help.

† The figure in brackets denotes reference cited at the end of the paper.

1. In almost all the empirical literature it is not clear when the authors say that farmers are inefficient whether their inefficiency accrues from technological inefficiency or price inefficiency. Often they ignore the problem of technical inefficiency and attribute the inefficiency totally to price inefficiency or allocative inefficiency. This is because the researchers assume that all farms are efficient technically or to put it in other words they always choose the best technology available, *i.e.*, everyone of the producers derive the maximum output from any chosen level of inputs. But this assumption is highly unrealistic because to what extent they utilize the inputs to their optimum level depends on the knowledge that the entrepreneur has about the technology he has chosen, to what extent the labour he employs also understands his role and the extent of his entrepreneurial ability and knowledge. It is well-known that these qualities are not evenly distributed among the farms and so the amount of output produced per given level of inputs has to vary a great deal across farms. If so, then technological inefficiency would account a great deal to the prevailing level of economic inefficiency. This then would necessitate the need for distinguishing and estimating the relative importance of technological inefficiency and allocative inefficiency to the prevailing level of economic inefficiency.

(*i*) It needs the constant returns to scale assumption and relaxation of this assumption leads to ambiguity in the definition.

(*ii*) This definition does not allow us to compare the farms in an imperfectly competitive market.

(*iii*) This method neglects the differences in the environments of different farms compared.

In the literature the following methods have been suggested to overcome the problems mentioned above: (*i*) the programming approach in input-input space of Farrell, (*ii*) the programming approach in output-input space of Aigner and Chu (1) and (*iii*) a chance constrained frontier or density function approach. The first method utilizes only extreme observations fiom the data set; the second and third methods utilize all or a certain proportion of the data.[2]

*Measurement of Price or Allocative Efficiency*

Given the technology, allocative efficiency refers to the achievement of optimum output so as to maximize profit or net income. The optimality conditions for price efficiency can be developed in terms of different assumptions: (*i*) in terms of single output multi-input production functions (such as Cobb-Douglas) with or without equality budgetary constraints; or, (*ii*) in terms of multi-input, multi-output approach subject to equality constraints as studied by Hicks (10), Samuelson (21), Allen (2) and Kuenne (12) using a straightforward Lagrangian differential gradient method to solve the problem of multi-product, multi-factor production functions; or, (*iii*) in terms of multi-product, multi-factor approach with inequality constraints (with or without linearity assumptions) using the Kuhn-Tucker theorems for solving the problems. We do not intend to discuss here in any detail these approaches as they are already available in any textbook. We intend to discuss briefly and critically the often used Cobb-Douglas production function approach[3] to bring together various criticisms lodged against it by others along with our own and in that context to show why we have developed a newer approach to this problem of measurement of Economic Efficiency.

1. At the outset it should be pointed out that the Cobb-Douglas production function approach does not distinguish between technical efficiency and allocative efficiency. It ignores the problem of technical efficiency by assuming that all the techniques of production (and thereby the Isoquants) are identical across farms and as such everybody has achieved perfect technical efficiency. In other words, by implication it assumes there are no differences in entrepreneurial ability, managerial capacity and technical know-how among different farms as far as the use of technology is concerned.

2. For details about these methods, see Sampath (19), Chapter IV.

3. Since the publication of Theodore W. Schultz's "Transforming Traditional Agriculture" in 1964, a number of articles appeared using Cobb-Douglas production approach to evaluate the allocative efficiency of the Indian farmer [see Chennareddy(5), Hopper (11), Sahota (17), Saini (18), Srivastava and Nagadevara (23), Wise and Yotopoulos (25), Dey and Rudra (6) and Hati and Rudra(8)].

2. The mechanics of measurement of allocative efficiency involve the use of transformation of the Cobb-Douglas production function into the log-linear equation and the use of the standard least squares estimation procedures to estimate the elasticity parameters. Then by multiplying the elasticity parameter of a particular input by the average productivity of that factor (which is obtained by dividing the geometric mean value of the output by the geometric value of the input) they obtain the marginal productivity of that input. Now by comparing the marginal productivity of the input with the market price of the input, they evaluate the allocative efficiency of the farmer. Thus the reliability of the results obtained from these exercises crucially depends upon the relevance and realism of the assumptions and conclusions of the Cobb-Douglas technology in the context of Indian agriculture and the statistical properties (such as unbiasedness, consistency and efficiency) of the estimated parameters. If the estimated elasticity parameters are not unbiased then the conclusions based on these parameters are not dependable and possibly they would be misleading. Let us discuss briefly how far the assumptions behind Cobb-Douglas technology are realistic and how far the estimated parameters are unbiased.

*Unrealistic Assumptions*[4]

Originally Cobb-Douglas production was applied to industry and since then agricultural economists mechanically applied it to agriculture without looking in detail the relevance of Cobb-Douglas assumptions for agr culture. Actually, the main reason for its extensive use in agriculture was the relative simplicity of estimation of its parameters. .t we pay a high price for this simplicity in terms of its unrealistic assumptions, namely, the constancy of partial and total elasticities of production and of unit elasticity of substitution between factors of production. As Anderson and Jodha (3) point out: "The restrictiveness enters implicitly into his test of the hypothesis of allocative efficiency so that the conditional question he is asking is effectively 'Do farmers maximize profits given that they are operating under a single Cobb-Douglas production function that is common to all members of some group (*i.e.*, common Cobb-Douglas technology')?" So before one tries to use Cobb-Douglas for evaluating the allocative efficiency of the farmers one has to find the following:

(*i*) Does every activity have Cobb-Douglas as the underlying production function?

(*ii*) Does every member (or farmer) have the same Cobb-Douglas technology?

But unfortunately, none of the empirical studies dealt with these aspects in any detail. It should also be noted in this context that for the Cobb-Douglas production function case, differences in technical efficiency and relative differences in price efficiency cannot be separately identified from the actual profit or production functions.

4. For complete treatment, see Sampath (19), Chapter IV.

It is well-known that all farms would have the same quantities of inputs and outputs (and as a result have only one point on the production surface that would be observable) if (*i*) all farms have the same production function, *i.e.*, the same technical knowledge, and identical fixed factors; (*ii*) all farms faced the same prices in the produce and factor markets; and, (*iii*) all farms maximized profits perfectly. But the fact that we observe differences in factor intensities with varying factor productivities implies that (*i*) different farms face different factor prices (and possibly different product prices also); and/or, (*ii*) they have different endowments of fixed factors of production; and /or, (*iii*) they use different technologies of production.

These aspects of the problem have not been dealt with in the empirical studies, and the empirical studies have assumed that farmers have identical technologies and face perfectly competitive factor and product markets.

Further, it may be noted that, while the hypothesis of allocative efficiency does not call for the assumption of a perfectly competitive market (in both commodity and factor markets), the researchers nevertheless make this assumption implicitly or explicitly which is evident from the fact that they make use of unique product and factor prices and a common production function.

### *Estimation Problems*

As we have noted already, the reliability of the conclusions reached in the above-mentioned studies to a great extent depends upon the reliability of the estimated parameters. These estimated parameters suffer from three major econometric problems, namely, mis-specification bias problem, simultaneous equation bias problem, and aggregation bias problem, and a few other minor problems concerning the use of geometric mean. Because of these problems, the conclusions reached in these studies are unreliable.[5]

## II

### MODIFIED APPROACH

The conventional approach discussed above is rather limited and narrow in its definition of Economic Efficiency. One of the drawbacks of this approach is that it does not separate out the influence of the environment (or the system) from the influence (or contribution) of the individual upon the 'total (in)efficiency' in the economy. We intend to develop a framework in this section to separate out the role played by the environment (or the system) from the role played by the individual in contributing to the level of Economic Efficiency at any point of time prevailing in the system.

Let us define a few terms for our purposes.

*The system:* By system or environment we mean all those factors which are external to the farmer (or decision-maker) which influence his decision

5. For details, see Sampath (19), Chapter IV, Appendix IVA.

but which are not under his control such as the infrastructure available (to the decision-makers) in the economy at any point of time, the nature and structure of commodity and factor markets, the institutional structure, etc. A system is said to be *perfect* if it satisfies all the conditions of a perfectly competitive market such as perfect mobility of factors of production, perfect competition in factor and product markets, *i.e.*, innumerable buyers and sellers (in other words, the absence of monopoly and monopsony situations), perfect knowledge, perfect diffusion of technological know-how among all the producers, free entry and free exit. The absence of one or more of these conditions will make the system *imperfect*.

*The individual:* By the individual we mean the decision-maker. The decision-maker is said to be *rational* if he, given the system characteristics, maximizes his profit or net income.

*Economic efficiency:* Economic efficiency comprises technological efficiency and price or allocative efficiency.

*Perfect economic efficiency:* A system is said to have achieved 'perfect economic efficiency' *if both the system and the individuals are both technologically and allocatively efficient.* In other words, the system portrays the characteristics of a perfectly competitive market facilitating perfect diffusion of scientific and technological knowledge among all the producers (in other words, absence of dual or several technological systems operating at the same time in the production of commodities) so that no producer is prevented from using the best technology available and achieving the 'technological efficiency' and absence of any impediments (such as monopoly or oligopoly or oligopsony conditions) in the system which would impede a few or many producers from achieving perfect 'allocative efficiency', and all the individual producers also (under these 'perfect system' conditions) act 'rationally' by choosing the most efficient technology and allocation of resources. We can call the 'output' associated with this 'perfect economic efficiency' situation for the given endowment of resources and given commodity and factor prices for the given technology as the 'pareto optimal output'. This output can be taken as the 'norm' with which every other output generated under 'imperfect economic efficiency' situations will be compared and the level of economic efficiency evaluated.

### *Classification of Economic Efficiency*

At any point of time, 'perfect economic efficiency' of both the system and the individuals may or may not exist. If there is imperfection in the achievement of economic efficiency, it may be due to imperfection in the achievement of either technological efficiency or the price efficiency or both which, in turn, may be due to inefficiency either at the system level or at the individual level or at both these levels. The 'economically inefficient situations', logically, can be classified, on the basis of nature and sources of economic inefficiency, into 16 mutually exclusive and collectively exhaustive categories which are given in the form of a table below. Thus, at any point of time, only one of the following situations will be prevailing in the economy.

TABLE I—CLASSIFICATION OF ECONOMICALLY INEFFICIENT SITUATIONS

| Situation | Component | Technology | Allocation | Overall |
|---|---|---|---|---|
| | | *Perfect Economic Efficiency Situation* | | |
| 1 | System (S) | Efficient | Efficient | Efficient |
| | Individual (I) | Efficient | Efficient | Efficient |
| | Overall (S & I) (System and Individual) | Efficient | Efficient | Efficient (Perfect Economic Efficiency) |
| | | *Imperfect Economic Efficiency Situations* | | |
| 2 | S | E | E | E |
| | I | E | IE | IE |
| | S & I | E | IE | IE |
| 3 | S | E | E | E |
| | I | IE | IE | IE |
| | S & I | IE | E | IE |
| 4 | S | E | E | E |
| | I | IE | IE | IE |
| | S & I | IE | IE | IE |
| 5 | S | IE | E | IE |
| | I | E | E | E |
| | S & I | IE | E | IE |
| 6 | S | E | IE | IE |
| | I | E | E | E |
| | S & I | E | IE | IE |
| 7 | S | IE | IE | IE |
| | I | E | E | E |
| | S & I | IE | IE | IE |
| 8 | S | IE | E | IE |
| | I | IE | E | IE |
| | S & I | IE | E | IE |
| 9 | S | E | IE | IE |
| | I | E | IE | IE |
| | S & I | E | IE | IE |
| 10 | S | E | IE | IE |
| | I | IE | IE | IE |
| | S & I | IE | IE | IE |
| 11 | S | IE | E | IE |
| | I | IE | IE | IE |
| | S & I | IE | IE | IE |
| 12 | S | IE | IE | IE |
| | I | E | IE | IE |
| | S & I | IE | IE | IE |
| 13 | S | IE | IE | IE |
| | I | IE | E | IE |
| | S & I | IE | IE | IE |

(*Contd.*)

TABLE I (*Concld.*)

| Situation | Component | Technology | Allocation | Overall |
|---|---|---|---|---|
| | | *Imperfect Economic Efficiency Situations* | | |
| 14 | S | IE | E | IE |
| | I | E | IE | IE |
| | S & I | IE | IE | IE |
| 15 | S | E | IE | IE |
| | I | IE | E | IE |
| | S & I | IE | IE | IE |
| 16 | S | IE | IE | IE |
| | I | IE | IE | IE |
| | S & I | IE | IE | IE |

*Notes:*— E = Efficient. IE = Inefficient. S = System. I = Individual. S & I = System and Individual overall.

This classification will help us in understanding the nature (technological, allocational or both) of economic inefficiency and the sources (the system, individual or both) of economic inefficiency. In all previous studies,[6] the difference between the 'optimum output' and the 'real output' have all been identified with the economic inefficiency of the individual. This is not only misleading in terms of explanation of the phenomena but also may lead to wrong policy prescriptions. For example, the prevailing inefficiency may have been entirely due to 'system inefficiency' as depicted in situations 5, 6 and 7 whereas by identifying the total inefficiency with the irrational behaviour of the individual, we will be making a wrong diagnosis of the situation. To improve the economic efficiency what is required is not any change in the behaviour of the individual, but only the removal of the system impediments which stand in the way of the individual achieving 'perfect economic efficiency'. These system's impediments may be in the form of lack of perfectly competitive market structure or lack of adequate infrastructural facilities, or lack of perfect and instantaneous diffusion of technological and scientific knowledge, or lack of perfect mobility of factors or production, or lack of free entry and exit.

In our study we intend to find out the nature and sources of economic inefficiency in terms of an 'optimizing model' using linear programming technique which is the most suitable technique available for incorporating system rigidities and imperfections in the form of constraints. It is almost impossible to use the continuous production function approach of the neo-classical type for our present purposes. To cite an example, let us consider the case of subsistence farmers. Even though subsistence farmers are (or may be) also profit maximizers, they have to allocate certain amount of their resources for the production of certain crops irrespective of their profitability. It is because they require these crops for their own consumption and there is no market or institutional system through which they can be able to meet their own de-

6. Actually, none of the studies on 'Allocative Efficiency of the Farmer' has made any detailed study of the *Nature and Sources of Economic Efficiency*. They merely pointed out whether the farmer is 'price efficient' or not by comparing the market input price with the marginal productivity of the input derived from the Cobb-Douglas production function.

mands for these crops. Thus lack of 'rural supply systems' (the non-existence of which may be due to high transport costs) may force the farmers to allocate a minimum amount of their resources for the production of their own consumption crops. And these kinds of rigidities can be easily incorporated in the form of constraints in the linear programming approach whereas in the neo-classical, continuous production function approach, it is not possible to do so. Moreover, the ability to incorporate such system rigidities into our model also helps us in evaluating the economic cost (welfare loss) of such rigidities and this way it also helps us in separating out the contribution of the system's imperfections (from that of the irrational behaviour of the individual) upon the prevailing level of economic (in)efficiency in the economy. To sum up: our argument is that the achievement of Perfect Economic Efficiency (PEE) depends not only on the decisions of the individual but also upon the nature and structure of the economic system (of which the individual is only one of the innumerable entities) we are dealing with.

Let us now discuss briefly as to what goes to make up the system (or the environment) under which the individual operates. A system (or the environment) is composed of certain socio-economic-cultural-political-institutional and technological characteristics. This set of factors go to affect the type of decision that an individual takes. For example, in our 'Perfect Economic Efficiency Situation" the socio-economic-cultural-political-institutional and technological characteristics are such that if every individual behaves rationally every one would be able to achieve 'Perfect Economic Efficiency Optimal Output' in which he would be using the best technology that is available and would be using the optimal combination of inputs. But in reality, the system may not be perfect. There may be any number of distortions and restrictions and because of this the individual simply cannot be able to achieve PEE output in which case it is irrational on the part of the economist to attribute the difference between the optimal output and the real output to the irrationality of the farmer. To a great extent, the system imperfections themselves might be responsible for this difference. But this does not mean or imply that the farmers' decisions are always rational. It is for the researchers to find out how much of this difference between PEE output and real output is due to system inefficiency and how much due to sub-optimal decisions of the farmer. This is precisely what we intend doing in the rest of the paper.

## III

### EMPIRICAL ANALYSIS OF ECONOMIC EFFICIENCY: A CASE STUDY OF FARMERS IN DEORIA DISTRICT IN UTTAR PRADESH

In the last section we discussed the traditional approach to measurement of economic efficiency and pointed out the superiority of programming approach to Cobb-Douglas production function approach for empirical analysis of economic efficiency of farmers. We also modified the traditional approach by broadening the concept of measurement of economic efficiency to separate out the contributions made by the individual and the factors external to him (the system or the environment) to the level of total economic efficiency prevailing in an economic system at any point of time. In this section we intend to empirically estimate the level of economic efficiency of farmers in Deoria district in Uttar Pradesh in terms of the theoretical framework developed in the earlier sections.

*Methodology*

In any empirical study of this nature, one has to decide whether the analysis should be conducted at an aggregate or disaggregate level. The choice of methodology depends on whether the size of farms makes any difference to the conclusions. Most of the previous studies used some sort of a 'representative farm' approach. This 'representative farm' approach is highly questionable because it is based on average data and assumes that all farms have similar technological and economic characteristics. But it is now a well-known fact that agriculture in under-developed economies are 'dualistic' in nature, *i.e.*, the agricultural sector is characterized by market based capitalistic farmers, on the one hand, and by family based subsistence farmers, on the other. The nature of farming of these two groups of farmers differs substantially from one another in terms of the type of technology used in the production of crops, the nature of cropping pattern selected, etc. The capitalist farming is based on hired labour and market oriented. In contrast, the subsistence farming is predominantly based on family labour and not so much market oriented because of low level of production and comparatively high level of self-consumption. And as such, using a common input-output coefficient matrix and a common objective function coefficients vector for all the farmers is unrealistic. That there exists wide inter-farm size-group differences in input-output coefficients is evident from the available evidence.[7] Unmindful of these inter-farm differences, if one uses an average input-output matrix and objective function coefficients vector, then one would get highly aggregation biased results[8] which are useful neither for proper assessment of the level of economic efficiency of farmers nor for any prescriptive policy purposes. So our study will be based on a disaggregate analysis of data, disaggregation being done on the basis of the size of farms. Even though on certain grounds one may object to using farm size as a measure for differentiating farms, it is the best empirically feasible measure.

*Data*

The data involved in calculating the input-output coefficient matrices and the objective function coefficients vectors for the farm size-groups were taken from Farm Management Survey Report for Deoria district for the year

7. For details, see Sampath (19), Chapter III and references therein.

8. An empirical analysis of the kinds of biases that aggregation introduces in the estimation of Linear Programming results is discussed in detail in Sampath (19), Chapter V, Appendix VB and (20) and references therein.

1967-68. The resource vector for each group of farms is the sum of all the resources used by each member of the group in the year 1967-68.[9]

*Objectives*

The objectives of this empirical analysis are the following:

1. To suggest computational methods through which the relative importance and actual magnitude of the influence of different sources of (namely, technological and allocational) economic inefficiencies and different components (or agents) of (namely, the system or the environment and the individual) economic inefficiencies.
2. To compute for the economy (here the term economy refers to the total of all groups of farmers under study) as a whole the level of economic (in)efficiency.
3. To estimate the relative economic (in)efficiencies of different size-groups of farmers and to derive some policy conclusions out of it.
4. To test the following hypotheses, namely, (*a*) Small farmers in general have less economic inefficiency than large farmers. (*b*) Smaller farmers' major source of economic inefficiency is due to their technical inefficiency which is due to the difficulties they have in adopting modern technology in terms of high cost, high risk and uncertainty and indivisibility involved. If this hypothesis is correct then we would expect that the contribution by technical inefficiency would be higher in comparison to the contribution made by allocational inefficiency to the prevailing level of economic inefficiency of the small farmer. A comparison of the results across farm size-groups will also be made.[10]

*General Nature of the Model*

The models we have used are all Linear Programming Models. There is a linear objective function which the farmer is supposed to maximize subject to linear constraints. There are altogether 53 crop activities and ten input availability constraints such as land, human labour, bullock labour and working capital. In addition, there are also other constraints such as upper bound on the area that can be allocated for sugarcane ratoon unirrigated and sugarcane ratoon irrigated, etc.

Symbolically, the model is:

$$\text{Maximize } Z = CX$$
$$\text{Subject to } AX \leqslant b$$
$$X \geqslant 0$$

9. It should be noted in this context that we have defined the resource vector in terms of the amount they actually used instead of what is available with them because the primary purpose of our analysis is to show how much the economic efficiency can be improved without any further use of resources.

10. There are also a number of other hypotheses which were tested and developed during the course of our study which are reported in Sampath (19) Chapters III, V, and VI. For lack of space we have not included them here.

where C = vector of crop activity net incomes per hectare,
X = vector of optimal level of activities,
A = input-output coefficient matrix,
b = input availability vector.

For purposes of our analysis, first of all, we have to define the norm or ideal output with which we will compare different outputs that will accrue as optimal outputs under varying conditions of system rigidities and imperfections. Then with these optimal outputs we will compare the actual output to estimate and evaluate the importance of different components and sources of economic inefficiencies for the farm economy as a whole and across different farm size-groups. So let us first define the perfect economic efficiency optimal output.

*Model I: Perfect Economic Efficiency—Optimal Output Model*
*Assumptions of the Model*

(*i*) Technology of production for each crop across farm size-groups is identical and the best among the available,[11] which means input-output matrix and objective function coefficient vector are identical for every farm size-group.[12]

(*ii*) All inputs are limited in supply and given (it is a short run static model) and prices of inputs and outputs are identical for everyone.

(*iii*) The objective of the farmer is to maximize his total farm net income.

(*iv*) There is perfect mobility and divisibility of factors of production within a farm size-group and across farm size-groups. This assumption helps us to aggregate the vectors of inputs across farms into one macro vector of inputs.

(*v*) There are no socio-politico-institutional and cultural constraints affecting the profit maximizing behaviour of the farmer.

The optimal solution that results from the above model will correspond to our 'Perfect Economic Efficiency Output' and there is no possibility for increasing the output level by any reallocation of resources, given the prices, technology and endowment of inputs.

*Model II*

In this model we retain all the assumptions of the previous model (I) except the assumption (*iv*). Because of the existence of indivisibility and prevalence of certain institutional constraints, it is possible that the mobility of factors of production from one group of farmers to another may not be perfect.

11. Even though ideally, one would like to estimate the 'best technology' of production for each crop by following one of the three methods we suggested earlier, the kind of data available to us did not allow us any choice other than identifying the 'best technology input-output coefficients' for each crop with those input-output coefficients corresponding to that farm group which had the lowest per quintal cost of production for that crop.

12. For a list of the crop activities and input constraints, see the Appendix. For further details concerning data, etc., see Sampath (19)

So essentially what we have here is that each group of farms has identical (best available) technology but the total availability of inputs for each farm size-group is limited by what is endowed with them (in our case used by them). Thus we have as the total optimal output (under the conditions of imperfect mobility of factors of production) the aggregate of optimal outputs of each of the four farm size-groups. The difference in the optimal outputs of Model I and Model II is due to immobility in the factors of production. This difference can be termed as the (welfare) output loss due to imperfection in the mobility (in the factor markets) of factors of production.

Here it should be noted that the individual is not responsible for this imperfection in the mobility of inputs which are due to technological and/or socio-institutional reasons. So the resulting inefficiency in production should be attributed to system inefficiency.

*Model III*

Model III differs from the previous model in that it assumes, in addition to lack of perfect mobility of factors of production, that there are also inter-farm size-groups' differences in the nature of technology used in the production of crops which in turn implies that the objective function coefficients vector and the input-output coefficient matrix will not be identical across farm size-groups. In other words, this model attempts to estimate the optimal output using the 'present technology' that is being used by each group of farms. Thus the overall optimal output that can be generated under these conditions is the aggregate of all optimal outputs of each of these four farm size-groups. Thus what this model does essentially is that it calculates the optimal output that can be produced by each farm size-group given the technology and the level of inputs they are actually at present using. By comparing this model output solution with the other models' solutions we can be able to estimate the effects of factor market imperfections and technological inefficiencies on the optimal output. Lastly, by comparing these model solutions with the prevailing actual outputs we can be able to estimate the level of economic efficiency of different farm size-groups and the relative importance of various factors to the prevailing level of economic efficiency of different farm size-groups and the relative importance of various factors to the prevailing level of economic inefficiency. These are the three models which we will use for various purposes in our empirical study.[13]

*Discussion of the Empirical Results*[14]

The detailed information regarding the empirical results we got from the analysis of the above models is given in the form of Tables in Sampath (19).

13. One would be tempted to ask the question why there is no optimum output defined corresponding to a model in which there are inter-farm size-group differences in technology but perfect mobility in the factors of production; but unfortunately even at the theoretical level there is no way of defining this output as the shadow prices (or the marginal productivities) of inputs differ from group to group at the optimal level and without specifying the input market interactions, there is no way of defining the equilibrium conditions which would bring about an optimum aggregate output defined in some sense.

14. For details of the results, see Sampath (19), Chapter V and the appendices therein.

In this section our main objective is to estimate the level of economic efficiency (which comprises the level of price or allocative efficiency and the level of technological efficiency) on the whole and for each farm size-group separately.

*Aggregate Analysis*

For the purpose of measurement of aggregate economic efficiency, let us define the following symbols:

$O_A$ = Optimum 'Perfect Economic Efficiency' output (derived from Model I).

$O_D$ = Optimum output corresponding to Model II assumptions (with immobility in the factors of production).

$O_P$ = Optimum output corresponding to Model III (with each farm size-group using its present technology and immobility in the factors of production across farm size-groups).

$O_E$ = Existing (present) level of output.

Thus the level of total economic efficiency prevailing at any time in the economy can be defined as:

$$\text{Existing Level of Economic Efficiency} = \frac{O_E}{O_A}.$$

If $\frac{O_E}{O_A}$ is equal to unity, then there is perfect economic efficiency, but if it is less than unity, then the level of economic efficiency is equal to $\left(1 - \frac{O_E}{O_A}\right)$.

The relative figures are given in Table II for different farm size-groups and all farms as a whole.

TABLE II—THE PREVAILING LEVEL OF ECONOMIC EFFICIENCY IN DEORIA AGRICULTURE

| Farm size-group (hectares) | Level of economic efficiencies (per cent) |
|---|---|
| Farm I (0-1·04) .. .. .. .. .. | 64·73 |
| Farm II (1·05-1·79) .. .. .. .. | 62·65 |
| Farm III (1·80-3·07) .. .. .. .. | 71·26 |
| Farm IV (3·08 and above) .. .. .. .. | 63·17 |
| All farms .. .. .. .. .. .. | 63·47 |

From Table II it can be seen that there does not exist much difference between small and large farms in the level of economic efficiency achieved. Of all the farm size-groups, group III (1.80-3.07) comes out to be the most efficient in the sense of having the highest level of economic efficiency achieved.

As we know from previous discussion, the prevailing inefficiency is due to inefficiencies in the use of technology and/or in the mode of allocation of resources emanating from both the individual and the environment (the system). So let us separate out the influence of each of these factors upon the total economic inefficiency on the economy.

$O_A — O_D$ = Loss in output due to immobility in the factors of production (system inefficiency).

$O_A — O_P$ = Loss in output resulting from immobility in the factors of production (due to system inefficiency) and lack of perfect diffusion of technological knowledge (due to both system and individual inefficiencies).

$O_P — O_E$ = Loss in output due to allocative inefficiency on the part of the farmer (individual inefficiency).

$O_D — O_P$ = Loss in output due to technological inefficiency (system and individual inefficiencies).

TABLE III—AGGREGATE MEASURES OF ECONOMIC INEFFICIENCIES

| Inefficiency measures (Sources) | Loss in output (Rs.) | Loss in output as per cent of $O_A$ |
|---|---|---|
| $O_A — O_D$ | 6,508 | 0·64 |
| $O_A — O_P$ | 2,49,188 | 24·42 |
| $O_D — O_E$ | 3,66,226 | 35·89 |
| $O_P — O_E$ | 1,23,546 | 12·11 |
| $O_D — O_P$ | 2,42,680 | 23·78 |
| $O_A — O_E$ (total inefficiency) | 3,72,734 | 36·53 |

From Table III it is evident that the extent of economic inefficiency for all the farms as a whole is very large of the order of 36.53 per cent. In other words, the actual income as a percentage of potential income is about 63.47 per cent. Of this 36.53 per cent inefficiency, only 0.64 per cent is due to lack of perfect mobility of factors of production given the present distribution of factors of production across farm size-groups, 12.11 per cent due to allocative inefficiency on the part of the farmers and about 23.78 per cent is due to lack of perfect diffusion or adoption of technological knowledge. Thus if we hold the system as being responsible for diffusion of technological knowledge and for the setting up of proper institutional mechanisms for bringing about perfect mobility of factors of production, then we find that 24.42 per cent (or in other words, 65.85 per cent of the total inefficiency in the economy) of the 36.53 per cent total inefficiency is due to system inefficiency. Also we find that the contribution made by technological inefficiency to total inefficiency is of the order of 23.78 per cent in contrast to 12.11 per cent of that of allocative inefficiency.

*Disaggregate Analysis*

Let us now analyse our disaggregate results on the measures of economic efficiency for each farm size-group. Table IV summarises the main results.

TABLE IV—FARM SIZE MEASURES OF ECONOMIC INEFFICIENCIES ACROSS FARM SIZE-GROUPS

| Farm size-group | $O_B$ (Rs.) | $O_P$ (Rs.) | $O_E$ (Rs.) | $\frac{O_B-O_P}{O_B}\times 100$ | $\frac{O_B-O_E}{O_B}\times 100$ | $\frac{O_P-O_E}{O_B}$ |
|---|---|---|---|---|---|---|
| I | 47,429 | 41,222 | 30,702 | 13·09 | 35·27 | 22·18 |
| II | 1,09,432 | 79,266 | 68,565 | 27·57 | 37·35 | 9·78 |
| III | 1,71,053 | 1,43,220 | 1,21,886 | 16·27 | 28·74 | 12·47 |
| IV | 6,85,888 | 5,07,414 | 4,26,423 | 26·02 | 37·83 | 11·81 |

$O_B$ = Optimum output for Best Technology model.
$O_P$ = Optimum output for Present Technology model.
$O_E$ = Present level of output.

From the above table it is evident that there exists substantial economic inefficiencies, irrespective of the size of farm, which is indicated by the index

$\left(\frac{O_B-O_E}{O_B}\times 100\right)$ The relative contribution made by technological inefficiency

$\left(\frac{O_B-O_P}{O_B}\times 100\right)$ to total inefficiency is consistently higher than the contribution made by allocative inefficiency to total economic inefficiency for all farms except for farm I for which it is the otherway round. This is consistent with the observation that we made elsewhere that small farmers are comparatively technologically superior in the production of many food crops than others.[15]

The conclusions that emerge from the above aggregate and disaggregate empirical analysis are the following:

1. There exists considerable economic inefficiency in the Indian agricultural system. Thus there exists ample scope for increasing farm income by utilizing the existing resources optimally. This inefficiency is of the order of 36.53 per cent. In other words, the difference between the potential output and the actual output as a percentage of the potential output is 36.53

15. See Sampath (19), Chapters III and V.

per cent, *i.e.*, we can increase the farmers' income by 56.55 per cent over the existing level by proper utilization of the existing resources and technology by only providing the necessary infrastructural facilities and by removing some of the obstacles.

2. To a large extent this inefficiency results from technical inefficiency which is of the order of 23.78 per cent out of the economic inefficiency of 36.53 per cent. In other words, technical inefficiency in the system contributes 65.1 per cent to the total economic inefficiency in the system. Only 12.11 per cent (in other words, 33.15 per cent of the total economic inefficiency) is contributed by allocative inefficiency and the rest 1.75 per cent is by lack of mobility of factors of production (or agents).

3. In terms of the components of the economy which are responsible for the prevailing level of economic inefficiency, we find that the prevailing imperfections in the system (which are external to the individual decision-maker over which he has no control) are responsible to the tune of 24.42 per cent of the 36.53 per cent total economic inefficiency. In other words, the system (or the environment) is responsible for 65.85 per cent of the economic inefficiency in the economy.

4. In the economy as a whole, lack of perfect mobility of factors of production as such is responsible for only 1.75 per cent of the economic inefficiency.

5. Contrary to expectations, we find that the difference between the small farmer and the large farmer in terms of the level of economic efficiency achieved is insignificant. Economic inefficiency of the small farmer is 35.27 per cent in comparison to 37.83 per cent of the large farmer. In terms of the sources of inefficiency, these two groups differ a lot. The major source of economic inefficiency of the small farmer is his allocative inefficiency which contributes 22.18 per cent of the total 35.27 per cent, *i.e.*, 62.89 per cent of the total economic inefficiency. This high allocative inefficiency among small farmers might be due to several other socio-economic-institutional constraints they might be facing, some of which we might not have taken into account and to that extent it might be an over-estimate of their inefficiency. In contrast, for the large farmer the major source of inefficiency lies in his technological inefficiency (surprisingly) which contributes 26.02 per cent of the 37.83 per cent economic inefficiency, *i.e.*, 68.78 per cent of the total inefficiency. If this conclusion is generally valid across farms in India then it would follow that the small farmer is much more enterprising and innovative than the large farmer in adopting the best technology given the resource position of the farmer.

6. According to the framework that we developed in section II, Table I, for classifying any agricultural economy as belonging to one of the sixteen situations described, our Deoria agricultural economy as a whole seems to belong to situation 16, which means that neither the system (the environment) nor the individual is economically efficient both in terms of technological efficiency and allocative efficiency.

## APPENDIX

### List of Crop Activities and Input Constraints Used in the Model

| Activity No. | Crop activity | Activity No. | Crop activity |
|---|---|---|---|
| 1 | Early paddy (UI) | 28 | EP(I)-W HYV (I) |
| 2 | Early paddy (I) | 29 | EP(I)-B(UI) |
| 3 | Late paddy (UI) | 30 | EP(I)-B(I) |
| 4 | Late paddy (I) | 31 | EI(I)-W-B-M(UI) |
| 5 | Paddy HYV | 32 | EP(I)-W-B-M(I) |
| 6 | Wheat (UI) | 33 | P HYV-W(UI) |
| 7 | Wheat (I) | 34 | P HYV-W(I) |
| 8 | Wheat HYV(I) | 35 | P HYV-W HYV(I) |
| 9 | Barley (UI) | 36 | P HYV-B (UI) |
| 10 | Barley (I) | 37 | P HYV-B (I) |
| 11 | Wheat-barley mixture (UI) | 38 | P HYV-W-B-M (UI) |
| 12 | Wheat-barley mixture (I) | 39 | P HYV-W-B-M (I) |
| 13 | Sugarcane planted (UI) | 40 | ML(UI)-W (UI) |
| 14 | Sugarcane planted (I) | 41 | ML(UI)-W (I) |
| 15 | Sugarcane ratoon (UI) | 42 | ML(UI)-W HYV(I) |
| 16 | Sugarcane ratoon (I) | 43 | ML(UI)-B(UI) |
| 17 | Maize local (UI) | 44 | ML(UI)-B(I) |
| 18 | Maize HYV(UI) | 45 | ML(UI)W-B-M(UI) |
| 19 | EP(UI)-W(UI) | 46 | ML(UI)-W-B-M(I) |
| 20 | EP(UI)-W(I) | 47 | M HYV(UI)-W(UI) |
| 21 | EP(UI)-W HYV | 48 | M HYV(UI)-W(I) |
| 22 | EP(UI)-B(UI) | 49 | M HYV(UI)-W HYV(I) |
| 23 | EP(UI)-B(I) | 50 | M HYV(UI)-B(UI) |
| 24 | EP(UI)-W-B-M(UI) | 51 | M HYV(UI)-B(I) |
| 25 | EP(UI)-W-B-M(I) | 52 | M HYV(UI)-WB-M(UI) |
| 26 | EP(I)-W(UI) | 53 | M HYV(UI)-W-B-M(I) |
| 27 | EP(I)-W(I) | | |

*Input constraints*

*Kharif* land (UI)
*Kharif* land (I)
*Rabi* land (UI)
*Rabi* land (I)
*Kharif* human labour
*Rabi* human labour
*Kharif* bullock labour
*Rabi* bullock labour
*Kharif* working capital
*Rabi* working capital

*Notes:*—

| | | |
|---|---|---|
| UI | = | Unirrigated. |
| I | = | Irrigated. |
| EP | = | Early paddy. |
| LP | = | Late paddy. |
| ML | = | Maize local. |
| MHYV | = | Maize HYV. |
| W-B-M- | = | Wheat-barley mixture. |
| WHYV | = | Wheat HYV. |
| P | = | Paddy. |
| B | = | Barley. |

*Subsistence requirements constraints*

We also had subsistence requirements constraints for meeting the farmer family's food needs. But in all cases except in one situation, these constraints turned out to be redundant.

In addition, we also had a constraint in the form of an upper bound on the amount of area under sugarcane ratoon as the area under it cannot exceed the area under planted in the previous year.

## REFERENCES

1. D. J. Aigner and S. F. Chu, "On Estimating the Industry Production Functions", *The American Economic Review*, Vol. LVIII, No. 4, September 1968.
2. R. G. D. Allen: Mathematical Economics, Macmillan & Co. Ltd., London 1956.
3. Jock R. Anderson and N. S. Jodha, "On Cobb-Douglas and Related Myths", *Economic and Political Weekly*, Vol. VIII, No. 26, June 30, 1973.
4. J. N. Boles, "Efficiency Squared—Efficient Computation of Efficiency Indexes", *Western Farm Economic Association Proceedings*, 1966.
5. Venkareddy Chennareddy, "Production Efficiency in South Indian Agriclture", *Journal of Farm Economics*, Vol. 49, No. 4, November 1967.
6. Amal Krishna Dey and Ashok Rudra, "A Test of Hypothesis of Rational Allocation under Cobb-Douglas Technology", *Economic and Political Weekly*, Vol VIII, No. 12, March 24, 1973.
7. M. J. Farrell, "The Measurement of Productive Efficiency", *Journal of the Royal Statistical Society*, 1957.
8. Ashok Kumar Hati and Ashok Rudra, "Calculation of Efficiency Indices of Farmers: A Numerical Exercise", *Economic and Political Weekly*, Vol. VIII, No. 13, March 31, 1973.
9. J. M. Henderson and R. E. Quandt: Micro Economic Theory, McGraw-Hill, New York, 1971.
10. J. R. Hicks: Value and Capital, Clarendon Press, Oxford, 1946.
11. W. David Hopper, "Allocation Efficiency in Traditional Indian Agriculture", *Journal of Farm Economics*, Vol. 47, No. 3, August 1965.
12. Robert Kuenne: The Theory of General Economic Equilibrium, Princeton University Press, Princeton, New Jersey, 1963.
13. Lawrence J. Lau and Pan A. Yotopoulos, "A Test for Relative Efficiency and Application to Indian Agriculture", *The American Economic Review*, Vol. LXI, No. 1, March 1971.
14. Vahid F. Nowshirvani, "Allocation Efficiency in a Traditional Indian Agriculture: Comment", *Journal of Farm Economics*, Vol. 49, No. 1, Part I, February 1967.
15. Lionel Robbins: An Essay on the Nature and Significance of Economic Science, Macmillan & Co. Ltd., London, 1932.
16. Ashok Rudra, "Allocative Efficiency of Indian Farmers: Some Methodological Doubts", *Economics and Political Weekly*, Vol. VIII, No. 3, January 20, 1973.
17. Gian S. Sahota, "Efficiency of Resource Allocation in Indian Agriculture", *American Journal of Agricultural Economics*, Vol. 50, No. 3, August 1968.
18. G. R. Saini, "Resource-Use Efficiency in Agriculture," *Indian Journal of Agricultural Economics*, Vol. XXIV, No. 2, April-June 1969.
19. R. K. Sampath: Nature and Measurement of Economic Efficiency, Harvard University Centre for Population Studies, Cambridge, Massachusetts, U.S.A., 1976 (mimeo.).
20. R. K. Sampath: Aggregation Bias in LP Models and Its Implications for Empirical Analysis (under publication), 1977.
21. P. A. Samuelson: Foundations of Economic Analysis, Harvard University Press, Cambridge, Mass., 1948.
22. T. W. Schultz: Transforming Traditional Agriculture, Yale University Press, New Haven, 1964.
23. Uma K. Srivastava and Vishnuprasad Nagadevara, "On the Allocative Efficiency under Risk in Transforming Traditional Agriculture", *Economic and Political Weekly*, Vol VII, No. 26, June 24, 1972.
24. C. Peter Timmer: On Measuring Technical Efficiency, Ph.D. Thesis, Harvard University, Cambridge, Mass., 1969.
25. John Wise and Pan A. Yotopoulos, "A Test of Hypothesis of Economic Rationality in a Less-developed Economy: An Abstract", *American Journal of Agricultural Economics*, Vol. 50, No. 2, May 1968.