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Two general conclusions underline the results presented above; one is that it is farmers with larger holdings who can more readily adopt technological change which then seeps down gradually to farmers with smaller holdings. The second is that independently of the size of holding, farmers who accept one improved practice also accept other similar practices more readily than farmers not employing any improved practice. It would appear from this that if extension efforts are concentrated on the most important improved practice, namely, fertilizers, which a very large proportion of farmers can adopt profitably under their present methods of cultivation, then they will also be induced to adopt other improved practices like plant protection, improved implements, etc.

BENEFIT-COST EVALUATION OF TECHNOLOGICAL CHANGE IN AGRICULTURE

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INTRODUCTION

A benefit-cost evaluation of technological change in agriculture seeks to relate the economists' theory of decision-making with that of the social psychologist. In other words, it attempts to link the social influences on choices faced by the consumer and producer with the principle of maximization, the function to be maximized being the present value of benefits minus costs. For purposes of benefit-cost appraisal, technological change in agriculture must be understood as the entire process, starting from investments which result in the flow of goods and services that make the introduction of change possible to the actual introduction of the change at the field level.

The benefit-cost models[1] that have been constructed are basically simple and require very elementary disaggregation of the variables. Their major contribution lies in sharply bringing into focus some of the important variables associated with decision-making.

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1. Some of the important contributions are : John V. Krutilla and Otto Eckstein : Multiple Purpose River Development, John Hopkins Press, Baltimore, 1957; P.O. Steiner, "Public Investments in the Water Resource Field : Choosing Among Alternatives," *American Economic Review*, Vol. XLIX, 1959, pp. 893-916; J. Margolis, "The Economic Evaluation of Federal Water Resource Development," *American Economic Review*, Vol. XLIX, 1959, pp. 96-111 ; Stephen Marglin: Approaches to Dynamic Investment Planning, North Holland Publishing Company, Amsterdam, 1963 ; Martin S. Fieldstein, "Net Social Benefit Calculations and Public Investment Decision," *Oxford Economic Papers*, New Series, Vol. 16, No. 1, March, 1964, pp. 114-131.

The utility of benefit-cost calculations depends upon the extent to which they are able to help in answering two questions, namely, how much to invest and when to invest ? Assuming investment is in the public sector, both these questions are asked at the government level. Once the investment actually takes place it leads to a flow of intermediate goods like fertilizers, seeds, pesticides, etc. The real worthwhileness of this investment depends upon the extent to which it helps to bring about an increase in agricultural output. The actual increase in agricultural output depends upon the efficient use of fertilizers, seeds, etc., by the cultivators. Before the cultivator actually uses them, he would like to know how much additional investment would be required and what would be the corresponding benefits. The total investment, therefore, that is relevant for a benefit-cost analysis is made up of investment in the public sector and the sum of investments by the individual cultivators. The direct benefits are represented by the addition to agricultural output as a result of the adoption of changes in technology. This paper is limited to an examination of some of the problems that arise in estimation of benefits and costs.

PROBLEMS IN THE ESTIMATION OF DIRECT BENEFITS

Technological Change and the Absolute Flow of Benefits

The diffusion of technological change takes time. Before a new technological development can be adopted by a cultivator, he must be convinced of its utility and must also know how to introduce it. Besides, the first application of a newly developed technique generally involves some risk and the farmer must be in an economic position to take the risk. Hence the speed with which the technological change is likely to be introduced depends upon the reactions[2] of the cultivators to technological change. It follows that an estimate of the direct flow of benefits depends upon an estimate of the speed with which the technological change will be introduced.

Once the change has been introduced, it influences the absolute flow of benefits through a substitution effect and through an output effect. A pure substitution effect exists when a new input is substituted for an earlier one without any effect on output or reduction in costs. It is quite conceivable that substitution can take place even if it leads neither to a reduction in costs nor increase in output. This can happen when the input currently in use is in short supply or it is an imported input and it is considered necessary to curtail its imports. However, what does appear to be unrealistic is the underlying assumption that the elasticity of substitution between the two inputs is perfect. By and large, the effect of a technological change will tend to be the combined result of the substitution effect and the output effect.

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2. For a study of the facts that influence the introduction of improved seeds, fertilizers, pesticides and improved methods of cultivation, reference may be made to the Fifth Evaluation Report on the Working of Community Development and N.E.S. Blocks, Programme Evaluation Organisation, Planning Commission, Government of India, 1958, pp. 65-92 and Evaluation of the 1958-59 Rabi Crop Campaign in Punjab, Rajasthan, and U.P., Programme Evaluation Organisation, Planning Commission, 1960.

Project Age and Calendar Time[3]

The project age, from the point of view of its effect on the flow of benefits may be divided into three stages: the period of construction, the period from the completion of construction to full development, and the period from full development onwards.

During the period of construction, the flow of benefits may be zero or may be very small; for example, in the case of an irrigation project, unless the dam has been constructed, the flow of benefits is zero, but after the completion of the dam, the flow of benefits increases with the increase in the area covered by canals, distributories and field channels. Once the construction is complete the stage is reached when the water can in fact be supplied to the entire command area; but it is quite possible that there is not yet sufficient demand for irrigation water in the whole of the command area; hence time has to be given for this demand to be created. When this demand has been created the period of full development is reached.

In view of what has been said in the foregoing paragraph, it is quite possible that the economic benefits from a project can be improved by postponing construction.[4] The explanation is that the postponement of construction may change the net present value of a project from a negative amount, if constructed today to a positive amount, if the construction is deferred to some future date. The postponement of construction will tend to reduce the present value of construction as long as the absolute cost does not increase over the time and the interest is positive. Hence it follows, that if over time, the benefit rate is increasing, the loss in the present value of benefits due to postponement of construction may be more than offset by the savings in the present value of the cost. A simple test would be that so long as the annual interest cost is greater than the annual benefits, the net present value is increased by postponing construction.

Change in Relative Prices

Changes in the absolute level of prices, that is a uniform change in all prices can be taken care of, or rather ignored, by making calculations in terms of constant prices. Changes in relative prices, however, should be taken account of as far as possible. A unique forecast of price changes would tend to give a false idea about the accuracy of the calculations. It may probably be more useful to show how the outcome would be affected if several assumptions about prices were used.

The Choice of the Discount Rate

The benefits that occur at different points of time have to be made comparable by reducing them to a common time basis. This may be done by discounting the

3. This distinction between project age and calendar time was probably first put into print by Stephen Marglin : Approaches to Dynamic Investment Planning, *Op. cit.* It was introduced independently in the unpublished Major Irrigation Study by the Programme Evaluation Organisation, Planning Commission.

4. This point was probably raised for the first time by Joe Bain, "Criteria for Undertaking Water Resource Development," *American Economic Review*, Vol. L, May, 1960 and was further developed by Stephen Marglin, *Op. cit.*, Chapter I.

benefits accruing at different points of time by an appropriate discount rate and finding the equivalent present worth of the benefits. As far as traditional capital theory is concerned the market rate of interest equates the marginal time preference of savers with the marginal productivity of capital in investment; since the benefit-cost approach is intended specifically for overcoming the deficiencies caused by investments based on the market rate of interest, the market rate itself cannot be used as a discount rate for finding the present worth of the time stream of benefits.

Two possible methods have been suggested for determining a discount rate which expresses adequately the society's demand for future benefits. This rate may either be determined by an administrative decision as suggested by Pigou,[5] Ramsay[6] and Sen[7] or through the political process as suggested by Bain,[8] Eckstein[9], Marglin[10] and McKean.[11] In a democratic form of government, these two methods are neither inconsistent nor independent of each other.[12] It is clear that policy relating to public investment is actually formulated by a few persons. In the formulation of this policy a certain rate of discount is used. If the investment policy as formulated is accepted by the public then it means that the rate of discount allowed for in the formulation of policy is also accepted.

Some of the important factors that influence the discount rate are firstly, the pure time discount, secondly, the size and age composition of the population, thirdly, the level of output and fourthly, changes in the relative utility of goods, reflecting changes in tastes, scarcities, etc. It follows from a consideration of these variables that it would be advisable to use more than one discount rate for a given period, and that so far, the search which has been for a single discount rate[13] has possibly not been in the right direction. Again, it would be appropriate not to use a constant discount rate for the entire period for which calculations are made, but to vary the discount rate over time. If benefits are calculated for a period of, say, 50 years it would be better to use one discount rate for the first 25 years and another discount rate for the next 25 years.

ESTIMATION OF DIRECT COSTS OF THE PROJECT

The costs of the project must include the total capital invested, the interest on the capital, depreciation and maintenance costs. To this must be added the total costs of cultivation of individual farmers.

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5. A. C. Pigou : Economics of Welfare, 4th Edition, London, pp 23-30.
6. F. P. Ramsay, "A Mathematical Theory of Saving," *Economic Journal*, Vol. XXXVIII, December, 1928.
7. A. K. Sen : Choice of Techniques, Basil Blackwell, Oxford, 1960, Chapter 8.
8. Joe Bain, *Op. cit.*
9. Otto Eckstein, "Investment Criteria for Economic Development and the Theory of International Economics," *Quarterly Journal of Economics*, Vol. LXXXI, 1957, pp. 56-85.
10. Stephen Marglin, "The Social Rate of Discount and the Optimal Rate of Investment," *Quarterly Journal of Economics*, Vol. LXXXVII, 1963, pp 95-111.
11. R. McKean, "The Unseen Hand in Government," *The American Economic Review*, Vol. XV, June, 1965, pp. 496-506.
12. A similar point of view is expressed by M.S. Fieldoterin, "The Social Time Preference Discount Rate in Cost-Benefit Analysis," *The Economic Journal*, Vol. LXXIV, 1964, pp. 376.
13. J. V. Krutilla and Otto Eckstein : *Op. cit.*; Otto Eckstein: Water Resource Development: The Economics of Project Evaluation, Harvard University Press, Cambridge, 1958; R. N. McKean: Efficiency in Government through Systems Analysis, New York, John Wiley and Sons, Inc., 1958.

ESTIMATION OF SOCIAL BENEFITS AND COSTS

The estimation of social benefits and costs presents more difficulties than the estimation of direct benefits and costs. A method for measuring social benefits and costs was put forward first by Otto Eckstein and subsequently taken up by Stenier, Marglin and Fieldstein. The method suggested by Eckstein will be briefly reviewed here to show the limitations of the approach and the difficulties of the problem. Eckstein has attempted to measure the social cost of capital employed in a project. It is assumed that the project is financed from funds raised through taxation. A tax leads either to a reduction in the consumption of households or a reduction in investment or both. Hence the social cost of capital, according to Eckstein, is made up of two components, first, the cost of funds which in the absence of taxation would have been invested in the private sector and secondly, the cost of funds which would have been spent on consumption. He states that if the funds had been invested in the private sector, they would have yielded a certain rate of return to the community which would have increased the future flow of real national income in the country. The social cost, therefore, is equal to the foregone rate of return on real investment.

In order to find out the cost of funds that would have been spent on consumption, the saving and borrowing behaviour of individuals needs to be examined. It is known that each individual has certain preferences about the allocation of his expenditure over time. If he postpones consumption he earns an interest on the resultant saving; if he pays outstanding debts, he reduces his interest payments. A rational consumer will, therefore, allocate his expenditure over time in such a way that the rate at which he is willing to give up the present consumption for the income stream generated from the saving due to the postponement of consumption is equal to the interest rate which he faces in making the choice. Hence in order to find out the social cost of funds raised through taxation, the interest rate must be determined for individuals on the assumption that they have given preferences about saving and consumption and given opportunities for investment.

This method of calculating the social cost of funds that would have been invested in the absence of taxation clearly leads to an over-estimate of social costs, because it does not take into account the rate of return on government investment. Assuming that the rate of return on government investment is lower than that on private investment, the social cost would be more appropriately measured by the difference between the rates of return on public and private investment. This measure of social costs must be supported by a factual description of the social costs like water logging, salinity of the soil, submergence of the land under dams, etc.

An average interest rate applicable to the distribution of tax savings from increasing personal exemption is calculated. The consumers are divided into income classes. Their asset-debt position is ascertained and the marginal borrowing or lending rates applicable to them are calculated. The final figure for the interest rate is computed by weighting the average rates applicable to these income classes by their shares of tax savings. It is clear that the interest rates on Government bonds stocks, reduction in consumer debt incorporates varying degrees

of risk allowances and in averaging the rates the different degrees of risk are not taken into account. It would be appropriate if some allowance for different degrees of risk was also made.

Thirdly, the method of arriving at the cost of capital by examining the distribution of an individual's income between consumption and savings gives an undue significance to consumer's sovereignty that is not necessarily consistent with the planning of public investment.

Fourthly, the use of time preferences of the current generation of tax-payers is not justified. Eckstein recognizes the fact that the political process does not view investment in terms of the preferences of the current population, but in spite of it he uses a time preference of the current generation. This approach is defended on the ground that a measure of the social cost of capital which is consistent with an economic efficiency approach must accept the sovereignty of consumer's choice even with regard to the allocation of expenditure over time.

Fifthly, if the social cost of capital is to be estimated by examining the effects on consumption and savings of the taxes required to raise the necessary funds for the project, then account must also be taken of the stream of tax receipts generated by the project over time.

Sixthly, the use of the model for actually measuring benefits and costs is difficult where the appropriate data are not available. In such a situation it would be necessary to reformulate the model in the light of the available data.

CONCLUSION

It is clear from the various problems examined in this paper that a number of uncertainties enter into the estimation of even direct benefits and costs, for instance the response of the cultivators to technological change, efficiency of cultivators, movements in relative prices, etc. In view of the presence of uncertainties it would be useful to have alternative sets of time streams of benefits and costs. The assumptions on the basis of which each time stream of benefits and costs has been arrived at should be clearly spelled out. Each time stream should be discounted by more than one discount rate. If the time period for which the benefits and costs are being discounted is sufficiently long then a constant discount rate should preferably not be used. From the calculations based on alternative time streams and discount rates it will be possible to determine a range of benefits-cost ratios within which the actual ratio is likely to lie.