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United Nations Industrial Development Organisation

TRAINING WORKSHOPS ON INDUSTRIAL PROJECT FORMULATION AND EVALUATION

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AN ECONOMIC EVALUATION OF THE DURGAPUR FERTILIZER PROJECT: A CASE STUDY OF SOCIAL BENEFIT-COST ANALYSIS FROM INDIA

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I. Introduction

Some 157 Km by railroad from the metropolitan city of Calcutta lies the industrial township of Durgapur in West Bengal. There is a sizeable industrial complex here, including a major iron and steel unit. The fertilizer project to be studied in this paper will be located in this industrial centre. It is to be put up by the Fertilizer Corporation of India, a State-owned limited company, which is already producing fertilizers in Sindri (Bihar) and in Nangal (Punjab), and is also constructing fertilizer production units in Trombay (Maharashtra), Gorakhpur (U.P.), Namrup (Assam), and Korba (M.P.), in addition to that in Durgapur. This general background is important to bear in mind, since the Durgapur project is only a part of a wider fertilizer programme of the Government of India.

In many ways the Durgapur Fertilizer Project (hereafter, DFP) is an extremely interesting project to evaluate. A number of intricate aspects of project evaluation assume considerable importance in this analysis, and as an illustrative case study on project evaluation it has obvious merits. However, there is one problem with the DFP that is rather disturbing. The plans for the project have been frequently revised, and the evaluator has to run to keep at the same place. At the time when this evaluation was undertaken, some considerable uncertainties persisted about the exact shape of the project. The latest report that was provided to us by the good offices of the Planning Commission of India was one entitled: Economic and Technical Soundness Analysis : Durgapur Fertilizer Project of the Fertilizer Corporation of India Ltd. (mimeographed). While it is an un-dated document, it is clear from the figures and the estimates that the calculations preceded the devaluation of the Indian Rupee in June 1966. Furthermore, it is common knowledge that the exact specifications of the DFP, including its output targets, have changed somewhat from that given in the Economic and Technical Soundness Analysis (hereafter ETSA). Since, however, later estimates could not be obtained, and also since the object of this study is mainly to illustrate the methods and techniques of project evaluation, we decided to do the evaluation entirely within the framework put forward by the ETSA. This means, in effect, that the evaluation is done from the point of view of the information available at some point of time preceding June 1966, when the ETSA represented the available body of knowledge. This way we get an internally consistent picture, in terms of which the methods of project evaluation can be illustrated, rather than introducing some piecemeal changes, without knowing their impact on the rest of the estimates and calculations.

II. The Project and its "Soundness"

As envisaged in the ETSA, the DFP will produce per year 135,000 tonnes of Nitrogen and 110,000 tonnes of P_2O_5, in the form of a "complex fertilizer" (viz. Ammonium Sulphate Phosphate) and Urea. The former will be made out of Ammonium Sulphate and

Phosphoric Acid, with the possibility of adding Potash to it. The Report of the ETSA is based on the assumption of mixing Nitrogen and P_2O_5 in equal proportions, with the question of Potash left open. If the mixture is in the proportion of 19:19:0, then 579,000 tonnes of the "complex fertilizer" will have to be produced. If, however, the mixture is 20:20:0, then 550,000 tonnes of it will be made. In addition 55,000 tonnes of Urea will also be produced, with 46% Nitrogen. Further, 15,000 tonnes of Anhydrous Ammonia will be produced exclusively for sale. The position is summarized in Table I.

The Report of the ETSA, as its name indicates, goes into the economic and technical "soundness" of the DFP. It does not use any one criterion of evaluation, but refers to several indicators. It finds the "investment output ratio" of the project to be 1 : 0.8 (ETSA, p.19), which amounts to a marginal capital output ratio of 1.25. It estimates the profitability at market prices with standard assumptions about depreciation, etc., to be 24.4 per cent (ETSA, p.19). It also quotes a return on equity capital of 44.6 per cent. These figures are undoubtedly high, but for reasons discussed elsewhere,[1] these may not necessarily tell us much about the national economic profitability of the DFP.

1 See S.A. Marglin, Public Investment Criteria (London: Allen and Unwin, 1967); O. Eckstein, "A Survey of Public Expenditure Criteria," in R.Musgrave, et al, Public Finances : Needs, Sources Utilization (Princeton, 1961), National Bureau of Economic Research; A.K. Sen, General Criteria of Project Evaluation, United Nations, CID/IPE/WP.8.

The ETSA Report itself goes into one important aspect of the national economic profitability. It is the question of foreign exchange saving. It calculates the foreign exchange expenditure per year during the operation of the DFP to be Rs.29 million, which is contrasted with the saving of foreign exchange worth Rs.310 million, in the shape of imports of fertilizers replaced by domestic production at DFP. This amounts to an annual saving of Rs.281 million, on an initial foreign exchange investment of Rs.170 million. Thus, reports the ETSA, "the foreign exchange expenditure incurred in the setting up of the project will be earned back completely in terms of foreign exchange saving in a very short period of less than an year." (ETSA, p.84).

The picture is even more rosy if the foreign exchange saving is calculated not in terms of the replacement of fertilizer imports, but in terms of the replacement of food imports by the use of these fertilizers. The annual saving of foreign exchange in this case will be as much as Rs.756 million (ETSA, p.84), which does compare extremely well with the initial foreign exchange investment of Rs.170 million. The picture is summarized in Table II.

These foreign exchange figures are somewhat misleading, since they do not fully take into account the indirect foreign exchange implications of the DFP. These implications are of two different kinds. First, some of the "domestic" components of cost do have indirect import content. It is understandable that it is not easy to trace back all the import implications of the initial and operating costs of the DFF, and the ETSA need not be blamed for not trying to do this exercise. However, the fact remains that the actual imports caused by the DFP will be somewhat larger than the figures quoted when the import components at various stages of production are summed together.[2]

Second, there may be possible foreign exchange losses even when an entirely domestically produced input is used, if that input is potentially exportable. For example, Naptha, which is an important input in the DFP, is potentially exportable, though possibly at a lower price than that at which it can be imported. It has, therefore, to be borne in mind that when an input like Naptha is used, there is some sacrifice of possible exports and thus of foreign exchange. We shall go into these corrections later on. It should be noted, however, that even after these corrections, the saving of foreign exchange involved in the DFP is quite considerable, and indeed the "shadow price" of foreign exchange will be found to be a crucial variable in the estimation of the national economic profitability of the DFP.

III. The Basic Sets of Time Series

As seen in the ETSA Report, the DFP will take three years to construct. By taking the first year as year 0, the DFP will be complete by the end of year 2. In our estimation of the present value we shall convert all benefits and cost figures into equivalent

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2 Information is relatively scanty in this field, and one of the few sources is T.A. Weisskopf, "A Multi-sectoral Programming Model for India : Some Numerical Results," Economic and Political Weekly, April 22, 1967.

amounts of benefits of year 0.

The ETSA Report gives the operating costs and output figures for ten years of operation (Annexure No. 15(a)). In their calculation of the depreciation figures, the ETSA Report assumes a life of 9 years (ETSA, p.78). We have, however, chosen 10 years as the life since depreciation figures often understate the actual productive life of a unit, and the table in Annexure No.15(a) clearly indicates the expected outputs and inputs in the 10th year of operation. We shall assume that the residential building, roads and culverts will live beyond this period.

In Table III the symbols that are being used are explained, In Table IV we present the basic sets of time series of items of benefits and costs. The first eight rows are simply taken from the ETSA, particularly from Annexures 12(a), 12(b), and 15(a). These items include the direct domestic component of investment (I_d), the direct foreign exchange component of investment (I_f), the value of output in terms of today's outlook of market prices (V_x), the value of the same output in terms of the foreign price of the replaced imports of fertilizers (V_f), the direct domestic component of operating costs (C_d), the direct foreign exchange component of operating costs (C_f), the value of investment in "buildings, roads and culverts" (I_B), and the labour cost as part of operating cost (L). The value of each of these items for each year during the thirteen-year period from year 0 to year 12 is given in Table IV. Naturally, the output and operating cost figures do not begin until year 3, and the bulk of the investment figures are over by year 2. There are, however, some investments for the first three years of operation (years 3 to 5), due to the accumulation of real working capital.

The last four rows in Table IV are not raw data but the results of some operations with such data. I_f gives the value of the direct foreign exchange component of investment, but does not include the indirect content significantly. As we mentioned before, data on this subject is scarce, but on the basis of the data that exist, we have tried to make rough corrections for the indirect foreign exchange component, taking into account both (a) indirect import component, and (b) loss of export earning because of the absorption of potentially exportable commodities in domestic production. The resultant changes in the domestic and foreign components in the investment are given by the corrected figures of $\overline{I}_d$ and $\overline{I}_f$, respectively.

In the case of operating costs, it was found that some considerable provision has been made already in the ETSA for the indirect exchange components. However one further correction was introduced into the figures of $\overline{C}_d$ and $\overline{C}_f$. The requirement of Naptha for the DFP is estimated to be 158,400 thousand tonnes per year (ETSA, 3.35). The ex-refinery price of Naptha is taken to be Rs.85 per tonne (ETSA, 3.38). Since this is domestically produced (the DFP will get its Naptha from the Barauni refineries), this cost was put under C_d. However, Naptha is potentially exportable so that its use in the DFP involves some loss of possibilities of earning foreign exchange. Furthermore, there are reasons to expect a shortage of Naptha to develop in India by around 1971, so that the marginal Naptha may have to be imported in the period following.[3] The fact that the Barauni Naptha will still

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[3] We are grateful to Professor Alan Manne for educating us on the international trade position of Naptha.

come to DFP makes no difference, since it could have been used elsewhere otherwise, thereby cutting down imports.

There is currently a difference in the export price and import price of Naptha thanks to market imperfections as well as the cost of shipping. Further, the future prices of Naptha may well be different. Since there are considerable uncertainties about all this, we have made a rather simpler assumption, viz., taking the foreign exchange price of Naptha as Rs.76 per tonne at the nominal exchange rate (corresponding to $16 at Rs.4.75 per $).[4] As the shadow price of foreign exchange is raised, the value of Naptha in our calculations will be correspondingly increased. This nominal exchange cost is added to the C_f figure to obtain the corrected figure of $\overline{C}_f$. Regarding domestic operating costs, C_d, the cost of Naptha at Rs.85 per tonne is subtracted. This assumes the same transportation cost in each case, since we have not changed the transportation cost of Naptha included in the operating costs.

Finally, a word about the value of output in terms of foreign exchange. The ETSA Report quotes two sets of figures on this, as we noted in Section II above. One is in terms of the cost of replaced imports of fertilizers, which is the one we have taken, since at the margin the DFP is an import-substituting project. The other is in terms of the cost of food imports saved, taking credit for the amount of food grains to be produced by using the fertilizers manufactured

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4 It is to be remembered that all the calculation here are being done in terms of the point of reference of the ETSA Report, which is in a pre-devaluation situation. We shall, however, introduce shadow price corrections of foreign exchange, including (in one case) a shadow price equivalent to the post-Devaluation par value.

in the DFP. The latter figure is much higher than the former (see Section II above), since the return on fertilizers is extremely high in Indian agriculture. But we are evaluating here the gains from the <u>production</u> of fertilizers and not from its <u>use</u>; even if we do not produce any fertilizers, we still have the option of using the same amount by importation of it.[5] What domestic production of fertilizers permits us to do is precisely to replace these imports, and therefore the relevant value of the output is that given by the import cost of the fertilizers replaced, with suitable correction for the shadow price of foreign exchange, to be introduced later. It should be noted, however, that in choosing this method of evaluation we are ruling out prejudices and other constraints that might prevent the importation of fertilizers if it is not manufactured at home. If foreign exchange is very scarce, we can attach a high shadow price to the cost of importing fertilizers; what we are ignoring is simply the possibility of imports of fertilizers being ruled out on some other ground, e.g., some peculiar prejudice of the planners.

IV. <u>The Values of the Parameters Used in the First Evaluation</u>

For the purpose of our first set of estimates we shall assume a social rate of discount of 10 per cent and a shadow price of foreign exchange of 1.57. Since we started with the pre-Devaluation price of dollar at Rs.4.76, this shadow price makes the price of foreign exchange equal the post-Devaluation official price. In later sections

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5 On this question see I.M.D.Little, "Public Sector Project Selection in Relation to Indian Development" (Mimeographed); to be published in volume edited by A.V.Bhuleskar, essays in the memory of Nehru; A.K.Sen, <u>The Role of Policy Makers in Project Evaluation</u>, United Nations, CID/IPE/TW.12.

we shall try out many other values of the social rate of discount and the shadow price of foreign exchange.

It is assumed that 80 per cent of the investment cost in the DFP represents a sacrifice of alternative investment (possibly private investment). This alternative investment would have yielded a perpetual return of 20 per cent per year. This is the return for the society as a whole and not only to the investor himself. Of this return a proportion of 20 per cent would have been reinvested, again at 20 per cent perpetual return with similar proportion of reinvestment at further stages. These assumptions are made to get an idea of the alternative benefits streams sacrificed by having the DFP. Since the rate of discount (10%) is lower than the alternative rate of return on capital investment (20%), there is a premium on investment vis-a-vis consumption.[6] Therefore, in evaluating the alternative opportunities sacrificed in having the DFP, we have to find out the exact pattern of reinvestment out of alternative investment. The assumptions outlined above represent the best guess that we could make given the available evidence, which is somewhat scanty. Some alternative assumptions will be tried out in the later sections.

Regarding the DFP itself, it is assumed that of the benefit from the project output, one-third will go to the Government. The Government in its turn will reinvest a proportion of 80 per cent of it, yielding 20 per cent rate of return, with 20 per cent reinvestment at every stage. The remaining two-thirds of the benefit from project output will go to the farmers and other non-government

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6 See Marglin, Public Investment Criteria, op.cit.; T.Weisskopf et al, Lectures on Social Cost-Benefit Analysis for Industrial Project Formulation and Evaluation, United Nations, CID/IPE/TV.5.

recipients, who in their turn will consume 95 per cent of these benefits and reinvest the rest yielding 20 per cent marginal return with 20 per cent plough back at every successive stage. Once again these represent our best guess, but the nature of some of these parameters need to be somewhat clarified.

The division of the direct benefit from the DFP between the Government on the one hand and the farmers and other non-government recipients on the other, depends much on the fertilizer sales policy of the Government. As has been explained before, the DFP will substitute the import of fertilizers from abroad, and as such the benefit is in the form of the saving of the true value of the foreign exchange costs. If the Government sells the fertilizer relatively cheap when it manufactures it at home, compared with the price at which the fertilizer will sell if it were imported from abroad, this will tend to make the farmers' share of the benefits from DFP to be considerable. If, on the other hand, the Government sells the fertilizer at exactly the same price at which it would have sold if it were imported, then the farmers' are not directly affected at all by the production of fertilizer at the DFP compared with it being imported. Then the gain from domestic manufacture will go totally to the Government.

From the point of view of the Government the relative shares of the DFP benefits are policy variables, though constrained by various political and other pressures. From the point of the evaluator of the DFP, however, the general fertilizer sales policy of the Government is not within his jurisdiction. For him, this policy is simply one of the given facts of the situation. Given the premium on investment and the Government's ability to reinvest a much larger share of the benefits accruing to it vis-a-vis those going to the farmers, there is a case for raising the value of g as far as possible. There are, however, limits that operate on the Government policies, and for the purpose of this evaluation it has been assumed that the price policy will be such that the Government will get one-third of the benefits and the farmers and other non-government recipients the rest. In a later section we shall show how sensitive the profitability of the DFF is to changes in this price policy affecting the distribution of benefits. Alternative assumptions will then be taken.

Regarding the supply of unskilled labour, it is assumed that considerable unemployment of unskilled labour will persist for at least ten years after the beginning of the DFF operation. Thus the value of unskilled labour (in investment as well as in operations) does not reflect its opportunity cost in terms of alternative output. A proportion of 10 per cent of the cost of domestic investment is taken to be the wage cost of unskilled labour, and a proportion of 50 per cent is taken to be the share of unskilled labour in the total labour cost in the operations. It is assumed that the unskilled labourers consume everything they earn.

Finally, since the DFF like other public industrial undertakings will provide some subsidized housing and other township facilities, there are also some indirect benefits from the project. We take these to amount to a perpetual return of 15 per cent on the value of investment on building, roads and culverts in the colony (I_B). This is net of maintenance and depreciation, and it is assumed that even when the production unit of the DFF will have to be replaced, the colony will persist, with its accompanying indirect benefits. These benefits are assumed to be wholly consumed.

The values of the parameters to be used are summarized in Table V.

V. Present Value of the DFF at the Market Prices

As preparatory to the calculation of the present value of the DFF at market prices and at the relevant shadow prices, we calculate the present value of the relevant sets of time series given in Table IV. We use for this purpose a rate of discount of 10 per cent, as explained in the last section. The present values are all done in terms of year 0. The results are given in Table VI.

As the first step we calculate the present value of the DFF at market prices. If this were negative, then the DFF will be shown to be commercially non-profitable at a rate of interest of 10 per cent. But in fact the present (P_1) value at market prices turns out to be Rs.241.5 million (See Table VII.A). In commercial terms P_1 represents the net profits that can be earned in the DFP today by future sales and purchases of the outputs and inputs of the DFF with borrowing and lending at 10 per cent interest. The project is clearly commercially profitable.

VI. Present Value After Correction for Foreign Exchange Price and for Indirect Benefits

If the value of the fertilizer output is equated not to market price but to the cost of importing the corresponding amount of fertilizers from abroad, we have to replace V_x by V_f. After this correction, the present value (P_2) of the DFF rises to Rs.288 million, as shown in Table VII.B.

So far the cost of foreign exchange has been taken to be that given by its nominal price at the time of the ETSA evaluation. If the shadow price is taken to be higher than this, the present value will rise, since the DFF is a foreign exchange earning project. Taking a foreign exchange price of 1.57, i.e., a premium on foreign exchange of 57 per cent, the present value (P_3) becomes Rs.851 million, as shown in Table VII.C. This figure is obtained by raising by 57% the value of output in terms of foreign exchange (V_f) as well as the cost of the foreign exchange components of investment costs and operating costs ($\bar{I}_f$ and $\bar{C}_f$).

The correction for indirect benefits from building, roads, and culverts in the colony is introduced by adding to P_3, the present value of a perpetuity of 15% return on I_B, in the light of the line reasoning outlined in Section IV. The new present value (P_4), as shown in Table VII.D, is Rs.872 million.

VII. Correction for Labour Cost and the Price of Investment

Because of the presence of unemployed labour in the unskilled category in substantial amount, the alternative output sacrificed by employing unskilled labour in the DFF may be taken to be negligible. Taking half of the present value of the operating labour cost as the present value of the wage cost of unskilled labour in operations, and taking a tenth of the domestic investment cost as the unskilled wage element in it, we obtain the overstatement of costs implied in the nominal cost figures. When these corrections are made, as shown in Table VII.E, we obtain a new present value of the DFF equal to Rs.904 million.

We now go into a major correction in the present value estimates. Since the rate of discount is 10 per cent, and the rate of return on investment in general is taken to be 20 per cent, there is a clear premium on investment vis-a-vis consumption. If there was no reinvestment out of the return to investment, a rupee of investment would have yielded 0.20 per year in perpetuity, which when discounted at 10% would have given us a value of Rs.2. In this situation a unit of investment would be twice as valuable at the margin as a unit of present consumption, and the price of investment would be 2.

The picture is more complicated in reality, since there is some reinvestment out of the return to investment itself, and further reinvestment out of the return to reinvestment, and so on. It can be shown[7] that with a uniform rate of return of r, a uniform rate of plough-back of a, and a social rate of discount of i, the present value ($\bar{F}$) of unit of investment is given by:

$$\bar{F} = \frac{(1 - a)\, r}{i - a.r} \qquad (6^*)$$

In our case, since we take a = .2, r = .2, and i = .1, this yields a price of investment of 2.67, as shown in Table VII.F. If the real cost of investment (including the correction for the price of foreign exchange) is multiplied by this price 2.67, we get the proper present value of the investment cost.

Since this type of correction is still not widely practiced in the literature of project evaluation, a word in explanation is called for. The source of the problem, as we noted before, is the difference between the rate of return on investment (0.2) and the

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7 See U.N., A Social Cost-Benefit Analysis of the Fanaugua Project, United Nations, CID/IIE/TW.2.; see also Weisskopf et al, Lectures, op.cit.

rate of discount (0.1). Suppose a rupee of investment is diverted from an alternative investment to the DFF. Its nominal price may be Re.1, but what this implies is a sacrifice of return of 0.2 per year with 20% of it reinvested each year. Thus what we are really sacrificing is a certain time stream of consumption which is quite high thanks to the rate of return to investment in the economy in general being rather high (20%), in particular higher than the rate of discount 10% used. We have to calculate the present value of this sacrificed stream of investment at 10% discount rate, which we are using to calculate the present value also of the DFF return. Using our formula, it is found that every rupee of alternative investment sacrificed implies a loss of a time stream of consumption which has a present value of 2.67. Unless the DFF can yield more than this loss, it will not make a net contribution. Hence the need for correcting the nominal capital costs.[8] We take 80% of DFF investment to represent reduction of investment elsewhere and use the price of investment (2.67), obtained above.

After this correction (see Table VII.F), we obtain a present value of the DFF equal to Rs.188 million, which is substantially lower than the earlier estimate, but still significantly positive. It is easy to check, however, that we have now over-corrected. We have corrected only the investment cost of the DFF, taking into account that 80% of the DFF investment came from reduced investment elsewhere; but we have not given any credit to the DFF for the part of its output that will be reinvested. This correction is carried out in Table VII.G, which we now explain.

8 See Marglin, Public Investment Criteria, op.cit.

Of the direct benefit from the output of the DFP, a third will go to the Government, of which 80% will be invested. The rest two-third will go to the farmers and other non-government recipients, of which only 5% will be invested. This yields a 30% reinvestment out of the project output, as shown in (7a). The part that will be thus invested will itself yield a 20% return and a 20% continuous reinvestment, the present value of a unit of which has already been estimated to be 2.67 in the year in which this reinvestment takes place. If we, therefore, raise 30 per cent of the present value of the output (net of operating cost but with correction for the price of foreign exchange) by 1.67, i.e., the premium of the price of investment over its nominal price of 1, then we get the required correction for the present value of the DFP. This is done in (7) in Table VII.G. The corrected present value is thus Rs.882 million.

Since this exhausts the corrections that we wished to introduce in the first round of the DFP evaluation, Rs.882 million is the figure we have been trying to get. The correction for the shadow price of investment in the project output almost cancels out the negative correction in the cost of investment.

Before going on to a different set of exercises on the DFP, we should explain one aspect of the calculation that may not be entirely clear. Corrections for labour cost introduced in equation (5) in Table VII.E may give the impression that we are treating unskilled labour as costless for the DFP project. This will seem to go counter to a considerable volume of literature on the subject explaining the cost of labour in terms of reducing the investible surplus in an economy. There is, however, no such conflict. A rise of Re.1 in wage payment to unskilled labour, given other things, reduces the profits from the project output by that amount, and therefore, reduces investment out of it equal to 30 per cent of it, given our assumption. The wage earners are assumed to consume their whole earnings, so that this additional wage payment does not cause any extra savings by the wage earners. In net terms, therefore, there is a consequent reduction of investment by Re.0.3, and an increase in consumption of the same amount. This shift from investment to consumption to the extent of 30 per cent of the wage cost implies a loss to the community given our assumption of a price of investment (2.67) in excess of unity. The exact measure of the loss from this shift is given by 1.67 times Re.0.3. Thus the employment of even unskilled labour is not treated as totally costless for the DFI; it is justified only when the return from unskilled labour use in the DFI compensates for the loss induced by this shift from investment to consumption.[9]

VIII. An Alternative Set of Assumptions

Since the object of this paper is to illustrate the methods of project evaluation in the context of the DFI, it may be useful to consider a somewhat different set of assumptions. We may change the DFI specifications in two respects. It is fair to say that the plans of Indian public projects have often painted a somewhat rosier picture of the output possibilities and of the gestation lag than what have

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9 See Marglin, Industrial Development in the Labour Surplus Economy, January, 1966 (mimeographed); Sen, Choice of Techniques (Oxford, 1967, Third Edition).

been found later. We shall assume that the DFI will (i) take three years longer to construct than planned, and (ii) the output stream will in fact be only 75% of the capacity planned in the ETSA Report. This alternative specification will be called ADFP, an alternative DFI. Being less favourable than the DFI, which was shown earlier to be very profitable both commercially and from the point of view of the nation, the ADFP will also be a more interesting project as an exercise, the profitability depending critically on the values to be selected.

In the analysis that follows, we shall take alternative values of:

1. The social rate of discount (i).
2. The shadow price of foreign exchange (e).
3. The proportion of the ADFP investment coming from reduction of alternative investment (y).
4. The proportion of ADFP benefits reinvested (s).

Previously we took $i = .10$, $e = 1.57$, $y = 0.8$, and $s = 0.3$. The last was obtained by our assumption about the division of the net benefit from the project (a third going to the Government) and the respective proportions of reinvestment (80% of the Government net benefits reinvested and 5% of the net benefits going to the farmers reinvested), as shown in (7a) in Table VII.G. Without going into the genesis of s, we shall simply take alternative values of s in the exercises that follow.

In the last exercise we took the general rate of social return (r) in the economy to be 20%. We do not believe this rate to be too high, but in many studies it is conventional to take a lower general rate of return. For the exercise that follow, we shall take 15% as the general rate of return on alternative investment in the economy. Otherwise we retain all the value and time series used in the preceding analysis.

IX. Sensitivity Analysis: Social Rate of Discount and Shadow Price of Foreign Exchange

We may first examine the present value for ADFF, corresponding to the values of the social rate of discount (i), shadow price of foreign exchange (e), the project benefit reinvestment ratio (s), and the proportion of displaced alternative investment (y), as assumed in the previous exercise, viz., i = 0.10, e = 1.57, s = 0.3 and y = 0.8. This happens to be Rs.68.8 million. It is, as we could expect, a substantially lower sum than the DFF present value for the same assumptions.

Keeping s = 0.3, and y = 0.8, we may now examine variations in the ADFF present value for various values of i in the range (5%, 15%) and e in the range (1.00, 2.25). The results are given in Table IX. Several observations can be made on the observed pattern.

(1) By and large, the present value of ADFF is highly sensitive to the shadow price of foreign exchange, which is not surprising since it is an import replacing project. While for e = 1.00 or e = 1.25, the present value of ADFF is negative for <u>any</u> rate of interest in the range in question, it is positive for <u>any</u> rate of interest in the range when e = 2.00, or e = 2.25.

(2) However, the sensitivity to the shadow price of foreign exchange is greatest at low interest rates and least at high rates of interest. While at 5% discount rate the present value shifts from <u>Minus</u> Rs.2,724.7 million at e = 1.00 to <u>Plus</u> Rs.1,427.8 million at

e = 2.25, at 15% rate of discount the corresponding shift is only from Minus Rs.124.7 million to Plus Rs.135.4 million.

This is relevant in anticipating the likely extent of error in getting a "wrong" shadow price of foreign exchange. This may not be much at relatively at high rates of social discount but is very big at lower discount rates.

(3) Related to the above observation is the one concerning the impact of variations of interest rate given the shadow price of foreign exchange. The present value worsens monotonically as we move to higher rates of discount with e = 2.00, or e = 2.25, and improves monotonically with e = 1.00. The former is the usually expected result, for a typical investment project is supposed to worsen with higher interest cost. The latter phenomenon is closely related to the fact that the shadow price of investment, (a cost element), is negatively related to the social rate of discount, as can be seen from (6*) above. In fact since a.r = 0.045, as the interest approaches 4.5%, $\bar{P}$ rises without bound, since the discounted value of the returns from a unit of displaced investment moves towards infinity (given the rate of return of 15% and a proportion of re-investment of 0.3). Thus a rise in interest rate, in reducing $\bar{P}$, gives some relief. This effect is naturally strongest at low rates of discount close to 4.5%.

Of course, $\bar{P}$ also enters the benefit side in terms of the reinvested portion of the project benefit and this works the other way. This being a foreign exchange saving project, a higher value of the shadow price of foreign exchange has a bigger impact on the benefits, and then a high $\bar{P}$ is (in net) a favourable factor. At high values of foreign exchange, therefore, we do not notice this trend of improvement with a higher i (i.e., with a lower $\bar{F}$). At intermediate values, a higher i improves matters for a while through the impact of $\bar{F}$ on the cost side, but after a limit this effect weakens out and is compensated by the normal deteriorating effects of a high interest rate on the profitability of an investment project.

X. Sensitivity Analysis: Reinvestment of Project Benefits

As was explained earlier, one of the relevant considerations is the proportion of the benefits reinvested (s). This is so because the social rate of discount (i) may lie below the rate of social return on general investment in the economy (r). The value of s depends on the price policy of fertilizer sale, among other things, as was discussed in an earlier section. It will also depend on such things as the fiscal and monetary policies of the Government as well as on all factors influencing the distribution of project benefits between the Government and the different classes.[10]

How sensitive are the results to our reinvestment assumption? In Table X the value of s is shifted from 0 to 1 at different rates of interest, with e = 1.57, and y = 0.8. The following observations can be made.

(1) The sensitivity to s is, by and large, very high. It shifts the present value from Minus Rs.8,416.3 million to Plus Rs.16,867.6 million at 5% as s is moved from 0 to 1.

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10 On this, see Weisskopf et al, Lectures; United Nations, Fanagua Project.

(2) The sensitivity diminishes steadily as we consider higher values of the social discount rate. This is as one would expect, since the impact of s on the present value is through the shadow price of investment ($\bar{P}$) being greater than unity. As i approaches r, the value of $\bar{P}$ drops towards unity. At $i = 0.15$, we have $i = r$, since $r = 0.15$, and then s makes no difference, as is shown in the last row of Table X.

If we take a relatively low social rate of discount, we must be very careful about our assumption regarding reinvestment of project benefits. We can, however, afford to relax on this if the discount rate is close to the social rate of return on investment.

There is also a policy implication. A project of this kind can be vastly improved by deliberately fostering policies that raise the ratio of reinvestment, e.g., high fertilizer prices, high marginal rates of taxation.

XI. Sensitivity Analysis: Displacement of Alternative Investment

The higher the proportion of displaced investment (y), the greater the opportunity cost of a unit of our public investment, when i is below r, i.e., when $\bar{P}$ is greater than unity. Table XI goes into three values of y at various rates of interest, with $s = 0.3$, and $e = 1.57$. We note the following.

(1) By and large, the present value is very sensitive to the proportion of displaced investment. At 5%, while $y = 0.6$ gives a present value of Plus Rs.1,446.6 million, $y = 1.0$ yields Minus Rs.3,108.9 million.

(2) The sensitivity to y diminishes as i is raised towards r. At i = r (here 15% each), $\bar{F}$ is unity, and whether the public project is obtained by displacing other investment or other consumption makes then no difference whatever. This is the other side of the coin studied in the last section.

If i is low, we must be very careful about the correctness of our assumption regarding y. At high rates of interest close to r, it makes no difference.

Policy-wise, if i is low, it makes sense to finance the project through means that displace other investment least. At rates of interest between, say, 5% or 13%, it makes a difference between a positive and a negative present value, and the difference is large in magnitude towards the bottom of the range.

XII. Range of Variation of Present Value

With 7 values of s in the range (0, 1), 3 values of y in the zone (0.6, 1.0), 7 values of o in (1.00, 2.25), and 11 values of i in (5%, 15%), we have 1,617 alternative cases. We do not have the space for all the results, but the range of variation of the present value of ADFP is worth commenting on. This is given in Table XII.

Depending on our assumption the present value of ADFP can be as high as Rs.32,902.1 million, or as low as Minus Rs.13,702.5 million. Interestingly, both the extreme values occur at 5% interest rate and 2.25 shadow price of foreign exchange, and the variation is entirely due to the proportion of displaced investment (y) and the reinvestment rate of project benefits (s), which are 0.6 and 1.0 in the former case and 1.0 and 0 in the latter case, both at the borders of our parameter ranges. However while the sensitivity to s and y is large, and is largest at low interest rates (most at 5%) as explained before, i and e are also important. Even with y = 0.6, and s = 1, a shift of i from 5% to 12% and of e from 1.00 to 2.25 transforms the maximum present value of Rs.32,902.1 million to a negative value. Similarly, a shift of i alone from 5% to 11% transforms the minimum present value of Minus Rs.13,782.5 million to a positive present value.

XIII. A Concluding Remark

With our standard assumptions, viz., s = 0.3, y = 0.8, i = 0.05, and e = 1.57, both DFT and ADFT are good projects. As is to be expected, DFT yields us much higher present value than ADFT.

Variations of s, y, i and e in the case of ADFT show (i) the sensitivity of the present value to each of those, and (ii) the crucial importance of these values in certain ranges in making ADFT an acceptable project or not. The sensitivity to each being fairly large in many cases, we have to be very careful in selecting these values. Even a small error in these may distort our results very substantially.

However, in certain ranges the sensitivity is not so large. If, for example, i is in the neighbourhood of 15%, the present value is not sensitive at all to variations in s and y, and is not very sensitive to changes in e. But at low interest rates, e, s and y are all very influential. How much time and energy we should spend on correctly estimating the values of these parameters should depend very much on the values of the other parameters. The depth of the empirical exercises to be done on this should depend on the guidance provided by sensitivity analyses as illustrated above. This is one more field of public policy where empirical work has strong analytical prerequisites.

Table I

Annual Capacity of DFP

Output	Metric Tonnes per Year
1. "Complex Fertilizer" (Ammonium Sulphate Phosphate)	
19 : 19 : 0 or 20 : 20 : 0	579,000 or 550,000
2. Urea (46% Nitrogen)	
[Equivalent of 1 and 2 :	
(i) Nitrogen	135,000
(ii) P_2O_5	110,000]
3. Anhydrous Ammonia for sale	15,000

[Source: Economic and Technical Soundness Analysis : Durgapur Fertilizer Project of the Fertilizer Corporation of India Limited, 1966, p. 3.]

Table II

Soundness Indicators Used in the Project Report

1.	Marginal capital output ratio	1.25
2.	Profitability per unit of capital investment	24.4 per cent
3.	Foreign exchange saving:	
	(i) "Saving" of foreign exchange per year in terms of alternative import of fertilisers (=foreign exchange value of fertilizer output *minus* annual direct foreign exchange cost)	Rs.281 million
	(ii) "Saving" of foreign exchange per year in terms of alternative import of food (=foreign exchange value of food-output resulting from the fertilisers produced *minus* annual direct foreign exchange cost)	Rs.756 million
	(iii) Initial foreign exchange investment	Rs.170 million

[Source: *ETEA*, pp. 19, 84.]

Table III

Symbols Used

I_d = direct domestic component of investment;

I_f = direct import component of investment;

$\bar{I}_d$ = real domestic component of investment;

$\bar{I}_f$ = real foreign exchange component of investment;

V_x = value of output at market prices;

V_f = value of output at c.i.f. prices of alternative imports;

I_p = investment on plants and offsite facilities;

I_b = investment on buildings, roads and culverts;

C_d = direct domestic component of operating cost per year;

C_f = direct import component of operating cost per year;

$\bar{C}_d$ = real domestic component of operating cost per year;

$\bar{C}_f$ = real foreign exchange component of operating cost per year;

L = operating labour cost per year;

r = marginal rate of social return per unit of alternative investment sacrificed;

i = the social rate of discount;

a = marginal proportion of reinvestment out of return to alternative investment sacrificed;

b = marginal proportion of reinvestment out of benefits from project output accruing to the government;

g = proportion of the benefits from project output going to the government;

y = proportion of DFP investment coming from reduction of alternative investment;

e = shadow price of foreign exchange;

m = proportion of unskilled labour cost in the cost of domestic investment;

n = proportion of unskilled labour cost in total operating labour cost;

c_1 = marginal propensity to consume of unskilled wage earners;

c_2 = marginal propensity to consume of farmers and other non-Government recipients of direct benefit from output;

P()= present value of the stream of the variable within brackets.

Table IV

Time Pattern of Benefits and Costs of DFP

Unit: Rs.Million

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
I_d	63.0	86.9	86.5	16.2	4.7	3.5	0	0	0	0	0	0	0
I_f	24.1	70.9	75.4	8.4	2.4	1.8	0	0	0	0	0	0	0
V_x	0	0	0	152.85	229.27	305.69	305.69	305.69	305.69	305.69	305.69	305.69	305.69
V_f	0	0	0	158.95	243.00	314.80	314.80	314.80	314.80	314.80	314.80	314.80	314.80
C_d	0	0	0	83.68	115.27	130.69	132.31	133.57	134.38	135.44	136.30	137.51	138.57
C_f	0	0	0	14.28	21.41	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55
I_B	13.685	0	0	0	0	0	0	0	0	0	0	0	0
L	0	0	0	6.39	7.06	7.23	7.40	7.57	7.74	7.91	8.08	8.25	8.24
$\bar{I}_d$	36.84	45.08	49.60	16.2	4.7	3.5	0	0	0	0	0	0	0
$\bar{I}_f$	50.26	112.72	112.30	8.4	2.4	1.8	0	0	0	0	0	0	0
$\bar{C}_d$	0	0	0	70.22	101.81	117.23	118.85	120.11	120.92	121.98	122.84	124.05	125.11
$\bar{C}_f$	0	0	0	26.32	33.45	40.59	40.59	40.59	40.59	40.59	40.59	40.59	40.59

[Source : ETSA]

Table V

Values of Parameters Taken

1. Marginal rate of social return on alternative investment (r)	= 0.20
2. Marginal proportion of reinvestment out of return on alternative investment (a)	= 0.20
3. Proportion of benefits from project output that will go to the Government (g)	= ½
4. Marginal proportion of reinvestment out of benefits from project output accruing to the Government (b)	= 0.80
5. Proportion of DFP investment cost coming from reduction of alternative investment (y)	= 0.80
6. Proportion of unskilled labour cost in the cost of domestic investment (m)	= 0.10
7. Proportion of unskilled labour cost in the total operating labour cost (n)	= 0.50
8. Social rate of discount (i)	= 0.10
9. Shadow price of foreign exchange (e)	= 1.57
10. Propensity to consume of unskilled wage earner (c_1)	= 1.00
11. Propensity to consume of farmers and other non-government recipients of direct benefit from output (c_2)	= 0.95
12. Building services ("indirect benefit") per year as percentage of I_B	= 0.15

Table VI

Present Value of the Main Sets of Time Series (in Rs.million)

$P(\bar{I}_d)$	=	136.36
$P(\bar{I}_f)$	=	254.61
$P(V_x)$	=	1,385.31
$P(\bar{C}_d)$	=	562.66
$P(\bar{C}_f)$	=	190.53
$P(L)$	=	38.15

[Source: Calculations using the values given in Tables IV and V]

Table VII

Alternative Measures of Present Value of Net Benefit

(In Rs. million)

A. Estimate of present value of DFP at market prices:

$$P_1 = P(V_x) - P(\bar{C}_d) - P(\bar{C}_f) - P(\bar{I}_d) - P(\bar{I}_f) \quad (1)$$

$= 241.5$

B. Correction for output prices at alternative import cost (c.i.f.):

$$P_2 = P_1 + P(V_f) - P(V_x) \quad (2)$$

$= 288$

C. Correction for shadow price of foreign exchange:

$$P_3 = P_2 + 0.57 \left[P(V_f) - P(\bar{I}_f) - P(\bar{C}_f) \right] \quad (3)$$

$= 851$

D. Correction for indirect benefits, i.e., housing, roads, etc:

$$P_4 = P_3 + I_B \left(\frac{0.15}{0.10} \right) \quad (4)$$

$= 872$

E. Correction for labour cost (unskilled) with surplus labour:

$$P_5 = P_4 + (0.5 \times 38.15) + (0.1 \times 136.36) \quad (5)$$

$= 904$

F. Correction for shadow prices of investment in capital cost:

$$\bar{P} = \frac{(1-.2)\ (.2)}{.1 - .2 \times .2} = 2.67, \text{ giving a "premium" of } 1.67 \quad (6a)$$

$$P_6 = P_5 - \left[P(\bar{I}_d) + 1.57.P(\bar{I}_f) \right] \times 0.8 \times 1.67 \quad (6)$$

$= 188$

G. Correction for shadow price of investment in benefit stream:

Reinvestment ratio of net benefit (except of indirect benefit and benefit of consumption out of wages of unskilled labour)

$$s = (0.80 \times 1/3) + (0.05 \times 2/3) = 0.3 \quad (7a)$$

$$P_7 = P_6 + (\bar{P} - 1) \left[\left\{ P(V_f) - P(\bar{C}_f) \right\} 1.57 - \bar{C}_d \right] \times .3 \quad (7)$$

$= 882$

[Source: Calculations Using Tables IV, V and VI.]

Table VIII

Differences between ADFP and DFP Evaluation

1.	ADFP output capacity as a proportion to ADFP	=	0.75
2.	ADFP gestation lag in excess of that of DFP	=	3 years
3.	General rate of social return to investment in the economy (r):		
	(i) DFP	=	0.20
	(ii) ADFP	=	0.15
4.	Marginal proportion of reinvestment out of social return to general investment (a):		
	(i) DFP	=	0.2
	(ii) ADFP	=	0.3
5.	Indirect benefits	:	nil for ADFP.
6.	Labour cost	:	as given by market for ADFP.
7.	Other respects	:	the same in ADFP as in DFP.

Table IX

Sensitivity to Discount Rate and Foreign Exchange Price : Present Value of ADFP

Unit = Rs. 1 million

e \ i	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
1.00	-2,724.7	-808.6	-445.5	-301.7	-229.2	-188.2	-163.1	-147.2	-136.7	-129.6	-124.7
1.25	-1,894.2	-478.7	-225.0	-133.4	--93.5	- 75.4	- 67.9	- 65.9	- 66.9	- 69.4	- 72.6
1.50	-1,063.7	-148.9	- 4.5	34.8	42.2	37.3	27.3	15.3	2.9	- 9.2	- 20.6
1.57	- 831.1	- 56.5	57.3	81.9	80.2	68.8	53.9	38.1	22.5	7.7	- 6.1
1.75	- 233.2	181.0	216.0	205.0	177.9	150.0	122.5	96.6	72.7	51.0	31.4
2.00	597.3	510.8	436.5	371.2	313.6	262.7	217.7	177.8	142.5	111.2	83.4
2.25	1,427.8	840.7	657.1	539.5	449.4	375.5	312.9	259.1	212.3	171.4	135.4

[With y = 0.8, and s = 0.3]

Table X

Sensitivity to Reinvestment of Project Benefits : Present Value of ADFP

i \ s	0	0.2	0.3	0.4	0.6	0.8	1.0
5%	-8,416.[illegible]	-3,359.5	-831.1	1,697.3	6,754.1	11,810.9	16,867.6
7%	- 939.5	- 275.0	57.3	389.5	1,054.0	1,718.5	2,383.0
9%	- 263.0	- 34.2	80.2	194.6	423.4	652.2	881.0
11%	- 77.7	10.1	53.9	97.8	185.6	273.4	361.1
13%	- 19.6	8.4	22.5	36.5	64.5	92.6	120.6
15%	- 6.1	- 6.1	- 6.1	- 6.1	- 6.1	- 6.1	- 6.1

[With $y = 0.8$, and $e = 1.57$]

Table XI

Sensitivity to the Sacrifice of Alternative Investment in Financing ADFP: Present Value of ADFP

Unit = Rs. 1 million

i \ y	0.6	0.8	1.0
5 %	1,446.6	-831.1	-3,108.9
7 %	412.8	57.3	- 298.3
9 %	224.8	80.2	- 64.4
11 %	119.2	53.9	- 11.3
13 %	46.8	22.5	- 1.9
15 %	- 6.1	- 6.1	- 6.1

[With s = 0.3, and o = 1.57]

Table XII

Present Value of ADFF : Range of P
Unit/= Rs. 1 million

Constants:	r = 0.15, a = 0.3.
Variables:	s = (0, 0.2, 0.3, 0.4, 0.6, 0.8, 1.0);
	y = (0.6, 0.8, 1.0);
	i = (0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15);
	e = (1.00, 1.25, 1.50, 1.57, 1.75, 2.00, 2.25).
Present Value:	P = P(s, y, i, e).
Number of Cases Considered	= 1,617.
Extremes:	Max P = P(1, 0.6, 0.05, 2.25) = 32,902.1
	Min P = P(0, 1, 0.05, 2.25) = -13,782.5
Relevant Contrasts with Extremes:	P(1, 0.6, 0.12, 1.00) = - 27.3
	P(0, 1, 0.11, 2.25) = 14.8

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