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APPLICATION OF SOCIAL COST-BENEFIT ANALYSIS TO THE PROBLEM OF CHOOSING AMONG ALTERNATIVE TECHNOLOGIES: A SURVEY

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I

Introduction

In the description of the Pilot Project on Transfer of Technology (OEA/Ser. J/II. 12, pp. 12-13) the regional coordinating office is assigned the task of elaborating a methodology for the evaluation of technologies "taking into consideration technical, economic and social criteria". Furthermore, the regional coordinating office will hold a meeting with the participating countries to agree upon a common methodology. Using this common methodology, the national coordinating centers are expected to perfom the evaluations on "the basis of social costs and markets for factors of production in each country".

In the request which the Institute received from the OAS, the task of the Institute in the elaboration of this methodology was defined in correspondence and conversations in Santiago as that of preparing a paper in the brief period of three months which would (1) extract from the bibliography on the evaluation of alternative technologies those considerations which would be most pertinent to the aims of the Pilot Project and (2) perform the first stage of a process of critical analysis of these points as a means of indicating the methodological focus most useful for the Pilot Project.

In the same request the comment was made that the final methodology to be elaborated by the "Punto Focal Regional" should permit (1) an evaluation at the national, or macroeconomic, level in which factor availabilities and the objectives of national policy could be taken into account and (2) an evaluation at the microeconomic level based on the viewpoint of the firm.

The first problem which had to be faced in writing this paper was, therefore, that of choosing a suitable framework for reviewing the literature

/pertinent to

pertinent to the aims of the Pilot Project. Social cost-benefit analysis was chosen as this framework. In a wide sense social cost-benefit analysis is nothing more or less than a way of presenting the economic problem: maximization of an objective function subject to contraints. In the first place, the flexibility of cost-benefit analysis permits the analyst to incorporate the objectives of national economic policy in the evaluation of alternative technologies. In the second place, there exists an abundance of economic literature dealing with the application of cost-benefit analysis to a variety of problems, while there is very little written on alternative methods of evaluation. One could stay much closer to the traditional analysis by using a two-factor analysis of the combinations of capital and labour required per unit of output. Then, by varying relative factor prices, one could determine which technique is the most efficient one for various assumptions about relative factor prices. One problem with this approach is the difficulty of extending the analysis to include more than two factors, for instance, foreign exchange requirements or labor of differing qualities.

It is also difficult to take into account other important differences between alternative techniques such as the benefits which may accrue to the labour force from working with more advanced techniques. Finally, this approach does not usually take into account the time pattern of costs and revenues; hence, it is difficult to allow for changes in prices over time and to apply a social rate of discount to the stream of future costs and benefits 1/.

This approach can, in any case, be embraced by the framework of cost-benefit analysis when the only costs are capital and labour, and where the only benefit is the value of the output produced. Indeed, cost-benefit analysis is a highly flexible technique which, by the choice of the costs and benefits to be included, can be made to reflect any of the several investment criteria encountered in the literature of economic development.

1/ Probably, the best presentation of more traditional approaches to the problem of choice of techniques (and also their limitations) may be found in Tinbergen (38B).

/Besides writing

Besides writing a critical review of the literature bearing on the evaluation of alternative technologies within the framework of social cost-benefit analysis, it seemed that a major contribution to the Project Pilot could be the development of a concrete example of the application of cost-benefit analysis to the problem of choice of techniques. Thus, section VIII which sets forth that example is given about the same emphasis as sections II-VII combined which review the literature bearing on different aspects of cost-benefit analysis, mainly, the determination of the appropriate shadow prices of inputs. Since the literature on cost-benefit analysis and on shadow prices has been the subject of several recent reviews of high quality 1/ the elaboration of this example may constitute more of a contribution to the Pilot Project than the review itself.

What may be most interesting about the example is the use of sensitivity analysis. Under two alternative assumptions about the size of the market sensitivity analysis is used to show which technique is optimal for various combinations of values for the social rate of discount and for the weight to be attached to increasing employment. These objectives have been chosen since they are the two to which most attention is usually given in the formulation of national economic policy.

These parameters are presumed to be unknown to the planner because they are not empirically measurable, depending instead on the political process for their determination. However, sensitivity analysis may also be used where there may be considerable doubt over the reliability of estimates of parameters which are in principle measurable when one wishes to know how sensitive the conclusion of the analysis may be to possible errors of this sort. For instance, it may be found that the conclusions of the analysis hold if the marginal propensity to save of capitalists is in the range of 6 + 1.0 (the original estimate, let us say, was .8) but not if it is less than .6. In the example of section VIII, an exercise of this sort is performed for the shadow price of foreign exchange.

1/ See, particularly the articles by Harberger and Feldstein and Fleming in the United Nations volume (44) and the paper prepared by Guadagni for the Interamerican Development Bank (18). His paper also contains a review of empirical estimates of shadow prices.

/Besides the

Besides the usefulness of sensitivity analysis in evaluating the effect of changes in the values of parameters, the entire exercise of cost-benefit analysis can be repeated to determine the implications of alternative formulations of the shadow price of labour, the shadow price of foreign exchange and other parameters. Particularly, when there may exist considerable controversy over the appropriate formula to be used in calculating the value of a parameter, such exercise may be used to determine how critical the choice of the formula may be to the outcome of the evaluation.

Even though the example presented in this paper runs to considerable length, it is by no means exhaustive. One could and certainly should, in view of the large degree of uncertainty involved in most empirical estimates of the parameters required in cost-benefit analysis, and in view of the controversial nature of the formulas used, multiply the exercises many times over. What has been done here is no more than a first step, although hopefully a useful one, in indicating the potential usefulness of this framework of analysis.

The focus of this paper then, is the application of social cost-benefit analysis to the problem of choosing among alternative production processes. By cost-benefit analysis is meant the identification of the costs and benefits of a project at the time when they are realized over the lifetime of the project, discounting each of these elements to the present and subtracting costs from benefits. The resultant value is the net discounted present value. This may be calculated for each technological alternative, and the one with the greater net present value may be regarded as the most efficient one. By social cost-benefit analysis is meant that market prices of inputs are replaced by shadow prices, or, rather, "corrected" prices, for such important components as unskilled labour, foreign exchange and investment funds of the public sector financed by taxation of the private sector.

As was mentioned above, cost-benefit analysis was chosen as the focus for this paper among other reasons, because of the flexibility of the

/technique. By

technique. By choosing which costs and which benefits to include one can reduce cost-benefit analysis to any one of the several investment criteria encountered in the literature of economic development. In a recent article (37) Sen develops a general framework in which the goal of a society is assumed to be that of maximizing the sum of consumption plus savings subject to the constraint of a linear homogeneous production function of two factors, capital and labour. Within this general framework the recommended investment criteria of various growth theorists can be seen as special cases, depending upon the weight attached to savings relative to consumption, the nature of the relationship assumed to exist between factor incomes and savings, and the opportunity costs of using capital and labour.

The recommendations of Lewis (29), Polak (32) and Buchanan (10) that the output per unit of capital be maximized can be interpreted as placing zero weights on the value of savings generated by investment projects as distinct from total output and on the marginal product of labour. Dobb (13), Galenson and Leibenstein (17) emphasized the link between the reinvestible surplus as a function of choice of technique and the rate of growth. This approach places a high weight on project-generated savings. Kahn (25), on the other hand, argued that the social opportunity cost of labour be subtracted from output and that what should be maximized is the social marginal product. This is equivalent to assuming a positive marginal product of labour and a zero weight for additional savings.

Bator (2) argued that there was no constraint on the rate of savings; in other words that savings were independent of the investment projects chosen. This is equivalent to assigning a weight of zero to savings generated by a project and the policy recommendation is to maximize present output, that is to choose the most labour intensive processes consistent with efficiency.

Eckstein (14) has presented a general framework similar to that of Sen, as did Chenery (11) implicitly in his application of programming techniques.

/Marglin (31,

Marglin (31, 32, 45) has extended the general framework to allow for shadow prices of several factors, weights for different goals of public policy and a theoretical method for linking the premium attached to savings to the optimal growth path. He has also dealt with the problem of the optimal timing of investment decisions.

We have already mentioned that section VIII contains a well-developed example of the application of cost-benefit analysis to the problem of choice of technologies.

In sections II-VII preceding the example, the literature pertinent to various aspects of cost-benefit analysis has been surveyed and a brief summary of the material covered there may be useful at this point.

In section II, there is a brief discussion of the nature of shadow prices. The way in which shadow prices are derived from general equilibrium economic models is described. These shadow prices are constrasted with accounting prices or corrected prices which are derived from partial equilibrium models or simply calculated by adjusting market prices to take into account generally recognized distortions. The relationship between national economic profitability based on shadow prices and commercial profitability based on market prices is also discussed.

Section III, "The Shadow Price of Capital" deals with three topics. The first is the procedure of Marglin for estimating the opportunity cost of capital in the public sector when financed by taxation of the private capitalistic sector. The second is the procedure of Little-Mirrlees for converting the consumption benefits of a project to their equivalent value as invested capital. Finally, complications in measuring the opportunity cost of capital are mentioned including the effect of direct and indirect taxes, the presence of monopoly, and the opportunity cost of raising funds through the issue of private debt.

The social rate of discount is the subject of section IV. Here the problems of discounting future costs and benefits is reviewed. Some authors prefer to use the opportunity cost of capital in the private sector as the appropriate discount rate. Marglin has argued convincingly that this procedure is incorrect; rather, the time preference of society ought to be used. Since this involves measuring the marginal utility of per capita income, a value cannot convincingly be calculated for this parameter. Hence, Marglin and Sen propose the use of sensitivity analysis for making explicit the social rate of discount implicit in the decisions of policy-makers. Little-Mirrlees offer a formula for computing the social rate of discount based on assumptions about the marginal utility of income in the rural and urban sectors.

Section V deals with the shadow price of labor under two headings: direct costs and indirect costs. Under direct costs, various considerations regarding the appropriate measure of the direct opportunity cost of labor, particularly, unskilled labor, are dealt with. In particular, the question is considered whether the marginal product in agriculture, taking into account transport costs, or the marginal product of labor in the unprotected urban sector ought to be taken as the relevant direct opportunity cost of labor in an industrial project.

By indirect cost is meant the effect of a labor-intensive alternative on savings and investment. The argument often advanced is that recipients of income from capital have a higher propensity to save than recipients of wage income. Hence, while a labor-intensive alternative might yield a higher rate of return on invested capital, the amount available for reinvestment might be less. Thus, a conflict is posed between techniques which maximize output and those which maximize savings and, hence, the rate of growth. Formulas are presented which take into account both the direct and indirect costs of labor. Moreover, the formulas also provide for the positive valuation of employment so that the tradeoff between employment and growth acceptable to economic planners can be made explicit.

The shadow price of foreign exchange is the subject matter of section VI and Appendix II. Of several variant procedures found in the literature, the most attractive theoretically is the estimating of the shadow price of

/foreign exchange

foreign exchange from a linear programming model. Since, however, this has not yet been possible due to the difficulties of constructing a reasonably accurate model, the remaining candidates are general and partial equilibrium formulas, on the one hand, and methods for ranking projects in the order in which they would become competitive as the exchange rate varies, on the other.

The general equilibrium formula takes, as a standard of reference, the free trade situation. Other authors prefer to work with only those relaxations in trade barriers which can be reasonably anticipated. These formulas may be considered as partial equilibrium approaches. The ranking methods employ a static theory of comparative advantage which limits their usefulness. Parity rates of exchange may be useful for adjusting general or partial equilibrium rates, but otherwise are not useful as guides to resource allocation.

In contrast with the above methods, all of which require the calculation of a single shadow price of foreign exchange, is the Little-Mirrlees method. These authors prefer to use foreign prices for all inputs and outputs, having recourse to a single rate only for converting from domestic to foreign prices a large number of material inputs when each of them is needed in rather small quantities.

Finally, Section VII deals with some complications in applying cost-benefit analysis, such as differences in the quality of product, the existence of joint products, and the correct use of certain engineering date. An Addendum of three pages contains the variable definitions used in the text.

The objective of this paper was not to arrive at definite conclusions regarding the various issues involved in evaluating alternative technologies, still less to present a definitive methodology. Rather, it aims at a preliminary examination of the principle problems. Much of the pertinent literature has been reviewed with this aim in mind, and a fairly detailed example has been worked out to illustrate how social cost-benefit analysis might be applied to the problem of evaluating alternative technologies. By this proceudre it is to be hoped that the paper has been successful in

/extracting points

extracting points fundamental to the formulation of a methodology. Following are some considerations which arose in the course of writing this paper, not all of which have been treated in the detail they warrant due to the stringent time constraint imposed on the preparation of the paper.

Points for Discussion in Choosing a Methodology

1. The first question is whether to apply some form of cost-benefit analysis or whether to use an apparently simpler analysis based only on quantities of capital and labor per unit of output and their prices. The advantage of cost-benefit analysis over the second procedure lies in its flexibility. In the analysis of alternative technologies, benefits may include, in addition to the product produced, externalities arising from the use of advanced technology quantified, for example, as the value of on-the-job training. Slight quality differences in the outputs may be taken into account by using different prices for the outputs. On the cost side, scarce inputs other than capital and unskilled labor may be included, e.g., the cost of foreign exchange, highly skilled labor which may require special training facilities, etc. An apparent disadvantage of cost-benefit analysis when compared with a simpler analysis of capital/labor ratios is its complexity. Complexities emerge with the simpler technique as well, however, For instance, the necessity of computing production time per unit of output to accurately determine the capital and labor costs per unit of output is a difficult task. Another difficulty is in aggregating various types of labor requiring different amounts of training, and in evaluating the cost of capital goods.

2. If cost-benefit analysis is chosen, the question which must then be faced fall under two headings: whether to use market prices or shadow prices, and which types of indirect costs and benefits to include. As far as the pricing question is concerned, the following observations may stimulate discussion. In the first place, since the economy is an interrelated system, shadow prices should be derived from a general equilibrium model. Since

/this is

this is not usually a feasible procedure, recourse is usually had to adjusted, or "accounting" prices. These prices are known to be inaccurate estimates of shadow prices because of their failure to reflect interdependence. However, market prices are known to involve distortions as well. The real question is whether the use of corrected prices instead of market prices can improve upon the allocation of resources which would result from their use. Besides the problem of interdependence among shadow prices, there is an obvious problem of inconsistency in using market prices for material inputs and shadow prices for foreign exchange, investment, and labor which is the usual practice. This inconsistency arises from the obvious fact that material inputs are produced using factors which are given shadow prices when directly used in the project. Thus the same factors will have a different price when used as an indirect input than it will have when used as a direct input. The Little-Mirrlees approach avoids this type of inconsistency by valuing all inputs at their foreign prices, although the appropriateness of foreign prices may be questioned.

3. Another problem in the use of shadow prices is the difficulty in using them in the implementation of a project or choice of production process. If the government is involved in implementing the undertaking, it may use shadow prices, covering such deficits as may result from their use with tax receipts. When a project is intended for the private sector, this is more difficult. If the government wishes to adapt fiscal policy to the end of bringing market prices into line with shadow prices, it can tax capital and subsidize labor with the proceeds. However, since taxes presently in force affect the relative prices of factors the whole tax system must be reconstructed to bring about the desired factor price ratios. Thus the evaluation of which of several techniques is optimal from the point of view of the national economy may result in a recommendation for the use of a technique which cannot be implemented if the project is in the private sector.

/4. One advantage

4. One advantage of cost-benefit analysis understood in the broad sense, is the possibility of including as many indirect costs and benefits as seems reasonable from the point of view of the analyst. As will be seen in the discussion of the shadow price of labor, it is also possible to incorporate conflicting objectives in the shadow price of an input if those objectives are related only to the input in question. In the example in section VIII this is the procedure used where the only objectives considered are the effects of the choice on aggregate output and on employment. Another example is given in Appendix I where special weight is given to the location of a project in an economically depressed region. This is a case of expanding the list of benefits.

Among the indirect benefits which may also be included are the training provided by using advanced techniques and increased independence from foreign dependence which may result, for example, if one technique can use domestically produced capital goods. One could quite easily extend the list.

5. Consideration might also be given to projections of capacity utilization over time and the likely paths of product and factor prices to avoid falling into the trap of a purely static analysis. When, for instance, one of the alternative technologies involves a minimum plant size with a volume of production at full utilization exceeding the absorption capacity of the market, fixed costs per unit of output will be higher in earlier years of operation than in later years. Also, since different technologies will use different combinations of inputs by definition, changes in relative factor prices over time will affect the relative profitability of the technologies in question.

6. Scale of production is important since scale may affect the optimal technique in some not very obvious ways. For example, general purpose machines may be more efficient for relatively small scale operations whereas more highly specialized machinery may be more efficient for relatively large scale levels of production.

7. The size of plant may also have effects on the capacity of social infrastructure and on the ability of the environment to absorb polution.

Thus a number of small dispersed plants might entail reduced indirect costs in this regard when compared with a large plant of necessity to be constructed in a large urban center. The increased production efficiency of the larger plant may be offset by the lower social costs of the dispersed design.

II

Shadow Prices and Accounting Prices

A very good discussion of the general concepts of shadow and accounting prices is given in Fleming and Feldstein (15). Assume that an economy could be adequately described by a general equilibrium system of equations which incorporates all significant externalities. Then, maximizing the value of the social welfare function subject to the constraints given by the system of equations would assign to each input a weight representing its marginal productivity. These weights would be the shadow prices of the factors of production. Market prices would be identical to such shadow prices only in the mythical world of perfect competition and no externalities. In the real world, however, shadow prices may be expected to differ from market prices for a number of reasons: among others, externalities, monopoly, incidence of taxes, etc. In the case of the rate of interest other considerations enter as well which will be dealt with later.

Now, obviously, shadow prices, strictly speaking, cannot be calculated with any accuracy. Programming models of sufficient sophistication have not been developed. Consequently, adjustments are made to market prices which it is hoped will bring them closer to their "shadow prices". These corrected prices are called accounting prices. As Feldstein & Flemming put it, accounting prices are shadow prices which meet a certain standard of administrative feasibility. Another way of speaking of this distinction is in terms of general equilibrium vs. partial equilibrium. In a general equilibrium model which describes the whole economy, shadow prices would be obtained by a simultaneous solution of all equations. In a partial equilibrium analysis, the effect of one sector or one activity, e.g., a project, is assumed to have no effect on the value of the prices for the economic system as a whole. It is in this sense that accounting prices – as rather crude estimates – are likely to be acceptable approximations to shadow prices. If, however, the project is large enough to affect the price of any output or input, then the interaction between the project and the rest of the economy should be considered using some sort of general

/equilibrium model.

equilibrium model. It can probably be assumed that in the case of choice of technique for the production of a particular product - which is the focus of this review - the use of partial equilibrium techniques and, hence, estimates of shadow prices by adjusting market prices is a fully acceptable technique. In the rest of the paper the term "shadow price" is used interchangeably with "accounting price" although it should be clear we will always, in fact, be talking about accounting prices.

It must be emphasized that the discussion so far has been in static terms. When a project can be assumed to have a lifetime of several years, e.g., 20 years, one must estimate changes in prices for each year of the duration of the project. Changes in relative factor prices, likely changes in the export price over time, etc., must all be considered.

It is worth discussing the relation between social and commercial profitability. The use of shadow prices is intended to reflect the social profitability of the project in terms of the complexity of goals of the society. Since, however, an entrepreneur in the private sector, or even the manager of a state enterprice, must maintain his accounts on the basis of actual prices, and, further, is subject to income taxes as well as various indirect taxes, the determination of a certain rate of social profit says nothing about the commercial profitability of the undertaking in question. Consequently, an analysis of the commercial profitability of a project intended for the private sector should be undertaken as well as an analysis of social profitability. If on the basis of social profitability a project or particular technique of production is worth implementing, the level of commercial profitability can then be used to guide the government in the application of an appropriate tax/subsidy scheme which may be necessary to cause private incentives to conform to social needs. The practicality of such a scheme can then be used to determine whether private enterprise or the public sector is best suited for the undertaking.

In fact, this procedure is possible only in the case of projects or enterprises iniciated by the state. When a private concern presents a project for financing to obtain an import license, or in some other way to obtain state approval, only one technique is presented. It is up to the state representative, then.to ask intelligent questions: are there other techniques? What is the difference between them and the one chosen? Why were the others rejected? etc.

/III

III

The Shadow Price of Capital

By the price of capital most people mean the rate of interest, or the rental price of capital, which would, in a well-functioning capital market, equal the marginal productivity of capital. Some authors propose the use of the marginal productivity of capital in the private sector for the rate of discount to be applied to projects in the public sector rather than the social rate of time preference. In this section, we are concerned with something quite different, that is, the adjustment to be made to the value of investment funds used in a public sector project when some of these funds displace investments in the private sector. This concept has nothing to do with determining the rate of discount to be used in expressing future benefits and costs as their present value equivalents.

The UNIDO Formula

In his several writings, and in his contribution to the UNIDO volume Marglin (31, 32, 45) develops a formula for the shadow price of investment funds used in public sector projects whose financing reduces investment in the private sector.

For that proportion of investment funds which comes from private investment, the reasoning is as follows. An investment yields direct contributions to consumption $(1 - s)y$ and direct contributions to investment, sy. Evaluating new investment at its shadow price, p^{inv}, and summing, the annual gain from a unit of investment is

$$(1 - s)y + p^{inv} sy \qquad (1)$$

If the investment extends indefinitely into the future and the parameters are assumed constant, the present value of (1) may be calculated:

$$p^{inv} = \sum_{t=1}^{\infty} \frac{(1 - s)y + p^{inv} sy}{(1 + i)^t} \qquad (2)$$

/This geometric

This geometric sum may be rewritten as

$$p^{inv} = \frac{(1 - s) + p^{inv} sy}{i} \qquad (3)$$

Solving for p^{inv}:

$$p^{inv} = \frac{(1 - s)y}{i - sy} \qquad (4)$$

In the surplus labour economy, y, the rate of return to capital is expressed as the difference between the marginal output/capital ratio and the actual wage bill per unit of investment which is the product of the wage rate and the labour/capital ratio. Another term is added to the expression for the increase in consumption made possible by the differential between the wage and the marginal productivity of labour in agriculture or the unprotected urban sector. We thus have:

$$p^{inv} = \frac{(1 - s)(y - wb) + (w - z)b}{i - s(y - wb)} \qquad (5)$$

The derivation is as follows. Given the definitions of b, w and y, capitalist incomes are equal to the nominal profit rate, $y - wb$. If capitalists save s and consume $1 - s$, the annual aggregate consumption value of a marginal unit of investment is, by reasoning analogous to the preceding derivation,

$$(1 - s)(y - wb) + p^{inv} s(y - wb) \qquad (6)$$

If workers save nothing, the annual consumption they derive from a unit of investment is $(w - z)b$. The sum of these aggregate benefits is equal to

$$p^{inv} s(y - wb) + (1 - s)(y - wb) + (w - z)b \qquad (7)$$

Discounting the annual stream of benefits to infinite yields

$$p^{inv} = \frac{p^{inv} s(y - wb) + (1 - s)(y - wb) + (w - z)b}{i} \qquad (8)$$

Solving for p^{inv},

$$p^{inv} = \frac{(1 - s)(y - wb) + (w - z)b}{i - s(y - wb)} \qquad (9)$$

/Marglin's shadow

Marglin's shadow price of capital not only affects the evaluation of the initial capital outlay, and the evaluation of working capital, but it also affects the shadow wage of labour as will be shown in section V.

The OECD Formula

In the Little-Mirrlees OECD Manual (30), little attention is paid to the method of finance; hence, there is no discussion of the shadow price of investment for evaluating the initial capital costs and the operating costs of a project. However, in evaluating the shadow price of labour, a shadow price of investment is used. Little & Mirrlees call this the value of investment in terms of consumption, and in their formula, presented in our Section V, they are forced to use the social rate of discount, which they call the consumption rate of interest, in a way very similar to the UNIDO authors. For comparison, the Little and Mirrlees formula, with the same notation as the UNIDO authors, is:

$$p^{inv} = \left(\frac{1 + sy}{1 + i}\right)^{T} \left(\frac{(w - z)b}{sy - i} + 1\right) - \frac{(w - z)b}{sy - i} \qquad (10)$$

Their shadow price is derived as follows. Let p^{inv} represent the value of consumption arising from an investment over T years where T represents the point in the future when consumption is valued equally with investment. With sy equal to the rate of growth of investment (the product of the output/capital ratio and the marginal propensity to save) and i equal to the social rate of discount, one unit of investment will grow by year T to a value of

$$\left(\frac{1 + sy}{1 + i}\right)^{T} \qquad (11)$$

In each year this growing investment fund will also provide consumption benefits equal to (w - z) multiplied by the labor/capital ratio, b. Discounted to the present, we have

$$(w - z)b \left[1 + \frac{1 + sy}{1 + i} + \left(\frac{1 + sy}{1 + i}\right)^{2} + \dots + \left(\frac{1 + sy}{1 + i}\right)^{T-1}\right] \qquad (12)$$

/which is

which is a geometric progression equal to

$$\frac{(w - z)b}{sy - 1} \left[\left(\frac{1 + sy}{1 + i} \right)^T - 1 \right] \qquad (13)$$

Adding this term to $\left(\frac{1 + sy}{1 + i} \right)^T$, we have equation (10)

$$p^{inv} - \left(\frac{1 + sy}{1 + i} \right)^T \left(\frac{(w - z)b}{sy - 1} + 1 \right) - \frac{(w - z)b}{sy - i} \qquad (14)$$

The formulas of the OECD authors and the UNIDO authors are broadly similar to one another since they both deal with the same concepts: the growth potential of investment funds and the additional consumption benefits arising from higher future levels of investment. The UNIDO formula assumes an infinite time horizon and no changes of parameters, whereas the OECD formula utilizes a time horizon T, when the shadow price of investment in terms of consumption is abruptly equal to 1, i.e., the nominal value of the investment, whereas up to that point, the shadow price of investment in terms of consumption is some magnitude greater than 1. The discontinuity is offered as a simplifying assumption in view of their supposition that the premium attached to savings declines over time. The UNIDO formula avoids making a judgment about the relative values of future consumption and future investment by developing a shadow price of capital based directly on the opportunity cost of foregone investment in the private sector.

Other authors have pointed out the need for care in estimating the return to capital in the private sector, and have also considered the cost of capital when displacing private consumption through taxes, or private consumption through public debt.

As regards the opportunity cost of capital in the private sector, Stockfish (38) and Harberger (22) have noted the necessity of taking into account the effect of income taxes, indirect taxes, and monopoly on the private rate of return.

Haveman (23) has pointed out the fact that taxes displace investment as well as consumption and thus alter interest rates, and savings decisions. Using this concept, he has estimated the social rate of discount in the U.S.

/Harberger (20, 21)

Harberger (20, 21) has analized the opportunity cost of funds raised through the issue of public debt. This has the effect of raising the interest rate which decreases private investment and increasing savings. The public debt is, thus, equal to the sum of the investment displaced plus the additional savings generated. The opportunity cost is thus represented by the gross rate of return on private investment displaced by the rise in the interest rate and by the rate of interest net of taxes corresponding to the increased savings caused by the higher rate.

Of the various approaches, that of the UNIDO authors can be recommended for the relative ease with which it can be applied. On theoretical grounds, such a judgment is rather more difficult to make since the differences among the underlying theories depend on judgments about the relative importance of the variables considered.

IV

The Social Rate of Discount

Since consumption is less valuable in the future than in the present, it is necessary to discount the future net benefits of a project. On this everyone involved in project analysis agrees. The disagreement consists in deciding which rate of discount to use, and to some extent when to use it. Marglin, for example, uses it in three steps of the analysis: (1) in estimating the shadow price of investment in the public sector since private sector investment projects, which yield a stream of future consumption, are foregone; (2) in evaluating the shadow wage of labor since the wage bill may displace investment funds which would have resulted from a more capital intensive alternative; and (3) in evaluating the net future benefits of a project.

Little & Mirrlees (30) use the shadow price of investment, termed by them the consumption rate of interest, in estimating the shadow wage of labor. However, they neglect the shadow pricing of initial investment and working capital costs. For discounting future net benefits which is necessary for estimating the present discounted value of a project, they prefer to use an accounting rate of interest which is such that the least profitable project necessary to exhaust the investment fund has a net present value of zero.

In terms of finding a value for the social rate of discount, this approach differs sharply from that of the UNIDO authors. They use sensitivity analysis to produce a range of values for unknown parameters, one of which is the social rate of discount - a technique which will be discussed shortly and which is utilized in the example in Appendix II.

Other authors have argued for the use of the opportunity cost of capital rather than the social rate of discount in calculating net present values.

Harberger (21, 22), for example, has argued that the use of social rates of discount in the manner suggested by Eckstein and Marglin, rather than the marginal productivity of capital in the private sector, may lead

/to situations

to situations in which the rate of return on public sector investment is less than that on private sector investments. Marglin has shown (45), however, that this contention rests on rather stringent assumptions: (1) the volume of investment is fixed independently of project choice in the public sector. If this assumption does not hold, it must then be assumed (2) that the relevant model is a two-period model, or (3) that the growth path of the economy is already optimal.

If project analysis requires the use of a social rate of discount, what should project analysis assume about the magnitude of this parameter? Marglin provides a formula for this discount rate:

$$i = -\eta_{up} \cdot r_p \qquad (15)$$

in which i is the product of the elasticity (negative) of marginal utility of consumption with respect to increases in per capita consumption (η_{up}) and the rate of growth of per capita consumption (r_p). Of course η_{up} is not a measurable quantity so Marglin (45) advocates the use of sensitivity analysis, an example of which is presented in Appendix I, to produce a range of discount rates which will yield a positive cost-benefit ratio. Successive choices by planners among the alternative projects will shortly produce a narrow range of values for the social discount rate consistent with these choices. From that point on the project analysed can point out to planners which are the values consistent with their choices and through a combination of revealed preferences and dialogue establish a discount rate for future projects.

Little-Mirrlees, on the other hand, actually attempt to estimate a value for the social rate of discount. Earlier in this section, it was noted that they use the consumption rate of interest (social rate of discount) only in evaluating the foregone investment possibilities associated with the wage bill in order to determine the appropriate shadow price of labour.

They argue, that a weighted sum of the growth of wage earners' consumption and the growth of rural consumption levels with weights of 1/2 to 3/4 for the first, and 2 to 3 for the second, is a good approximation, with perhaps an additional 2 to 3 per cent for government time preference:

/This, if

This, if wage earners' consumption per capita is growing at 1.8 per cent and social consumption per capita is growing at.48 per cent, with weights of 2/3 for the first and 3 for the second, the weighted sum is $1.8 \times \frac{2}{3} + .48 \times 3 = 1.2 + 1.4 = 2.6$ per cent. The addition of government time preference of 2.4 per cent would yield a discount rate of about 5 per cent.

How the authors of the OECD Manual (30) feel that these weights, which are equivalent to the absolute values of Marglin elasticity of per capita consumption, can be assigned a value is not completely clear. In any case, Marglin's approach - the use of sensitivity analysis to provide planners with a range of values and, consequently, encourage them to consider well the implication of their choices - avoids making such heroic assumptions about the marginal utility of income.

V

The Shadow Price of Labor

Direct Opportunity Costs

The direct social cost of labor of a given skill-level in a marginal project to the society is the marginal contribution of labor to output in the activity in which he would otherwise be employed. This is the opportunity cost of labor in the project to be considered and it is this which is estimated as the shadow or accounting price of labor. Usually only unskilled and semi-skilled labor is assumed to have an accounting price different from the market wage and it is with this type of labor that the following discussion will be concerned.

Perhaps, the best-known case of shadow-pricing of labor was the investment criteria which recommended maximizing the output/capital ratio. This criteria assumes that capital is the only scarce factor, and thus attributes to labor, as well as to all other factors of production, and implicit shadow price of zero. The classic analysis of economic growth which made use of the explicit assumption of a zero shadow price of labor was made by W. Arthur Lewis (29). There has subsequently grown up a very large literature which has arrived at a consensus that the subject is not so simple. Harberger (19) whose ideas will be more fully explored later, points out that the labor force contains many sub-sections and that labor drawn from different subsectors will have different shadow prices. In the controversy over the unlimited surplus labor model of Lewis, it was pointed out that the opportunity cost of supplying labor, formerly in the rural sector, to an urban project involves transfer costs and must, therefore, be positive even if marginal productivity in agriculture is close to zero. Thus, it is probably only rarely true that the marginal product in agriculture is zero. Recently, a sophisticated model of rural urban migration has been proposed by Todaro (39) in which the rate of flow of workers from the rural to the urban sector is itself a function of employment opportunities. If this model holds, the employment of one additional man in urban employment,

/may entail

may entail not only the loss of his output in agriculture, but also the foregone output of those additional men who consequently move from the rural to urban sector in search of work opportunities.

In an important paper (19) Harberger has suggested a division of the labor force into three basic sector: (i) agricultural sector, (ii) non-protected urban sector, (iii) protected urban sectors. A protected sector may be for example, one in which wages are high as a consequence of labor strength due to: effective unions, public relations policy of foreign corporations, greater readiness of monopolistic industry to yield to pressure for higher wages which may be passed forward to the public in the form of higher prices, higher wage levels in state enterprise, or government minimum wage legislation. Harberger argues that unskilled labor in the non-protected urban sector commands a wage that probably reflects its opportunity cost. This wage is higher than that in the rural sector because it reflects higher costs of living in the city and the costs of transfer. It is this wage for an unskilled worker in the unprotected urban sector which should be used in evaluating unskilled labor in the protected sector.

Harberger argues that the high market wage for skilled workers reflects the genuine scarcity of such talent and, consequently, does reflect the opportunity cost of employment.

In the rural sector, Harberger argues that freely contracted labor, particularly that of single men, probably represents their opportunity cost. This assumes that minimum wage legislation does not effectively cover this sector, which may not be a strong assumption.

It has also been argued by Haveman (23) that during swings of the business cycle, the shadow wage rate will change, in particular, that during periods of cyclical unemployment, the shadow wage falls to zero. It may be noted that the reserve price of labor, that is, the wage required by a worker to sacrifice leisure is seldom zero, so that this estimate is surely too low. Besides, the labor in a particular project must be evaluated carefully to determine which categories of labor are subject to unemployment of other than a frictional sort. For the purpose of project

/analysis, however,

analysis, however, this effect can probably be ignored since fluctuations over the time horizon of the project may cancel out.

Indirect Opportunity Costs

Todaro (39) makes the point that the reduction of output in the rural sector is some multiple of the foregone production of the worker transferred from the rural to urban sector because of the added inducement for others to migrate in search of more remunerative employment. Todaro's model is fairly complex; its parameters must be estimated for each country to which it is to be applied. Consequently, this effect has not been empirically verified, at least for Latin America, and is usually ignored in project analysis.

The effect of the size of the wage bill in determining the investible surplus is not ignored, however. The indirect cost of labor consists in future consumption foregone due to reduced investment as a consequence of increasing the wage bill at the expense of the reinvestible surplus, or return to capital. It is important to note that the introduction of this consideration not only assumes a difference in the marginal propensities to save between owners of capital and wage earners - an assumption which may be reasonable for some countries, especially where state enterprises are important, but by no means for all countries - but also that governments are not able to offset this differential through taxation or other tools of fiscal and monetary policy. A conflict is thus posed between the rate of economic growth (which is higher, the larger is the investible surplus) on the one hand, and maximum employment, which is equivalent to maximum output or national income, on the other. This conflict is discussed quite well in K. Laski (28).

In the long run, as Laski summarizes the argument put forward by Galenson and Lebenstein, Dobb, Sen and others, the rate of growth is decisive. Maximization of surplus, i.e., the rate of growth, can be expected to liquidate surplus labor more rapidly than maximization of national income. Furthermore, if real wages remain stable it can also be expected to give a higher level of aggregate and per capita consumption.

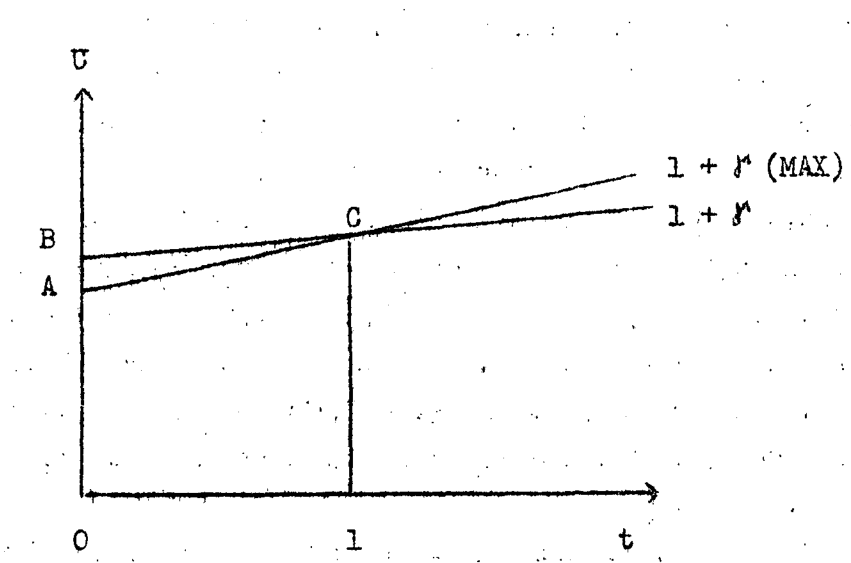
/Laski takes

Laski takes pains to point out that this result applies only in an economy in which all income is in the form of wage payments, that is, in a socialist country. In mixed enterprise economies, it is always theoretically possible to reduce the consumption of wealthier classes before reducing that of workers.

Using a simple diagram, Laski shows how lower level of income (A) in time zero, will lead to higher levels of income after time 1, because of the higher growth rate made possible by the reduction in potential income (B) to actual income (A).

Figure 1

Effect of Alternative Technologies on the Growth Rate



/He then

He then goes on to argue, however, that the time interval between 0 an 1 may be quite long. One reason is that an economy starts with a given degree of capital intensity. The old techniques are yielding an investment fund as well as the newest techniques. During the transition period to a more capital-intensive economy, the growth rate may even fall since the initial investment fund derived from the old production techniques is being invested in more capital-intensive technique which yield a lower rate of return. Thus, some time will pass before the greater aggregate surplus offsets the decrease in the productivity of capital. If technical progress occurs in both types of economics at the same rate, it will take even longer for the maximum surplus solution to yield higher income than the maximum employment version.

An additional interesting point raised by Laski is that the problem as a technical one exists only in socialist economies, because in such economies there are no classes enjoying disproportionately high incomes. In mixed economies, it is always technically possible to reduce the consumption of wealthier classes before reducing that of workers via high unemployment levels or general taxes.

Nevertheless, if the government prefers to think that the rate of investment is dependent upon the degree of capital intensity of the project, then the reduction in investment and, consequently, future consumption, should be included in the shadow price of labor.

Alternative Formulations of the Shadow Price of Labor

Both Little & Mirrlees in the OECD Manual (30), and Sen, Dasgupta and Marglin in the UNIDO Guidelines (45) include foregone investment as an indirect cost in the shadow price of labor, and both offset this cost by providing for the positive valuation of increased consumption by workers. There are significant differences, however. One is that the OECD authors value everything in terms of government income converted into its foreign exchange equivalent. Beyond this choice of numeraire however, the OECD authors present a much simpler but also much less comprehensive measure of the indirect costs and benefits of hiring additional workers than the

/UNIDO authors.

UNIDO authors. It is less comprehensive in its treatment of indirect costs because it assumes the full difference between the wage and the direct opportunity cost to be a reduction in investment, whereas the UNIDO authors incorporate savings propensities and the shadow price of investment. As far as benefits are concerned, the OECD authors ignore the effect on future employment, while the UNIDO authors incorporate this effect in their analysis.

The Unido Formula

When the assumption is made that the wage bill is financed from capitalist income, as in the case of government projects financed by taxation or when a more labor-intensive process is chosen over a relatively capital-intensive one, then the aggregate consumption loss associated with the wage bill is

$$\left[(1 - s) + p^{inv}s\right] w \qquad (16)$$

where w is the wage rate, s is the proportion saved by capitalists and p^{inv} is the shadow price of investment previously derived in Section III, equation (9). The loss of consumption by capitalists is $(1 - s)w$ and the reduction in investment evaluated at its shadow price is $p^{inv}sw$. Workers, however, gain consumption equal to w. Subtracting w from equation (16) yields $s(p^{inv} - 1)w$ as the indirect cost of labor.

Adding this expression to the direct opportunity cost of labor, the marginal product in the sector from which labor is recruited, represented by z, we have the following formula for the total opportunity cost of labor:

$$w^* = z + s(p^{inv} - 1)w \qquad (17)$$

The preceding expression takes into account the direct and indirect costs of labor under numerous assumptions, one of which is that the sole objective is maximization of the aggregate consumption stream. In order to incorporate a distinct employment objective, it is necessary only to add a third term reflecting the increment to workers consumption made possible by

/hiring workers.

hiring workers. The UNIDO formula applies a distributional weight to workers' consumption relative to total aggregate consumption, but values future workers' consumption (properly discounted) equally with present consumption. Thus, in considering the gain to workers, the loss of future consumption must be netted out. Toward this end, a term, p^{wkr}, is developed which represents the discounted present value of a unit of future consumption foregone.

Foregone income consists of two components: wage increments $(w - z)b$, generated by each unit of investment plus investment increments evaluated at the shadow price, p^{wkr}, of workers future consumption: $s(y - wb)p^{wkr}$. p^{wkr}, then, equals the sum of these two components discounted by the social rate of discount, i.

$$p^{wkr} = \frac{(w - z)b + s(y - wb)p^{wkr}}{i} \qquad (18)$$

solving this expression for p^{wkr}:

$$p^{wkr} = \frac{(w - z)b}{i - s(y - wb)} \qquad (19)$$

Now, the increment to present workers' consumption is $w - z$. The loss of future consumption is $sw\ p^{wkr}$. That is, the increment which would have been invested, sw is evaluated at the shadow price of workers' consumption benefits arising from the stream of proceeds of one unit of additional investment. The net gain is thus

$$w - z - sw\ p^{wkr} = - \left[z + (s\ p^{wkr} - 1)\ w \right] \qquad (20)$$

to which a weight of v is applied. This weight represents the value placed on the employment objective relative to total aggregate consumption. Weighting equation (2) by v and subtracting from equation (17) yields our final shadow price of labor:

$$w^{*} = z + s\ (p^{inv} - 1)\ w + v \left[z + (s\ p^{wkr} - 1)\ w \right] \qquad (21)$$

/It can

It can easily be seen that assigning a value of zero to v reduces equation (21) to equation (17) in which only the effects on aggregate consumption are considered. Contrary to appearances, the addition of the term $v [z + (sp^{wkr} - 1) w]$ will reduce the value of w*. This is true because the expression in brackets will tend to be negative as long as w, the market wage, is substantially greater than z, the direct opportunity cost of unskilled labor.

The OECD authors use as their unit of account the value of uncommitted current government revenues converted into its foreign exchange equivalent. The UNIDO authors, on the other hand, employ aggregate consumption as their numeraire. Hence, the UNIDO authors speak of a shadow price for investment, p^{inv}, while Little-Mirrlees apply a shadow price of consumption, $1/p^{inv}$, to convert consumption benefits to the value of investment foregone. They derive their formula as follows.

The shadow wage of labor is composed of the marginal product of labor in the sector from which it is recruited plus the difference between the wage paid on the project and the marginal product offset by the same increment multiplied by the inverse of the shadow price and investment. Thus,

$$w^* = z + (w - z) - \frac{1}{p^{inv}} (w - z) \qquad (22)$$

The first two terms represent the direct and indirect costs of installed labor: the loss of the marginal product is the sector from which installed labor is assumed to have been drawn, and the difference between that amount and the actual wage which difference represents foregone investment. Offsetting these costs is the value of the increase in current consumption measured by the value of investment which such a sum represents. The shadow price of investment, p^{inv}, is, of course, the one derived in Section III under the subheading, "The OECD Formula".

The chief differences in the two formulas other than the choice of numeraire and the time horizon are the following. As regards the indirect cost of labor, the UNIDO formula assumes the whole of the nominal wage to

/be a

be a transfer from capitalist income to workers consumption, and that only a part of capitalist income would have been invested. The OECD authors, on the other hand, assume that the full increment between the wage rate and the alternative marginal product is to be charged directly against investment.

As regards the value of employment opportunities, the UNIDO authors take into account foregone future employment opportunities and use a flexible weight. The OECD authors, on the other hand, treat the increment of consumption income at its value in terms of investment as the gain without regard to future employment. Implicitly, they assign a weight of 1 to this increase in workers' income. On balance, the UNIDO formula seems a more flexible one.

VI

The Shadow Price of Foreign Exchange

When imported goods or domestic goods for which importable substitutes exist are inputs to a project, it is, of course, necessary to convert their price in foreign currency to domestic prices. The persistence of over-valuation and the widespread use of tariffs, quantitative import restrictions, export subsidies, etc. cause virtually all observers to agree that the official exchange rate is an inappropriate measure of the socially relevant factor for converting foreign to domestic values. The candidates for shadow foreign exchange rates are, however, legion. No less than seven principal approaches have been identified in recent reviews of the subject by Guadagni (18) and Bacha and Taylor (1), the principal features of which are presented in this section. These seven are the following: (1) linear programming estimates (2) general equilibrium calculations (3) domestic cost of producing foreign exchange, (4) calculations of the effective rate of protection (5) the opportunity cost of foreign exchange (6) the Little-Mirrless approach and (7) parity calculations.

The linear programming approach consists in estimating production functions for the various activities of the economy, including export and import activities at whatever level of disaggregation may be feasible. Combined with resource constraints and final demand equations, the system can be solved for the "equilibrium prices" of all inputs and outputs. The foreign exchange prices thereby calculated take into account all the interactions of the modern economy. As Chenery argued in his book, (12) and as Bacha and Taylor emphasized in their recent review article, this approach is theoretically the most desirable, but typically altogether unfeasible in terms of both data availability, and the computational capacity of computers to solve models sufficiently disaggregated to indicate the relative comparative advantage at the 3 or 4 digit level necessary for project analysis. Furthermore, the existence of quantitative

/trade restrictions

trade restrictions and the timing of devaluations in response to a deteriorating trade balance pose special problems. A programming model of an economy engaged in world trade would certainly have to include non-linear equations to incorporate the above-mentioned features, reducing even further the feasibility of constructing a sufficiently realistic programming model.

The Bacha and Taylor Equilibrium Rate

In the absence of the conditions necessary for the use of a programming model, Bacha and Taylor argue for the calculation and use of an equilibrium exchange rate, that is, the rate which would prevail in a world with no import or export restrictions. They define this rate as that which would hold constant the current trade balance if all import and export subsidies were to be removed.

In deriving their formula, Bacha and Taylor develop a simple trade model in which each demand functions depends solely on the good's own price. Holding the balance of trade constant, the model is solved for the degree of revaluation required to offset the removal of all trade restrictions. Thus, the import and export elasticities (understood as refering to volume indices) represent goods which would enter into trade as well as those goods actually traded. Since the formula as developed from the simplified model is for one import good and one export good, its generalization to a multiple product economy would require using weighted averages of elasticities where the weights would reflect the appropriate shares in the export and import bills expected to prevail in equilibrium. We simply present the final formula below. Its complete derivation may be found in Appendix III.

$$R^* = RT^* \frac{1}{1-q} \qquad (23)$$

$$\text{where } q = D \frac{(1 + x) \ E_x \ (E_m - \mu_m)}{(1 + E_m) \ \mu_m \ (x - E_x)} \qquad (24)$$

/Definitions of

Definitions of the other variables are given in the Addendum.

If $x = E_m = \infty$, which may very well be true for small countries, the formula for q simplifies to

$$q = D \frac{E_m}{\mu_m} \qquad (25)$$

The chief criticism which may be levelled against this approach is the normative use of the free trade assumption. It may properly be asked: if a substantial movement toward free trade is not envisaged within the planning horizon of the country in question, of what use is such a rate?

Most other authors avoid the normative assumption of equilibrium. This is true of the demand-oriented, opportunity-cost approaches of Harberger (22), Fontaine (16) and Schydlowsky (35), as well as the Bruno (7, 8, 9) and Kreuger (26, 29) domestic-cost-of-producing-foreign-exchange model. It is less true of the effective-rate-of-protection-model applied by Bela Balassa.

The Bruno-Kreuger model will be presented next. Both this model and the effective-rate-of-protection approach have been used in project evaluations - the Bruno-Kreuger model by Israel, and the effective-rate-of-protection model by the World Bank.

<u>The Domestic Cost of Producing Foreign Exchange</u>

It is important to note that the Bruno-Kreuger formula does not aim directly at calculating a shadow price of foreign exchange. Rather, by analyzing domestic cost of production, a ranking of commodities is obtained which yields the order in which commodities could be profitably exported as the exchange rate rises.

Beginning with an input-output model of the economy the prices of domestic goods are expressed in terms of domestic factor costs. An export sale will be profitable when the net foreign exchange earnings multiplied by the exchange rate exceeds the domestic cost. The formula derived expresses this relation as the ratio between total domestic value added and net foreign exchange earnings. Net foreign exchange earnings are equal to the sales price minus foreign exchange costs of production.

/This ratio

This ratio provides a means of ranking goods in the order of their foreign exchange profitability. If this ratio is less than the exchange rate, exporting will be profitable. The higher the exchange rate, the more goods will meet the profitability criteria. This method yields no information on what the exchange rate should be, although applying the formula to marginal import-substitution projects may provide a lower limit on what planners believe the rate to be, while marginal export projects may provide an upper limit. This is so because the infant-industry argument for establishing import-competiting projects implies a higher shadow price of foreign exchange to be profitable than does an export project. If planners approve an export project, i, and an import competiting project, j, and if the shadow exchange rates necessary for profitability are $R_j^* > R_i^*$, then by implication of the planners decision, the actual shadow price may be assumed to lie between these two rates. Their formula is

$$c = \frac{\sum_s f_{sj} \; v_s + \sum_i a_{ij} p_i}{u_j - m_j} \qquad (26)$$

Export sale of a product will be profitable if $C < R$. If R, the official exchange rate, is not considered to be a valid criteria, a shadow price of foreign exchange, R^*, may be used instead. Indeed, by letting R^* vary it is possible to rank goods in the order in which they would become competitive as the exchange rate rises.

In the case where the intermediate goods, aij, of the preceding formula are imports, the formula takes the following form:

$$c = \frac{\sum_s \bar{f}_{sj} \cdot v_s}{u_j - m_j} \qquad (27)$$

where $\bar{f}_{sj}$ represents the direct and indirect inputs of primary factor's per unit of output and $\bar{m}_j$ represents the direct and indirect foreign exchange costs per unit of output.

/This approach

This approach has been criticized by Balassa and Schydlowsky (5) who point out that projects using highly protected domestic inputs will be discriminated against. An example may make the strength of their argument apparent.

Let us consider two goods, A and B, which require the same labor inputs, the same value of non-tradeables and which sell for the same world price. They differ only in that A uses a highly protected domestic input while B uses an imported input. Now let us assume that the value of the highly protected input used by A would have the same value - if imported - as the imported input used by B. In this case, A will appear to be less profitable in producing foreign exchange than B when, in fact, they are both equally efficient. If now, the highly protected input were evaluated at world prices and treated as a foreign exchange cost, the two projects would show the same value for C. Actual practitioners, in fact, do revalue such domestic inputs when it seems reasonable to envisage trade liberalization for the input in question. If all tradeable inputs are valued at world prices, the resultant ranking will be identical to one resulting from calculating effective rates of protection.

The Effective Rate of Protection

The effective rate of protection is that exchange rate at which a product would become competitive if all tradeable material inputs were valued at world prices. Like the Bruno-Kreuger method, the resultant ranking carries no implication for the "correct" foreign exchange rate. An effective rate of protection, H_i, is calculated for each product as the ratio between the value added at prevailing domestic prices, P_i^*, and the value added when output and tradeable inputs are valued at world prices, ρ_i^*. Their formula, then, is

$$H_i = P_i^* / \rho_i^* \qquad (28)$$

/where P_i^* =

where $P_i^* = P_i - \sum_{j=0}^{n} a_{ji} P_j$ and $\rho_i^* = \rho_i - \sum_{j=0}^{n} a_{ji} \rho_j$

Aside from the well-known problem of the introduction of biases from the use of fixed input-output coefficients, the principal objection to both the effective-rate-of-protection approach and the domestic-cost-of-producing-foreign-exchange evaluation is that neither produces a shadow price of foreign exchange. The strength of these approaches, on the other hand, is their analysis of supply which makes it possible to rank products according to their comparative advantage. This is, of course, useful if project analysts are choosing among alternative export-earning projects. Even then, the analysis is static and, consecuently, not well-suited for evaluating the long-term advantages to a country of developing certain branches of industry. Application of this approach within a given branch of industry at the product level might be somewhat less objectionable.

The Harberger-Schydlowsky-Fontaine Shadow Price

We have just considered two approaches which analyze foreign exchange rates from the point of view of production. In the social-opportunity-cost version proposed in several variants by Harberger, Schydlowsky and Fontaine a model is presented in which the foreign exchange effects of a project are evaluated in terms of changes in aggregate output. In other words, these authors utilize a model in which aggregate output is maximized. Theirs is, thus, a consumption-oriented model. Furthermore, their model considers marginal changes for traded goods, taking into account tariffs, but not the possibility of relaxing quantitative restrictions on trade. It may, thus, be considered a partial equilibrium construct as opposed to the Bacha and Taylor general equilibrium formula presented earlier.

Their formula is as follows:

$$R^* = \frac{R\ (1 + T_x)\ E_x - R\ (1 + T^*)\ \mu_m}{E_x - \mu_m} \qquad (29)$$

where the definitions of variables may be found in the Addendum.

/It may

It may easily be seen that if the price elasticity of the supply of exports is zero, i.e., $E_x = 0$, then

$$R^* = R\ (1 = T^*) \qquad (30)$$

Formula (29) was derived for one export commodity and one import commodity. The formula may be generalized as follows:

$$R^* = R \sum_j (1 + t_j^x) \frac{x_j}{x} E_j - \sum_i (1 + t_i^m) \frac{m_i}{M} \mu_i \qquad (31)$$

The social value of foreign exchange, as calculated by this formula, will be some magnitude in between the official rate and the "equilibrium rate" of Bacha and Taylor.

The Schydlowsky version, as presented by Guadagni (18), is the following:

$$R^* = \sum_i R\ (1 + t_i^m) \frac{\Delta m_i}{\Delta M} \qquad (32)$$

This is obviously a generalization to many commodities of equation (30), but where the weights are derived from the marginal import bill rather than the average.

Use of this formula will, in general, lead to a higher rate than the full formula.

<u>The UNIDO Formula</u>

In the UNIDO <u>Guidelines</u> (45), the authors propose as a shadow price of foreign exchange, the weighted average of market clearing (domestic) prices to foreign prices (c.i.f.) converted at the official exchange rate where the weights are the shares in the marginal import bill. Actually, their shadow price is expressed as a <u>premium</u> added to domestic currency used to purchase imports which is a somewhat different usage than that followed by other others. In what follows their formula has been recast

/so that

so that R^* represents the social cost in domestic currency of one unit of foreign exchange.

$$R^* = \sum_i P_i \,/\, \rho_{i\ (c.i.f.)} \qquad (33)$$

Now, if $P_i = (1 + t_i^m)\, R \cdot \rho_{i\ (c.i.f.)}$ (34)

We have $(1 + t_i^m)\, R = \dfrac{P_i}{\rho_{i\ (c.i.f.)}}$ (35)

and $R^* = R\,(1 + t_i^m)\,\dfrac{\Delta\, m_i}{\Delta\, M}$ (36)

which is the same as the Schydlowsky formula, equation (32).

These authors argue that what is relevant in project analysis is the alternative uses to which foreign exchange is likely to be put, not how it might be used in a world of free trade; they thus argue that the search for equilibrium rates is utopian, and prefer to measure the value of foreign exchange according to the uses to which it is currently put.

If certain goods are rationed, so that a market clearing price is unavailable, the UNIDO authors suggest excluding these items and reweighting the included items so that $\sum_i \dfrac{\Delta\, m_i}{\Delta\, M} = 1$

Implicit in their procedure, the UNIDO authors argue, is that increases in imports are net additions to supplies; if not, substitution would be taking place and, ultimately, other domestic resources would become available and this would justify a different price ratio. For capital goods, however, such an assumption would imply that net additions to capital goods depends on foreign exchange. These authors feel, however, that net additions to capital goods depend on the marginal savings rate. Thus to include capital goods in the marginal import bill is, for purposes of analyzing the value of foreign exchange in a developing economy illusory. Their foreign exchange calculation is thus limited to consumer goods and intermediate goods used in the production of consumer goods.

/Their argument

Their argument at this point is subject to the following criticisms. Investment does not consist solely in importables, or imports. Infrastructure, for example, is highly intensive in domestic inputs. Moreover, machines of specific type very likely are net additions to stocks. While it may be true that the aggregate value of capital goods should not be taken as net additions to total capital, it does not follow that imports of specific machines may not nevertheless, be net additions to machinery of that type. One could equally well argue that imports of consumer goods are not net additions to total consumption, because the value of consumption is determined by social policy, and not by foreign exchange constraints. This review would thus contend that investment goods not be excluded from a calculation of the UNIDO type.

Bacha and Taylor levy three basic criticisms at the Harberger-Fontaine-Schydlowsky approach, and pro tanto, at the UNIDO authors, whose work was not then published. (1) Only marginal changes for traded goods are considered in a situation where import quotas and prohibitions are often more important than simple tariffs. Consequently, the approach takes for granted the established positions of highly protected domestic industries and fails to consider the effects of removing quantitative protective measures in these industries. (2) Differences in cost structures in the domestic economy and the world market are not considered, so there is no explicit attention paid to comparative advantage. (3) One is accepting a good deal on faith about the state of the economy and the validity of consumers preference in using changes in measured national income as a welfare criteria in the derivation of the formula (Appendix III).

In rejoinder it may be pointed out with respect to (1) that in a choice between alternative techniques, one is dealing with marginal changes in which the effect of trade restrictions will be invariant to the choice in question. With respect to (2), for the purpose of project analysis, the proper costing of foreign exchange inputs is the relevant factor, not which of several products has comparative advantage, although comparative advantage will be reflected in the over-all rate of return. In any case choice of techniques is to be made independent of comparative advantage.

/The OECD

The OECD (Little-Mirrless) Method

All of the preceding approaches have proceeded from the point of view of the domestic economy and have used domestic currency as the unit of account. The Little-Mirrless method, on the other hand, takes the opposite approach and recommends using foreign (border) prices to evaluate all the inputs of the investment project.

Their method consists basically in the following steps:

1. Value all tradeable inputs at their c.i.f. prices.
2. Decompose non-tradeables into tradeables and the primary factor (labour).
3. Evaluate the tradeables in (2) as in (1).
4. Evaluate labour in terms of the foreign exchange cost of the average basket of goods consumed by workers' families.
5. Where the evaluation of non-tradeable involves many small quantities of items, use a standard conversion factor.
6. Value tradeable outputs at their f.o.b. prices.

Their standard conversion factor referred to in step 5 is not comparable to any of the methods previously considered. It consisted in following steps 1-4 for a wide range of "representative commodities". This will yield accounting prices in foreign exchange for a selection of tradeable and non-tradeable goods. The authors then suggest calculating a simple average of the ratios of these accounting prices to their actual c.i.f. prices in foreign currency.

Among the criticisms of this approach are implicit assumptions of perfectly elastic supply and demand elasticities for imports and exports. Thus when the domestic opportunity costs of supplying additional foreign exchange increase with the quantity of foreign exchange earned, such costs are understated by the Little-Mirrless approach as was emphasized by Mishan (33). Some attention is paid, however, to foreseen declines in export prices. Heather Joshi (24) has pointed out that the existence of substantial excess capacity, inelastic external markets, government intervention, and poor internal market integration - all conditions which prevail to greater or lesser degree in most developing countries - substantially increase the category of non-traded inputs. For this category the theoretical recommendation of Little-Mirrless to decompose these into tradeables and non-tradeables is generally unfeasible and, consequently, considerable reliance must be placed on the standard conversion factor, their presentation of which is not bolstered by theoretical arguments of the cogency underlying the other methods reviewed.

Parity Exchange Rates

Finally, a word about parity rates will conclude this enumeration of approaches to the shadow pricing of foreign exchange. Suggested for use in project analysis by ECLA (41) as early as 1955, parity rates represented a methodological advance over the previous standard procedure of ignoring the possibility of distorted exchange rates in project evaluation. There are two variants of parity rates:

(1) the first calculates the exchange rate required to equate the price of a well-defined basket of consumption goods;

(2) the second uses the movement of price indices to "reestablish" equilibrium rates assumed to have prevailed at some point in time.

The first variant is useful for comparing consumer welfare in different countries, but since it includes services, prices of which are not equalized by trade, the parity rates give no guide to the allocation of resources. Balassa (4) has shown that, since the prices of services are roughly correlated with per capita income, parity rates converge toward equilibrium rates as per capita incomes approach one another. Thus the divergence of parity rates from equilibrium rates is greatest when comparing countries of high per capita incomes with countries of low per capita incomes.

As for the second use of parity rates, namely, to adjust the equilibrium exchange rate established for one period for subsequent periods by using price indices requires rather strict assumptions, violations of which are more likely in the long run than the short run. Thus, if equilibrium rates were known for one year, parity adjustments might be close enough for a period up to five years.

Conclusion

Of the several procedures proposed for dealing with obviously misleading exchange rates, the partial equilibrium formulas of the Harberger-Schydlowsky-Fontaine variety seem the most practical to apply, and for this reason can be recommended. On theoretical grounds alone, it is difficult to choose between the partial and general equilibrium approaches. This must be largely a matter of judgment. If an export project is being considered and it is necessary to analyze the project from the standpoint of comparative advantage, then a modified Bruno-Kreuger analysis could be applied using the H.S.F. shadow price as the cut-off rate of foreign exchange.

VII

Additional Complications

In this section two complications are dealt with in the application of cost-benefit analysis to the problem of choice of techniques. The first complication arises from slight differences in the output of alternative designs differences sufficiently small that, in a certain sense, the outputs are regarded as close but not perfect substitutes. A related problem is when is joint production taking place, i. e., alternative A produces an output $Za = \alpha_1 X_1 + \alpha_2 X_2$ and alternative B produces an output $Z_b = X_1$ where X_1's of the two alternatives are identical, but alternative A produces some X_2 in addition. The second complication consists in the correct use of certain types of engineering data when different machine configurations are involved in the choice of technique.

Lack of Homogenity of Output

It may sometimes happen that when alternative production processes are considered their outputs are not exactly similar. For instance, the type of fabric produced by a textile mill of a given technology may be of a coarser grade than that produced by another, more advanced process. If this is the case, and the analyst still wishes to regard the two alternatives as mutually exclusive, the project's outputs should be evaluated in value terms using market prices which should reflect the relative superiority of the finer product. In this situation it would be possible for the government to assign a smaller price differential to the pair of products than that given by the market if it felt competent to overrule the apparent preferences of consumers. If the products are near enough to one another, i. e., if the elasticity of price substitution is "high enough" in the judgement of the planner, then the problem may be considered one of choice of techniques although, strictly speaking, if the elasticity of substitution is less than infinite, one should speak of alternative projects rather than alternative techniques.

/Another way

Another way in which lack of homogeneity may appear is when joint production is involved. For instance, it might be argued that in addition to providing a certain product, the use of a more advanced technology might result in valuable on-the-job-training. If this is considered to be the case, an attempt might be made to quantify the value of the training involved, for instance, by estimating the number of men who would benefit and evaluating the training at the cost which would be incurred by sending them to a technical institute in their own or in another country. Once this is done, the two alternatives may be regarded as alternative projects in which the benefits have one element in common, the marketable product, but the more technologically sophisticated alternative includes, as an additional benefit, the value of the training provided. Admittedly, this element will be difficult to evaluate to monetary terms, but reference to alternative ways of providing the training could be helpful in making such an evaluation. Some estimate must be made, however, if a valid comparison of the alternatives is to be made.

The Use of Engineering Data

A major difficulty in comparing alternative technologies is the detailed nature of the data required for a complete evaluation. Boon (6) has shown, that for light manufacturing processes, it is of considerable importance to have such engineering data as: time required to set a machine for a production run, the direct machine time required to produce the product, and the lot size of production. These data are shown to be important because setting time and piece time require labour of different skill levels and these two elements vary systematically with the degree of mechanization - setting times increasing and piece times decreasing. Futhermore, the setting time per unit output varies inversely with the size of the production run. Fixed costs per unit also vary with the production run since longer production runs save setting time and increase the volume of production thus leading to lower production costs per unit.

/Since different

Since different technological alternatives usually have different capacity outputs, it may be necessary to have several identical machine units of a lesser degree of mechanization to produce the same output as a more advanced machine with a larger capacity output. Since capacity output is a function of production time, data on setting time and piece time are necessary to determine the number of machine units required for a given output. The following cost function embodying these considerations was developed by Boon (6).

$$t_c = F \cdot c + \left(\frac{a_1}{n} \cdot h_1 + a_2 \cdot h_2\right) U \qquad (31)$$

where

$$c = E \; \frac{(a_1/n + a_2)}{k \cdot K} + 1 \qquad (38)$$

Total costs t_c equal the sum of fixed and variable costs. Fixed costs, F_c is the product of the cost per machine and the number of machines required. The number of machines required is in turn calculated as the product of the total daily output required and the total time required per unit of output divided by the total amount of time spent in production.

Variable costs per unit of output equal the cost of setting time plus direct machine time. The cost of the setting time equals the setting time per production run a_1, divided by the size of the production run, multiplied by the wage rate of the operative h_1. The cost of the direct machine time is simply equal to the product of the machine time per unit of output and the wage rate of the operative, h_2.

In his empirical studies, Boon found that relative prices of factors of production were important in determining the optimum technique of production when output levels are relatively low. Below a certain output range higher interest rates and lower wage costs increased the output range for which lower levels of mechanization were optimum. Above a certain output range, changes in relative prices had little effect. As might have been anticipated, when production is relatively more homogeneous, so that production runs are longer, capacity output increases which favors the more highly mechanized technique.

/The foregoing

The foregoing consideration should also emphasize the necessity of having rather good estimates of likely output levels over the lifetime of a project. In particular, it is of critical importance to know for how long excess capacity is likely to prevail if a highly mechanized technique is chosen, the capacity output of which is expected to be larger than can be absorbed by the market initially. The alternative - smaller, less mechanized units of which multiplies may be required when demand expands - can only be evaluated properly if demand is adequately projected.

/VIII

VIII

Application of Cost Benefit Analysis to Choice of Technologies in the Latin American Textile Industry

The ECLA Study

The data for this example were drawn from a 1966 ECLA study (40) on the choice of technologies in the Latin American textile industry. In their study of integrated cotton mills five vintages of technologies were identified: 1930, 1950, 1960, 1965 and 1965 experimental. Of these five, the technology of 1930 was ignored because at the time of writing no organized markets existed for machines of this vintage. The 1965 experimental technology was not considered for two reasons: smooth functioning of the machinery could not be guaranteed, especially in countries where highly skilled labor is in short supply; secondly, manufacturers were not willing to quote prices for many of their experimental machines.

Three technologies were analyzed through the device of designing three hypothetical plants each of which was assumed to use a technology of the same vintage in each of the 11 stages of production. In fact, it would have been possible to use any of the three technologies in each of the eleven stages, so that for the plant as a whole 11^3 or 727, 147 different combinations would have been possible: some characteristics of the three technologies shown are presented in Table 1.

Table 2 presents some of the data of Table 1 as index numbers. The differences in capital per person employed rise by 300 per cent from A to C. While capital per metre of cloth rises by 15 per cent, labor per metre of cloth falls by 63 per cent.

The average number of spindles for levels B and C was 15 000 and considerably less for level A. In each case the productive capacity was determined by the size of the machinery available in such a manner as to minimize idle capacity at each stage of the process. There is a steady increase in the volume of output as one progresses from A the most labor-intensive technique to C the most capital-intensive technique.

/Table 1

Table 1

DATA FOR INTEGRATED COTTON MILLS IN LATIN AMERICA

	Level A	Level B	Level C
Capital investment ($1 000)	4 453.3	5 658.5	6 507.6
Number of spindles installed	13 600.0	15 200.0	14 800.0
Number of looms installed	534.0	530.0	524.0
Yarn output (tons p.a.)	2 265.0	2 643.0	2 895.0
Cloth output (1 000 metres)	16 800.0	19 600.0	21 500.0
Number employed	668.0	446.0	315.0
Cost of cloth (dollars per 1 000 metres) a/	176.0	156.0	149.0
Return on investment b/ (percentage)	28.1	32.6	33.3

Source: ECLA, document, E/CN.12/746; (43), p. 44

a/ Excluding any allowance for remuneration of the entrepreneurial skills exercised and the capital invested.

b/ Gross margin before tax, assuming cloth is sold at $250 per thousand metres. The return compares with an average interest rate for long-term credits of 12 per cent.

/Table 2

Table 2

COMPARISON OF RESULTS OF DIFFERENT LEVELS OF TECHNOLOGY IN INTEGRATED COTTON MILLS IN LATIN AMERICA

(index numbers: level A = 100)

	Level B	Level C
Cloth output p.a.	117	128
Capital invested	127	146
Capital per metre of cloth p.a.	109	115
Capital per person employed	190	310
Number employed	67	47
Number employed per metre of cloth p.a.	57	37
Cost of cloth per metre a/	92	89
Gross margin p.a. b/	147	174

Source: As for table 1

a/ b/ See footnotes a/, b/ to table 14

Source (43), p. 45.

Each technique was designed to produce a single type of cotton, cloth, plain weave, 90 cm. wide, made of 18 count yarn, 20 threads per square cm. (both warp and woof). The sales price of the cloth was assumed to be ¢250. per thousand metres.

Prices of machinery were those prevailing in July 1965. Building costs were assumed to vary with the technique chosen because of differences in humidity control and air conditioning required. A permanent fund of working capital was assumed to be part of investment costs.

Detailed investment costs presented in the ECLA document are given in Table 3. Under the heading of fixed investment, items C and D were added to B for the cost benefit analysis, and this sum is assumed to

/represent the

represent the foreign exchange costs of installed machinery. Item F was excluded in our analysis under an assumption that investment is made instantaneously in year zero. All other items were considered to be costs in domestic currency.

Table 3

TOTAL INVESTMENT REQUIREMENTS FOR EACH PRODUCTION HYPOTHESIS

(Dollars)

Item	Level A	Level B	Level C
I. Fixed investment	3 992 780	5 136 792	5 942 273
A. Buildings and ancillary fittings a/	922 090	962 720	1 108 190
B. Equipment b/	2 170 602	2 987 102	3 459 942
C. Freight and insurance c/	217 060	298 710	345 994
D. Installation cost d/	90 675	126 185	146 573
E. Pre-operational costs e/	102 012	131 241	151 821
F. Interest payments during construction period f/	490 341	630 834	729 753
II. Working capital	460 560	521 750	565 360
A. Permanent stock of working capital g/	460 560	521 750	565 360
III. Total investment	4 453 340	5 658 542	6 507 633

Source: (40), p. 64

a/ See Table I.

b/ See Table H.

c/ 10 per cent of the total value of the equipment.

d/ 5 per cent of the value of the basic equipment (see Table H).

e/ 3 per cent of the value of the fixed assets.

f/ 12 per cent yearly on items A to E, for a period of 14 months.

g/ See Table J.

/Under the

Under the heading of working capital, detailed in Table 4, it was assumed that domestic labor accounted for 25 per cent, 15 per cent, and 10 per cent of the costs of items II and III, for techniques A, B, C. respectively. These were roughly the percentages of variable labor to total variable costs. This amount plus the minimum cash supply were assumed to be domestic resources.

Table 4

ESTIMATED MINIMUM WORKING CAPITAL NEEDED FOR MILL OPERATION

(Dollars)

Item		Level A	Level B	Level C
I.	Minimum stock of raw cotton	274 000	319 600	350 150
II.	Material in course of processing	83 220	83 950	86 640
III.	Stock of finished products	41 610	41 970	43 320
IV.	Stock of spare parts and ancillary materials	36 270	50 470	58 630
V.	Minimum cash supply	25 460	25 760	26 620
	Total working capital	460 560	521 750	565 360

Bases of estimates: I. Two months' production supply

II. Ten days' production supply at cost of raw material and labour (including social security charges).

III. Five days' production at cost of raw material and labour (including social security charges).

IV. 2 per cent of the value of the basic equipment.

V. 1 per cent of the annual cost of raw material and labour (including social security charges).

Source: (40), p. 63.

Table 5 presents the ECLA breakdown of annual production costs. In our analysis labour costs were assumed to include social security costs. From Table I of the ECLA study it was possible to distinguish between unskilled and semi-skilled labour on the one hand, and skilled and administrative labour on the other hand.

Since operation at full capacity output was assumed in our analysis, it was not necessary to make a distinction between fixed and variable capital.

Maintenance, overhead, ancillary materials, electric power, water and steam, and sales expenditures were all assumed to be domestic materials.

Depreciation and interest were not included as costs. We accepted the assumption of the ECLA study that the machinery would have zero value after a lifetime of 15 years, but that buildings have a lifetime of 40 years. Hence they retain 25/40 of their value at the end of 15 years. Since the full investment is taken as a cost, and benefits are discounted by the social rate of discount rate, it was not appropriate to include interest under the heading of operating costs in our analysis. Depreciation is really part of surplus earmarked for replacing capital; thus we eliminate this item from operating costs as well.

Raw material was assumed to be a foreign exchange cost. In the ECLA study it was assumed to be of the Sertão type produced in Brazil with a staple length of 28 mm. sold at the c.i.f. Liverpool price of 60 dollars per kg.; adjusted for wastage, the real cost of using cotton was set at .664 dollars per kg.

The ECLA study, using free exchange rates, found little variation in labour costs among countries. They assumed hourly wages of $.25, $.35, $.50 and $.75 for unskilled, semi-skilled, skilled, unit supervisory labour plus 40 per cent for social security and 20 per cent for third shift work. The third shift was also assumed to operate 7 hours instead of 8 so production was considered to absorb 23 hours per day. The number of working days in a year were set at 300.

/Table 5

Table 5

ANNUAL PRODUCTION COSTS ACCORDING TO THE DIFFERENT HYPOTHESES STUDIED

(Dollars)

Specification	Level A	Level B	Level C			
I. Fixed costs	1 130 812	1 304 969	1 470 927			
Fixed labour	165 000	134 400	126 120			
Administrative labour a/	81 840	75 840	93 120	0.02053	0.01499	0.01427
Social security b/	98 736	84 096	87 696			
Maintenance c/	18 135	25 237	29 315			
Depreciation d/	227 751	302 339	349 976	0.01353	0.011540	0.01628
Interest e/	534 400	679 025	780 916	0.03175	0.03459	0.03633
Overheads f/	4 950	4 032	3 784			
II. Variable costs	2 361 023	2 437 663	2 514 539			
Raw material g/	1 644 064	1 917 632	2 100 896			
Ancillary materials h/	32 881	38 352	42 018			
Variable labour i/	397 272	240 432	153 864	0.03304	0.01715	0.01002
Social security j/	158 909	96 173	61 546			
Maintenance k/	36 270	50 474	58 630			
Electric power, water and steam l/	56 735	58 576	60 424			
Sales expenditure m/	34 892	36 024	37 161			
III. Total costs	3 491 835	3 742 632	3 985 466			

a/ See Table .
b/ 40 per cent of fixed and administrative labour costs.
c/ Fixed maintenance costs, calculated at 1 per cent of the cost of the basic equipment.
d/ Linear depreciation over 40 years for buildings and 15 years for machinery at cost, installed and ready to operate.
e/ 12 per cent of total investment per annum.
f/ 3 per cent of fixed labour costs.
g/ See Tables E, F and C.
h/ 2 per cent of raw material costs.
i/ See Table I
j/ 40 per cent of variable labour costs.
k/ Variable maintenance costs, calculated at 2 per cent of the cost of the basic equipment.
l/ About 2.5 per cent of variable production costs.
m/ About 1.5 per cent of variable production costs.

/The conclusion

The conclusion of the ECLA study was that the intermediate technique B might be the preferred technique. The most labour-intensive technique A, it was felt, offered too small of a reinvestment surplus and would thus lower the rate of growth. Also the authors felt that there were risks associated with adopting techniques as obsolete as A. On the other hand, C, the most advanced technique was felt to sacrifice too much employment for an only slightly higher reinvestment surplus than B. As will be seen in the cost-benefit analysis, this conclusion holds true under certain assumptions about the size of the country, the degree of overvaluation of the currency, whether or not the raw material is produced within the country the nature of the capital goods industry, the relative weights to be attached to employment creation and economic growth, whether or not aggregate investment is assumed to be a function of choice of technique, and the social rate of discount.

The project is assumed in the cost-benefit to be wholly financed within the private sector. Hence, the cost of investment is not adjusted as it would have to be if the project were placed in the public sector at the cost of displacing investment in the private sector.

The project is further assumed to be an import substituting one. Hence the value of output represents foreign exchange savings while foreign exchange components of investment and operating capital are regarded as costs. It is also assumed that the propensities to reinvest and the rate of return on such reinvestments is considered to be the same for both the private and public sectors. Hence, the loss by the government of tariff revenue is assumed to be transferred to the private sector in the form of higher prices and to have no net impact on the rate of growth.

National Economic Profitability

In most, if not all, Latin American countries the objective of increasing employment weighs heavily among the objectives of government planners along with the rate of growth of per capita GNP. As has been argued earlier, these are also the two most relevant considerations in evaluating alternative techniques since other objectives which may weigh heavily in the planning process are met by a decision to invest in a certain sector of the economy, i.e., in a certain product, or to locate the site of production in a certain region of the country. Once these decisions have been made, the question of technique still remains. In fact, evaluation should proceed the other way round. Given an optimal technique for each feasible product, one then must choose among competing products within and among economic sectors and then decide where to locate the project.

Consequently, the tecniques of cost-benefit analysis will be illustrated in this example taking into account the dual objectives of increasing employment and of maximizing the rate of economic growth. Assumptions which it is hoped are reasonable ones, will be used to assign values to those parameters which, in principles are measurable.

These will include all parameters but two, namely, the social rate of discount and the weight to be assigned to the employment objective. This weight is actually the weight attached to employment relative to the weight attached to the growth objective which will be set equal to 1.

Since overvaluation of the currency is assumed and since the market wage for unskilled and semi-skilled labor is assumed not to reflect its opportunity cost, we must distinguish among these and domestic inputs other than unskilled or semi-skilled labor. This has been done in Tables 6 and 7.

Foreign Exchange Saving

It is assumed that the direct benefits of the textile mill, i.e., the market value of the cloth provided, will replace imports of this commodity. Naturally, the foreign exchange costs include the purchase of machinery, the foreign exchange component of working capital, i.e., the value of raw

/Table 6

Table 6

BENEFITS AND COSTS BY YEAR FOR THREE TEXTILE TECHNOLOGIES

(Market prices in pesos)[a]

Item	A year			B year			C year		
	0	1-15	16	0	1-15	16	0	1-15	16
(1) Output		4 208 250.0			4 907 250.0			5 373 750.0	
(2) Construction and machinery	3 502 439.0			4 505 958.0			5 212 520.0		
(2-a) Foreign exchange	2 478 337.0			3 411 997.0			3 952 509.0		
(2-b) Domestic materials	102 012.0			131 241.0			151 821.0		
(2-c) Skilled labor	829 881.0			866 448.0			997 371.0		
(2-d) Domestic unskilled labor	92 209.0			96 272.0			110 819.0		
(3) Working capital	460 560.0			521 750.0			565 360.0		
(3-a) Foreign exchange	403 893.0			577 102.0			525 744.0		
(3-b) Domestic materials	56 667.0			44 648.0			39 616.0		
(4) Operating costs		2 729 684.0			2 761 268.0			2 854 574.0	
(4-a) Foreign exchange		1 644 064.0			1 917 692.0			2 100 896.0	
(4-b) Domestic skilled labor		279 048.0			246 288.0			270 480.0	
(4-c) Domestic unskilled labor		622 709.0			384 653.0			251 866.0	
(4-d) Domestic materials		183 863.0			212 695.0			231 332.0	
(5) Reclaimed working capital			460 560.0			521 750.0			565 360.0
(5-a) Foreign exchange			403 893.0			477 102.0			525 744.0
(5-b) Domestic materials			56 667.0			44 648.0			39 616.0
(6) Depreciated value of building			576 306.2			602 700.0			692 618.8

a/ 10 pesos = US$ 1.

/material in

material in inventory and goods in process and the value of raw material included in operating costs. At the termination of the project, the portion of working capital tied up in raw material will be recovered.

These items are found in Table 6 and 7. Net foreign exchange benefits at market prices discounted to the present are as follows from Table 7:

$$F = (1) - (2\text{-a}) - (3\text{-a}) - (4\text{-a}) + (5\text{-a}) \qquad (1)$$

Line 2 of Table 9 shows these values of F for alternatives A, B and C at various rates of discount.

Unskilled Labor

Aside from foreign exchange costs, wages of unskilled labor represents the other cost which will have to be evaluated at shadow prices. Offsetting the cost factor will be the positive weight attached to the net benefits of unskilled and semi-skilled workers hired.

The unskilled labor component consists of unskilled labor used in construction and in production: lines 2-d and 4-c in Tables 1 and 2. Line 3 of Table 9 shows the outlays to unskilled labor properly discounted as the sum of 2-d and 4-c of Table 7.

$$L = -(2\text{-d}) - (4\text{-c}) \qquad (2)$$

As a cost element, these outlays take a negative sign.

Methodology of the Evaluation of Aggregate Consumption Benefits

Market Prices

To evaluate the net aggregate-consumption benefits the alternative techniques will first be appraised at market prices. This first approximation will then be adjusted by replacing the market prices of foreign exchange and of unskilled labor with their shadow prices. Finally, this second approximation will be adjusted for the reinvestment propensities of the different beneficiaries of the project to yield the final approximation to aggregate-consumption benefits.

/Table 7

Table 7

PRESENT VALUE OF ITEMS IN TABLE 6

(Market prices in pesos)

	i = 12%			i = 16%			i = 20%			i = 24%			i = 30%		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
(1) Output	32 168 578.4	37 511 853.2	41 077 858.5	23 462 845.4	27 360 077.9	29 961 020.7	19 675 462.5	22 943 602.0	25 124 699.4	16 837 208.3	19 633 907.3	21 500 373.8	13 753 402.7	16 037 874.5	17 562 489.8
(2) Construction and machinery	3 502 439.0	4 505 958.0	5 212 520.0	3 502 439.0	4 505 958.0	5 212 520.0	3 502 439.0	4 505 958.0	5 212 520.0	3 502 439.0	4 505 958.0	5 212 520.0	3 502 439.0	4 505 958.0	5 212 520.0
(2-a) Foreign exchange	2 478 337.0	3 411 997.0	3 952 509.0	2 478 337.0	3 411 997.0	3 952 509.0	2 478 337.0	3 411 997.0	3 952 509.0	2 478 337.0	3 411 997.0	3 952 509.0	2 478 337.0	3 411 997.0	3 952 509.0
(2-b) Domestic materials	102 012.0	131 241.0	151 821.0	102 012.0	131 241.0	151 821.0	102 012.0	131 241.0	151 821.0	102 012.0	131 241.0	151 821.0	102 012.0	131 241.0	151 821.0
(2-c) Skilled labor	829 881.0	866 448.0	997 371.0	829 881.0	866 448.0	997 371.0	829 881.0	866 448.0	997 371.0	829 881.0	866 448.0	997 371.0	829 881.0	866 448.0	997 371.0
(2-d) Unskilled labor	92 209.0	96 272.0	110 819.0	92 209.0	96 272.0	110 819.0	92 209.0	96 272.0	110 819.0	92 209.0	96 272.0	110 819.0	92 209.0	96 272.0	110 819.0
(3) Working capital	460 560.0	521 750.0	565 360.0	460 560.0	521 750.0	565 360.0	460 560.0	521 750.0	565 360.0	460 560.0	521 750.0	565 360.0	460 560.0	521 750.0	565 360.0
(3-a) Foreign exchange	403 893.0	477 102.0	525 744.0	403 893.0	477 102.0	525 744.0	403 893.0	477 102.0	525 744.0	403 893.0	477 102.0	525 744.0	403 893.0	477 102.0	525 744.0
(3-b) Domestic materials	56 667.0	44 648.0	39 616.0	56 667.0	44 648.0	39 616.0	56 667.0	44 648.0	39 616.0	56 667.0	44 648.0	39 616.0	56 667.0	44 648.0	39 616.0
(4) Operating costs	20 866 168.5	21 107 602.0	21 820.848.9	15 219 189.4	15 395 284.1	15 915 506.1	12 762 501.1	12 910 170.5	13 346 418.0	10 921 465.7	11 047 833.3	11 421 150.6	8 921 153.2	9 024 376.1	9 329 318.7
(4-a) Foreign exchange	12 567 504.7	14 658 705.0	16 059 606.2	9 166 380.2	10 691 642.2	11 713 419.6	7 686 739.0	8 965 792.5	9 822 634.2	6 577 900.1	7 692 445.6	8 405 684.9	5 373 130.0	6 267 204.9	6 866 148.3
(4-b) Domestic skilled labor	2 133 090.4	1 882 667.3	2 067 595.1	1 555 815.4	1 373 164.0	1 508 045.0	1 304 675.0	1 151 507.2	1 264 615.7	1 116 471.0	985 398.3	1 082 190.5	911 984.7	804 918.4	883 982.7
(4-c) Domestic unskilled labor	4 760 093.5	2 940 352.9	1 925 306.5	3 471 876.7	2 144 609.7	1 404 263.8	2 911 444.8	1 798 425.9	1 177 586.9	2 491 458.7	1 538 996.7	1 007 715.9	2 035 137.6	1 257 122.9	823 148.5
(4-d) Domestic materials	1 405 480.0	1 625 876.7	1 768 341.1	1 025 117.1	1 185 868.2	1 289 777.7	859 642.3	994 444.8	1 081 581.2	735 635.9	850 992.7	925 559.3	600 901.1	695 129.8	756 039.2
(5) Reclaimed working capital	75 085.1	85 060.9	92 170.6	42 850.5	48 543.6	52 601.1	24 911.7	28 221.5	30 580.3	14 742.5	16 701.2	18 097.2	6 922.2	7 841.9	8 497.4
(5-a) Foreign exchange	65 846.7	77 781.9	85 712.0	37 578.2	44 389.6	48 915.2	21 846.6	25 806.4	28 437.5	12 928.6	15 272.0	16 829.1	6 070.5	7 170.8	7 901.9
(5-b) Domestic materials	9 238.4	7 279.0	6 458.6	5 272.3	4 154.0	3 685.9	3 065.1	2 415.0	2 142.8	1 813.9	1 429.2	1 268.1	851.7	671.1	595.4
(6) Depreciated value of buildings	93 955.2	98 095.2	112 917.6	53 619.5	55 982.2	64 441.2	31 172.4	32 545.9	37 463.8	18 447.6	19 260.4	22 170.7	8 661.9	9 043.6	10 410.1
	7 508 451.2	11 559 699.3	13 684 217.8	4 477 127.0	7 041 611.6	8 384 676.9	3 006 046.5	5 066 490.9	6 068 445.5	1 985 933.7	3 594 327.6	4 341 611.1	884 834.6	2 002 675.9	2 474 198.6

/the net

The net present value of the aggregate-consumption benefits at market prices is given by the sum of benefits and (negative) costs detailed in Table 7. This sum (MC) appears as the final line of Table 7 and is repeated as line 1 of Table 9, adjusted for the level of output of the three techniques [1/].

$$MC = (1) - (2) - (3) - (4) + (5) + (6) \qquad (3)$$

It may be immediately noted that at any rate of discount, technique C will be preferred to B and technique B to technique A: C > B > A. Also, the net benefits for any given technique decline as the social rate of discount is increased.

<u>Shadow Prices for Foreign Exchange and Unskilled Labor</u>

As was mentioned earlier, it is assumed that the currency of the country is overvalued. Market prices assumed an official exchange rate of 10 pesos = 1 U.S. Dollar. For the purpose of evaluating the foreign exchange projects we have assumed a premium of ϕ to be applied to the foreign exchange costs and benefits of the project.

Similarly, for unskilled labor, a discount (a negative weight) has been used to adjust the wage bill. This weight is less straight-forward than that to be attached to foreign exchange. Hidden behind this premium are the following factors: the direct opportunity cost of labor in an alternative activity (assumed here to be the unprotected urban sector), the indirect cost of labor in terms of the stream of investment proceeds foregone, the increased consumption benefits of workers taking into account both present consumption benefits and future consumption benefits foregone as a result of the foregone investment; this last item is weighted by the premium attached to net consumption benefits.

1/ As was shown in Table 1, the level of output varies from one technique to another because of differences in the minimum optimal size for achieving economies of scale in the respective techniques. Thus there is a problem of indivisibilities. For a country with a sufficiently large market, however, this problem does not exist for if 10 plants of type A were established, the same level of output would be reached as with 8 plants of type C. We begin with the large market assumption (population more than 51 million) and multiply the net benefits at market prices of techniques A and B by 1.280 and 1.097 respectively to equalize their outputs with those of technique C. Later we will examine the small market case where indivisibilities cannot be overcome on the basis of the internal market size.

/This use

This use of net consumption benefits stands for the employment benefits because these will only exist to the extent that the remuneration to workers exceeds their earnings in alternative activities. Hence, the net gain to workers is our measure of employment benefits.

λ is defined as follows:

$$w^* = z + s\,(p^{inv} - 1)\,w + v\,[\,z + (s p^{wkr} - 1)\,w\,] \qquad (4)$$

$$\frac{w^*}{w} = \frac{z}{w} + s\,(p^{inv} - 1) + v\,[\,\frac{z}{w} + (s p^{wkr} - 1)\,] \qquad (5)$$

$$w^* = w\,(1 + \lambda) \qquad (6)$$

$$\frac{w^*}{w} = 1 + \lambda \qquad (7)$$

$$\lambda = \frac{w^*}{w} - 1 \qquad (8)$$

$$\lambda = \frac{z}{w} + s\,(p^{inv} - 1) + v\,[\,{}^{z}/_{w} + (s p^{wkr} - 1)\,] \qquad (9)$$

We have seen in the text that both p^{inv} and p^{wkr} depend upon the social rate of discount, which is to be regarded as an unknown. The weight to be attached to workers consumption benefits, v, is also to be regarded as an unknown. Hence λ , the premium (negative) to be attached to the market wage bill of unskilled labor is a function of two unknowns, i, the social rate of discount and v, the employment weight.

It should be intuitively clear, for given social rates of discount that as v increases, the most capital intensive process, C, will have a progressively smaller advantage over B, and at same point will yield less net benefits than B. Similarly, as v increases still further, B, will at same point give way to A.

The net benefits of the various alternatives are now expressed, using shadow prices or premiums for foreign exchange and unskilled labor in the following way:

$$SC = MC + \emptyset F + \lambda L \qquad (10)$$

/Correction for

Correction for Reinvestment Propensities of Different Beneficiaries

We have assumed that there is no difference between the reinvestment propensities of government and the private sector and that both sectors earn the same rate of return. The benefits that accrue to the goverment and private sector combined (SC^{GP}) are then equal to the net benefits of the project at market prices plus the additional benefits arising from applying the foreign exchange premium:

$$SC^{GP} = MC + \emptyset F \qquad (11)$$

The benefits accruing to the workers evaluated at shadow prices are:

$$SC^{L} = \lambda L \qquad (12)$$

Since we assume that workers save nothing, no reinvestment accrues to their portion. Consequently, the net consumption benefits arising from SC^L, C^L, is identical to SC^L.

For the government and private sectors combined, however, it is assumed that there is savings and reinvestment.

Thus, the net gains arising from SC^{GP}, C^{GP} is expressed as follows:

$$C^{GP} = [(1-s) + s_p^{inv}]\ SC^{GP} \qquad (13)$$

Denoting the value of $[(1-s) + s_p^{inv}]$ as χ , $C^{GP} = \chi\ SC^{GP}$ (14)

Since χ is a function of i, it assumes a different value for each social rate of discount.

The final calculation of net aggregate consumption benefits is given by the following formula:

$$C = C^{GP} + C^{L} \text{ or,} \qquad (15)$$

$$C = \chi\ (MC + \emptyset F) + \lambda L \qquad (16)$$

The values of v have been identified as Vc, Vb, Va where Vc represents the lowest weight which results in choosing alternative C; Vb represents the lowest weight for which B will be chosen over C; and Va represents the lowest weight for which A will be chosen over A. The set of "switching values" for the V's, of course, changes with the level of the social rate of discount.

/Values of

Values of Parameters

Table 8 gives the values of the national parameters assumed to hold for the evaluation of national economic profitability.

Foreign Exchange Premium, $\emptyset$

We assumed, for ease of computation, a premium of .1 to be attached to foreign exchange earnings. Thus the ratio of domestic currency to the value of foreign exchange at the official rate is given by $\frac{D}{F.R\ (1+\emptyset)}$, where D is one unit of domestic currency, F is one unit of foreign currency, R is the official exchange rate, and $\emptyset$ is the premium attached to foreign exchange. We assume that the official exchange rate is 10 pesos to 1 U.S. dollar. The correct shadow price, then would be $R = 10\ (1+\emptyset) = 10\ (1.1) = 11$.

As was indicated earlier, the shadow exchange rate can be estimated using a weighted average of domestic market prices of importable to c.i.f. prices at the official exchange rate where the weights represent the share of the imported good in the marginal import bill. This is the formula given on page of the text.

Marginal Labor/Capital Ratio, b; Marginal Output/Capital Ratio y; and the Marginal Rate of Savings, s.

The marginal output/capital ratio for the economy was assumed to be somewhat lower than that in technique A where the ratio of investment to employment is \$ 6 666 per man. We assumed a ratio of \$ 5 000 per man arbitrarily. Given an exchange rate of 10, this meant 50 000 pesos per man or .00002 men per peso of investment. The value of the marginal output/capital ratio was assumed to be 0.35 and the value of the marginal rate of savings was assumed to be 0.20. These values were of the order of magnitude used in the examples presented in the UNIDO Guidelines. If anything, they are on the low side and higher values would tend to favor even more capital-intensive over labor-intensive projects under the assumption that the rate of reinvestment is, to same extent, dependent upon project selection.

/Table 8

Table 8

VALUES OF NATIONAL PARAMETERS

			Unaffected by discount rate	12%	16%	20%	24%	30%
ϕ	Foreign exchange premium		0.1					
b	Marginal labor/capital ratio		0.00002					
q	Marginal return on investment		0.35					
s	Marginal rate of savings		0.20					
pinv	Shadow price of investment			2.330	1.634	1.259	1.014	.799
χ	Reinvestment adjustment			1.266	1.127	1.052	1.003	.960
p^{wkr}	Present value of workers future consumption			2.053	1.440	1.109	.894	.704
λ	Unskilled labor premium (large countries)							
Vc	.743			-.954				
Vb	.746	12%		-.955				
Va	1.541			-1.324				
Vc	.017				-.758			
Vb	.019	16%			-.759			
Va	.492				-1.037			
Vc	-.270					-.647		
Vb	-.268	20%				-.648		
Va	.247					-.984		
Vc7	-.454						-.556	
Vb	-.453	24%					-.557	
Va	.026						-.890	
Vc	-.644							-.442
Vb	-.643	30%						-.443
Va	-.184							-.780
	(small countries)							
Vc	4.90			2.880				
Vb	4.95	12%		2.908				
Va	5.15			3.001				
Vc	2.50				2.216			
Vb	2.55	16%			2.245			
Va	2.65				2.304			
Vc	1.55					1.836		
Vb	1.60	20%				1.868		
Va	1.90					2.064		
Vc	.95						1.534	
Vb	1.00	24%					1.568	
Va	1.30						1.777	
Vc	0.35							1.140
Vb	0.40	30%						1.177
Va	0.76							1.441

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/The authors

The authors of the UNIDO Guidelines recommend the use of current 5 year plans as the basis for estimates of these parameters if no better alternative studies exist and if it can be fairly assumed that the plan set realistic targets that is to say, if it is more than a mere propaganda document. Crude ratios may be made of incremental retained earnings to gross profits in the private sector, and of incremental investment to incremental expenditure in the public sector over the period of the plan.

The Market Wage, w, and the Marginal Productivity of Labor, z

It has been argued that the relevant opportunity cost of unskilled labor in the urban sector can be taken as equal to the average annual earnings of an unskilled worker in the unprotected urban sector. We have assumed this wage, z, to be equal to one-eighth of the wage assumed paid in the textile industry in the ECLA study upon which this example is based. Their wage, w, equals $ 1 104.10 per year including social security payments and premium hight-shift pay on a 300 day working year. One-eighth of this amount is $ 138 a year, or at 10 pesos to the dollar, 1 380 pesos per year. Since a recent study of ECLA on income distribution in Latin America shows a range of 4:1 to 10:1 for wages paid in manufacturing compared with self-employed artisans, a ratio of 8:1 does not seem an unreasonable assumption.

Values of p^{inv},)(and p^{wkr}

These are, respectively, the opportunity cost of one unit of investment taking into account reinvestment and savings rate, the reinvestment multiple of benefits accruing to the private sector, and the value of consumption foregone by workers in the future in consequence of an increase in consumption in the present. Each of these parameters is calculated using the parameters already described plus the social rate of discount.

$$p^{inv} = \frac{(1-s)\ (y-wb) + (w-z)\ b}{i - s(y-wb)}$$

$$)(= (1-s) + sp^{inv}$$

$$p^{wkr} = \frac{(w-z)\ b}{i-s\ (y-wb)}$$

/The Weight

<u>The Weight Attached to Workers Consumption: Parameters λ and v.</u>

The relationship of v to λ has already been discussed. The formula for λ requires knowledge of the correct values for b, y, s, p^{inv} and p^{wkr}. The latter two require a knowledge of the social rate of discount, an unknown. Similarly, v itself is an unknown. The values of v and the corresponding values of λ shown in Table 8 have been calculated for various social rates of discount in such a way as to yield switching points between alternative techniques.

/Table 9

Table 9

PRESENT VALUE OF NET SOCIAL BENEFITS

(Large countries)

	12%			16%			20%			24%			30%		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
MC (Market prices)	96 108 175	126 809 901	136 842 178	57 307 226	77 246 479	83 846 769	38 477 395	55 579 405	60 684 455	25 419 951	39 429 774	43 416 111	11 325 883	21 969 355	24 741 986
F (Foreign exchange)	214 844 037	208 888 887	206 257 113	146 583 212	140 676 278	130 182 663	116 842 753	110 956 250	108 522 497	94 592 087	88 721 353	86 332 650	70 452 649	64 599 493	62 259 904
L (Unskilled labor)	-62 109 472	-33 311 775	-20 361 255	-45 620 297	-24 582 472	-15 150 828	-38 446 769	-20 784 836	-12 884 059	-33 070 947	-17 938 898	-11 185 349	-27 230 036	-14 846 742	-9 339 675
$SC^{GP} = MC + \phi F$	117 592 579	147 698 790	157 467 889	11 965 546	91 314 107	97 665 092	50 161 670	66 675 030	71 536 705	34 879 160	48 301 909	52 049 376	18 371 148	28 429 304	30 967 976
$C^{GP} = \chi\ SC^{GP}$	148 872 205	186 986 669	199 354 347	81 105 170	102 910 999	110 068 491	52 770 077	70 142 132	75 256 614	34 983 797	48 446 815	52 205 524	17 636 302	27 292 132	29 729 257
$SC^{L} = \lambda L$															
Vo	59 252 436	31 779 433	19 424 637	34 580 185	18 633 514	11 484 328	24 875 060	13 447 789	8 335 986	18 387 447	9 974 027	6 219 054	12 035 676	6 562 260	4 128 136
Vb	59 314 546	31 812 745	19 444 999	34 625 805	18 658 096	11 499 478	24 913 506	13 468 573	8 348 870	18 420 517	9 991 966	6 230 239	12 062 906	6 577 107	4 137 476
Va	82 232 941	44 104 790	26 958 302	47 308 248	25 492 023	15 711 409	37 831 621	20 452 279	12 677 914	29 433 143	15 965 619	9 954 961	21 239 428	11 580 459	7 284 947
$SC = SC^{GP} + SC^{L}$															
Vo	176 845 015	179 478 223	184 426 191	106 545 731	109 947 621	109 149 360	75 036 730	80 122 819	79 872 691	53 266 607	58 275 936	58 268 430	30 406 824	34 991 564	35 096 112
Vb	176 907 125	179 511 535	176 912 888	106 591 351	109 972 203	109 164 510	75 075 176	80 143 603	79 885 575	53 299 677	58 293 875	58 279 615	30 434 054	35 006 411	35 105 452
Va	199 825 520	191 803 580	184 426 191	119 273 794	116 806 130	113 376 441	87 993 291	87 127 309	84 214 619	64 312 303	64 267 528	62 004 337	39 610 576	40 009 763	38 252 923
$C = C^{GP} + (C^{L} = SC^{L})$															
Vo	208 124 641	218 766 102	218 778 984	115 685 355	121 544 513	121 552 819	77 645 137	83 589 921	83 592 600	53 371 244	58 420 842	58 424 578	29 671 978	33 854 392	33 857 393
Vb	208 186 751	218 799 414	218 799 346	115 730 975	121 569 095	121 567 969	77 683 583	83 610 705	83 605 484	53 404 314	58 438 781	58 435 763	29 699 208	33 869 239	33 866 733
Va	231 105 146	231 091 459	226 312 649	128 413 418	128 403 022	125 779 900	90 601 698	90 594 411	87 934 528	64 416 940	64 412 434	62 160 485	38 875 730	38 872 591	37 014 204
$C^{GP} - L$	210 981 677	220 298 444	219 715 602	126 725 467	127 493 471	125 219 319	91 216 846	90 926 968	88 140 673	68 054 744	66 385 713	63 390 873	44 866 338	42 138 894	39 068 932

/Evaluation of

Evaluation of the Alternatives

Countries with Sufficiently Large Markets

The data from Tables 8 and 9 have been used to produce figure 2 which presents graphically the elements for the sensitivity analysis. In this diagram, there are two loci, CB and BA each representing the possible combination of social rates of discount and values of v which form a boundary between regions in which one technique is preferred to the other two. Thus any combination which falls to the left of the CB boundary line implies that the socially most profitable alternative is technique C, the most capital-intensive technique. Similarly, any combination of social rates discount and values of v which fall to the right of boundary line CB, but to the left of boundary line BA, lie in the region where technique B is the optimal technique. Finally, points to the right of boundary, line BA fall in the region where A is the dominant technique.

As can be verified from Figure 2, for example, at a social rate of discount of 20 per cent, a value of v equal to -0.270 implies that C is the optimal technique. The aggregate social benefits for those values of v and i are given in line 15 and columns 7, 8 and 9 of Table 4 where the aggregate social benefits of C are slightly greater than those of B and substantially greater than those of A.

The UNIDO authors suggest that evaluation ends here, for the project analyst is generally not able to assign values to i and v since these are essentially political in consideration. In the previous appendix one of their examples was presented to show how a series of project evaluations could result in an ever-narrowing range of values for the unknown parameters.

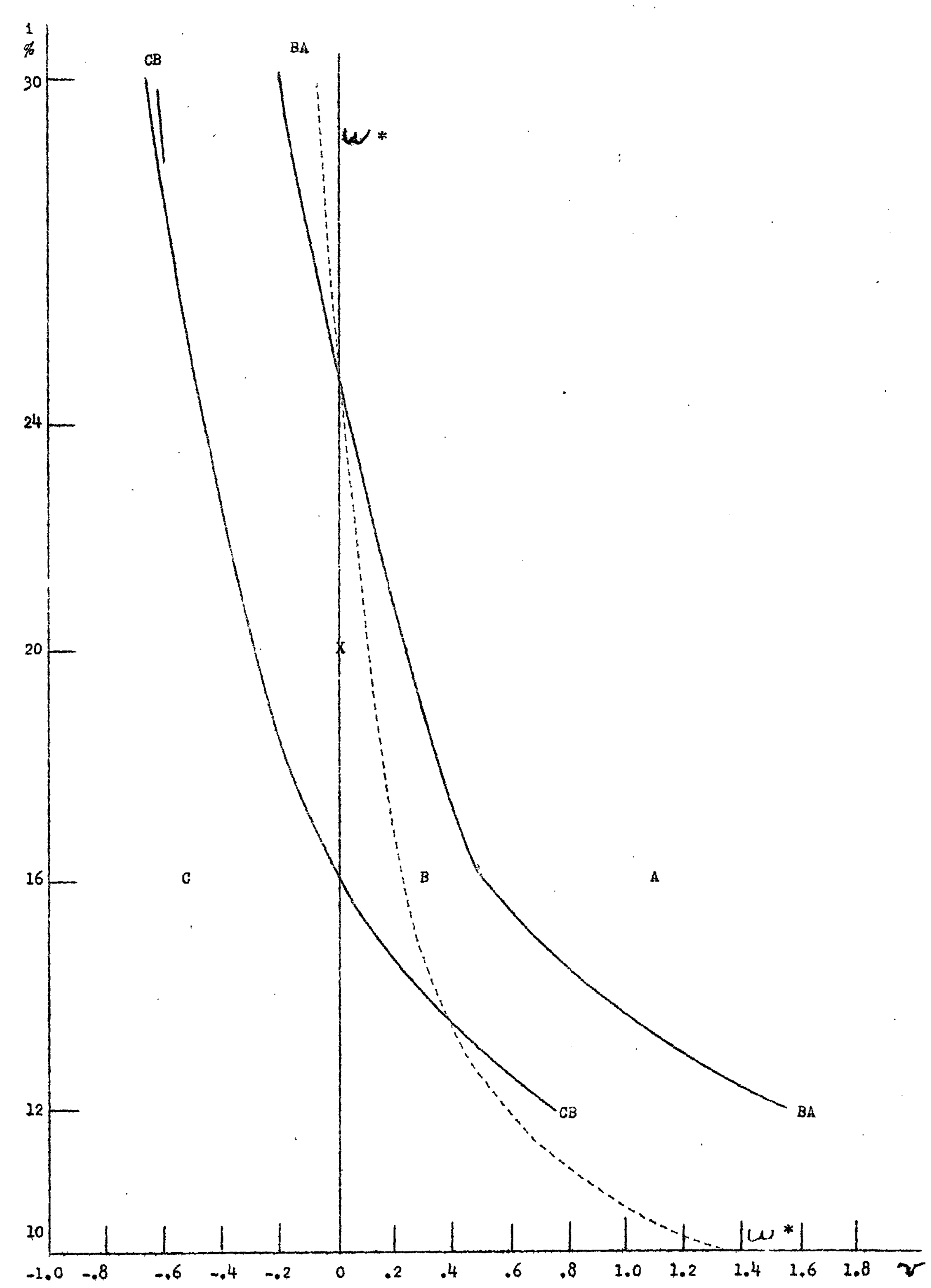
It may be recalled that the conclusion of the ECLA study, represented in an UNIDO volume, was that B should be chosen since it "balanced" employment consideration with a concern for the rate of growth and the problem of obsolescence. If such a choice were made, the range of values for parameters i and v would be obviously reduced to those in the B region.

With v as one of the unknowns, however, our analysis may proceed a step further. It should be obvious that the shadow price of labour cannot

/Figure 2

Figure 2

SWITCHING VALUES FOR ALTERNATIVE TEXTILE TECHNOLOGIES
(LARGE MARKET ASSUMPTION)



/bo lower

be lower than the direct opportunity cost of labour in the unprotected urban sector. It may be greater because of the investment which will be foregone as a consequence of an increase in the wage bill, and this cost may be offset by attaching sufficiently high weights of v to the consumption gains of workers. If it were lower, however, it would imply that aggregate output could be increased by shifting workers from the textile industry to the unprotected urban sector. Put the other way, it would imply that sufficient weight be placed on employment in <u>this</u> industry to compensate for a <u>reduction</u> in output for the economy as a whole. This seems patently unreasonable. Consequently, it is possible to solve for those values of v which equate the shadow wage, w^*, to the direct opportunity cost, z. The locus of these values is given by w^* in Figure 2.

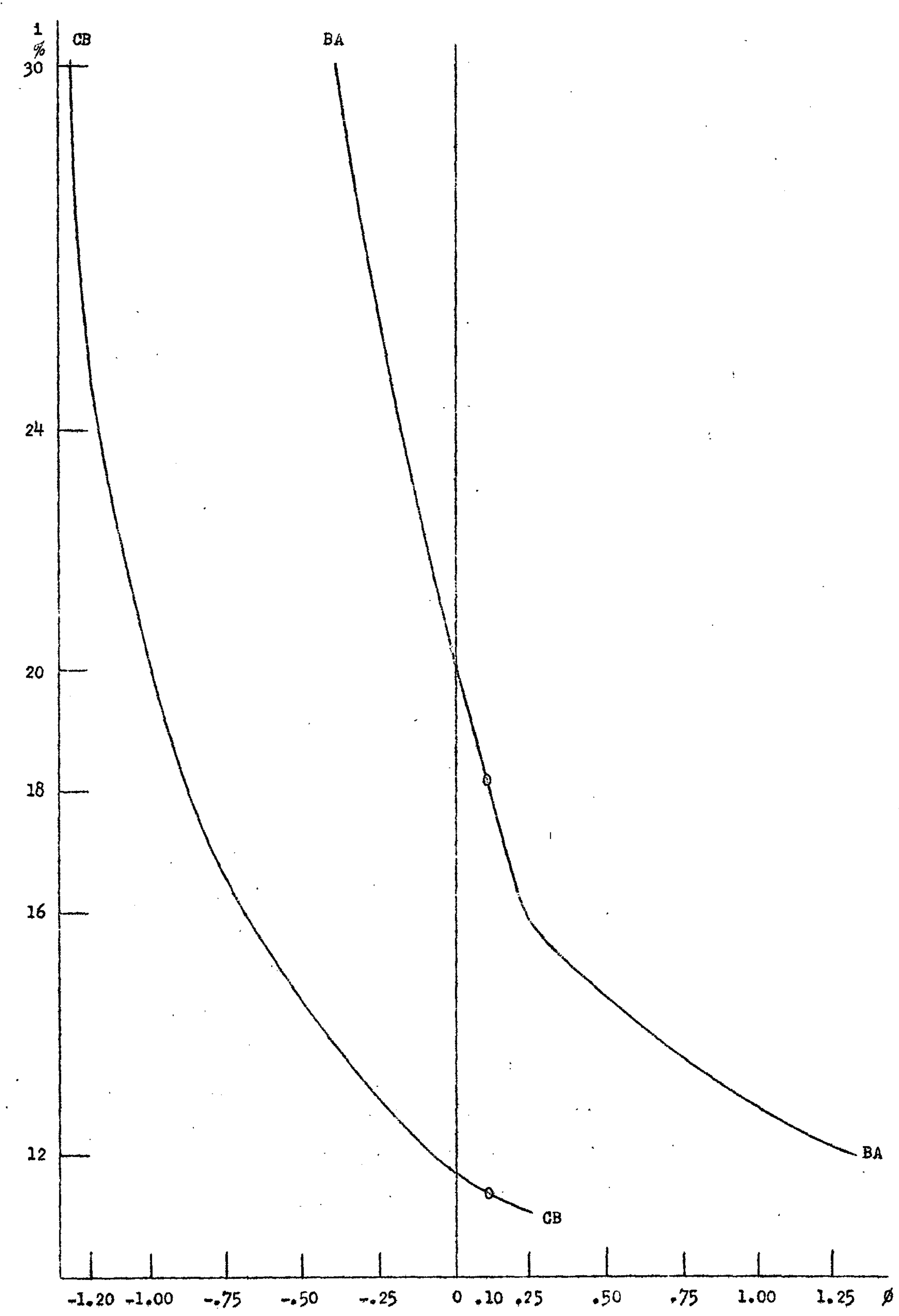
Any value of v which falls to the right of the locus implies that $w^* < z$ and is hence, unreasonably high. Since planners, by assumption, place a positive value on employment, v must be to the right of zero. The shaded region, then, includes the possible values of v for given interest rates. Since no part of this region lies in the zone where A is dominant, A is not a feasible choice. Whether or not B is preferred to C depends upon the values of the social rate of discount, i, and the employment weight, v. The rate of discount must be at least 13.7 per cent with a v weight of .38. For rates of discount above 16 per cent, however, B would be preferred to C regardless of the employment weight. As can be appreciated from an examination of Figure 2, the rate of discount is much more important than the employment weight is determining the choice of technique.

We have been assuming that the reinvestible surplus of the economy is dependent upon the choice of technique. If we relax that assumption by assuming that the government through appropiate fiscal policy can direct into investment as large a reinvestible surplus as in considered optimal, then the shadow wage as given on p. , w^* is equal to z. The second term of the right hand side of the equation represents foregone investment due to the size of the wage bill which we eliminate by the assumption of an adequate fiscal structure. Consequently, v is set equal to zero since the third term was designed to offset the second term. If, then, v = 0, $w^* = z$;

/Figure 3

Figure 3

SWITCHING VALUES FOR ALTERNATIVE TEXTILE TECHNOLOGIES ACCORDING TO THE EXTENT OF CURRENCY OVERVALUATION



/mow, tn

now, to strengthen the likelihood of choosing the A technique, let us assume that z = 0. Then the net benefits of the project are represented by the sum of C^{GP} and -L which is shown on the final line of Table 9. Technique A is preferred over B at a discount rate of 20 per cent; and technique B is preferred over C at a discount rate of 12 per cent. The corresponding points on Figure 2 are represented by X's.

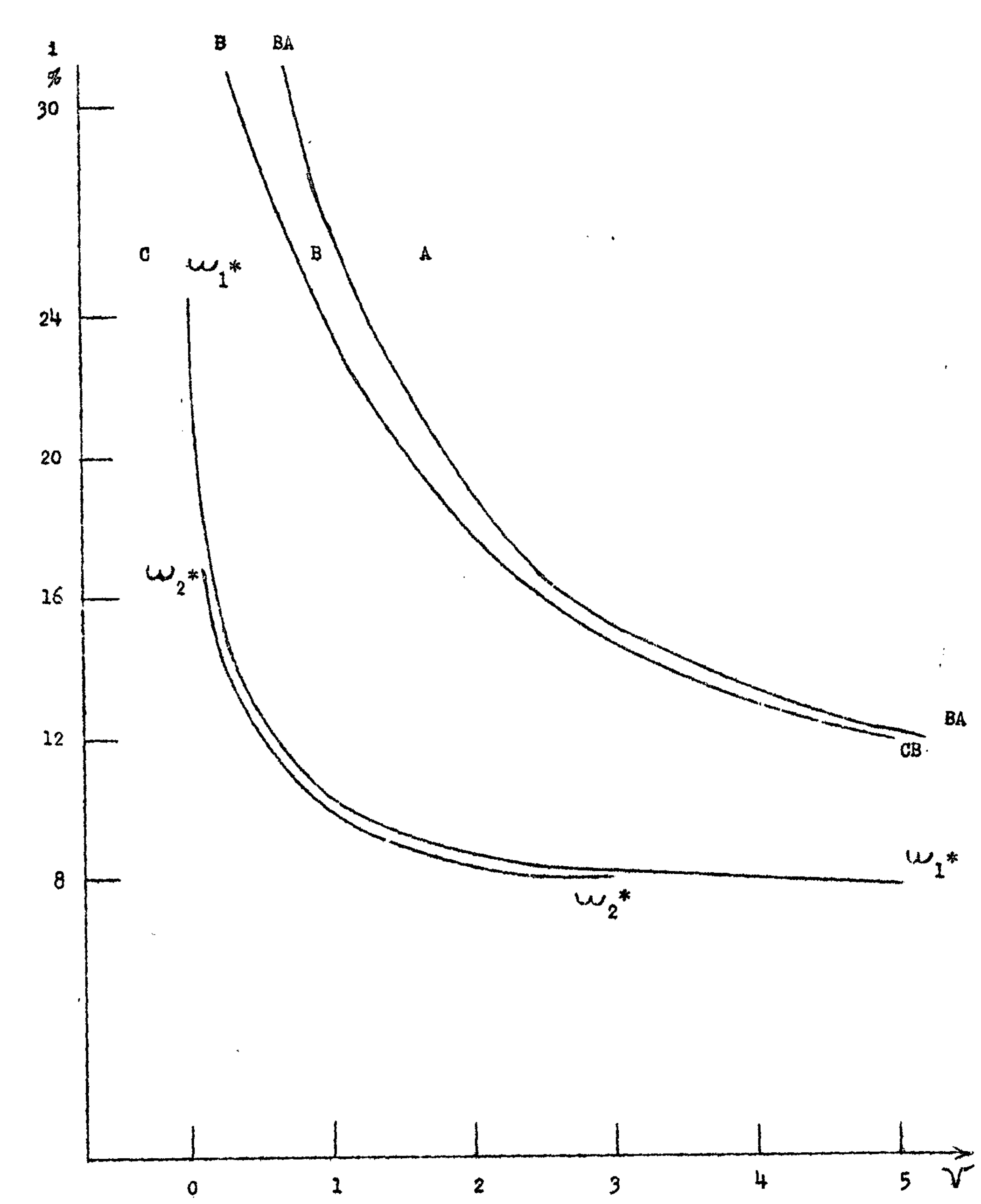
Now recall that we have been assuming a premium of .1 to be attached to foreign exchange costs. This implies that a devaluation of 10 per cent would eliminate the over-valuation. Retaining the assumption of a shadow wage of labor equal to zero, Figure 3, depicts the foreign exchange premiums required to choose B over C or A over B at given interest rates. Premiums to the left of the vertical line are ruled out by assumption that there is some degree of over-valuation. It is clear that for rates of discount above 11.75 per cent even for a zero foreign exchange premium, B is preferred to C, and for rates above 20.8 per cent, A is preferred to B. Moreover, A is preferred to B even for a rate of discount as low as 12 per cent if the premium on foreign exchange were 1.34, implying that a devaluation of 134 per cent would eliminate the over-valuation. Points in Figure 3 corresponding to our initial assumption, that $\emptyset = .1$, are represented by O's.

Since foreign exchange is being discussed, it is worthwhile noting that cotton has been treated as a foreign exchange cost. It might be argued that countries producing their own cotton would use domestic prices of cotton instead of world prices. If so, the evaluation might very well be different since raw cotton as a percentage of foreign exchange earnings happens to decrease with increasing capital intensity. For example, at a discount rate of 12 per cent, these proportions are .852, .821 and .808 for techniques A, B and C, respectively. Evaluating cotton at domestic prices would be an error, however, since the cotton could be exported if not used domestically. Thus a country producing its own cotton should use the f.o.b. export price rather than the c.i.f. import price. The foreign exchange savings for such a country would be the difference between these two prices, i.e., transport costs. This refinement has not been introduced in the present analysis.

/Figure 4

Figure 4

SWITCHING VALUES FOR ALTERNATIVE TEXTILE TECHNOLOGIES
(SMALL MARKET ASSUMPTION)



/Table 10

Table 10

PRESENT VALUE OF NET SOCIAL BENEFITS

(Small countries)

		12%			16%			20%			24%			30%		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
MC	(Market prices)	75 084 512	115 596 993	136 842 178	44 771 270	70 416 116	83 846 769	30 060 465	50 664 909	60 684 455	19 859 337	35 943 276	43 416 111	8 848 346	20 026 759	24 741 986
F	(Foreign exchange)	167 846 904	190 418 311	206 257 113	114 518 134	128 237 263	138 182 663	91 283 401	101 145 169	108 522 497	73 900 068	80 876 347	86 332 650	55 041 132	58 887 414	62 259 904
L	(Unskilled labor)	-48 523 025	-30 366 249	-20 361 255	-35 640 859	-22 408 817	-15 150 828	-30 036 538	-18 946 979	-12 884 059	-25 836 677	-16 352 687	-11 185 349	-21 273 466	-13 533 949	-9 339 675
SC	(Shadow prices exc. capital)															
	Vo (Wt. on labor benefits)	231 615 514	222 093 621	216 108 303	135 203 222	132 897 780	131 239 267	94 335 889	95 566 079	95 191 837	66 882 807	69 115 933	69 207 701	38 604 210	41 344 202	41 615 206
	Vb	232 974 159	222 943 876	216 678 419	136 236 807	133 547 636	131 678 641	95 297 058	96 172 383	95 604 127	67 761 254	69 671 924	69 588 003	39 391 328	41 844 958	41 960 773
	Va	237 486 800	225 767 937	218 572 015	138 339 618	134 869 756	132 572 540	101 184 219	99 885 991	98 129 403	73 161 119	73 089 636	71 925 741	45 007 524	45 417 921	44 426 448
SC^{GP}	(Gov't + plus private share)	91 869 202	134 638 824	157 467 889	56 223 083	83 239 842	97 665 032	39 188 805	60 779 426	71 536 705	27 249 344	44 030 911	52 049 376	14 352 459	25 915 500	30 967 976
SC^{L}	(Labor share)															
	Vo	139 746 312	87 454 797	58 640 414	78 980 139	49 657 938	33 574 235	55 147 084	34 786 653	23 655 132	39 633 463	25 085 022	17 158 325	24 251 751	15 428 702	10 647 230
	Vb	141 104 957	88 305 052	59 210 530	80 013 724	50 307 794	34 013 609	56 108 253	35 392 957	24 067 422	40 511 910	25 641 013	17 538 627	25 038 869	15 929 458	10 992 797
	Va	145 617 598	91 129 113	61 104 126	82 116 535	51 629 914	34 907 508	61 995 414	39 106 565	26 592 698	45 911 775	29 058 725	19 876 365	30 655 065	19 502 421	13 458 472
C	(Shadow prices inc. capital)															
	Vo	256 052 722	257 907 548	257 994 761	142 332 309	143 452 592	143 623 193	96 365 869	98 714 453	98 897 438	66 959 105	69 239 220	69 353 439	38 030 112	40 307 582	40 376 487
	Vb	257 411 367	258 757 803	258 564 877	143 365 894	144 102 448	144 062 567	97 327 038	99 320 757	99 309 728	67 837 552	69 795 211	69 733 741	38 817 230	40 808 338	40 722 054
	Va	261 924 008	261 581 864	260 458 473	145 468 705	145 424 568	144 956 466	103 214 199	103 034 365	101 835 004	73 237 417	73 212 923	72 071 479	44 433 426	44 381 301	43 187 729

/The cost-benefit

The cost-benefit analysis cannot say precisely which technique will be preferred because the values of i and v are unknowns to be determined according to the political preferences of the countries in question. For a large country however, not burdened with the problem of indivisibilities in a capital project of this sort, with a moderately over-valued exchange rate, a positive value assigned to v for employment creation, and a mode moderately high social discount rate (in the neighborhood of 14-16 per cent), B would most likely be the optimal technique.

Countries with Relatively Small Markets

The preceding analysis assumed we were dealing with countries of more than 5.7 million (assuming per capita consumption of cotton textile of 4 kilogrames per person as was found to be true for Brazil in 1960, a population of 5.7 million could consume 20,000 tons a year, slightly more than would be produced by 10 type A plants). A country so small that its internal market could absorb no more than the output of one plant would vary from .57 million to .72 million depending on whether type A, B or C were built. Countries of intermediate size would have the small market problem in a less severe form 2/. The analysis of countries with small markets where the constraint of indivisibilities is binding is of more general applicability than might at first be suspected. It applies not only to a country with a small market, but also to a country where a decision may be made as to the appropriate technology for one additional plant in an industry which already has several plants. The constraint of indivisibilities is fully applicable in this situation as well.

2/ Countries with sufficiently large markets on the basis of projection to 1980 given in ECLA, Statistical Bulletin for Latin America, Vol. VIII, N° 2 would include Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Perú, Venezuela, Cuba, Haití, México, the Dominican Republic, Paraguay, Uruguay, and the Central American Common Market. "Intermediate" countries would include Guyana, Jamaica, Trinidad-Tobago, and Puerto Rico. The remainder, mainly Caribbean Islands, would fall in the category of countries with small markets.

/Figure 4

Figure 4 depicts graphically the data of Tables 8 and 10 which are relevant for the small country case. In this case, the three plants are regarded as mutually exclusive projects and, as will shortly be seen, the fact that aggregate output and foreign exchange earnings increase with capital-intensity gives an advantage to the capital-intensive alternatives.

As in Figure 2, the same locus of feasible values of v is drawn, here identified as w^*. Since this locus lies entirely within the C region, it is clear that there is no value of v, given the rest of the data of the model, which is compatible with $w^* \geq z$ and which also falls in the B or A region.

It may be recalled that w, the market wage, was assumed to be 8 times the direct opportunity cost. If we relax this assumption and assume z equals zero, there is little change in our example. The locus of points where $w^* = z$ shifts slightly to the left, but even for a rate of discount as high as 30 per cent. C is still the preferred technique. This can be verified directly from Table 10, columns 13, 14 and 15 by adding to the values of $SC^G \chi = SC^G (.96)$ the wage cost of unskilled labor.

Table 11

Calculation of Aggregate Consumption Benefits with a Zero Shadow Wage for Labor

	A	B	C
SC^G	14 352 459	25 915 500	30 967 976
$\chi \; SC^G$	13 778 361	24 878 880	29 729 257
L	21 273 466	13 533 949	9 339 675
$C^G + L$	35 051 827	38 412 829	39 068 932

Since lower rates of discount favor capital-intensive relative to labour intensive projects our conclusion, that C is the optimal technique under any reasonable value of v, is strengthened still further.

It was mentioned earlier that a positive foreign exchange premium tended to favor the relatively capital intensive alternatives because the absolute value of net foreign exchange earnings increased with capital

/intensity. In

intensity. In order to strengthen the position of the relatively labour intensive alternatives we assume an equilibrium exchange rate, i.e., $\emptyset$=0. In this case $C^G = SC^G = .96MC$, and at a social discount rate of 30 per cent, we have the following

Table 12

<u>Aggregate Consumption Benefits with a Zero Shadow Wage for Labor and a Zero Foreign Exchange Premium</u>

	A	B	C
MC	8 848 346	20 026 759	24 741 986
C^G	8 494 412	19 225 689	23 752 307
L	21 273 466	13 533 949	9 339 675
C^G + L	29 767 878	32 759 638	33 091 982

The advantage of C over its less capital intensive alternative B is narrowed from 656 103 pesos to 332 344 pesos, but it persists nevertheless. The only other way in which the advantage might be narrowed is to assume a higher social rate of discount.

The UNIDO authors argue that the social rate of discount will generally be less than the social marginal productivity of capital given by the formula $SMP = (1-s)\ y + p^{inv}\ sy$. In the case where i = 30 per cent and z = 1/8 w, SMP = .286, only slightly less than i, and for z = w = o, SMP = .343. Thus the value of 30 per cent for i is definitely an upper limit given the data of our example.

There remains one situation, however, in which the labour-intensive alternative might be chosen. If a country had a capital goods sector which could produce technology A, for example, using few or no imported inputs, but could not produce technique B or C, A might be the preferred technique above a certain interest rate given a certain foreign exchange premium.

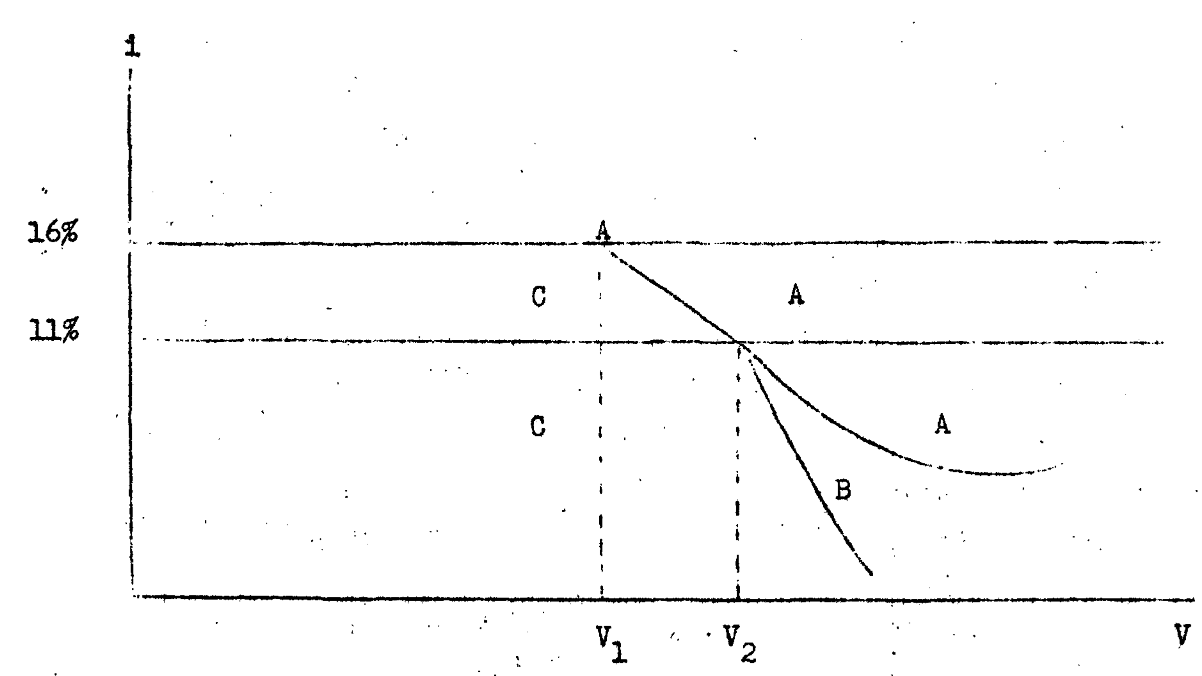
A necessary condition would be that at a "threshold" interest rate, the discounted net foreign exchange earnings of A exceed those of C. In that case there would exist some foreign exchange premium, $\emptyset$, for which A would be preferred to C for any value of v. Below this threshold rate of

/interest, but

interest, but above that rate of interest where the discounted net foreign exchange earnings of A exceed those of B there would exist a range where the value of v would determine the choice between A and C. Below the second threshold the same ordering would occur as in our original example. This analysis is shown in Figure 5, with approximate values for the parameters in terms of the data of our example.

Figure 5

Sensitivity Analysis when there Exists the Capacity to Produce Technology "A" Domestically



$\emptyset = 1.6$, $V_1 = 2.5$, $V_2 = 4.9$

If the premium on foreign exchange is smaller, the threshold interest rates rise. Indeed, for a $\emptyset$ of only .16 the threshold interest rate is 30 per cent and the original conclusions of our evaluation hold.

/For a

For a country with fairly high rate of discount, say, between 20 per cent and 30 per cent, a currency overvalued to the extent of 16 per cent to 100 per cent, and a capacity to produce machines for technology A but not B or C, A could well be the preferred alternative, but on grounds largely independent of the shadow wage of labour.

If a country does not presently produce textile machinery, but wishes to do so, it must analyze the costs and benefits of producing each type of machinery. To perform such an evaluation it would be best to treat the production of the machinery and the production of the fabric together as a vertically integrated industry and analyze the combination as a single project.

Conclusion

For a country with a market so small that only one plant of type A, B, or C could be built, it is extremely likely that technique C would be the optimal one. On the other hand, for a large country - at least 5.7 million - technique B would almost certainly be chosen over C. Technique A might even be chosen depending upon the extent of overvaluation, the discrepancy between market wages and the opportunity cost of labour, and the social rate of discount. If the capital goods industry could produce equipment of type A, but not of type B or C, it is likely that A would be the preferred technique.

Appendix I

Sensitivity Analysis in the UNIDO Guidelines

The short-run goal of project analysis is to focus policy markers' attention on the relevant political choices inherent in project design and to extract political decisions with respect to these choices. In this context, the bounds on weights and shadow prices serve to illuminate the value judgments implicit in one decision or another The long-run goal is to narrow the bounds on weights and shadow prices to a sufficiently small range that the top-down version of planning becomes feasible.

As an example, the authors of the UNIDO Guidelines (45) constructed an hypothetical decision-making scenario. The first project presented in this example is a pulp and paper mill. It was postulated that the government had two principle objectives with respect to this project: an increase in aggregate consumption, and the redistribution of income in favor of the hypothetical district of Sendesh. The planners, therefore, prepared two alternative designs: one, alternative A, to be located in the district of Guptania where a well-developed infrastructure would keep investment costs to a minimum; alternative B to be located in Sendesh.

The chief differences between the alternatives are: (1) the capital costs of B are significantly higher because of the investment in roads and other infrastructure, and (2) B would bring income and employment to the poorest region of the country, whereas A would cost less initially but would contribute to the economic polarization of the country. The real costs in terms of aggregate consumption, of operating the two projects are about equal. On the one hand, the direct opportunity cost of unskilled labor is practically zero in Sendesh, but approximately equal to the market

/wage in Guptania.

wage in Guptania. On the other hand, transport costs for inputs and outputs will be higher for B even after the infrastructure has been completed. Distances to markets and sources of supply are greater. Moreover, supervisory personnel would have in any case to come from Guptania for some time to come, and they would require a wage supplement to balance the higher cost of transporting goods in Sendesh. These two tendencies work in opposite directions and just about cancel each other out.

The aggregate-consumption benefits of the two projects are equal since the two alternatives produce essentially identical outputs.

To illustrate the necessity of choosing both the social rate of discount and the weight to be attached to consumption in Sendesh, the authors present the following summary of data and the steps involved in making the comparison of present values.

/Summary of Data

Summary of Data on Alternative Projects

(Thousands)

	Aggregate Consumption			Annual Consumption
	Annual Benefits	Annual Operating Cost	Capital Cost	Generated to Sendesh
Alternative A	200	100	500	0
Alternative B	200	100	600	50

Assuming the project will last indefinitely, and that the gap between Sendesh and the rest of the country will remain at its present level indefinitely, the two present values are given by the formulae:

$$NPV_A = sp^{inv} + (1 - s) \frac{200-100}{i} - p^{inv} \times 500$$

$$NPV_B = sp^{inv} + (1 - s) \frac{200-100}{i} - p^{inv} \times 600 + W \frac{50}{i}$$

s = marginal propensity to save, assumed equal to the reinvestment propensity for both alternatives;

i = social rate of discount;

p^{inv} = shadow price of investment;

W = premium o. income generated to Sendesh

Thus,

$$NPV_A \begin{Bmatrix} \geq \\ = \\ \leq \end{Bmatrix} NPV_B \text{ as } - p^{inv} \times 500 \begin{Bmatrix} \geq \\ = \\ \leq \end{Bmatrix} - p^{inv} \times 600 + W \frac{50}{i}$$

/Using as a

Using as a formula for the shadow price of investment defined earlier in the book in a hypothetical example.

$$P^{inv} = \frac{0.225}{i-0.075}$$

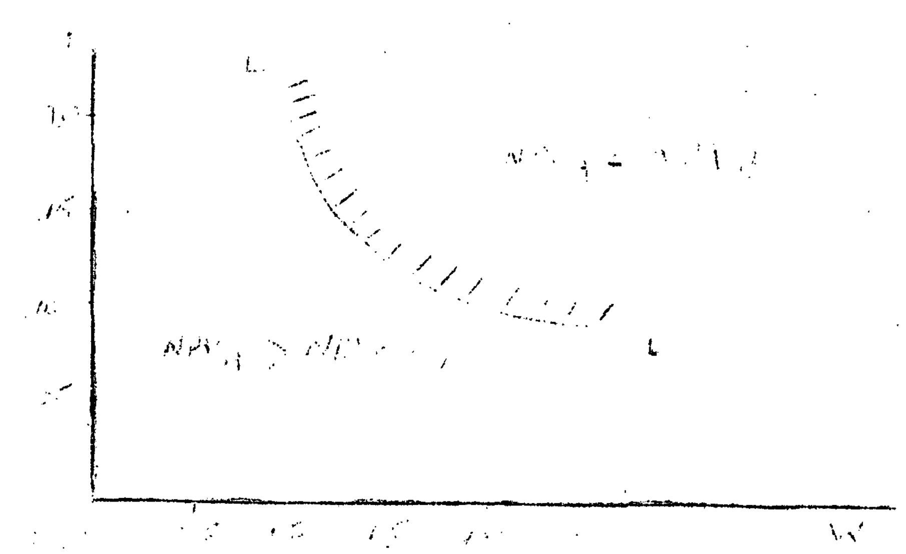
The comparison of present values reduces to

$$NPV_A \begin{Bmatrix} \geq \\ = \\ \leq \end{Bmatrix} NPV_B \quad \text{as} \; - \frac{0.225}{i-0.075} \times 500 \begin{Bmatrix} \geq \\ = \\ \leq \end{Bmatrix} - \frac{0.225}{i-0.075} \times 600 + \frac{U}{i} \, 50$$

The authors then produce a drawing of the locus of those pairs of values for which the present values of the two alternatives are equal. Such a locus separates the region where $NPV_A > NPV_B$. from that where $NPV_A < NPV_B$.

Figure 1

Locus of switching values for paper mill



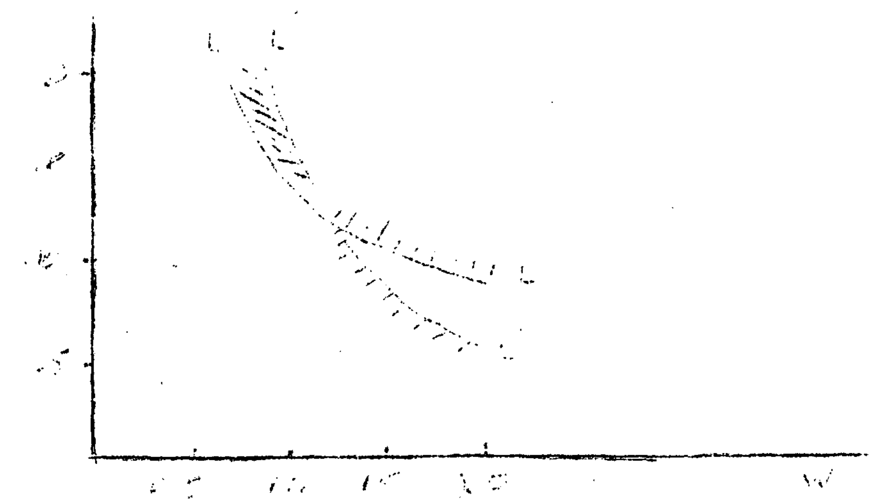
/If the government

If the government chooses alternative B, the Sendesh alternative, on the grounds that an extra capital outlay of £ 100,000 seems a small price to pay to generate £ 50,000 per year to Sendesh, then the implication is that if the social rate of discount ranges from .20 to .10, then the implied value of W is in the range of 0.72 to 1.8.

If in a subsequent decision, for example, to build a steel mill, the decision went against Sendesh, the situation might appear as follows with the shaded region containing values consistent with both the paper mill and the steel mill decisions.

Figure 2

Loci of switching values for paper mill and steel mill

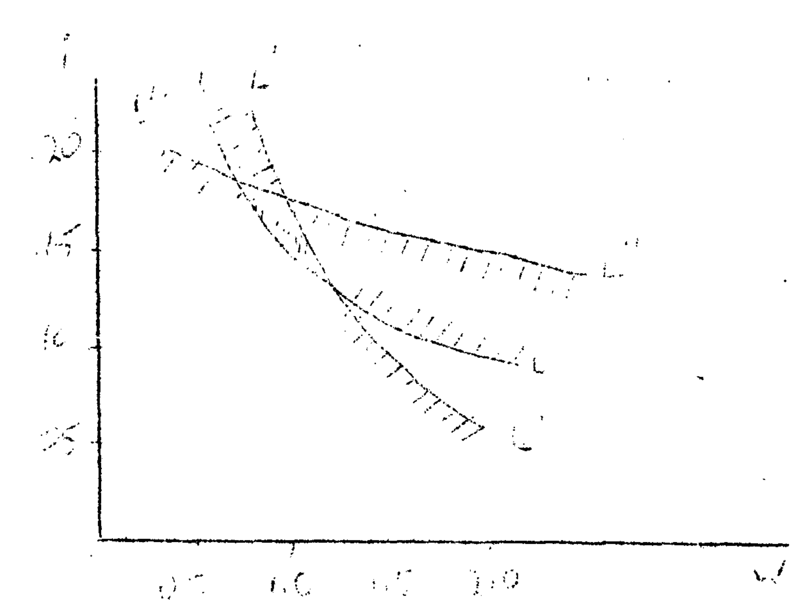


If now a third decision, to build a textile mill, also went against Sendesh, the following picture might emerge which implies roughly that W = 0.95 and i = 0.15.

/Figure 3

Figure 3

Loci of switching points for all three mills



Thus, the approach of the UNIDO authors, in treating the social rate of discount as an unknown along with other weights reflecting value judgements, combined with the use of sensitivity analysis for presenting to decision makers the consequences and implied value judgments of choices among alternatives, provides a framework in which such values can be made explicit and consistent. Should the process not lead to consistent weights, the project analyst can point this out to the decision-makers who may find that political pressures often render consistent decisions making impossible. In any case, the project analyst avoids in this manner having to make decisions about the values of national parameters which are properly the responsibility of governments.

/Appendix II

Appendix II

Derivations of Foreign Exchange Formulas

The derivations which follow are from the article by Bacha and Taylor (1). We include here derivations of the "equilibrium" exchange rate of Bacha and Taylor, the Harberger Schydlowsky-Fontaine formulation, and the Bruno-Kreuger domestic cost of producing foreign exchange. The definitions of variables are found at the end of this Appendix, not in the Addendum to be used in following the discussions in the main text.

Bacha and Taylor's Equilibrium Rate

Their model utilizes demand and supply functions, accepting the Robinson-Metzler assumption that these functions for each good depend only on the good's own price. The equations of the model are as follows:

Balance of trade in foreign currency,

$$\pi_x x_d + \Delta = \pi_m m_s \qquad (1)$$

Equality between export demand and supply functions

$$x_d(\pi_x) = x_s(p_x) \qquad (2)$$

Equality between import demand and supply functions

$$m_s(\pi_m) = m_d(p_m) \qquad (3)$$

Definition of domestic price of exports

$$p_x = \pi_x R \qquad (4)$$

Domestic price of imports

$$p_m = \pi_m RT \qquad (5)$$

The problem is to determine the revaluation in the exchange rate needed to reestablish the prexistent balance of trade when trade restrictions are removed.

/Taking total

Taking total log differentials of equations (1) - (5)

$$\left(d\pi_x/\pi_x + dx_d/x_d\right) D = d\pi_m/\pi_m + dm_s/m_s \qquad (6)$$

$$\mu_x \left(d\pi_x/\pi_x\right) = E_x \left(dp_x/p_x\right) \qquad (7)$$

$$E_m \left(d\pi_m/\pi_m\right) = \mu_m \left(dp_m/p_m\right) \qquad (8)$$

$$dp_x/p_x = d\pi_x/\pi_x + dR/R \qquad (9)$$

$$dp_m/p_m = d\pi_m/\pi_m + dR/R + dT/T \qquad (10)$$

The change in the exchange rate necessary to compensate for the removal of protection is

$$d\,R/R = -\left(d\,T/T\right)\left(1/(1 - q)\right) \qquad (11)$$

where

$$q = \frac{D\,(1 + \mu_x)\,E_x\,(E_m - \mu_m)}{(1 + E_m)\,\mu_m\,(\mu_x - E_x)} \qquad (12)$$

Taking the integral of (II) and assuming constant elasticities,

$$k = R^{(1 - q)}T \qquad (13)$$

Setting $T = 1$, and $R = R^*$, the zero tariff exchange rate is

$$k = R^{*\,(1 - q)} \qquad (14)$$

Substituting into (13)

$$R^* = RT^{\frac{1}{1 - q}} \qquad (15)$$

Since $T = T^* + 1$

$$R^* = R(1 + T^*)^{\frac{1}{1 - q}} \qquad (16)$$

which is equation (23) of the main text.

For a small country, it may be assumed that

$Em = \mu x = \infty$, in which case

$$q = D\;Ex/\mu m \qquad (17)$$

/Harberger-Schydlowsky-

Harberger-Schydlowsky-Fontaine Formula

This approaches analyzes the effect on national income of a project having foreign exchange links. There are three sectors: an import competing sector, a sector producing exports, and a third sector producing non-tradables. The equations of the model are as follows:

Domestic prices are

$$P_i = R\,(1 + t_i)\quad_i = RT_i\,\pi_i \qquad i = 0,1 \tag{18}$$

$$P_2 = R\,(1 + t_2)\quad_2 = R\,\phi_2\,\pi_2$$

The linear homogeneous production functions are

$$Z_i = p^i\,(L_i,\ K_i) \qquad i = 1,\ 2,\ 3 \tag{19}$$

Full employment of resources is assumed:

$$\sum_i L_i = L \tag{20}$$

$$\sum_i K_i = K \tag{21}$$

where $i = 0$ for non-competitive intermediate imported inputs and $i = 1, 2, 3$ for domestically produced or competitively imported intermediate inputs.

Net prices are given by

$$P^*_j = P_j - \sum_{i=0}^{3} a_{ij}\,P_i \qquad j = 1,\ 2,\ 3 \tag{22}$$

The first order production equilibrium conditions are

$$P^*_i\ f^i_l = w \qquad i = 1,\ 2,\ 3 \tag{23}$$

$$P^*_i\ f^i_k = s \qquad i = 1,2,\ 3 \tag{24}$$

/The physical

The physical balance equations for domestic goods are given in matrix notation:

$$\begin{bmatrix} z_1^* \\ z_2^* \\ z_3^* \end{bmatrix} = (I-A) \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} - \begin{bmatrix} m_1 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ x_2 \\ 0 \end{bmatrix} \qquad (25)$$

where the z_1^* (P_0, P_1, P_2, P_3) are net supply functions homogeneous of degree zero in the prices $P_0 - P_3$.

In the foreign exchange market, the balance of payments in world prices is:

$$\pi_2 x_2 = \pi_i m_1 + \pi_o a_o' z = \pi_1 m_1 + \pi_o m_o \qquad (26)$$

Define y as the sum of total final demand for goods and money valued at domestic prices.

$$y = \sum_i P_i c_i + c_M = p'c + c_M \qquad (27)$$

The final demand functions for goods is homogeneous of degree zero in prices and the supply of money

$$C_i = C_i (p, y, M) \qquad i = 1, 2, 3 \qquad (28a)$$

The demand for money is assumed to be homogeneous of degree one.

$$C_M = C_M (p, y, M) \text{ homogeneous of degree 1} \qquad (28b)$$

Now let there be a project $d\xi$ which produces $d\Delta$ of foreign exchange. The change in the balance of payments induced by the project is:

$$d\Delta + \pi_2 dx = \pi_1 dm_1 + \pi_o a_o' dz \qquad (29)$$

/where

where

$$dm_1 = \left[\partial (c_1 - z_1^*) / \partial R\right] dR + \left[\partial(c_1 = z_1^*)/\partial M\right] dM \qquad (30)$$

and

$$- dx_2 = \left[\partial (c_2 - z_2^*)/ \partial R\right] dR + \left[\partial(c_2 - z_2^*)/\partial M\right] dM \qquad (31)$$

Assuming a constant money supply and negligible non-competitive intermediate imports:

$$dR = \frac{d\Delta}{\pi_1 \partial(c_1 - z_1^*)/\partial R + \pi_2 \partial(c_2 - z_2^*) - \partial R} \qquad (32)$$

The change in y induced by the additional foreign exchange is:

$$dy = p_1 \frac{\partial(c_1 - z_1^*)}{\partial r} R \frac{dR}{R} + p_2 \frac{\partial(c_2 - z_2^*)}{\partial R} R \frac{dR}{R} \qquad (33)$$

Substituting from (32),

$$dy = \frac{p_1 \frac{\partial(c_1 - z_2^*)}{\partial R} R + p_2 \frac{\partial(c_2 - z_2^*)}{\partial R} R}{\frac{\pi_1 \partial(c_1 - z_1^*)}{\partial R} R + \frac{\pi_2 \partial(c_2 - z_2^*)}{\partial R} R} \qquad (34)$$

With negligible noncompetitive imports for intermediate uses, the world price value of exports and imports become equal from equation (2)

Dividing top and bottom of (34) by the world price values of exports or imports,

$$\frac{dy}{d\xi} = \frac{(1 + t_2^*) E_2 - (1 + t_1^*)\mu_1}{E_2 - \mu_m} R \frac{d\Delta}{d\xi}$$

/where $^{w}j/X$

where x_j/X are the shares of exports of sector j, and $\frac{m_i}{M}$ are the shares in total imports of sector i, the above formula generalizes to

$$R^* = R \frac{\sum_j (1 + t_j^*) \frac{x_j}{X} E_j - (1 + t_i^m) \frac{m_i}{M} \mu_i}{\sum_j \frac{xj}{x} E_j - \sum_i \frac{mi}{M} \mu_i} \qquad (36)$$

which is formula (31) in the main text.

The Domestic Cost of Producing Foreign Exchange

The Bruno Kreuger formulation is derived from the supply side of the economy, equation (9) - (24) above, except that there are n sectors instead of three.

Application of Euler's theorem gives the following equations for the exhaustio of value added by factor payments.

$$p_i^* z_i = p_i^* f_L^j L_i + p_i^* f_K^i K_i = wL_i + sK_i \quad i = 1,2,\ldots n \qquad (37)$$

Dividing this equation by z_i gives,

$$p_i^* = wl_i + sk_f \qquad 1,2,\ldots n \qquad (38)$$

where l_i and k_i are the labor/output and capital/output ratios for sector i.

If l' and k' are the vectors of these sectoral ratios, and p' the vector of prices,

$$p' (I-A) - p_o a_o' = wl' + sk' \qquad (39)$$

or,

$$p' = p_o a_o' (I-A)^{-1} + (wl' + sk') (I-A)^{-1} \qquad (40)$$

which expresses domestic goods prices in terms of factor costs.

/If a producer

If a producer in sector i can sell his product abroad and receive $R\pi_i$ pesos where R is the market exchange rate, the sale will be profitable if

$$R\pi_i \geq p_i \quad \text{or} \quad R\pi_i \geq p'h_i \tag{41}$$

where h_i is the "unit" vector with unity as its i^{th} coordinate and all other coordinates are equal to zero.

Substituting for p' from (40)

$$R\pi_i \geq \left[p_o a'_o (I-A)^{-1} + (vl' + sk') (I-A)^{-1} \right] h_i \tag{42}$$

Setting tariffs on non-competitive imports equal to zero, $p_o = R\pi_o$, and we have,

$$\frac{(vl' - sk') (I-A)^{-1} h_i}{\pi_i - \pi_o a'_o (I-A)^{-1} h_i} < R \tag{43}$$

To arrive at equation (27) in the main text, it is only necessary to redefine a few terms. The top half of the equation represents the value of all domestic inputs of product i. This can be alternatively written as $\sum_s \bar{f}_{si} v_s$

where the $\bar{f}_{sj}$ represent inputs of factor s per unit of output i. Let $\pi_i = u_j$ and $\pi_o a'_o (I-A)^{-1} h_i = \bar{m}_j$, the direct and indirect foreign exchange costs per unit of output, and we have

$$c = \frac{\sum_s \bar{f}_{si} v_s}{u_i - \bar{m}_i} \; R \tag{44}$$

which is equivalent to equation (27) in the main text.

/Definitions of

Definitions of variables in Appendix II

π_x	=	foreign price of exports
x_d	=	export demand
Δ	=	balance of trade deficit = $\pi_x x - \pi_m m$
π_m	=	foreign price of imports
m_s	=	import supply
x_s	=	export supply
m_d	=	import demand
P_x	=	domestic price of exports
R	=	market exchange rate
R^*	=	shadow exchange rate
P_m	=	domestic price of imports
T^*	=	the ad valorem tariff equivalent to protection
T	=	$1 + T^*$
q	=	$D \frac{(1 + \mu x)\ Ex\ (Em - \mu m)}{(1 + Em)\ \ m\ (\mu x - Ex)}$
D	=	π_x^{X} / π_m^{M}
μ_x	=	price elasticity of export demand
Ex	=	price elasticity of export supply
μ_m	=	price elasticity of import demand
Em	=	price elasticity of import supply
π_o	=	foreign price of non-competitive imports
π_1	=	foreign price of competitive imports
π_2	=	foreign price of exports
t_i	=	the ad valorem tariff (subsidy) equivalent to protection (tax) applied to commodity i

/T_i =

T_i	=	$1 + t_i$ (force of tariff)
ϕ_i	=	$1 + t_2$ (force of subsidy or tax on exports)
P^*_j	=	"net prices" $= P_j - \sum_{i=o}^{3} a_{ij} P_i \quad j = 1, 2, 3$
z_i	=	production of goods i
L	=	labor
K	=	capital
a_{ij}	=	input i into activity j
f^i_L	=	derivative with respect to labor of the production function in sector i
f^i_K	=	derivative with respect to capital of the production function in sector i
w	=	wage rate
s	=	rental price of capital
A	=	domestic input-output matrix
c_i	=	sectoral final demand level
m_1	=	level of competitive imports into sector 1
x_2	=	level of exports of sector 2
a'_o	=	row vector of intermediate non-competitive import coefficients
z	=	column vector of output levels
m_o	=	total of non-competitive imports
y	=	sum of total final demand for goods and money at domestic prices
c_M	=	final demand for money
M	=	money stock
$d\xi$	=	activity level of a new project
$\underline{x_j}$	=	share of exports of sector j in total exp rts

$/\frac{m_i}{M}$

$\frac{m_i}{M}$	=	share of imports of sector i in total imports
l_i	=	labor/output ratio for sector i
k_i	=	capital/output ratio for sector i
p'	=	vector of prices
l'	=	vector of labor/output ratios
k'	=	vector of capital/output ratios
h_i	=	"unit" vector with unity as the $_i$th coordinate, and all other coordinate equal to zero
$\bar{f}_{sj}$	=	input of factor s per unit of output i
$\bar{m}_j$	=	direct and indirect foreign exchange costs per unit of output
u_j	=	foreign price of exports.

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/ ADDENDUM

ADDENDUM

Definitions of Variables in the Main Text

s	=	marginal propensity to save
y	=	rate of return on capital (marginal output/capital ratio)
p^{inv}	=	shadow price of capital
t	=	time
i	=	social rate of discount
b	=	incremental labor/capital ratio
w	=	annual wage of unskilled labor
z	=	marginal productitivy of labor in the unprotected urban sector
T	=	number of years at the end of which consumption is valued equally with investment.
η_{up}	=	elasticity of marginal utility with respect to per capita income
rp	=	rate of growth of per capita consumption
r	=	rate of growth of aggregate income
w^{*}	=	shadow price of labor
p^{wkr}	=	discounted percent value of the stream of future consumption foregone by not making an additional unit of investment
R	=	official exchange rate
R^{*}	=	shadow price of foreign exchange
T^{*}	=	equivalent level of <u>ad valorem</u> tariff
μ_x	=	price elasticity of demand for exports
E_x	=	price elasticity of supply for exports
μ_m	=	price elasticity of demand for imports
E_m	=	price elasticity of supply for imports
D	=	initial trade balance

/q =

q = $$D \frac{(1+\mu_x) E_x (E_m - \mu_m)}{(1+E_m)\mu_m (\mu_x - E_x)}$$

c = domestic cost of producing foreign exchange

f_{sj} = input of primary factor s per unit of output

a_{ij} = input of good i per unit of output

v_s = price of factor s

p_i = price of good i

u_j = foreign exchange earnings per unit of output

m_j = foreign exchange costs per unit of output

$\bar{f}_{sj}$ = direct and indirect input of primary factor s per unit of output

$\bar{m}_j$ = direct and indirect foreign exchange costs per unit of output

H_i = effective rate of production of product j

P_i^* = "net price" or value added at domestic prices = $P_i - \sum_{i=o}^{n} a_{ij} P_j$

P_i = domestic price of product i

P_j = domestic price of input j

ρ_i^* = "net price" or value added at world prices = $\rho_i - \sum_{i=o}^{n} a_{ij} \rho_j$

ρ_i = world price of product i

ρ_j = world price of input j

T_x = export subsidy

t_j^x = export duties on com odityj

t_i^m = import duties on commodity i

$\frac{x_j}{}$ = share of export j in total exports

/ $\frac{m_i}{M}$ = share

$\frac{m_i}{M}$	=	share of import i in total imports
$\frac{\Delta m_i}{\Delta M}$	=	share of import i in the marginal import bill
t_c	=	total costs
[illegible]	=	fixed costs per machine
c	=	number of machine units required
a_1	=	setting time
n	=	size of the production run
h_1	=	wage rate of machine setter
a_2	=	piece time (direct machine time) per unit of output
h_2	=	wage ra e of operator
U	=	volume of output
k	=	number of hours per shift
X	=	number of shifts per day
E	=	the largest integral number contained in the bracketed expression when evaluated.