Shadow Prices for Project Selection in the Presence of Distortions: Effective Rates of Protection and Domestic Resource Costs

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The paper addresses the problem of deriving shadow prices for use in project evaluation when the existing allocation is characterized by ad valorem trade distortions. The analysis is used to clarify and resolve the long-standing debate among effective-rate-of-protection and domestic-resource-cost proponents as to the respective merits of their measures as methods of project evaluation. The derivation of shadow factor prices is then extended to three major factor market imperfections familiar from extensive trade-theoretic analysis.

Until recently, theorists of trade and welfare have, by and large, ignored the ever-increasing literature on project evaluation. This is puzzling since the bulk of the project evaluation literature attempts to derive shadow prices to replace the market prices that, in distorted situations, clearly will not reflect true opportunity costs whereas the major advances in the welfare theory of international trade have consisted precisely in the analysis of issues in trade and welfare when the market is characterized by a number of alternative endogenous or policy-imposed distortions.[1]

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[1] See Bhagwati and Ramaswami 1963; Johnson 1965; Bhagwati, Ramaswami, and Srinivasan 1969; Bhagwati 1971; and the numerous writings of Kemp, Findlay, Corden, Magee, Brecher, and several trade theorists.

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Trade theorists have generally considered second-best problems characterizing the nature of optimal policy intervention when the given distortions cannot be (directly) removed. Project analysis, on the other hand, poses a related, but different, question: if the given distortions defining current resource (and expenditure) allocations cannot be removed, would the introduction of a project which withdraws resources from this existing allocation for project use be welfare-improving? The solution to this latter problem naturally follows from the derivation of the shadow prices of factors and outputs for use in project evaluation.

As it happens, this problem has been posed by Findlay and Wellisz (1976) in a most elegant, recent contribution, illuminating how trade-theoretic tools can be deployed to advantage in analyzing it.[2] We follow them in Section I, essentially taking over their simple model of trade theory, with primary factors producing traded goods (including the project output), with no intermediates and with fixed international prices for the traded goods, and considering with Findlay and Wellisz the case of a trade distortion (i.e., a tariff or trade subsidy). We parallel the Findlay-Wellisz analysis, using somewhat different analytical techniques, managing therefore to both complement and correct it in critical ways.

Next, in Section II, we relate these results on the appropriate shadow prices in project evaluation to the two measures which have been proposed as project-evaluation criteria in the developmental and trade literature: the effective rate of protection (ERP) and the domestic resource cost (DRC). It is shown that the ERP is an inappropriate measure for this purpose; and that DRCs, if they must yield the correct social evaluation of a project, must use the second-best shadow prices that are derived in Section I, that is, they must be appropriately defined DRCs. Thus we succeed in casting light on the inconclusive debate among the ERP and DRC proponents—as typified, for example, by the controversy in this *Journal* among Balassa and Schydlowsky (1968, 1972), Bruno (1972), and Krueger (1972)—as to their relative merits as techniques of project appraisal.[3]

Finally, in Section III, we analyze the derivation of shadow factor prices when the given distortions arise from three alternative, polar types of factor market imperfections familiar to trade theorists, rather than from the presence of a trade tariff or subsidy.

[2] Very early and pioneering analyses by Joshi (1972) and Lal (1974) attempting to examine the Little-Mirrlees (1969) *Manual* rules along trade-theoretic lines must also be mentioned. Corden (1974) also has a discussion of these rules.

[3] For a historical review of the antecedents of the DRC concept, especially in Israel, see Bruno (1972). The use of ERP as a project criterion appears, on the other hand, to have been the subject of internal World Bank memoranda during the mid-1960s, stemming presumably from the notion that, in some sense, they reflected "comparative advantage."

I. The Model and Derivation of Shadow Prices

As stated above, we consider the usual trade-theoretic model with two primary factors, k and l, producing two traded outputs, X_1 and X_2, that enjoy fixed international prices p_1^* and p_2^*. The "small" project being considered will produce commodity X_3, at fixed international price p_3^*. It is assumed that the planner is working with a well-behaved social utility function. The problem of project analysis then is to evolve suitable prices, for the primary factors and output (X_3) in the project, which would enable the analyst to decide whether the project should be accepted or rejected.

The problem would be straightforward indeed if there were no distortions in the system: the correct valuations of the primary factors would clearly be those in the market, as reflected by the international price-ratio p_1^*/p_2^*, and the correct valuation for X_3 would be the international price p_3^*. But the situation we must now introduce is one where the domestic price-ratio between commodities X_1 and X_2 is *distorted* by a tariff and/or trade subsidy and it is further assumed that this distortion must be taken as *given*. The problem then, as noted by Findlay and Wellisz (1976, p. 545) is "an inherently second best one" in which "the criterion for acceptance of the project is whether or not it will increase the value of total production at world prices as compared with the existing situation, assuming that the distortional policy on the existing goods continues unchanged":[4] this being, of course, the procedure suggested by Little and Mirrlees (1969) in their celebrated *Manual* and also by Bruno (1962, 1967*b*) in his important analytical work on project evaluation.

In applying this criterion for a "small" project, we note first that the introduction of the project will use labor and/or capital that are withdrawn from their present use. As such, the answer to the question whether or not the project (producing X_3) will increase the value of production at world prices is the *same* as to the question whether the world price of a unit of output of the project exceeds or falls short of its cost of production as obtained by evaluating the labor and capital used in producing X_3 at their *shadow* prices, that is, at prices that equal their marginal con-

[4] Provided that inferior goods are ruled out, there is of course a monotonic relationship between welfare and the distance of the availability locus (at international prices) from the origin, given a well-behaved social utility function. Thus, provided the degree of protection, and hence the degree of consumption distortion, remains unchanged over the entire economy before and after the acceptance of the project, one can disregard without error the fact that trade distortions will also distort consumption. It follows immediately, of course, that if one is dealing with a quota restriction, rather than an ad valorem tariff, so that we have essentially a *variable* (degree of) distortion, the aforementioned monotonic relationship between welfare and the distance of the availability locus (at international prices) will break down. More on this is to be found in Bhagwati and Wan (1977).

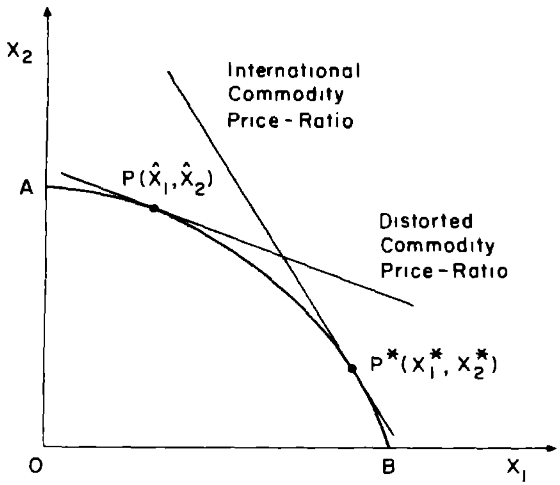

FIG. 1

tribution in their existing use to the value of total production at world prices.

Turn now to figure 1. Here AB is the production possibility curve, defined on commodities X_1 and X_2. At free trade, production would be at $P^*(X_1^*, X_2^*)$ reflecting the international commodity prices. However, with trade distortion, the commodity price-ratio is more favorable to commodity X_2 and production is at $P(\hat{X}_1, \hat{X}_2)$. Now, the planner is assumed unable to correct the situation directly, so that the commodity price-ratio, the factor price-ratio, and factor proportions for X_1 and X_2 are to be held fixed at their respective values at $P(\hat{X}_1, \hat{X}_2)$. Denote then the corresponding input coefficients as $(\hat{k}_1, \hat{l}_1)$ and $(\hat{k}_2, \hat{l}_2)$ and factor rentals as $\hat{w}$ and $\hat{r}$.

Now, as noted above, the *second-best* shadow prices of labor ($\hat{w}^*$) and capital ($\hat{r}^*$) in this situation must equal the change in the quantities of X_1 and X_2 output, evaluated at *international* prices p_1^* and p_2^*, resulting from a marginal change in labor and capital, respectively, starting at $P(\hat{X}_1, \hat{X}_2)$ and maintaining the distorted commodity price-ratio for production decisions.[5] Thus, defining $W = p_1^* X_1 + p_2^* X_2$ and the total availability of capital and labor as $\bar{K}$ and $\bar{L}$, respectively, it is clear that the shadow price of labor will be $dW/d\bar{L}$ and that of capital will be $dW/d\bar{K}$, where the derivatives must be evaluated for the distorted situation. This is readily done as follows. First, since capital supply is fixed ($\bar{K}$), we have: $\hat{k}_1(dX_1/d\bar{L}) + \hat{k}_2(dX_2/d\bar{L}) = 0$, and, for labor, the corresponding equation is: $\hat{l}_1(dX_1/d\bar{L}) + \hat{l}_2(dX_2/d\bar{L}) = 1$. Therefore, $dX_1/d\bar{L} = -\hat{k}_2/(\hat{k}_1\hat{l}_2 - \hat{k}_2\hat{l}_1)$ and $dX_2/d\bar{L} = \hat{k}_1/(\hat{k}_1\hat{l}_2 - \hat{k}_2\hat{l}_1)$. Hence, the shadow

[5] The notation $\hat{w}^*$, $\hat{r}^*$ is used here because the circumflex refers to the distorted situation and the asterisk to the evaluation of output change at international prices.

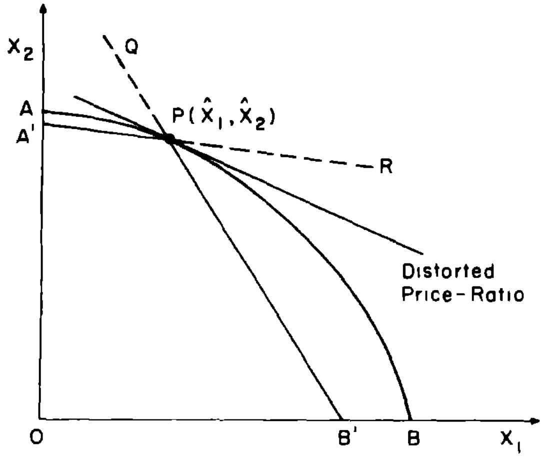

FIG. 2

price of labor, defined as: $\hat{w}^* = p_1^*(dX_1/d\bar{L}) + p_2^*(dX_2/d\bar{L})$ is seen to be equal to:

$$\hat{w}^* = \frac{p_2^*\hat{k}_1 - p_1^*\hat{k}_2}{\hat{k}_1\hat{l}_2 - \hat{k}_2\hat{l}_1}. \tag{1}$$

Similarly, we can see that the shadow price of capital is:

$$\hat{\gamma}^* = \frac{p_1^*\hat{l}_2 - p_2^*\hat{l}_1}{\hat{k}_1\hat{l}_2 - \hat{k}_2\hat{l}_1}. \tag{2}$$

It is readily seen that these are also the values of $\hat{w}^*$ and $\hat{\gamma}^*$ that satisfy the equations:[6]

$$p_1^* = \hat{w}^*\hat{l}_1 + \hat{\gamma}^*\hat{k}_1 \tag{3}$$

$$p_2^* = \hat{w}^*\hat{l}_2 + \hat{\gamma}^*\hat{k}_2. \tag{4}$$

Now, it is easy to see that the shift in outputs, as labor (capital) is withdrawn from P, maintaining the distortion and hence the distorted commodity price-ratio, is yielded by the corresponding Rybczynski line. So, assuming that X_1 is K-intensive at P (i.e., $\hat{k}_1/\hat{l}_1 > \hat{k}_2/\hat{l}_2$), one can see, in figure 2, that the economy will move from P down line PB' as

[6] This is also the procedure suggested for deriving shadow factor prices by Diamond and Mirrlees (1976) in their analysis of a similar problem. It may be noted here that, in the case where the trade distortion is not ad valorem but, say, a specific tariff (or subsidy) or a quantitative restriction, the coefficients $\hat{l}_1$, $\hat{k}_1$, $\hat{l}_2$, and $\hat{k}_2$ will change with the withdrawal of factors even for a "small" project and one cannot use this procedure for estimating shadow factor prices. Moreover, note also that, if the number of factors differs from the number of goods, then shadow factor prices may not be uniquely defined for small changes and/or may be nonstationary for large changes. On all this, see Bhagwati and Wan (1977).

labor is reduced, up line PQ as labor is increased, up PA' as capital is reduced, and down PR as capital is increased. It equally follows, from the evaluation of these shifts at the *international* (rather than the distorted) commodity price-ratio, that $\hat{w}^*$ will be negative if the international price line is steeper that PB' (i.e., $p_1^*/p_2^* > \hat{k}_1/\hat{k}_2$) and $\hat{y}^*$ will be negative if the international price line is flatter than PA' (i.e., $p_1^*/p_2^* < \hat{l}_1/\hat{l}_2$); and that nonnnegative values for $\hat{w}^*$ and $\hat{y}^*$ will obtain only when the international price-ratio is in the range spanned by PB' and PA'.

That it is possible for $\hat{w}^*$ *or* $\hat{y}^*$ to be negative would appear to be a paradox. For, it of course implies, for instance, that when (say) $\hat{w}^* < 0$, it would pay society to implement a project with zero output (X_3) and positive labor input: in other words, that if labor were withdrawn from existing production, thanks to the project, this will increase the value of such production at international prices. But then this paradox is only yet another instance of "immiserizing growth"; the presence of the marginal labor is immiserizing, given the distortion;[7] and thus the paradox is readily resolved.

In their derivation of shadow factor prices for the above problem, however, Findlay and Wellisz (1976) bypass this possibility of negative factor prices by deriving these prices instead via the solution to a programming problem which is tantamount to (see fig. 2) deriving the shadow factor prices corresponding to the international prices *but* subject to a "feasible" production possibility curve defined by $A'PB'$. These Findlay-Wellisz shadow prices ($\hat{w}^*$, $\hat{y}^*$) are clearly yielded by putting the international price-ratio tangent to $A'PB'$, in the usual way, and are illustrated to advantage in figure 3.

Figure 3 is the all-too-familiar Samuelson diagram and needs no explanation. Now, movement along the *unrestricted* production possibility curve APB in figure 2 corresponds to movement along the curve QPR in figure 3, relating the commodity price-ratio to the corresponding factor price-ratio. Similarly, movement along the *restricted* production possibility curve $A'PB'$ in figure 2 corresponds in figure 3 to following the y-axis in the fourth quadrant from ∞ up to the point S where $OS = \hat{k}_1/\hat{k}_2$, then along the curve $SPNZ$ up to Z (where N is at a distance $\hat{l}_1/\hat{l}_2$ from the x-axis) and then following a straight line parallel to the x-axis. The (restricted) curve $SPNZ$, depicting w/y as a function of p_1/p_2, can be shown to be increasing and concave, with a common tangent with the (unrestricted) curve QPR at P. Thus, the Findlay-

[7] Cf. Bhagwati (1968); Johnson (1967) who deals with the precise distortion in our model here; and Bhagwati (1971) who states the general theory of immiserizing growth that explains and ties together the different instances of immiserizing growth. The phenomenon of negative shadow factor prices, in turn, is related to the empirically important phenomenon of value subtraction at international prices: the latter requires, but does not necessarily follow from, the former; see Bhagwati, Srinivasan, and Wan (1977).

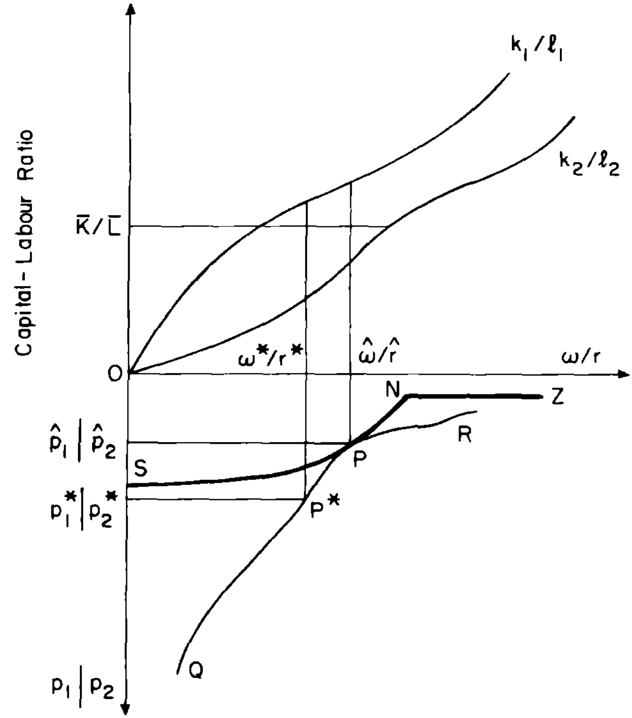

FIG. 3

Wellisz shadow price-ratio $\hat{w}^*/\hat{y}^*$ will be infinite for $p_1^*/p_2^* \geq \hat{k}_1/\hat{k}_2$ and zero for $p_1^*/p_2^* \leq \hat{l}_1\hat{l}_2$, while taking positive values in the range spanned by $\hat{k}_1/\hat{k}_2$ and $\hat{l}_1/\hat{l}_2$. This procedure therefore clearly will yield shadow prices that coincide with the correct ones yielded by our procedure only when $\hat{w}^*/\hat{y}^* \geq 0$, that is, in figures 1 and 2, only for the parametric case where the international price-ratio lies in the range spanned by *PA′* and *PB′*. For the parametric cases where the international price-ratio lies outside of this range, the Findlay-Wellisz procedure will incorrectly yield, not negative shadow factor prices, but a shadow factor price-ratio, $\hat{w}^*/\hat{y}^* = 0$ or ∞, according to whether the production specialization, corresponding to the international price-ratio, occurred in figure 2 at *B′* (on X_1) or *A′* (on X_2).[8]

II. ERPs, DRCs, et Al.

We have thus deduced, in the preceding section, the precise shadow prices that must be used, in a distorted situation, for project appraisal. We are

[8] An alternative analysis of the inappropriateness of the Findlay-Wellisz procedure, in programming terms, is available from the authors, on request.

therefore now in a position to decide on the competing claims of the ERP and DRC proponents as to their relative merits as techniques of project appraisal. As careful reading of this debate in this *Journal* (1972), already cited, will unmistakably reveal, the first priority in this area is to define one's concepts unambiguously.

Since these and other economists distinguish between direct and indirect use of factors, thus including intermediates which were not included in the analysis in Section I above, we should first state that our project-acceptance criterion, suitably amended, is the following:

$$p_3^* \geq k_3\hat{r}^* + l_3\hat{w}^* + f_1p_1^* \tag{5}$$

where it is now assumed that X_1 is used in project (X_3) with coefficient f_1 per unit output of X_3 and where k_3, l_3, and f_1 are assumed fixed so that one is essentially treating each process as a project. What the criterion says, of course, is that the project, to be accepted, must produce output which, when evaluated at international prices, exceeds or equals the cost of production evaluated at the (second-best) shadow factor prices. Now, note that the right-hand side of (5) is written in a form that includes the primary and intermediate inputs. But, it can *equivalently* be written in the form including direct *plus* indirect primary factors, that is, by decomposing intermediates into primary factors:

$$p_3^* \geq (k_3 + f_1\hat{k}_1)\hat{r}^* + (l_3 + f_1\hat{l}_1)\hat{w}^*. \tag{6}$$

Now, noting that the DRC concept implies that one is measuring the domestic resources used in an activity to produce a unit of foreign exchange, we can distinguish sharply among the following, alternative concepts that correspond, in one way or another, to the concepts that are often apparently used indistinguishably in the literature.

Note, initially, that by first best we will refer to factor valuations (w^*, r^*) corresponding to the *first-best* optimal situation at $P^*(X_1^*, X_2^*)$ in figure 1. By second best, we will denote instead the factor valuations ($\hat{w}^*$, $\hat{r}^*$) that reflect the second-best optimal situation, given the distortion. Finally, by "private" we will denote the factor valuations ($\hat{w}$, $\hat{r}$) that actually obtain in the distorted situation at P.

Next, we should also note that the debate includes additionally a distinction among measures working with intermediates or alternatively with the intermediates decomposed into the primary factors producing them. Hence, we will distinguish also between decomposed-intermediates and direct-intermediates measures.[9] We will thus have altogether six measures of DRCs and one for ERP. We may therefore now state these alternative concepts/measures in regard to the project producing X_3, with

[9] We could also, in principle, have distinguished between "gross" and "net" values, as explained in the text presently. However, there is no evidence that gross measures have been computed so that we confine ourselves in the text to only the net measures.

brevity, noting that, in the denominator of all the measures set out below, commodities (X_1, X_2, and X_3) are always valued at their international prices.[10]

DRC_I: First-best, Direct-Intermediates Measure

Here, we have the evaluation of the primary factors at first-best shadow wage and rental (w^*, γ^*), corresponding to the situation where the international commodity prices obtain domestically and therefore the distortions have been eliminated. These are also the shadow prices suggested by Bacha and Taylor (1971). In this case, we define:

$$\mathrm{DRC_I} = \frac{k_3\gamma^* + l_3 w^*}{p_3^* - f_1 p_1^*} \tag{7}$$

for the project, using the "direct" formulation: $f_1 p_1^*$ in the denominator, rather than decomposing that into $[(f_1 k_1^*)\gamma^* + (f_1 l_1^*)w^*]$ as in the next measure $\mathrm{DRC_{II}}$ (where k_1^* and l_1^* are the coefficients corresponding to first-best shadow prices).

DRC_{II}: First-best, Decomposed-Intermediates Measure

Here, $\mathrm{DRC_I}$ modifies equivalently therefore to:

$$\mathrm{DRC_{II}} = \frac{k_3\gamma^* + l_3 w^*}{p_3^* - [(f_1 k_1^*)\gamma^* + (f_1 l_1^*)w^*]}\,. \tag{8}$$

(Now, note that we have been referring *only* to formulations that deal with *value added* in the denominator. These DRC measures are therefore "net" measures. Alternatively, we could have also chosen "gross" measures, rewriting $\mathrm{DRC_I}$, for example, as $[k_3\gamma^* + l_3 w^* + f_1 p_1^*]/p_3^*$, and $\mathrm{DRC_{II}}$, for example, as $[(k_3 + f_1 k_1^*)\gamma^* + (l_3 + f_1 l_1^*)w^*]/p_3^*$. But, as already remarked earlier, none of the DRC practitioners have used gross measures; hence they are not added here.)

DRC_{III}: Second-best, Direct-Intermediates Measure

Here, we replace the first-best shadow factor prices with the second-best shadow prices, to alter $\mathrm{DRC_I}$ to:

$$\mathrm{DRC_{III}} = \frac{k_3\hat{\gamma}^* + l_3 \hat{w}^*}{p_3^* - f_1 p_1^*}\,. \tag{9}$$

[10] While the DRCs are conceptually stated below for the project X_3, they can be readily adapted for the existing activities as well.

DRC_{IV}: Second-best, Decomposed-Intermediates Measure

Similarly, we alter $\mathrm{DRC_{II}}$ here to:

$$\mathrm{DRC_{IV}} = \frac{k_3 \hat{r}^* + l_3 \hat{w}^*}{p_3^* - [(f_1 \hat{k}_1)\hat{r}^* + (f_1 \hat{l}_1)\hat{w}^*]} \tag{10}$$

which is equivalent to $\mathrm{DRC_{III}}$.

DRC_V: Private, Direct-Intermediates Measure

Here, we use the market prices and hence get a "private" DRC measure:

$$\mathrm{DRC_V} = \frac{k_3 \hat{r} + l_3 \hat{w}}{p_3^* - f_1 p_1^*}. \tag{11}$$

DRC_{VI}: Private, Decomposed-Intermediates Measure

Here, we get:

$$\mathrm{DRC_{VI}} = \frac{k_3 \hat{r} + l_3 \hat{w}}{p_3^* - [(f_1 \hat{k}_1)\hat{r} + (f_1 \hat{l}_1)\hat{w}]} \tag{12}$$

which is clearly *not* equivalent to $\mathrm{DRC_V}$ since the factor quantities yielded by the decomposition are being evaluated at the distorted, actual factor prices whereas the intermediates in $\mathrm{DRC_V}$ are directly being evaluated at the undistorted, international prices.

ERP

Then, finally, we have the well-known ERP measure:

$$\mathrm{ERP} = \left[\frac{\hat{p}_3 - f_1 \hat{p}_1}{p_3^* - f_1 p_1^*}\right] - 1 \tag{13}$$

where $\hat{p}_3$ is chosen such that $(\hat{p}_3 - f_1 \hat{p}_1) = (\hat{k}_3 \hat{r} + \hat{l}_3 \hat{w})$. Note that, in consequence, the numerator in the bracketed part of the ERP measure refers to the evaluation of domestic primary factors via the valuation of output and intermediates at actual (rather than shadow) prices; the numerators of (the bracketed term in) ERP and $\mathrm{DRC_V}$ *as also* $\mathrm{DRC_{VI}}$ are therefore identical. However, the denominator in the ERP measure represents value added at international prices and is identical with the denominator of $\mathrm{DRC_V}$ ***but not*** $\mathrm{DRC_{VI}}$.

Now, the relevant question before us is whether, if a project is accepted by our (correctly derived) criterion, it will also be accepted if we were instead to compute the ERP or DRC for it and for the existing activities and then rank it correspondingly vis-à-vis these other activities. In short, would the ERP, and the DRC, be less for an acceptable project (X_3) than for the existing activities (X_1 and X_2)?

To answer this question, note first the fact that, for the existing activities (X_1 and X_2) at first-best *or* second-best *shadow* factor prices, the DRCs must necessarily be unity.[11] It is equally evident that the DRCs at the *private* factor prices will differ from unity. Thus we have DRC_I to $DRC_{IV} = 1$, but DRC_V and DRC_{VI} are not necessarily unity.

By comparing the above with our project acceptance criterion, we then see right away that, if we do have to take the distorted situation as given, the measures DRC_{III} and DRC_{IV} will be unity for the existing activities and less than unity for the project if the project is acceptable. Hence, the DRCs using appropriately derived second-best shadow factor prices (and international-price valuation of the traded commodities) will lead to a correct acceptance/rejection of a project.

However, it is equally evident that neither the DRCs using the first-best shadow factor prices (i.e., DRC_I and DRC_{II}) nor those using private, market prices of factors (i.e., DRC_V and DRC_{VI}) can, as a general rule, lead to the correct acceptance/rejection of the project.[12] In particular, it is clear that the ERP measure, which corresponds to DRC_V, will identically therefore be quite inappropriate to the task.[13]

While therefore ERP is an inappropriate measure to use for project analysis, it may be suggested that it be replaced by a so-called social ERP measure. The only operational implication of such a suggestion would be to convert ERP into (the *correct* criterion) DRC_{III}, that is, to replace the incorrect numerator ($\hat{p}_3 - f_1\hat{p}_1$) in the bracketed term in ERP by the correct numerator ($k_3\hat{r}^* + l_3\hat{w}^*$). But this implies revaluing domestic factors *directly* at the second-best prices, in the manner set out in Section I, whereas the essence of the ERP approach (which was developed in the context of the quite different, "positive," problem of predicting resource-allocational effects of a tariff structure) has always been to arrive at the numerator *indirectly* as the difference between the domestic values of inputs and outputs (yielding equivalently value added at domestic, "private," prices, of course). To derive DRCs, by estimating (as must be

[11] For complexities that arise in this regard, however, when the number of primary factors is less than the number of traded goods, see Bhagwati and Wan (1977).

[12] For an interesting analysis of the problem as to when a project accepted (rejected) by the incorrect use of first-best factor prices would be rejected (accepted) by the correct use of second-best factor prices, see Findlay-Wellisz (1976).

[13] Of course, the choice of a project on the basis of ERP rankings may nonetheless, in specific cases, be a correct choice. In fact, the interested reader may well analyze the conditions under which this will be the case, just as Findlay-Wellisz (1976) have analyzed elegantly the conditions under which the use of first-best shadow factor prices à la Bacha-Taylor (1971) will nonetheless result in a correct choice/rejection of a project.

done) the correct shadow factor prices ($\hat{w}^*$ and $\hat{r}^*$), and then to rechristen them as "social ERPs" is therefore likely to lead to confusion; and, in our judgment, it is best therefore to drop the terminology and concept of ERPs altogether from cost-benefit analysis.

Next, it is also evident that it makes absolutely no difference whether one uses the direct-intermediates measure DRC_{III} or the measure DRC_{IV} where the intermediates are decomposed into the primary factors used up in them; *as long as* second-best shadow factor prices are used for project appraisal, as indeed they should be, the two methods are identical and equally correct. This demonstration, therefore, also seems to bear out Bruno's (1972) rejection of the Balassa-Schydlowsky (1968) contention that this distinction matters: Bruno (1966, 1967*a*) was clearly working within an institutionally (quantity-) constrained framework which therefore yielded second-best shadow prices.

Furthermore, note that if the project analyst were to use the following "hybrid" DRC measure:

$$DRC_{VII} = \frac{k_3\hat{r}^* + l_3\hat{w}^*}{p_3^* - f_1\hat{p}_1} \tag{14a}$$

$$= \frac{k_3\hat{r}^* + l_3\hat{w}^*}{p_3^* - (f_1\hat{k}_1\hat{r} + f_1\hat{l}_1\hat{w})} \tag{14b}$$

then clearly the numerator is correct but the denominator is erroneous; but this clearly is *not* what Bruno (1972) proposes. In fact, this would be precisely the opposite kind of error to that which ERP would imply as a project criterion: for, with ERP, the denominator is correct but the numerator is not.

Finally, the question has been raised in this ERP versus DRC debate: what if the introduction of the garment project *leads* (via a rule for example which requires that domestic fabrics *must* be used) to the licensing and creation of a tariff-protected fabric industry?[14] If such is indeed the case, we should naturally wish to redefine and consider, as a project, the *vertically integrated* project involving *both* the garments and the fabrics that are produced for the garments. And then, the correct project appraisal would be along exactly the same lines as before, with DRC_{III} and DRC_{IV},

[14] Such a rule (or variations thereof) can be found in the context of import-substituting industrialization in many less developed countries. See Bhagwati and Desai (1970) and Bhagwati and Srinivasan (1975) for India, and Bhagwati (1977) for more extended discussion of such rules and the associated policies of "automatic" protection. An early and correct analysis of the implications of such a rule on cost-benefit analysis is in Little-Mirrlees (1969). In fact, Bruno (1962, pp. 112–13, 147) appears to have had the earliest analysis of this "fabric-garment" example!

all using second-best shadow factor prices, providing the correct method for doing project appraisal for this redefined project.

III. Alternative Factor Market Distortions and Second-best Shadow Factor Prices

In this section, we briefly extend our analysis to three standard factor market distortions which trade theorists have analyzed in great depth, deriving second-best shadow prices in each case in the manner set out in Section I. The three distortions are: (*a*) a sector-specific sticky wage;[15] (*b*) a generalized sticky wage;[16] and (*c*) a wage differential between sectors.[17]

Sector-specific Sticky Wage

Consider a typical two-sector model of the Harris-Todaro variety.[18] Here, the minimum wage is set in the manufacturing sector, producing X_2, in terms of X_2 at $\bar{w}$. The workers from the agricultural sector, producing X_1, migrate to the manufacturing sector until the agricultural wage equals the *expected* manufacturing wage. The expected wage is defined as the sticky manufacturing wage, $\bar{w}$, multiplied by the probability of a worker in the manufacturing sector obtaining employment therein. This probability, in turn, is assumed equal to the ratio of actual employment (L_2) in manufacturing to the total labor force there, (i.e., $\bar{L} - L_1$).

Assuming perfect competition and the production functions in the two sectors to be strictly concave functions of employment, and denoting the latter by F_1 and F_2 and the international price-ratio as p_1^*/p_2^* as before, we can now write the Harris-Todaro equilibrium as:

$$F_2'(L_2) = \bar{w} \tag{15}$$

$$\frac{p_1^*}{p_2^*} \cdot F_1'(L_1) = \bar{w} \cdot \frac{L_2}{\bar{L} - L_1}. \tag{16}$$

[15] This distortion was brought into analytical discussion by Harris and Todaro (1970); the "sector specificity" and its critical importance were noted and analyzed in Bhagwati and Srinivasan (1974) and in Srinivasan and Bhagwati (1975).

[16] This is the distortion where the sticky, actual wage exceeds the shadow wage but the sticky wage applies universally across sectors. The major papers on this distortion, initially analyzed by Haberler (1950), are by Lefeber (1971) and Brecher (1974*a*, 1974*b*).

[17] Among the principal positive analyses of the distortion when the same factor must be paid for differentially by different sectors are those by Hagen (1958), Johnson (1966), Bhagwati and Srinivasan (1971), Herberg and Kemp (1971), Jones (1971*a*), and Magee (1976); the welfare analyses are by Hagen (1958) and Bhagwati and Ramaswami (1963). Pearce and Mundlak have made valuable contributions also.

[18] The model as set out in Harris and Todaro (1970) is misspecified on the demand side. See therefore the correct specification, as set out in Bhagwati and Srinivasan (1974) and followed here.

Since the availability of foreign exchange in this model is given by $Z = F_2 + (p_1^*/p_2^*) \cdot F_1$, the second-best shadow price of labor is clearly:

$$\hat{w}^* = \frac{dZ}{d\bar{L}} = \frac{p_1^*}{p_2^*} \cdot F_1' \left[\frac{F_1'}{F_1' - (\bar{L} - L_1)F_1''}\right]. \tag{17}$$

With $F_1'' < 0$ by strict concavity of F_1, and $\bar{L} > L_1$, we then see that the second-best shadow wage for labor is less than the agricultural wage which, in turn, is less than the manufacturing wage. Note also that the shadow wage is positive, instead of zero, despite the unemployed labor; this is because any withdrawal of labor from the labor force ($\bar{L}$), while initially reducing unemployment, will simultaneously raise the expected wage in manufacturing and hence result in reduction of agricultural employment and output.

The foregoing analysis assumes that the employment (at whatever wage rate) in the project has no impact on the expected wage in the manufacturing sector except insofar as it affects the manufacturing labor force. Thus writing ε as the employment in the project and η as the resulting migration from agriculture, the expected wage in the manufacturing sector after migration is $\bar{w}L_2/(\bar{L} - \varepsilon) - (L_1 - \eta)$ which is equated in turn to the agricultural wage $p_1^*F_1'(L_1 - \eta)$. However, if we were to assume that the project laborers are employed at some wage, w^p, and that project employment at this wage affects the expected wage in the manufacturing sector, the latter would be $wL_2 + w^p\varepsilon/\bar{L} - (L_1 - \eta)$ which again is equated to $p_1^*F_1'(L_1 - \eta)$. Solving the latter for η and noting that the shadow wage is the loss in agricultural output per unit of project employment, that is, $p_1^*F_1'(\eta/\varepsilon)$, we get shadow wage $= (w^p \cdot F_1')/[F_1' - F_1''(\bar{L} - L_1)]$. In the case where $F_1'' = 0$, this reduces to w^p, the wage paid to the project laborer. If we make the further assumption that $w^p = \bar{w}$, that is, the project employs labor at the manufacturing wage, the shadow wage equals the manufacturing wage: a highly special case, as we have just shown, but one which has been focused upon in the standard cost-benefit analysis of the Harris-Todaro model.

Generalized Sticky Wage

Shift now to the model where the wage is sticky across the two sectors at the level $\bar{w}$. Assuming then that commodity X_2 is capital-intensive, that is, $(K_2/L_2 > K_1/L_1)$, we now get:

$$\frac{F_2}{L_2} - \frac{K_2}{L_2} \cdot F_2^K \geq \bar{w} \tag{18}$$

$$\frac{F_2}{L_2F_2^K} - \frac{K_2}{L_2} = \frac{F_1}{L_1F_1^K} - \frac{K_1}{L_1} \tag{19}$$

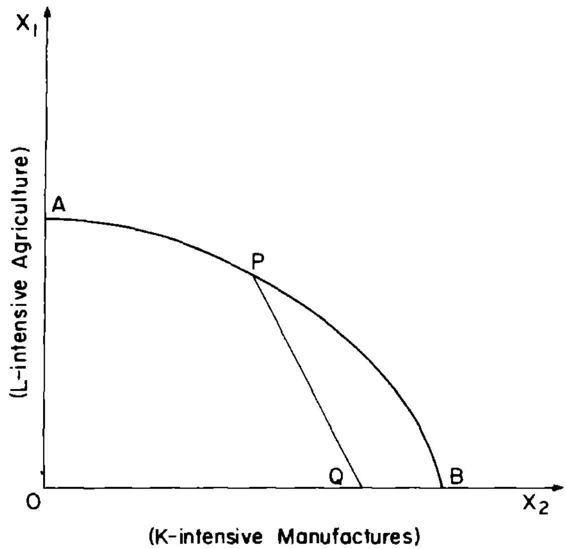

FIG. 4

where F_1^K, F_2^K, F_1^L, and F_2^L are the partial derivatives with respect to K and L, respectively; that is, they are marginal products of capital and labor; and F_2/L_2 and F_1/L_1 are the average products of labor in production of X_2 and X_1, respectively.

We can then see that, in terms of figure 4, the production possibility curve is APB, P representing the point at which $(F_2/L_2 - K_2/L_2 \cdot F_2^K) = \bar{w}$. At points to the left [right] of P, $(F_2/L_2 - K_2/L_2 \cdot F_2^K) > [<] \bar{w}$. It is evident then that, with the minimum wage constraint, the feasible production possibility curve will be APQ where PQ is the Rybczynski line (for variations in labor) and, at points on PQ other than P, there is unemployed labor. Let the capital-labor ratios at P then be $\bar{K}_2/\bar{L}_2$ and $\bar{K}_1/\bar{L}_1$.

Now, when the international price-ratio p_1^*/p_2^* yields tangency along AP, the market and shadow wages will be naturally identical, and will exceed $\bar{w}$ if the tangency is off P. For the price-ratio tangent to APB at P, the production equilibrium however may be anywhere between P and Q, the different production equilibria implying different labor availabilities. Therefore, for this tangential price-ratio, the shadow and actual wages will be $\bar{w}$ for production at P, whereas the actual wage will be $\bar{w}$ but the shadow wage will be zero for points other than P on PQ.[19] Finally, for all commodity price-ratios steeper than the price-ratio tangent at P, there

[19] At points other than P on PQ, furthermore, the shadow rental of capital will be the *average* product of capital in X_2 at P along the curve APB, rather than its market value which will equal the marginal product.

will be complete specialization on X_2 at Q and the corresponding actual wage will be $\bar{w}$ while the shadow wage will be zero.[20]

Hence, unlike in the sector-specific wage stickiness case, the unemployment of labor can indeed be taken to imply a zero shadow wage for labor. However, associated with this, the shadow rental of capital will exceed its market rental, so that the standard prescription of putting the wage of unemployed labor equal to zero but using the market rental of capital is wrong.

The Wage-Differential Case

Take, finally, the distortion where the wage in X_2 is a multiple λ of that in X_1. In this case, it is well known that the production possibility curve will shrink to AQB, in figure 5. Furthermore, AQB need not be concave to the origin, the market equilibrium need not be unique for any commodity price-ratio, and the commodity price-ratio will not equal the marginal rate of transformation along AQB.[21]

Let the market equilibrium in the initial, distorted situation be at Q. Then, we can derive the two Rybczynski lines, QB' (for variations in labor availability) and QA' (for variations in capital availability), assuming as earlier that X_2 is capital intensive.

Now, the international price-ratio equals the ratio of *marginal* products of capital in producing X_2 and X_1 with the techniques corresponding to Q (i.e., $p_1^*/p_2^* = F_K^2/F_K^1$, the latter derivatives as at Q). On the other hand, the slope of QB' (measured against the vertical axis) will equal the ratio of the corresponding *average* products.

It follows then that the international price-line would be flatter than QB' and steeper than QA', given the capital intensity of X_2 relative to X_1, provided there were no wage differential λ. However, in the presence of the wage differential, the international price-line may well be steeper (flatter) than $QB'(QA')$, with the wage in X_2 exceeding that in X_1 by factor $\lambda(>1)$, the condition for this "reversal" of relative slopes of the price-ratio and the Rybczynski line being that X_2 ceases to be capital intensive relative to X_1 if the factor intensities are compared on a *differential-weighted* basis.[22]

It is then easy to see that, as in Section I, the second-best shadow wage of labor, that is, $[p_1^*(\bar{K}_2/F_2) - p_2^*(\bar{K}_1/F_1)]/[(\bar{K}_2/F_2)(\bar{L}_1/F_1) - (\bar{K}_1/F_1)(\bar{L}_2/F_2)]$, or the shadow rental on capital, that is, $[p_2^*(\bar{L}_1/F_1) -$

[20] At Q also, the shadow price of capital will continue to be the average product of capital in manufacturing at point P, since at Q only the manufactured good, X_2, is produced using all the available capital and the same technique as at P.

[21] For these and other pathologies, see Bhagwati and Srinivasan (1971) and Magee's excellent survey (1976).

[22] Jones (1971*a*) calls the differential-weighted intensities the "value" as against the Samuelsonian "physical" factor-intensities.

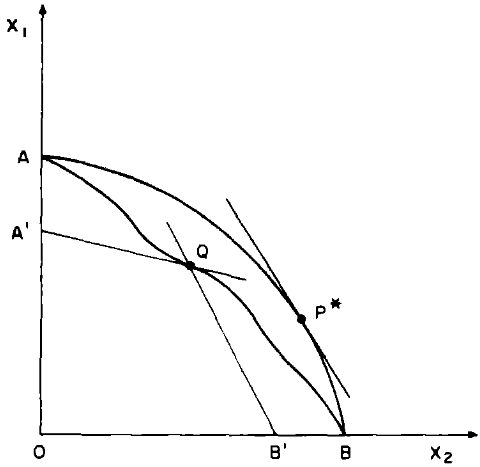

FIG. 5

$p_1^*(L_2/F_2)]/[(\bar{K}_2/F_2)(L_1/F_1) - (\bar{K}_1/F_1)(L_2/F_2)]$, will be negative when such reversal of relative slopes exists; and, once again, the Findlay-Wellisz procedure of deriving shadow prices would yield an incorrect zero wage (rental).

IV. Concluding Remarks

A few concluding observations are in order. First, while our results on project appraisal have been shown to be successfully convertible into appropriately defined DRCs, this is not the same thing of course as having shown that these were precisely the DRC definitions (as against the many others that we have distinguished) that one or more of the DRC proponents, in the project-appraisal debate among the DRC and ERP proponents, had in mind.

Second, while we have confined our analysis to "small" projects, drawing infinitesimal resources away from the existing distorted situation, it is equally clear from our analysis that the results will hold also for "large" projects. Given the Rybczynski-line properties of the different models, the shadow prices of factors will be identical for small and large shifts of factors into the project.[23]

Third, we might as well note explicitly that our analysis could be extended to models involving nontraded goods; this would permit the introduction of the real exchange rate in a meaningful manner into the

[23] On the analysis of the possibility of such "stationarity" of the "marginal-variational" shadow factor prices, in more general models with many goods and factors, see Bhagwati and Wan (1977).

analysis. The extension to models with sector-specific factors is not merely readily done;[24] it will however introduce no special insights that qualify what has been learned from the present paper.

Fourth, note that we are implicitly assuming that, in respect of projects which will be chosen under shadow prices but *not* under actual market prices, the resulting losses are covered in some nondistortionary way. However, if the losses can be covered only by some form of distortionary taxation, then the shadow prices (for both inputs and outputs) have to be calculated reflecting this fact. *Alternatively*, our analysis can be held to apply without modification to the case where the planning authorities are investigating the social profitability of a private project which is commercially viable at market prices. In this instance, if social profitability is absent, the planning authorities can decide to eliminate the activity by prohibiting it, and the revenue problem does not arise.

Fifth, note also that we evaluated the project at a given technique. Thus, if a project can exploit alternative techniques, from which entrepreneurs would choose the cost-minimizing one, then the revenue problem will arise *also* because a suitable factor-use tax-cum-subsidy will have to be provided so that the "correct" technique (i.e., that using coefficients k_3, l_3, and f_1 if the project X_3 has been shown to be socially profitable) is chosen.

Finally, it is also clear that implicit in our analysis is the assumption that problems of income distribution and savings can be tackled through deployment of appropriate nondistortionary instruments. Obviously, if this is not possible, the shadow prices will have to be calculated afresh by introducing additional constraints which reflect the feasible set of public policy instruments.

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[24] For example, the latter is done readily, using the Jones (1971*b*) model where each of two sectors has a specific factor. The project (X_3) can then be thought of as drawing one or both of these specific factors and/or the mobile, nonspecific factor(s) from the existing, distorted situation.

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