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Domestic Resource Cost*

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Abstract

This paper resolves several points about proper use of the domestic resource cost (DRC) concept. It explores its relationship to the effective rate of protection, resolves the conflict between differing views of the DRC, generalizes it, and argues that the DRC depends on the assumptions made about the hypothetical policy intervention and adjustment mechanisms, so these should always be specified along with any DRC calculation. Finally, DRCs are argued to be only some of many potentially useful cost/benefit ratios that a general equilibrium model will generate, and a plea is made for more frequent use of such models in cost/benefit analysis.

I. Introduction

Domestic resource cost (DRC) is frequently used as a tool of cost/benefit analysis in less developed countries, both to appraise hypothetical projects and to evaluate the costs of using protection to maintain existing industries. This paper attempts to resolve a number of points relating to the concept of the DRC. It

1. explores its relationship to the effective rate of protection (ERP),
2. resolves the conflict between the Srinivasan-Bhagwati [1978] and Corden [1984]-

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Krueger [1984] views of the DRC,
3. generalizes the DRC concept in order to use it for cost/benefit analysis of non-traded sectors,
4. argues that the DRC is a product of the assumptions one makes about the hypothetical policy intervention and the adjustment mechanisms which prevail in the economy, so it is worthless to present a DRC for a sector without specifying the conceptual model which lies behind the calculation, and
5. make a case that DRCs are only one set of the many sensible cost/benefit ratios that one might wish to calculate. The final section is a detailed summary which also serves as a readers' guide to the paper.

II. The DRC, the Activity Cost/Benefit Ratio and Cost/Benefit Analysis

The shadow price of an item is the social value of endowing the private sector with one more unit of it.[1] We define a project as the net sale of a set of items by the government (more rigorously an exogenous sector as discussed in Dreze and Stern [1986]) to the private sector (more rigorously the endogenous sector). Thus the shadow value or net social product of a project is the sum of the items it provides (net) to the private sector each weighted by its shadow price. A project is desirable if and only if its shadow value is positive. This is the sole appropriate criterion for evaluating projects. Another way to write this relationship is: the shadow value of the project is equal to the shadow value of its net output of goods, V^s, minus the shadow value of its net use of factors, L^s, where the shadow value of the net output of goods is the shadow value of the output minus the shadow value of the intermediate inputs used up. In the usual (but not general) case where V^s is positive we can rewrite the project evaluation criterion as the project is desirable if and only if the activity cost/benefit ratio, which we define as ACBR$=L^s/V^s$ is less than 1, and we define our *activity* as converting primary factor services into net output. In the special case where the outputs and intermediate inputs are all traded at fixed world prices their shadow prices expressed in Little-Mirrlees (foreign exchange) numeraire are world prices, and the ACBR is referred to in the literature as the DRC. In early work on the

1. For an introduction to shadow pricing see Tower [1991].

DRC, L^s was expressed as a shadow value in utility numeraire, while in later work, starting with Srinivasan and Bhagwati [1978], L^s has also been expressed in foreign exchange numeraire, so that the project selection criterion is simply that the DRC be less than 1.[2]

This discussion boils down to the fact that the DRC has in the numerator the social value of resources used up in order to perform an activity and in the denominator the social value of net outputs produced by the activity. Thus, it is a special case of the activity cost benefit ratio, and it is helpful to present the DRC as such in order to focus attention on the idea that a DRC type concept can be used to evaluate any activity regardless of which items are traded or non-traded. Rather than try to popularize a new term like *generalized DRC* or *ACBR*, throughout the paper we will refer to all cost benefit ratios which have the shadow values of primary resources used up in the numerator and shadow values of net outputs in the denominator as DRCs.

III. The Srinivasan-Bhagwati Analysis of an Economy with Traded Goods Only

Srinivasan and Bhagwati [1978], henceforth SB, ask to what extent the ERP is a reliable guide to cost benefit analysis in a world where all goods are traded at fixed world prices. They conclude [p. 107] that in the presence of distortions, the ERP is inappropriate to the task of project selection and that the correct criterion is the DRC. Bhagwati and Srinivasan [1980] explore the problem further and come up with two special cases in which the use of ERPs will yield the correct decision that appropriately defined DRCs inevitably yield. They conclude that in the absence of non-traded goods and in the presence of fixed world prices, no quantitative restrictions on trade, and constant returns to scale, a project necessarily will be beneficial (harmful) if there exists a critical ERP level, ERP^c, such that in response to implementation of the project no good with a higher (lower) ERP experiences an expansion in its production, and no good with a lower (higher) ERP experiences a contraction. In sections III-V of this paper, we argue that either the DRC or the ERP is an appropriate tool for project selection, and we

2. On the alternative shadow pricing concepts, see Fane [1991b].

generalize the Bhagwati-Srinivasan [1980] argument to cover cases where no critical ERP separates the expanding and contracting industries.

The only difficulty is that if one uses effective protection, one must know and use data on the ERPs for each of the sectors whose production is affected by the expansion of the sector in question (call it the zeroth) as well as the extent of resource movements in and out of these sectors. However if one chooses instead to use the DRC route, all of the relevant information about ERPs in sectors other than the zeroth, and resource flows elsewhere in the economy per unit of resources attracted into the zeroth sector, will be subsumed in the shadow prices for the resources. Thus, in calculating the DRC for the zeroth sector, it is not necessary to look at resource flows and ERPs elsewhere in the economy. Clearly, if many projects are to be evaluated, it is computationally more efficient to calculate shadow prices for domestic resources, and use these to calculate DRCs, than to calculate a batch of differentially weighted ERPs for each sector. But logically, the two approaches are equivalent.

We follow SB in assuming all goods are traded and that there are no quantitative restrictions on trade, so that relative prices of all goods to consumers are fixed; output is taken to be a constant returns to scale (CRS), fixed proportions function of intermediate inputs and a value added aggregate, where this aggregate is itself a CRS (but not necessarily fixed proportions) function of capital and labor. Also, we assume world prices are fixed and the only distortions we permit are those assumed by SB: import tariffs, export subsidies, sticky factor prices and factor price differentials, which may reflect themselves in Harris-Todaro type unemployment. Finally, like SB, we assume competition except for those factor price differentials and sticky factor prices.

We follow SB in defining the domestic resource cost in sector zero, DRC_o, as

$$DRC_o = \frac{k_o r^s + \ell_o w^s}{p_o^* - \sum_i p_i^* a_{io}}$$

where

P_i^* is the world price of commodity i;

a_{io} is the physical input/output coefficient showing the amount of good i used to produce a unit of good 0, using home technology;[3]

3. We differ from SB in that we have assumed multiple tradable inputs, whereas they assumed just one. We did this in order to be consistent with much of the other literature.

k_o and l_o are the physical input/output coefficients in sector *0* for the primary factors, capital and labor. (Thus, in the particular model assumed by SB, where relative factor prices and goods prices are fixed, they are the amounts of capital and labor used to produce an additional unit of good *0*.);

r^s and w^s are the Little-Mirrlees shadow prices of capital and labor respectively, where by Little-Mirrlees shadow price, of a factor or good, we mean the amount of foreign exchange which could be withdrawn from the economy in response to a unit increase in the economy's endowment of the factor or good and still leave domestic utility unchanged, given all of the incentives like taxes and tariffs in place.

Thus, we have in effect defined the DRC as the foreign exchange value of the incremental primary factors attracted to the sector divided by the foreign exchange value of the change in the sector's net output, i.e., the foreign exchange saved or earned in the sector as a result of the net change in the production of tradable goods in the sector. Defining everything in units of foreign exchange means that the project will be found to be desirable if and only if the DRC is less than unity.

The ERP for sector i is defined as

$$v_i=[1+ERP_i]v_i^* \tag{2}$$

where v_i and v_i^* are unit domestic value added in sector i at domestic and international prices, respectively.

By definition,

$$v_o^*=p_o^*-\sum_i p_i^* a_{io} \tag{3}$$

and

$$v_o=k_o r_o+\ell_o w_o \tag{4}$$

where r_o and w_o are the wage and rental rates actually paid in sector *0*, so that *unit value added at domestic prices* represents the cost (at domestic prices) of the primary factors used up in order to produce an extra unit of good *0*.

IV. Modeling

Combining equations (1)-(3) yields

$$DRC_0=[1+ERP_0]\ [k_0r^s+\ell_0w^s]\ /\ v_0 \tag{5}$$

World prices and prices to consumers measured in units of foreign currency are fixed. Thus, the private sector's budget constraint will be described solely by the amount of foreign exchange which consumers have to spend, which (given no government spending) will be equal to domestic value added at world prices minus any growth in foreign exchange reserves. We make one of the assumptions discussed in Tower, Pursell and Han [1987] that allows us to define community indifference curves, and we assume away inferior goods so that domestic utility is an increasing function solely of the distance of the community's budget constraint from the origin. Thus, to hold domestic utility constant, the government must absorb as reserves foreign exchange equal to any change in domestic value added measured at world prices. This means that our previous definition of the shadow price of a factor (see the definitions of r^s and w^s) leads to an alternative definition in this special case. Namely, the shadow wage rate can be defined as the increase in domestic value added at world prices that results from a unit increase in the economy's endowment of labor.[4] Thus,

$$w^s=\sum_{i=1}^{N} v_i^*\left[\frac{\partial X_i}{\partial L_i}\frac{dL_i}{d\bar{L}}+\frac{\partial X_i}{\partial K_i}\frac{dK_i}{d\bar{L}}\right]$$

where

$d\bar{L}$ is a *small* increase in the economy's endowment of labor,

X_i is output of good i,

$\partial X_i/\partial L_i$ and $\partial X_i/\partial K_i$ are the marginal products of labor and capital respectively in sector i, allowing intermediate inputs to vary,

$dL_i/d\bar{L}$ and $dK_i/d\bar{L}$ are respectively the increases in labor and capital allocated to sector i per unit increase in the economy's endowment of labor.

We sum from *1* to N because there are N goods initially produced and we assume that good *0* is not profitable at market prices. Hence it is not produced in small perturbations about the initial equilibrium without government intervention. Since factors are paid the value of their net marginal products

4. More specifically, $\bar{K}$ and $\bar{L}$ are the amounts of capital and labor in the economy which are allocated to the private sector, i.e., not allocated to government projects.

$$w_i = v_i \frac{\partial X_i}{\partial L_i} \tag{7}$$

and

$$r_i = v_i \frac{\partial X_i}{\partial K_i} \tag{8}$$

Combining (2), (6), (7) and (8) yields

$$w^s = \sum_i \frac{dR_i/d\bar{L}}{1+ERP_i} \tag{9}$$

where $dR_i/d\bar{L} = w_i dL_i/d\bar{L} + r_i dK_i/d\bar{L}$ and $dR_i/d\bar{L}$ is defined as the value in units of domestic currency of resources (i.e., primary factors) attracted to industry i, per unit of increased labor endowment, with these resources evaluated at the wages and rentals paid in sector i. Equation (9) makes intuitive sense when we realize that efficiency occurs when the value of output at world prices is maximized and $1+ERP_i$ is the proportion by which resources in sector i are overvalued in the domestic market place, for it is the proportion by which the marginal net product of primary factors in sector i at domestic prices exceeds the marginal net product at world prices.

By analogy, we have for capital

$$r^s = \sum_i \frac{dR_i/d\bar{K}}{1+ERP_i} \tag{10}$$

where $dR_i/d\bar{K} = w_i dL_i/d\bar{K} + r_i dK_i/d\bar{K}$

V. Conclusions: The Relationship between the ERP and the DRC

Substituting (9) and (10) into (5) yields

$$DRC_0 = [1+ERP_0] \sum_{i=1}^{N} \frac{\lambda_i}{1+ERP_i}$$

where $\lambda_i = \dfrac{k_0[dR_i/d\bar{K}] + \ell_0[dR_i/d\bar{L}]}{v_0}$

Since unitary expansion of sector 0 involves withdrawing k_o units of capital and l_o units of labor from the rest of the economy, λ_i is the value of resources drained from sector i per unit value of resources attracted to sector 0.

Equation (11) is the relationship between the DRC and ERPs, and as such it indicates the appropriate use of ERPs in project evaluation. Moreover, it helps clarify the meaning of the DRC, as the examination of some special cases indicates.

If all ERPs are the same, $DRC_0=\sum_{i=1}^{N}\lambda_i$. If there are no factor market distortions, $\sum_{i=1}^{N}\lambda_i=1$, because each dollar's worth of resources transferred into one sector is drawn from some other sector. These two assumptions together mean that $DRC_o=1$, and the project is on the borderline of acceptability.

If wages are higher in the project than elsewhere in the economy, but no Harris-Todaro unemployment is generated, the value of resources expelled from other sectors will be less than that of those attracted to 0, $\sum_{i=1}^{N}\lambda_i<1$, and if all ERPs are equal the project should be accepted. However, if the project creates a great deal of Harris-Todaro unemployment $\sum_{i=1}^{N}\lambda_i>1$, and the project should be rejected. Similarly, high taxes on value added in certain sectors which supply resources combined with after-tax equality of wages and rentals will lead to $\sum_{i=1}^{N}\lambda_i>0$, and hence project rejection.

Also, if there are no factor market distortions, so $\sum_{i=1}^{N}\lambda_i=1$, the project should be accepted if and only if its ERP is small relative to the ERP of the sectors which supply resources to it, and in the special case of only one supplying sector, the project should be accepted if the ERP is less than that of the supplying sector.

It should be noted that so far we have concluded nothing that SB would disagree with. We have just chosen to look at their model in a different way, which we believe clarifies the issue of the role of the ERP in DRC calculations.

VI. The Case of Only One Mobile Factor of Production[5]

There is one special case in which there will be a correlation of +1 between the DRCs and ERPs attached to proposed new activities.[6] That is when there is only one mobile factor, and it has a positive shadow price. Here, the DRC of the 0-th project is still given by (11), but the λ_i's in (11) will be the same

5. This section follows from a discussion with Neil Roger.

6. Fane [1991a] has independently proven the same point.

regardless of what new sector the labor is being drawn to.[7] Such a model might be a reasonable first approximation to reality in the short run if over that time horizon the capital stock is assumed to be immobile between sectors.[8] In this case, there will be some critical ERP which separates good projects from bad.

VII. More than Two Factors of Production

We have chosen to follow SB in postulating two mobile factors of production but have departed from them in assuming that the private sector produces many traded goods instead of just two. The reason they assumed just two goods is so that with constant returns to scale and only two factors of production which are mobile the pattern of production would be determinate with no further constraints on the system (see Bertrand [1979] and Bhagwati and Wan [1979]). Implicitly, we are pretending that the government's incentives (perhaps progressive value added taxes on a sector by sector basis) or else the presence of immobile factors or else the presence of more factors than traded goods sectors are sufficient to maintain the determinancy of resource allocation.

Our equation (11) relating the DRC to ERPs would be valid regardless of the number of primary factors postulated. The only problems are that the more factors and goods there are, the larger the matrix that one must invert in order to obtain resource flows and hence shadow prices and that in the presence of more factors than traded goods produced in the private sector factor prices will alter when new projects are undertaken, which will alter income distribution. Thus, we need one of the four assumptions discussed in Tower, Pursell, and Han [1987] to avoid reckoning with income distribution, i.e., to make social welfare a function solely of the location of the economy's consumption budget constraint.[9]

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7. This is obvious since there is only one factor to shadow price in the numerator of the expression. The relationship is DRC = [ERP + 1] w^s/w where w^s and w are the shadow price and market price of the mobile factor, respectively.
8. Of course, if $w^s < 0$ (say because labor is being withdrawn from a sector with negative value added at world prices) the correlation between the DRC and ERP will be -1. On the impossibility of negative shadow prices when the government is investing in its optimum set of projects see Lucas, Pursell and Tower [1987].
9. This is a caveat to the propositions I and II on p. 209 of Bhagwati-Srinivasan [1980], which the authors, like Maneschi [1986], failed to mention.

VIII. Non-Traded Goods

If there are no more factors of production than traded goods, constant returns to scale, and all factors of production are used in different proportions in producing the traded goods, the fixed world prices for traded goods will freeze the domestic factor prices, which in turn will freeze the prices of non-traded goods. Consider an example where primary factors plus traded iron and non-traded coal are used to produce traded steel, and where coal is produced using primary factors along with traded shovels. In this circumstance, introducing non-traded goods doesn't change our analysis at all. One could simply work with integrated industries in the *sophisticated* Corden fashion.[10] This DRC gives the cost benefit ratio for using primary factors to change the net output of traded goods. In our example, it gives the cost benefit ratio for using primary factors (say labor and capital) in coal and steel to convert iron and shovels into steel. Alternatively, one could work with the disaggregated industries, but define the DRC in one of two different ways.

The first alternative would be to leave the numerator as before, defined as the amounts of primary factors directly employed in producing the good evaluated at shadow prices which would be used, while the denominator would be the increase in output minus the increases in the intermediate inputs used by the project, all evaluated by their shadow prices.[11] In this case the DRC would be the cost benefit ratio for using primary factors to convert iron and coal into steel. The second alternative would be to treat the non-traded goods just like the primary factors of production, and place them in the numerator instead of the denominator. In this case the DRC would be the cost benefit ratio for using coal and primary factors in steel to convert iron into steel.

Regardless of which of these methods one used, assuming the denominator is positive, there is a positive net social benefit associated with the project if and only if the DRC is less than one. This is because the numerator is the social cost associated with using up those good and/or factors which enter the numera-

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10. For discussion of this, see for example, Tower [1984]. This corresponds to the gross DRCs and ERPs discussed in Srinivasan-Bhagwati [1978, section II].
11. More generally, if this were a project which used inputs to produce various outputs jointly, the denominator would simply be the sum of the increases of net outputs of these various inputs and outputs, each evaluated at its shadow price.

tor while the denominator is the social benefit from producing the net changes in quantities of those things which enter the denominator. Of course, shadow prices and effective protection may be negative, and to reckon with that case, it is necessary to modify our project selection criterion to be: select the project if and only $D-N>0$ where D is the denominator and N is the numerator of the DRC ratio. When $D>0$ this boils down to the familiar $DRC=N/D<1$, but when $D<0$ it becomes $DRC=N/D>1$.[12]

Once we relax the assumption that the prices of non-traded goods are fixed our earlier conclusion that the DRC is a weighted sum of ERPs breaks down, because withdrawing goods and factors will cause the relative prices faced by consumers to alter. This means that social welfare will no longer be a function of the economy's net output at world prices, and this must be reckoned with in calculating shadow prices. However, even in this circumstance we can still use the DRC ratio to assess whether or not activities which produce and/or use up non-traded goods should be encouraged at the margin. It is only necessary that we evaluate all factors and goods used or produced at their shadow prices, which will be somewhat harder to calculate, and for the purpose we would need to use the approach advocated in chapter V of Tower [1984] and Tower [1992b] which involves the flow of consumption across final demand distortions as well as primary factors across production distortions.

IX. How to Use the DRC

It is not possible to use the DRC for ranking industries from most desirable to least desirable, because as argued in section VIII, it is arbitrary how one defines an activity. For example, suppose that making steel requires mining coal domestically. One could either calculate the DRC for steel or the DRC for the steel and associated coal mining combined where the former DRC would be calculated using a shadow price for coal which reflects its actual source of supply.

There is a second reason why such a ranking would not be productive. As resources are coaxed into one sector out of others through changes in incentives or government activities, the shadow prices of those goods and factors which

12. This discussion was drawn from Pursell and Papageorgiou [1980].

are not frozen by fixed world prices will alter, so that to evaluate the costs and benefits of further adjustments, further DRC calculations would be needed. Thus, to conclude, except under extraordinary circumstances DRC is a cost benefit ratio only for marginal changes, and all we can say with precision is that a small expansion (contraction) of any industry with a DRC which is less than (exceeds) unity is desirable (undesirable), and that our target should be to implement a set of projects such that no prospective project has a DRC less than 1 and no existing project has a DRC greater than 1.[13]

X. The DRC and the Adjustment Mechanism Assumed

Srinivasan and Bhagwati [1978, p. 107] note that assuming the equilibrium is unique, for existing activities DRCs must necessarily be unity.[14] As Bertrand [1979] notes, this is because if the government uses exactly the same technology as the private sector a project consisting of expanding the output of good i in a government firm, will have the effect of drawing all of its resources from the private sector's production of good i, and leave the economy's product mix the same as before. In terms of our mathematics, if sector *1* were already producing, and we calculated DRC_1, we would recognize that $\lambda_1=1$ with all other λ's equal to zero, which clearly would give us $DRC_1=1$.

This is not surprising for as SB note, Diamond and Mirrlees [1976] have shown: for a product which is produced with constant returns to scale and under competitive conditions, if the government takes over some of the private sector's production by withdrawing inputs and producing output in the same proportions that the private sector had been previously using no levels of outputs or inputs or prices will alter. This will leave welfare unchanged which means that the shadow price of the output must equal the value of the inputs at shadow prices. Another way of saying this is that the shadow value of the resources needed to perform

13. For a discussion of the general impossibility of ranking mutually exclusive projects by DRC when the shadow exchange rate is unknown and shadow prices of factors are expressed in utility numeraire, see Warr [1983].
14. SB [1978, p. 107] are incorrect when they write that the DRCs at first-best shadow prices for existing activities must be unity. The correct statement is that the DRCs at first-best shadow prices for activities which would exist in the first best equilibrium must be unity.

the activity will be equal to the shadow value of the activity's net output, which implies that the DRC is unity.

While the logic behind this point is incontrovertible, this result is certainly at variance with the DRC calculations as typically applied. For example, Krueger [1966] finds that DRCs for activities performed by the private sector in Turkey varied between 1.07 and 1.60.[15] Suppose we view the adjustment mechanism that is causing the increased output to be a small increase in the value added subsidy in the sector in question, so use of the calculus is legitimate. Then the appropriate measure of net benefit would be the marginal social value (MSV) of that subsidy multiplied by the proposed change in the subsidy, as discussed in Tower [1991].

An alternative method which will yield the same result is to calculate the net changes in the sector's factor inputs and goods outputs that will result from the subsidy. Then imagine that the government takes over operation of the sector from the private economy (which as noted above involves no changes in prices, inputs or outputs). Next calculate shadow prices for goods and factors holding the sector's inputs and outputs fixed. Finally weighting changes in the sector's net outputs of goods and factors by their shadow prices will give the same measure of net benefit as multiplying the MSV of the subsidy by the proposed change in the subsidy. Moreover, one could then define the DRC as the sum of the shadow-price weighted changes in factor inputs divided by the sum of the shadow-price weighted changes in net outputs of goods from the industry in question, and the project should be undertaken if and only if the $DRC \leqq 1$. Such an approach is consistent with the discussions of DRCs by Bruno [1972], Krueger [1966; 1972] and Balassa-Schydlowky [1968; 1972]. Note that the DRC calculated thusly will depend on the set of instruments which the government uses to intervene and the adjustment mechanisms which prevail in the economy,[16] so it is unhelpful to present a DRC for a sector without specifying the conceptual model (i.e., the policy perturbation and the adjustment process) which lies behind the calculation.

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15. Also, Krueger [1984, p. 540] writes "Usually, they [DRCs] are used when the intention is to infer the cost of the protective structure directly from the estimates."

16. The one exception is if the economy were initially distortionless, so that incremental changes in distortions have a zero first order impact on welfare. In such a case the DRCs calculated in this way would always equal one.

XI. Making Sense of the Corden-Krueger View of the DRC as Expounded in the Handbook of International Economics[17]

Both Corden [1984, p. 103] and Krueger [1984, p. 540] in their essays in the *Handbook of International Economics* and also Bliss [1987] have argued that if there are no distortions other than tariffs and quotas on international trade that DRCs are identical to effective rate of protection coefficients (ERPCs), where the EPRC is defined as 1 + the ERP.[18] As I noted in my (Tower [1986]) review of the volume, this contradicts the SB view. Is there an assumption which allows the Corden-Krueger analyses to be logically consistent? The main purpose of this section is to argue that a sufficient assumption is that all trade barriers consist of exogenously determined quotas. The ancillary purpose is to present three applications of the DRC idea. As in much of the rest of the paper, we assume that all internationally traded goods are traded at fixed world prices. We also assume that all import and export licenses are auctioned off.

A. Corden-Krueger Application 1: Using the DRC to Evaluate a Small Project

Suppose the government is contemplating a project which uses primary factors of production to produce a set of net outputs which it buys or sells on world markets. If there are no home tariffs and the only home restrictions which apply to international trade are quotas on some private sector imports and exports, then in the absence of domestic distortions, including distortionary taxes levied for revenue purposes, as Bhagwati and Srinivasan [1981] note shadow prices of primary factors will equal market prices. Therefore, the DRC will equal the ERPC and will measure the ratio of the social value of the primary factors used up in

17. For the discussions of shadow pricing on which this section is based, see Dixit [1985], Dreze and Stern [1986], Tower [1984], Tower [1991], and Tower and Pursell [1986, 1987].

18. Corden [1984, p. 103] writes "ERPs normally take into account all policy-induced distortions affecting the tradable sector directly, notably tariffs, export taxes and subsidies, input quotas, and perhaps consumption taxes and subsidies on inputs as well as production taxes and subsidies. If there are no other distortions a DRC calculation will yield the same result." Krueger [1984, p. 540] writes "If factor markets functioned well, DRC estimates would be identical with ERP estimates plus one..."

the project to the social value of the foreign exchange it generates.[19, 20] It should be noted that the DRC of this project need not be unity even if the private sector is initially using the same technology to produce the same good, because of our assumption that the government activity engages in international trade at the margin whereas the private sector activity does not buy all of its inputs and sell all of its outputs on world markets.

B. Corden-Krueger Application 2: Using the DRC to Evaluate a Finite Change in the Size of a Sector

Now let us build a model in which the DRC measures the desirability of excising an entire large sector. We consider an economy with both import and export quotas and import or export taxes. We want market and shadow prices to be fixed. We achieve this by assuming equality between the number of primary factors of production and the number of sectors using solely primary factors and traded intermediate inputs which are not subject to quotas to produce output which is not subject to a quota. This means that the pattern of production is determinate and all domestic prices of factors will be invariant with respect to small changes in initially binding quotas (see Bertrand [1979]).

Suppose that the government contemplates liberalizing imports of good *0* and restricting imports of zero's intermediate inputs by enough to eliminate the sector entirely, where there are initially binding import quotas on all goods sector zero uses as inputs and on its output. Competition will have driven profits in the sector to zero. We assume that the sector is small, in the sense that it faces given domestic prices for its primary factors of production, regardless of its level

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19. More generally, with domestic distortions, distortionary taxation and tariffs (since factor shadow prices are expressed in foreign exchange numeraire) the DRC will continue to measure the ratio of the social value of the primary factors used up in the project to the social value of the foreign exchange it generates.

20. Fane and Jones [1989, p. A10] make a similar point in their section "DRCs When All Trade is Licensed." They note that in this case "shadow prices are market prices and the best decision rule for the bureaucrats is to allocate each dollar of foreign exchange to the imports with the highest NRPs [nominal rates of protection]. Similarly, if investment decisions are also controlled by licensing committees, the licenses should be allocated to the projects whose profitability at market prices is greatest."

of production. This implies that an infinitesimal reduction in its unit value added at domestic prices will obliterate it. Thus, if the *liberalization* takes the form of increasing permissible imports of good zero and decreasing permissible imports of its intermediate inputs to just match initial supplies and demands in the zeroth sector, the zeroth sector will entirely disappear, and its primary factors will disburse themselves to the rest of the economy with no price changes anywhere in the economy.

The quota adjustment can be thought of as a project that creates the bundle of its intermediate inputs to just match initial supplies and demands in the zero-th sector, the zero-th sector will entirely disappear, and its primary factors will disployed in sector zero disburse. The social value of the project measured in foreign exchange numeraire, F, is value added at shadow prices, V^s, minus value added at world prices, V^*:

$$F = V^s - V^*. \tag{12}$$

By Diamond-Mirrlees [1976], value added at shadow prices must equal the value of primary factors employed in the sector at shadow prices, L^s. Thus, the savings in foreign exchange, holding utility constant, must equal $[L^s - V^*]$, so

$$F = V^* [(L^s/V^*) - 1] = V^* [DRC - 1], \tag{13}$$

and if $DRC > 1$, the *liberalization* is a good thing, i.e., the sector is an inefficient way of converting primary factor services into foreign exchange. The same result would have obtained in the limiting case as sector zero becomes infinitesimal relative to the rest of the economy, even when market prices and shadow prices are not stationary. Moreover, as in Application 1, assuming no distortions other than quotas, shadow prices and market prices for all factors coincide, and the DRC equals the ERPC.[21]

The same logic would apply if the government were contemplating replacing imports of a final good by the finite expansion or establishment of a large import-

21. The same analysis would have applied so long as there was a binding quota on only the output or on only one input that was used solely by sector zero, for that is enough to tie the size of the sector to the size of the quota.

competing sector. It would also apply if the government were contemplating the finite expansion or establishment of a large export sector.

C. *Corden-Krueger Application 3: Using the DRC to Evaluate an Incremental Change in the Size of a Sector*

Now we postulate that the industry is large, and that it is to be squeezed by restricting imports of intermediate inputs into the sector and liberalizing imports of the final product by some small proportion, say 1%, of the initial net input and output levels of the sector. The foreign exchange saved, F, is given by M, where M is the MSV of the quota adjustment which in effect creates 1% of the bundle of net outputs in sector zero out of its foreign exchange equivalent. Thus M is 1% times the value added at shadow prices in sector zero minus its value added at world prices: $M = .01\,[V^s - V^*]$. Thus,

$$F = .01[V^s - V^*] = .01V^*\,[(V^s/V^*) - 1] \tag{14}$$

where V^s and V^* are values added in the sector at shadow prices in foreign exchange numeraire and world prices respectively. Again, since by Diamond-Mirrlees value added in the sector equals the value of primary factors in the sector, where both are measured at shadow prices, this relationship can be written as

$$F = .01V^*\,[DRC - 1] \tag{15}$$

and the liberalization is good if and only if $DRC > 1$. Of course since shadow prices are not stationary in this model and the sector is big, we can only use this approach to evaluate small changes in quota levels. As in the other two models, assuming no distortions other than quotas, shadow factor prices will equal market prices, and the DRC and ERPC will coincide.

The same logic applies if the sector is an exporter and for the incremental expansion of a sector.

D. One Mobile Factor of Production and Incremental Changes

Fane [1991a] rehabilitates the Corden-Krueger approach as follows. He assumes that each traded good is produced using a mobile factor (e.g. labor) plus a sector specific factor and intermediate inputs, where non-traded intermediate inputs use no specific factors, so their supply curves are perfectly elastic. He notes that in such a model one can calculate a DRC for marginal expansion of each existing sector, generated by some sort of incentive scheme. He points out that these DRCs will be proportional to the ERPs, and they will not necessarily equal unity for existing sectors.

However, for the DRC to equal the ERP + 1, (See the Krueger [1984, p. 540] quote above) the shadow price of labor must equal its market price. This will be the case if in alternative use labor is paid the value of its marginal product at world prices. For this to happen, one must make an additional assumption. One possibility is to assume in addition that there is exactly one tradable good that is produced with a zero ERP and uses no specific factors, so that when labor flows to or from other sectors it is the output of this sector which rises or falls.

E. Summary

To summarize, the Corden-Krueger-Handbook version of the DRC makes sense when all trade barriers consist of import and export licensing, and (1) we wish to evaluate a project in which the government buys and sells the project's inputs and outputs on world markets, or (2) we wish to evaluate the desirability of a finite change in the size of a sector where changes in the levels of import and export licenses are assumed to balance this change, and either (A) market prices and shadow prices are stationary or (B) the sector in question is small, or (3) we wish to evaluate the desirability of slightly contracting or expanding the sector, and the proposed policy change is a small adjustment in import and export licenses for the sector's inputs and outputs in proportion to the sector's initial net output of each good. Thus, under appropriate assumptions, the Corden-Krueger concept of the DRC can be used to evaluate projects and the desirability of either small or large changes in the size of sectors. But for the DRC to equal the ERP, shadow prices must equal market prices, and this obtains if (A) all trade barriers are exogenously determined quotas or if (B) there is one mobile primary

factor of production, and exactly one good which is produced with no specific factor and this good is characterized by a zero ERP.[22]

XII. Is the DRC the Best Cost-Benefit Ratio?

We have already seen that the DRC is a cost benefit ratio. Thus we can use the DRC to measure the net welfare benefit (in units of foreign exchange) of incrementally expanding a sector by taking the value at shadow prices of the additional primary factors to be devoted to it and multiplying by one minus the reciprocal of its DRC. Still, one cannot generally use the DRC to measure the total costs or benefits associated with operating a given industry at its current level, because (as noted in section IX), shadow prices of goods and factors will generally change as industries expand or contract.

Another use of DRCs, as Kemal Dervis has pointed out to me, it that they indicate the percent by which efficiency in the use of primary factors would have to grow in order to make a project viable as an efficient use of society's resources. Suppose we are contemplating a project with a DRC of $1+\alpha$. To reduce the DRC to unity we would need to increase the productivity of primary factors by a proportion α. Thus DRC $-$ 1 measures how far away a project is from being viable.

However, the kind of ratio that is most likely to interest a policymaker is the economic cost at the margin of doing something the policymaker wishes to accomplish but to which he has trouble attaching a specific economic value, such as increasing employment in a particular sector or redistributing income or fostering economic activity in a particular region. This argues for calculating the economic costs of achieving a unit of non-economic benefits[23] through the expansion of par-

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22. Condition B may be written more generally as: (B) there are N mobile primary factors of production, and exactly N goods which are produced with no specific factors and these goods are characterized by zero ERPs.

23. Appropos *non-economic* arguments, Corden [1974, p. 155] writes, "Actually the techniques of economics can be used to analyze, or at least define more precisely, *all* arguments and the use of the term *non-economic* sometimes means no more than economists have not got around to analyzing an argument properly, rather as miracles are phenomena that scientists have not yet caught up with." In other words one should be able to take account of all *non-economic* benefits by appropriately defined shadow prices. The only problem is that different observers are likely to attach different values to the same *non-economic* result.

ticular industries or through the use of particular economic instruments, along the lines of general equilibrium models (linearized or nonlinear) discussed in Dixon, Parmenter, Sutton and Vincent [1982], Gan and Tower [1987], Tower [1991] and elsewhere. Thus the DRC is only one of many cost-benefit ratios that policy makers might wish to use.[24]

XIII. Summary

This paper has made a number of hard-to-grasp technical points as well as some very straightforward points about the calculation and interpretation of the DRC coefficient. Lest the reader lose the forest for the trees, we close by summarizing our major points, some of which are all too frequently ignored in studies which employ the DRC concept.

Section II argues that the DRC is simply the cost benefit ratio which applies to an activity, where the activity is defined as the conversion of primary factor services into net output of traded items. It then argues that it is helpful to present the DRC as a special case of an activity cost benefit ratio in order to focus attention on the idea that a DRC type concept can be used to evaluate activities involving the production of traded and non-traded items using both traded and non-traded factors of production as well as the elementary case where non-traded primary factor services are used to produce net outputs of traded goods.

Sections III through V develop a modified version of the Srinivasan-Bhagwati model which assumes that all goods are traded to derive a formula which relates

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24. In fact, there are two other DRC-type measures that may prove to be useful options. The value of primary factors used evaluated at market prices and divided by value added at shadow prices gives the value of domestic resources needed to produce a unit of foreign currency in a particular sector. If all goods in the calculation are traded at fixed world prices, this is simply the effective rate of protection coefficient.

    Another measure is a net DRC which would be the value of primary factors which must be transferred to a sector to earn a unit of foreign currency net. This would be calculated as N/D with N being the market value of resources needed to produce a unit of output and D being unit value added at shadow prices minus the shadow price of the primary factors used to produce a unit of output. The reason that D measures net foreign exchange earnings is that the shadow price of the primary factors indicates the opportunity cost of the primary factors in their previous uses.

the domestic resource cost of a sector to the primary factor flows which result from an expansion of the sector's output, and the ERPs in the sectors which are affected by the primary factor flows. Using it we conclude, contrary to SB, that ERPs are an appropriate tool for project selection, so long as they are multiplied by weights which reflect factor movements between the various sectors of the economy. This formula is useful for understanding how to think about the roles of ERPs and DRCs and cost benefit analysis in open economies.

Section VI notes that ERPs and DRCs of proposed new activities will be perfectly correlated when there is only one mobile factor of production, say homogeneous labor, which is combined with sector specific capital to produce output. In this circumstance, replacing a low ERP project with a high ERP project that uses the same amount of the mobile factor of production will always serve economic welfare.

Section VII indicates how to extend the analysis to more than two factors of production and two traded goods.

Section VIII extends the discussion to the existence of non-traded goods, both when prices of such goods are held constant by the structure of the model and when they are allowed to vary.

Section IX dispels the idea that DRCs can be used to rank sectors, noting that all we can say is that sectors with DRCs less than one should be expanded at the margin while sectors with DRCs greater than one should be contracted at the margin until ultimately a set of projects is generated where no prospective project has a DRC less than unity and no existing project has a DRC which exceeds unity.

Section X discusses how to calculate the DRC for incremental changes in private sector activities induced by government actions like adjustments in sector-specific taxes and subsidies. Such DRCs will depend on which instruments are used, and of course they will not all equal unity.

Section XI notes that SB have argued that the DRC for all existing private sector activities equals 1 while Corden and Krueger mention that the DRC for any activity in an economy whose only distortions are trade barriers is equal to 1 + the ERP. This occurs only if shadow prices for primary factors equal market prices, which occurs when all trade barriers are fixed quotas or certain sectors have zero ERPs. This section resolves the contradiction implicit in these two positions by arguing that Corden and Krueger may be assuming that all trade bar-

riers consist of quantitative restrictions on the amount of international trade which the private sector is permitted to undertake, whereas SB assume that all restrictions on international trade take the form of tariffs. It then discusses three perturbations of economic policy for which the Corden-Krueger concept of the DRC provides a correct cost/benefit measure.

Finally, section XII suggests that the DRC can be used to measure the extent of efficiency gains that would be needed to make a project viable on efficiency grounds, and it proposes, as an alternative to focussing on DRCs, a more frequent use of general equilibrium models to calculate the economic costs at the margin of doing things that policymakers wish to accomplish but have trouble attaching specific economic values to, such as increasing employment in a particular sector, redistributing income or fostering economic activity in a particular region.

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