

Evaluating Public Expenditures When Governments Must Rely on Distortionary Taxation

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Abstract

We provide simple, robust operational rules for evaluating public expenditures in distorted economies. Our analysis integrates previous treatments of project evaluation as special cases within a clean unified framework. In particular, the border price rule developed in the shadow pricing literature requires very strong assumptions to be valid when governments must rely on distortionary taxation and are unable or unwilling to cover the costs of the project through user charges. We develop general project evaluation rules that are more complex than the border price rule, but involve only one additional parameter, the Marginal Cost of Funds.

Abstract

The evaluation of public expenditures is a central concern of development economics--and a concern highlighted by the increasingly stringent budget constraints in both developing and developed countries. This task has also become increasingly difficult as governments have moved their focus away from providing private, tradable, goods towards public goods that are provided either without charge, or at a charge considerably below their value to consumers.

Until recently, it was widely believed that government projects could be evaluated without reference to the costs of raising tax revenues. The classic border price rule provided a simple and apparently robust procedure for project evaluation.

Anderson and Martin use a rigorous formal model to explore the welfare consequences of government provision of different types of goods in economies in which governments must rely on distortionary taxation. They show that the border price rule is accurate only in the rather special case where the project outputs are sold at their full value to consumers-- something that is difficult to do for a public good such as a lighthouse or a functioning judicial system.

Whenever a publicly provided good is sold for less than its full value to consumers, Anderson and Martin show that the implications of public good provision for government revenues needs to be taken into account. They provide simple rules for project evaluation that depend on only one additional parameter, the compensated Marginal Cost of Funds for the taxes on which the government relies. With an estimate of this additional parameter, analysts are able to prepare unbiased evaluations of the particular types of government projects.

The rules suggested involve adjusting the fiscal revenues generated (or destroyed) by the project by the marginal cost of funds before comparing them with the assessed benefits to producers and/or consumers of the project. In the case of a protected, but tradable, good provided by the government, this results in a shadow price that is below the world market price. Where projects produce output that is sold without charge, the costs of the project inputs must also be adjusted using the MCF. In intermediate cases, where the government levies user charges that fall below the full value of the goods to the private sector, the revenue shortfall from the project must be adjusted by the MCF.

After presenting their key results, the authors compare them with the results presented in the literature for cases where governments must rely on distortionary taxation. The border price rule for traded goods has almost invariably been invoked except in recent papers by Devarajan, Squire and Suthiwart-Narueput, and by Harberger. Anderson and Martin show that most studies have based their support for the border price rule on the rather special case where governments sell their project outputs at full market prices.

The valuation principles presented in this paper appear to provide a practical basis for evaluation of government expenditure projects. While more complex than the border price rule, they do not appear to be unmanageably so, as long as estimates of the compensated marginal cost of funds are available to the analyst.

Evaluating Public Expenditures: A Simple General Framework

Governments and international lending organizations need simple, robust frameworks for evaluating project proposals in distorted economies. The border pricing rule for traded goods (see, for example, Squire 1989; Drèze and Stern 1987) provides an attractively simple basis for project evaluation: regardless of distortions, governments should evaluate the tradable goods they provide at border prices. Unfortunately, the border price rule needs modification when projects are not revenue neutral and when governments must rely on distortionary taxation to fund their projects. Government sale of goods below their market price creates a revenue need which must be met from distortionary taxation. The purpose of this paper is to provide rigorously derived guidelines for evaluating government projects in this situation. The rule we obtain is operational with an additional 'parameter', the Marginal Cost of Funds, which is frequently available.

The literature on project evaluation has focused heavily on projects in which governments produce goods that are sold to the private sector at their market price (see, for example, Squire 1989; Blitzer, Dasgupta and Stiglitz 1981). This formulation may have been reasonably appropriate in an era where attention focused primarily on industrial projects but, as Devarajan, Squire and Suthiwart-Narueput (1997) point out, is of limited relevance now that the concerns of governments and international organizations have shifted so strongly to the provision of an enabling environment for private sector development. Charging a price that equals the marginal valuation of project output to the private sector is impossible in government projects that provide Samuelsonian public

goods (such as lighthouses or functioning judicial systems) and difficult for many semi-public goods such as roads.

In this paper, we use a general system of fiscal accounting for marginal changes in the provision of public goods first outlined in Anderson and Martin (1996) that allows us to account for various approaches to the funding of government projects. We begin with the pure public-good case where governments provide goods without charge, but must pay for the inputs to these projects. We then consider the continuum of cases between provision without charge and pricing at the marginal value of the government output to the private sector. Throughout, we emphasize the case where the government must rely on distortionary taxation to fund any deficit or surplus associated with the project, and compare this with the case where governments can obtain revenues without resorting to distortionary taxation.

We obtain two key results that seem likely to be useful for project evaluation. Firstly, the shadow prices of traded (as well as nontraded) goods are not generally equal to their world prices, but differ from world prices by an amount that depends upon the impact of the project on government revenues and on the Marginal Cost of Funds. Secondly, the costs of a government project need to be adjusted by the Marginal Cost of Funds before being compared with the benefits accruing from the project.

The analysis leads to operational rules for project evaluation that are only slightly more complex than the border pricing rule. The new rules depend on only one additional parameter whose value must be estimated/simulated, the Marginal Cost of Funds (MCF). The CGE models (or back of the envelope approximations) required to produce MCF

measures are now fairly widely available. The analyst will typically have available a range of values that can be plugged in to satisfy conservative evaluation procedures.

To conduct the analysis, we utilize a framework that makes explicit the role of government in providing public goods and services subject to a budget constraint. We consider first in Section 1 a general welfare analysis of the provision of a public good which is purchased from the rest of the world and paid for out of distortionary tax revenue. In Section 2 we consider the nature of the resulting shadow prices in more detail. We specialize the general expression for the shadow price of public goods in stages, first by assuming that the public good is a perfect substitute for a private good and then by assuming that the MCF is equal to one. Only with both assumptions met is the shadow price equal to the border price. In Section 3 we consider the role of the MCF in evaluating the cost of project inputs. Section 4 deals with user charges for public goods, which are of course only feasible when such goods are excludable. Section 5 places our results in the context of the earlier literature in order to clarify the relationship between our results and those obtained by earlier authors. Section 6 provides some simple numerical examples to highlight the potential importance allowing for the costs of raising funds.

1. The model

The analysis is conducted with a representative agent economy which faces fixed international prices. Trade distortions and inefficient public goods supply are the only distortions. The set of public goods provided by the government is denoted by the vector

G .¹ Positive elements of G are goods supplied by the government; negative elements of G are inputs purchased by government for use in its project.

The marginal willingness to pay for a unit of G by the representative agent is determined by the supply of G along with the prices of private goods which complement or substitute for the public goods. A convenient approach to specifying the marginal willingness to pay is through a constrained net expenditure function $E(p,G,u)$ which gives the minimum net expenditure on the set of privately provided goods necessary to maintain a particular utility level given G . The vector p refers to the prices of the privately produced and traded goods, the vector G to the quantities of goods provided by the government, and u refers to the utility level of a representative consumer. E is defined as the difference between the representative consumer's constrained expenditure function, $e(p,G,u)$, and the constrained gross domestic product function, $g(G, p)$. The public goods argument in the gross domestic product function is understood to mean that public goods may serve as inputs to production. The supply of public goods is purchased abroad.

Increases in elements of G which are valued by consumers or by producers will lower the cost of achieving any given level of utility — either by reducing the expenditure on private goods required to achieve that level of utility or, as in the case of many infrastructure investments, by increasing gross domestic product. E_G is therefore negative for products valued by the private sector, and equal to minus the virtual price, π , or marginal willingness to pay, vector of the representative agent. Where the publicly provided goods are excludable and do not generate externalities, π may be directly

¹ In the representative agent model, government supplied private goods and pure public goods are equivalent. For treatment of the approach of this paper in the many household case, see Anderson

observable in secondary markets. However, where the publicly-provided goods are non-excludable and/or where they create externalities², π will not be directly observable and will need to be inferred through some form of elicitation process.

Where the publicly provided good, say good i , is a perfect substitute for a pure private good, π_i must be equal to the price of the identical private good, p_i , up to the point where the supply of good G_i exceeds total market demand at the domestic price p_i determined by world prices, p_i^* and the relevant tariff $(p_i - p_i^*)$. This perfect substitutes case is the one generally considered in the literature on shadow pricing of traded goods, with the assumption of perfect substitutability underlying proposals for use of world prices as shadow prices of government-provided goods.

The specification of π using E_G differs from the usual specification in the shadow pricing literature. The usual assumption is that the output of government projects is sold at market prices (see, for example, Bell and Devarajan 1983; Blitzer, Dasgupta and Stiglitz 1981; and Squire 1989), and hence π is observable. In contrast, here the government determines the quantity of the good that it supplies, the supply curve to the private sector is perfectly inelastic and any price between zero and π is feasible³. The choice of a selling price within the feasible range is one of setting user charges, which are lump sum taxes in our representative agent model.

(1997b).

² Devarajan, Squire and Suthiwart-Narueput (1997) emphasize that government expenditures are and should be increasingly concentrated in such goods.

³ If the project generates negative externalities, the user charge may even exceed the marginal social value of the project output.

We assume a small country where the government can purchase the inputs into projects on world markets⁴ at an exogenous price π^* and private goods are traded at world prices p^* . For simplicity, we assume that the output of projects is produced using only purchased inputs. Following the standard approach in the cost-benefit literature (see, for example, Tower and Pursell, 1987), we assume that revenue is raised by trade taxation on private goods (other than a set of undistorted goods including the numeraire) at specific rate vector t , equal to $(p - p^*)$. Until Section 3, we assume that the government outputs are given away without user charges, either because the outputs are pure public goods, or because the government is unwilling to levy user charges.

With distortionary taxation, a given supply of public goods implies a rate of taxation which is endogenously determined along with the equilibrium real income. The fundamental equilibrium conditions are the government budget constraint and the private sector budget constraint. Formally:

$$(1) \quad \pi^*G - [p - p^*]E_p(p, G, u) = 0 \quad \text{government budget constraint}$$

$$(2) \quad E(p, G, u) = 0 \quad \text{private budget constraint.}$$

The government budget constraint specifies that the government's spending on the purchase of public goods is equal to its revenue from trade taxation, $[p - p^*]E_p(p, G, u)$.

This equation can readily be generalized to include taxation on producers or consumers, user charges, lump sum redistribution to the private sector, and capital inflows from

⁴ As long as the goods are traded goods with perfect domestic substitutes, it does not matter for the analysis whether they are imported or purchased domestically. If they are purchased domestically, the purchase price will be higher by the amount of the tariff, but this will be offset by the tariff revenue collections, leaving a net price to the government of p^* . Anderson (1996) considers an alternative case

abroad. Similarly, the private budget constraint can be generalized to include redistribution from the government, or inflows from abroad. While relevant in specific applications, these extensions are not needed for the specific points that we seek to establish.

Equations (1) and (2) determine the real income u and the required taxation. The vector p is underdetermined, so some convention is needed to reduce the endogenous level of taxation to a scalar. The fiscal experiment we analyze is a parametric change in G , to be financed by an endogenous change in the taxes, dp . Totally differentiating (1) and (2) with respect to G , p and u we obtain:

$$(3) \quad [\pi^* - (p - p^*)'E_{pG}]dG = [E_p' + (p - p^*)'E_{pp}]dp + (p - p^*)'E_{pu}du = 0$$

$$(4) \quad E_G'dG + E_p'dp + E_u'du = 0.$$

The term multiplying dG in (3) combines the direct cost π^* with $(p - p^*)'E_{pG}$, the impact of a change in G on government tax revenues. This is the full fiscal cost of the public good. Against this, tariff revenues must be raised through a change in p , dp , sufficient to pay the full fiscal cost after offsetting the income effect (the term multiplying du).

To solve this problem uniquely, we need to specify a particular type of tax package. If we focus initially on the case of proportional increases⁵ in all of the taxes, we can express the resulting price changes as $dp=(p-p^*)d\tau$, and solve the government budget constraint for $d\tau$:

where the government purchases its inputs from from domestic producers. Neary (1995) provides an excellent analysis of the large country case.

⁵ A straightforward generalization of this analysis, considered later in the paper, is to focus on a tax package where prices are changed by different amounts.

$$(5) \quad d\tau = 1/[E_p'(p-p^*) + (p - p^*)'E_{pp}(p-p^*)].[-(p - p^*)'E_{pG}dG - (p - p^*)'E_{pu}du]$$

Substituting $p d\tau$ into (4) and rearranging, we obtain:

$$(6) \quad (1 - \text{MCF}(p - p^*)'X_I)E_u du = \{\pi - \text{MCF}[\pi^* - (p - p^*)'E_{pG}]\}dG.$$

where MCF (discussed below) is the compensated Marginal Cost of Funds and X_I is a vector of income effects equal to E_{pu}/E_u . The expression in curly brackets on the right hand side of (6) is the net benefit of an increase in G : the difference between its virtual price and the product of the MCF and the direct plus indirect cost of provision of the good. The overall expression on the right hand side of (6) gives the marginal impact of the change in G on the balance of trade, or the size of the transfer from the rest of the world needed to compensate for the change in G , and hence provides a compensation measure of the welfare impact of the change (see Anderson and Martin 1996).

The MCF term is defined as $E_p'(p-p^*) / [E_p'(p-p^*) + (p - p^*)'E_{pp}(p-p^*)]$ (See Anderson and Martin 1996 for a more detailed discussion). Its numerator is the increase in government revenue that would have arisen from a unit increase in τ in the absence of any behavioral response. Its denominator is the increase in revenue achieved with the (compensated) household free to respond to the incentives created by the tax changes. Intuitively, the MCF shows the marginal increase in the tax rate that is required to achieve the desired increase in tax revenues. Because the denominator of the MCF will generally be smaller than the numerator, the MCF will be greater than one. One important special case is that of a tax on a good in perfectly inelastic supply-- in this case, the MCF is unity

since all of the relevant components of E_{pp} are zero. Clearly, the MCF will also be unity when taxes are initially zero.

We diverge from much of the public economics literature in defining the MCF as a compensated concept. We do so because to be operational, the MCF should be comparable across models, years and countries. The uncompensated MCF utilized in much of the literature is non-comparable, being a money-metric utility measure. The definition of MCF given above is restrictive in assuming that the tax rate increase is equiproportional on all non-numeraire goods. A straightforward generalization is to focus on a tax package where different prices are increased by different amounts, and some taxes may even be lowered. This can be done by specifying a diagonal weighting matrix W and replacing p with Wp in the expression for the MCF. If desired, the elements of the W matrix may be chosen to minimize the MCF for any given level of required revenues given knowledge of the E_{pp} matrix and the initial vector of taxes ($p-p^*$). Adapted in this way, the formula given in equation (6) applies in the case where revenue is raised by optimal taxes, as well as to cases where the tax revenues are raised with any arbitrarily specified tax⁶.

⁶ As is emphasized by Drèze and Stern (1985, p919), there is an element of arbitrariness in specifying how revenue impacts will be dealt with, and the combination of a bad project and a good tax reform could result in acceptance of a project that is, in isolation, welfare reducing. Sieper (1981) proposes to deal with this by restricting attention to optimal tax changes. A more pragmatic solution, consistent with the widespread practice of calculating generalized MCFs for each economy (see Devarajan, Squire and Suthiwart-Narueput 1997), would be to estimate a feasible marginal tax mix for revenue expansion (or reduction), and to use this same MCF in the evaluation of all project alternatives.

2. Evaluating the shadow prices

We follow standard practice by evaluating the shadow price of any good as the change in aggregate welfare resulting from a marginal increase in the net supply of that commodity by the public sector where the good is costlessly provided from outside the system (Squire 1989, p 1103; Drèze and Stern 1985, p911). Then, using this definition on the right hand side of (6), we obtain:

$$(6') \quad (1 - \text{MCF}(p - p^*)'X_I)E_u du = \sigma \cdot dG, \text{ where}$$

$$(7) \quad \sigma = [\pi + \text{MCF}(p - p^*)'E_{pG}],$$

is the shadow price of the publicly provided good.

The shadow price includes the virtual price, which measures the direct welfare impact of the public good, and a term reflecting the need to make up the budgetary consequences of the public good supply with distortionary taxation. Even if the good really is provided without direct budgetary cost, tax changes are required because of the indirect revenue consequences of its provision. This specification is consistent with Harberger's (1997, p74) identification of the need to allow for the private sector taxes that would have been paid in the absence of the project. Equation (6') implies that the desirability of a project is based on the difference between the shadow price of the government good and its direct cost times the MCF of the public funds needed to pay for it.

We now proceed to several special cases of the shadow price of public goods analyzed in the literature. When the public good and a private good are *perfect substitutes*, $E_{p_i G_i} = -1$ and $E_{p_j G_i} = 0$ for $j \neq i$; and (7) reduces to:

$$\sigma_i = p_i - \text{MCF}(p_i - p_i^*).$$

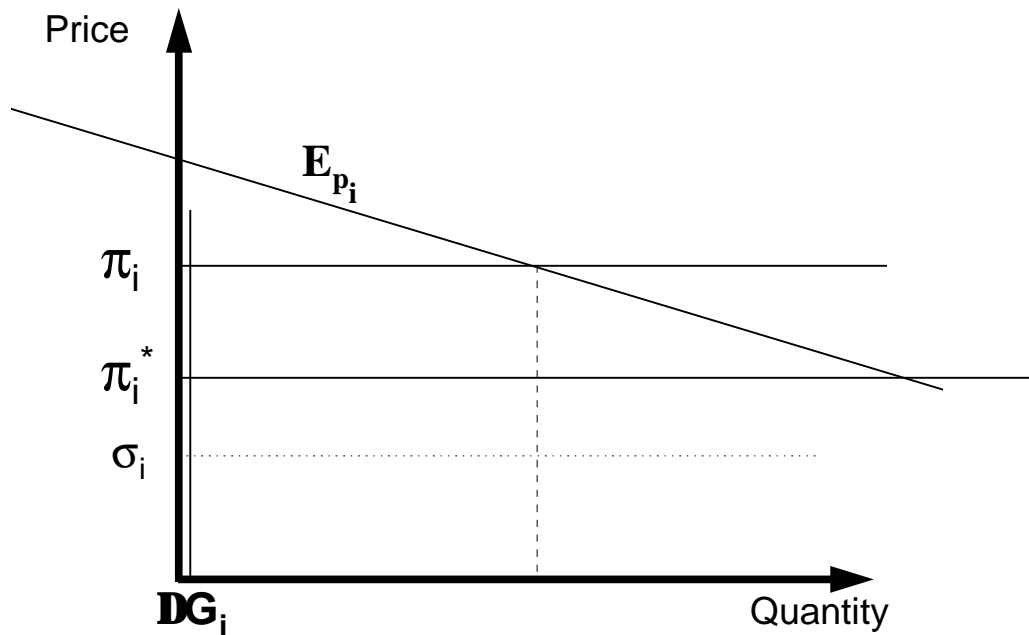
If in addition $\text{MCF}=1$, as when *a lump sum tax is available at the margin*, then

$$\sigma_i = p_i^*.$$

The shadow price is equal to the border price under these assumptions. When user charges are levied sufficiently to pay for the project, the lump sum tax assumption is not objectionable, and when the government project is an industrial one such as a fertilizer plant the perfect substitutes assumption is reasonable. But the general expression in (7) must be applied when these assumptions cannot be met.

Figure 1 allows us to provide some intuition into the difference between the shadow price of a good and the world market price in the important case where the government good is a perfect substitute for a privately provided good.

Figure 1. Interpreting the shadow price for a government good that is a perfect substitute for a traded good.



The E_{p_i} line in Figure 1 shows the compensated excess demand for good i from the private sector. The case illustrated is one for an imported good produced and consumed domestically at price π_i and available internationally at world price π_i^* . Because of the assumption of perfect substitutability between government good i and private good i at this stage of the analysis, $\pi_i = p_i$ and $\pi_i^* = p_i^*$. The provision of an amount of government good i equal to ΔG_i effectively shifts the y axis rightwards, reducing the compensated quantity of good i imported by ΔG_i . The only impact of government provision of the good is to crowd out an exactly equal amount of the private imported good. There are no impacts in other markets since there are no induced price changes in this perfect-substitutes case-- nor are there any impacts through factor markets, since the good is assumed to be produced without cost in this section. Without price impacts, there are also no impacts on the profitability of existing government projects to be considered.

In this case, the shadow price of government good i is given by: $\sigma_i = [\pi_i + \text{MCF}(p_i - p_i^*)]E_{p_i, G_i} = [\pi_i - \text{MCF}(\pi_i - \pi_i^*)] = \pi_i^* - \text{MEB}(\pi_i - \pi_i^*)$, where $\text{MEB} = \text{MCF} - 1$ is the marginal excess burden of the taxes under consideration. Clearly, if MCF is unity and $\text{MEB} = 0$, as in the case where the government has available a lump sum tax, we obtain the conventional result that $\sigma_i = \pi_i^*$ as a special case.

Where the government relies on distortionary taxes to replace lost revenues, the shadow price of a public good that is a perfect substitute for a protected import will be less than its world market price. This result has a simple intuitive explanation. It arises because the reduction in government revenues resulting from provision of this good has a social cost greater than the amount of revenue lost. It also has a simple policy implication. The benefit of government provision of a good that is subject to domestic protection is even less than would be implied by the border price rule. In this case, the benefit must be adjusted to allow for the costs of raising the tariff revenues dissipated by provision of the government good.

It is clear that the reformulation of shadow prices developed above has fundamental implications for shadow pricing. The level of the shadow price for each traded good is changed away from its border price by an amount that depends upon the size of the distortion in that particular market so relative shadow prices must change, potentially substantially. It is even possible that the shadow price for a good perfectly substitutable with a highly protected import will be negative. This is particularly likely if the government must rely on severely distortionary taxes at the margin.

The right hand side of equation (7) also gives the shadow prices in cases where the government good is an imperfect substitute for the privately traded good, or the private

good is nontraded. In this case, the interpretation is somewhat more complex than in Figure 1, since revenue impacts beyond the market for this particular commodity must be taken into account. However, all that is required is to consider the compensated impacts on distorted markets and modern computing software allows simplified models incorporating such interactions to be solved in spreadsheet packages such as EXCEL or programming languages such as GAMS (see Anderson (1997a) or Martin and Alston (1996) for analyses of welfare impacts in distorted open economies). Alternatively, simple back-of-the-envelope calculations of the type used by Loo and Tower (1995) might be used to take into account these cross-market interactions. For practical studies, a counterpart of the standard conversion factor that looms so large in partial equilibrium cost-benefit techniques could be estimated and applied to a range of nontraded goods.

3. Calculating the cost of project inputs

Given our simple formulation, the direct cost to the government of its project inputs is given by $\pi_i^* dG^I$ where π_i^* is the price vector and dG^I is a vector of inputs purchased for use in the project. Where the role of the government is merely to purchase and supply goods, as in countries where government agencies supply fertilizer to farmers, dG^I will be the negative of the dG discussed in the previous section. Most projects involve government agencies in purchasing one set of inputs (eg building materials and electricity) which are combined to produce a different set of outputs (eg lighthouse services).

The cost of purchasing the project inputs can be obtained by totally differentiating equations (1) and (2) with respect to dG^I , p and u and following the approach used in obtaining equation (6). Since we are considering the purchase, but not the installation, of

the public goods in this section, the E_{pG} terms are all zero and the social cost of purchasing this package of inputs is given by:

$$(8) \quad (1 - \text{MCF}(p - p^*)'X_I)E_u du = \text{MCF} \cdot \pi^* dG^I$$

Equation (8) has a simple intuitive interpretation. The costs of project inputs must be scaled, relative to the benefits of project outputs, by the marginal costs of raising the tax revenues required to finance them. Since this is a relative price change, it will have real implications for resource evaluation; in the normal case where the MCF is above unity, it will increase the height of the hurdle which must be jumped before projects are accepted. It will not, however, change the relative prices of inputs since MCF is a scalar.

Equations (6) and (8) highlight the importance of the tax mix used, at the margin, to fund government projects. Only in some circumstances will it be clear what tax mix is relevant to a particular project. One such case is where a broadly satisfactory tax regime has been established and budget balancing takes place through marginal changes in rates within that tax base. Another is the case where the public output is excludable and the direct and indirect changes in government revenues generated by the project can be accommodated through user charges.

4. Incorporating user charges

A major difference between this paper and the earlier theoretical literature is that we view the price charged by government for its output as the outcome of a decision on user charges. In most of the earlier literature, it is assumed that output is automatically sold at its marginal value to the private sector. In practice, the level of user charges varies

greatly depending both upon economic factors such as the ease by which private agents can be excluded from consumption of the publicly-provided good, and upon political economy considerations. Thus, it seems important to provide a formal analysis incorporating the consequences of different settings of user costs.

Allowing for user charges set at $c.\pi$ per unit of project output, where c is a diagonal matrix showing the share of the marginal social valuation of each output levied as a user charge, and introducing the impacts of changes in G on the revenues raised by the government from user charges on its entire portfolio of projects, the counterpart of equation (6) is

$$(9) \quad (1 - \text{MCF}(p - p^*)'X_I)E_u du = [\{\pi + \text{MCF}(p - p^*)'E_{pG}\} + \text{MEB} \cdot \{c.\pi + G'cE_{GG}\}]dG - \text{MCF}\pi^*dG^I.$$

The first term in curly brackets on the right hand side of (9) gives the shadow price for government output in this case. The second term in curly brackets reflects the impact of this project on revenue from user charges both from this project and from other affected projects. The $\text{MEB} \cdot c.\pi$ component of this term reflects the reduction in the costs of distortionary taxation resulting from the user charges on the new government output. The $\text{MEB} \cdot G'cE_{GG}$ component reflects the impact of changes in the virtual prices of existing government projects on the revenues collected by the government from user charges on its entire portfolio of projects (see Squire 1989).

If the goods under consideration are perfect substitutes for privately traded goods, E_{pG} is -1 for each government supplied good, and the term E_{GG} disappears, allowing (9) to be simplified to:

$$(9') \quad (1-MCF(p - p^*)X_I)E_u du = [p - MCF(p - p^*) + MEB.c.p]dG - MCF.\pi^*dG^I$$

The expression in square brackets on the right hand side of (9') has three elements: the virtual prices of project outputs, p ; the induced impacts on tariff revenues; and the impact of user charge revenues on the provided goods. Equation (9') seems likely to be of wide use, since it treats the elements of c as choice parameters, as is generally the case in practical applications, rather than assuming unrealistically that they are always unity.

Equation (9') may be rewritten in an alternative form consistent with the recommendations of Devarajan, Squire and Suthiwart-Narueput (1997) and Harberger (1997) that project evaluation should take into account both the value of the project at shadow prices, and the impact of the project on net government revenues:

$$(9'') \quad (1-MCF(p - p^*)X_I)E_u du = p^*dG - \pi^*dG^I + MEB\{(c.p - (p-p^*))dG - \pi^*dG^I\}$$

Equation (9'') has the desirable feature of making very clear what revenues need to be taken into account when premultiplying by MEB, and their dependence on decisions about user charges. If, for instance, user charges are set to zero, the adjustment to the border pricing rule would involve both the direct costs of the project π^*dG^I and the indirect impacts on government revenues created by the project, $-(p-p^*)dG$. If full user charges are levied, the adjustment will be applied to the project's losses or gains at border prices.

If c equals unity, (9') may be simplified further to:

$$(1-MCF(p - p^*)X_I)E_u du = MCF.(p^*.dG - \pi^*dG^I).$$

With c equaling unity, we return to the traditional result that shadow prices for traded goods with full user pricing are, up to a scalar multiple, equal to their border prices.

However, the formulation used highlights how sensitive this result is to the assumption that full user charges are applied.

The assumption of full user pricing embodied in the last equation is very strong and it seems very desirable to have equations (9') and (8) available to deal with the common situation in which full user pricing is infeasible either on economic or political grounds.

5. Relationship with the earlier literature

Given the importance placed on the border price rule in the literature, it seems worthwhile examining why our results differ from those previously reported. Some studies that have focused on the evaluation of projects when governments must rely on distortionary taxation are Warr (1979), Bell and Devarajan (1983), Blitzer, Dasgupta and Stiglitz (1981), Drèze and Stern (1985), Dinwiddy and Teal (1987), Squire (1989), Kaplow (1996), Devarajan, Squire and Suthiwart-Narueput (1997), and Harberger (1997). Much of the early literature concerned itself with sufficient conditions for the border price rule under the perception that the general case was not operational. Our dealing with the general case, in contrast, yields simple rules which are operational, even for nontraded goods, in an era of commonly available CGE models.

Warr (1979) provided an important justification for the border price rule, even when governments must rely on distortionary taxation. Assuming that governments levy full user charges, he demonstrated using a 2 factor, 3 product model, that a project that breaks even at shadow prices will have a zero impact on the government budget once the induced impact on project revenues and tax receipts is taken into consideration. In this

situation, the appropriate shadow price for a traded good will be the border price. A similar result could be obtained quite generally by integrating over changes in project outputs using the definition of a shadow price as the value at domestic prices plus the induced impact on government revenues (Drèze and Stern 1985, p964). While valid, and important, both of these results are specific to the case of full user charges, and apply only at the criterion point where the project has a zero value at shadow prices.

Bell and Devarajan (1983, p469) showed, using specific functional forms for a 3 sector, one factor model, and assuming full user charges, that the shadow prices of traded goods are equal to border prices when governments rely on nondistortionary taxation. When governments must rely on distortionary taxes or transfers, they showed (p474) that the shadow prices of traded goods were border prices multiplied by a scalar which corresponds to the MCF in our framework. Our result is consistent with theirs for the special case of full user pricing but allows, like the intuitive argument in Devarajan, Squire and Narueput-Suthiwart (1997), for user charges below the full virtual prices of government outputs.

Blitzer, Dasgupta and Stiglitz (1981) concluded that shadow prices for traded goods are equal to border prices when governments rely on nondistorting taxation. However, when governments must rely on commodity taxation, they concluded that shadow prices lie above border prices, and below domestic market prices (1981, p67). Dinwiddy and Teal (1987) showed that this sharp difference in results from the rest of the literature arose because the Blitzer, Dasgupta and Stiglitz model did not specify how tax revenues were utilized in the model.

After specifying that tax revenues were redistributed costlessly to the consumer, Dinwiddie and Teal (1987) obtained shadow prices for traded goods equal to border prices both when the government relied on nondistorting taxation and when it relied on distortionary taxation. The second result is surprising since, in this model, public sector output is obtained without cost, and is sold to the private sector at market prices. The profit from this should allow tax rates to be lowered, and generate a second round benefit equal to $MEB.p.dG$, yielding a marginal welfare impact of $MCF.p^*$ as shown by equation (9'). The difference between their results and ours seems to arise because the Dinwiddie and Teal analysis did not take into account the second-best welfare impacts arising from the induced change in the volume of imports passing over the trade distortion (see their equation 23, page 483). Their result corresponds to ours only in cases where the MCF is unity, such as where the tax distortion is introduced from an initial zero tax rate, or lump sum taxes are available.

The general shadow pricing formula provided by our equation (9) clearly has a great deal in common with the expressions for the shadow prices of nontraded goods provided by Drèze and Stern (1985, p964) and Squire (1989, p1110), both of which included one term for the marginal domestic valuation of the good and a second for the impact on government tax revenues. Ignoring, for a moment, our expression for the revenue impacts through project user charges, our formulation differs from theirs in pre-multiplying the government revenue term by the MCF to take into account the costs of raising revenues. Where the MCF is unity, our expression becomes identical with the shadow pricing expression given by Drèze and Stern and by Squire. Squire's analysis (1989, p1114) clearly recognized the costs of raising revenues in one important case.

When he generalized his shadow price expression to incorporate the impacts on the revenues obtained from government projects, he included a term analogous to the MCF.

Our analysis is consistent with Kaplow's (1996) in excluding the income effects of taxation from the criterion for project acceptance. These terms appear only on the left hand side of equation (9) and hence have no impact on the sign of the cost-benefit criterion. However, our results show that, in a distorted economy where full user cost pricing is not adopted, the distortionary costs of taxation must be taken into account when evaluating the desirability of a project, even where all goods are traded. When the public goods being provided are nontraded, the marginal cost of taxation must always be taken into account because of the need to finance the induced impact on government revenues.

As can be seen from equations (9) and (9'), our recommendations are completely consistent with those advanced by Devarajan, Squire and Narueput-Suthiwart (1997) and endorsed by Harberger (1997). The contribution of our analysis is to provide a rigorous derivation of the shadow pricing formulas to be used. Having a more rigorous foundation for the analysis is appealing given the confusion that has arisen in the past, particularly when the border price rule was used without recognizing the extent to which it is conditional on the costs of replacing induced changes in government revenues. Our formulas are likely to be particularly useful in evaluations involving government provision of nontraded goods, where the impacts on government revenues extend further than in the case of traded goods.

6. Implications for project acceptance decisions

The approach to shadow pricing outlined in this paper has potentially major implications for project evaluation. To illustrate the potential magnitude of the adjustments likely to be required, we consider a very simple project involving only traded goods. The project produces a good that, at world prices, generates \$100 of benefits and is supplied without user charges. It requires inputs valued at \$100 at world prices. We consider border price distortions on outputs ranging from -25 percent (an export tax or import subsidy) to 50 percent. We consider MCF values ranging from 1 (the lump-sum tax case) to 1.5, which are well within the range reported by Devarajan, Squire and Suthiwart-Narueput (1997) for developing countries.

Table 1. Shadow values of the project under different assumptions

MCF	Tariff rate on outputs			
	-25	0	25	50
1	0	0	0	0
1.25	-18.75	-25	-31.25	-37.5
1.5	-37.5	-50	-62.5	-75

The results presented in Table 1 highlight the great practical importance of the adjustments outlined in this paper for accurate shadow pricing and project evaluation. Even if the project's inputs and outputs are undistorted, the need to resort to distortionary funding may dramatically lower the net benefits of the project, as is evident in Column 2. The net costs will be lower if the outputs from the project are subject to negative taxation.

When the project outputs are perfect substitutes for private goods that are protected, the distortionary costs associated with project financing are compounded by the need to finance the tax revenue losses created by the project. Even for the parameter values identified in Table 1, these costs may dramatically change the outlook for a project. Where protection rates or the MCF are higher, the impact will be even greater.

These results highlight a need to pay particular attention to the financing implications of a government project and its interaction with government policies. The hurdle for project acceptance is likely to be substantially lowered if it can be financed by non-distortionary taxes, such as user charges. Further, government projects that increase output in industries that are taxed are far more likely to contribute to social welfare than projects that increase output of subsidized commodities. These examples also highlight the ease with which the adjustments may be made, as long as an estimate of the MCF is available.

The dramatic impacts observed in this numerical example are not confined to textbook cases. Devarajan, Squire and Suthiwart-Narueput (1997, p42) found in real-world examples that the net present values of their projects were highly sensitive to the level of the user charges used to fund them, and hence the distortion costs induced by having to raise revenues to cover the project's operating deficit. A key point of their paper is that the incorporation of the government revenue implications of projects is typically quite manageable, even in practical project evaluations.

Conclusions

In this paper, we provide a general framework for estimating shadow prices of traded and nontraded goods taking into account the implications of project financing decisions, and particularly the choice of user charges for government-provided goods. Using this framework, we develop simple rules for project evaluation that take into account the implications of the project for the government budget, and the induced need to change distortionary tax rates.

One of our key results is that the border pricing rule for traded goods can be preserved, but only if project outputs are subject to full user charging, and then only as a decision criterion, rather than as a method of evaluating total project benefits or costs. A more general rule, taking into account the impact of partial user charges on the financing burden imposed by the project, is presented to deal with situations involving other levels of user charges. This rule appears to be new, and to be of wide applicability.

Our analysis highlights the importance of the (compensated) marginal cost of funds when evaluating government projects. While the rules we propose for the evaluation of public projects are more complex than the standard use of world prices, they do not seem unmanageably so. If an estimate of the MCF applying to funds raised for a government project is available, then shadow prices for traded goods can readily be calculated using only the MCF and the price information (domestic and world prices) generally required for cost-benefit analysis. We hope that the formal derivations of rules for project evaluation presented in this paper will be of use in practical project evaluation.

References

- Anderson, J.E. (1997), 'Trade reform with a government budget constraint', forthcoming in J. Piggot and A. Woodland, eds, *Trade Policy and the Pacific Rim*, Macmillan for the International Economic Association.
- Anderson, J.E. (1997b), 'Revenue neutral trade reform with many households, quotas and tariffs', NBER Working Paper No. 6181.
- Anderson, J. E. and Martin, W. (1996), 'The welfare analysis of fiscal policy: a simple unified account' Working Paper No. 316, Department of Economics, Boston College.
- Auerbach, A. (1985), 'The theory of excess burden and optimal taxation', in Auerbach, A. and Feldstein, M. eds. *Handbook of Public Economics, Vol I*, Elsevier North Holland, Amsterdam.
- Bell, C. and Devarajan, S. (1983), 'Shadow prices for project evaluation under alternative macroeconomic specifications' *Quarterly Journal of Economics* 98:457-77.
- Blitzer, C., Dasgupta, C and Stiglitz, J. (1981), 'Project evaluation and foreign exchange constraints', *Economic Journal* 91:58-74, March.
- Devarajan, S., Squire, L. and Suthiwart-Narueput, S. (1997), 'Beyond rate of return: reorienting project appraisal' *World Bank Research Observer* 12(1):35-46.
- Dinwiddy, C. and Teal, F. (1987), 'Project appraisal and foreign exchange constraints: a comment' *Economic Journal* 97(386):479-87.
- Dinwiddy, C. and Teal, F. (1989), 'Relative shadow prices and the shadow exchange rate' *Journal of Public Economics* 40:349-58.
- Drèze, J. and Stern, N. (1987), 'The theory of cost-benefit analysis', in Auerbach, A. and Feldstein, M. eds. *Handbook of Public Economics, Vol II*, Elsevier North Holland, Amsterdam..
- Fane, G. (1991), 'The social opportunity cost of foreign exchange: a partial defense of Harberger *et al.*' *Economic Record* 67(199):307-16.
- Harberger, A. (1997), 'New frontiers in project evaluation: a comment on Devarajan, Squire and Suthiwart-Narueput' *World Bank Research Observer* 12(1):73-82, February.
- Kaplow, L. (1996), 'The optimal supply of public goods and the distortionary cost of taxation' *National Tax Journal* 49(4):513-30.

- Loo, T. and Tower, E. (1995), 'Agricultural liberalization, welfare, revenue and nutrition in the developing countries' in Goldin, I. and Knudsen, O. eds. *Agricultural Trade Liberalization: Implications for Developing Countries*. OECD and the World Bank, Paris.
- Neary, J. P. (1995), 'Trade liberalisation and shadow prices in the presence of tariffs and quotas' *International Economic Review* 36(3):531-554, August.
- Sieper, E. (1981), The structure of general equilibrium shadow pricing rules for a tax distorted economy, Mimeo, Australian National University, Canberra.
- Squire, L. (1989), 'Project evaluation in theory and practice' in Chenery, H. and Srinivasan, T. N. eds. *Handbook of Development Economics, Volume II*. Elsevier Science Publishers.
- Tower, E. and Pursell, G. (1987), 'On shadow pricing labour and foreign exchange' *Oxford Economic Papers* 39:318-32.
- Warr, P. G. (1977), 'On the shadow pricing of traded commodities.' *Journal of Political Economy* 85(4):865-72.
- Warr, P. (1979), 'Shadow prices, market prices, and project losses' *Economics Letters* 2(4):363-7.