PROJECT APPRAISAL AND FOREIGN EXCHANGE CONSTRAINTS*

It is a commonplace that the shadow (or accounting) prices appropriate for use in project selection in an economy depend on the 'market' imperfections that are judged to be present. What has received far less attention in the theoretical literature on social cost-benefit analysis is the fact that they depend as well on the response of the government to the perturbation which the undertaking of projects entails. It is convenient to suppose that the government simultaneously optimises with respect to all variables within its control, and it is the implication of this supposition that has been explored in much of the recent literature on project evaluation. But as a model of government behaviour it is not persuasive. Moreover, the analysis of government behaviour becomes critical in situations where prices and wages are not perfectly flexible.

This paper is concerned with economies in which markets are characterised by price rigidities and where governments behave *systematically*, but not necessarily *optimally*. In such a world we wish to obtain rules for project selection. The analysis is conducted in the context of the foreign exchange market. We shall focus on this, not only because of its importance in developing countries but also because there is considerable evidence that for one reason or another there often appears to be an excess demand for foreign exchange in such economies. Specifically, what we wish to do is to evaluate the meaning of the idea of a foreign exchange constraint (as contrasted with 'resource constraints' in general), together with the notion of the shadow price of foreign exchange, and their connection with the structure of accounting prices of goods and services involved in investment projects.[1]

We shall present the analysis in the context of the simplest of economies, in order that some of the discussion can be presented in diagrammatic form. Most of the time, for instance, we shall consider what is essentially a single-consumer economy. Nevertheless, we shall have a multi-consumer economy as a motivation for the assumptions that are made.[2] Moreover, excepting Section I, we will not consider factor markets or their shadow prices; rather, we will think of projects as alternative uses of identical factor inputs. We employ this device in order to develop a methodology for the derivation of the accounting prices of produced commodities.

In Section I, we draw on recent work in the theory of public finance to discuss

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[1] For earlier discussions of this class of problems, see e.g. Little and Mirrlees (1974), Dasgupta, Marglin and Sen (1972), Bacha and Taylor (1971), Balassa (1974), Batra and Guisinger (1974), Bertrand (1974), and Scott (1974). A good evaluation of the arguments is in Hughes (1978).

[2] Mirrlees (1977) has, among other things, extended some of the results obtained below to the case of a many-consumer economy.

conditions under which it makes no sense to distinguish between a foreign exchange constraint and a general resource constraint. In Section II we discuss the case where all goods that are produced can be traded with the rest of the world at fixed border prices. Here, the major issue involves the implications of border prices differing from market prices. In Section III we shift our attention to the difference between the ratio of the shadow prices of traded goods to those of non-traded goods and the ratio of their corresponding market prices. In Section IV we shall summarise our main conclusions, compare them with some of those in the earlier literature and also comment on the methodology we have chosen to pursue here.

I. THE IMPLICATIONS OF PRODUCTION EFFICIENCY

A full-optimum allocation of resources is, under quite general circumstances, characterised by overall production efficiency for the economy. If trade possibilities exist these are included as 'production options'.[1] But overall production efficiency also implies that at the margin the social value of foreign exchange is the same as that of domestic resources.

In order to realise a full-optimum a government would need to be able to implement optimal lump sum transfers. Suppose that this is not feasible. Distorting taxes are then a device by which the government can hope to increase social welfare. Suppose now that there are no constraints on the extent to which commodities can be taxed. It is then possible to show that under fairly general circumstances a second-best optimum is characterised again by overall production efficiency.[2] While at such an optimum the value of domestic consumption *measured in consumer prices* differs in general from the value of domestic production, *measured in producer prices*, overall production efficiency implies that at the margin the social value of foreign exchange is the same as that of domestic resources. Again, one concludes that at a second-best optimum of this kind it is not meaningful to distinguish between a foreign exchange constraint and a general resource constraint.

Overall production efficiency for a small trading economy implies that accounting prices are the same as the prices faced by domestic private producers, and that in particular, accounting prices for tradeables equal their border prices. However, the existence of widespread concern about foreign exchange suggests that there is more to the notion of a foreign exchange constraint than the above literature would suggest.[3]

What we propose to do in the remainder of this paper is to derive criteria for social benefit–cost analysis in open economies that do not aspire to the second-best optima discussed above. We study an economy in 'equilibrium' in which the government has not adopted a fully optimal course of action. A small project

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[1] It is most convenient to suppose trade to be controlled by the government, and we shall often suppose this to be so.

[2] See Diamond and Mirrlees (1971).

[3] There is another notion of foreign exchange constraint which arises in the context of a country facing a demand for its exports which is not perfectly elastic. This is a transformation constraint, made familiar by trade theorists.

is contemplated, and the economy is assumed to find a new resting place. To calculate the appropriate shadow prices with which to evaluate the project we compare this new 'equilibrium' with the old.

II. TRADED GOODS

II.1. *The Problem*

In Fig. 1 we have drawn the production possibility schedule between two produced commodities (I and E), which are assumed to be traded freely on the world market. The undistorted market equilibrium production point is given by Q, the point of tangency between the production possibility schedule and the international price line. The consumption point of this economy is given by
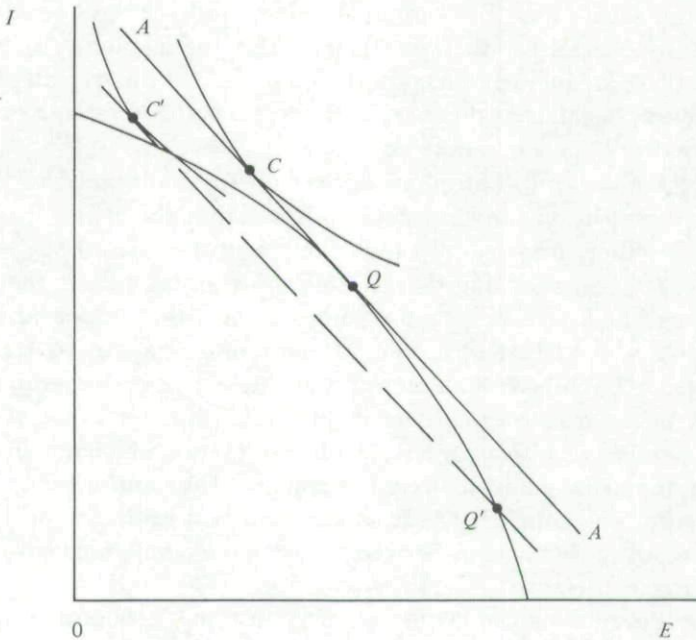

Fig. 1

C, the point of tangency between the indifference curve of the representative individual and the budget line, AA. The trade vector is CQ. In such an economy it makes no sense to talk of a foreign exchange constraint (or bottleneck). Rather, the economy faces general resource constraints. Since the exchange rate itself does not affect relative prices, it has no effect on resource allocation and serves merely as an arbitrary scaling parameter.

As regards project evaluation, the rule is clear: a project should be accepted if and only if it is profitable at border prices P_I^w and P_E^w. Since in fact Q is the optimum, all other feasible projects will yield negative profits when evaluated at border prices. To put it differently, suppose Q' is the contemplated production point and C' the consumption point. Consider a feasible project which consists in moving from Q' to Q. The project uses E (of amount ΔE) to produce I (of

amount ΔI). The 'real value' of the project is $P_I^w \Delta I - P_E^w |\Delta E|$. It is, as the figure makes clear, positive. Welfare is increased by project acceptance, as the consumption point moves from C' to C.

Now consider what happens if the domestic price ratio differs from the international price ratio. In what follows we shall thoughout suppose that the domestic price of exports (E) relative to imports (I) is greater than the international price ratio. In such a situation domestic producers will be induced to produce less of I and more of E. The production point is then represented by Q'' in Fig. 2, which is to the south-east of the undistorted production point Q.
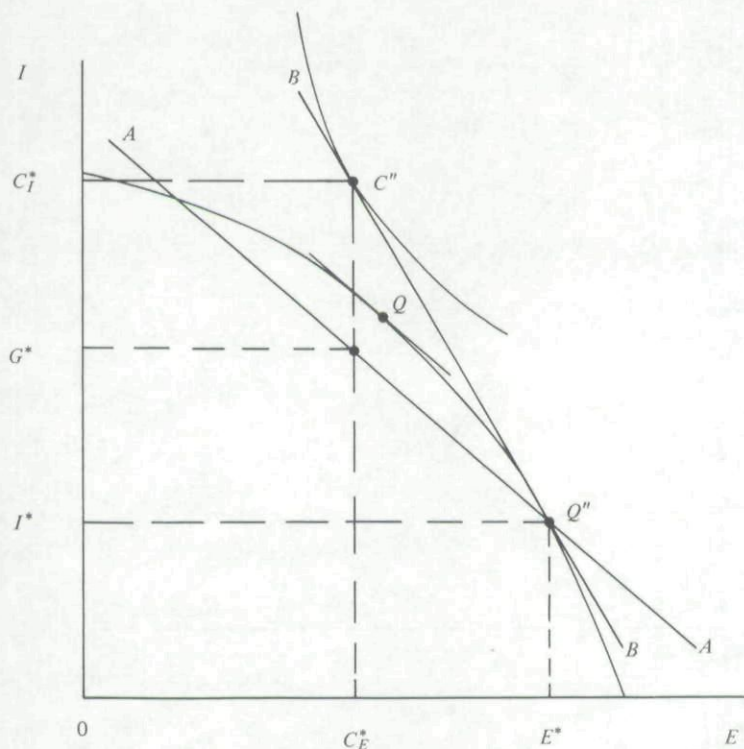

Fig. 2

If no taxes were to be imposed on consumers they would believe that they could trade along the budget line BB (whose slope gives the domestic price ratio of the two goods) and would choose consumption point C'', as Fig. 2 makes clear. Thus, their 'equilibrium' supply of exports would be given by $E^* - C_E^*$, and their demand for imports by $C_I^* - I^*$ (see Fig. 2). Unfortunately, although they *believe* they can trade along BB, the *true* trading possibilities for the economy as a whole are given by AA, a line through Q'' with a slope equal to the border price ratio, which represents the value of production in terms of foreign exchange. Thus the distance $C_I^* - G^*$ represents the trade gap – the excess demand for imports – at the perceived market prices, which cannot be met by trading with foreigners (see Fig. 2). It is because of this perceived excess demand for imports –

to which government policy is directed – that governments become very conscious of a foreign exchange 'constraint'. However, the origin of this sort of disequilibrium is not the foreign exchange market but the domestic price distortion.

Given that a 'wrong' set of domestic relative prices may manifest itself as a foreign exchange problem, the next question is – given this gap, how is the economy to equilibrate? One way is to suppose that the excess demand for imports leads to an increase in its price relative to exports, until equilibrium is attained with the domestic price ratio equal to the border price ratio. This is,
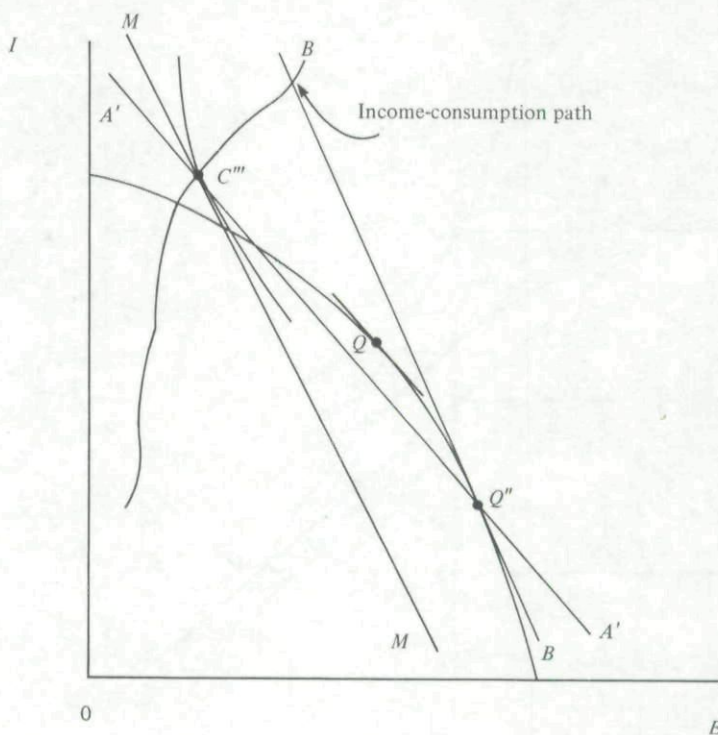

Fig. 3

of course, the first-best solution and merely begs the issue. There are reasons why a government may not or cannot allow this to happen. For whatever reason, however, we assume the price ratios do not equilibrate (or that market forces, even if they work, do so slowly). There are indeed many equilibrating mechanisms that a government may follow. For the purpose of illustration we shall, in what follows, consider four such mechanisms.

(a) The government can reduce demand by imposing a lump-sum (or income) tax. The equilibrium consumption point is at the point where the income-expenditure curve intersects the balance of payments equilibrium line (such as point C''' in Fig. 3).

(b) The government can reduce demand for the imported good by taxing consumption of that good directly. The equilibrium consumption point would

then be the intersection of the price–consumption curve and the foreign exchange budget line (such as point C'''' in Fig. 4).

(c) The government can *ration* the imports; for example by imposing a surtax on consumption above a certain level. This converts the linear budget line BB into a non-linear locus, with the equilibrium consumption point being on the true trade possibilities line AA. By varying the surtax, any point on AA can be obtained[1] (see Fig. 2).

(d) The economy can borrow the required foreign exchange to finance the deficit. This, of course, simply means a postponement of the problem: at some
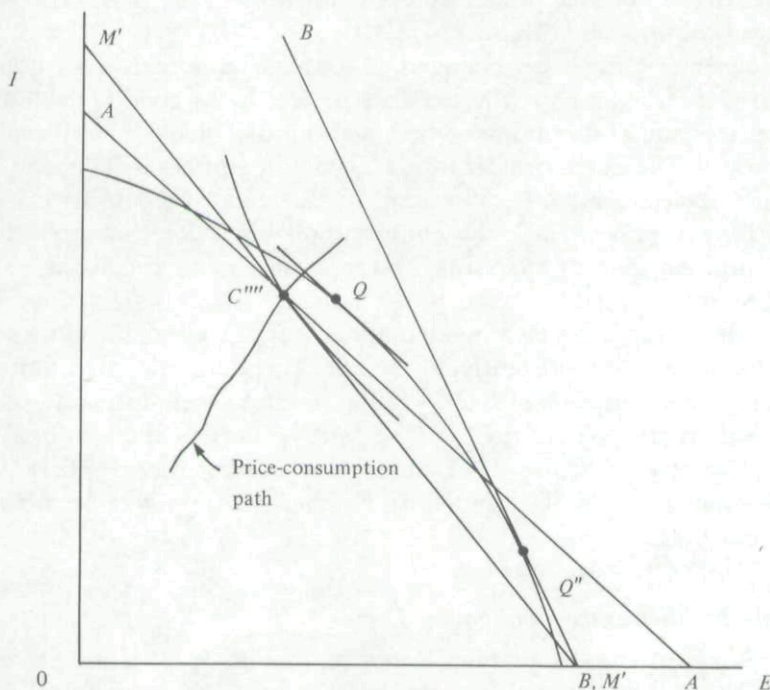

Fig. 4

later date, imports will have to be decreased or exports increased. This may make sense, if it is believed that whatever the constraints are which prevent the current price ratios from adjusting to clear the foreign exchange market will not be binding at some future date. This raises interesting problems, the analysis of which requires an intertemporal model.

For each of these methods of adjusting to the disequilibrium induced by incorrect domestic prices, we can calculate the social value of a project. A project in our problem can be viewed as a small shift in production around the point Q'' in Figs. 2–4. The question is this: what is the effect of any particular perturbation, taking into account the demand for imports, the supply of exports

[1] This is equivalent to the government controlling most foreign exchange transactions, but there being a black market as well.

and the government's reactions to any change in the gap between exports and imports?

It will have been noted that there are two basic categories of situations that one needs to consider. In some circumstances, in the new equilibrium consumer prices are the same as the old consumer prices. Whether a project increases or decreases welfare can be evaluated simply in terms of its effect on 'net' income (after taxes) measured in consumer prices. But since taxes have to be adjusted so that the foreign exchange market clears, provided only that there is a positive marginal propensity to consume imports, any increase in real 'net' income (at fixed consumer prices) must correspond to an increase in real income (before taxes) evaluated at border prices, and we can use border prices to evaluate projects (see Dasgupta and Stiglitz (1974)).

But if consumer prices are changed, the above argument does not hold. One can construct examples where a bad project looks good if evaluated at consumer prices and also examples where a bad project looks good if evaluated at border prices. The exact formula for the accounting prices will depend on the way in which the economy is equilibrated. In particular, accounting prices will not equal border prices, since the consumption distortion changes with the project in question. For an analysis of this in a more general context, see Dasgupta and Stiglitz (1974).

Before undertaking the relevant calculations it is as well to introduce some of the notation we shall consistently be using: X_i = domestic production of i ($i = I, E$); C_i = consumption of i; Y^d = value of total consumption at domestic prices; P_i^d = domestic price of i; $P^d \equiv P_I^d/P_E^d$; P_i^w = border (international) price of i; $P^w \equiv P_I^w/P_E^w$; Y^w = value of consumption at border prices; and $W(C_I, C_E)$ the community's social welfare function. Further notation will be introduced when necessary.

II.2. *Income Taxation as the Equilibrating Device*

This is the simplest case to analyse. Referring to Fig. 3, Q'' is the production point and BB represents its value at domestic prices. The economy as a whole equilibrates at consumption point C'', which is on the foreign exchange budget line $A'A'$, and which measures the value of production at the border price ratio. MM represents the level of consumer income required for equilibrium if consumers trade at domestic prices. Hence, the slope of MM is the same as the slope of BB and the distance between the two is the amount of income taxation required.[1] A new equilibrium, with production slightly different from Q'', will increase welfare only if it allows MM to shift out. Since MM is determined by the level of income at world prices, $A'A'$, the new equilibrium represents a higher level of utility only if the new production point lies above $A'A'$. Thus, the accounting price ratio for project appraisal is the international price ratio. The standard recommendation that traded goods be revalued to reflect their border prices can be seen as a logical consequence of assuming that at the margin

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[1] The two slopes need not be identical; they would differ if there were differential consumption taxes on the two goods.

excess demand for imports is met by income taxation (and not by borrowing or price changes, as the analysis in sections II.3 and II.5 will make clear).

It will be useful to present a formal analysis of this. A project is a perturbation in production, represented by the vector (dX_I, dX_E). Our problem is to relate (dX_I, dX_E) to a change in welfare, dW. Clearly,

$$dW = \mu(P_I^d \, dC_I + P_E^d \, dC_E), \tag{1}$$

where μ is the marginal social utility of (aggregate) domestic consumption. Now, by definition

$$Y^d = P_I^d C_I + P_E^d C_E (= P_I^d X_I + P_E^d X_E) \tag{2}$$

and

$$Y^w = P_I^w C_I + P_E^w C_E (= P_I^w X_I + P_E^w X_E). \tag{3}$$

Define $\alpha \equiv P_I^d \, \partial C_I / \partial Y^d$. It follows immediately that

$$dY^d = \frac{P_I^d}{P_E^w} \left[\frac{1}{\alpha P^w + (1-\alpha) P^d} \right] dY^w \equiv \beta \, dY^w, \tag{4}$$

where β is the marginal rate of exchange of foreign currency for domestic currency at the equilibrium in question. Now use equation (4) and the differential of Y^w from (3) in (1) to obtain

$$dW = \mu\beta(P_I^w \, dX_I + P_E^w \, dX_E), \tag{5}$$

from which we conclude that *the ratio of the shadow prices of I and E is the border price ratio P_I^w / P_E^w, and the exchange rate is irrelevant for project appraisal.*

We can still ask whether or not it is reasonable to say that the existing rate is overvalued at the margin. We can define the existing exchange rate as $b \equiv Y^d / Y^w$, which on using (3) can be expressed as

$$b = \frac{P_I^d}{[aP^w + (1-a) P^d] P_E^w}, \tag{6}$$

where $a \equiv P_I^d C_I / Y^d$ is the average share of domestic income spent on the consumption of I. Using (4) and (6) yields

$$\beta/b = \frac{P^d + a(P^w - P^d)}{P^d + \alpha(P^w - P^d)}. \tag{7}$$

The existing exchange rate is overvalued if $\beta/b > 1$. Since we have assumed $P^d < P^w$, the average share of imports must exceed the marginal share, i.e. $a > \alpha$, for there to be an overvalued exchange rate. But if $a = \alpha$ then $\beta = b$. Thus the shadow exchange rate, β, equals the existing exchange rate b, if either (i) $P^d = P^w$, or (ii) $\alpha = a$ (i.e. all income elasticities of demand equal unity). For the exchange rate to be overvalued (a case of particular interest), not only must both (i) and (ii) be violated but also the income elasticity of demand for the protected good (in this case, exports) must be greater than unity (i.e. $a > \alpha$).

II.3. *Commodity Taxation as an Equilibrating Device*

In the previous section it was supposed that relative prices were not affected by the project's implementation. We are now concerned with the case in which the government varies the consumption tax on imports to maintain equilibrium

(see Fig. 4). In addition to the symbols introduced earlier we need the following: P_i^c = consumer price of i $(i = I, E)$; P_i^d = producer price of i; $P^c \equiv P_I^c/P_E^c$; $P^d = P_I^d/P_E^d$; and

$$\epsilon \equiv -\frac{P_I^c}{C_I}\frac{\partial C_I}{\partial P_I^c}$$

the price elasticity of demand for the imported commodity.

Assuming that initially an equilibrium exists we note that instead of equation (2) we now have

$$Y^d = P_I^d X_I + P_E^d X_E = P_I^c C_I + P_E^c C_E. \tag{8}$$

However, equation (3) continues to hold. We wish to compute dW, where dW is given by equation (1).

By normalisation $dP_E^c = 0$. Moreover, from the definition of α (now defined as $P_I^c \partial C_I/\partial Y^d$) and ϵ we have

$$dC_I = \frac{\alpha dY^d}{P_I^c} - \frac{\epsilon C_I}{P_I^c} dP_I^c. \tag{9}$$

Taking the differentials of (8) and (3) one notes that

$$dP_I^c = \frac{dY^d}{C_I} + (P^w P_E^c - P_I^c)\frac{dC_I}{C_I} - \frac{P_E^c dY^w}{C_I P_E^w},$$

and therefore that

$$dC_I = \frac{1}{[\epsilon P^w + (1-\epsilon)P^c]}\left[\frac{(\alpha-\epsilon)\,dY^d}{P_E^c} + \frac{\epsilon dY^w}{P_E^w}\right] \tag{10}$$

and

$$dC_E = \frac{1}{[\epsilon P^w + (1-\epsilon)P^c]}\left[\frac{(\epsilon-\alpha)\,P^w dY^d}{P_E^c} + \frac{(1-\epsilon)\,P^c}{P_E^w}\,dY^w\right]. \tag{11}$$

We can now substitute (10) and (11) in (1) (with P_I^c, P_E^c for P_I^d, P_E^d) to obtain

$$dW = \theta dY^d + \phi dY^w, \tag{12}$$

where

$$\theta = \frac{\mu(\epsilon-\alpha)\,(P^w - P^c)}{\epsilon P^w + (1-\epsilon)\,P^c},$$

and

$$\phi = \frac{\mu P_I^c/P_E^w}{\epsilon P^w + (1-\epsilon)\,P^c}.$$

Equation (12), as it stands, is still not useful. In order to obtain the rule for project appraisal, substitute the differentials of (3) and (8) in (12) to obtain

$$dW = (\theta P_I^d + \phi P_I^w)\,dX_I + (\theta P_E^d + \phi P_E^w)\,dX_E;$$

from which we conclude that *the shadow price of imports relative to that of exports*, P^s, *is given by the expression*

$$P^s = \frac{(\epsilon-\alpha)\,(P^w - P^c)\,P^d + P^w P_I^c/P_E^d}{(\epsilon-\alpha)\,(P^w - P^c) + P_I^c/P_E^d}. \tag{13}$$

By assumption $P^w > P^c > P^d$ (see Fig. 4). It is simple to confirm that if the

two goods are gross-substitutes then $\epsilon - \alpha > 0$, which on using (13) implies that $P^w > P^s > P^d$.[1] In this case the accounting price ratio lies between the international price ratio and the domestic producer price ratio.

II.4. *Rationing*

Governments often resort to rationing to cope with disequilibria in the foreign exchange market. Return once again to Fig. 2. By hypothesis $P^d < P^w$. The idea now consists in the government allowing the consumer to trade freely at the price ratio P^d up to a maximum consumption of I given by the level of domestic production I^*. On looking at Fig. 2 it is clear that this means that equilibrium consumption is at Q''. There is no trade at this equilibrium; thus $C_I = X_I = I^*$ and $C_E = X_E = E^*$. More formally, (I^*, E^*) is the welfare-maximising consumption point when the consumer chooses (C_I, C_E) subject to the constraints

$$P_I^d C_I + P_E^d C_E \leqslant Y^d \equiv P_I^d I^* + P_E^d E^* \tag{14}$$

and

$$C_I \leqslant I^*. \tag{15}$$

Let ψ and ν be the multipliers associated with constraints (14) and (15). It follows immediately that a perturbation in consumption at (I^*, E^*) yields a welfare change given by

$$dW = (\psi P_I^d + \nu) \, dC_I + \psi P_E^d \, dC_E. \tag{16}$$

Clearly also, if production is perturbed at (I^*, E^*) we shall have $dC_I = dX_I$ and $dC_E = dX_E$. It follows immediately from (16) that in this case

$$P^s = P^d + \frac{\nu}{\psi P_E^d} > P^d.$$

In fact, from Fig. 2 it is clear that $P^s > P^w > P^d$.

We conclude that *under a rationing scheme the shadow price of imports relative to that of exports, P^s, exceeds both the world price ratio and the domestic price ratio.*

Equation (16) makes clear that for the problem at hand one wants to calculate the consumer's 'willingness to pay' at the rationed equilibrium. The key problem in this lies in estimating ν/ψ, which measures the extent to which realised consumption, I^*, falls short of that which is desired at the price ratio P^d. For the model we have been studying this is a simple enough matter. For more general economies estimating these is problematic. For a general discussion of this, see Little and Mirrlees (1974, pp. 167–9).

II.5. *Foreign Borrowing as an Equilibrating Mechanism*

A full intertemporal analysis, which this case ideally demands, would take us beyond the scope of this paper. What we shall do here is to consider a simpler problem, where the project engenders a balance of payments deficit in the current year, which is repaid in the future. The deficit, in the meanwhile, is

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[1] If the two goods are gross-substitutes, the own price elasticity (ϵ) of I must exceed in absolute terms its income elasticity. But by definition the latter is $\alpha/a > \alpha$. (Since $a < 1$.)

financed by foreign borrowing. We establish the result that *if and only if foreign borrowing is currently at its optimal level should accounting prices equal international prices.*

To see this, we divide the effects of a project into two components: its impact on current welfare (as measured by change in Y^d), and the opportunity cost of any induced changes in foreign borrowing. Thus having, by normalisation, set $\mu = 1$, we have

$$dW = dY^d - \lambda dF, \tag{17}$$

where dF represents the increased foreign borrowing (or reserve reduction) and λ is the marginal value of foreign borrowing in terms of domestic income (the shadow price of foreign borrowing). Leaving aside the problem of calculating λ, we are interested in determining how the project affects Y^d and F.

Since, by hypothesis, excess demand for imports is met at the margin by borrowing (increasing F), we have on using equation (2) that

$$dY^d = P_I^d dX_I + P_E^d dX_E = P_I^d dC_I + P_E^d dC_E. \tag{18}$$

Now the increase in borrowing induced by the project is the foreign exchange costs of the additional expenditure minus the foreign exchange earned by the project. Thus,

$$dF = P_I^w(dC_I - dX_I) + P_E^w(dC_E - dX_E). \tag{19}$$

Next define the 'consumption conversion factor', ϕ, by the expression

$$\phi(P_I^w dC_I + P_E^w dC_E) = P_I^d dC_I + P_E^d dC_E. \tag{20}$$

ϕ is the marginal cost of foreign exchange in terms of domestic income. Now use (18)–(20) in (17) to obtain the total effect of the project on welfare as

$$dW = \left[P_I^d \left(1 - \frac{\lambda}{\phi} \right) + \lambda P_I^w \right] dX_I + \left[P_E^d \left(1 - \frac{\lambda}{\phi} \right) + \lambda P_E^w \right] dX_E, \tag{21}$$

from which we conclude that the accounting price ratio of imports and exports, P^s, is

$$P^s = \frac{P_I^d \left(1 - \dfrac{\lambda}{\phi} \right) + \lambda P_I^w}{P_E^d \left(1 - \dfrac{\lambda}{\phi} \right) + \lambda P_E^w}. \tag{22}$$

Equation (22) says that *the accounting prices for the two tradeables are not their border prices if there is a divergence between the marginal cost $(1/\phi)$, and the marginal value $(1/\lambda)$, of domestic income in terms of foreign exchange.* In particular, we note that $P^s = P^w$ if and only if $\lambda = \phi$; i.e. the government has optimised its level of borrowing in the presence of the divergence between domestic and international prices. Note as well that the relative shadow price of the protected good is less than the existing domestic price. If too much is being borrowed (i.e. $\lambda > \phi$), the shadow price of the protected good must be reduced *below* even world price levels (i.e. $P^s > P^w > P^d$).

Since additional foreign borrowing must be repaid in future years, its cost represents the discounted value of future income used for repayment. Thus a fully dynamic model must be used to calculate λ. Here we shall not go into this

issue. For an analysis of one such dynamic model, see Blitzer, Dasgupta and Stiglitz (1976).

III. NON-TRADED GOODS

The addition of non-traded goods complicates the analysis considerably. In the first place, we can no longer assume that all relative prices are determined by tariffs and consumers' taxes in conjunction with fixed border prices. Either the exchange rate or the prices of non-traded goods will usually shift as the production vector changes.

Second, we must make explicit our assumptions regarding production decisions. With fixed indirect taxes and all goods traded, private sector production is not affected by public sector production decisions, since they depend on producers' prices only. When a non-traded good is introduced, public sector production may affect producers' prices and hence private sector production decisions.

As in the previous discussion, the welfare impact of a project depends on the manner in which the government chooses to close any gaps caused by a sub-optimal tax system. For example, consider an economy which has three goods – two of which are traded, and one that is non-tradeable. Since an additional market (for non-traded goods) must be kept in equilibrium, public finance involves using more instruments. It follows that the number of possible cases that one may study here is much greater than that in the previous section.

In what follows we will consider the case where the government maintains equilibrium through changes in the consumers' price of the non-traded good. For simplicity, we assume that public investment decisions do not affect private sector production choices. This implies that relative producers' prices are fixed. Alternatively, one can envisage that all production is under direct government control.

In addition to the symbols defined in Section II, we make use of the following notation:

X_N = production of the non-traded good;
C_N = consumption of the non-traded good;
P_N^d = producers' price of the non-traded good;
P_N^c = consumers' price of the non-traded good;
$\bar{t}_i$ = total indirect tax rate on good i, $i = I, E$;
t_i = tariff rate on good i, $i = I, E$;
T_i = consumption tax on good i ($i = I, E, N$).

Assuming that initially an equilibrium exists, we have

$$Y^d = P_I^d X_I + P_E^d X_E + P_N^d X_N = P_I^c C_I + P_E^c C_E + P_N^c C_N. \tag{23}$$

Moreover, for 'balance of payments' equilibrium to hold,

$$Y^w = P_I^w X_I + P_E^w X_E = P_I^w C_I + P_E^w C_E. \tag{24}$$

Finally, the market for the non-traded good must clear. This means that

$$X_N = C_N. \tag{25}$$

Consumption of each good depends on consumers' prices and disposable income. Thus

$$C_i = C_i(P_I^c, P_E^c, P_N^c, Y^d), \quad \text{for} \quad i = I, E, N. \tag{26}$$

Now consider a small project which can be abbreviated as (dX_I, dX_E, dX_N). We want to consider its impact on welfare. By hypothesis consumer prices reflect 'willingness to pay'. Since only the sign of the welfare change matters we write (normalising μ at unity)

$$dW = P_I^c dC_I + P_E^c dC_E + P_N^c dC_N. \tag{27}$$

As earlier, we need to express dW as a linear combination of dX_I, dX_E and dX_N. By differentiating equation (23) and substituting into (27), we have

$$dW = dY^d - C_N dP_N^c \tag{28}$$

(since our hypothesis regarding government policy implies $dP_I^c = dP_E^c = 0$). We wish to calculate the effect of the project on Y^d and P_N^c. Taking the differentials of (23) and (26), one obtains

$$(1 - a) dY^d = (b + C_N) dP_N^c + P_N^c dC_N \tag{29}$$

and using (24) and (26)

$$dY^w = \bar{a} dY^d + \bar{b} dP_N^c, \tag{30}$$

where

$$a = P_I^c \frac{\partial C_I}{\partial Y^d} + P_E^c \frac{\partial C_E}{\partial Y^d}, \quad \bar{a} = P_I^w \frac{\partial C_I}{\partial Y^d} + P_E^w \frac{\partial C_E}{\partial Y^d},$$

$$b = P_I^c \frac{\partial C_I}{\partial P_N^c} + P_E^c \frac{\partial C_E}{\partial P_N^c}, \quad \text{and} \quad \bar{b} = P_I^w \frac{\partial C_I}{\partial P_N^c} + P_I^w \frac{\partial C_E}{\partial P_N^c}.$$

Equations (29) and (30) can then be solved for dY^d and dP_N^c as functions of dY^w and dC_N. Then, using (28), it follows that dW is proportional to dW^*, where

$$dW^* = \frac{aC_N + b}{\bar{a}C_N + \bar{b}} (P_I^w dX_I + P_E^w dX_E) + P_N^c dX_N. [1] \tag{31}$$

While equation (31) yields the accounting prices that we need to estimate, it does not express them in an intuitive form. The troublesome bit is the factor, $(aC_N + b)/(\bar{a}C_N + \bar{b})$, which needs to be expressed in terms of initial conditions (i.e. the equilibrium point) and the more familiar price and income elasticities. Towards this we may as well normalise and set $P_I^w = P_E^w = 1$. Now let q denote the nominal exchange rate (q units of domestic currency per unit of foreign exchange). Then $P_i^d = q(1 + t_i)$ and $P_i^c = (1 + T_i) P_i^d = q(1 + \bar{t}_i)$, for $i = I, E$ Now define

$$\eta_i \equiv \frac{Y^d}{C_i} \frac{\partial C_i}{\partial Y^d} \quad \text{and} \quad \epsilon_{iN} \equiv \frac{P_N^c}{C_i} \frac{\partial C_i}{\partial P_N^c} \quad \text{for} \quad i = I, E$$

and let α_N denote the marginal consumption share of the non-traded good.

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[1] In fact $dW^* \equiv R dW / (\bar{a}C_N + \bar{b})$, where $R \equiv \bar{b}(1 - a) + \bar{a}(b + C_N)$.

Simple manipulation of equation (31) then reduces it to the form

$$dW^* = q[1 + \gamma \bar{t}_I + (1 - \gamma)\bar{t}_E](dX_I + dX_E) + P_N^c \, dX_N, \qquad (32)$$

where

$$\gamma \equiv \frac{C_I(\alpha_N \eta_I + \epsilon_{IN})}{C_I(\alpha_N \eta_I + \epsilon_{IN}) + C_E(\alpha_N \eta_E + \epsilon_{EN})}.^1$$

Equation (32) is the key result of this section, because we can now conclude:

(*i*) *The ratio of the shadow price of I to that of E equals their border price ratio (unity)*, and

(*ii*) *in pricing traded goods relative to the non-traded good a shadow exchange rate (SER) must be used. The SER is the nominal rate times one plus a weighted average of total indirect taxes, $\bar{t}_I$ and $\bar{t}_E$. The weights depend on demand elasticities and initial conditions.*

It is the first part (*i*) that requires comment, since it seemingly runs counter to the result in Section II.3. But the point is that here we have not allowed any adjustments in the relative prices of the traded goods in the description of the government's equilibrating mechanism. If we allowed the government to equilibrate, say by taxing imports only, then as in Section II.3 the first part of the foregoing result would not hold. This would be the case as well were the government to resort to foreign borrowing to close the trade deficit.

IV. COMMENTARY

In these concluding remarks, we shall clarify some of the differences between the approach we have taken and that of others. Methodologically, our study differs somewhat from that which is now prevalent in the modern public finance literature, which is to obtain rules for taxation and criteria for public production from conditions the (possibly second-best) optimum must satisfy (i.e. the first-order conditions).[2]

Instead we have studied an economy in equilibrium in which the government has not adopted an optimal course of action. In this economy a small project is contemplated. The economy is assumed to find a new resting place, and the problem is to calculate the accounting prices with which to evaluate the project.[3] Stated so baldly the *approach* is uncontroversial. Controversies usually arise when precise assumptions are made about the government's sub-optimal policies; or, in the terminology of this paper, the equilibrating mechanisms that the government pursues. Here we have not been concerned with evaluating the relative merits of one over the others, but rather with studying the implications of a few such mechanisms on project choice. To an extent this has enabled us to trace the structure of the shadow prices to the equilibrating mechanism. In this

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[1] Note that $\alpha_N \eta_i + \epsilon_{iN}$ is the general equilibrium, or compensated price elasticity of good *i*. It should be noted also that equation (32) is a special form of an expression developed by Harberger (1971) and Balassa (1974) for the shadow price of non-tradeables. It is a special case because we have supposed government action not affecting relative producers' prices. Moreover, we have assumed that the exchange rate is held constant.

[2] See, for example, Diamond and Mirrlees (1971) and Dasgupta and Stiglitz (1974).

[3] The relationship between these two approaches is clear enough. For a more complete discussion of these matters, see Dasgupta (1978) and Hughes (1978).

sense this paper is complementary to Dasgupta and Stiglitz (1974), for in the earlier paper no particular attention was given to the nature of the equilibrating mechanism the government was assumed to follow.

The results of this paper force one to reject approaches that propose shadow prices based on the desire for free trade as a final resting place. The point is not whether free trade is desirable, but rather that shadow prices – if they are to be *meaningful* – must be calculated on the basis of a clear recognition of the actual (possibly sub-optimal) policy being pursued.

At issue is the distinction between a foreign exchange constraint, the shadow price of foreign exchange, and the accounting prices of the different goods and services involved in an investment project. Stated loosely the multi-sector programming approach to development planning (as in, e.g. Blitzer, Clark and Taylor (1975)) views the shadow price of foreign exchange as the Lagrange multiplier associated with the constraint reflecting the balance of payments. For our purpose this is not of great help since the focus of attention in this paper has been the study of equilibria that may be quite sub-optimal. For example, we noted in Section II that it is possible that there is a wedge between the social value of foreign exchange, λ, and its social cost ϕ. For project planning the need is to obtain the relative shadow prices of all the goods and services, in the calculation of which ϕ and λ may or may not play an important role. There are circumstances (e.g. as in Section II.5, when foreign borrowing is optimal, and $\phi = \lambda$), where the shadow price of foreign exchange is of no interest (see equation (22)). Then again, it was noted that if $\phi \neq \lambda$, the precise values of ϕ and λ are required to obtain the relative shadow prices of goods and services (equation (22)).

If all goods and services are traded the nominal exchange rate is immaterial. Relative shadow prices are independent of the exchange rate. If the nominal exchange rate is altered by a given proportion, each of the 'prices', P_I^d, P_E^d, λ and ϕ is altered by the same proportion and, as (22) makes clear, P^s remains the same.

Matters are different when non-traded goods are introduced into the picture. The nominal exchange rate influences the prices of non-traded goods as a whole relative to the prices of traded ones. Now suppose, for simplicity, that the circumstances are such that the appropriate accounting prices of traded goods are their international prices (as in the example of Section III). What remains is to calculate the shadow prices of the non-traded goods relative to any one of these traded goods. The nominal exchange rate (q) will now clearly matter. But the accounting prices of non-traded goods may not equal their market prices. A different factor is then required to convert the market price of each non-traded good to its shadow price. For this reason it is often said that one needs to calculate as many shadow exchange rates as there are non-traded goods (see, e.g. Scott (1974)). In the example of Section II a single non-traded good was postulated, and therefore only a single shadow exchange rate (SER) is required. It is defined in equation (32) as the factor $q[1 + \gamma \bar{t}_I + (1 - \gamma) \bar{t}_E]$. This is the terminology followed in Dasgupta, Marglin and Sen (1972), Balassa (1974) and Bruno (1976).

An equivalent approach would be to measure values in foreign currency.

Since it is only the sign of dW^* in equation (32) that matters we could as well divide both sides of (32) by the *SER* to obtain

$$dW^{**} = (dX_I + dX_E) + P_N^c \, dX_N / \{q[1 + \gamma \bar{t}_I + (1 - \gamma) \, \bar{t}_E]\}.$$

Here, the factor converting the market price of the non-traded good (expressed in foreign currency), P_N^c/q, to its shadow price is $1/[1 + \gamma \bar{t}_I + (1 - \gamma) \, \bar{t}_E]$. It is this last term that is often referred to as the *conversion factor* for the non-traded good.[1] In general, a separate conversion factor is required for each non-traded good. But this can be very hard work. Both Dasgupta, Marglin and Sen (1972) and Balassa (1974) have therefore suggested formulae for calculating the shadow prices of non-tradeables, *as a group*, in terms of tradeables, by using a single shadow exchange rate. In the language of Little and Mirrlees (1969; 1974), this is equivalent to using a single conversion factor (the *standard conversion factor*) to transform the market price of every non-traded good into its shadow price. This is, of course, a crude approximation, since it supposes that the *relative* shadow prices of non-tradeables are equal to their relative market prices.[2]

In a sense the results of this paper are depressing, for they suggest that very general results are hard to come by in the field of cost-benefit analysis: accounting prices of goods and services appear not to be insensitive to the equilibrating mechanisms that are pursued by a government. However, the models we have chosen to study here are mere examples; nothing more. We have chosen to work with them not only for the purpose of illustrating a methodology for social cost-benefit analysis, but also to highlight the fact that what appears as a 'foreign exchange constraint' often arises because of domestic price distortions. However, several of the specific results in this paper may appear at variance with recommendations in earlier works on the subject of social cost-benefit analysis. The procedure we have pursued in this paper consists in expressing the change in social welfare, dW, due to a project *solely* as a weighted sum of the goods and services involved in the project, dX_i ($i = I, E, N$). The shadow prices are then these weights (see e.g. equations (21) and (32)). Therefore, for example, in Section II.5 we concluded that the border prices of tradeables are not their accounting prices if the government has not sub-optimised the level of foreign borrowing (equation (22)). However, if we use equations (17)–(20) we can, equivalently, express dW in equation (21) as

$$dW = \phi(P_I^w \, dX_I + P_E^w \, dX_E) - (\lambda - \phi) \, dF, \tag{33}$$

and claim that the appropriate accounting price ratio *is* the border price ratio, but that in evaluating a project the foreign borrowing engendered by the project must in *addition* be taken into account by the use of a conversion factor $(\lambda - \phi)$. Thus, if we express $-dF$ as the change in government revenue, equation (33) requires of us to use $(\phi - \lambda)$ as a conversion factor for the social cost of extra government revenue.[3] The point, of course, is that unlike equation (21), dW in

[1] See Little and Mirrlees (1969; 1974).

[2] The supposition is of course correct if, as in the economies discussed in Section I, overall production efficiency is desired. It is an open question if the supposition is correct under more general circumstances.

[3] For the example at hand the Little and Mirrlees procedure would recommend an appeal to equation (33) rather than the equivalent expression (21). See Hughes (1978) for an excellent discussion of the different approaches.

equation (33) has not been expressed solely as a weighted sum of the goods and
services involved in the project in question. At a formal level it makes no dif-
ference whether one uses expression (21) or expression (33). But at the practical
level it may matter greatly, for it is *always* possible to express the change in
social welfare as a weighted sum of the tradeable inputs and outputs of a project
(with the relative weights equal to their relative border prices), *and* the sum
of a set of residual terms – as in equation (33). Unless the residual terms add up
to zero – as in equation (33) when $\lambda = \phi$ – it is surely misleading to say that
border prices are the appropriate prices to use in measuring the social values of
tradeable goods and services. It bestows on the 'border price rule' a degree of
generality that it does not in fact possess. In particular there is the inevitable
temptation for the project evaluator to suppose that the residual terms are
negligible, and to use the border price rule in its unbridled form.

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