

Bridging the Tax-Expenditure Gap: Green Taxes and the Marginal Cost of Funds.

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Abstract

The marginal cost of public funds is usually seen as a number greater than one, reflecting the efficiency cost of distortionary taxes. But economic intuition suggests that since green taxes are efficiency-enhancing the MCF with such taxes will be less than one. The paper demonstrates that this intuition is not necessarily true, even when a green tax is the sole source of funds. The analysis also considers the MCF with a proportional income tax, given the presence of green taxes. It compares the optimization approach to the MCF with that of a balanced budget reform and shows that they lead to equivalent results.

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1. Introduction.

On several occasions Richard Musgrave has lamented the tendency in the theory of public finance to analyze questions of taxation and of the supply of public goods¹ in separate compartments. Although this practice can often be justified in terms of analytical tractability, it is true that a joint perspective on taxes and public expenditure is sometimes very important. In the recent literature this point has been emphasized in numerous studies of the concept of the marginal cost of (public) funds, or the MCF for short. The basic idea in this literature is that when public goods are financed by distortionary taxes, the efficiency costs that this entails should, in a cost-benefit analysis of public projects, be reflected in an adjustment of the marginal resource cost of increased supply. If public goods supply could have been financed by lump sum taxes, an increased supply involving a cost of 1 million euros and benefits of 1.2 million euros should definitely be carried out. But if each euro of tax revenue involves 0.3 euros of tax efficiency cost, the social cost should be computed as 1.3 times the direct resource cost, 1.3 being the MCF. With a social cost of 1.3 million euros the proposed increase in public goods supply no longer passes the cost-benefit test. Thus, the concept of the marginal cost of public funds is the modern theory's response to Musgrave's critique. Its origin lies in the tax side of the public budget, and its application is to the determination of the expenditure side.

Like a number of other fundamental ideas in public finance, this one can be traced back to Pigou (1928). It reentered the literature through the theory of optimal taxation, notably in a famous article by Atkinson and Stern (1974), although they did not use the MCF terminology, which was apparently introduced by Browning (1976). More recent contributions include Wildasin (1984), Mayshar (1991), Ballard and Fullerton (1992) and Håkonsen (1998). While most analyses of the MCF interpret it as a pure measure of inefficiency, some authors, like Wilson (1991), Dahlby (1998) and Sandmo (1998), have argued that the MCF should also incorporate a measure of the possible distributional gains from distortionary taxes. The basic argument for this is that taxes are distortionary precisely because one wants to achieve some distributional

¹ Or, more generally, publicly provided goods. These might – and indeed do – also comprise private goods in areas like health and education.

objective; hence the MCF should reflect the redistributive gain as well as the efficiency loss.

Underlying most of this literature is the crucial assumption that when lump sum taxes are not available, taxes used to finance the supply of public goods must be distortionary. But this is not necessarily the case. In the case of commodities or factors of production generating negative external effects, we know that the imposition of a tax reflecting the difference between marginal social and private cost (or between marginal private and social benefit) does not create any inefficiency; on the contrary, it leads to an efficiency gain. This insight has recently given rise to a large number of analyses of the so-called double dividend from a green tax reform, in which one studies the substitution of green or Pigouvian taxes for standard distortionary taxes, assuming that government revenue is to be held constant. That the existence of a double dividend turns out not to be so obvious as might be suggested by partial equilibrium analysis comes essentially from the cross-price effects between markets, an aspect not captured in the partial equilibrium approach².

The definition of the double dividend with constant tax revenue as the point of reference is, however, not the only one possible. If one believes that a distortionary tax system keeps the supply of public goods at an inefficiently low level, one way in which to reap the benefits of a less distortionary system would be to expand public expenditure, seeing that the MCF is now lower than it used to be. This idea has also a considerable appeal to economic intuition. In fact, partial equilibrium analysis would suggest that if increased public expenditure could be financed by Pigouvian or green taxes, the MCF should be *less than one*, since there is now an efficiency *gain* from tax finance which should be subtracted from the direct resource cost. But experience from following the double dividend debate should warn us that there may be complications ahead and that a more general analysis is called for.

Among the contributions that already address this or related questions from a theoretical angle, van der Ploeg and Bovenberg (1994) and Kaplow (1996), are

particularly noteworthy. van der Ploeg and Bovenberg study the effects of varying environmental preferences on the optimal supply of public goods, but they do not discuss the role of environmental taxes in determining the MCF. Kaplow's main concern is to study the role of optimal non-linear income taxation; under special assumptions about preferences he shows that we should think of the MCF in first-best terms³. The articles by Ballard and Medema (1993) and Brendemoen and Vennemo (1996) use computable general equilibrium models to study alternative sources of finance for public projects and find that the MCF for environmental taxes are much lower than for traditional taxes, sometimes indeed considerably below unity.

2. Individual behaviour and the first best allocation.

A desire for redistribution is essential for understanding why existing tax systems are distortionary. The efficiency loss from distortionary taxes therefore has to be balanced against redistributive gains, and to focus solely on the loss side, as one does in most of the literature on the marginal cost of funds, may therefore be misleading. However, in the interests of analytical simplicity, this is nevertheless what we shall do in the following, keeping in mind that distributional concerns can relatively easily be added on to the model, e.g. in the way in which it has been done in Sandmo (1998). Hence it is assumed that all consumers are alike, and that the representative consumer's utility function can be written as

$$U = U(y, x, l, z, e), \tag{1}$$

where y and x are the quantities of two consumer goods, l is leisure, z is the supply of a public good and e is environmental pollution. U is increasing in the first four arguments and decreasing in the fifth. Environmental pollution is generated by the aggregate consumption of the x -good, so that $e = nx$. Labour supply is denoted by h , with $h + l = T$, which is the time endowment.

² For a more detailed analysis see Sandmo (2000, ch. 6) and the review of the literature by Bovenberg (1999).

³ This is closely related to an earlier result in an important paper by Christiansen (1981).

Each consumer maximizes his utility, taking the supply of public goods and the amount of environmental pollution as given. His budget constraint is

$$y + Px = w(1-t)h + a. \quad (2)$$

The y-good is the *numéraire*, while the price of the x-good is $P = p + t$, with p being the producer price and t the tax rate. Labour income is subject to tax at the rate t . a is any exogenous income that the consumer might have; if $a < 0$, it is a lump sum tax.

Utility maximization leads to the first order conditions

$$U_x / U_y = w(1-t), \quad (3)$$

$$U_x / U_y = P. \quad (4)$$

This gives rise to a supply function for labour

$$h = h(w(1-t), P, a, z, e), \quad (5)$$

and demand functions for the two consumer goods. In particular, the demand function for the x-good or “dirty good” is

$$x = x(w(1-t), P, a, z, e). \quad (6)$$

We assume that the dirty good is normal ($\partial x / \partial a > 0$), implying that demand is a decreasing function of price ($\partial x / \partial P < 0$).

Note the dependence of these functions on the state of the environment, e . While this is an exogenous variable from the point of view of each single individual⁴, changes

⁴ This may require a comment in view of the assumption that all individuals are identical. The essential part of the assumption is that each consumer’s use of the dirty good is small relative to aggregate consumption and pollution. Under that assumption, even when individuals are not identical, each one of them may know that others respond to prices and income in the same way as he does himself, but it is still not rational for him to take this into account in his own consumption decisions. This is simply the assumption of perfectly competitive behaviour.

in prices, taxes and public goods supply will in the aggregate affect individual behaviour through their effects on e and the feedback effects on labour supply and commodity demands. Many writers have chosen to neglect these feedback effects; the case in which there is a rigorous justification for it is of course where the utility function is weakly separable between the state of the environment and other goods, so that

$$U = U(\mathbf{j}(y, x, l, z), e), \quad (1')$$

Separability is hardly a realistic assumption, and for a number of environmental problems, such as traffic congestion, non-separability and feedback effects are obviously very important. Nevertheless, it will be adopted in what follows, basically because it simplifies the analysis without distorting the conclusions that can be drawn from it.

Optimizing behaviour also implies the indirect utility function

$$V = V(w(I-t), P, a, z, e), \quad (7)$$

with the Roy conditions

$$V_t = -Iwh; \quad V_P = -Ix; \quad V_a = I. \quad (8)$$

We now turn from individual behaviour to social welfare maximization. With all individuals being alike the natural choice for a social welfare function is the utilitarian sum of utilities, which is simply $W = nU$. The production possibility schedule is assumed to be of the linear Ricardian form, so that it can be written as

$$-wnh + ny + pnx + qz = 0. \quad (9)$$

Here w , p and q are the technical production coefficients. The symbols have been chosen to reflect the fact that under competitive conditions the coefficients will be equal to equilibrium producer prices, again with the y -good as the *numéraire*.

Social welfare maximization is now characterized by the first order optimality conditions

$$U_x/U_y = w, \quad (10)$$

$$U_x/U_y + n U_e/U_y = p, \quad (11)$$

$$n U_z/U_y = q. \quad (12)$$

Comparing (10) and (11) with the conditions for individual utility maximization (3) and (4), we can characterize the first best optimal tax structure. This is simply $t = 0$ and $\tau = -nU_e/U_y$. There should be no distortionary tax in the labour market. The tax on the dirty good should reflect the marginal social damage, and this is the sum of the marginal damages imposed on all individuals. Finally, the public good should be supplied according to the Samuelson (1954) optimality rule; the sum of the marginal willingness to pay across all individuals should equal the marginal cost or the marginal rate of transformation, and the MCF is unity. If this combination of taxes and public goods supply leads to a deficit or surplus in the government's budget constraint, the gap should be filled by a lump sum transfer from or to the consumers, i.e. by an adjustment of the lump sum income term, a .

3. Public goods supply with distortionary taxes.

We now abandon the assumption that lump sum taxes are feasible. Of course, in a model economy of identical individuals, there is no real justification why it should be impossible to collect the same amount in taxes from all individuals. This must be seen simply as an *ad hoc* device to concentrate on the efficiency properties of a second best optimum situation. The government has to finance the cost of supplying the public good partly by means of the distortionary income tax, partly through the Pigouvian tax on the dirty good. As a natural point of reference, we begin by deriving the

conditions for a second best optimum. What is the optimal supply of the public good, and what is the best combination of the labour income tax and the Pigouvian tax?

The government's budget constraint says that taxes collected must equal expenditure, so that

$$ntwh + n\mathbf{t}x = qz, \quad (13)$$

while the social welfare function can be written on dual form as

$$W = n V(w(1-t), P, a, z, e), \quad (14)$$

where a must now be understood as being equal to zero.

We are now in a position to study how the cost of public goods supply depends on the costs of tax finance. But there are in principle two ways in which this can be done. We could, as Atkinson and Stern (1974) did, adopt the framework of optimal taxation and public goods, or we could, as is more or less implicit in cost-benefit analysis, consider a balanced budget change in public expenditure and taxes without assuming anything about optimality. The first approach gives the most straightforward interpretation of the MCF as a shadow price emerging from the optimality conditions. The second, however, is much less restrictive and more relevant for the view of the MCF as a practical tool for the evaluation of public projects. In the following we shall pursue both approaches and see how they are related.

Starting within the optimality framework, the problem is to maximize (14) with respect to the tax rates t and \mathbf{t} , subject to the budget constraint (13). The Lagrangian can be written as

$$L = n V(w(1-t), P, z, e) + \mathbf{m}[ntwh + n\mathbf{t}x - qz]. \quad (15)$$

The first-order conditions for this optimization problem⁵ are

$$\mathcal{L}/\mathcal{t} = -n\mathbf{l}wh + nV_e n(\mathcal{L}/\mathcal{t}) + \mathbf{m}[nwh + ntw(\mathcal{L}/\mathcal{t}) + nt(\mathcal{L}/\mathcal{t})] = 0, \quad (16)$$

$$\mathcal{L}/\mathcal{P} = -n\mathbf{l}x + nV_e n(\mathcal{L}/\mathcal{P}) + \mathbf{m}[nx + ntw(\mathcal{L}/\mathcal{P}) + nt(\mathcal{L}/\mathcal{P})] = 0, \quad (17)$$

$$\mathcal{L}/\mathcal{z} = nV_z + nV_e n(\mathcal{L}/\mathcal{z}) + \mathbf{m}[ntw(\mathcal{L}/\mathcal{z}) + nt(\mathcal{L}/\mathcal{z}) - q] = 0. \quad (18)$$

Although the three conditions provide a joint characterization of the optimal tax-expenditure policy, it is natural to see (18) as the optimality condition for public goods supply. Dividing through this equation by \mathbf{l} and rearranging terms, we obtain

$$n(V_z/\mathbf{l}) + (nV_e/\mathbf{l})n(\mathcal{L}/\mathcal{z}) = \mathbf{g}[q - ntw(\mathcal{L}/\mathcal{z}) - nt(\mathcal{L}/\mathcal{z})], \quad (19)$$

where $\mathbf{g} = \mathbf{m}\mathbf{l}$. The interpretation of this condition is straightforward. The first term on the left is the Samuelson sum of the marginal rates of substitution, i.e. the direct benefit of the increase in public goods supply. The second term is the indirect benefit that arises because the public good may cause a change in the amount of environmental damage. This benefit is positive if the dirty good and the public good are substitutes ($\mathcal{L}/\mathcal{z} < 0$) and negative if they are complements ($\mathcal{L}/\mathcal{z} > 0$). On the right-hand side, q is as before the direct resource cost of the public good. The direct resource cost is modified by the remaining two terms in square brackets. These terms represent the change in tax revenue that is generated by an increased public goods supply; to the extent that the public good increases the tax bases, it counteracts the adverse distortionary effects of the taxes, so that real resource costs are lowered. Finally, the parameter \mathbf{g} represents the ratio of the marginal utilities of income in the private and public sector and is a measure of the inefficiency of the tax system. It is this parameter that will be identified with the marginal cost of public funds.

However, a question may be raised as to whether \mathbf{g} alone is not too restrictive as a measure of the MCF. In particular, one might argue that the tax revenue effects should

⁵ The form of the optimality conditions reflects the assumption of separability. In the general case the partial derivatives \mathcal{L}/\mathcal{t} etc. would have to be replaced by derivatives dh/dt etc., which would take

also somehow be included, since they too characterize the second best optimality condition in contrast to the first best Samuelson rule. There may be something to be said for this, but the issue depends on how one sees the practical role of the concept of the MCF. The point of view taken here is that the potential usefulness of the MCF lies in cost-benefit analyses of public goods projects funded by general tax finance, and that it should be the same for all projects. But the bracketed expression in (19) is project specific, since the only realistic assumption is that each public good is characterized by a different degree of substitutability or complementarity with private taxed goods. g on the other hand, is a characteristic of the system of tax finance and does not vary with the nature of the project. Thus, the modification of the direct resource cost via the effect of the public good on the tax base should be seen as a separate operation, which is to be performed before the MCF is applied to the net resource cost of the project.

4. An optimal tax structure.

When both tax rates have been chosen in accordance with the second best optimal tax criterion⁶, it follows that the MCF at the optimum must be the same, *whatever the source of tax finance*. This follows by noting that when (16) and (17) both hold, we must have that

$$g = \left\{ \frac{[wh - n(V/I)(\frac{X}{I})]/[wh + tw(\frac{h}{I}) + t(\frac{X}{I})]}{[x - n(V/I)(\frac{X}{P})]/[x + tw(\frac{h}{P}) + t(\frac{X}{P})]} \right\} \quad (20)$$

account of the environmental feedback on demands and supplies. See Sandmo (2000, ch. 6 for details).

⁶ The reader may check that conditions (16) and (17) together imply the property of additivity, as it was called in Sandmo (1975), or the principle of targeting. Solving the two equations for t and τ , it can be shown that the characterization formula for the income tax rate is a generalized version of the Ramsey inverse elasticity and is independent of the marginal social damage, while the formula for the green tax is the weighted sum of a Ramsey term and one reflecting the marginal social damage. Of the available taxes, it is only the tax on the dirty good which, in the optimal design of the tax system, is targeted on improving the environment.

Can anything be said about the common value of the two expressions for the MCF? Simple conditions in terms of demand and supply derivatives seem difficult to derive. Still, there are two important messages to take away from (20). The first is the equality of the two measures of the MCF, and that it is only in the case where the whole tax system has been optimized that the concept of *one* MCF is a valid one. The second message has the form of a caution. It might be tempting to conclude that the common value of the MCF must be lower in this case than it would have been, had the green tax for some reason not been available – the reason being presumably that the value of the objective function must increase with the number of policy instruments that can be used. The fallacy in this line of reasoning is that it is not the MCF but social welfare which is the policy objective, and that there is no one-to-one correspondence between social welfare and the value of the MCF. We might still think that this would be a reasonably realistic conclusion, but it does not follow directly from the simple logic of optimization theory.

5. Beyond optimization: The reform perspective.

In the previous section we considered the marginal cost of public funds as a shadow price related to the solution of an optimization problem. But if the MCF is to be used in an evaluation of particular proposals for increased supply of a public good, the optimality setting is very restrictive. A more natural framework is that of the theory of tax reform, although extended to take account of the increase in public expenditure. The question is then whether increased expenditure increases welfare, given the nature of tax finance.

We begin by studying the condition for welfare improvement following a simultaneous change in tax rates and public goods supply. If we take the differential of the social welfare function (14), the condition can be written as:

$$dW = [-nI_w h + nV_e n(\mathcal{J}_x/\mathcal{J}_t)]dt + [-nI_x + nV_e n(\mathcal{J}_x/\mathcal{J}_P)]dt + [nV_z + nV_e n(\mathcal{J}_x/\mathcal{J}_z)]dz > 0. \quad (21)$$

The increased expenditure must be balanced by a corresponding increase in tax revenue, so that from the government's budget constraint we must have that

$$[nwh + ntw(\frac{\partial h}{\partial t}) + nt(\frac{\partial x}{\partial t})]dt + [nx + ntw(\frac{\partial h}{\partial P}) + nt(\frac{\partial x}{\partial P})]dt + [ntw(\frac{\partial h}{\partial z}) + nt(\frac{\partial x}{\partial z}) - q]dz = 0. \quad (22)$$

We can now use (21) and (22) to analyze the conditions for increased public goods supply to be welfare improving under alternative assumptions about the source of tax finance

6. The case of pure green finance.

It is useful to pursue the analysis via the simple case where there are no other taxes, so that the green tax is the only source of finance. One might perhaps think that this implies a reversion to the first best. This is not true, however, since there is no guarantee that the revenue generated by the first best level of the green tax would finance an optimal amount of the public good. The optimal resource cost of the public good might be either higher or lower than this, and budget balance must be achieved through a simultaneous adjustment of the tax and the public goods supply.

We start by considering the analysis in an optimal tax framework. With $t=0$, (19) becomes

$$n(V_z/I) + (nV_e/I)n(\frac{\partial x}{\partial z}) = g[q - nt(\frac{\partial x}{\partial z})]. \quad (23)$$

The MCF, which will now be written as g_t to indicate the source of finance, can now be obtained from the lower line of (20), after setting $t=0$, as

$$g_t = [x - n(V_e/I)(\frac{\partial x}{\partial P})]/[x + t(\frac{\partial x}{\partial P})]. \quad (24)$$

As pointed out above, one's intuition might suggest that with purely green taxation, the MCF could well be below one. However, the form of (24) does not immediately indicate that this is the case. A more careful analysis of this equation is accordingly called for.

Note first that the expression in the denominator represents the derivative of tax revenue with respect to the green tax. In standard optimal tax theory the tax revenue effect is positive at the optimum; an increase in the tax rate inflicts a loss on consumers, and to offset this loss, the tax revenue effect must be positive. In other words, each tax rate must be on the rising part of its 'Laffer curve'. In the case of a green tax, however, this is not necessarily the case. An increase in the price P involves a loss to the consumer through the negative effect on his purchasing power, but at the same time it improves the environment, which is a gain. A higher tax at the margin might therefore represent a net gain for the consumer, and in this case it could happen that the marginal tax revenue effect could be negative at the optimum. But this is an anomalous case, implying – as is easily seen from (24) – a *negative* MCF. Therefore, the conventional assumption of a positive revenue effect seems to be the interesting and relevant one, and I shall concentrate on this. Given that assumption (in addition to the assumption that the dirty good is normal), it is easy to see that (24) implies the following:

$$g_t > 1 \text{ if and only if } t > -n(V_e/I). \quad (25)$$

In words, the marginal cost of public funds exceeds one in the case where the optimum green tax rate exceeds its Pigouvian level; conversely, it is less than one if the tax is below this level. The intuition behind the result is easy to understand. When the tax exceeds its Pigouvian level, its role *on the margin* becomes that of an ordinary distortionary tax; it is higher than required to equalize marginal social benefits and costs. In that case the MCF must necessarily be greater than one. When, on the other hand, it is below that level, an additional increase goes further in the direction of internalizing the externality, so that there is a social benefit involved in a higher tax rate. The higher tax leads to a lower degree of distortion, so that the MCF becomes less than one.

It is worth noting that the borderline case $t = -n(V_e/I)$, where the second best tax rate coincides with the first best, also has the implication that the condition for optimal public goods supply (23) becomes simply $n(V_z/I) = q$. When the green tax internalizes the externality perfectly, there is no need to take account of the effect of public goods supply on the environmental externality, and the Samuelson optimality condition holds without modification.

We now adopt the reform perspective, where no assumption is being made about the optimality of taxes and expenditure. With pure green finance we have that $dt=t=0$ in (21) and (22). Eliminating dt from the last expression, we can rewrite (21) as

$$dW/dz > 0 \ll n(V_z/I) + (nV_e/I)n(\mathcal{J}_x/\mathcal{J}_z) > \mathbf{g}_t[q - n\mathbf{t}(\mathcal{J}_x/\mathcal{J}_z)], \quad (26)$$

where, as before,

$$\mathbf{g}_t = [x - n(V_e/I)(\mathcal{J}_x/\mathcal{J}_P)]/[x + \mathbf{t}(\mathcal{J}_x/\mathcal{J}_P)]. \quad (27)$$

The expression for the MCF is the same as (24), while the condition for welfare improvement has the same form as (23); the difference is simply that the equality sign in (23) has been replaced by an inequality. Whether the MCF is greater than or equal to one depends on whether the green tax is above or below its first best level. Thus, the basic logic of the analysis and the usefulness of the MCF concept is valid outside of the optimal tax-expenditure framework.

In comparing the identical expressions (24) and (27) it should of course be kept in mind that although the expressions have the same form, the actual *value* of the MCF is unlikely to be the same in both cases. In the case represented by (24) the value has been derived as a shadow price in a second best optimization problem, while in (27) there are no such restrictions on taxes and quantities. The important message – which is easily seen to be valid beyond this particular example - is that the correct way to think about the components of the MCF is independent of any optimality assumptions. This is consistent with the more general analysis of the principles of

cost-benefit analysis by Drèze and Stern (1987), who also point out that the definition of shadow prices does not depend on the assumption that the government has carried out an optimal plan.

7. A fixed distortion in the labour market.

A natural extension of the previous analysis is to the case where the green tax is still the marginal source of finance, but where there is a fixed tax distortion in the labour market. This case can be seen as representing the more general case where the income tax system has been designed to a large extent with distributional objectives in mind and where the marginal tax rate accordingly is not adjusted to finance the marginal expenditure on public goods.

With the insights established in the previous section, it is now natural to focus on the reform framework. Thus, in (21) and (22) we have $t > 0$, but $dt = 0$. Proceeding as above we derive the expression for the MCF as

$$g_t = [x - n(V_e/I)(\partial x/\partial P)]/[x + tw(\partial h/\partial P) + t(\partial x/\partial P)]. \quad (28)$$

To study the condition for $g_t > 1$, we continue to assume that the effect on tax revenue of raising t is positive. The condition then becomes

$$[t + n(V_e/I)](\partial x/\partial P) < -tw(\partial h/\partial P).$$

Dividing through by $\partial x/\partial P$, which is negative, we may conclude that

$$g_t > 1 \text{ if and only if } t + n(V_e/I) > -tw(\partial h/\partial P)/(\partial x/\partial P). \quad (29)$$

The left-hand side of the inequality is the deviation of the green tax from its first-best level.⁷ The right-hand side has the sign of $\frac{\partial h}{\partial P}$. In the absence of quantitative information about the relationships involved, one firm conclusion that can be drawn is the following:

$$g_t > 1 \text{ if } t > n(V_e/I) \text{ and } \frac{\partial h}{\partial P} < 0. \quad (30)$$

It also follows that

$$g_t < 1 \text{ if } t < n(V_e/I) \text{ and } \frac{\partial h}{\partial P} > 0. \quad (31)$$

Both (30) and (31) state *sufficient* conditions for the MCF to be greater than or less than one, respectively, but each of them also alerts us to the difficulties involved in providing necessary conditions in this type of setting. From our previous discussion of the benchmark case of pure green finance, we would indeed expect the MCF to exceed one in the case where the green tax is above its Pigouvian level. If $\frac{\partial h}{\partial P} = 0$, that result would have carried over to the present case. But when the cross price effect differs from zero, the increase in the price of the dirty good affects the magnitude of the labour market distortion. Suppose that labour and the dirty good had been complements ($\frac{\partial h}{\partial P} > 0$). Then, while a further increase in t would exacerbate the distortion in the market for the dirty good, it would counteract the distortion in the labour market by increasing the supply of labour. Depending on the relative strengths of the two effects, the MCF could be either less than or equal to one. If, however, labour and the dirty good are complements, as in (30), an increase in t has the effect of worsening the distortion in both markets, so that the MCF is unequivocally greater than one.

Condition (31) has a similar interpretation. A value of t below its Pigouvian level would seem to indicate an MCF less than one. But because of the effect on labour supply of an increase in the price of the dirty good, it is only in the case of

⁷ Or, more correctly, the deviation of the tax from its first-best *characterization*. In a distorted equilibrium the value of an environmental improvement will in general differ from what it would have been under first-best conditions, although its analytical representation has the same form.

complementarity ($\partial h/\partial P > 0$) that this conclusion can be firmly extended to the case of a distorted labour market.

In connection with condition (31) there is a special case which deserves particular attention, viz. that where the initial value of t is zero. In discussions of the double dividend from a green tax reform, the thought experiment that some people seem to have in mind is where green taxes are introduced into an overall tax system where they were previously not present. In general, (28) indicates that such a reform will imply an MCF below unity provided that the green tax does not sufficiently strongly magnify the effects of previous tax distortions in the economy.

8. The income tax as the marginal source of funds.

As a further thought experiment we may briefly consider the case where the increase in public expenditure is financed by means of increased income taxation and where the level of green taxes is held constant. Going back to the inequalities (21) and (22), this involves setting $dt=0$, and the marginal cost of funds can then be derived as

$$g = [wh - n(V_e/I)(\partial x/\partial t)]/[wh + tw(\partial h/\partial t) + t(\partial x/\partial t)]. \quad (32)$$

Again assuming the denominator of the right-hand side to be positive, it follows that

$$g > 1 \text{ if and only if } [t + n(V_e/I)](\partial x/\partial t) > tw(\partial h/\partial t). \quad (33)$$

This condition does not give us a clear answer as to the numerical magnitude of g . It does, however, give rise to the same type of classification as (29), which, it will be recalled, concerns the “reverse” case, where t is fixed and the green tax is the marginal source of funds. Let us assume that labour supply is a decreasing function of the marginal tax rate. Sufficient conditions for (33) to hold are then either

- that the green tax is below its Pigouvian level and that the demand for the dirty good is a decreasing function of the income tax rate, or

- that the green tax is above its Pigouvian level and that the demand for the dirty good is an increasing function of the income tax rate.

In both cases the economic intuition behind the conclusion is that the increase in the rate of income tax magnifies an existing distortion in the market for the dirty good. The form of the conditions also alerts us to the fact that there are interesting cases of income tax finance where the increase in the tax rate modifies the existing distortion in the market for the dirty good, and where the MCF might accordingly be less than one.

It is also worth pointing out than while in the standard analysis of the income tax the MCF equals one if the labour supply elasticity is zero, this is not the case here. This is easily seen from (33). The two cases of sufficient conditions mentioned above would continue to yield an MCF in excess of one. Moreover, with the RHS of (33) being zero, the reverse cases, viz. where the words “above” and “below” in the two cases change places, would be examples where the MCF is below one. The general message is as before that under second best conditions it is essential to consider the interaction between markets and distortions.

9. A simplified rule for green taxes.

A weak point of optimal tax theory is its neglect of the administrative costs of the tax system. Including the administrative costs of taxes explicitly into the optimization framework raises a number of difficulties, particularly with regard to the non-convexities involved, and to tackle these is far beyond the scope of the present paper. However, one topic that deserves discussion in the present context is the question of decentralization of tax decisions. If green taxes and environmental charges come to be more widely used in the coming decades, there will be a heavy burden on the ministry of finance, in terms of information collection and decision-making capacity, if all decisions about taxes are to be its responsibility. A more realistic scenario is one where decisions about a large number of environmental taxes and charges become decentralized to the ministry of the environment or perhaps regional authorities with

responsibility for local pollution control. In that case, it would be unreasonable and impractical to ask all these units to take account of all possible secondary effects of the tax system, e.g. the green tax effects on labour market performance. Instead, the central government should provide more simple guidelines for lower level units, and one such guideline might be to set environmental taxes according to the first-best Pigouvian formula $t = -n(V_e/I)$. Calculations of the MCF for the central government would then be based on the assumption that revenue is to be generated through variations in the income tax rate t , assuming that those responsible for environmental taxes keep these linked to the expression for marginal social damage.

The MCF can now be derived as a special case of (32), viz. where $t = -n(V_e/I)$. We then get

$$g = [wh + t(\eta_x/\eta_t)]/[wh + tw(\eta_h/\eta_t) + t(\eta_x/\eta_t)] \quad . \quad (34)$$

It follows immediately, assuming again that the tax revenue effect is positive, that

$$g > 1 \text{ if and only if } tw(\eta_h/\eta_t) < 0. \quad (35)$$

With a positive tax rate the MCF exceeds one if the labour supply elasticity with respect to the tax rate is negative, and is below one if it is positive. This is a very simple condition, providing a clear focus on what determines the magnitude of the efficiency costs of financing public goods. The decentralization scheme on which this condition is based is suboptimal in the sense that one can always do better by coordinating decisions – in principle. But the decentralization rule is likely to be better in terms of administrative resource use, representing a practically feasible division of responsibilities within the public sector.

10. Concluding remarks.

Simple economic intuition suggests that when the supply of public goods can be financed by means of environmental taxes, the method of finance provides an

efficiency gain to the economy; hence, the marginal cost of public funds should be less than one. The present paper has shown that this intuition should be handled with care. Even in the case where there are no traditional income or commodity taxes, the intuition fails to be valid if the level of the Pigouvian tax has been set above its first best level. In the more general case where there exist both traditional and environmental taxes, the implications for the MCF depend crucially on the nature of interaction between markets. The existence of environmental taxes also has important implications for the magnitude of the MCF from traditional taxes such as the income tax. However, in all the thought experiments that we have considered there emerges a formula for the MCF which has a strong appeal to the not-so-simple intuition that one develops from the study of optimal second best tax systems. Moreover, these formulae can be shown to be valid not only when the tax system is assumed to satisfy the conditions for second best optimality, but also in the much less restrictive framework of a balanced budget expansion of public goods supply.

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