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THE OPTIMAL SUPPLY OF PUBLIC GOODS AND THE DISTORTIONARY COST OF TAXATION

LOUIS KAPLOW*

Abstract - *The conventional view of economists is that the optimal supply of public goods must directly take into account the cost of financing them with distortionary taxes, notably, the income tax. However, this article demonstrates, under standard simplifying assumptions, that it is possible to finance a public good in a manner that results in no additional distortion, by using an adjustment to the income tax that offsets the benefits of the public good. In this case, it is optimal to supply the public good whenever the simple cost-benefit test is satisfied. The article also shows that if a different tax adjustment is made, the difference in outcome will be purely redistributive; thus, any change in distortionary costs will be accompanied by an opposing change in redistributive benefits. In this case, the cost-benefit test should be modified to reflect both of these changes. Finally, it is explained that the present analysis is fully applicable to determining the optimal level of environmental taxes.*

INTRODUCTION

The conventional view of economists is that the optimal supply of public goods is not determined by the simple cost-benefit test—which asks whether the sum of individuals' benefits exceeds a project's direct cost—because financing public goods involves the use of distortionary taxes, notably, the income tax. This view dates from Pigou (1947), who stated that the benefits of public goods must exceed their direct costs by an amount sufficient to outweigh the distortionary cost of taxation. Pigou's argument has been formalized and refined in subsequent work, beginning with important contributions by Atkinson and Stern (1974), Diamond and Mirrlees (1971), and Stiglitz and Dasgupta (1971) and continuing more recently with, for example, Ballard and Fullerton (1992), Fullerton (1991), and Mayshar (1990). In particular, this literature emphasizes the income effect of taxation: because taxation reduces individuals' incomes, it may induce more work effort, which increases the revenue produced by preexisting taxes.¹ Accordingly, the literature uses estimates of the elasticity of labor supply to compute an appropriate "marginal cost

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of funds" for purposes of adjusting the simple cost-benefit formula.

This article reexamines the relationship between the optimal supply of public goods and the distortionary cost of income taxation. The article first demonstrates that, under standard simplifying assumptions (including the separability of leisure), there exists a way to modify the income tax to finance a public good such that there is no additional distortion. Suppose that the preexisting income tax schedule is adjusted so that, at each income level, the tax change just offsets the benefits from the public good. By construction, an individual's *net* reward from any level of work effort will be unaltered: any reduction in disposable income due to the tax adjustment is balanced by the benefit from the public good. Because an individual's after-tax utility as a function of his work effort will thus be unchanged, his choice of work effort—and utility level—will also be unaffected.

To complete the argument, observe that the increase in tax revenue due to this adjustment in the tax schedule will equal the sum of individuals' benefits from the public good. Hence, if the sum of benefits from the public good exceeds its direct cost, the government will have surplus revenue, which can be rebated in a manner that makes everyone better off. In this case, therefore, the simple cost-benefit formula indicates whether the public good should be supplied. There should be no adjustment to account for the distortionary cost of labor income taxation because labor supply does not change. Although this argument will be qualified, it will be explained that the necessary adjustments have little to do with the usual view concerning the distortionary cost of raising funds.

The second part of the analysis addresses the situation in which a public good is not financed by the foregoing tax adjustment that offsets the benefits from the public good. When a different tax adjustment is made to finance the public good, there generally will be a change in distortionary costs. But in such cases there also will be an opposing change in redistributive benefits. (For example, the literature sometimes stipulates that higher marginal income tax rates will finance a public good that produces a uniform monetary benefit; this combination does increase distortionary costs but it also creates redistributive benefits because the poor gain at the expense of the rich.)

In general, it will be explained that the act of supplying of a public good financed with a non-offsetting tax adjustment can be decomposed into (1) financing the public good with a tax adjustment that does offset the benefits of the public good (as described above) and (2) a further, *purely redistributive* adjustment to the tax system. How one should modify the cost-benefit test to account for this second component will depend upon whether increasing the degree of redistribution raises social welfare, which is determined by the policymaker's distributive preferences and the preexisting level of redistribution (and not by the marginal cost of funds).

The next two sections of this article will focus on the point that there is no change in labor supply when the tax adjustment offsets the benefits of the public good. Illustrations will be followed by a more general analysis, accompanied by a discussion of qualifications. After this, the point about the need to examine redistribution in the case of more general methods of finance will be presented. (It will be

observed, however, that the offsetting-benefit case may, at least roughly, be descriptively accurate and thus be more relevant for policy analysis.) After developing these ideas, the argument will be related to the existing literature on the subject as well as to prior literatures on a number of closely related topics: Musgrave's (1959) proposed separation of the allocation and distribution functions of government, the Kaldor–Hicks compensation test, benefits taxation, the use of distributive weights in cost-benefit analysis, and optimal income taxation.

Finally, it will be explained that the present analysis of distortionary costs is fully applicable to another important problem: the assessment of environmental taxes. For example, if one were to implement a Pigouvian tax at the first-best level and achieve budget balance with a distribution-neutral adjustment to the income tax, there would be a Pareto improvement in the basic case. And, as above, the difference in outcome that would arise from using some other income tax adjustment would be purely redistributive. This result is contrary to the suggestion of a growing literature which, like that on public goods, typically examines some stipulated income tax adjustment that entails redistribution and documents the efficiency cost from the resulting distortion while not considering the distributive benefit.

ILLUSTRATIONS

Proportional Case

Suppose initially that there is in place a proportional income tax under which individuals pay taxes equal to 30 percent of their earnings. Now consider supplying a public good that produces benefits that increase with income; specifically,

assume that the benefits equal one percent of income. (Individuals with more income might use the good more or place a greater value on its use; for example, police protection of private property may be more valuable to higher-income individuals who have more property to protect.²) Next, we can construct a tax adjustment that offsets the benefits of the public good. Because these benefits equal one percent of income, the tax adjustment that offsets these benefits consists of requiring that an additional one percent of income be paid in tax—that is, raising the income tax rate from 30 to 31 percent.³

Consider now the effect of adjusting the income tax in this manner combined with the effect of providing the public good. For each additional dollar an individual might earn, he will have one cent less than otherwise available for private consumption, 69 cents instead of 70 cents. However, the individual will benefit in an amount worth one additional cent due to the availability of the public good, raising his aggregate marginal benefit from earning a dollar back to 70 cents.⁴ *That is, his net utility benefit from earning an additional dollar will be precisely what it was before—without the public good and the tax adjustment.* Because each individual's net benefit from any level of labor effort is thus unchanged, labor supply will be unaffected, and each individual's utility will be the same as it was before.

Finally, consider the government's budget. Because labor supply is unchanged, the tax adjustment, which absorbs each individual's benefits from the public good, will increase government revenue by the sum of individuals' benefits. If this sum exceeds the direct cost of supplying the good—which is to say, if the simple cost-benefit test is

passed—there will be a government surplus. Then, the surplus can be rebated *pro rata* to achieve budget balance in a manner that makes all individuals better off.⁵

Uniform Case

Suppose that the public good provides a uniform monetary benefit to individuals, say, a park producing a per capita benefit of \$100.⁶ Here, the tax adjustment that offsets (absorbs) the benefits from the public good consists of adding \$100 to the tax each individual owes (rather than increasing the marginal tax rate, as in the previous example).⁷ It is obvious that this tax adjustment would involve no distortion.⁸ Thus, as long as the park costs less than \$100 per capita—again, if the simple cost-benefit test is passed—there will be a government surplus that can be rebated in a manner that makes everyone better off. (Although uniform tax changes of the sort considered here, akin to uniform lump-sum taxes, are often ruled out because they are deemed to be objectionable on distributive grounds, when the uniform tax change finances a public good that produces uniform benefits, such an objection is inapposite; after all, a Pareto improvement results.⁹)

Discussion

How can one explain the difference between the result in these examples and that in the recent literature on public goods? Essentially, the present examples involve *matching the distributive incidence of the method of finance to the incidence of the public good*. When the public good is worth more to high-income individuals, the offsetting (benefit-absorbing) tax adjustment requires that they pay more; when the benefit is uniform, so is the tax. The literature, by contrast, typically stipulates

a public good (usually without exploring its distributive incidence) and stipulates one or more tax mechanisms.¹⁰ It so happens that the combinations that are usually selected often result in greater distortion.¹¹

For instance, one can obtain the standard distortionary result by combining a tax adjustment that increases marginal income tax rates with a public good that produces uniform monetary benefits.¹² This combination involves a tax adjustment that does not offset the benefit of the public good; instead, the rich pay an amount in excess of their benefits, so they are worse off, and the poor pay less than they benefit, so they are better off. In other words, this assumed combination involves more distortion because it involves greater redistribution. But if redistribution is greater, the resulting beneficial effect on social welfare must be considered along with the distortionary cost of the tax adjustment, as will be emphasized below. Nevertheless, the literature, often implicitly and sometimes explicitly, ignores redistributive benefits.¹³ (In many models appearing in the literature, there would not be a redistributive benefit because individuals are assumed to be identical, but one must keep in mind that this assumption is merely for analytical simplicity.¹⁴)

ANALYSIS

Generalizing the Argument

This section will explain when and why the use of a tax adjustment that offsets the benefits of a public good will involve no distortion. A more formal presentation and a worked-out example of the proportional case appear in the Appendix.

It is useful to begin by defining more precisely the offsetting adjustment to the labor income tax (taken here to refer to the combination of the tax itself and government transfer programs).

Essentially, the offsetting adjustment is a benefits tax, which is set equal to the monetary value of the benefit of the public good to individuals at each income level.¹⁵ In more technical terms, the tax adjustment equals individuals' marginal rate of substitution.

When a public good is financed using an offsetting adjustment to the income tax scheme, each individual's monetary benefit from the public good just equals the additional tax he pays. If individuals who earn \$20,000 have a benefit worth \$126, they will be paying an additional \$126 in taxes; if those earning \$21,000 enjoy a benefit of \$135, their additional tax will be \$135. Thus, the direct effect of the public good combined with such a tax is to leave everyone as well off as before, as long as each individual chooses to earn the same level of income.

Next, consider whether there can be any distortion or other revenue effect due to a change in labor supply, the focus of the recent literature on public goods provision. It can readily be demonstrated that there will in fact be no effect on behavior when the tax adjustment is offsetting, if one assumes that individuals' utility functions are weakly separable in the disutility of labor. (This assumption is stated precisely in the Appendix and is relaxed in the discussion below.) Labor effort does not change because, for any level of before-tax income one might earn, the offsetting tax adjustment leaves individuals with the same utility from the combination of private and public goods as they had in the absence of the public goods and the offsetting tax

adjustment. In particular, there is now more utility from public goods and less from private goods. The offsetting tax adjustment is constructed so that the reduction in expenditures on private goods for a given level of before-tax income produces a reduction in utility just equal to the increase in utility from the public goods. *Thus, any chosen level of labor effort will produce precisely the same utility with public goods and the offsetting tax adjustment as it produced without them.* Because individuals' utility-opportunity sets are unaffected, their choice of labor remains the same. (In the preceding example, an individual who must decide between earning \$20,000 and \$21,000 will receive the same utility from each choice after the reform as he did before the reform; thus, whichever level of labor supply was chosen before will be selected afterward.)

This logic should be familiar from the illustrations offered previously. In the first, the monetary benefit from the public good and the supplemental tax both increased at a rate equal to one percent of income. In the second, both the monetary benefit from public good and the offsetting tax increase were uniform—*independent* of income. The present, more general case simply allows for any relationship between the monetary benefit from the public good and income.

Up to this point, it has been shown that, if one provides a public good and imposes a tax that soaks up each individual's benefits from the public good, individuals' utility levels and behavior will remain the same. Now, one can ask whether this method of finance produces a budget surplus or deficit. If the simple cost-benefit test is satisfied, there will be a surplus, for the revenue yielded by the tax adjustment

precisely equals the sum of individuals' monetary benefits from the public good and the only new expenditure is the direct cost of supplying the public good. One can rebate this surplus uniformly to produce a Pareto improvement.¹⁶

Qualifications

The qualifications that follow will be familiar to some readers from the optimal income taxation literature. It should be emphasized at the outset that these qualifications concern only how the simple cost-benefit test should be adjusted in light of certain complications; they do not affect the validity of the central argument in this article. In particular, neither the direction nor the magnitude of the appropriate adjustments to the cost-benefit test is indicated by a general measure of the marginal cost of funds, which, in turn, would depend on the uncompensated elasticity of labor supply. Moreover, the qualifications do not affect the argument elaborated upon below that, when taxes are not offsetting, there is a general tendency for distortionary and distributive effects to run in opposing directions, requiring that both effects be considered.

Relative complementarity of private and public goods with leisure. The simple cost-benefit rule should be adjusted when private and public goods do not have the same degree of complementarity with leisure.¹⁷ This possibility is absent in the preceding analysis because the utility function is assumed to be weakly separable in leisure.¹⁸ This caveat is analogous to Atkinson and Stiglitz's (1976) result that optimal commodity taxes are zero in the presence of an optimal nonlinear income tax except to the extent that commodities are substitutes for or complements with leisure. To pursue the

analogy, interpret private goods as one set of commodities and public goods as another; applying a higher (lower) relative tax on public goods would correspond to reducing (increasing) their supply relative to that indicated by the simple cost-benefit test.

To illustrate the phenomenon, it might be argued that there should be smaller public libraries than otherwise would be efficient, because libraries make leisure more attractive, reinforcing the adverse incentive effect of the income tax. Conversely, there perhaps should be greater police protection of private property than otherwise would be efficient, because this increases the value of goods that are purchased from the fruits of labor. The relevant point for present purposes is that this qualification, however important it may be in some instances, does not justify the type of adjustment to cost-benefit analysis proposed in the literature. The marginal-cost-of-funds adjustment depends most directly upon the income and substitution effects of taxation on labor effort; it is not suggested that the validity and direction of any adjustment depend upon whether public goods are leisure substitutes or complements.

Heterogeneity of preferences. The analysis may also need qualification when the benefits of public goods vary *within* income classes due to differences in tastes or opportunities.¹⁹ Then, individuals having the same income but different preferences would need to pay different offsetting taxes in order to make feasible a Pareto improvement whenever the simple cost-benefit test was satisfied. If differences in benefits are observable, offsetting taxes can take the differences into account. For example, if a project will benefit a particular region, the corresponding adjustment to the tax system would

apply solely to that region. (Financing local public goods with local taxes tends to accomplish this result.)

But often, differences in preferences are neither directly observable nor readily elicited; indeed, a substantial literature is addressed to this problem.²⁰ Moreover, even if detailed information were available, perfectly offsetting taxes may be administratively impractical. To this extent, compensation is inevitably imperfect, so there will be "redistribution." But this redistribution is not of a conventional sort—such as results from changing the progressivity of the overall tax/expenditure system. If it were, it could be offset by adjusting the income tax schedule. Rather, any unavoidable redistribution is *within* income groups, so-called horizontal inequity.²¹ For example, physically weak individuals might benefit more from police protection than physically stronger ones (holding income constant). In this instance, the public good may be equality enhancing in a relevant sense, and thus more should be provided than otherwise. In other instances, a public good may create disparities in "effective" income between individuals with equal nominal income, in which case public goods provision may be less desirable than otherwise. Note, however, that the appropriate adjustment to the simple cost-benefit test is unrelated to the conventional view in the literature, for the adjustment is not based on the distortionary cost of taxation.²²

APPLICATION TO POLICY

In order to explore further the policy relevance of the foregoing analysis, which assumes that public goods will be financed by tax adjustments that offset the benefits from the public goods, this

section considers how analysis should proceed when such adjustments are not used and then examines whether it is plausible that such offsetting tax adjustments will in fact be used.

Policy Analysis When Tax Adjustments Do Not Offset Benefits from Public Goods

Initially, observe that, when a tax adjustment does offset the benefits from a public good, the net result is *distribution-neutral*: because individuals at each income level pay additional taxes in an amount that equals their benefits from the public good, it follows that the combination of the public good and the tax adjustment involves no redistribution. If some other finance mechanism is used, however, the distribution will change.

To elaborate, consider the prospect of supplying a public good that is to be financed by some method T (where T refers to the adjustment to the income tax and transfer payment system that provides the revenue for the project). Decompose this reform into two components:

- (1) Finance the public good by an offsetting tax adjustment, T_0 .
- (2) Reform the tax system, changing the tax scheme from T_0 to T .

The first component consists of the hypothetical reform already considered. It involves no additional distortion of labor effort and no redistribution; in the basic case, it is properly evaluated using the simple cost-benefit test. One would now supplement this evaluation by considering the second component, which consists of a *purely redistributive* (revenue-neutral) reform of the tax/transfer system. Thus, in the example of the park that produces uniform mon-

etary benefits of \$100 and is presumed to be financed by raising the marginal income tax rate, one would now evaluate the greater redistribution that results from raising the marginal income tax rate instead of raising taxes by a uniform dollar amount. In this regard, there is a familiar trade-off: increased redistribution entails more distortion. If, according to the policymaker's social welfare function, the preexisting regime provided too little redistribution, an increase in redistribution would count as a supplemental net benefit despite the increase in distortionary cost. If, instead, there previously was too much redistribution, the prospect of additional redistribution and the accompanying distortion would constitute a net cost.

Knowledge that the aggregate reform—the public good and the tax adjustment, taken together—causes distortion thus provides little guidance, because the existence of distortion is associated with greater redistribution. Whether the net effect is good or bad depends upon the extent of preexisting redistribution and the policymaker's judgment about the optimal extent of redistribution. Analogously, reforms that reduce distortion are not *per se* desirable on this account, because such reforms entail correspondingly less redistribution. Therefore, when the tax adjustment does not offset the benefits of the public good, there can be no presumption that the appropriate "adjustment" to the cost-benefit test is even in the *direction* indicated by conventional analysis.²³

To summarize, the proposed two-part decomposition is analytically useful for the general case in which a public good may not be financed by a tax adjustment that offsets the benefits from the public good. The first step of the analysis involves assessing the merits of

the public good, and the second step involves determining whether any change in the extent of redistribution is desirable. To a significant extent, these conceptually distinct questions are also separable in practice because either component can be implemented independently: the public good could be financed with an offsetting tax adjustment T_0 instead of with T , and the extent of redistribution could be increased or reduced without regard to whether the public good is provided.

The Likelihood That Actual Tax Adjustments Will Offset Benefits from Public Goods

It seems plausible that the preexisting tax/transfer regime will reflect some equilibrium of political forces that, among other things, entails a level of redistribution. In this case, one's best guess might be that projects will be financed in a manner that is, on net, distribution-neutral. And, as just explained, distribution-neutral finance consists precisely of using a tax adjustment that offsets the benefits from the public good.²⁴ Moreover, when the extent of redistribution does change, one would expect the change to result from a realignment of political forces. Furthermore, one would expect such a realignment to produce a change in redistribution even if no new project were to be implemented.

The increasing use of distribution tables in assessing government policy and in packaging proposals suggests that politicians do keep an eye on distribution. The 1986 tax reform was explicitly formulated to be distribution-neutral (changes unfavorable to the rich were consciously balanced by targeted tax rate reductions), and the 1993 tax reform, enacted shortly after a change in the ruling political party, was de-

signed to increase redistribution (although it contained what was believed to be a regressive gasoline tax increase, which was offset by progressive income tax adjustments).

It remains true that the legislature is not in the business of fine-tuning the tax system each time a program is enacted or repealed. But the distortions examined in the existing literature arise only after the tax system is adjusted (which, lately, happens quite often). When such adjustments are made, the legislature can (and, given the preceding observations, likely would) take into account any significant changes in the distribution of income. To be sure, one would not expect tax adjustments to offset the benefits of new public projects completely and precisely. Nevertheless, if one had to guess, it seems plausible that roughly, on average, and over time, changes in the level of public goods will tend to be accompanied by tax adjustments that offset changes in the distributive incidence of the benefits produced by those goods.²⁵

RELATIONSHIP TO PRIOR LITERATURE

The present argument is related to—and draws upon the insights of—a range of prior literature. Most familiar to many readers will be Musgrave's (1959) proposed separation of the allocation and distribution functions of government. This view, in turn, is related to the Kaldor–Hicks hypothetical compensation test, under which a project is deemed to be desirable if it constitutes a potential Pareto improvement—that is, if the winners could compensate the losers. Although still seen as helpful, these ideas are not generally accepted as valid in a second-best world: public goods are financed by distortionary taxation, and losers are not directly compensated by winners. Thus, the modern literature on

public goods provision emphasizes the need to account for tax distortions, and other writing on cost-benefit analysis advocates the use of distributive weights to account for the redistributive effects of public projects.²⁶

The offsetting tax construct suggested here is a scheme of benefits taxation (often referred to as Lindahl pricing). If such taxation is used, compensation is not merely hypothetical. Thus, in the analytical section, it was shown under standard simplifying assumptions that financing public goods with an offsetting tax adjustment results in an actual Pareto improvement whenever the Samuelson (1954) cost-benefit test is met.

Benefits taxation has received relatively little attention for two reasons: it is difficult to implement because each individual's benefits cannot readily be measured, and the actual tax system seems to be (and should be) redistributive rather than grounded in a benefits principle. The present article offers a different perspective on each of these points. The infeasibility of pure benefits taxation was admitted in the discussion of heterogeneous preferences, but it was emphasized that the only necessary differences between taxes paid and benefits received consist of differences *within* income groups. As a result, there need not arise the distortion associated with the labor income tax, which arises from redistribution among individuals at *different* income levels.

The suggestion that the actual tax system involves redistribution, not pure benefits taxation, also does not disrupt the present argument. The relevant question is not the redistributive character of the entire tax system but of the marginal decision to finance more of a public good. As noted previously, this

decision might be distribution-neutral even when the preexisting regime is redistributive. More importantly, when finance is not distribution-neutral, it does not follow that the cost-benefit test should be modified in the manner suggested in the recent literature to account for the distortionary cost of taxation. There generally is a redistributive effect directly opposed to the distortionary effect. Thus, if the simple cost-benefit test requires modification, one cannot ascertain even the direction of the adjustment without assessing both of these effects and determining whether the status quo involves too little or too much redistribution.

Less familiar branches of prior literature are also directly relevant to the present inquiry. In particular, the construct of offsetting taxes is used in Hylland and Zeckhauser's (1979) important (but surprisingly overlooked) article arguing that distributive objectives should not affect program choice in cost-benefit analysis.²⁷ Whereas Hylland and Zeckhauser emphasize that distributive effects are not inherent, the present article emphasizes that distortion is not inherent and underscores the point that distortionary effects tend to be accompanied by offsetting distributive effects.²⁸ Hylland and Zeckhauser's analysis has been extended in Christiansen (1981) and Broadway and Keen (1993), who investigate public goods provision in the presence of optimal nonlinear income taxes.²⁹ Unfortunately, insights from these prior investigations do not appear in the extensive literature on public goods provision. The present article attempts an integration. It differs from the optimal tax literature in two respects. First, using an argument like the original one of Hylland and Zeckhauser, this article emphasizes a result that holds without regard to whether the initial

income tax is optimal.³⁰ Second, the current investigation addresses how one should analyze the public goods problem when neither assumption—the presence of an optimized income tax or the use of an offsetting tax adjustment—holds; in particular, it highlights the existence of generally opposing influences on social welfare, one from distortionary effects and the other from distributive effects.

The dominant literature in the past few decades, which is referred to throughout this article, is concerned with determining an appropriate adjustment to the simple cost-benefit test to account for the distortionary cost of taxation. This literature generally makes little reference to the others discussed in this section. In particular, the conventional approach focuses on distortion, ignoring the fact that distributive concerns are the primary motivation for using distortionary income taxation. As a result, the literature presents measures—often embodied in a marginal cost of funds—that provide an incomplete and misleading basis for policy.

To further illustrate the problem, consider the case in which public goods substitute for private consumption.³¹ The literature suggests that such an assumption would produce the Pigouvian result that public goods provision is distortionary, requiring benefits to exceed costs by at least the distortionary cost of taxation. For example, Ballard and Fullerton (1992) explain that, in such a case, the income effect of the tax (which raises labor supply and thus produces a positive revenue effect) would be fully offset by the opposing income effect of the public good, leaving only the substitution effect of the tax, which entails distortion. But if an offsetting tax is used to finance the public good, whenever

there is a substitution effect due to the tax, it will be precisely offset by that due to the public good, so there would be no labor supply effect. The standard distortionary effect identified in the literature, therefore, arises because it is implicitly assumed that the finance mechanism (say, a proportional income tax) will have a more progressive incidence than the benefits of the public good (taken to be uniform).³² But if this assumption is to be made, the distributive benefit of the more progressive tax/expenditure system should be included in the final account. When that is done, the marginal cost of funds is not the appropriate adjustment to the simple cost-benefit test.

ENVIRONMENTAL TAXES

Analogous to the past decades of literature on public goods provision that emphasizes distortionary costs of taxation is a rapidly growing literature that examines the effects of environmental taxes, taking into account how any revenue raised will allow the government to reduce the level of other, distortionary taxes.³³ The framework of the present article can be applied directly to this context. After all, correcting externalities may be viewed as a public good. That the revenue produced by a corrective tax is positive rather than negative, as when financing a tangible public project, does not affect the analysis in any fundamental way. (It implies that the offsetting tax adjustment to the income tax will offset both the benefits from correcting the externality and the incidence of the environmental tax.)

In particular, one can decompose any corrective tax scheme—consisting of a corrective tax and an income tax adjustment T' that achieves budget balance—into two components:

- (1) Impose the corrective tax and make an offsetting (distribution-neutral) tax adjustment, T'_0 .
- (2) Reform the income tax system, changing the scheme from T'_0 to T' .

As before, the first component, which is both distribution- and revenue-neutral, involves no change in distortion (aside from influencing the level of the externality). Under the standard simplifying assumptions, familiar, first-best reasoning would be valid. This suggests (contrary to the environmental tax literature) that the optimal Pigouvian tax will tend to be that which fully internalizes the externality.³⁴ The second component, as before, is a purely redistributive tax change, and it can be evaluated as such. If the actual tax adjustment is not offsetting, it follows (as in the public goods case) that one cannot ascertain even the direction of any adjustment to the first-best Pigouvian tax without first determining whether the existing extent of redistribution is too little or too much.

To illustrate the argument, consider a gasoline tax and suppose that the demand for gasoline is proportional to income. This gasoline tax, in addition to reducing gasoline use, would have an effect on labor supply similar to that of a proportional income tax. The reason is that, because gasoline demand rises proportionately with income, the gasoline taxes one must pay also rise proportionately with income. The gasoline tax, therefore, would not succeed in raising revenue without distorting the labor-leisure choice. Moreover, if one restored the prior budget balance (or degree of imbalance) with an offsetting tax adjustment, this would entail an equal-proportionate reduction in the income tax. This

offsetting adjustment would, in turn, have an effect on labor supply precisely opposite to that of the gasoline tax.

In addition, the income tax adjustment would need to offset the benefits from controlling the externality, just as the tax adjustment in the case of public goods absorbed the benefits from the public goods. Therefore, the combined income tax adjustment will eliminate any effects on labor supply from both the environmental tax itself and from the effects of that tax on environmental benefits. Thus, as with public goods, finance by an offsetting tax adjustment eliminates distortionary (and distributive) effects. Finally, if the gasoline tax indeed corrects an externality, precisely the concern in the traditional analysis of Pigouvian taxes, the government will have a surplus after the tax adjustment because the positive net benefits will be in the government's coffers due to the income tax adjustment that absorbs all the benefits.

Now, suppose that the gasoline tax is regressive. Finance by an offsetting tax would involve adjusting the income tax schedule to raise less revenue but in a somewhat more progressive manner. The net effect of the regressive gasoline tax and the progressive adjustment to the income tax would be to raise the same revenue with the same distributive effect and the same labor-leisure distortion as that which existed previously. On the other hand, if the income tax were reduced in a proportional rather than an offsetting manner, there would be less distortion through use of the regressive gasoline tax, but there also would be less redistribution. This illustrates the more general and by now familiar point that, when there is change in the distortionary cost of taxation, there also will be a countervailing change in the extent of

redistribution. The existence of a change in distortionary costs depends on the assumption that the tax adjustment will not be offsetting, and, when this is the case, a proper policy evaluation must consider both the distortionary and distributive effects.

The perspective on Pigouvian taxes offered here is related to the argument of Atkinson and Stiglitz (1976) that it is not optimal to employ differential commodity taxes in the presence of an optimal nonlinear income tax (subject to the previously noted qualifications). Taxing a commodity more heavily will distort the labor-leisure choice because bundles of goods will be made more expensive; by adjusting the nonlinear income tax instead, the same revenue can be raised, with the same distributive incidence and effect on labor supply, but without distorting individuals' choices among goods. Consumer choices are optimal when price ratios reflect full social costs—producers' costs plus any external costs—and nothing else.

Conclusion

A substantial literature is concerned with determining how to modify the simple cost-benefit test for public goods provision to account for the distortionary cost of taxation. The present article argues, however, that the proposed adjustment, based upon the marginal cost of funds, is inappropriate.

The correct analysis of public goods supply follows from two findings. First, under standard simplifying assumptions, there exists a way to modify the income tax to finance a public good such that there is no additional distortion. The method of finance involves adjusting the income tax so that, at each income level, tax increases just offset the

benefits from the public good; the net effect is distribution-neutral. It is also suggested that, roughly speaking, public goods might plausibly be financed in this manner. If this is the case, no adjustment to the simple cost-benefit test should be made. (Qualifications to this conclusion are noted, but they entail subtle adjustments that are unrelated to the conventional view of the distortionary cost of taxation.)

Second, when public goods are not financed in the manner just described, it is explained that the distortionary cost identified in the literature will arise, but it will be accompanied by a countervailing change in redistributive benefits that has been ignored. In this case, policy analysis should have two components: assessing the merits of the public good according to cost-benefit analysis and determining whether the change in redistribution is desirable. This latter step does not involve an adjustment for the marginal cost of funds because distortion is only half of the story. Instead, distortionary costs must be balanced against redistributive benefits. Greater redistribution will, on net, be desirable when the policymaker believes that there is too little redistribution to begin with (and, conversely, when initially there is too much). *Ceteris paribus*, knowledge that the distortion associated with a particular method of finance is positive indicates that redistribution is greater, but this does not answer the question of whether the result is beneficial.

Regardless of the actual method of finance (the actual method often is unknown to the analyst), the assumption that public goods will be financed by income tax adjustments that offset the benefits from the public goods provides a useful way of conceptualizing the problem of public goods supply. The

approach reveals that neither distortionary nor redistributive effects are inherent when changing the level of public goods, and it makes clear how analysis should proceed when distortion and redistribution are involved.

The present analysis also casts the recent literature on environmental taxes in a different light. When the income tax adjustment used to balance the budgetary impact of Pigouvian taxes is designed to offset the distributive effects of the latter, conventional first-best analysis is correct (under standard, simplifying assumptions). And, when the income tax adjustment is different, for any change in the net distortion of labor supply, there will be opposing redistributive effects that must be considered.

ENDNOTES

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¹ The literature also indicates that the supply of public goods may itself affect revenue because of the interaction between public goods and the demand for private goods, a factor that has received comparatively little attention. In particular, much analysis of distortionary taxation assumes that public goods enter utility in an additively separable manner, in which case this interaction does not arise. See, e.g., Ballard, Shoven, and Whalley (1985) and Stuart (1984). (The interaction also does not arise in models that simply omit public goods from individuals' utility functions.) Browning (1987) and Wildasin (1984) emphasize the revenue effect of public goods. Some of the limitations imposed by assuming separability are analyzed in Ahmed and Croushore (1994).

² Benefits could be proportional to income either because those with more income get more direct benefit from the public good, as explained in the text, or due to an income effect (i.e., the same good is worth more, measured in dollars, to those with higher income due to the declining marginal utility of income). The latter case would be

applicable if benefits were additively separable, as commonly assumed in the literature. See note 1. Both cases are illustrated in the Appendix.

- ³ More realistically, one might suppose that the benefits are a function of disposable (after-tax) income. In that case, benefits equal to one percent of disposable income would be offset by a tax increase of 0.7 percent on before-tax income (because, prior to the adjustment, after-tax income was only 70 percent of before-tax income). The offsetting tax adjustment would be complicated further if the preexisting tax was not linear (with a zero intercept). The simplifications in the example are for expositional clarity; the general argument to follow shows that they are inessential.
- ⁴ As already stated in note 2, the individual might directly benefit from the public good (those with more income to consume may make more use of the public good or gain more from its presence) or it may be that his marginal utility of private consumption is higher on account of the tax adjustment. As will become clear in the more general analysis, what matters is that an individual's *utility* benefit from earning an additional dollar is the same with the public good and tax adjustment as it was in the absence of the them. (Both cases are illustrated in the Appendix.)
- ⁵ For an account of the income effect of providing this rebate, see note 16.
- ⁶ A uniform *utility* benefit—as implied by the common additively separable specification—does not imply a uniform *monetary* benefit. Indeed, when the utility from consumption is logarithmic, there is a proportional benefit, as previously considered. See note 37.
- ⁷ This can be accomplished by adjusting the level of exemptions and tax brackets; for poor persons who pay no tax, welfare payments could be cut by \$100.
- ⁸ There would be an income effect due to the tax increase, which would tend to increase labor supply, but there is an offsetting income effect from the public good.
- ⁹ See note 14. As a further example of contemporary interest, suppose that the government decided to provide free basic health care at a level most individuals would purchase in any event, financed by a uniform increase in the tax schedule. This would be equivalent to a requirement of compulsory purchase from the government. Even if the government revenue requirement grew by hundreds of billions of dollars, there need not be any distortion involved in financing the reform. See Summers (1989).
- ¹⁰ It might be supposed that the common assumption that the public good enters utility in an additively separable manner (see note 1) indicates that there is a neutral distributive incidence, which thus may be ignored. If this were true, however, it would be natural to consider a uniform (in dollar amount)

tax increase rather than an increase in the tax rate. In any event, it is not the case that an additively separable public good produces a uniform benefit when measured in dollars (which is relevant for present purposes). This case is discussed further in the Appendix.

- ¹¹ Of course, this is not necessarily the case, as the recent literature has emphasized. See, e.g., Ballard and Fullerton (1992) and Fullerton (1991).

- ¹² For the average individual, there would be an offsetting income effect from the public good—the tax reduces income whereas the public good increases effective income by \$100—but no offsetting substitution effect.

- ¹³ For examples of the latter, see, e.g., Auerbach (1985) and Ballard and Fullerton (1992).

- ¹⁴ The representative individual approach appears, for example, in Atkinson and Stern (1974) and Stiglitz and Dasgupta (1971). If all individuals really were identical, then the optimal tax scheme would be a uniform tax, and there would be no distortionary cost. However, a uniform tax is ruled out, and instead it is assumed that an income tax must be used; this approach is motivated by our understanding that individuals are not in fact identical and, as a result, the income tax is distributively superior. (See Drèze and Stern's (1987) and Oakland's (1987) surveys of the theories of cost-benefit analysis and public goods.) Under this rationale, however, distributive benefits should not be ignored.

There is sometimes confusion about lump-sum taxation: the lump-sum taxes familiar from the second theorem of welfare economics are individualized, and it is generally agreed that these are infeasible, or at least subject to error, because differences in individuals' ability are not observable. It is not the case, however, that *uniform* lump-sum taxes raise serious problems of feasibility, particularly with regard to financing a modest change in the level of public goods. The present tax/transfer system already has a uniform component because the intercept of the tax/transfer schedule is not zero: the tax system has exemptions and the welfare system provides positive transfers. See, e.g., Mirrlees (1994). Both can be raised or reduced (and adjustments are in fact made with some regularity). As a result, if a public good did produce uniform monetary benefits, it is plausible to imagine financing it by a uniform tax adjustment of the sort discussed in the text.

- ¹⁵ Here, as in other work on the subject, individuals are assumed to differ only in their ability, and preferences are taken to be independent of ability. The case of heterogeneous preferences is addressed in the text below, and the possibility that preferences depend on ability is considered in note 17.

- ¹⁶ More precisely, one can uniformly decrease the tax schedule slightly until one reaches the point at which the budget balances. As one rebates the surplus, there will be effects on behavior (an income effect). But as long as changes in labor effort are continuous (except perhaps for a set of individuals having measure zero), there will exist a modification that involves a positive rebate to everyone while balancing the budget.
- ¹⁷ Another qualification arises when individuals' tastes vary in a manner related to their unobservable ability. In that instance, public goods preferred more by the less (more) able would be more (less) desirable than otherwise (Mirrlees, 1976). For example, if higher ability increases appreciation for sophisticated art, the optimal subsidy for lowbrow art would exceed that for highbrow art.
- ¹⁸ More formally, the assumption implies, in the model in the Appendix, that $\partial U/\partial l$ is unaffected when the offsetting tax keeps $v(c, g)$ constant. But if c and g can interact differently with l , rather than through the common substitutability function $v(c, g)$, the combination of a higher g and lower c could affect the marginal disutility of effort; the direction of the effect depends on the relative complementarity of c and g to l . See Broadway and Keen (1993) and Christiansen (1981). (Although their analyses assume that optimal nonlinear income taxation is employed, this limitation is immaterial for present purposes, as will be discussed below.)
- ¹⁹ See Broadway and Keen (1993) and Hylland and Zeckhauser (1979). If public goods produce separable benefits, as many studies assume, heterogeneity would not affect social welfare in a utilitarian framework. (Heterogeneity would affect the distribution of welfare, but not individuals' marginal utilities of income or labor effort.)
- ²⁰ The most important source of unobservable differences probably is variation in preferences rather than in opportunities. While a strict utilitarian would wish to account for this, others may argue that such heterogeneity should be ignored in setting government policy.
- ²¹ Such redistribution can be understood as presenting a more refined problem of vertical equity or, equivalently, from an *ex ante* perspective, one involving the imposition of risk. See Kaplow (1989). The vertical equity comparison is also suggested in Atkinson's (1980) discussion of how measuring the inequality resulting from a reform can be misleading if one examines the postreform averages for groups of prereform equals who are not treated equally by the reform.
- ²² Also, the adjustment does not entail a simple weighting of costs and benefits to reflect the income levels of winners and losers because the winners and losers are, by assumption, *within* income groups.
- ²³ Similarly, knowing that the chosen tax adjustment involves, say, a particularly high level of distortion is, by itself, a misleading basis for policy because, *ceteris paribus*, tax adjustments cause greater distortion when they produce more redistribution.
- ²⁴ If the preexisting regime were thought to reflect a desire to implement the optimal distributive scheme, the assumption that offsetting taxes would be used is also a plausible approximation. (Moreover, when the preexisting regime is optimal, distortionary and distributive effects will have an offsetting influence on social welfare in any event, as discussed in note 30 with reference to the prior optimal nonlinear income taxation literature.)
- ²⁵ The competing assumption most common in the current literature—that finance will involve a proportional income tax or a uniform increase in the rates of all taxes without regard to the distributive incidence of the benefits of the goods being financed—has not, to my knowledge, been defended as descriptively accurate, and recent tax reforms in the United States do not suggest that this is the case.
- ²⁶ On the latter, see Weisbrod (1968) and Drèze and Stern (1987).
- ²⁷ The idea is also used by Shavell (1981) to show that distributive objectives should not affect the choice of legal rules regulating activity that produces externalities.
- ²⁸ Put another way, some literature on cost-benefit analysis advocates the use of distributive weights, implicitly assuming that the finance mechanism is nonredistributive; other literature on cost-benefit analysis advocates an adjustment for the distortionary cost of taxation, implicitly assuming redistributive finance. The present effort can be seen as integrating both aspects of the problem.
- ²⁹ Mirrlees (1976, 1994) and Tuomala (1990) briefly analyze public goods provision with optimal nonlinear income taxation. There also has been work restricting attention to linear taxation. See, e.g., King (1986) and Wilson (1991).
- ³⁰ The argument in the optimal tax literature follows automatically from the fact that deviations from the social optimum involve no first-order welfare loss. That is, any marginal change in the tax schedule will produce distortionary and distributive effects on social welfare that precisely offset.
- ³¹ Formally, this case assumes that the utility, v , of private consumption (c) and public goods (g) can be expressed as $v(c, g) = v(c + b(g))$, where $b(g)$ is the consumption value of public goods. The other special case emphasized in the literature, involving public goods that produce additively separable benefits, is discussed in the Appendix. Many public goods do not produce additively separable benefits but rather substitute for consumption to some extent. For example, road repair reduces costs of automobile repair; greater police protection reduces spending on private security measures;

more and better parks reduce expenditures on private yards. See Ahmed and Croushore (1994), Aschauer (1985), and Browning (1987).

³² Ballard's (1991) survey identifies consensus on the view that, if a project is a close substitute for cash, the marginal cost of funds for labor taxes or lump-sum taxes will be higher than for a project producing separable benefits. He further suggests that an evaluator needs to know the marginal cost of funds and the (nontax) costs and benefits of the project. The marginal cost of funds is understood to be independent of the particular project, implying that there is some given tax source (such as a proportional increase in all taxes).

³³ On the revenue benefits from Pigouvian taxes, see, e.g., Ballard and Medema (1993) and Cordes, Nicholson, and Sammartino (1990). For more elaborate analyses that account for general equilibrium effects and the effect of environmental taxes on labor supply, thereby reaching different conclusions, see, e.g., Bovenberg and de Mooij (1994), Bovenberg and van der Ploeg (1994), Bovenberg and Goulder (1996), and Goulder (1995). There is an analogous literature that considers the optimal level of Pigouvian subsidies. See, e.g., Browning (1993) and Ng (1980). And there is a literature that assesses the distributive consequences of environmental taxes, motivated by the general concern that such consequences provide an independent ground for evaluation. See, e.g., Casler and Rafiqi (1993).

The argument in the text also implies that distributive effects should not play a role in assessing the desirability of legal rules that regulate harm-causing behavior. See Shavell (1981). (Legal rules enforced by private suits are like Pigouvian taxes, where the victim receives the proceeds, whereas rules that stipulate fines owed to a public authority are tantamount to the tax enforcement mechanism for a Pigouvian tax.)

³⁴ For a formal statement of the problem analyzed in this section, see note 35. Because the analysis is essentially the same, the qualifications raised in the context of public goods are equally applicable here.

The "conventional" view in this literature has gone through two stages. Earlier writing emphasized the possibility of an environmental "double dividend"—a corrective tax both internalizes an externality and allows reduced reliance on preexisting distortionary taxes. More recent work, emphasizing how environmental taxes themselves affect labor supply, suggests a more complicated story in which there typically is no double dividend. For a discussion of the literature, see, e.g., Goulder (1995).

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APPENDIX

Individuals have utility functions $U(v(c,g),\ell)$, where c is consumption, g the level of expenditures on the public good, and ℓ labor effort. Individuals' wages (ability) w have density $f(w)$. Each individual chooses ℓ to maximize $U(v(c,g),\ell)$ subject to the budget constraint

1

$$c = wl - T(wl, g)$$

where $T(wl, g)$ is the tax (which may be negative) that an individual pays as a function of the income, wl , he earns, which is all that the government observes.¹ The term T is also a function of g to denote that, when the government changes the level of the public good, it also must change the tax schedule. (It is assumed that initially the budget balances, and it is required that, after all adjustments, the budget must again be in balance.)

Examples

Before proceeding with the general case, some illustrations will be useful. Consider first the special case in which

2

$$U = v(c(1 + g)) - z(\ell).$$

Assume that there is initially a proportional income tax at rate t_0 , the revenue from which finances the public good at the level g_0 . Substituting from the budget constraint (equation 1), the initial level of utility can be expressed as

3

$$U = v(wl(1 - t_0)(1 + g_0)) - z(\ell).$$

(Observe that, in this case, as in the illustration in the body of the article, the value of the public good is proportional to income.)

Suppose that we increase the level of the public good by Δg . At income wl , this will raise the value of individuals' "effective income" by $wl(1 - t_0)\Delta g$. Now consider an increase in the tax rate (which, as in the illustration in the body of the article, is a proportional one) given by

4

$$\Delta t = \frac{(1 - t_0)\Delta g}{1 + g_0 + \Delta g}.$$

It is straightforward to show that this tax rate adjustment reduces individuals' effective income and thus their utility to the prior level, for any given amount of earned income, wl : that is, $wl(1 - t_0)(1 + g_0) = wl(1 - t_0 - \Delta t)(1 + g_0 + \Delta g)$.² Therefore, every individual's utility function after the reform precisely equals his utility function (expression 3) before the reform for every ℓ . Thus, each individual, in choosing a level of labor supply, ℓ , is maximizing the same function before and after, so labor supply will be unaffected.

Finally, observe that total tax revenue will, by construction of the offsetting tax Δt , just equal the sum of individuals' benefits (measured in dollars) from the change in the

level of the public good, Δg . Hence, if the Samuelson (1954) cost-benefit test is met, there will be a surplus, which can be rebated in a manner that makes all individuals better off.

Another special case is where utility is additively separable in private consumption (c), public goods (g), and labor (l). More formally, $U(c, g, l) = v_1(c) + v_2(g) - z(l)$. Here, the level of the public good will not affect labor supply. Nonetheless, the offsetting tax, which absorbs the benefits from the public good, will keep labor supply constant. To see this, note that one can keep labor supply constant by using a tax adjustment that produces offsetting income and substitution effects for all levels of income. It turns out that the offsetting (benefit-absorbing) tax in this case has just this feature. As an example (which is worked out in note 3), suppose that the utility from consumption is given by the natural logarithm of consumption. Then the benefits from the public good, which are constant when measured in *utility*, will rise proportionately with income when measured in *dollars*. Thus, a proportional tax rate adjustment will be offsetting in the manner described.³ (This again parallels the illustration in the body of the article.)

General Case

If utility is weakly separable in labor (leisure), as specified above and discussed in the text, then any marginal change in g that produces positive unweighted net benefits—i.e., for which the integral (“sum”) of individuals’ marginal rates of substitution (v_g/v_c) exceeds the cost—will result in a Pareto improvement when financed through an appropriate change in the tax schedule T .

Holding l fixed, examine how utility changes with a marginal change in g .

5

$$\frac{\partial U}{\partial g} = \frac{\partial U}{\partial v} (v_c c_g + v_g).$$

From the budget constraint (equation 1),

6

$$c_g = \frac{dT(wl, g)}{dg}.$$

Now, set the tax adjustment as follows (which, as discussed below, equals the marginal rate of substitution):

7

$$\frac{dT(wl, g)}{dg} = \frac{v_g}{v_c}$$

Using equations 6 and 7 to substitute into 5, it follows that $\partial U/\partial g = 0$ for any given w and l . Thus, for any ability level (w), each choice of l produces the same utility when g is raised and T is adjusted in an offsetting manner as it does when g is not raised. Because individuals’ opportunity sets are thus unaffected, they will choose the same l .⁴

It remains to determine whether a balanced budget results. Revenue is given by

8

$$R = \int T(wl(w), g) f(w) dw$$

where $l(w)$ denotes the amount of labor effort chosen by individuals of ability w . Because l is unaffected by g when taxes are adjusted in the assumed manner,

9

$$\frac{dR}{dg} = \int \frac{dT(wl(w), g)}{dg} f(w) dw = \int \frac{v_g}{v_c} f(w) dw.$$

The right side is the integral of individuals' marginal rates of substitution. If this total exceeds one (the cost of the public good, expressed as a one unit increase in g), there is a budget surplus. To complete the argument, the adjusted tax schedule can be uniformly decreased until the point at which the budget balances.⁵ Then, a marginal increase in g financed by this modified tax schedule will increase the utility of all individuals.⁶

Comments

The offsetting tax adjustment for any wl was stipulated in expression 7 to equal individuals' marginal rate of substitution, v_g/v_c . Observe that, for any level of g , $v(.,.)$ is a function of (only) wl , just as is the tax schedule. In particular, v does not depend on l or w independently (this relates to the assumed separability of the utility function). This implies that the marginal rate of substitution and thus the tax adjustment that absorbs benefits from the public good at each level of income are the same for all individuals. Those with different wages, w , will in general earn different levels of income, but each type of individual faces the same tax schedule, as a function of income, and the same subutility (v) schedule, both initially and as the level of the public good is adjusted.

To reinforce the intuition that labor supply is unaffected, it is helpful to think about the $v(wl, g)$ schedule changing in stages. Each individual begins with the same v schedule. If one were to increase g without adjusting the tax schedule, this common v schedule would shift up in some manner (depending upon the incidence of the public good). Next, the offsetting tax adjustment, $dT(wl, g)/dg$, is designed such that, at every level of income, wl , the common v schedule is shifted down to exactly where it was initially. (That is, at each level of wl , one asks how much income one would have to take from individuals so that their subutility, v , falls by just the amount it rose due to the

increase in the public good, g .⁷ By definition, this amount is given by the marginal rate of substitution.) Because the v schedule ends up being the same as it was before the changes, every individual, when choosing l , is maximizing the same function after the reform as he was initially.

APPENDIX ENDNOTES

¹ This formulation can readily be restated for the case of externalities and environmental taxes. The utility function would then be $U(v(c, g, e), l)$, where c is now interpreted as a vector of consumption goods and e is a vector of externalities. (Each element of e is simply the total consumption of the corresponding element of c ; only some of the elements of e need affect utility.) The budget constraint becomes

$$\rho c = wl - T(wl, g, p)$$

where ρ is a price vector that includes Pigouvian taxes and subsidies. Now, as one adjusts a commodity tax toward the level of the first-best Pigouvian tax, one adjusts the tax schedule in a manner analogous to that described below, so that, for each level of income, wl , individuals' subutility functions, v , have the same value as before the adjustment. Such an adjustment will ensure that labor effort and utility are unchanged. The net revenue from the adjustment will be the sum of individuals' compensating variations, which will be positive (producing a surplus) if one moves to the first-best Pigouvian tax vector. For further discussion, see Kaplow (1993).

² Starting with the right side and substituting for Δt using expression 4, we have

$$\begin{aligned} wl \left(1 - t_0 - \frac{(1 - t_0)\Delta g}{1 + g_0 + \Delta g} \right) (1 + g_0 + \Delta g) &= \\ wl \left((1 - t_0)(1 + g_0 + \Delta g) - (1 - t_0)\Delta g \right) &= \\ wl(1 - t_0)(1 + g_0). \end{aligned}$$

³ Let $v_i(c) = ln(c)$, which implies that the marginal utility of consumption is inversely proportional to consumption. Then, if all individuals receive the same utility benefit from the public good, the monetary benefit of the good will be strictly proportional to disposable income. Now, if one raises the level of the public good by Δg , there will be a constant utility benefit, say, β , for all individuals. (i.e., $\beta = v_2(g_0 + \Delta g) - v_2(g_0)$) Simply set the tax adjustment $\Delta t = (1 - t_0)(1 - e^{-\beta})$. Then, the fall in utility from the tax adjustment equals $\ln\{wl/(1 - t_0)\} - \ln\{wl/(1 - t_0)(1 - e^{-\beta})\}$; the

latter term is just $\ln \{wl(1-t_g)e^{-\beta}\}$, so the difference is $-\ln \{e^{-\beta}\}$ or just β . That is, the fall in utility from the tax adjustment will just equal the increase in utility from the public good, and this will be true at every income level. Thus, each individual's utility as a function of labor, l , is the same both before and after the public good and tax adjustment are introduced; hence, behavior is unchanged. Here, by contrast to the previous case, the public good itself has no effect on labor supply, so it is necessary that the tax adjustment itself have no effect on labor supply.

- ⁴ Equivalently, one can show that the derivative of individuals' first-order condition for the choice of l with respect to g , after using expression 7 to substitute for the tax change, equals zero. (The only qualification is that some individuals may have multiple optima. Assuming that they make the same choice independent of the regime or that such individuals comprise a set of measure zero, the conclusion is unaffected.)
- ⁵ As the surplus is rebated, there will be effects on behavior (an income effect). But as long as changes in labor effort are continuous (except perhaps for a set of individuals having measure zero—see note 38), there will exist a modification that involves a positive rebate to everyone while balancing the budget.

⁶ Similarly, if benefits are less than costs, welfare can be improved by reducing public goods and reducing taxes in an offsetting manner. When the sum of individuals' marginal rates of substitution is less than one, there might exist some method of financing the public good (other than an offsetting tax) that would increase welfare. The work of Christiansen (1981) and Broadway and Keen (1993) shows that this is not the case in the presence of an optimal nonlinear income tax. (The intuition is that, in such an instance, any small adjustment to the tax system—including an offsetting tax—to raise or rebate a given amount of revenue will have the same effect on welfare.) But if the prevailing tax regime were not optimal, it would be possible to increase the level of public goods and improve welfare even when the project was otherwise undesirable if the adjustment to the tax system moved it sufficiently closer to the optimal system. But any such benefit is more naturally attributed to the tax reform itself rather than to providing more of the public good.

⁷ As explained in the preceding paragraph, because labor enters U in a weakly separable manner, this amount of income is the same for all types, even though different types would have different levels of l at a given level of income.