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GREEN TAXES: A NOTE ON
THE DOUBLE DIVIDEND AND
THE OPTIMUM TAX RATE

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Abstract

The simplest pedagogical tools are employed to clarify that there is a double dividend from shifting the tax policy towards green taxes only if taxes were not set optimally before the environmental concern was put on the agenda. In general a single or less than single dividend cannot be ruled out. The note revisits the result of Sandmo (1975) that the second best optimal tax on a dirty commodity can be interpreted as being composed of a fiscal and an environmental part, and shows how the latter can be derived from a simple cost-benefit trade-off.

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Green Taxes: A Note on the Double Dividend and the Optimum Tax Rate.

1. Introduction.

The dual purpose of this note is to make some remarks on the double dividend concept in environmental tax analysis and the interpretation of the optimum rate of an environmental tax. The ambition is to clarify some aspects of these concepts that in my opinion have not received due attention in the literature. By using a simple approach it is hoped that the discussion may be of some pedagogical help. Some central references to the theoretical double dividend literature are Bovenberg and de Mooij (1994), Bovenberg and van der Ploeg (1994), Goulder (1995), Parry (1994), Schöb (1994) and Sørensen et al. (1995). I shall, however, take as my point of departure what seems to be a rather general and widespread notion of a double dividend rather than a specific representation in the literature. Some empirical studies are presented in Jorgensen and Wilcoxen (1994) and Shah and Larsen (1992). The pioneering study of optimal environmental taxes in a second best setting was Sandmo (1975).

The introduction of environmental taxes in order to improve the environment has for decades been advocated by economists. The theoretical rationale is that such taxes are Pigovian taxes that improve the social efficiency of the economy by correcting externalities. It is an accepted view in public finance that such taxes are preferrable to purely fiscal taxes (on income, consumption, etc.) that do in fact distort the allocation of real resources in the economy. This line of reasoning has been pursued further to the argument that the introduction of environmental taxes yields a double dividend because they not only improve the environment, but also make it possible to improve the efficiency further by lowering distortionary taxes. This is the dual gain known as the double dividend.

The precise line of reasoning behind this idea is not always easy to grasp. Let me therefore tell one simple story that is compatible with this notion. In fact, I believe that this story is fairly representative of the double dividend notion. In constructing this story I will resort to the simplest textbook tools that can be adopted in tax analysis. In figure one I consider the competitive markets for two goods, the quantities of which are denoted by x and c, respectively. Let q_x and q_c be the corresponding prices. Let MC and SMC denote private and social marginal cost, respectively. The MB curve expresses the marginal benefit or simply

the demand curve. It is assumed that initially there is a unit tax t imposed on the c good. Using a simple consumer's surplus measure, the deadweight loss is measured by the shaded (Harberger) triangle in figure 1b. There is no tax on the x good. In order to simplify as much as possible, the MC and the demand curve have been given the same location in the two figures.

Now assume that an environmental problem arises or is discovered. The problem is an externality associated with the x good, and the external cost is a constant e per unit. If a unit tax equal to e is imposed to internalise this external cost, there is a (net) social gain from this market intervention which is measured by the shaded triangle in figure 1a. To make everything as nice and simple as possible, the figures are by construction (locations of MC and demand schedule) such that the tax revenue from the taxes in (1a) and (1b) are the same. Hence the revenue from the green tax can be used to abolish the distortionary tax on c. There is an efficiency gain from eliminating the deadweight loss, and the total gain is twice the area of each triangle. There is, indeed, in a literal sense a double dividend.

Even if this story may capture the basic notion of a double dividend, it is most likely too simple to capture the true features of the tax system and a green tax reform. There is no good reason why the tax burden should be confined to one market initially. Figure 2 illustrates the case in which the initial, and, by assumption, purely fiscal tax burden is shared between the two markets. The gain from increasing the tax on x to the optimum environmental level (e), would then be smaller and the deadweight loss to be eliminated in the market for c would be lower.

2. Double or single dividend ?

To address the double dividend question in a more satisfactory way, let us consider a more general model. Let us assume that there is an economy with two taxed and one untaxed commodity (for instance leisure). In line with the assumptions of the simplest tax models the pretax prices (reflecting privat marginal cost) are constant. Let E be a measure of environmental quality that can be improved by imposing an environmental tax. Let the taxes be two unit commodity taxes t_D and t and a uniform poll tax T. The notation t_D reflects that this may be a tax on a dirty good, or, in other words, an environmenal tax. I do not specify the individuals of the economy, but assume that their utility levels are determined by the taxes and other exogenous circumstances that are suppressed in the analysis. Analytically we can

then sum up the welfare of the society by an indirect welfare function given by

$$V(t_D,t,T,E). \tag{1}$$

The tax rate arguments represent their price and income effects, while their environmental effects are channelled through E. Moreover, let there be a tax revenue function

$$R(t_D,t,T). \tag{2}$$

Leaving environmental concerns on one side, the optimum fiscal tax problem is that of maximising V s.t. a predetermined tax revenue requirement $R=R_o$.[1] Let us introduce the Lagrange function of the problem

$$L=V(t_D,t,T,E)+\mu[R(t_D,t,T)-R_o]. \tag{3}$$

The first order conditions of the maximisation problem are then

$$V_{t_D}+\mu R_{t_D}=0, \tag{4}$$

$$V_t+\mu R_t=0, \tag{5}$$

$$V_T+\mu R_T=0, \tag{6}$$

where subscripts denote partial derivatives. It follows that at the optimum

$$\frac{R_{t_D}}{R_T}=\frac{V_{t_D}}{V_T} \tag{7}$$

and

[1]In addition to the fiscal consideration there may also be a distributional concern captured by the welfare function.

$$\frac{R_{t_D}}{R_t} = \frac{V_{t_D}}{V_t} \tag{8}$$

Assume that the effect of E is discovered, and t_D is adjusted to affect the environment. The welfare effect is then found by differentiating the welfare function. Let us first assume that T is adjusted to preserve the tax revenue. Then it follows from fixing the value of the tax revenue function that

$$\frac{dT}{dt_D} = -\frac{R_{t_D}}{R_T}. \tag{9}$$

Let V'_T denote the total derivative of V w.r.t. t_D when T is adjusted to restore the initial tax revenue, and let us apply similar notation to E.

$$V'_T = V_{t_D} + \underline{V_T(-\frac{R_{t_D}}{R_T})} + V_E E'_T \tag{10}$$

Assume that the last term is positive: The effect of increasing the green tax is a better environment. There is a double dividend if the underlined term is positive, too.

If it is t which is adjusted to keep the tax reveneue unchanged, we get the following expressions corresponding to those above:

$$\frac{dt}{dt_D} = -\frac{R_{t_D}}{R_t}, \tag{11}$$

$$V'_t = V_{t_D} + \underline{V_t(-\frac{R_{t_D}}{R_t})} + V_E E'_t. \tag{12}$$

Assuming again that the green tax improves the environment and the last term is positive, we get a double dividend if and only if the underlined term is positive.

We see from the first order optimality conditions above that *if the fiscal tax policy is optimal before the environmental policy is introduced*, the underlined terms in (10) and (12)

are zero, and *there is no double dividend.* For this result it makes no difference whether the resulting tax money is recycled through a cut in the lump sum tax or an excise tax. It is sometimes argued (e.g. Bovenberg and de Mooij (1994) and Goulder (1994)) that there will be a double dividend from an environmental tax if the tax money is rebated by cutting a distortionay tax rather than a lump sum tax[2]. This is true in a one consumer economy in which it would never be optimal to impose other than lump sum taxes for fiscal reasons. But it will not be true in a many consumer economy in which distribution is an issue and a (positive or negative) uniform lump sum tax will be no more efficient than any other tax instrument at the social optimum. There will be a double dividend only if the initial tax policy was inoptimal in the sense that one had failed to realise a welfare gain from increasing the tax on the good that has now been revealed to be a dirty good, and lowering some other tax. This was obviously the case in the illustration in figure one.

3. The optimum environmental and fiscal commodity tax.

The second purpose of this note is to give a simple interpretation of the optimum commodity tax resulting from environmental and fiscal concerns. The approach may even be perceived as a shortcut in deriving the optimum environmental tax in a second best setting. I will consider a model that is similar to the pioneering model of Sandmo (1975) and the models used in several recent papers on green taxation. Let us consider an economy with n identical consumers, and three goods, of which two are taxed and one is untaxed. The latter may be interpreted as leisure, which implies that the model may be perceived as capturing labour supply distortions. Let x_0 denote the quantity of an untaxed good and let x_1 and x_2 denote the quantities of the respective taxed goods. All quantities are per capita measures. Let q_0, q_1 and q_2 denote the corresponding after-tax prices and let t_1 and t_2 be the unit taxes on commodities one and two. For simplicity before-tax prices are treated as fixed. The total amount of commodity one, nx_1, causes an environmental damage, and we can write the social welfare (neglecting the benefits derived from the tax revenue) as $V(q_1,q_2,nx_1)$, where V is the indirect utility function of an individual. Let V_3 be the marginal effect of an increase in the environmentally harmful consumption. Let the government's tax revenue be expressed by

[2]Goulder has termed this the weak form of double dividend.

$R=t_1nx_1+t_2nx_2$. There is a preset tax revenue requirement. The optimal tax structure is the vector of tax rates that maximises the social welfare subject to the tax revenue requirement. Let α be the shadow price assigned to government revenue, and λ denote the marginal private utility of income. The optimum taxation is then characterised by the formula:

$$\frac{t_1 - \frac{-nV_3}{\lambda}\frac{1}{\alpha/\lambda}}{q_1} = \frac{t_2}{q_2}\sigma, \tag{13}$$

where

$$\sigma = \frac{\sigma_{11}+\sigma_{22}+\sigma_{10}}{\sigma_{11}+\sigma_{22}+\sigma_{20}}. \tag{14}$$

Here σ_{ij} denotes the compensated elasticity of the demand for the i'th good with respect to the price of good j. Let us first assume that there is no environmental effect. Then the ratio of the relative tax rates (t_i/q_i) are determined by the parameter σ which depends on the compensated cross effects between the respective goods and the labour market. If $\sigma=1$, the cross effects are the same for the two goods, and they should be taxed at the same rate. If for instance $\sigma>1$, the cross effects to the labour market are more harmful when good two is taxed than when good one is taxed, and commodity one should be taxed at a higher rate . ($\sigma_{20}>\sigma_{10}$, and commodity two is more complementary with labour than is commodity one, such that a tax on commodity two reduces the labour supply more.) This result is known as the Corlett-Hague result due to Corlett and Hague (1953-54).

When in fact there is an environmental effect, we can, with a certain qualification, interpret the left hand side of (13) as *the relative tax on commodity one beyond the tax justified on environmental grounds*. We can interpret this as *the fiscal part* of the tax. In a sense this is the true tax wedge on commodity one, since the environmental tax is a non-distortionary tax. The qualification is that the marginal environmental effect is devided by the marginal cost of public funds α/λ. Since this factor normally is less than unity, the environmental tax should be set below the level implied by the conventional environmental argument[3].

[3]Bovenberg and de Mooij (1994) discuss the conditions under which this will happen

We can interpret $-nV_3/\alpha$ as the optimal *environmental* tax within a system of otherwise distortionary taxes. We assume for a moment that we impose a tax solely on environmental grounds. We define this optimal environmental tax, t_m, as the tax which yields the optimal environmental quality, as we do in the case with no distorting taxes. The optimal environmental quality is the one that equates the marginal (gross) benefit from an environmental improvement to the marginal social cost of achieving such an improvement. The marginal valuation of an environmental improvement corresponding to a one unit reduction in the harmful consumption is equal to $-nV_3/\lambda$, measured in private income. The marginal cost has two components. One is the utility that the consumers must forego in order to obtain the environmental improvement. This is measured by the environmental tax t_m itself, which is equal to the difference between the price of the good, reflecting the consumers' marginal valuation, and the marginal cost of producing it. The latter reflects that the sacrifice of the consumers is mitigated by the fact that resources are released for producing other useful commodities. The other component is the cost due to the loss of tax revenue from a one unit reduction in the tax base. This cost is due to the fact that the foregone tax proceeds must be offset by increasing distortionary taxes, and this financing entails a social cost equal to $(\alpha/\lambda-1)t_m$ measured in private income. The condition characterising the optimal environment (equality between marginal benefit and cost) is then

$$-nV_3/\lambda = t_m + (\alpha/\lambda - 1)t_m. \tag{15}$$

By solving with respect to t_m, we get an expression for the optimal environmental tax :

$$t_m = \frac{-nV_3}{\alpha} = \frac{-nV_3}{\lambda}\frac{1}{\alpha/\lambda}. \tag{16}$$

And we can rewrite (13) as

$$\frac{t_1 - t_m}{q_1} = \frac{t_2}{q_2}\sigma. \tag{17}$$

The left hand side can be interpreted as the fiscal part of the commodity tax, and it is characterised by exactly the same *kind* of formula as the optimal fiscal tax in a non-environmental setting.

The result that the marginal social damage of a dirty commodity enters the tax formula

for that commodity additively was derived already in Sandmo (1975)[4]. The proper weighting of the marginal damage allowing for the marginal cost of public funds was also established there. Thus the basic insight into the optimal environmental taxation in a second best world preceded by two decades the recent confusion over double dividends.

4. Concluding remark.

This note has pointed out the implication of the envelope theorem that if taxes have been set optimally from a purely fiscal perspective, i.e. neglecting environmental concerns, further increasing the tax on an environmentally harmful commodity, has *a single dividend in terms of a better environment.* In other words, the existence of a double dividend requires that taxes have not been optimised before the environmental issue was put on the agenda. This may, of course, be empirically true, but two things seem worth noting. Even if such optimality is wanting, it is hard to see why there would be systematic undertaxation of dirty commodities. Overtaxation would seem equally likely, implying that there would be *a less than single dividend.* And, even when there is a second dividend from further fiscal taxation of dirty commodities, this is due to properties of the commodities that have nothing to do with there capacity to pollute. Carbon content, or, any other dirty characteristic, is no substitute for the elasticity properties of demand that are the determinants of the optimal fiscal tax structure.

Finally, the note has pointed out that the optimal tax on an environmentally harmful commodity may be interpreted as consisting of a fiscal tax and a second best environmental tax that can be derived from a simple cost-benefit trade-off. This is done by setting the marginal benefit from a better environment equal to the proper cost of achieving it. This tax is analogous to a conventional Pigovian tax; only the cost is different. The fiscal part is then determined in exactly the same way as prescribed by standard second best optimum tax formulae.

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[4]One should distinguish additivity from separability since in general the environmental and fiscal part must be determined simultaneously.

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Figure 1

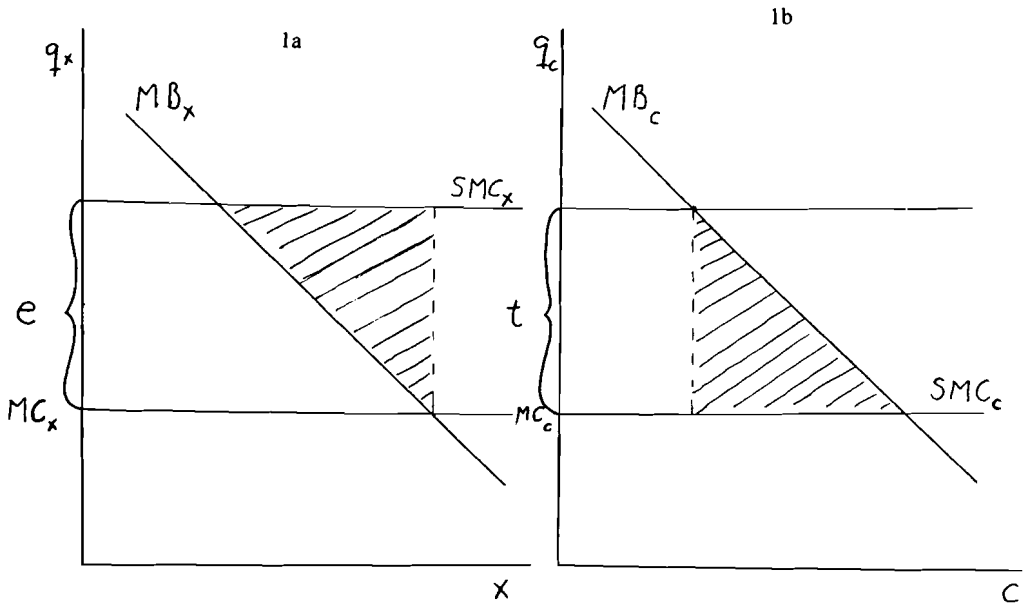
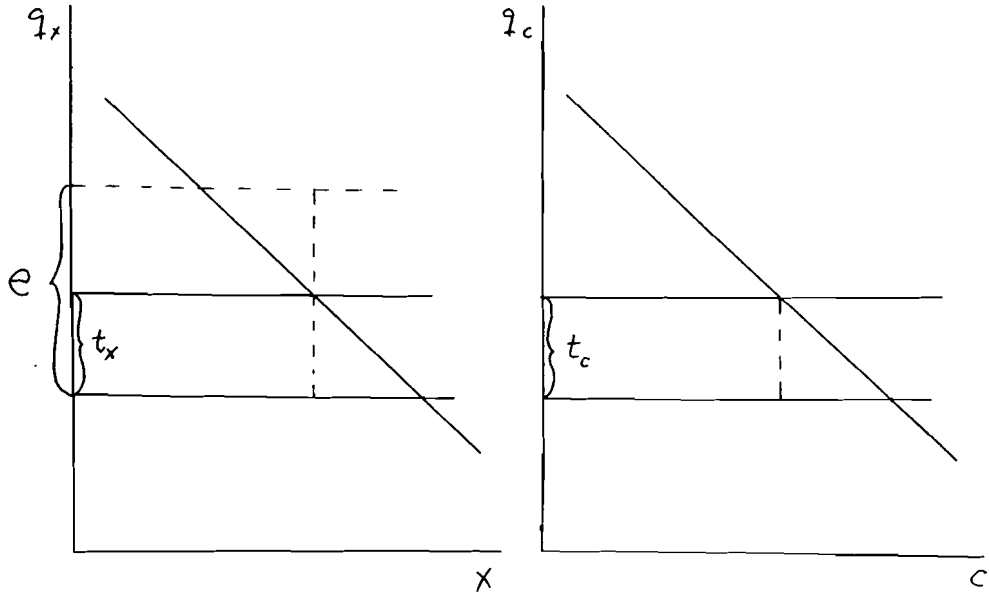


Figure 2



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