Published in: *International Tax and Public Finance* 4.1997, pp. 167-176

Environmental Taxes and Pre-Existing Distortions: The Normalization Trap*

Ronnie Schöb

Abstract

The double-dividend hypothesis claims that green taxes will both improve the environment and reduce the distortions of existing taxes. According to the earlier literature on the double dividend the tax rate for polluting goods should be higher than the Pigovian tax which fully internalizes the marginal social damage from pollution, in order to obtain a 'second dividend'. On the contrary, Bovenberg and de Mooij (1994) argue that environmental taxes typically exacerbate, rather than alleviate, pre-existing distortions. The optimal pollution tax should therefore lie below the Pigovian tax. This paper points out that there is no real contradiction between these apparently opposing policy recommendations. It will be shown that the difference in the results appears because, implicitly, different definitions of the second-best optimal pollution tax are chosen.
JEL classification: H21, Q28

Address:

Ronnie Schöb
Department of Economics
University of Munich
Schackstrasse 4
D-80539 Munich
tel. ++49/89/2180-6261
fax ++49/89/397303
email ronnie.schoeb@ces.vwl.uni-muenchen.de

* Comments by Michael Keen, Jack Mintz, Gerhard Orosel, Ray Rees and three anonymous referees are gratefully acknowledged. The usual disclaimer applies.

1. Introduction

In recent years, the prospect of a double dividend from green taxes has become very attractive. While it is taken for granted that green taxes improve the environment and hence yield a positive environmental dividend, there is an ongoing discussion about the existence of the 'second dividend' which relates to the effect of a green tax on the efficiency of the tax system.

According to Goulder (1995), we can distinguish a 'weak' form and a 'strong' form of the second dividend. The double-dividend hypothesis in its weak form claims that tax revenues from green taxes can be used to reduce *other distortionary taxes* like taxes on labour or capital income, and hence yield a second dividend. The idea of such an "excess benefit" originates with Tullock (1967), and was put forward by several papers in the mid-eighties (cf. Nichols 1984, Terkla 1984, and Lee and Misiolek 1986). The second dividend was considered originally to be a welcome side-effect of environmental tax policy only. A logical consequence of the existence of such a second dividend for policy recommendation is that the optimal pollution tax should be set higher than the Pigovian tax, which is equal to the marginal environmental damage of a polluting good. Going beyond the Pigovian tax further increases the environmental quality *and* raises additional public funds. These funds can be used to reduce the distortion from other taxes.[1]

The 'stronger' form of the second dividend concerns the effect of green taxes on the efficiency of the *whole tax system*. According to this definition, a positive second dividend exists if the excess burden of the tax system declines. Analysing the consequences of green taxes for the optimal tax structure, Bovenberg and de Mooij (1994) argue "that environmental taxes typically exacerbate, rather than alleviate, pre-existing distortions - even if revenues are employed to cut pre-existing distortionary taxes. [...] in the presence of existing distortionary taxes, the optimal pollution tax typically lies below the Pigovian tax..." (Bovenberg and de Mooij 1994, p. 1085). Increasing a narrow-based green tax and reducing a broad-based tax

[1] This view has recently been promoted by Pearce (1991) and Oates (1993).

like a tax on labour income will typically increase the overall distortion of the tax system. Hence, the second dividend is negative and the double-dividend hypothesis fails. Therefore they oppose the policy recommendation that going beyond the Pigovian tax increases welfare.[2]

As will be shown in this note, there is no real contradiction between these two apparently opposite conclusions, which have caused significant confusion in the debate on the double-dividend hypothesis. The difference in the results appears because, implicitly, different definitions of the pollution tax are chosen in evaluating second-best optimal environmental taxes. While the earlier contributions to the double-dividend debate focus on tax systems where only commodity taxes are present, the more recent contributions focus on tax systems where green taxes are introduced in addition to a labour tax. Consequently, the former approach includes a tax component which is raised for non-environmental reasons in its definition of the second-best optimal pollution tax while the latter defines the tax on a polluting good as the tax component which is imposed for environmental reasons only. The different definitions are due to different normalizations of the consumer price system chosen. Therefore, a comparison between the second-best optimal pollution tax and the first-best Pigovian tax turns out to be an inappropriate indicator for the existence of a second dividend.

Section 2 sets out an optimal taxation model similar to Sandmo (1975). In Section 3, this model will be used to analyse tax systems with different normalizations which may be characterized as a *labour tax system* and a *commodity tax system*, respectively. Section 4 then shows the differences and reconciles the two apparently opposing policy recommendations. Section 5 concludes.

---

[2] In a previous version of this paper (Schöb 1994) I refer to the earlier contributions to the double-dividend literature as the environmental view and to the Bovenberg and de Mooij approach as the public finance view.

2. The model

Consider a closed economy with N households. Assume a linear technology to produce a private dirty good D, which consumption creates a negative externality, a private clean good C, which causes no externalities, and a public good G, with labour L being the only input into production. The notation is similar to Bovenberg and de Mooij (1994). Assuming perfect competition, we can normalize the wage rate to unity and choose units for all goods such that all producer prices are equal to one:

$$NL = NC + ND + G. \tag{1}$$

The preferences of a representative household depend on the consumption of the private commodities C and D, and on leisure V. Preferences also depend on the public good G and on the environmental quality E. These preferences are described by a twice continuously differentiable, strictly quasi-concave utility function $u = (C, D, V, G, E)$. The time endowment is normalized to one, hence $V + L = 1$. The budget constraint of the representative household is given by

$$(1+t_C)C + (1+t_D)D = (1-t_L)(1-V), \tag{2}$$

where t_L denotes the tax rate on labour income while t_C and t_D denote the commodity taxes on the clean and the dirty good, respectively.

The consumption of D creates a negative externality on the environmental quality, which the household does not take into account when consuming the dirty good:

$$E = e(ND),\ de/d(ND) < 0. \tag{3}$$

The government maximizes welfare by maximizing the utility of a representative household. For convenience, we make use of the indirect utility function w which already takes into account the utility maximizing behaviour of the household. Hence, the government maximizes

$$W = w(t_C, t_D, t_L, G, E) \tag{4}$$

subject to the government budget constraint per capita, which is given by:

$$\frac{G}{N} = t_C C + t_D D + t_L L. \tag{5}$$

Without using a lump-sum tax, the government can only raise revenues by introducing taxes on the commodities *C* and *D* or by introducing a tax on labour.

3. The optimal tax structure

To define the optimal tax structure, we can proceed in two alternative ways. As the demand functions are homogeneous of degree zero in consumer prices - we have no exogenously given income - we can normalize one consumer price at unity without loss of generality [cf. Dixit and Munk (1977) or Auerbach (1985)]. This is equivalent to normalizing one tax rate to zero as we have already normalized all producer prices to unity. On the one hand, we can normalize the tax on the clean good to zero. In this case, we analyse a tax system with a labour tax and an additional tax on the dirty good. In what follows we refer to this as a labour tax system. On the other hand, we can normalize the labour tax to zero. In this case we analyse a commodity tax system.

3.1 A labour tax system

Maximizing (4) with respect to (5) for $t_C = 0$, using the Slutsky decompositions ($\partial I/\partial t_D = \partial I/\partial p_D = s_{ID} - D\,\partial I/\partial Y$ and $\partial I/\partial t_L = -\partial I/\partial p_L = -s_{IL} - L\,\partial I/\partial Y$) with $I = C, D, L$, and s_{IJ}, $J = D, L$, denoting the Slutsky terms and using Cramer's rule we obtain the optimal tax structure in the presence of externalities:[3]

$$t_L = \frac{(1-\nu)(L s_{DD} + D s_{DL})}{s_{DD} s_{LL} - s_{DL} s_{LD}} \equiv t_L^R, \tag{6}$$

$$t_D = \frac{-(1-\nu)(D s_{LL} + L s_{LD})}{s_{DD} s_{LL} - s_{DL} s_{LD}} - \frac{\lambda}{\mu} N \frac{u_E}{\lambda} \frac{de}{d(ND)} \equiv t_D^R + \frac{\lambda}{\mu} t_P. \tag{7}$$

The shadow price λ denotes the *marginal utility of private income*. The shadow price μ denotes the *marginal utility of public expenditures*. The term ν,

[3] For a formal derivation of optimal tax rates, see e.g. Sandmo (1975). Note that $w_E = u_E$.

$$\nu = \frac{\lambda}{\mu} + \sum_{I,i=L,D} t_i \frac{\partial I}{\partial Y} + \frac{\lambda}{\mu} N \frac{u_E}{\lambda} \frac{de}{d(ND)} \frac{\partial D}{\partial Y},$$

defines the *net social marginal utility of private income Y* of the representative household - measured in units of public expenditures. It can be attributed to Diamond [1975, see his eq. (6)]. However, the expression derived here also takes into account the impact of private income on the social evaluation of the externality. Note, that ν is independent of the particular tax rate considered.

The optimal tax on labour consists of one term only, which relies on the efficiency of the tax system. The tax on the dirty good, however, consists of a term, which relies on the efficiency of the tax system and which we will call the Ramsey component, and an environmental component. The latter equals the marginal environmental damage weighted with the inverse of the marginal cost of public funds λ/μ. As the marginal environmental damage equals the (first-best) Pigovian tax, we will denote it by t_P.

With lump-sum taxes we obtain $\lambda = \mu$ and $\nu = 1$. There is no labour taxation and the optimal tax on the dirty good is equal to the marginal environmental damage. Only a Pigovian tax t_P is raised in addition to lump-sum taxes, which fully internalizes the external effect.[4]

Bovenberg and de Mooij (1994) assume that the utility function is separable between environmental quality, public good, leisure and consumption goods and homothetic in consumption goods. Under these rather restrictive assumptions, the Ramsey component of the dirty good becomes zero (see the appendix). If there is no lump-sum tax available, the inverse of the marginal cost of public funds is then given by:

$$\frac{\lambda}{\mu} = 1 + \frac{t_L}{L} \frac{\partial L}{\partial t_L}. \quad (8)$$

[5]

---

[4] We assume throughout that the revenue requirement exceeds the tax revenues the government raises if it only imposes a Pigovian tax on the dirty good.

[5] Eq. (8) can be derived by inserting $t_D = \lambda/\mu \cdot t_P$ [cf. eq. (7)] into the first-order condition for the labour tax.

If the labour supply curve is upward sloping, we have $\partial L/\partial t_L < 0$ and therefore for $t_L > 0$ we have $\lambda/\mu < 1$.[6] It turns out that the second-best optimal tax on the dirty good falls below the first-best Pigovian tax. Hence, it does not cover the total marginal environmental damage.

To see the intuition of this result, we have to analyse the consequences of a revenue-neutral shift from a broad-based labour tax to a narrow-based tax on the dirty good. Consider the whole consumption bundle and its consumption price index. It is obvious that a reduction in the labour tax and a revenue-neutral increase of t_D will not affect the real after-tax wage, if the household does not alter the composition of its consumption basket. However, if it substitutes the clean good for the dirty good, there will be a negative tax-base effect. Revenue-neutrality requires that the consumer price index will increase at a higher rate than the net wage. As a consequence the real after-tax wage actually falls. Labour supply falls and welfare decreases. Since the Pigovian tax completely internalizes the marginal environmental damage, the only effect of a marginal increase of the Pigovian tax is a higher marginal cost of public funds, i.e. a negative second dividend occurs.

3.2 A commodity tax system

Now we normalize the net wage rate to unity, i.e. $t_L = 0$. Maximizing (4) with respect to (5), the optimal tax structure in the presence of externalities is given by:

$$t_C = \frac{-(1-\hat{\nu})(Cs_{DD} - Ds_{DC})}{s_{DD}s_{CC} - s_{DC}s_{CD}} \equiv t_C^R, \tag{9}$$

$$t_D = t_D^R - \frac{\hat{\lambda}}{\mu} N \frac{u_E}{\lambda} \frac{de}{d(ND)} \equiv t_D^R + \frac{\hat{\lambda}}{\mu} t_P, \tag{10}$$

where $t_i^R, i = C, D,$ denotes the Ramsey tax component, which relies on the efficiency of the tax system only. Note that although the real allocation is identical to the one described for a labour tax system, the marginal utility of income $\hat{\lambda}$ and hence $\hat{\nu}$ are different due to normalization. The marginal utility of public expenditures μ however is identical.

---

[6] The labour tax is positive if, for the compensated elasticities, we have: $\varepsilon_{LD} > \varepsilon_{DD}$.

From eq. (10) it is no longer clear whether the tax on the dirty good lies above or below the Pigovian tax even if $\hat{\lambda}/\mu < 1$. According to this analysis, one could claim that going beyond the Pigovian tax is welfare improving. To see this, assume that the initial tax rate on the dirty good is equal to the Pigovian tax, $t_D = t_P$, and consider a marginal revenue-neutral tax reform which increases the tax on the dirty good. Total differentiation of eqs. (4) and (5) yields

$$d\tilde{W} \equiv \frac{dW}{\hat{\lambda}} = N\left[-C + \frac{u_E}{\hat{\lambda}}\frac{de}{d(ND)}\frac{\partial D}{\partial t_C}\right]dt_C + N\left[-D + \frac{u_E}{\hat{\lambda}}\frac{de}{d(ND)}\frac{\partial D}{\partial t_D}\right]dt_D \qquad (11)$$

and

$$dG = N[C + t_C\frac{\partial C}{\partial t_C} + t_D\frac{\partial D}{\partial t_C}]dt_C + N[D + t_C\frac{\partial C}{\partial t_D} + t_D\frac{\partial D}{\partial t_D}]dt_D = 0. \qquad (12)$$

Adding eq. (12) to eq. (11) and substituting in the definition for the Pigovian tax, we obtain:

$$d\tilde{W} = t_C[N\frac{\partial C}{\partial t_C}dt_C + N\frac{\partial C}{\partial t_D}dt_D]. \qquad (13)$$

Assuming both goods to be Non-Giffen and the marginal tax revenues to be positive, the welfare change is positive if, due to the marginal revenue-neutral tax reform, the consumption of the clean good increases. The partial equilibrium models used by Nichols (1984) and Lee and Misiolek (1986) implicitly assume all cross price effects to be zero. In this case, the welfare change is guaranteed to be positive. Taxing the dirty good at the Pigovian tax, the reduced marginal environmental damage completely outweigh the partial loss in revenues due to reduced consumption of the dirty good $t_D \cdot \partial D/\partial t_D$. The additional public funds (assuming positive marginal revenues), however, can be used to reduce the distortion of taxing the clean good. This enhances the efficiency of the tax system and therefore welfare.

However, it need not be the case that the consumption of the clean good increases. In general, the welfare change is determined by the following condition:

$$\frac{d\tilde{W}}{dt_D} \gtrless 0 \Leftrightarrow \frac{\frac{\partial C}{\partial t_D}}{\frac{\partial C}{\partial t_C}} \gtrless \frac{\frac{\partial R}{\partial t_D}}{\frac{\partial R}{\partial t_C}}. \qquad (14)$$

The welfare effect is positive if the clean good is an uncompensated substitute for the dirty good, i.e. $\partial C / \partial t_D > 0$. For C being an uncompensated complement to the dirty good, i.e. $\partial C / \partial t_D < 0$, the consumption of the clean good may actually decrease. To see this, assume that the government increases the tax on the dirty good by one unit. If the marginal revenue $\partial R / \partial t_D$ is very low, the additional funds the government raises are small. These have to be rebated by reducing the tax on the clean good, $dt_C < 0$. If the marginal revenue of the clean good $\partial R/\partial t_C$ is relatively high compared to ∂R/###t_D, the clean good will be reduced at a relatively small rate. The ratio of marginal tax revenues, $\partial R/\partial t_D/\partial R$/###$t_C$, is just the weight of the own-price effect $\partial C / \partial t_C$. If the weight is small, it might happen that, even in the case of a low cross price-effect, relative to the own-price effect, the increased consumption of the clean good resulting from a reduction in t_C is outweighed by the reduction in consumption resulting from an increase in t_D.

4. Reconciliation

Comparing eqs. (7) and (10) we find two different definitions of what the tax on the dirty good is even though we consider two identical tax systems which differ only with respect to normalization. The different definitions of the pollution tax are illustrated in Figure 1 for the case analysed by Bovenberg and de Mooij (1994). In a world without externalities the 45º-line OA indicates the optimal uniform commodity tax structure which is equivalent to pure labour taxation. The line O'A' indicates the optimal commodity tax structure in the presence of externalities (whereby, for simplicity, the marginal environmental damage is kept constant). Moving up and to the right, the tax revenue increases ($R_2 > R_1$; $dR = 0$ indicates iso-revenue lines) and so does the marginal cost of public funds. The two lines converge [cf. eq. (7)].

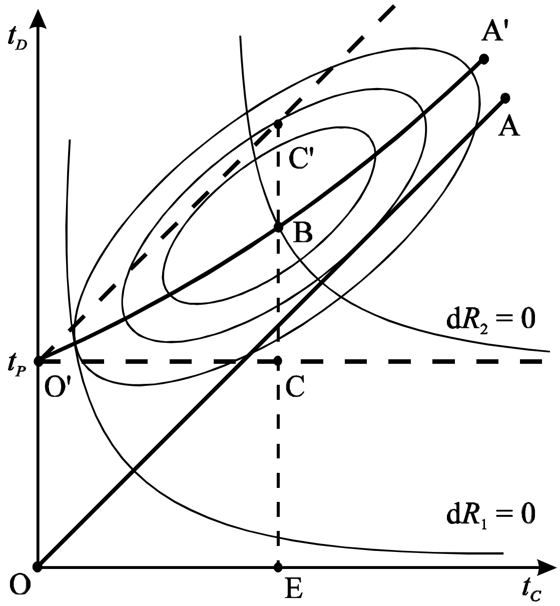

Figure 1: *An optimal green tax system*

B represents the summit of the utility hill which is represented by indifference contours. Moving up and to the right, private consumption decreases while public good provision increases first (on the Laffer-efficient side). This implies welfare gains as long as the marginal rate of substitution between consumption and the public good is larger than the marginal cost of public good provision including the marginal excess burden (cf. Atkinson and Stern 1974). The summit B indicates the optimal tax structure which yields the revenues necessary for supplying the second-best optimal quantity of public goods.

Within an existing labour tax system, the tax rate t_D drives a wedge between the commodity prices of the clean and dirty good only. It does not cover the distortion the labour tax itself has already imposed on the price ratio of the dirty good and leisure. The tax rate t_D indicates only the *additional* wedge between the price of the dirty good and the price of leisure, which is given by the OA-line. In the optimum, the tax on the dirty good is therefore given by the vertical distance between the OA-line and the O'A'-line. Figure 1 shows that the optimal tax rate on the dirty good will decrease according to this definition as the marginal cost of public funds increases. A more cautious interpretation of the Bovenberg and de Mooij (1994) result is that adding a tax rate to the existing tax system OA, which is marginally smaller than the Pigovian tax t_P, is always better than adding the Pigovian tax (which would be indicated by a point on the line O'C'). Hence, the scope for environmental policy is smaller compared to the scope in a first-best world because, due to distortionary taxation, the environmental quality is already closer to the second-best optimum than the laissez-faire situation in a non-distorted economy.[7]

For the commodity tax system, however, the optimal tax rate t_D indicates the *total* wedge between the price of the dirty good and the price of leisure which is represented in Figure 1 as the difference between the O'A'-line and the abscissa, i.e. the distance BE. This tax rate explicitly covers the Ramsey component, i.e. the vertical distance between the OA-line and the abscissa. According to this definition, a tax rate which exceeds the Pigovian tax turns out to be optimal as long as the O'A'-line is upward sloping: The O'A' line is strictly above the dotted horizontal line of the Pigovian tax (O'C). From this definition we learn that the total tax borne by the dirty good (in units of leisure) should be higher than the Pigovian tax.

5. Conclusions

We have chosen two different normalizations for the optimal tax structure in order to construct two reference tax systems, namely a tax system with labour taxes and a pure commodity tax system. It is seen that the difference of the first-best and second-best optimal tax on the polluting good depends on the normalization chosen. Therefore, we have to conclude that such a comparison provides an inappropriate indicator for the existence of a second dividend.[8] This becomes even clearer if we consider other possible normalizations.

---

[7] As was pointed out by one referee, by interpreting the environment as a public good, this result restates the modified Samuelson rule (cf. Atkinson and Stern 1974). This rule shows that it is optimal to provide less of the public good than in a first-best world if the marginal cost of funds exceeds unity. Parry (1995) estimates the additional wedge to be between 63% and 78% of the marginal environmental damage.

[8] A second dividend in the strong form can occur only if increasing the tax on the dirty good is welfare improving even if there are no externalities present. Hence, only a comparison of the actual tax rates - in the case of the dirty good: the actual tax rate minus the environmental component -with the second-best optimal Ramsey components may be used as an indicator for a positive second dividend.

For example, we can normalize the sum of consumer prices to unity or even normalize the tax on the dirty good to zero.[9] In each case we get different looking answers on what should be the optimal tax on the polluting good.

Real tax systems consist of both income taxes and commodity taxes like value added taxes and excise taxes. In particular, goods with already high excise taxes as fuel are considered to be good candidates for imposing additional green taxes. Given that the tax system was optimized with respect to minimizing the excess burden of public revenues, we know from our analysis that additional green taxes should be lower than the marginal environmental damage. However, this should be not confused with comparing the nominal fuel tax with the marginal environmental damage which equals the first-best Pigovian tax.

Appendix

The separability and homogeneity assumptions made by Bovenberg and de Mooij (1994) imply that the Ramsey component has to be identically zero, i.e. $t_D^R = 0$ in eq. (7).

Proof: For the nominator of the Ramsey component we have $(Ds_{LL} + Ls_{LD}) = LD\left[(1-t_L)s_{LL}/L - (1-t_L)s_{DL}/D\right]/(1-t_L) = LD(\varepsilon_{LL}^c - \varepsilon_{DL}^c)/(1-t_L)$, whereby ε_{ij}^c denotes the compensated (cross-)price elasticities (note that $s_{LD} = -s_{DL}$). From the homogeneity condition we also know that $\varepsilon_{VV}^c + \varepsilon_{VC}^c + \varepsilon_{VD}^c = 0$ (cf. e.g. Deaton and Muellbauer 1980, p 62). Using the following condition for the compensated labour supply elasticity, $-(V/L)\varepsilon_{VV}^c = \varepsilon_{LL}^c$, and substituting into the former equation we have:

$$(Ds_{LL} + Ls_{LD}) = -LD\left(\frac{V}{L}\varepsilon_{VV}^c + \varepsilon_{DL}^c\right)/(1-t_L) = VD\left(\varepsilon_{VC}^c + \varepsilon_{VD}^c - \frac{L}{V}\varepsilon_{DL}^c\right)/(1-t_L).$$

Sandmo (1974, p. 705) shows that separability between leisure and consumption goods and homogeneity in consumption goods implies $\varepsilon_{DV}^c = \varepsilon_{DL}^c = \alpha V(1-t_L)$, $\varepsilon_{VI}^c = \alpha I(1+t_I)$ (whereby $\alpha = \beta / V$ in his notation). Substituting in yields

$$(Ds_{LL} + Ls_{LD}) = \frac{-VD}{(1-t_L)}\alpha\left[(C(1+t_C) + D(1+t_D) - L(1-t_L)\right]$$

Comparing the term in square brackets with eq. (1) shows that this term is identically zero. Hence, $t_D^R = 0$.

[9] Cf. Fullerton (1996), who independently derives very similar conclusions than those presented in this paper.

For a commodity tax system the separability and homogeneity assumptions guarantee uniform commodity taxes to be optimal in the absence of externalities [cf. Sandmo 1974)]. Ramsey components are thus equal if consumer prices are equal, as assumed here.

References

Auerbach Alan J. (1985): "The Theory of Excess Burden and Optimal Taxation, " in Alan J. Auerbach and Martin Feldstein (eds.): *Handbook of Public Economics I*, 61-127.

Atkinson, Anthony B. and Nicolas H. Stern (1974): "Pigou, Taxation and Public Goods," *Review of Economic Studies* 41, 119-128.

Bovenberg, A. Lans and Ruud A. de Mooij (1994): "Environmental Levies and Distortionary Taxation," *American Economic Review* 84, 1085-1089.

Deaton, Angus and John Muellbauer (1980): *Economics of Consumer Behavior*, Cambridge University Press: Cambridge.

Diamond, Peter A. (1975): "A Many-Person Ramsey Tax Rule," *Journal of Public Economics* 4, 335-342.

Dixit, Avinash K. and Knud Jørgen Munk (1977): "Welfare Effects of Tax and Price Changes: A Correction," *Journal of Public Economics* 8, 103-107.

Fullerton, Don (1996): *Second Best Pollution Taxes*, NBER Discussion Paper No. 5511, March.

Goulder, Lawrence H. (1995): "Environmental Taxation and the "Double Dividend:" A Reader's Guide," *International Tax and Public Finance* 2, 157-184.

Lee, Dwight R. and Walter S. Misiolek (1986): "Substituting Pollution Taxation for General Taxation: Some Implications for Efficiency in Pollution Taxation," *Journal of Environmental Economics and Management* 13, 338-347.

Nichols, Albert L. (1984): *Targeting Economic Incentives for Environmental Protection*, MIT-Press: Cambridge Mass. and London.

Oates, Wallace E. (1993): "Polluting Charges as a Source of Public Revenues," in Herbert Giersch (Eds.): *Economic Progress and Environmental Concerns*, Springer: Berlin, 135-152.

Parry, Ian W. H. (1995): "Pollution Taxes and Revenue Recycling," *Journal of Environmental Economics and Management* 29, S64-S77.

Pearce, David W. (1991): "The Role of Carbon Taxes in Adjusting to Global Warming," *Economic Journal* 101, 938-948.

Sandmo, Agnar (1974): "A Note on the Structure of Optimal Taxation," *American Economic Review* 64, 701-706.

Sandmo, Agnar (1975): "Optimal Taxation in the Presence of Externalities," *Swedish Journal of Economics* 77, 86-98.

Schöb, Ronnie (1994): *Environmental Levies and Distortionary Taxation: Environmental View vs. Public Finance View, Department of Economics,* University of Essex, Discussion Paper Series No. 436, November.

Terkla, David (1984): "The Efficiency Value of Effluent Tax Revenues," *Journal of Environmental Economics and Management* 11, 107-123.

Tullock, Gordon (1967): "Excess Benefit," *Water Resources Research* 3, 643-644.