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ALLEVIATING UNEMPLOYMENT: THE CASE FOR GREEN TAX REFORMS

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Abstract

It has been argued recently that imposing taxes on pollution produces additional tax revenues which can then be used to replace labour taxes and thus reap a double dividend in the form of improving environmental quality and alleviating unemployment. This paper analyses the employment effects of revenue-neutral green tax reforms by focusing on the revenue recycling effect on employment. Our model contains three features which are important when looking at the employment effects of green tax reforms: first, there is unemployment in equilibrium, second, wages are determined endogenously and third, various institutional arrangements for taxing unemployment benefits, for the price-indexation of unemployment benefits, and for personal tax allowances are considered. The employment effects of a revenue-neutral green tax reform are sensitive to institutional arrangements concerning taxation and indexation of unemployment benefits and personal tax allowances. A revenue-neutral green tax reform will boost employment if unemployment benefits are untaxed and nominally fixed. Employment actually falls if unemployment benefits are taxed and price indexed. When employment changes, the functional distribution of income also changes. Total private income, after-tax profits, and after-tax labour income increase with employment while transfer income decreases. If the polluting good is normal, a positive employment effect reduces the environmental dividend obtained from a revenue-neutral green tax reform.

Keywords: Environmental tax reform, tax shifting, equilibrium unemployment, trade union behaviour, wage bargaining, unemployment benefit taxation, indexation

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1. Introduction

Fighting unemployment has been at the top of the political agenda for the last decade. Europe suffers from persistently high levels of unemployment. In the third quarter of 1995, the unemployment rates in the European Union were between 6.4 % in the Netherlands and 22.8 % in Spain, with an average unemployment rate for the EU member countries of 11.0 %.[1] As well as other factors which are made responsible for the high unemployment, such as the mismatch of skills and the shortfall in demand, it is frequently claimed that the government's interventions in the labour market also significantly contribute to unemployment. High taxes on labour income combined with high levels of unemployment benefits distort labour supply and increase wage pressure in the wage negotiations between unions and employer organizations. Indeed, there is lot of empirical evidence showing that taxes have significant effects on unemployment. Surveying the empirical literature on this issue, a recent OECD (1995) study on taxation, employment and unemployment concludes:

> "Evidence that taxes on labour increase wage pressure and thereby increase unemployment (at least in the short-run) is, with some exceptions, reasonably convincing and in some countries, the increase in the tax wedge may have accounted for a significant proportion of the increase in unemployment." (OECD 1995, p. 68)

It is now widely accepted in the political discussion that reducing the share of the tax burden borne by labour is a necessary policy measure for boosting employment. One possibility for lowering taxes is to reduce the size of the public sector. The other possibility is to shift the tax burden away from labour. One popular proposal for this is to increase consumption taxes as these taxes are also paid by other income groups. This will partly reduce the tax burden borne by labour while leaving the overall tax burden constant.

Another possibility is to shift the tax burden to environmentally damaging behaviour. For the last two decades environmental problems have ranked high on the political agenda and

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[1] These are standardized unemployment rates in the definition of the OECD, cf. Main Economic Indicators, February 1996, p. 22.

the introduction of green taxes to fight pollution has become quite popular. It is therefore no great surprise that it has become politically very appealing to combine the two policy issues. Imposing taxes on pollution raises additional tax revenues which can be used to replace labour taxes and thus reap a double dividend in the form of improving the environmental quality and alleviating unemployment.

In the literature, however, we observe widespread pessimism about whether there is a double dividend. Bovenberg and de Mooij (1994) and Bovenberg and van der Ploeg (1994a) show that normally we can expect labour supply to fall as a result of a green tax reform. These authors develop their arguments using a model with market clearing in the labour market. With full-employment, however, the reduction of labour supply only indicates the willingness of society to produce fewer consumption goods in order to enjoy better environmental quality. The decrease in labour supply is always welfare improving.[2]

However, there are also some papers which find positive employment effects. Bovenberg and van der Ploeg (1994b) show, in a model with production externalities, that if nominal net wages are fixed and green taxes are low initially, and if substitution between labour and resources within the production sector is easy, employment may increase. The shortcoming of their approach is, however, that the labour market is not modelled explicitly, and that both labour taxes and green taxes are assumed to be fully borne by the production sector.

Only recently have first attempts been made to consider green tax reforms within models which allow for unemployment in equilibrium and for endogenous wage setting. Schneider (1995) shows, within an efficiency wage model, that employment may increase due to an increase in green taxes. Nielsen, Pedersen and Sörensen (1995) choose a monopoly union labour model where production externalities are present. In their model, however, marginal tax revenues of green taxes are always zero. Employment effects therefore only

[2] For surveys of the literature on the double dividend hypothesis, see e.g. Goulder (1995) and, with particular focus on the employment effects, Bovenberg (1995).

result from changes in the provision of public goods and not because additional tax revenues are used to cut back labour taxes. Bovenberg and van der Ploeg (1995) look at the effects of revenue-neutral environmental tax reforms on wage formation, employment and environmental quality within a search theoretic framework where unemployment is caused by hiring costs. If an energy tax is levied on the polluting factor of production, these authors show that under certain conditions a revenue-neutral cut in labour taxes may boost employment. This will be the case only if the green tax reform succeeds in shifting the tax burden away from labour income to transfer income. Their result is driven by the reduction in labour productivity due to a reduced input of the complementary polluting factor.

This paper considers the introduction of green taxes in a model with endogenous wage determination. The main focus is on the impact the revenue recycling effect has on employment. Two different types of *revenue-neutral green reforms* are considered: i) a rebate of green tax revenues via a reduction in labour taxes and ii) a rebate via an increase in personal tax allowances. Using a 'right-to-manage' approach, we model the wage negotiations between trade unions and employer organizations and analyse the effects tax rate changes and changes in the personal tax allowances have on wage negotiations. This is an appropriate framework for analysing tax reforms if wage negotiations are centralized as it is the case in the European Union (cf. Layard, Nickell and Jackmann 1991 pp. 517f).

Our model contains three important features. Firstly, there is involuntary unemployment in equilibrium. Secondly, wages are determined endogenously. Thirdly, we explicitly distinguish between various institutional arrangements concerning the taxation of unemployment benefits, price-indexation of unemployment benefits, and personal tax allowances. It will be shown that these institutional features, which have been largely neglected both in the literature on tax reform and in the trade union literature, are crucial in terms of how green tax reforms actually work.

The paper is organized as follows. Section 2 gives a brief sketch of the institutional arrangements for unemployment benefits regulations and personal tax allowances in the EU

member states. It also presents the basic model and provides comparative statics of the tax parameters for various institutional arrangements. In section 3 the implications of a revenue-neutral green tax reform, which increases the tax rate on the dirty good and reduces the income tax accordingly, is analysed. Section 4 in turn develops the consequences of increasing personal tax allowances and financing them by increasing the tax on the dirty good. Section 5 considers the changes in the nominal after-tax income and its various components and analyses the environmental effects associated with a green tax reform. Some welfare considerations are also pointed out. Finally, there is a brief concluding section.

2. Model structure

The economy consists of H households split into two groups. There are N worker whose incomes depend on labour income or public transfers only and M shareholder whose income consist of profits only. The household's utility depends on leisure, the consumption of a clean good C, the consumption of a dirty good D, and the environmental quality E, which depends negatively on the consumption of the dirty good, i.e. $E(D)$, $E'<0$. It is further assumed that each worker supplies one unit of labour inelastically if she is employed, or zero labour if unemployed. Hence, leisure is fixed and can be suppressed in the utility function. By assuming separability between pollution and private consumption, the preferences can be described by a twice continuously differentiable, strictly quasi-concave utility function

$$u^h = \tilde{u}(C^h, D^h) + v(E). \tag{1}$$

A worker's income consists of labour income if she is employed, $Y^h = Y^l$, and of unemployment benefits if she is unemployed, $Y^h = Y^{u-t}$. The income of a shareholder consists of profits only, $Y^h = Y^m$.[3] As the actual labour supply of each worker household is determined by both wage bargaining and the subsequent decisions of firms, from the viewpoint of a single

[3] A precise definition of the household's income will be given in section 3.

worker household, total income Y is exogenously given. Apart from labour taxes (cf. section 2.2) the government may impose a so-called green tax t_D on the dirty good. Choosing the quantities of both commodities so that all producer prices are equal to unity, the household's budget constraint is given by

$$C^h + (1+t_D)D^h = Y^h. \tag{2}$$

To solve for the household maximum we assume that the elasticity of substitution between the clean and the dirty good is positive and less than infinity. The uncompensated demands are $C^h = C^h(t_D, Y^h)$ and $D^h = D^h(t_D, Y^h)$ and the corresponding Slutsky decompositions $C_{t_D} = C^c_{t_D} - DC_Y$ and $D_{t_D} = D^c_{t_D} - DD_Y$, where $C^c_{t_D} > 0$ and $D^c_{t_D} < 0$ denote the compensated price effects and D_y and C_y the marginal income effects, respectively. which can be obtained as a solution to the dual problem:

$$\begin{aligned} &\min_{C,D} \left[C + (1+t_D)D\right] \\ &s.t. \\ &\tilde{u}(C,D) = \bar{\tilde{u}} \end{aligned} \tag{3}$$

This gives the expenditure function $H(P, \tilde{u})$ where the price index P associated with the composite commodity is implicitly defined by the expenditure function. The partial derivative of the domestic price level with respect to the tax on the dirty good is assumed to be positive, i.e.

$$P_{t_D} > 0. \tag{4}$$

Thus the domestic consumer price level is higher the higher the tax on the dirty good. This assumption holds if the elasticity of substitution between the clean and the dirty goods is finite.[4]

[4] If preferences are given by a CES utility function, then $P_{t_D} = \left[1 + (1+t_D)^{1-\sigma}\right]^{\frac{\sigma}{1-\sigma}} (1+t_D)^{-\sigma}$ where σ is the elasticity of substitution between the clean good and the dirty good. It is easy to see that $P_{t_D} > 0$ if $\sigma < +\infty$.

2.1 *Firm behaviour*

Firms produces output Q with labour as the only input, $Q = f(L)$. As they consider the wage rate and producer prices (normalized to unity) as given, they maximize profit with respect to labour input. The profit maximization of the firms,

$$\max_{l} \pi = Q(L) - wL, \tag{5}$$

which, with a strict concave revenue function, yields the labour demand function $L = L(w)$ with $L_w < 0$ and the output supply function $Q = Q(w)$ with $Q_w < 0$. In what follows we assume that the wage elasticity of labour demand $\delta = -wL_w / L$ is constant and exceeds unity.[5]

2.2 *Trade union objective function*

The objective of the trade union is to maximize its members' real income. This consists of the *real after-tax wage income* and the *real unemployment benefits*. Each household is either employed supplying one unit of labour or is unemployed. In the latter case the household is entitled to unemployment benefits. As the actual form of the objective function depends on the various institutional arrangements, it is worthwhile discussing the variables which determine the trade union behaviour briefly in the next subsections before modelling the labour market completely.

Labour income

The real after-tax wage depends on the nominal wage rate w, which is determined by the union, the income tax t_L and the personal tax allowance a, or alternatively a tax credit,[6] which is granted to each tax payer. Thus nominal after-tax wage can be written as

[5] For instance, $f(L) = AL^{\gamma}$ has this property. We have $\delta = (1-\gamma)^{-1} > 1$ if $0 < \gamma < 1$ in the case of a strictly concave revenue function.

[6] As the qualitative results do not change if we consider personal tax allowances or a tax credit, we do not analyse the two cases separately.

$w - t_L(w-a) = w(1-t_L) + t_L a$. The personal tax allowance a may be either nominally fixed or price indexed.[7] Hence, we have to distinguish two types of real labour income which depend on the institutional design of personal tax allowances. In the case of nominally fixed personal tax allowances, net real wage $\tilde{w}$ is given by:

$$\tilde{w} = \frac{w(1-t_L) + t_L a}{P}.$$

If the personal tax allowance is price indexed, net real wage equals

$$\tilde{w} = \frac{w(1-t_L) + t_L aP}{P}.$$

Column 3 of table 1shows the institutional arrangements for the 15 EU countries.

Unemployment benefits

In Europe, we can distinguish three types of unemployment benefits.[8] Most countries have introduced unemployment insurance where unemployment benefits are related to past contributions.. Usually, unemployment insurance payments are limited to a certain maximum time period of unemployment. Either unemployment assistance or some type of guaranteed minimum income then replaces insurance payments. With rare exceptions (e.g. Germany), these unemployment assistance payments are not related to the previous earnings of an unemployed person. There may either be a fixed amount or the amount may increase with the inflation rate.

Normally, unemployment insurance is linked to previous *gross* earnings. An exception is Germany where unemployment benefits are linked to previous *net* earnings. Payments may

[7] Price indexation may be institutionalized as e.g. in Belgium. It may also be the case that the government increases the tax allowances on a regular basis according to the preceding inflation rate as in the U.K.

[8] We focus here on unemployment benefits only. Depending on the availability and attractiveness of other social security contributions like early retirement or invalidity benefits, these may be substitutes for unemployment benefits for individuals who become unemployed. In this case, the trade union has to take account of these substitutes and the frequency with which these alternative benefits are used by the unemployed or the government to hide unemployment in the unemployment statistics. For a survey, see Blöndal and Pearson (1995).

Table 1: Unemployment benefit and tax allowance regulations in the EU

Country	Unemployment benefit rules	Personal tax allowance, tax credit
Austria	a) linear indefinite b) taxable	Tax credit
Belgium	a) proportional indefinite b) taxable	Personal tax allowance, price indexed
Denmark	a) proportional 36/48 months; then fixed b) taxable	Tax credit[1]
Finland	a) linear 24 months; then fixed b) taxable	Personal tax allowance, price indexed
France	a) linear 4-60 months; then fixed b) taxable, unemployment tax allowance	Personal tax allowance
Germany	a) proportional indefinite b) non-taxable[1]	Personal tax allowance, nominally fixed
Greece	a) proportional 5-12 months b) taxable	Personal tax allowance
Ireland	a) linear 15 months; then fixed b) non-taxable	Personal tax allowance
Italy	a) proportional 6 months b) taxable, unemployment tax allowance	No personal tax allowance
Netherlands	a) proportional 9-54 months; then fixed 12 month b) taxable	Personal tax allowance
Portugal	a) proportional 10-30 months;[2] then fixed 5-15 months b) non-taxable	Tax credit
Sweden	a) proportional 60 weeks; then fixed b) taxable	Personal tax allowance
Spain	a) proportional 24 months, then fixed b) taxable	Personal tax allowance
United Kingdom	a) fixed, but regularly adjusted b) taxable	Personal tax allowance fixed, but regularly adjusted

Sources: OECD (1991): Employment Outlook 1991, tables 7.2 and 7.3.; MISSOC (1995), Soziale Sicherheit in den Mitgliedstaaten der Europäischen Union, chapters 4,11 and 12; International Bureau of Fiscal Documentation (1994): European Tax Handbook 1995; Layard, Nickell and Jackman (1991).
Legend: Unemployment benefits: a) linear: unemployment benefits increase linearly with gross earnings; proportional: unemployment benefits increase proportionately with gross earnings; fixed: unemployment benefits are fixed; b) Unemployment benefits are subject to income taxation (taxable) or not (non-taxable); Tax allowances: Comments: [1)] Benefits are paid proportional to earnings after tax and social security contributions. I.e., as taxes changes so does the unemployment benefit; [2)] Duration depending on age; [3)] The tax value of the personal allowance is deducted from the amount of tax, i.e. in effect it is a tax credit.

be proportional to earnings as in e.g. Belgium and Germany, or may increase linearly with previous earnings, starting from a minimum compensation, as e.g. in Austria and France. Unemployment benefits may also be subject to income taxation as in the Benelux countries or the UK - in this case we have to consider the personal tax allowance for the unemployed as well - or may be exempted from taxation as in Germany or Portugal.

As we are interested in price changes and changes in the wage rate, we have to be careful about how price and wage changes interfere with the unemployment benefit payments. In what follows we assume that unemployment benefits b are always determined by the wage rate and the income tax that prevails before a tax reform takes place. Hence, unemployment benefits have the form $b = \alpha w^0$ if they are proportional to previous gross earnings w^0 and $b = \alpha w^0(1-t_L^0)$ if they are proportional to previous net earnings $w^0(1-t_L^0)$.

Hence, the real net unemployment benefit $\tilde{b}$ a household receives may take four different forms, assuming nominally fixed tax exemptions.[9] If unemployment benefits are nominally fixed and untaxed we have

$$\tilde{b} = \frac{b}{P}.$$

If they are taxed, we have

$$\tilde{b} = \frac{b(1-t_L)+t_L a}{P}.$$

If unemployment benefits are price indexed we have to distinguish between

$$\tilde{b} = b$$

and

$$\tilde{b} = \frac{Pb(1-t_L)+t_L a}{P},$$

[9] If unemployment benefits are subject to income taxes, each household is eligible for a personal tax allowance or a tax credit. Therefore, this personal allowance can be considered as a lump-sum component of a household's income.

where the latter case assumes that the personal tax allowance is nominally fixed. Column 2 of Table 1 summarizes the institutional regulations for the 15 EU countries with respect to unemployment benefit payments.

Having analysed the different real income components that the trade union takes into account, we can specify the objective function of the trade union. Utilitarian trade unions are trying to maximize the real income of all N members. Each member is either employed and receives the real net wage $\tilde{w}$ or unemployed and receives real net unemployment benefits $\tilde{b}$. Hence, the objective function of the trade union can be written as[10]

$$\tilde{V} = (\tilde{w} - \tilde{b})L + \tilde{b}N \tag{6}$$

Within the bargaining process, the fall-back position of the trade union is given by

$$V^0 = \tilde{b}N, \tag{7}$$

i.e. all members remain at their reservation wage. Defining $V = \tilde{V} - V^0$ as the objective function for the Nash bargaining, we can distinguish 6 different objective functions for the trade union, depending on the institutional arrangements. These cases are summarized in table 2 below. If unemployment benefits are untaxed we can distinguish four cases depending on whether

- unemployment benefits are nominally fixed (cases A and B) or price indexed (cases C and D);
- personal allowances are nominally fixed (cases A and C) or price indexed (cases B and D).

If unemployment benefits are subject to taxation we only have to distinguish between the case of nominally fixed unemployment benefits (case E) and price indexed unemployment benefits (case F). Thus it does not matter whether the personal tax allowances are nominally fixed or price indexed.

[10] The use of a linear objective function is for analytical convenience. It is often claimed that trade unions do not care about the level of employment if lay offs follow an inverse seniority rule. In this case the objective function of the trade union would reduce to $\tilde{V} = \tilde{w}$ (cf. Oswald 1993).

2.3 Wage negotiations between trade unions and employer organizations

Usually, wages are determined in a bargain between trade unions and employer organizations. Then firms unilaterally determine employment. In what follows we use a 'right-to manage' model which represents the outcome of the bargaining by an asymmetric Nash bargaining with β representing the power of the trade union.[11] Assuming that the threat point of the employer organization is zero, the Nash bargaining maximand can be written as

$$\Omega = (\tilde{V} - V^0)^{\beta} \pi^{1-\beta}, \tag{8}$$

where the objective functions are defined by equations (5) to (7). Note that for $\beta = 1$ the model reduces to the case of a monopoly union (cf. Oswald 1985 or Creedy and McDonald 1991). Using $V = \tilde{V} - V^0$, the first-order condition with respect to nominal wage is

$$\Omega_w = 0 \;\Leftrightarrow\; \beta \frac{V_w}{V} + (1-\beta)\frac{\pi_w}{\pi} = 0, \tag{9}$$

where variables with subscripts refer to partial derivatives (e.g. $V_w = \partial V / \partial w$). Provided that $\Omega_{ww} < 0$, equation (9) defines the optimal nominal wage from Nash bargaining as a function of t_L, a, b, and t_D so that $w^* = w^*(t_L, a, b, t_D)$. All these parameters affect equation (9) only via the first term of the right hand side so that for parameter $\Psi = t_L, a, b, t_D$

$$\operatorname{sign}(w^*_{\Psi}) = \operatorname{sign}(\Omega_{w\Psi}) = \operatorname{sign}(VV_{w\Psi} - V_w V_{\Psi}). \tag{10}$$

The calculations for the comparative statics, presented in table 2 are given in Appendix 1.

[11] This approach can be justified either axiomatically (cf. Nash 1950), or strategically (cf. Binmore, Rubinstein and Wolinski 1986).

Table 2: Comparative statics of the nominal wage rate with Nash bargaining

	Unemployment benefits are untaxed and nominally fixed	Unemployment benefits are untaxed and price indexed	Unemployment benefits are taxed, personal tax allowance is nominally fixed	
	Case A: Personal tax allowance is nominally fixed **Case B: Personal tax allowance is price indexed**	**Case C: Personal tax allowance is nominally fixed** **Case D: Personal tax allowance is price indexed**	**Case E** **Unemployment benefits are nominally fixed**	**Case F** **Unemployment benefits are price indexed**
Objective function for the trade union V (6-I)	A: $\frac{1}{P}[(1-t_L)w+t_La-b]L$ B: $\frac{1}{P}[(1-t_L)w+t_LaP-b]L$	C: $\frac{1}{P}[(1-t_L)w+t_La-bP]L$ D: $\frac{1}{P}[(1-t_L)w+(t_La-b)P]L$	$\frac{1}{P}(1-t_L)(w-b)L$	$\frac{1}{P}(1-t_L)(w-bP)L$
$w^{\bullet}_{t_L}$ (11-I)	$w^{\bullet}_{t_L} > 0$	$w^{\bullet}_{t_L} > 0$	$w^{\bullet}_{t_L} = 0$	$w^{\bullet}_{t_L} = 0$
$w^{\bullet}_{t_D}$ (12-I)	(12-A) $w^{\bullet}_{t_D} = 0$ (12-B) $w^{\bullet}_{t_D} < 0$	$w^{\bullet}_{t_D} > 0$	$w^{\bullet}_{t_D} = 0$	$w^{\bullet}_{t_D} > 0$
$w^{\bullet}_{a}$ (13-I)	$w^{\bullet}_{a} < 0$	$w^{\bullet}_{a} < 0$	$w^{\bullet}_{a} = 0$	$w^{\bullet}_{a} = 0$
$w^{\bullet}_{b}$ (14-I)	$w^{\bullet}_{b} > 0$	$w^{\bullet}_{b} > 0$	$w^{\bullet}_{b} > 0$	$w^{\bullet}_{b} > 0$

Comparative statics

In what follows we consider how the negotiated nominal wage reacts to changes in taxes, the unemployment benefit, and the personal tax allowance. The trade union tries to maximize the rent, i.e. the surplus of real wages over real unemployment benefits. The maximum is obtained when the marginal real after-tax wage income for the trade union (!) equals the net real unemployment benefits. A change of the labour tax will lead to an increase in the nominal wage:

$$w^{\bullet}_{t_L} > 0. \tag{11-A}$$

If labour taxes increase, the after-tax wage income decreases while unemployment benefit remains constant. It becomes profitable for the trade union to bargain for a higher nominal wage because the possible increase in labour income of those employed more than outweighs the income loss of those workers who are laid off.

This, however, is only true in the case of untaxed unemployment benefits. If unemployment benefits are subject to taxes, as in cases E and F, marginal net real wage income for the trade union and the net real unemployment benefits change by the same amount when the labour tax rate changes leaving the first order condition of the bargaining solution unchanged. The labour tax rate has no effect on the optimal nominal wage.

An increase in the personal tax allowance a reduces the optimal nominal wage in cases A-D:

$$w^{\bullet}_{a} < 0. \tag{13-A}$$

Since only employed workers receive the additional benefit of higher tax exemptions, an increase in a can be interpreted as a subsidy on labour. This induces the trade union to accept a lower nominal wage as the marginal worker can now gain more from working than those already employed will lose from the necessary nominal wage reduction.

If unemployment benefits are subject to taxation, then every member of the union can claim the tax exemption. The increase in a is equal to an increase in the lump-sum transfer households receive from the government. This leaves the optimality condition for the bargaining solution unchanged (cases E and F). Formally, both the objective function and the fall back position increase by the same amount.

An increase in the unemployment benefit makes the outside option for the trade union members more attractive and it becomes more profitable to bargain for a higher nominal wage. This distorts labour. For all cases we have $w_b^* > 0$. This is a standard result of the unionized labour market models (cf. Oswald 1985).

Next consider a change in the tax on the dirty good. A higher tax increases the price level – see equation (4) – and therefore influences real wages, real unemployment benefits and so on. If both unemployment benefits and personal allowances are nominally fixed (case A), all relevant variables are devalued by an increase in t_D. The arbitrage calculus of the bargaining solution remains unchanged, i.e.

$$w_{t_D}^* = 0. \qquad (12\text{-A})$$

If, as in case B, personal tax allowances are price indexed, bargaining leads to a reduction in the nominal wage. The reason for this is the fact that the price indexation keeps the personal tax allowances in real terms constant while all other values fall in real terms, as only employed workers are eligible to claim personal tax allowances. The mechanism works in the same way as an increase in nominal personal tax allowances. Hence working becomes more attractive and the trade union will be willing to accept a lower nominal wage.

The result is reversed if unemployment benefits, though untaxed, are price indexed. In this case net real wage income still declines in real terms while real net unemployment benefits remain constant (cases C and D). The interpretation of cases E and F is straightforward.

Comparative statics shows that, with respect to the further analysis of revenue-neutral green tax reforms, three main effects can be identified which are summarized in the following results.

Result 1: A rise in the labour income tax will (i) increase the nominal wage if the unemployment benefits are untaxed, but (ii) will have no effect when unemployment benefits are taxed at the same level as labour income.

Result 2: An increase in the personal tax allowances will (i) decrease the nominal wage if the unemployment benefits are untaxed, but (ii) will have no effect when unemployment benefits are taxed at the same level as labour income.

Result 3: An increase in the tax on the dirty good will (i) increase the nominal wage if the unemployment benefits are price indexed, (ii) lower the nominal wage if the unemployment benefits are nominally fixed and if the personal tax allowance is price indexed, (iii) leave the nominal wage unchanged if unemployment benefits and personal tax allowances are nominally fixed.

Note that our results for the cases E and F are based on the assumption that the reservation wage is taxed at the same level as wage income. If, however, the tax rate on unemployment benefits is lower than the tax on wage income, or if the trade union takes account of the (untaxed) benefits accruing from leisure consumption, we obtain intermediate cases. For example, if both unemployment benefits and personal tax allowances are nominally fixed, we obtain a case in between cases A and E with the qualitative results being the same as in case A.

The results hold even if the trade union is not interested in the level of employment, i.e. if its objective function is given by $\tilde{V} = \tilde{w}$ and hence $V = \tilde{w} - \tilde{b}$ (cf. Appendix 2). As is shown in Oswald (1993), this may represent a trade union's objective function when lay offs will be by inverse seniority within the firm.

As indicated earlier, the monopoly union model can be obtained as a special case by imposing $\beta = 1$. It is easy to show that the monopoly model gives qualitatively the same results as presented in table 2 for the right-to-manage model.

In the next section we will apply the results from the comparative statics to analyse revenue-neutral green tax reforms. Section 3 considers the case where additional revenues from increasing green taxes are recycled by reducing taxes on income. Section 4 will analyse the case where the additional tax revenues are used to increase the personal tax allowances.

3. Revenue-neutral green tax reform I: Reducing the income tax

We now turn to the description of a revenue-neutral green tax reform which increases the tax on the dirty good and reduces the income tax correspondingly. Here, we focus on the case where we have a comprehensive income tax with a single tax rate, i.e. labour income and profits are taxed at the same rate t_L. To obtain the aggregate income we have to add the income of the N worker households, which are either employed or unemployed, and of the M shareholder households. Defining aggregate after-tax income as $Y \equiv \sum_{h=1} Y^h, H = N + M$, private aggregate income in case A is given by

$$Y = (1 - t_L)(wL + \pi) + t_L a(M + L) + b(N - L). \tag{15-A}$$

Notice that the aggregate income of the M shareholder households equals total profits π and that only M shareholder households and L worker households who are employed are eligible for personal tax allowances. Substituting in the definition of profits $\pi = Q - wL$, cf. equation (5), from the viewpoint of the government, the private sector's nominal income is given by:

$$Y = (1 - t_L)Q + t_L a(M + L) + b(N - L). \tag{16-A}$$

Hence, private income is a function of t_L, w and L.

Given a certain amount of public good G, the government budget is now given by:

$$G = t_L(Q - a(M + L)) + t_D D - b(N - L), \tag{17-A}$$

where $D \equiv \sum_{h=1}^{H} D^h$ defines the aggregate consumption of the dirty good. A revenue-neutral green tax reform is then described by

$$\begin{aligned} dG = &\left[Q - a(M + L) + t_D D_{t_L}\right] dt_L + \left[D + t_D D_{t_D}\right] dt_D \\ &+ \left[(t_L Q_L + b - t_L a) L_w + t_D D_w\right] dw = 0. \end{aligned} \tag{18-A}$$

where dw is determined by the reaction of the Nash bargaining solution to the tax rate changes. From the analysis of wage negotiation we know that the reaction of the nominal wage to a green tax reform is given by

$$dw = w^*_{t_L} dt_L + w^*_{t_D} dt_D. \tag{19}$$

Substituting the RHS of (19) into (18) yields

$$\begin{aligned} dG = &\left[Q - a(M + L) + t_D(D_{t_L} + D_w w^*_{t_L}) + (t_L Q_L + b - t_L a) L_w w^*_{t_L}\right] dt_L \\ &+ \left[D + t_D(D_{t_D} + D_w w^*_{t_D}) + (t_L Q_L + b - t_L a) L_w w^*_{t_D}\right] dt_D \\ \equiv &\frac{\partial G}{\partial t_L} dt_L + \frac{\partial G}{\partial t_D} dt_D = 0. \end{aligned} \tag{20-A}$$

Here $\partial G/\partial t_L$ and $\partial G/\partial t_D$ denote the marginal tax revenues from the income tax and the tax on the dirty good, respectively. Assuming that we are on the Laffer-efficient side of both tax revenue curves is equivalent to assuming that the marginal tax revenues of each tax are positive, i.e.

$$\frac{\partial G}{\partial t_L} > 0, \quad \frac{\partial G}{\partial t_D} > 0. \tag{21}$$

While the first condition is quite reasonable as labour taxes are imposed in order to raise tax revenues, we should point out that the second effect might be negative because green taxes are also imposed in order to improve the environment. If the environmental damage caused by the consumption of the dirty good is high, the government may be forced to levy such a high green tax that marginal tax revenues may actually become negative. Using conditions (21), however, we have for a revenue-neutral green tax reform:

$$\text{sign}(dt_L) = -\text{sign}(dt_D). \tag{22}$$

Table 3:
Employment effects of a revenue-neutral green tax reform which reduces the income tax rate

Case	Changes in nominal wage	Employment effect
A	$dw = \underset{+}{w^{\bullet}_{t_L}}\ \underset{-}{dt_L} < 0$	$dL > 0$
B	$dw = \underset{+}{w^{\bullet}_{t_L}}\ \underset{-}{dt_L} + \underset{-}{w^{\bullet}_{t_D}}\ \underset{+}{dt_D} < 0$	$dL > 0$
C, D	$dw = \underset{+}{w^{\bullet}_{t_L}}\ \underset{-}{dt_L} + \underset{+}{w^{\bullet}_{t_D}}\ \underset{+}{dt_D} \left\{ \begin{matrix} > \\ 0 \\ < \end{matrix} \right\} 0$	?
E	$dw = 0$	$dL = 0$
F	$dw = \underset{+}{w^{\bullet}_{t_D}}\ \underset{+}{dt_D} > 0$	$dL < 0$

From (22) we can now easily derive the employment effects of the cases A, B, E and F. Further work, however, has to be done for cases C and D in order to determine the employment effect of a revenue-neutral green tax reform. Table 3 summarizes the results. For cases A and B this leads to our first result.

PROPOSITION 1: A revenue-neutral green tax reform, which reduces the income tax rate, will increase employment if unemployment benefits are untaxed and nominally fixed.

Due to the reduction in labour taxes, net wage income increases while net unemployment benefit remains constant. Hence it becomes profitable for the trade union to bargain for a lower nominal wage because the loss in wage income for all workers is more than outweighed by the gain from hiring more workers. If both unemployment benefits and personal tax allowances are nominally fixed (case A), all relevant variables are devalued by an increase in t_D. The arbitrage calculus of the bargaining solution remains unchanged due to change in t_D. Hence, there is no countervailing effect in case A. If, as in case B, personal tax allowances are price indexed, an increase in consumer prices devalues real wage and unemployment benefits but the price indexation keeps the real personal tax allowances constant. As only employed worker households are eligible to claim personal tax allowances, working becomes more attractive and the union will be in favour of more employment. According to table 1 only Germany and Portugal fall into categories A and B. In these countries we can therefore expect a reduction in unemployment due to revenue-neutral green tax reforms.

The results change drastically if unemployment benefits are taxed as in cases E and F. Proposition 2 summarizes the employment effects for these cases.

PROPOSITION 2: A revenue-neutral green tax reform will have no effect on employment if unemployment benefits are taxed and nominally fixed. If unemployment benefits are taxed and price indexed, employment will actually fall.

If unemployment benefits are subject to taxation, the real after-tax wage for the trade union and the real after-tax unemployment benefits change proportionately, leaving the first order conditions for the bargaining solution unchanged. Hence, a tax cut for labour has no effect on the optimal nominal wage or on employment. If unemployment benefits are price indexed, however, the increase in t_D will lower the real wage while real unemployment benefits remain constant. Therefore, the trade union bargains for higher nominal wages. In this case, the

overall effect on employment becomes negative. As table 1 suggests, most countries in Europe belong to the cases E and F. Hence, the hope that reforming the tax systems in the direction of green taxes will boost employment seems to be disappointing in so far as revenue-neutral green tax reforms focus on reducing labour taxes. Note, however, that a country belongs to category E or F only if unemployment benefits are taxed at the same rate as the wage income. If they are taxed at a lower rate, it is easy to see that the same comparative statics result apply as in cases A and B, if unemployment benefits are nominally fixed, and cases C and D, if unemployment benefits are price indexed. It is then the tax rate differential which determines the quantitative maginitudes of the effects considered.

Although no country belongs to the categories C and D according to table 1, these cases may become relevant, if we consider long-term unemployment benefits which are often price indexed as they are determined by the minimum existence level to be sustained.

To derive the employment effect for these cases, we focus on case D. The analysis for case C proceeds in the same way. Aggregate private income is given by

$$Y = (1-t_L)Q + t_L aP(M+L) + bP(N-L). \tag{16-D}$$

Hence, private income is a function of t_L, w, L and, due to the price indexation, of P. The government budget is now given by:

$$G = t_L(Q - aP(M+L)) + t_D D - bP(N-L). \tag{17-D}$$

A revenue-neutral green tax rat reform is then described by

$$\begin{aligned} dG = &\left[Q - aP(M+L) + t_D D_{t_L}\right]dt_L + \left[D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right]\right]dt_D \\ &+ \left[(t_L Q_L + P(b - t_L a))L_w + t_D D_w\right]dw = 0. \end{aligned} \tag{18-D}$$

After some calculations, given in Appendix 3, we obtain the following condition for case D:

$$\left.\frac{dw}{dt_L}\right|_{dG=0} \left\{\begin{matrix} > \\ = \\ < \end{matrix}\right\} 0 \;\Leftrightarrow\; \frac{\varepsilon^{\bullet}_{t_L}}{\varepsilon^{\bullet}_{t_D}} \left\{\begin{matrix} > \\ = \\ < \end{matrix}\right\} \frac{\eta_{t_L}}{\eta_{t_D}}, \tag{23-D}$$

where $\varepsilon^{\bullet}_{t_L} = w^{\bullet}_{t_L} t_L / w^{\bullet}$, $\varepsilon^{\bullet}_{t_D} = w^{\bullet}_{t_D} t_D / w^{\bullet}$ denote the income tax and green tax elasticities of nominal wages, respectively; $\eta_{t_L} = (\partial G / \partial t_L) t_L / G|_{dw=0}$, and $\eta_{t_D} = (\partial G / \partial t_D) t_D / G|_{dw=0}$ denote the income tax and green tax elasticities of tax revenues conditional on a constant nominal wage.

If unemployment benefits are untaxed and price indexed, employment will decrease (increase) because of a revenue-neutral green tax reform if the ratio between the income tax and green tax elasticities of nominal wages is smaller (larger) than the ratio between the income tax and green tax elasticities of the government tax revenues conditional on a constant nominal wage. The reason for these ambiguities lies in the fact that, in the cases C and D, both the income tax and the green tax will have a positive effect on nominal wages and thus a negative effect on employment. The revenue-neutral effects of a change in the tax switch therefore depend upon their relative magnitudes.

4. Revenue-neutral green tax reform II: Increasing the personal tax allowance

For the discussion of a revenue-neutral green tax reform which, instead of reducing labour taxes, increases the personal tax allowances a, we focus again on case A as the analysis of the other cases is very similar. From the government budget constraint (18-A) we can derive the condition for the revenue-neutral green tax reform

$$\begin{aligned} dG = &\left[-t_L(M+L)\right]da + \left[D + t_D D_{t_D}\right]dt_D \\ &+ \left[(t_L Q_L + b - t_L a)L_w + t_D D_w\right]dw = 0, \end{aligned} \tag{24-A}$$

where dw is determined by the reaction of the Nash bargaining solution to the tax rate changes. The change in the nominal wage is given by

$$dw = w_a^{\bullet} da + w_{t_D}^{\bullet} dt_D. \tag{25}$$

Substituting the RHS of (25) into (24-A) yields

$$\begin{aligned} dG = &\left[-t_L(M+L) + (t_L Q_L + b - t_L a) L_w w_a^{\bullet}\right] da \\ &+ \left[D + t_D(D_{t_D} + D_w w_{t_D}^{\bullet}) + (t_L Q_L + b - t_L a) L_w w_{t_D}^{\bullet}\right] dt_D \\ &\equiv \frac{\partial G}{\partial a} da + \frac{\partial G}{\partial t_D} dt_D = 0. \end{aligned} \tag{26-A}$$

$\partial G/\partial a$ and $\partial G/\partial t_D$ now denote the marginal tax revenues from increasing the personal tax allowances and the tax on the dirty good, respectively. The assumption that we are on the Laffer-efficient side of both tax revenue curves implies that the marginal tax revenues of an increase in the personal allowances is negative, while the marginal tax revenue of the tax on the dirty good is positive, i.e.

$$\frac{\partial G}{\partial a} < 0, \quad \frac{\partial G}{\partial t_D} > 0. \tag{27}$$

Using conditions (30) a revenue-neutral green tax reform has the property:

$$\text{sign}(dt_D) = \text{sign}(da). \tag{28}$$

Table 4 summarizes the employment effects for the various institutional arrangements.

As it turns out, for the cases A to B the employment effect is always positive. Furthermore, the employment effect is negative for case F. A comparison with the results derived in section 3 yields proposition 3.

Table 4:
Employment effects of a revenue-neutral green tax reform which increases the personal tax allowance.

Case	Changes in nominal wage	Employment effect
A	$dw = \underset{-}{w_a^{\bullet}} \underset{+}{da} < 0$	$dL > 0$
B	$dw = \underset{-}{w_{t_D}^{\bullet}} \underset{+}{dt_D} + \underset{-}{w_a^{\bullet}} \underset{+}{da} < 0$	$dL > 0$
C, D	$dw = \underset{+}{w_{t_D}^{\bullet}} \underset{+}{dt_D} + \underset{-}{w_a^{\bullet}} \underset{+}{da} \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0$	?
E	$dw = 0$	$dL = 0$
F	$dw = \underset{+}{w_{t_D}^{\bullet}} \underset{+}{dt_D} > 0$	$dL < 0$

PROPOSITION 3: A revenue-neutral green tax reform which increases the personal tax allowance will affect employment qualitatively in the same way as a revenue-neutral green tax reform which reduces the income tax rate.

Though the results are qualitatively the same as in the case of reducing the income tax, they differ quantitatively. To see this, we will split a green tax reform which increases the personal tax allowance into two succeeding tax reforms. First, we increase the green tax and reduce the income tax accordingly. Then, in a second step, we undo the reduction of the income tax and increase the personal tax allowance accordingly. This can be interpreted as an increase in the progressivity of the tax system. As Koskela and Vilmunen (1995) have shown, increasing progressivity in a revenue-neutral way will increase employment in popular models of trade union behaviour including the 'right-to manage' model. In trade union models an increase in progression moderates wages because it acts as a tax on wage increases. This result is not only a theoretical possibility but has also received an increasing amount of supporting empirical

evidence.[12] We can conclude that for cases A-D, employment will be higher for a green tax reform which increases personal tax allowances than for a green tax reform which reduces the income tax. As table 2 shows, however, in the cases E-F a more progressive tax system does not lead to more employment.

COROLLARY 3: A revenue-neutral green tax reform will generally be more successful with respect to reducing unemployment if it rebates green tax revenues via increasing the personal tax allowance instead of reducing labour taxes.

5. Effects on private incomes and the environment

So far we have focused on the employment effects. In this section we first analyse how revenue-neutral green tax reforms affect nominal private income and its distribution over different income groups. Then we will look at the environmental dividend of a green tax reform and discuss briefly the implications for welfare.

5.1 Changes in nominal private income

An easy way to define private income is to take the difference in total output minus the government expenditures which are financed by direct taxes, i.e. income taxes. Hence total private income is given by:

$$Y = Q(L) - G + t_D D. \tag{29}$$

If a green tax reform leaves the wages, and therefore total output $Q(L)$, unchanged, nominal private income will nevertheless increase as the tax burden is shifted from direct taxes to indirect taxes ($t_D D$ increases in the Laffer-efficient area). Hence, we can immediately conclude that, if unemployment does not fall because of a revenue-neutral green tax reform,

[12] For empirical evidence in Italy see Malcomson and Sartor (1987), for the U.K. Loockwood and Manning (1993), and for Sweden Holmlund and Kolm (1995).

nominal private income increases. This, however, does not necessarily imply that the income of all household types – shareholders, worker households and unemployed worker households – increase. Therefore we have to look at the different income groups in more detail.

Starting with the green tax reform I ,which leads to a reduction in income taxes, after-tax profits are given by (assuming nominally fixed personal tax allowances)

$$\hat{\pi} = (1 - t_L)\pi + t_L a M \tag{30}$$

The green tax reform changes after-tax profits in the following way:

$$d\hat{\pi} = (-\pi + aM)dt_L + (1 - t_L)\pi_w dw, \tag{31}$$

where $\pi_w = -L$ and $dw = w^*_{t_L} dt_L + w^*_{t_D} dt_D$, cf. equation (19). As the first term of the right hand side is positive, after-tax profits will always rise if $dw \le 0$. For $dw > 0$, after-tax profits will increase if $dw < -(\pi - aM)dt_L / [(1 - t_L)L]$.

Looking at the nominal income of the worker households, we have to distinguish according to the institutional arrangements. For case A, the after-tax income of an employed worker household is given by

$$Y^L = (1 - t_L)wL + t_L aL. \tag{32-A}$$

The revenue-neutral green tax reform I will change total income of all employed workers by

$$\begin{aligned} dY^L &= -(w - a)Ldt_L + (1 - t_L)L + [(1 - t_L)w + t_L a]L_w dw \\ &= -(w - a)Ldt_L + \left[(1 - t_L)(1 - \delta) - \frac{t_L a}{w}\delta\right]Ldw. \end{aligned} \tag{33-A}$$

As the first term of the right hand side is positive, and with the wage elasticity of labour demand $\delta > 1$, it follows immediately that a reduction in nominal wages will increase total nominal labour income. The nominal wage income per worker, however, increases only if the

tax rate cut more than outweighs the nominal wage reduction. This is the case if $dw > (w-a)dt_L / (1-t_L)$.

Table 5: Changes in nominal after-tax income due to a revenue-neutral green tax reform

Cases	Nominal wage	After-tax Profits	After-tax labour income	Transfer income	Total private income
A, B	$dw < 0$	$dY^M > 0$	$dY^{L} > 0$	$dY^{N-L} < 0$	$dY > 0$
C, D	$dw \begin{cases} > \\ \leq \end{cases} 0$	$\begin{cases} dY^M = ? \\ dY^M > 0 \end{cases}$	$\begin{cases} dY^{L} = ? \\ dY^{L} > 0 \end{cases}$	$\begin{cases} dY^{N-L} > 0 \\ dY^{N-L} = ? \end{cases}$	$\begin{cases} dY = ? \\ dY > 0 \end{cases}$
E	$dw = 0$	$dY^M > 0$	$dY^{L} > 0$	$dY^{N-L} > 0$	$dY > 0$
F	$dw > 0$	$dY^M = ?$	$dY^{L} = ?$	$dY^{N-L} > 0$	$dY = ?$

The nominal transfer income of an unemployed worker household remains constant if unemployment benefits are untaxed and nominally fixed (cases A and C). If unemployment declines, total nominal transfer income declines. If unemployment benefits are price indexed and/or taxed (cases B, D, E, F), nominal transfers per unemployed household increase. For $dw < 0$, total nominal transfer payments then become ambiguous. Note, however, that total nominal income of all worker households increases if $dw < 0$ because the wage elasticity of labour demand exceeds unity. Table 5 summarizes the effects of a revenue-neutral green tax reform of type I. The analysis of the income effects for type II yields similar results and is not presented separately

Employment will rise if the tax reform succeeds in shifting the tax burden away from labour. This will change the functional distribution of income. Total private income, after-tax profits, and labour income all increase while transfer income decreases.[13]

5.2 The environmental dividend

Environmental quality is affected in two ways. First, an increase in the tax rate of the dirty good will affect the consumption of the dirty good negatively. Second, an increase in nominal income will lead to higher consumption, provided that the dirty good is a normal good. Hence,

$$dD = D_{t_D} dt_D + D_Y dY \tag{34}$$

From equation (29) we can derive the change in nominal income due to a green tax reform of type I:[14]

$$dY = \frac{1}{1 - t_D D_Y}\left[wL_w dw + (D + t_D D_{t_D}) dt_D \right]. \tag{35}$$

Substituting (35) into (34) and applying the Slutsky decomposition, we finally obtain:

$$dD = \frac{1}{1 - t_D D_Y}\left[D^c_{t_D} dt_D + D_Y wL_w dw \right] \tag{34'}$$

As $\text{sign}(dE) = -\text{sign}(dD)$, rearranging yields the following condition for the environmental dividend

$$dE \begin{cases} > \\ = \\ < \end{cases} 0 \quad \Leftrightarrow \quad \varepsilon^c_{dd} \cdot \frac{dt_D}{1 + t_D} \begin{cases} > \\ = \\ < \end{cases} \theta_d \frac{wL_w dw}{Q}, \tag{36}$$

[13] This effect is also pointed out in Bovenberg and van der Ploeg (1995) in a different model. In their approach, however, the tax burden is shifted to transfer income only while in our model the burden of the green tax is also borne by profit income.

[14] As the income effects are qualitatively the same for a green tax reform of type II, we do not analyse the environmental dividend of the second reform separately.

where $\varepsilon^c_{dd} = -D^c_{t_D}(1+t_D)/D$ denotes the compensated price elasticity of the dirty good and $\theta_d = D_Y Q_D / D$ the output elasticity of the dirty good, respectively. wL_w denotes the additional output (measured in producer prices). If the nominal wage does not decline, i.e. $dw \geq 0$, the environmental dividend is always positive. If, on the contrary, the nominal wage declines and hence employment rises, condition (36) states that the environmental dividend is positive if the compensated price elasticity times the relative price change for the dirty good is larger than the output elasticity of the dirty good times the relative change in output. This may be summarized in proposition 4:

PROPOSITION 4: If the dirty good is a normal good and the consumer price of the dirty good increases by one percent due to a revenue-neutral green tax reform I, the environmental dividend will be positive if the compensated price elasticity is larger than the output elasticity times the relative change in output due to the green tax reform. For inferior goods, higher environmental quality goes along with higher employment.[15]

Intuitively the environment improves if the substitution effect due to the change in relative consumer prices more than outweighs the positive income effect. The larger the employment effect is , the larger is the output change. Hence, there is a trade off between the environmental dividend and the employment dividend. This, however, only indicates that there is no free lunch, as obtaining a higher level of environmental quality goes along with a smaller employment effect. Note, however, that the opposite conclusion applies in the case of an inferior dirty good.

5.3 Welfare effects

Households derive utility directly from consumption and, in addition, utility from environmental quality [cf. equation (1)]. Any increase in environmental quality will increase

[15] A similar result showing that a revenue-neutral green tax reform might actually worsen the environmental quality is derived by Schöb (1994) for the cases of commodity taxes.

environmental utility but lower utility from consumption as higher environmental quality implies less consumption of the dirty good. However, this loss may be (partly) compensated, or even overcompensated, by an increase in the consumption of the clean good. A revenue-neutral green tax reform will change the consumption of the clean good by

$$dC = C_{t_D} dt_D + C_Y dY. \tag{37}$$

If the clean good is normal and a uncompensated substitute to the dirty good, consumption of the clean good will unambiguously increase if nominal income increases as a consequence of a green tax reform. Hence, the total effect on utility from consumption (or equivalently on real income) is unclear.

In what follows we relinquish a formal analysis of the different possible welfare effects and use a brief graphical illustration of the welfare effects.

Figure 1: Welfare effects of a revenue-neutral green tax reform

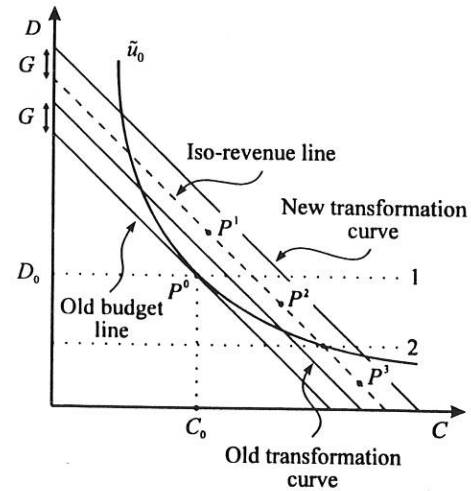

Figure 1 shows the aggregate consumption of the economy. Before the green tax reform the optimal consumption bundle is indicated by P^0. As the government needs revenues to finance

the public good G, the aggregate household budget line has to be below the transformation curve by the distance G. Assume that, due to a revenue-neutral green tax reform, employment and hence output increases. The transformation curve shifts outwards. The new optimum must be on a iso-revenue line which gives the government sufficient public funds to finance the public good G. The new budget line (not shown in Figure 1) must be flatter than the old one as the consumer price of the dirty good has increased relatively to the consumer price of the clean good.

In Figure 1 we can distinguish between three cases. If the new consumption optimum lies above the dotted line 1, e.g. at P^1, the consumption of both clean and dirty goods goes up and hence direct utility (real income) rises. In this case, the environmental dividend becomes negative. Only a comparison of the countervailing effects reveals whether the tax reform is welfare increasing or not. If the new optimum lies between the dotted lines 1 and 2, e.g. at P^2, both direct utility (real income) and environmental utility increases. This is the case of a double dividend in the strong form as both private real income and environmental quality increase (cf. Goulder 1995). If the optimum lies below line 2, e.g. at P^3, direct utility (real income) decreases while the environmental dividend is positive. This solution indicates that a higher level of environmental quality has to be paid for by a decline in real income. In so far as environmental damages are severe, it is reasonable to assume that there is a range of welfare improving revenue-neutral green tax reforms which increase employment and environmental quality by reducing total real income.

6. Concluding remarks

The paper analyses the employment effects of a green tax reform in a unionized labour market by focusing on the revenue-recycling effect. The model contains three important features which are largely neglected in the already huge literature of this field. Firstly, there is unemployment in equilibrium. Secondly, wages are endogenously determined via bargaining. Thirdly, a distinction is made between various institutional arrangements concerning taxation

of unemployment benefits, price-indexation of unemployment benefits and personal tax allowances. Using the 'right-to-manage' model as the framework of analysis we have considered two different revenue-neutral green tax reforms: a rebate of green tax revenues via a reduction in labour taxes and a rebate via an increase in personal tax allowances.

The employment effects of a revenue-neutral green tax reform are not sensitive to the question of how green tax revenues are rebated, though the increase in personal tax allowances will increase employment more than the reduction in income taxes does. However, the qualitative results are sensitive to institutional arrangements concerning taxation and indexation of unemployment benefits and personal tax allowances. We have shown that a revenue-neutral green tax reform will boost employment if unemployment benefits are untaxed and nominally fixed. The reason for this is that the tax burden is distributed more equally over all income groups and this reduces the tax burden borne by labour. This effect will become even stronger if the tax reduction is restricted to labour specific charges (e.g. unemployment insurance contributions) or labour specific tax exemptions. Employment actually falls if unemployment benefits are taxed and price indexed. Employment effects are indeterminate in the (not so common) case where unemployment benefits are untaxed but price indexed.

When employment is boosted, the functional distribution of income will change. Total private income, after-tax profits and labour income all increase while transfer income decreases because the number of transfer recipients decreases. If the dirty good is normal, there may be - but need not be - a trade-off between the environmental dividend and the employment dividend. In the case of an inferior dirty good, however, an increase in employment due to a green tax reform will further increase environmental quality.

As for the areas of further research we should mention the consequences of green tax reforms when environmental taxes are not levied on final output or on the consumption activities, but on production factors. While this has been analysed within fixed wage models and search theoretic models [see Bovenberg and van der Ploeg (1994b, 1995)], the impact on

the wage negotiation process has not yet been analysed. Pollution taxes can be levied on the production sector in various ways. Emissions of pollutants by industry can be subject to charges. Alternatively, the government may tax certain polluting factors of production like energy input. This raises the interesting question of which of the factors of production actually bears the burden of taxes and how the cost structure of firms is affected by a revenue-neutral tax reform which reduces the tax burden on labour by increasing the burden other factors bear.

In terms of policy recommendations, our analysis suggests that there are good reasons for arguing that green tax reforms can alleviate unemployment by shifting the tax burden away from labour towards other income groups. However, as we have stressed, in order to be successful, green tax reforms require certain institutional arrangements concerning the taxation and price-indexation of unemployment benefits and personal tax allowances.

Appendix 1: Some comparative statics of Nash bargaining

The following appendix shows some calculations which are necessary to understand the results of the comparative statics presented in table 2. We proceed case by case.

CASE A: From

$$V = \tilde{V} - V^0 = \frac{1}{P}\left[(1-t_L)wL + t_L aL + b(N-L)\right] - \frac{bN}{P} \tag{A1}$$

we obtain equation (6-A) in table 2. The partial derivative with respect to nominal wage is given by

$$V_w = \frac{1}{P}\left[(1-t_L)w(1-\delta) + (b-t_L a)\delta\right] \tag{A-2}$$

with $\delta > 1$ being the wage elasticity of labour demand. Straightforward calculations utilizing equation (10) yield the partial derivatives as given in table 2.

CASE B: From

$$V = \tilde{V} - V^0 = \frac{1}{P}\left[(1-t_L)wL + t_L aPL + b(N-L)\right] - \frac{bN}{P} \tag{A-3}$$

we obtain equation (6-B) in table 2. The partial derivative is given by

$$V_w = \frac{1}{P}\left[(1-t_L)w(1-\delta) + (b-t_L aP)\delta\right]. \tag{A-4}$$

Comparative statics is similar to the case A with the exception that

$$\operatorname{sign}(w^*_{t_D}) = \operatorname{sign}\left[-\frac{t_L a}{P}(V\delta + V_w L)\right] < 0. \tag{A-5}$$

CASE C: From

$$V = \tilde{V} - V^0 = \frac{1}{P}\left[(1-t_L)wL + t_L aL + bP(N-L)\right] - bN \tag{A-6}$$

we obtain equation (6-C) in table 2. The partial derivative is given by

$$V_w = \frac{1}{P}\left[(1-t_L)w(1-\delta) + (bP-t_L a)\delta\right]. \tag{A-7}$$

Comparative statics is similar to the cases A and B with the exception that

$$\operatorname{sign}(w^*_{t_D}) = \operatorname{sign}\left[\frac{P_{t_D} b}{P}(V\delta + V_w L)\right] > 0. \tag{A-8}$$

CASE D: From

$$V = \tilde{V} - V^0 = \frac{1}{P}\left[(1-t_L)wL + t_L aPL + bP(N-L)\right] - bN \tag{A-9}$$

we obtain equation (6-C) in table 2. The partial derivative is given by

$$V_w = \frac{1}{P}\left[(1-t_L)w(1-\delta) + (b-t_L a)P\delta\right]. \tag{A-10}$$

Comparative statics is similar to the case C with the exception that

$$\operatorname{sign}(w^*_{t_D}) = 0. \tag{A-11}$$

CASE E: The target function given in equation (6-E) from table 2 results from

$$V = \tilde{V} - V^0 = \frac{1}{P}\left[(1-t_L)(w-b) + (1-t_L)bN + t_L aN\right]L - \frac{1}{P}\left[(1-t_L)bN + t_L aN\right] \tag{A-12}$$

with

$$V_w = \frac{1}{P}\left[(1-t_L)w(1-\delta) + (1-t_L)b\delta\right]. \tag{A-13}$$

The determination of the signs in table 2 are straightforward.

CASE F: The target function given in equation (6-F) from table 2 results from

$$V = \tilde{V} - V^0 = \frac{1}{P}\left[(1-t_L)(w-bP) + (1-t_L)bN + t_L aN\right]L - \frac{1}{P}\left[(1-t_L)bN + t_L aN\right] \tag{A-14}$$

with

$$V_w = \frac{1}{P}\left[(1-t_L)w(1-\delta) + (1-t_L)bP\delta\right]. \tag{A-15}$$

Comparative statics is similar to the case E with the exception that

$$\operatorname{sign}(w^*_{t_D}) = \operatorname{sign}\left[\frac{(1-t_L)bP_{t_D}}{P}(V\delta + V_w L)\right] > 0. \tag{A-16}$$

Appendix 2: Comparative statics in a seniority model

If lay offs follow some type of seniority rule, the trade union will act as though it were locally indifferent to the level of employment (cf. Oswald 1993, p. 87). In our model the Nash maximand for case A then becomes

$$\Omega = \left[\frac{(1-t_L)w + t_L a - b}{P}\right]^{\beta} \pi^{1-\beta}. \tag{A-17}$$

Using equations (9) and (10), straightforward calculations show that

$$VV_{wt_L} - V_w V_{t_L} = (b-a)/P^2 > 0 \quad \Leftrightarrow \quad w^*_{t_L} > 0 \tag{A-18}$$

and

$$VV_{wt_D} - V_w V_{t_D} = 0 \quad \Leftrightarrow \quad w^*_{t_D} = 0. \tag{A-19}$$

The other cases can be proved analogously. A compelete set of results is available from the authors upon request.

Appendix 3: Derivation of the change in nominal wage for case D

Appendix 3 gives the calculations for deriving condition (23-D). Solving (18-D) for the tax on the dirty good, we obtain the following condition:

$$dt_D\big|_{dG=0} = -\frac{Q - aP(M+L) + t_D D_{t_L}}{D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right]}dt_L - \frac{(t_L Q_L + P(b-t_L a)L_w + t_D D_w}{D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right]}dw. \tag{A-20}$$

Substituting the right hand side of (A-20) into condition (19) and rearranging yields

$$dw\left[1 + \frac{(t_L Q_L + P(b-t_L a)L_w + t_D D_w}{D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right]} w^*_{t_D}\right] = \left[w^*_{t_L} - \frac{Q - aP(M+L) + t_D D_{t_L}}{D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right]} w^*_{t_D}\right]dt_L. \tag{A-21}$$

From the budget constraint (18-D) we have

$$G_{t_D} = D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right] + \left[(t_L Q_L + P(b-t_L a)L_w + t_D D_w\right]w^*_{t_D}. \tag{A-22}$$

Laffer efficiency implies $G_{t_D} > 0$. Hence, the term in brackets of the left hand side in (A-21) is positive. This means that the sign of the term in brackets of the right hand side determines the sign of the nominal wage rate change $dw/dt_L\big|_{dG=0}$. Defining [from equation (18-D)]

$$\left.\frac{\partial G}{\partial t_L}\right|_{dw=0} \equiv Q - aP(M+L) + t_D D_{t_L} \quad \text{and} \quad \left.\frac{\partial G}{\partial t_D}\right|_{dw=0} \equiv D + t_D D_{t_D} - P_{t_D}\left[t_L a(M+L) + b(N-L)\right]$$

as the marginal tax revenues conditional to a fixed nominal wage, we obtain the following conditions:

$$\left.\frac{dw}{dt_L}\right|_{dG=0} \left\{\begin{matrix}>\\=\\<\end{matrix}\right\} 0 \quad \Leftrightarrow \quad \frac{w^{\bullet}_{t_L}}{w^{\bullet}_{t_D}} \left\{\begin{matrix}>\\=\\<\end{matrix}\right\} \frac{\left.\frac{\partial G}{\partial t_L}\right|_{dw=0}}{\left.\frac{\partial G}{\partial t_D}\right|_{dw=0}}. \qquad \text{(A-23)}$$

Using elasticities, this can be reformulated yielding (23-D).

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