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Abstract

A politically intriguing question concerning the effects of a revenue-neutral ecological tax reform is whether such a political measure may succeed in providing a double dividend: to improve environmental quality and increase employment simultaneously. Theoretical studies reveal that for a competitive labor-market a green tax reform hardly yields a positive employment effect, whereas for a non-competitive market such an effect may well be obtained. However, little attention has focused on whether the ecological dividend remains attainable when an employment dividend accrues. We show for three different non-competitive labor-market scenarios that a positive employment effect can be expected, but that, for high-tax countries, environmental quality *deteriorates* when a revenue-neutral ecological tax reform is implemented.

Keywords: Environmental tax reform, unemployment, double dividend, non-competitive labor market, production externalities
JEL Classification: E24, H21, H23, J51, Q41

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1. Introduction

In recent years the idea of using the tax proceeds from an environmental tax reform to cut other distortionary taxes has attained increasing interest of politicians and economists. Particular attention is directed towards taxes on labor, i. e., income and payroll taxes. It is argued that when the tax revenue from green taxes is given back to the private sector by means of reduced labor taxes, an ecological tax reform may succeed in providing both an improvement of environmental quality and an alleviation of the unemployment problem — and in this sense a double dividend can be obtained.

Though the idea of a double dividend is politically appealing and intuitively quite convincing, the intuition rests upon partial-equilibrium arguments. General-equilibrium analyses, following the line of Bovenberg and de Mooij (1994a), demonstrate that under pre-existing distortionary taxes significant general-equilibrium effects are at work which counteract the primary positive welfare effects. As a consequence, tax interaction effects may outweigh the welcome revenue-recycling effect and most likely destroy the possibility of a double dividend.[1]

This rather negative result is typically derived within a competitive labor-market model (e. g., Bovenberg and de Mooij 1994a,b, Bovenberg and van der Ploeg 1994, Ligthart and van der Ploeg 1998). In a competitive framework, in particular with linear homogenous production functions, the driving force is the elasticity of labor supply: a negative employment effect results from a decline of the real after-tax wage, since the latter erodes the incentives to work. Thus, only when the labor-supply curve bends backwards or the initial tax system is sufficiently inefficient, can a green tax reform yield a positive employment effect.[2] Bovenberg and

[1]The different effects are discussed by Goulder (1995), and the importance of pre-existing tax distortions was recently (again) emphasized by Parry (1998).

[2]The fact that, under a highly inefficient tax system, a (green) tax reform may alleviate initial inefficiencies is highlighted by de Mooij and Bovenberg (1998) (refer to their discussion of the 'tax-shifting effect'). Of course, if a tax system is heavily inefficient, there are, apart from ecological considerations, strong reasons to revise tax policies, but these inefficiencies alone do not

van der Ploeg (1994) obtain an even more negative result: When a shift towards 'greener' social preferences occurs, employment declines independent of whether the labor supply curve is backward-bending or upward-sloping.

One may question, though, whether the competitive labor-market model is the appropriate framework for investigating the possibility of a double dividend. First, when there is, by definition, no involuntary unemployment, an employment increase has no positive welfare effects per se, so the target of stimulating employment is questionable. Second, existing high unemployment rates are decisively a problem of the labor demand side, not (primarily) of the supply side.[3] And third, in most OECD countries, in particular in Europe, labor markets are, in fact, non-competitive.

Some authors have acknowledged this by introducing labor-market imperfections. For example, Bovenberg and van der Ploeg (1996) assume that involuntary unemployment results from a rigid consumer wage. Koskela and Schöb (1998), using a model with consumption externalities, scrutinize the 'right-to-manage' approach under different institutional arrangements concerning taxation and indexation of unemployment benefits. They find that the outcomes are sensitive to the institutional arrangements, but that a green revenue-neutral tax reform may alleviate unemployment.[4] Schneider (1997), using an efficiency-wage model, finds that as long as the labor market is sufficiently distorted, i. e., high unemployment rates and high wage taxes prevail, a green tax reform provides a double dividend. Hence, the main conclusion which can be drawn from most of the recent double-dividend literature is that with non-competitive labor markets the possibility of a positive employment effect emerges.[5]

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justify pursuing an *environmental* tax reform. Hence, it follows almost trivially that the higher an economy's initial inefficiencies are, the more likely a double dividend can be reaped.

[3]This view is also shared by Nielsen, Pedersen, and Sørensen (1995), p. 198: '[...] *in the presence of involuntary unemployment labor supply does not impose any constraint on employment.*'

[4]In a closely related model with production externalities and factor substitution Koskela, Schöb, and Sinn (1998) are more optimistic that green tax reforms help to reduce unemployment.

[5]This holds, in particular, when households find it difficult to substitute leisure for private con-

In this paper we express our scepticism about this free-lunch hypothesis. However, contrary to the literature, we find that although a revenue-neutral ecological tax reform does seem to increase employment, the government may nevertheless fail to reap a double dividend: When initial labor taxes are high, the positive economic effect of the green tax reform destroys the ecological benefit.

To obtain this possibly surprising result, we investigate the consequences of a revenue-neutral ecological tax reform within the set-up of BOVENBERG AND VAN DER PLOEG (1996), where production causes environmental damage and firms are able to substitute between labor and a dirty factor (energy). By applying three different non-competitive labor-market scenarios — the right-to-manage approach, the monopolistic union, and efficient bargaining — we demonstrate that the income effects induced by positive employment effects of the tax reform outweigh the substitution effects when initial labor taxes are high. As a consequence, high-tax countries are not able to obtain a double dividend — not because there is no employment dividend, but because the environmental dividend is lost.[6]

Since the framework we use is standard, but the non-existence result we derive is at variance with previous analyses, we conclude that it is the institutional arrangement of the labor market which drives the results: In an economy with a competitive labor market, a double dividend, though a questionable target per se, can hardly be obtained; with non-competitive labor markets, a double dividend is attainable — but remarkably only for low-tax countries.

Given the appropriateness of a non-competitive labor-market approach, as argued above, and given the evidence of a strong need for environmental tax reforms to improve environmental quality, our criticism here is directed towards the principle of revenue-neutrality, at least for high-tax countries. If labor taxes are so high

sumption, labor is a good substitute for the polluting factor, unemployment benefits are nominally fixed, or initial inefficiencies are substantial.

[6] A similar conclusion is inferred by BAYINDIR-UPMANN AND RAITH (1997) in a model with consumption externalities. Yet, while their result requires a sufficiently high expenditure share of dirty goods, our result here is independent of the cost share of dirty goods.

that an economy is on the decreasing side of the Laffer curve, revenue-neutrality requires a labor-tax increase rather than a decrease. A further tightening of the tax screw implies that this environmental policy is, thus, harmful to the economy and employment. Presumably, however, most countries are on the increasing side of the Laffer curve. Nevertheless, when taxes are high — this is the situation in most countries that attempt to relieve their employment problems by means of revenue-neutral tax reforms — the resulting tax reduction stimulates the economy to such an extent that environmental policy becomes harmful to the environment. Unfortunately, only low-tax countries appear to be successful in reaping a double dividend from revenue-neutral ecological tax reforms. For high-tax countries, the only way out of this dilemma is to abandon revenue-neutrality — a political restriction which cannot be justified neither on ecological nor on economic considerations.

The rest of the paper is structured as follows. In Section 2 we present a model of a small open economy, consisting of households, firms, the government, a labor union, and an employers' association. In Section 3 we show how the three labor-market models (the right-to-manage approach, the monopolistic union model, and efficient bargains) can be analyzed within a unified framework and characterize the three corresponding equilibria. Comparative statics of the labor market are conducted in Section 4. The main conclusions concerning the effects of a revenue-neutral ecological tax reform are derived in Section 5. Finally, Section 6 concludes.

2. The Model

Consider a small open economy consisting of households, firms, and the government. We distinguish between three types of households who have identical tastes, but differ with respect to their incomes. First, there are L fully employed laborer households each of which has a real income Q, given by the real wage w minus the burden of a proportional labor-income tax with a tax rate t_L: $Q = (1 - t_L)w$. The second group consists of $N - L$ unemployed laborer households who receive no labor income. The total number of laborer households is thus N, which we assume to be exogenously given while the number of employed households is determined endogenously on the labor market. Aggregate laborers' real income is thus given by $QL = (1 - t_L)wL$.

The third group of households consists of identical, fully employed managers (or firm-owners) who all receive the same income. These households derive their income exclusively in the form of untaxed dividends paid out of firms' aggregate profits Π. Since manager households are identical with respect to income and their consumption of leisure, we can normalize their number to one, or simply view this group as one aggregate household, with an aggregate real income which amounts to Π.

The production sector is characterized by identical competitive firms producing an internationally traded good, whose world market price is exogenously given and normalized to unity. Each firm produces its output by means of three factors: labor; an environmentally harmful factor, such as energy (E); and a fixed factor, which can be interpreted as land or capital. The after-tax price of energy — a good which must be completely imported at a given world market price — is denoted by p_E. The production technology features constant returns to scale with respect to all three factors. (This assumption simplifies the aggregation over all firms.)[7] By omitting the fixed factor as an argument of the production function, we can write aggregate profits as

$$\Pi \;=\; \pi(L, E, w, p_E) \;=\; f(L, E) - wL - p_E E\,, \tag{1}$$

where f is monotonically increasing, twice continuously differentiable, and strictly concave in both arguments, with $f_{LE} \geq 0$.[8]

Before firms decide about their use of energy, the wage rate and the employment level are determined on the labor market. That is, firms, taking w and L as given, maximize their profits with respect to energy. This implies that energy demand,

[7]This set-up is standard in the literature. See, for example, BOVENBERG AND VAN DER PLOEG (1996).

[8]Subindices of functions denote partial derivatives.

$E = e(p_E, L)$, is implicitly given by[9]

$$f_E(L,E) = p_E \,.$$

Firms equate the marginal product of energy to its after-tax price, implying that

$$\frac{\partial E}{\partial p_E} = \frac{\partial e(p_E,L)}{\partial p_E} = \frac{1}{f_{EE}} < 0 \quad \text{and} \quad \frac{\partial E}{\partial L} = \frac{\partial e(p_E,L)}{\partial L} = -\frac{f_{LE}}{f_{EE}} \geq 0 \,. \tag{2}$$

Energy demand declines with its after-tax price, but rises with the amount of labor used in production.

The government raises its tax revenue, R, which is required to finance some exogenously given amount of public expenditures, from two sources — labor and energy taxation:

$$R := wLt_L + Et_E \,, \tag{3}$$

where t_E denotes the specific tax on energy.

3. Equilibrium on the Labor Market

On the supply side of the labor market, there is a labor union which represents all N laborer households and, on the demand side, an employers' association which acts on behalf of all firms. The labor union seeks to maximize the sum of its members' utilities, which is given by

$$LU + (N-L)\bar{U} \,,$$

where $U = u(Q)$, with $Q = (1-t_L)w$, denotes the utility obtained by a fully employed worker, and $\bar{U}$ represents the utility of an unemployed household from the consumption of maximal leisure.[10] The union's reservation utility is given by $N\bar{U}$,

[9] Our assumption of a sequential structure of the production decision is innocuous even if only the wage is determined on the labor market and firms are free to choose employment. In particular, for labor-market equilibria on the labor-demand curve, this sequential structure is equivalent to firms maximizing profits with respect to L and E simultaneously.

[10] This characterization of unions' preferences is standard in labor economics. However, within a general-equilibrium analysis, the union's preferences should be specified consistently with the representative household's utility function, u, the reservation utility level, $\bar{U}$, and aggregate labor supply. For completeness we provide such a setting in Appendix A.

viz., when all its members are unemployed. For any fixed N, the union's preferences can thus be represented by

$$\Psi \;=\; \psi(L, w; t_L) \;:=\; L\left[u\left((1-t_L)w\right) - \bar{U}\right] + N\bar{U}\,. \tag{4}$$

Differentiation of the union's utility with respect to employment and the wage, holding Ψ constant, yields

$$\frac{dw}{dL} \;=\; -\frac{u(\cdot) - \bar{U}}{(1-t_L)Lu'(\cdot)} < 0\,.$$

The union's indifference curves are downward sloping and lie above the reservation wage $\bar{w} := u^{-1}(\bar{U})/(1-t_L)$ — the gross wage at which households are indifferent between working and being unemployed.

The employers' association seeks to maximize firms' aggregate profits, Π. Differentiating this with respect to the employment level, L, and the wage, w, one obtains the slope of the employers' indifference curves or, alternatively, of the firms' iso-profit curves:

$$\frac{dw}{dL} \;=\; \frac{f_L(L,E) - w}{L}\,.$$

Since f is concave, the iso-profit curves are increasing in L until $f_L(L,E) = w$, and decreasing afterwards. In other words, for any given real wage and any given use of energy, the profit-maximizing level of employment is where the slope of the iso-profit curve is equal to zero. Consequently, $w = f_L(\cdot)$ characterizes the aggregate inverse labor-demand curve, the slope of which is $f_{LL} < 0$.

We consider three different scenarios on the labor market: (i) the *right-to-manage* approach, where first the wage is negotiated by the employers' association and the union, and afterwards firms choose the level of employment; (ii) the *monopolistic union* model, where the union alone determines the wage, and then firms decide about their labor demand; and (iii) *efficient bargains*, where both parties negotiate the wage and employment simultaneously, yielding a Pareto efficient contract. Which of these scenarios one considers as the most relevant depends on whether one believes that the presence of labor unions is employment-enhancing or -reducing. We do not discuss this issue here, but show that our results hold for all three labor-market models. Creedy and McDonald (1991) show how all three models can be dealt with in a generalized 'right-to-manage' approach. We first derive the equilibrium conditions of the labor market for the 'right-to-manage' model and then show how these conditions must be modified to obtain those for the 'monopolistic union' and the 'efficient bargains'.

The *right-to-manage* approach can be formalized as a firm–union negotiation over the wage and employment under the constraint that labor demand must satisfy $w = f_L(L, E)$. We focus on Nash bargains where $\mu \in [0, 1]$ is the weight which reflects the distribution of bargaining power between the union and the employers' association. We assume that the union's and the association's disagreement utilities are given by $N\bar{U}$ and 0 respectively. Taking into account that final energy demand depends on L, the negotiated wage and the employment level are found as the maximands of

$$\max_{w,L} \quad \Big[\psi(L, w; t_L) - N\bar{U}\Big]^{\mu} \times \Big[\pi(L, E, w, p_E)\Big]^{1-\mu} + \lambda\Big[w - f_L(L, E)\Big], \tag{5}$$

where the objective functions of both parties are defined by equations (1) and (4) respectively, the level of energy is given by $E = e(p_E, L)$, and λ denotes the Lagrange-multiplier of the labor-demand constraint. The first order conditions of (5) for w and L are (omitting arguments)

$$(\Psi - N\bar{U})^{\mu-1}\, \Pi^{-\mu}\, L\Big[\mu(1-t_L)\, u'(\cdot)\, \Pi - (1-\mu)\,(\Psi - N\bar{U})\Big] + \lambda \;=\; 0, \tag{6}$$

$$(\Psi - N\bar{U})^{\mu}\, \Pi^{-\mu}\Big[\mu\frac{1}{L}\Pi + (1-\mu)\,[f_L - w]\Big] - \lambda\Big[f_{LL} + f_{LE}\, e_L(\cdot)\Big] \;=\; 0, \tag{7}$$

and $w = f_L(\cdot)$ for the Lagrange multiplier. Combining equations (6) and (7) yields the optimality condition

$$\frac{\mu\left(\frac{f}{L} - w - p_E\frac{E}{L}\right) + (1-\mu)\,(f_L - w)}{-\mu\left(\frac{f}{L} - w - p_E\frac{E}{L}\right) L\,\frac{(1-t_L)u'(\cdot)}{U - \bar{U}} + (1-\mu)L} = f_{LL} + f_{LE}\, e_L(\cdot)\,. \tag{8}$$

We suppose in the subsequent analysis that output is produced according to a

Cobb–Douglas production function[11]

$$f(L, E) = \alpha_0 L^{\alpha_1} E^{\alpha_2} ,$$

where $\alpha_i > 0, i = 0, 1, 2$ and $\alpha_1 + \alpha_2 < 1$. Note that $\alpha_0 := \tilde{\alpha}_0 \bar{K}^{\alpha_3}$ includes the fixed factor of production, where, by assumption of linear homogeneity, $\alpha_3 = 1 - \alpha_1 - \alpha_2$. Applying this specification of f to equation (8) and using the fact that, for any employed worker, private consumption equals the net wage, $Q = (1 - t_L)w$, one obtains

$$\sigma(Q) = \frac{\mu(1-\alpha_2) + (1-\mu)\alpha_1}{\mu(1-\alpha_1-\alpha_2)} , \tag{9}$$

where, following CREEDY AND MCDONALD (1991),

$$\sigma(Q) := \frac{Qu'(Q)}{u(Q) - \bar{U}}$$

denotes the elasticity of workers' (excess) utility. We assume σ to be monotonically decreasing in Q, which is consistent with most interesting specifications of the utility function u and guarantees existence and uniqueness of a labor-market equilibrium. For any given value of t_L, the employers' association and the labor union determine the wage such that workers' resulting private consumption satisfies equation (9). (Note that, when the union's bargaining power vanishes, i. e., $\mu \to 0$, the labor market equilibrium converges to the competitive outcome, where $w = \bar{w}$.) Since the right hand side of equation (9) is constant, $\sigma(Q)$ must be constant as well — and so must Q. Consequently, shifts of the income tax do not affect an employed worker's utility since the nominal wage is adjusted in order to keep the real wage constant.

With a *monopolistic union*, the labor union has complete control over the wage. In order to derive the first order conditions for this labor-market scenario, we simply have to set $\mu = 1$, reflecting the union's total bargaining power. Equation (9) then

[11] The results of the present section are, at least for the Nash–bargaining solution, valid for any concave production function, as is shown in Appendix B. However, only little insight can be gained from a general function f when we consider a revenue-neutral tax reform in the next section. Thus, for the purpose of continuity, we introduce the Cobb–Douglas form from the outset.

reduces to

$$\sigma(Q) \;=\; \frac{1-\alpha_2}{1-\alpha_1-\alpha_2}\,. \tag{9'}$$

Comparing equations (9′) and (9), one directly infers that the monopolistic union enforces a higher wage than the union operating under the right-to-manage approach (i. e., for $\mu < 1$).

For *efficient bargains*, the union and the employers' association negotiate the wage and the employment level unrestrictedly. (This is the classic wage-bargaining model introduced by McDonald and Solow, 1981.) The corresponding *Nash-bargaining solution* is then obtained by setting λ equal to zero in equations (6) and (7). The latter condition then implies a relationship between w and L,

$$w \;=\; \mu\,\frac{f(L,E)-p_E E}{L} + (1-\mu)\,f_L(L,E)\,, \tag{10}$$

which we label '*Nash curve*'. For efficient bargains, the Nash-bargaining solution thus induces an agreement where the consumer real wage is equal to the weighted average of the marginal and net average product of labor. By rewriting equation (10) as

$$w \;=\; f_L(L,E) + \mu\frac{1}{L}\Big(f(L,E) - f_L(L,E)L - p_E E\Big),$$

one obtains an alternative interpretation: The negotiated wage equals the marginal product of labor plus a markup which is equal to the potential industry profit (per worker) if the wage were equal to f_L times the union's bargaining power. In the polar cases when the union has either no bargaining power ($\mu = 0$) or total bargaining power ($\mu = 1$), the wage equals the marginal product of labor or the total value added per worker ($w = (f(\cdot) - p_E E)/L$) respectively.

In addition, efficient wage–employment contracts must lie on the '*contract curve*' which is obtained by equating the slopes of the firms' iso-profit curves and the union's indifference curves. Equivalently, the equation of the contract curve is obtained by substituting equation (10) into equation (6), yielding the second relationship between w and L:

$$\frac{u((1-t_L)w)-\bar{U}}{u'((1-t_L)w)} \;=\; (1-t_L)(w - f_L(L,E))\,. \tag{11}$$

Since the labor union is only interested in contracts that guarantee $u((1-t_L)w) \geq \bar{U}$, equation (11) implies $w \geq f_L$. The contract curve thus lies above the labor-demand curve, and it only intersects the latter where $u((1-t_L)w) = \bar{U}$.[12] For efficient bargains the labor-market equilibrium is determined by equations (10) and (11). With the Cobb–Douglas specification of the production function these two equations imply

$$\sigma(Q) = \frac{\mu(1-\alpha_2) + (1-\mu)\alpha_1}{\mu(1-\alpha_1-\alpha_2)}, \tag{9''}$$

which gives us a single equation determining the negotiated wage. Note that the numerator of the right hand side of equation (9″) equals the wage share, generally defined as $\omega := wL/f(L,E)$. With $\mu \in [0,1]$, one obtains

$$\omega = \mu(1-\alpha_2) + (1-\mu)\alpha_1 = \alpha_1 + \mu\alpha_3 \quad \in \quad [\alpha_1, 1-\alpha_2]. \tag{12}$$

Hence, for efficient bargains, the wage share is larger than for equilibrium outcomes on the labor-market demand curve, where $\omega = \alpha_1$.

Since equation (9″) is identical to equation (9) and equal to equation (9′) for $\mu = 1$, a single equation characterizes the equilibrium wage for all three labor-market models. In addition, the right-to-manage approach and the efficient-bargains model feature identical wages, although employment and the wage share are higher in the latter case.

The outcome of all three labor-market models is depicted in Figure 1. L^d represents the labor-demand curve; $\mathcal{N}$, the Nash curve; and, $\mathcal{C}$ the contract curve. For the right-to-manage approach, the equilibrium is at point R. Geometrically this outcome is at the tangency point of the 'indifference' curves derived from the 'geometric' mean of the union's and the employers' association's utility. The higher the union's bargaining power, μ, the more R moves up along L^d. For $\mu = 1$, the outcome is at point M, which characterizes the equilibrium of the monopolistic union approach. At M the union's utility is maximal along L^d, i. e., the slope of the unions

[12] Total differentiation of (11) with respect to w and L reveals that the contract curve is upward sloping.

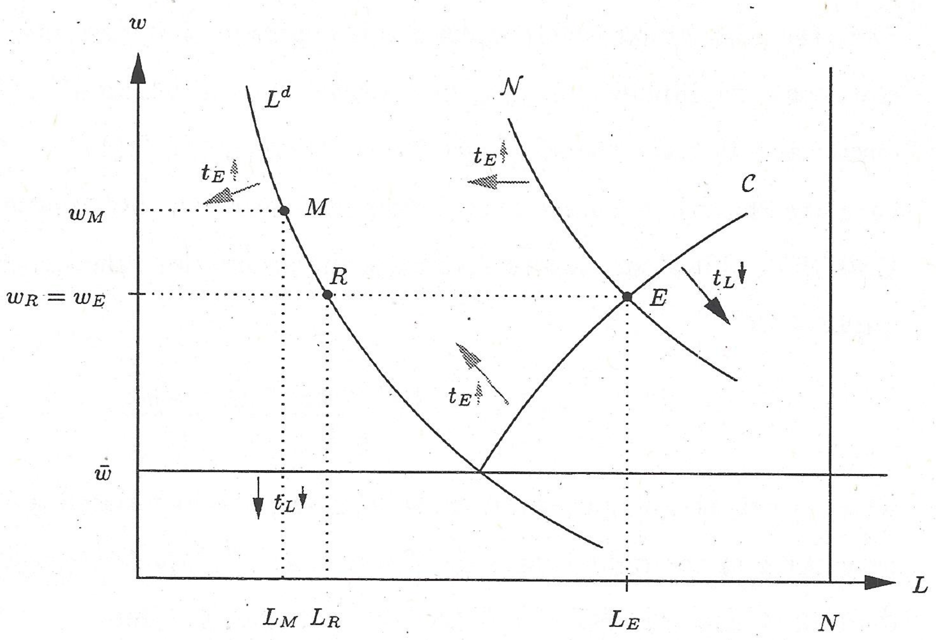

Figure 1: Three labor-market equilibrium scenarios

indifference curve is equal to that of the labor-demand curve. For efficient bargains (the Nash-bargaining solution), the equilibrium is characterized by the intersection of the contract and the Nash curve, represented by point E.

4. Comparative Statics of the Labor Market

Before turning to an ecological tax reform, we need to investigate the effects of both tax rates on the negotiated wage and the employment level, under different labor-market scenarios. To achieve this, differentiate the equilibrium conditions of the labor market — equation (9) and $w = f_L$, equation (9′) and $w = f_L$, or equations (9″) and (10) — with respect to t_L and t_E. In order to cover all three labor-market scenarios simultaneously, we use the definition of the wage share and write a household's real net income as

$$Q = (1 - t_L)\,\omega\,\frac{f(L, e(p_E, L))}{L}\,. \tag{13}$$

Recall that ω is either equal to α_1 (for equilibria on the labor-demand curve) or given by equation (12) (for efficient bargains). Since equations (9), (9′), and (9″) imply that Q remains fixed, $dQ = (1 - t_L)\,dw - w\,dt_L = 0$. Total differentiation of equation (13) then yields

$$\frac{dL}{L} = -\frac{1-\alpha_2}{\alpha_3}\frac{dt_L}{1-t_L} - \frac{\alpha_2}{\alpha_3}\frac{dt_E}{p_E}, \tag{14}$$

where we have used $p_E = f_E(L,E) = \alpha_2 f(L,E)/E$. As a first result, we obtain the partial derivatives:[13]

$$\frac{\partial w}{\partial t_L} = \frac{w}{1-t_L} > 0\,, \tag{15}$$

$$\frac{\partial L}{\partial t_L} = -\frac{L}{1-t_L}\frac{1-\alpha_2}{\alpha_3} < 0\,, \tag{16}$$

$$\frac{\partial w}{\partial t_E} = 0\,, \tag{17}$$

$$\frac{\partial L}{\partial t_E} = -\frac{L}{p_E}\frac{\alpha_2}{\alpha_3} < 0\,. \tag{18}$$

For all three labor-market models, an increase of the labor tax leads, ceteris paribus, to a higher negotiated wage but to a lower employment level. Employment also declines when the tax on (i. e., the price of) energy goes up, while there is no effect on the wage.[14]

Figure 1 illustrates the effects of changes of t_L and t_E and provides the intuition behind our results: While a decrease of the income tax does not affect firms' indifference curves and, therefore, leaves the labor-demand curve unaffected, it shifts the union's preferences. Since a lower level of t_L increases, ceteris paribus, the benefit from a given nominal wage, the union becomes more employment oriented, and hence, its indifference curves become steeper. For equilibria on the labor-demand curve — characterized by its tangency point with the union's indifference curve (monopolistic union) or with the indifference curve generated by the 'geometric' mean of the union's and the firms' utilities (right to manage) — the equilibrium point moves down the labor-demand curve, leading to higher employment and a lower wage. This effect is similar for efficient bargains: Steeper indifference curves shift the contract curve to the south-east and reduce the reservation wage. Since the

[13] Derivatives are written in such a way that one can immediately deduce the elasticities.

[14] At least for efficient bargains, these results can be generalized for any concave production function, except that the effect of t_E on the wage then becomes ambiguous (cf. Appendix B).

Nash curve is independent of the level of the labor tax and is therefore not affected by a change of t_L, the intersection of the contract curve with the Nash curve moves to the south-east, implying that the wage rate falls and employment rises. Note that the definition of the reservation wage implies

$$\frac{\partial \bar{w}/\partial t_L}{\bar{w}/(1-t_L)} = 1 = \frac{\partial w/\partial t_L}{w/(1-t_L)}.$$

That is, the elasticity of the reservation wage and of the equilibrium wage with respect to a change of the labor tax are both equal to unity.

If the government increases the tax on energy, this does not affect the union's preferences; only the firms' iso-profit curves change. A higher price of energy depresses labor demand shifting the labor demand curve to the left. Since this implies a leftward shift of the intersection point of the labor demand curve with the reservation wage, $\bar{w}$, the contract curve must also move to the left, because it meets the labor demand curve at the reservation wage. In addition, as can be seen from equation (10), a higher price of energy, p_E, shifts the Nash curve to the south-west, tending to depress both the wage and employment, ceteris paribus. The total effect of a higher energy tax on employment is clearly negative; but the effect on the negotiated wage is ambiguous for all three of our labor-market scenarios. With our specification of a Cobb–Douglas production function, though, equation (17) shows that the wage remains constant.

The compound effects of a simultaneous increase of the energy tax and a decrease of the labor tax are unclear, in general. The crucial point is whether the effect of a lower income tax dominates that of a higher energy tax in determining the labor-market equilibrium.

Note that when employment falls, total output must also fall. To see this, recall that the use of energy is higher, the more labor is used and the lower the price of energy is. Since the latter increases, the use of energy declines as employment falls, leading to a drop in output. Thus, a lower output level induces a higher environmental quality. Only when employment rises, there is the environmental risk that the output effect may dominate the substitution effect resulting in a higher rather than a lower demand for energy.

5. A Revenue-Neutral Ecological Tax Reform

In the context of this paper, we focus on a *revenue-neutral* ecological tax reform: a marginal introduction of an eco-tax (here, the energy tax) is completely offset by a corresponding change of other distortionary taxes (here, the labor tax) such that total public revenue, $R = wLt_L + Et_E = \omega f(L, e(p_E, L))\, t_L + e(p_E, L)\, t_E$, remains constant. Intuitively, for an ecological revenue-neutral tax reform to make sense from an environmental and a public finance perspective, the initial energy tax should be low. To focus on those cases where the possible gains from an ecological tax reform are potentially large, suppose that the initial energy tax is zero ($t_E = 0$).

In order to derive the fiscal effects of a tax reform, the dependence of public revenue on both tax rates is of particular interest. For $t_E = 0$, our previous results show that the impact of the labor tax on total public revenue is

$$\frac{\partial R}{\partial t_L} = \frac{R}{1-t_L}\left(\frac{1}{t_L} - \frac{1-\alpha_2}{\alpha_3}\right) \gtreqless 0 \iff t_L \lesseqgtr \bar{t}_1 := \frac{\alpha_3}{1-\alpha_2} < 1. \tag{19}$$

When labor taxes are the only source of public revenue, the labor-tax Laffer curve has its maximum at $t_L = \bar{t}_1$.

Next, using equations (17) and (18), $p_E = f_E(L, E) = \alpha_2 f(L, E)/E$, and the definition of ω, we obtain, with $t_E = 0$, the marginal impact of an introduction of an energy tax on total public revenue:

$$\frac{\partial R}{\partial t_E} = \frac{R}{p_E}\frac{\alpha_2}{\omega}\left(\frac{1}{t_L} - \frac{\omega}{\alpha_3}\right) \gtreqless 0 \iff t_L \lesseqgtr \bar{t}_2 := \frac{\alpha_3}{\omega}, \tag{20}$$

where $\bar{t}_1 < \bar{t}_2$, since $\alpha_1 \leq \omega \leq 1 - \alpha_2$. The introduction of a green tax raises a positive (overall) tax revenue only if t_L is not too high. From a public finance perspective, the introduction of an energy tax is welcome if it does not erode tax revenues from other sources (here, the labor tax) more quickly than it raises funds from energy taxation. When labor is subject to a high tax rate, a worker's dismissal causes a significant loss of tax revenue. Therefore, the higher the labor tax, the more costly an erosion of the tax base and, hence, a fall of employment is in terms of public revenue. This erosion of the labor tax base causes an increase of the price of energy to be detrimental from a public finance perspective.[15]

To investigate the overall consequences of a revenue-neutral tax reform, totally differentiate the public budget constraint while holding public revenue, R, constant. Together with equation (14) this yields the general-equilibrium effects for L and t_L:

$$\frac{dL}{dt_E} = \frac{L}{p_E}\frac{\alpha_2}{\alpha_3}\frac{\bar{t}_2 - \bar{t}_1}{\bar{t}_1 - t_L}, \tag{21}$$

$$\frac{dt_L}{dt_E} = -\frac{1-t_L}{p_E}\frac{\alpha_2}{1-\alpha_2}\frac{\bar{t}_2 - t_L}{\bar{t}_1 - t_L}. \tag{22}$$

From equations (15) and (17) one then obtains

$$\frac{dw}{dt_E} = -\frac{w}{p_E}\frac{\alpha_2}{1-\alpha_2}\frac{\bar{t}_2 - t_L}{\bar{t}_1 - t_L}, \tag{23}$$

implying that

$$\frac{dw(1-t_L)}{dt_E} = 0. \tag{24}$$

Finally, we can determine how the revenue-neutral tax reform affects the use of energy:

$$\frac{dE}{dt_E} = -\frac{E}{p_E}\frac{1}{1-\alpha_2}\frac{\bar{t}_0 - t_L}{\bar{t}_1 - t_L}, \tag{25}$$

where $\bar{t}_0 := \bar{t}_1\left(1 - \frac{\alpha_1\alpha_2}{\omega}\frac{1-\alpha_2-\omega}{\alpha_3}\right)$, and $\bar{t}_1$ and $\bar{t}_2$ are as defined in equations (19) and (20). Since $\bar{t}_0$ is increasing in ω, and $\omega \in [\alpha_1, 1-\alpha_2]$, this implies $0 \leq \bar{t}_0 \leq \bar{t}_1 \leq \bar{t}_2 < 1$. Equations (22)–(25) illustrate that, for each variable, the impact of a revenue-neutral ecological tax reform crucially hinges on the initial value of t_L. For convenience, we summarize the effects in Table 1 and proceed by discussing the different policy scenarios characterized by the parameter intervals.

Table 1 shows that there are three critical values determining the economic and ecological consequences of a revenue-neutral introduction of a green tax. Consider

[15] This is what GOULDER (1995) refers to as the 'tax-interaction' effect. In the analysis of BOVENBERG AND DE MOOIJ (1994), among others, this effect is responsible for the non-existence of a double dividend.

$t_L \rightarrow$

<table>
<tr><td></td><td>0</td><td>$\bar{t}_0$</td><td>$\bar{t}_1$</td><td>$\bar{t}_2$</td><td>1</td></tr>
<tr><td>t_L</td><td>$\downarrow$</td><td>$\downarrow$</td><td>$\uparrow$</td><td>$\downarrow$</td><td></td></tr>
<tr><td>w</td><td>$\downarrow$</td><td>$\downarrow$</td><td>$\uparrow$</td><td>$\downarrow$</td><td></td></tr>
<tr><td>L</td><td>$\uparrow$</td><td>$\uparrow$</td><td>$\downarrow$</td><td>$\downarrow$</td><td></td></tr>
<tr><td>E</td><td>$\downarrow$</td><td>$\uparrow$</td><td>$\downarrow$</td><td>$\downarrow$</td><td></td></tr>
<tr><td></td><td colspan="2">$\partial R/\partial t_L > 0$</td><td colspan="2">$\partial R/\partial t_L < 0$</td><td></td></tr>
<tr><td></td><td colspan="3">$\partial R/\partial t_E > 0$</td><td>$\partial R/\partial t_E < 0$</td><td></td></tr>
</table>

Table 1: Effects of a marginal revenue-neutral ecological tax reform ($t_E = 0$)

first the highest labor-tax regime, $\bar{t}_2 < t_L < 1$. Due to a particularly high labor tax, the government is confronted with the decreasing branch of the labor-tax Laffer curve, implying that *lowering* the labor tax results in higher tax proceeds. The energy tax, however, although it raises a positive revenue from its own tax base, does not yield a positive but a negative overall tax revenue. As a consequence, the *loss* of tax proceeds from the introduction of an energy tax has to be compensated by a decrease of the labor tax. The intuition behind this result is the following: From equations (17)–(18) we know that, ceteris paribus, the green tax depresses employment while the wage remains fixed; this effect is so significant that it even dominates the positive revenue effect from its own tax base, implying that, for a given value of t_L, public tax revenue declines. On the other hand, a lower labor tax induces, ceteris paribus, a lower wage but encourages employment, so that the composed effect on public revenue is positive. Since the labour market is highly distorted (t_L is very large), the partial effect of the decrease of the labor tax does not suffice to boost employment enough to outweigh the other negative effects on employment and public revenue. As a consequence, the revenue-neutral introduction of a green tax in an economy which is characterized by very high income taxes is good for the environment but depresses economic activity resulting in lower wages and lower employment. Hence, there is no double dividend.

Next consider the case where t_L is still considerably high but $\bar{t}_1 < t_L < \bar{t}_2$. In this case, the introduction of the energy tax yields a positive overall tax revenue. Since the government still faces the decreasing branch of the labor-tax Laffer curve, a redistribution of the tax proceeds from the green tax back to the households can only be obtained by means of a *higher* labor tax. This, of course, leads to higher wages and reduces employment, the channel by which households' tax burden is reduced. Again, the revenue-neutral tax reform improves the environmental quality but fails to mitigate the problem of unemployment, and a double dividend cannot be obtained.

With high taxes on the increasing branch of the labor-tax Laffer curve, i. e., when $\bar{t}_0 < t_L < \bar{t}_1$, the marginal tax proceeds from both tax rates are, positive. One may consider this to be the 'normal' case and, plausibly, this is the case which best fits the political discussions on revenue-neutral tax reforms. The tax yield from the green tax is given back to households through lower income taxes and this induces the union to accept lower wages in order to promote employment. However, although this wage policy is good for employment, the overall economic activity is encouraged to such an extent that the total use of energy rises, even though its price increases. As a consequence, environmental quality deteriorates. Thus, when it is the primary aim of a revenue-neutral ecological tax reform to improve the environmental quality, this policy is unsuccessful if the economy is characterized by high income taxes below the revenue-maximizing tax level. The revenue-neutral tax reform is too successful from an economic point of view to be recommended as an effective environmental policy. Within this intermediate interval of initial income taxes a double dividend fails to exist — not because of a failure of the employment dividend, but of the environmental dividend.

Only if the income taxes are sufficiently low, $0 < t_L < \bar{t}_0$, the revenue-neutral ecological tax reform will work the way it is supposed to: income taxes and gross wages decrease, thus boosting employment and improving environmental quality — hence, a double dividend can be obtained. Unfortunately, this is not the parameter range for which a double dividend is particularly attractive from a political point of view. Typically, politicians hope for a double dividend when the labor market is highly distorted through high labor taxes which depress employment.

Thus, the lesson to be learned from the present analysis is that, for non-competitive labor markets,[16] a double dividend can only be obtained for low-tax economies. Contrary to common belief, revenue-neutral ecological tax reforms cannot be recommended for high-income-tax countries. This is not to say that the consequence for the latter group is to abstain from green tax reforms, altogether. But high-tax countries should not insist on revenue neutrality, since this will endanger the ecological success of the green tax. Instead, a less than revenue-neutral decrease of the income taxes may provide both a better environment and a higher employment level.

6. Conclusion

To shed more light on the discussion of the double dividend, we investigated the consequences of a revenue-neutral ecological tax reform under different non-competitive labor-market scenarios. In order to ensure the robustness of our results we investigated three different labor-market models: the right-to-manage approach, the monopolistic union, and the efficient bargains between employers and the union. All of them provide the same qualitative results: For high-tax countries (high income and pay-roll taxes) there is, in our framework, no chance to obtain a double dividend, independent of the labor-market scenario: For those countries which are on the right (decreasing) branch of the labor-tax Laffer curve a revenue-neutral ecological tax reform, although successful in reducing pollution, fails to boost employment. For those high-tax countries which face the left (increasing) branch of the labor tax Laffer-curve, which we suppose is the most relevant interval, the reverse is true: employment increases, but the accompanying higher use of energy destroys the positive environmental effects one hopes to attain when pursuing a green tax reform. In the first case, the society has to pay for the improvement of environmental quality by

[16] Formally, even the case of a competitive labor market ($\mu = 0$) is included, but this is not the focus of our analysis.

a lower (overall) economic activity and thus by lower employment; in the second case, the revenue-neutral ecological tax reform is 'too successful' from an economic perspective to be recommend as a successful device of environmental policy. Only for low-tax countries a revenue-neutral green tax reform yields the effects one hopes for: a better environmental quality and higher employment. Unfortunately, from a political perspective, the high-tax countries are those which seek to alleviate their employment problems by means of revenue-neutral ecological tax reforms — but our analysis clearly indicates that there is little hope for this.

To conclude, it is not our purpose to campaign against environmental tax reforms, but rather to warn: although a green tax reform seems promising when dealing with the unemployment problem, a double dividend may nevertheless be out of reach since the environmental dividend can be lost. In particular for high-tax countries, it is precisely the positive economic effect, which helps to increase employment, that is responsible for higher pollutant emissions. However, this does not mean that politicians should abstain from ecological tax reforms. Instead, they should abandon revenue-neutrality. A green tax system should primarily be used for correcting prices; other tax instruments, for raising public funds and reducing labor-market distortions.

Appendix A

In order to justify our claim of a general-equilibrium framework, we provide here a simple characterization of the household sector that closes the model. Let each household's utility depend on two public goods — public consumption (G) and environmental quality (X) — on real income or, alternatively, on a private consumption good/bundle (Q), which is traded internationally at a given world market price, and on leisure (T). We interpret public consumption as goods that are publicly provided for all households, and which ensure a minimum standard of living.[17] Public consumption is financed by means of labor and energy taxation. So that the public budget constraint reads as $G = R$ (cf. equation (3)). Environmental quality is a measure which is inversely related to the aggregate of polluting activities, E. We assume preferences to be additively separable in public and private goods (including leisure),[18] so that we can define a household's utility as

$$w(G, X, Q, T) = v(G, X) + \tilde{u}(Q, T),$$

where the sub-utility functions v and $\tilde{u}$ are monotonically increasing, twice continuously differentiable, and concave in their arguments. For institutional reasons, households can supply only their complete allocatable time, $\bar{T}$, on the labor market, so that they are either unemployed with $\bar{T}$ units of leisure, or they have a job with 0 units of time left for additional leisure.[19] Moreover, laborer households can only consume the private consumption good if they earn some income: $Q = w(1 - t_L)$.

[17]Since we focus on a revenue-neutral tax reform and the public good is provided in favor of all households, the analysis applies to both pure public goods, which are non-rival and non-excludable, and publicly provided private goods. However, since they are provided in favor of all households, one would not regard them as unemployment benefits.

[18]The additive, or at least weak separability is a standard assumption in the literature. See, for example, Bovenberg and van der Ploeg (1996), Ligthart and van der Ploeg (1998), and Parry (1998) for the first category; Bovenberg and de Mooij (1994a,b) and Bovenberg and van der Ploeg (1996) for the second.

[19]Of course, a household's actual time for leisure exceeds $\bar{T}$, which is simply the 'normal' working time of a fully employed household.

Consequently, unemployed households with excess time but no private consumption have a private utility $\bar{U} := \tilde{u}(0, \bar{T})$. (We normalize $\bar{T}$ to unity.) Employed households, on the other hand, can consume private goods but have no allocatable time for leisure, so that their (private) utility is $u(Q) := \tilde{u}(Q, 0)$. Due to the fact that there are various factors that account for a disutility of working, households are only willing to give up leisure if $u(Q) > \bar{U}$. That is, there exists a reservation wage, defined as $\bar{w} := u^{-1}(\bar{U})/(1 - t_L)$, where households are indifferent between working and being unemployed (and able to consume public goods only).

Due to Walras' law the trade balance follows directly from the private budget constraints, $Q_L := QL = wL(1 - t_L)$ and $Q_M := \Pi$, and from the public budget constraint, $G = R$. This can easily be seen by adding up these three equations yielding $f(L, E) = Q_L + Q_M + G + (p_E - t_E)E$. This closes the general-equilibrium model discussed in the main text.

Appendix B

Throughout the paper we assume a Cobb–Douglas production function. Here we show that our comparative static results under efficient bargains (see Section 4.) are valid for any concave production function.

To investigate the consequences of a change of the government's fiscal policy tools under efficient Nash bargains, differentiate the equilibrium conditions of the labor market, equations (10) and (11). with respect to t_L and t_E using $E = e(p_E, L)$. This yields

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} dw \\ dL \end{bmatrix} = \begin{bmatrix} -a_{13} & b_1 \\ -a_{23} & b_2 \end{bmatrix} \begin{bmatrix} dt_L \\ dt_E \end{bmatrix},$$

where

$$
\begin{aligned}
a_{11} &:= -(1-t_L)^2(w-f_L)\,u'' \geq 0\,, \\
a_{12} &:= (1-t_L)\,(f_{LL}+f_{LE}(\partial E/\partial L))\;u' < 0\,, \\
a_{13} &:= -f_L\,u' + (1-t_L)w(w-f_L)\,u'' < 0\,, \\
a_{21} &:= 1\,, \\
a_{22} &:= (w-f_L)/L - (1-\mu)\,(f_{LL}+f_{LE}(\partial E/\partial L)) > 0\,, \\
a_{23} &:= 0\,, \\
b_1 &:= -(1-t_L)f_{LE}(\partial E/\partial p_E)\,u' > 0\,, \\
b_2 &:= -\mu(E/L) + (1-\mu)f_{LE}(\partial E/\partial p_E) < 0\,, \\
\Delta &:= a_{11}a_{22} - a_{12} > 0\,,
\end{aligned}
$$

provided that the income tax does not tax labor income fully away ($0 \leq t_L < 1$). According to equation (2), the term $f_{LL}+f_{LE}(\partial E/\partial L)$ equals $(f_{LL}f_{EE}-f_{LE}^2)/f_{EE}$ which is negative due to strict concavity of f. Solving this equation system for the desired derivatives yields

$$\frac{\partial w}{\partial t_L} = \frac{-a_{13}a_{22}}{\Delta} > 0\,, \tag{B.1}$$

$$\frac{\partial L}{\partial t_L} = \frac{a_{13}}{\Delta} < 0\,, \tag{B.2}$$

$$\frac{\partial w}{\partial t_E} = \frac{b_1a_{22}-b_2a_{12}}{\Delta} \gtreqless 0\,, \tag{B.3}$$

$$\frac{\partial L}{\partial t_E} = \frac{b_2a_{11}-b_1}{\Delta} < 0\,. \tag{B.4}$$

$$\frac{\partial wL}{\partial t_E} = \frac{-f_Lb_1+\mu Ea_{12}+wa_{11}b_2}{\Delta} < 0\,. \tag{B.5}$$

We get a slightly weaker result for the impact of t_L on aggregate wage income:

$$\frac{\partial wL}{\partial t_L} = \frac{a_{13}}{\Delta}\left(f_L\left[1+(1-\mu)\frac{Lf_{LL}}{f_L}\right]+(1-\mu)Lf_{LE}\frac{\partial E}{\partial L}\right) \gtreqless 0\,. \tag{B.6}$$

Yet, a sufficient condition for $\partial wL/\partial t_L$ to be negative is that the elasticity of the marginal product of labor exceeds $-(1-\mu)^{-1}$ (< -1).

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