WIFO
ÖSTERREICHISCHES INSTITUT
FÜR WIRTSCHAFTSFORSCHUNG

WORKING PAPERS

THE "EMPLOYMENT DOUBLE DIVIDEND" OF ENVIRONMENTAL TAX REFORM: AN OPEN QUESTION?

KURT KRATENA

147/2001

THE "EMPLOYMENT DOUBLE DIVIDEND" OF ENVIRONMENTAL TAX REFORM: AN OPEN QUESTION?

KURT KRATENA

WIFO Working Papers, No. 147
April 2001

E-mail address: Kurt.Kratena@wifo.ac.at
2001/109/W/

THE „EMPLOYMENT DOUBLE DIVIDEND“ OF ENVIRONMENTAL TAX REFORM: AN OPEN QUESTION ?

Kurt Kratena

Austrian Institute of Economic Research

P.O. Box 91 , A-1103 Vienna, AUSTRIA

Tel.: +43 1 7982601 246, Fax: +43 1 7989386

e-mail: Kurt.Kratena@wifo.ac.at

Abstract: This study deals with the ‚employment double dividend‘ of a tax shift from labour to energy. The current stage of the ‚critical view‘ on this issue derives such a dividend only under restrictive conditions. It is shown, that the issue of substitutability between energy and labour plays a major role than the ‚tax burden‘ arguments of the ‚critical view‘. An alternative general equilibrium model is set up with an integrated goods market to show additional channels of positive employment effects due to a reallocation of goods demand from imported energy to domestic non-energy goods.

Key words: environmental tax reform, double dividend, employment

JEL classification: Q4, E6, H2

Acknowledgments: The author would like to thank Terry Barker and Stefan Schleicher for very helpful comments and suggestions. The usual disclaimer applies.

Introduction

The economic impact of environmental tax reform has become the issue of theoretical as well as applied studies during the last decade. David Pearce (1991) has introduced the term of "double dividend" as a result of environmental tax reform. Generally speaking the notion of "double dividend" meant that shifting the tax burden from employment to natural ressources policymakers could improve environmental quality by internalizing external effects and at the same time boost employment by reducing the distortionary tax burden on labour. The current state of research can generally be described by an important amount of critical theoretical studies on the existence of a double dividend, which in the end leave it up to empirical analysis, if the theoretical conditions are fulfilled. The research has identified different aspects of multiple dividends accompanied with environmental tax reform, where on one side we find the general welfare double dividend and on the other side the 'employment double dividend' (s.: Bosello, Carraro, Galeotti (1999)). The debate on the welfare double dividend concentrated on the tax burden argument, i.e. if higher environmental quality can come 'for free' or if environmental taxation meant additional economic cost. As these early studies dealing with the double dividend issue often started from a first best setting, where all markets were in equilibrium, an increase in environmental quality implied costs in terms of reallocation of resources. Another aspect of this equilibrium assumption was that involuntary unemployment was ruled out and no 'employment double dividend' could be achieved.

This study only deals with the issue of the ‘employment double dividend’ induced by revenue neutral tax shifts from labour to energy. In order to deal with that issue in a meaningful way unemployment must not be ruled out. In the literature we find a ‘first stage’ of allowing for unemployment in the analysis of environmental tax reform without explicitly describing the causes of unemployment. An example for this stage is laid down in Bovenberg, van der Ploeg (1998a), where a non market clearing wage rate is assumed. Other recent studies on environmental tax reform as Schneider (1997), Bovenberg,van der Ploeg (1998b) deal with special features of labour markets and the causes of unemployment. Feed backs of labour market variables (e.g. wage rates) , which might change with environmental tax reform are integrated in the analysis in these studies. This additional development stage of environmental tax analysis puts the emphasis concerning employment effects on labour market mechanisms.

This study remains on the ‘first stage’ of analysis with unemployment due to a non market clearing wage rate, which might be motivated as in Bovenberg, van der Ploeg (1998a) by efficiency wage mechanisms or simply by the existence of distortionary labour taxation. The causes for unemployment are not the main issue as in Schneider (1997), Bovenberg,van der Ploeg (1998b), but nevertheless the framework does not rule out employment effects of environmental tax reform. In section 1 the Bovenberg, van der Ploeg (1998a) study is taken as a starting point for the ‘critical view’ on the employment double dividend of environmental tax reform. The ‘critical view’ derives positive employment effects only under very resrtictive conditions and only due to shifts of the tax burden to immobile factors (capital). I shall show that the results mainly depend on the

assumptions about cross substitutability or complementarity among the three factors energy, labour and capital. In a framework with fixed capital stock labour and energy must be substitutes, which also in the Bovenberg, van der Ploeg (1998a) model leads to positive employment effects. The role of tax burden shift effects as well as tax erosion effects compared to this substitutability/complementarity assumption are shown.

In section 2 an alternative general equlibrium model is lined out to show the various channels by which environmental tax reform with (not explicitly explained) unemployment might lead to an employment double dividend. The experience of recent empirical studies on environmental tax reform is taken as a starting point to identify new important model features. The studies of Barker (1999) as well as Conrad, Schmidt (1998) have shown, that in a macroeconomic framework environmental tax reform induces major changes in output as well as employment. The change in output is partly also determined by demand side reactions. As energy is also part of the demand side environmental tax reform leads to allocation effects on the goods demand side. These effects interact with the supply side effects on factor demand, which are generally treated in theoretical studies on environmental tax reform. Therefore employment changes might be the consequence of environmental tax reform due to (i) factor demand effects (substitution), (ii) changes in relative prices on the demand side leading to (iii) impacts on the level as well as the structure of goods demand.

The general equilibrium model allows to analyse these three components and their possible contribution to the ‘employment double dividend’ effect. In this general equilibrium model the direct impact of environmental tax reform on different prices, on the substitution of factors

in production and on goods demand can be derived. The goods demand effect is made up by a negative income effect due to higher demand prices and a positive substitution effect away from imported energy to domestic non – energy goods. This substitution effect has been largely neglected until now in theoretical work on environmental tax reform. At the same time the revenue neutrality condition of environmental tax reform in the public budget can be introduced as an additional restriction. Conditions for a positive employment effect can be formulated in terms of parameter values of the model.

The employment impact in the general equlibrium model is derived without any repercussions at the labour market, i.e. with a totally elastic labour supply. The reason for unemployment is an exogenously above market clearing level wage rate as in the Bovenberg, van der Ploeg (1998a) paper. The results in the general equilibrium model therefore can be directly compared to the Bovenberg, van der Ploeg (1998a) study. It can be shown, that in such a setting without feed backs of labour market variables (wage rates) environmental tax reform can be expected to lead to an increase in employment and – under certain circumstances – also to an increase in output. These results can be derived due to an appropriate integration of the goods demand side in the model.

1.The ‚critical view' on environmental tax reform

A sysnthesis of the current stage of the ‚critical' view is laid down in Bovenberg, van der Ploeg (1998a). In this model involuntary unemployment exists due to *exogenous* wages at a non market clearing level. In a note Bovenberg, van der Ploeg (1998a) suggest that such a wage level may be caused by an efficiency wage model, but they do not explicitly describe the factors behind this setting of the wage rate.

In the following the main arguments of the Bovenberg, van der Ploeg (1998a) study shall be discussed with slight changes in the notation and specification of functions. Bovenberg, van der Ploeg (1998a) describe a production function for gross output Y, from which factor demand for labour L and energy E can be derived for a given level of input of the fixed factor K. Profits are the income source of the fixed factor and the public sector faces some expenditure level G given by the availability of tax revenues from the three sources of factor taxation, so that the public budget is balanced. The model is closed on the macroeconomic side by private consumption absorbing household income.

(1.1) $Y = F(L, E, K)$

(1.2) $L = K\bullet\ (w_\tau, p_{E\tau})$

(1.3) $E = K\blacksquare\ (w_\tau, p_{E\tau})$

(1.4) $\Pi = Y - w_\tau L - p_{E\tau} E$

(1.5) $t_L wL + t_E p_E E + \tau\Pi = G$

(1.6) $C = wL + (1 - \tau)\Pi$

where

w is the wage rate and $w_\tau = (1 + t_L)w$

p_E is the net energy price and $p_{E\tau} = (1 + t_E)\, p_E$

t_E is the ad valorem energy tax rate

t_L is the payroll tax rate

Energy is an imported resource at world market price p_E and the wage rate w is also given exogenously. Bovenberg, van der Ploeg (1998 a) describe the derivatives of factor demand functions as:

$\delta\bullet / \delta w_\tau = \bullet_w = F_{RR}/\Delta \leq 0$

$\delta\bullet / \delta p_{E\tau} = \bullet_E = - F_{LR}/\Delta$

$\delta\blacksquare/\delta w_\tau = \blacksquare_w = - F_{LR}/\Delta$

$\delta\blacksquare/\delta p_{E\tau} = \blacksquare_e = F_{LL}/\Delta \leq 0.$

The derivatives of factor demand to the own price, i.e. $\delta\bullet / \delta w_\tau$ and $\delta\blacksquare / \delta p_{E\tau}$, both fulfill the minimum of microecomic theory restrictions, as they are negative. Bovenberg, van der Ploeg (1998a) leave it open, if in such a setting energy and labour are substitutes or complements, as the signs of $\delta\bullet / \delta p_{E\tau}$ and $\delta\blacksquare / \delta w_\tau$ are not well defined. It shall be shown here that (i) the results for the employment double dividend derived are highly sensitive to this assumption and (ii) in a setting with a short run fixed factor only substitutability between the variable factors makes sense with the consequence of an unambigously positive employment effect.

In the Bovenberg, van der Ploeg (1998a) setting there are three different forms by which the three production factors can be combined to produce output Y by introducing weak separability between them and forming a bundle out of two factors. This would mean, that (1.1) describes the long run production function of gross output Y , where the input of K also can be choosen by firms. On the other hand the factor demand functions (1.2) and (1.3) are clearly defined as bound to factor prices for L and E and *input quantity* of K, which corresponds to the usual treating of short run production and cost functions with a fixed factor. Important examples for this line of research mainly using flexible cost functions are Morrison (1989, 1990). The theoretical reasoning of the treatment of the capital stock as a fixed or quasi – fixed factor is the existence of a short and a long run cost function (s.: Thomsen (2000), who shows the relationship between these cost functions). In the short run (during one period) the capital stock is fixed and can only be adjusted in the next period. This adjustment process of the actual to some ‚optimum' or ‚desired' capital stock is governed by the relationship between the ‚shadow price' of the fixed factor (equal

to the cost saving effect of the fixed factor) and the market price. Inserting the ‚optimal' capital stock in the short term factor demand functions yields the long term factor demand functions (Thomsen (2000)), where the capital stock can adjust to factor price changes. Under certain not too restrictive conditions the sign of the short and the long term elasticities should also be the same, especially in the case of two variable factors (s.: the Appendix). The crucial point in the Bovenberg, van der Ploeg (1998a) paper therefore is an inconsistency between short and long term specification without an explicit long term specification shown. The analysis of environmental tax reform in the Bovenberg, van der Ploeg (1998a) paper on the other hand is carried out for the short run, as the input of the fixed factor is held *constant*. If K is kept constant the two variable factors E and L should be substitutes, so that $\bullet_E = \blacksquare_w \geq 0$. This corresponds to case (iii) of Bovenberg, van der Ploeg (1998a), where a bundle X of E and L are (long run) substitutes to the fixed factor K: Y = F (X(L,E), K). The corresponding elasticities in this case are given with:

$\varepsilon_{Lw} = \bullet_w w_\tau / \bullet \quad \leq 0$

$\varepsilon_{Ee} = \blacksquare_e p_\tau / \blacksquare \quad \leq 0$

$\varepsilon_{Le} = \bullet_e p_\tau / \bullet \quad \geq 0$

$\varepsilon_{Ew} = \blacksquare_w w_\tau / \blacksquare \quad \geq 0$

In analogy to Bovenberg, van der Ploeg (1998a) the factor demand functions can be written as:

(1.7) $L = \bullet_w w_\tau + \bullet_E p_{E\tau}$

(1.8) $E = \blacksquare_w w_\tau + \blacksquare_E p_{E\tau}$

Environmental tax reform is introduced by increasing the tax rate t_E by a quantity given by environmental targets and reducing the tax rate t_L to obtain a blanced budget, i.e. $\Delta G = 0$. We assume no changes in output Y brought about by changes in factor demand changes induced by environmental tax reform. For the case where E and L are substitutes, this means an elasticity of substitution of 1.

This yields:

(1.9) $\delta L = \bullet_w w\, \delta t_L + \bullet_E p_E\, \delta t_E$

(1.10) $\delta E = \blacksquare_w w\, \delta t_L + \blacksquare_E p_E\, \delta t_E$

The employment effect of environmental tax reform ($\delta t_L < 0$ and $\delta t_E > 0$) from (1.9) is clearly positive, *if L and E are substitutes, i.e.* $\bullet_w \leq 0$ *and* $\bullet_E \geq 0$. Equation (1.9) is analogous to equation (4a) in Bovenberg, van der Ploeg (1998a). It is important to note, that already at this stage without taking into account public budget repercussions

Bovenberg, van der Ploeg (1998a) only receive a restricted ‘employment double dividend’ whereas in the case presented here there is clearly an ‘employment double dividend’.

The model is not presented in rates of change of a variable X (i.e.: $\delta X/X$) as in Bovenberg, van der Ploeg (1998a), but in partial derivatives (δX) assuming that we look at marginal changes, where for example $\Delta(t_L wL) = (\delta t_L wL + \delta L w t_L)$. As government expenditure must not change ($\Delta G = 0$), we get for the budget balance condition (in analogy to Bovenberg, van der Ploeg (1998a)):

$$(1.11)\quad (1 - \tau)\,(\delta t_L wL + \delta t_E p_E E) + \delta L(wt_L - \tau w_\tau) + \delta E(p_E t_E - \tau p_{E\tau}) = 0$$

The energy input E decreases due to environmental tax reform, so that the environmental target can be reached. Bovenberg, van der Ploeg (1998a) discuss the ‘tax erosion effect’ arising from that.

The next step is again as in Bovenberg, van der Ploeg (1998a) inserting the factor demand changes in the environmental tax reform case ((1.9) and (1.10)) in the public budget restriction (1.12). This yields for the employment tax rate:

$$(1.12)\quad \delta t_L = -\delta t_E\,[(1 - \tau)\,p_E E + \bullet_E\, p_E(wt_L - \tau w_\tau) + \blacksquare_E p_E(p_E t_E - \tau p_{E\tau})\,] \;/\; \Delta^*$$

with $\Delta^* = [(1 - \tau)wL + \bullet_w w(wt_L - \tau w_\tau) + \blacksquare_w w(p_E t_E - \tau p_{E\tau})]$

From (1.12) we see that an increase in the tax rate for energy (δt_E) decreases the equilibrium employment tax rate via additional tax receipts, if the term Δ^* as well as the term $[(1 - \tau) p_E E + \bullet_E p_E(wt_L - \tau w_\tau) + \blacksquare_E p_E(p_E t_E - \tau p_{E\tau})]$ are positive. This is the case, if the profit tax rate is small enough compared at least to the labour tax rate or also to the energy tax rate. This condition is a necessary prerequisite for environmental tax reform and is equivalent to the same assumption Bovenberg, van der Ploeg (1998a) derive from their equation (6), which is the analogue to (1.12). The opportunity of a reduction in the labour tax rate when the energy tax rate is increased just reflects, that the economy is on the upward-sloping parts of the Laffer curves for both the energy and the employment tax.

Reinserting in the factor demand function for labour (1.9) with environmental tax reform we get the expression for the equilibrium employment effect:

(1.13) $\delta L = [(1 - \tau)(\bullet_E p_E L - \bullet_w p_E E) - (p_E t_E - \tau p_{E\tau}) p_E \Lambda_{wE}] w\delta t_E / \Delta^*$

with Δ^* as above and

$\Lambda_{wE} = \bullet_w \blacksquare_E - \bullet_E \blacksquare_w$.

This expression corresponds to equation (8) in Bovenberg, van der Ploeg (1998a) and has the same structure. The first term also represents a ‘tax shift’ effect, which is clearly positive and reflects the increase in labour demand due to lower labour costs. Lower labour costs *ceteris paribus* raise profit income and taxes from profits, which allows for a lower

equilibrium payroll tax rate with higher employment. The tax burden is shifted to the fixed factor through this effect and therefore away from energy.

Bovenberg, van der Ploeg (1998a) classify the second term, which is similar to the one derived in (1.13) as a tax burden effect of higher environmental taxes, where $\Lambda_{wE} = \bullet_{w}\blacksquare_{E} - \bullet_{E}\blacksquare_{w}$ and for small enough values of the profit tax rate ($p_E t_E - \tau p_{E\tau}$) would be positive. Bovenberg, van der Ploeg (1998a) state that due to concavity of the production function $\bullet_{w}\blacksquare_{E} - \bullet_{E}\blacksquare_{w}$ must be positive. Microeconomic theory on the other hand states that in the two factor case the cross price elasticities must sum to zero, which means $\bullet_{w}(w_\tau/L) = -\blacksquare_{w}(w_\tau/E)$ as well as $\bullet_{E}(p_{E\tau}/L) = -\blacksquare_{E}(p_{E\tau}/E)$. If the economy is equally labour and energy intensive (L = E), then Λ_{wE} would be zero. This also corresponds to the proposition, that in such an economy a decrease in the labour tax rate had an equivalent positive tax reduction effect as had an increase in the energy tax. We would in any case expect Λ_{wE} to be small and the tax burden effect therefore to be rather small and not sufficiently high to offset the positive tax shift effect on employment.

The tax burden effect contains the main argument of the ‘critical view’ on environmental tax reform, namely the higher cost for energy, which are in this case passed on partly to the profit income accruing to the fixed factor. In a case where L and E were complements, the employment effect of environmental tax reform would become ambigous, as no positive employment impact from cross substitution can be expected. In this case also the tax shift effect $(1 - \tau)(\bullet_{E} p_E L - \bullet_{w} p_E E)$ would be small. It is the mix of the tax shift and the tax burden effect, that decides on the employment double dividend of environmental tax reform in this model.

The assumption about the substitutability of E and L therefore is a crucial point for the results derived. It is not the 'tax burden' effect alone, on which Bovenberg, van der Ploeg (1998a) put the emphasis, which leads to ambigous results on the employment double dividend. This can be seen by comparing the *ceteris paribus* employment effect of equation (1.9) in this study (without taking into account budget restrictions feedbacks) with equation (4a) in the Bovenberg, van der Ploeg (1998a) study. The main argument here was an inconsistency between a short term perspective with a constant fixed factor input and different types of seperable long run production functions. The restrictions on the parameters would decide, if short run substitutes can become long run complements, which in the two variable factors case is highly unprobable. In any case the implicit long run function must be derived in a consistent way together with the short run function, which makes the introduction of an explicit formulation as e.g. the Generalized Leontief cost function necessary (see: Thomsen (2000)). The introduction of the budget balance restriction does not change the importance of substitutability.

2. A general equilibrium model: production, input demand and goods demand

To deal with environmental tax reform a general equilibrium model framework is set up here, which integrates important model features known from recent empirical studies. This framework shall allow to determine input demand (labour and energy) and output for *given wages and energy prices including payroll taxes and energy taxes* respectively. I start from the dual cost function approach with a Generalized Leontief short run cost function (SC), which can be seen as a flexible form without excessively restricting parameters a priori. The factor inputs *i* are labour (L) and energy (E) with the corresponding prices p_i and gross output, Y:

$$(2.1)\quad SC = Y \sum_{ij} \alpha_{ij} (p_i p_j)^{1/2} \qquad i = L, E$$

With Shephard's lemma ($\delta SC/ \delta p_i$) the input demand equations are derived :

$$(2.2)\quad (L/Y) = \alpha_{LL} + \alpha_{LE} (p_E (1 + t_E)/w(1 + t_L))^{1/2}$$

$$(2.3)\quad (E/Y) = \alpha_{EE} + \alpha_{LE} (w(1 + t_L)/p_E(1 + t_E))^{1/2}$$

where the variables are defined as above.

The symmetry restriction in the Generalized Leontief cost function implies : $\alpha_{LE} = \alpha_{EL}$. For ‚normal' reactions in factor demand we have $\alpha_{EL} > 0$ and we would also assume that $\alpha_{LL}, \alpha_{EE} > 0$. This means that *L and E are substitutes in the short run*. If we write for the tax including factor prices w_τ and $p_{E\tau}$ respectively we have that : $\delta(L/Y)/\delta w_\tau < 0$, $\delta(L/Y)/\delta p_{E\tau} > 0$, $\delta(E/Y)/\delta w_\tau > 0$, $\delta(E/Y)/\delta p_{E\tau} < 0$. So the kind of employment taxation dealt with is a payroll tax on the gross wage, which raises the producer wage. Included in the wage rate w there might be some income tax rate, which is not explicitly modelled and which is not analysed as a venue of revenue recycling of the environmental tax.

Factor demand is determined by the supply side in a perefect competition goods market, where profit maximizing firms set the output price p equal to marginal costs ($\delta SC/\delta Y$):

$$(2.4)\quad p = \Sigma\, \alpha_{ij}\, (p_i\, p_j)^{½} \;=\; \alpha_{LL}\, w_\tau + \alpha_{EE}\, p_{E\tau} + \; 2\, \alpha_{LE}\, (w_\tau\, p_{E\tau})^{½}$$

Writing for $\delta p/\delta w_\tau \;=\; \varepsilon_{pw}$ and for $\delta p/\delta p_{E\tau} = \varepsilon_{pE}$, we have : $\varepsilon_{pw} > 0$ as well as $\varepsilon_{pE} > 0$.

Extending the model to the long run (s.: Appendix) does not change the important properties of substitutability between L and E and is therefore not followed. On the other hand the implicit integration of a fixed factor plays a role on the income side, as Bovenberg, van der Ploeg (1998a) have shown possible shifts of the tax burden on profits. This income aspect of the fixed factor shall be kept in the analysis. The definition of gross output is given as in National Accounts from the ‚cost side' with:

$$(2.5) \qquad pY = p_{E\tau} E + w_\tau L + \Pi$$

where Π = profits and $GDP = w_\tau L + \Pi$.

The demand side of the economy consists of energy and non – energy goods and services with total nominal household demand Q and household energy consumption E_c: $Q = pY + p_{E\tau}E_c$. An implicit price index p* for Q exists, described by a simple weighted average with the π_i as weights of energy and non – energy in total demand :

$$(2.6) \qquad p^* = \pi_Y p + \pi_E p_{E\tau}$$

Energy appears in production as an input and in consumption as a category, so that total energy use of the economy is $E + E_c$, which is imported at the world market price

p_E and charged with the energy *ad valorem* tax. Leaving out macroeconomic closure means that all model analyses are carried out under the restriction of a constant nominal demand side, Q, i.e. *ex post* revenue neutral tax reform does not change nominal demand.

A demand function for Y can now be added to the model, where the output level (Y) depends on total *real* household income with an implicit income elasticity ($\eta_1>0$) and on the relative output price (p*/p) with an implicit price elasticity ($\eta_2>0$) :

(2.7) $$Y = \eta_1 (Q/p^*) + \eta_2 (p^*/p)$$

As total energy demand ($E + E_c$) is imported a substitution between energy and non - energy goods or between energy and labour has a c.p. positive impact on domestic output and/or employment. An unambigously effective energy taxation to reduce CO_2 emissions must fulfill : $\delta E/\delta p_{E\tau} < 0$ as well as $\delta E_c/\delta p_{E\tau} < 0$. These conditions imply that as in production the after tax energy price affects the input *coefficient* E/Y, the negative substitution effect on this coefficient ($\delta(E/Y)/\delta p_{E\tau}$) must dominate the possible positive output effect from a substitution away from energy products in demand ($\delta Y/\delta p_{E\tau}$). The public sector budget constraint is an important condition to derive the mechanisms of environmental tax reform. Exogenously given public expenditure G must be financed by the sum of energy tax revenues $t_E(E + E_c)$, employment tax

revenues $t_L wL$ and taxes on profits $\tau\Pi$. Private energy use E_c is also taxed, so that part of the tax burden is on households.

(2.8) $G = t_E p_E (E + E_c) + t_L wL + \tau\Pi$

This system of factor demand equations, price equations, the demand equation and the public budget constraint determine energy and labour demand for production simultaneously with the price and output level for given wages, energy prices, tax rates and total nominal income Q.

3. Environmental tax reform

Environmental tax reform is introduced by rising the energy tax rate t_E to a point, where a certain target of CO_2 emissions reduction is achieved and reducing the payroll tax rate t_L in an amount that revenue neutrality for the public sector holds. If social security contributions are reduced as is assumed in most studies (Conrad, Schmidt (1998), Barker (1999)) there is a first level incidence between firms and households, where neutrality is only guaranteed, if employees and employers contributions are reduced. If only employers contributions are reduced, all of the revenue recycling accrues to firms, although households have to pay part of the revenues. As Bovenberg, van der Ploeg (1998a) have pointed out, Laffer curves for employment tax as well as energy tax revenues must exist, so that one can assume to start at the increasing part of the Laffer curve. An erosion of the tax base means that E/Y and E_c/Y both decrease together with an increase in t_E, so that the possible reduction of the employment tax rate becomes smaller.

This model so far enables only to demonstrate the impact on employment with fixed wages, which implies totally flexible labour supply as the Bovenberg, van der Ploeg (1998a) study. Employment double dividend requires that $\delta L/\delta w_\tau > 0$ and at the same time $\delta L/\delta p_{E\tau} > 0$. In this study I first analyse the employment effects of a simultaneous

change in the gross factor prices (- δw_τ and + $\delta p_{E\tau}$) and then in a second step take into account revenue neutrality condition.

The model outlined allows us to differentiate between *price effects*, *goods demand effects* and *factor substitution effects* induced by the two factor price changes – δw_τ and + $\delta p_{E\tau}$. These factor price changes are by themselves functions of the tax rates t_E and t_L, as $\delta p_{E\tau}/\delta t_E = p_E$ and $\delta w_\tau/\delta t_L = w$.

The price effects ($\delta p/\delta w_\tau$, $\delta p/\delta p_{E\tau}$, $\delta p^*/\delta w_\tau$, $\delta p^*/\delta p_{E\tau}$)

Both factor prices have a direct impact on the output price p given by the marginal cost equation : $\delta p/\delta w_\tau = \varepsilon_{pw}$ and $\delta p/\delta p_{E\tau} = \varepsilon_{pE}$ with $\varepsilon_{pw} > 0$ and $\varepsilon_{pE} > 0$. The influence on the implicit price index of demand is given with:

$$(1.24) \qquad \frac{\delta p^*}{\delta w_\tau} = \frac{\delta p}{\delta w_\tau}\,\frac{\delta p^*}{\delta p} = \varepsilon_{pw}\,\pi_Y$$

$$(1.25) \qquad \frac{\delta p^*}{\delta p_{E\tau}} = \frac{\delta p}{\delta p_{E\tau}}\,\frac{\delta p^*}{\delta p} = \varepsilon_{pE}\,\pi_Y + \pi_E\,.$$

The effect of an energy price increase on the implicit price of total demand is expected to be higher than the impact on the output price, because energy is part of the consumption bundle of households. This can be also seen from the relatively large impact of energy tax reform on the consumer price index in empirical studies (e.g. Conrad, Schmidt (1998)).

The goods demand effects ($\delta Y/\delta w_\tau$, $\delta Y/\delta p_{E\tau}$)

The price effects can be directly used to derive the goods demand effects of $-\delta w_\tau$ and $+\delta p_{E\tau}$. The output effects are indirect impacts brought about by the price changes.

$$(1.26)\quad \frac{\delta Y}{\delta w_\tau} = \frac{-\eta_1 Q\, \varepsilon_{pw}\, \pi_Y}{p^{*2}} + \frac{\eta_2\, \varepsilon_{pw}\, (\pi_Y p - p^*)}{p^2} < 0$$

This expression is unambigously negative, as $p^* > \pi_Y p$, so that $(\delta Y / -\delta w_\tau) > 0$ and the decrease in the producer wage c.p. increases goods demand, which is a trivial result. The first term in (1.26) measures the income effect caused by a change in p* and the second term the substitution effect between energy and non – energy goods. As the wage cost decrease lowers p by ε_{pw} and p* only by $\varepsilon_{pw}\, \pi_Y$ demand shifts to non – energy goods.

$$(1.27)\quad \frac{\delta Y}{\delta p_{E\tau}} = \frac{-\eta_1 Q\,(\varepsilon_{pE}\pi_Y + \pi_E)}{p^{*2}} + \frac{\eta_2\,\varepsilon_{pE}\,(\pi_Y p + \pi_E p - p^*)}{p^2}$$

The first term in expression (1.27) again measures the income effect and is unambigously negative, whereas the second has a positive sign, since $p^* = \pi_Y p + \pi_E p_{E\tau}$ and from (2.4) $p_{E\tau} < p$ so that $p^* < \pi_Y p + \pi_E p$. This second term just measures the substitution effect away from energy in consumption, if the energy price increases and has a positive impact because *imported* energy is substituted by domestic output. In earlier theoretical studies this effect has been almost completly neglected, but has become an important feature in empirical studies for the European Union, where external trade is explicitly modelled (Barker (1999), Conrad, Schmidt (1998)). For the output effect (expression (1.27)) to be positive the substitution from energy to non – energy goods and services must outweigh the negative income effect from an increase in the general price level p* brought about by an increase in the energy price $p_{E\tau}$. If this condition holds an environmental tax reform has an overall positive impact on the output level, which already would suffice to guarantee a positive employment reaction. The core of the argument on *costs of environmental tax reform* is the first term in (1.27), which states that the economy has to pay higher energy costs for given resources, which

means an economic loss of welfare like is demonstrated in the studies showing the non – existence of a „double dividend“.

The factor substitution effect ($\delta(L/Y)/\delta(p_{E\tau}/w_\tau)$)

Environmental tax reform simultaneously influences the wage rate and the energy price and changes the relative price of energy and labour. So at least the overall impact on the labour input coefficient can be directly expressed in relation to the change in the relative price ($p_{E\tau}/ w_\tau$) :

$$(1.28)\quad \frac{\delta (L/Y)}{\delta(p_{E\tau}/ w_\tau)} = \tfrac{1}{2}\,\alpha_{LE}\,(p_{E\tau}/ w_\tau)^{-\frac{1}{2}} > 0$$

This expression can be used now together with the positive expression for the output effect of the wage costs reduction ($\delta Y/ -\delta w_\tau$) and the output effect of the energy cost increase ($\delta Y/\delta\ p_{E\tau}$) to assess the overall employment impact of environmental tax reform (Δ L). So the critical point in these three expressions lies in the energy cost induced output effect and therefore in the cross price elasticity between energy and non – energy consumption.

$$(1.29)\ \Delta L/(\delta w_\tau\ \delta p_{E\tau}) = \frac{\delta (L/Y)}{\delta(p_{E\tau}/ w_\tau)} Y + \frac{L}{Y}\left[\frac{\delta Y}{-\delta w_\tau} + \frac{\delta Y}{\delta p_{E\tau}}\right]$$

Inserting (1.26) to (1.28) into (1.29) and rearranging we get the explicit expression for the employment effect:

$$(1.30)\ \Delta L/(\delta w_\tau\ \delta p_{E\tau}) = [½\,\alpha_{LE}\,(p_{E\tau}/ w_\tau)^{-½}]\,Y + \frac{L}{Y}\left[\frac{\eta_1 Q(\pi_Y\,(\varepsilon_{pw} - \varepsilon_{pE}) - \pi_E)}{p^{*2}}\right] +$$

$$+ \frac{L}{Y}\left[\frac{[\eta_2\,(\pi_Y p - p^*)]\,(\varepsilon_{pE} - \varepsilon_{pw}) + \eta_2\,\varepsilon_{pE}\,\pi_E\,p}{p^2}\right]$$

In (1.30) within the goods demand effects (δY) the price induced income effect and the substitution effect (energy/non – energy) of both factor price changes ($\delta p_{E\tau}$ and $-\delta w_\tau$) have been summarized in two terms. It becomes obvious now, that the price induced

income effect must be negative, even if domestic price effects of energy tax increase and payroll tax cuts (ε_{pw} - ε_{pE}) would balance out, because energy is also a consumption category. The substitution effect can outweigh the income effect for large enough values of the parameter η_2.

The analysis with the help of these partial derivatives has not taken into account the equilibrium condition of revenue neutrality (1.23). The main difference to the Bovenberg, van der Ploeg (1998a) model is the consumption part of energy, that is also taxed. Therefore part of the tax burden of firms is shifted to consumers. On the other hand, if the payroll tax for employers as well as employees is reduced, revenue recycling not only accrues to firms. It may be noted that this conclusion is due to the simlple incidence in this model, where wage repercussions due to employment taxation are excluded.

Transforming (1.23) as before yields for the public budget restriction in the case of environmental tax reform (with $\Delta G = 0$) :

$$(1.31)\ (1 - \tau)\ (\delta t_L wL + \delta t_E p_E E) + \delta L(wt_L - \tau w_\tau) + \delta E(p_E t_E - \tau p_{E\tau}) + \delta t_E p_E E_c + \delta E_c p_E t_E$$
$$+ \tau(\delta pY + \delta Yp) = 0$$

The main difference to (1.11) above stems from additional energy tax receipts out of households energy consumption E_c and from additional profit tax receipts out of

(positive) output effects. The real output effect δYp consists of two different impacts of environmental tax reform on the demand side, namely an aggregate price induced negative income effect and a relative prices induced positive substitution effect.

In general in this framework the labour tax rate can be decreased more than in the model presented in the last section due to these additional features on tax receipts. This yields a different equilibrium labour tax rate equation :

$$(1.32)\quad \delta t_L = \frac{-\delta t_E\,[p_E E + p_E E_c + \tau p_E E] - \delta L(w t_L - \tau w_\tau) - \delta E(p_E t_E - \tau p_{E\tau}) - \delta E_c p_E t_E - \tau(\delta pY + \delta Yp)}{[wL(1-\tau)]}$$

One could now further insert the labour demand equation (1.30) and an analogous energy demand equation in (1.32) in order to derive the explicit function for t_L. On the other hand (1.32) suffices to show the main differences between this model and the model presented in the last section.

It becomes clear now, that energy taxation on households creates another tax shift effect, which increases the potential for the payroll tax cut. If we assume that employment taxation exists also in the form of employees contribution, then the gross wage rate w_τ must be assumed as partly fixed, so that an employment tax cut increases the wage income component $w_\tau(1 - t_L)L$ of household income and compensates for

energy taxation on households. If only the payroll tax rate for employers is reduced with environmental tax reform, we have a tax shift effect between firms and households. Labour costs in this case can be decreased by a larger amount than the energy taxes of firms, so that part of the labour cost decrease is passed on to employees. This on the other hand increases the employment double dividend of environmental tax reform.

In any case an additional source of a payroll tax decrease and therefore of an employment double dividend are tax receipts from the output effect $\tau(\delta pY+\delta Yp)$. Starting from the cost function and including the price equation in this model helps to decompose effects into supply side and demand side impacts. The output prices are not expected to rise significantly through environmental tax reform, because energy price effects are compensated by lower labour costs. The real output effect δYp might be an additional source of tax receipts. As lined out above, this effect is the balance of a negative real demand effect (higher prices) and a positive substitution effect between energy and non – energy commodities. The results of recent empirical studies (Conrad, Schmidt (1998), Barker (1999)) partly deliver evidence in favour of a positive output effect, which makes a higher payroll tax cut and therefore employment double dividend results more probable.

Conclusions

This paper started from the ‚critical view' on environmental tax reform in models with unemployment without explicitly dealing with labour market issues. The main characteristics of the production side is a three factor (labour, energy, capital) model with the capital stock as a quasi-fixed factor. It was shown, that the assumption about substitutability or complementarity between labour and energy might play a more important role than the issues of tax burden and revenue neutrality. If labour and energy can be complements as in Bovenberg, van der Ploeg (1998a) no cross substitution effects occur and the ‚employment double dividend' becomes doubtful even without tax burden effects and the reveue neutrality implications. On the other hand the results of recent empirical studies suggest a positive employment and even a positive output effect of environmental tax reform. An important model feature that contributes to these results is a substitution effect on the demand side between *imported* energy and domestic non-energy goods, which has been integrated in a small general equilibrium model, where labour and energy are substitutes. In such a setting a positive employment effect of environmental tax reform also under the condition of revenue neutrality becomes probable due to a possibly positive output effect.

The main conclusion is that without labour market feedbacks the employment effect of environmental tax reform only becomes doubtful under rather restrictive assumptions. Possible labour market feedbacks of environmental tax reform in a framework with an integrated labour market seem a promising field of further research .

Appendix

The model here can easily be enlarged by including a fixed factor, which does not change the short run substitutability between L and E:

$$(A1)\ SC = Y \sum_{ij} \alpha_{ij} (p_i\, p_j)^{½} + Y^{½} \sum_{i} \beta_{ik} (p_i\, K)^{½} + \sum_{i} p_i\, \gamma_{KK} K \qquad i = L, E$$

For short run factor demand including the fixed factor we get now:

$$(A2)\ (L/Y) = \alpha_{LL} + \alpha_{LE} (p_{E\tau}/w_{\tau})^{½} + \beta_{LK} (K/Y)^{½} + \gamma_{KK} (K/Y)$$

$$(A3)\ (E/Y) = \alpha_{EE} + \alpha_{LE} (w_{\tau}/p_{E\tau})^{½} + \beta_{EK} (K/Y)^{½} + \gamma_{KK} (K/Y)$$

The substitution between these variable factors only depends on the parameter α_{LE}, which is assumed to be positive in order to guarantee ‚normality' in terms of microeconomic theory, i.e. negative own price elasticities of factor demand. The usual concept of a fixed factor allows to derive a shadow price p_K^* for this factor, which equals the impact of one quantity input of this factor on short run cost (Thomsen (2000)), $= p_K^* - \delta G/\delta K$:

$$(A4) \quad p_K^* = -\tfrac{1}{2}(K/Y)^{-\frac{1}{2}}(\beta_{LK} w_\tau + \beta_{EK} p_{E\tau}) - \gamma_{KK}(w_\tau + p_{E\tau})$$

It must be noted that in this formulation a positive shadow price for the fixed factor requires, that it decreases short run costs, so that $\beta_{LK} < 0$, $\beta_{EK} < 0$ and $\gamma_{KK} < 0$. If a market price p_K of the fixed factor is available, in equilibrium this market price would be equal to the shadow price, which then allows to derive the ‚optimal' capital stock , K* (Thomsen (2000)):

$$(A5) \quad K^* = 0.25\, Y \frac{(-\beta_{LK} w_\tau - \beta_{EK} p_{E\tau})^2}{(p_K + \gamma_{KK}(w_\tau + p_{E\tau}))^2}$$

This allows to derive consistent long run factor demand functions. The actual capital stock could adjust according to some mechanism to the optimal stock. Another way is to directly introduce the optimal capital stock derived in (1.19) into the short run factor demand functions. This gives:

$$(A6) \quad (L^*/Y) = [\alpha_{LL} + \alpha_{LE}(p_{E\tau}/w_\tau)^{\frac{1}{2}} + 0.5\,\beta_{LK}((\beta_{LK} w_\tau + \beta_{EK} p_{E\tau})/(p_K + \gamma_{KK}(w_\tau + p_{E\tau}))) + 0.25\,\gamma_{KK}((\beta_{LK} w_\tau + \beta_{EK} p_{E\tau})^2/(p_K + \gamma_{KK}(w_\tau + p_{E\tau}))^2)]$$

(A7) $(E^*/Y) = \alpha_{EE} + \alpha_{LE} (w_\tau/p_{E\tau})^{1/2} + 0.5\ \beta_{EK} ((\beta_{LK} w_\tau + \beta_{EK} p_{E\tau}) /(p_K + \gamma_{KK} (w_\tau + p_{E\tau}))) + 0.25\ \gamma_{KK} ((\beta_{LK} w_\tau + \beta_{EK} p_{E\tau})^2 /(p_K + \gamma_{KK} (w_\tau + p_{E\tau}))^2)$]

Writing for $(\beta_{LK} w_\tau + \beta_{EK} p_{E\tau}) /(p_K + \gamma_{KK}(w_\tau + p_{E\tau})) = x_k^*$ we can derive the reaction in the long run factor demand L* and E* to factor prices. It can be shown, that to fulfill negative own price reactions, i.e. $\delta L^*/\delta w_\tau < 0$, the short run elasticities must compensate the additional terms in L* coming from $\delta x_k^*/\delta w_\tau$. Therefore the long run elasticities are not different in sign from the short run and L and E stay substitutes in the long run if they are in the short run.

References

Barker, T., (1999), Achieving a 10% cut in Europe‘s CO2 emissions using additional excise duties: multilateral versus unilateral action using an E3 model for Europe, *Economic Systems Research* 1999 (11) 401 - 421

Bosello, F., Carraro, C., Galeotii, M., (1999), The double dividend issue: modelling strategies and empirical findings, *CEPR Discussion Paper* No. 2117, April 1999

Bovenberg, A.L., van der Ploeg, F., (1998a),Consequences of environmental tax reform for unemployment and welfare, *Environmental & Ressource Economics*, 12, 1998, 137 - 150

Bovenberg, A.L., van der Ploeg, F., (1998b), Tax reform, structural unemployment and the environment, *Scandinavian Journal of Economics*, 100, 1998, 593 - 610

Conrad, K., Schmidt, T.F., (1998), Economic effects of an uncoordinated versus a coordinated carbon dioxide policy in the European Union: An applied general equilibrium analysis, *Economic Systems Research*, 10(2), 1998, 161 – 182

Goulder, L.H., (1994), Environmental taxation and the double dividend: A reader’s guide, *International Tax and Public Finance*, 2, 1994, 157 – 183

Koeppl, A., Kratena, K., Pichl, C., Schebeck, F., Schleicher, St., Wueger, M., Macroeconomic and Sectoral Effects of Energy Taxation in Austria, in: *Environmental & Ressource Economics*, (8) 4,1996, 417 – 430

Morrison, C.J. (1989), Quasi – Fixed Inputs in U.S. and Japanese Manufacturing: A Generalized Leontief Restricted Cost Function Approach, *The Review of Economics and Statistics*, 70, 275 – 287

Morrison, C.J. (1990), Decisions of Firms and Productivity Growth with Fixed Input Constraints: An Empirical Comparison of U.S. and Japanese Manufacturing, in: Hulten,C., (ed.), Productivity Growth in Japan and the United States, University of Chicago Press, 135 – 172

Pearce, D.W., (1991), The role of carbon taxes in adjusting to global warming, *Economic Journal*, 101, 1991, 938 - 948

Schneider, K., (1997), Involuntary unemployment and environmental policy: the double dividend hypothesis, *Scandinavian Journal of Economics*, 99, 1997, 45 - 59

Thomsen, Th., (2000), Short cuts to dynamic factor demand modelling, *Journal of Econometrics*, 97, 2000, 1 - 23

Medieninhaber (Verleger), Hersteller: Österreichisches Institut für Wirtschaftsforschung • Wien 3, Arsenal, Objekt 20 • A-1103 Wien, Postfach 91 • Tel. (43 1) 798 26 01-0 • Fax (43 1) 798 93 86 • http://www.wifo.ac.at/ • Verlags- und Herstellungsort: Wien

Verkaufspreis: ATS 100,00 bzw. EUR 7,27