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„Should high-tax countries pursue revenue-neutral ecological tax reforms?" : A Comment

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Introduction

In a recent paper on ecological tax reform Thorsten Bayindir-Upmann and Matthias G. Raith (2003) analyse the impact of revenue neutral ecological tax reforms on the labour market and on the environment in a model of production and labour market equilibrium according to three different models of wage bargaining. The main innovation in the results compared to the existing literature is that the double dividend fails, not because of a lacking positive employment effect, but because of a negative impact on the environment (loss of the first dividend): '*For those high-tax countries facing the increasing branch of the labor-tax Laffer curve, which in our view 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*.' (p.59)

In the following I will show, that the surprising and counter-intuitive results of the Bayindir-Upmann,Raith – model are very specific for marginal tax reforms, when no energy tax exists and labor taxes are at the Laffer curve maximum. The results are based on Laffer curve effects under the condition of revenue neutrality and are valid within a limited space of energy tax rates. The fact that Bayindir-Upmann,Raith (2003) also derive ambigous results concerning the double dividend without imposing revenue neutrality is due to the assumption of a Cobb-Douglas production function ignoring cross price effects.

Starting from the Bayindir-Upmann,Raith approach, I will first show that for the 'normal' microeconomic case with cross price effects, the factor price changes brought about by ecological tax reforms will very probably allow a double dividend. Then I will show in a numerical example with the same parameter values as in Bayindir-Upmann,Raith (2003), how taking into account revenue neutrality might pose a problem for the first dividend within a certain (limited) range of energy and labor tax rates. The result of the lost first dividend therefore is not a general one derived from a theoretical model, but a specific one depending on existing tax rates and parameter values. In the numerical model as lined out by Bayindir-Upmann,Raith (2003) an effective environmental tax reform with double dividend can easily be implemented, although this might be seen as a major tax reform.

Factor demand, the labour market and revenue neutrality

Starting point is the model of production suggested by Bayindir-Upmann ,Raith (2003), characterized by the following profit function, with Π as profits, the two inputs labour, L and energy, E, and the corresponding factor prices (w as wage rate and p_E as after tax energy price) and output determined by the production function $f(L,E)$:

$$\Pi = f(L,E) - wL - p_E E \qquad (1)$$

Bayindir-Upmann ,Raith (2003) state that they assume a 'sequential' structure of production, where employment and the wage rate are first determined on the labour market and then the profit maximizing level of energy is chosen, so that $L = l\ (w)$ and $E = e\ (L,\ p_E)$. Therefore a higher level of labour input is associated with a higher energy input due to a higher output level.

The labour market equilibrium is described in three different forms of wage bargaining according to Creedy,McDonald (1991), where workers aim at a constant consumer net wage $Q = (1 - t_L)\, w$. I will concentrate in the following on the 'right to manage' bargaining model, where the implicit wage rate is given by a constant Q following from the constant 'elasticity of workers´ excess utility'.

The explicit function chosen by Bayindir-Upmann,Raith (2003) in a next step for $f(L,E)$ is Cobb-Douglas, which is not fully consistent with the assumption of the two stage production decision (as will be shown). The production function is written as:

$$f(L,E) = \alpha_0 L^{\alpha 1}\, E^{\alpha 2} \qquad (2)$$

with $\overline{K}$ as a fixed factor ($\alpha_0 = \tilde{\alpha}_0 \overline{K}^{\alpha_3}$) and linear homogeneity for all factors $\alpha_1+\alpha_2+\alpha_3 = 1$, i.e. decreasing returns to scale in L and E for any given K. On the other hand Bayindir-Upmann,Raith (2003) close their model from the demand side by introducing the public sector with a given level of expenditure G and revenues R from a (ad valorem) labour (income) tax with tax rate t_L and a commodity tax on energy t_E: $R = wLt_L + Et_E$. The demand side is not further specified, which might also represent a bias against the first dividend compared with general equilibrium models, where energy also plays a major role in consumption (for example Conrad, Schmidt (1998)).

Starting from the supply side formulation of the model (equation (1) and (2)), profit maximization in the Cobb-Douglas case first at all yields the well known first order conditions (where subscripts refer to partial derivatives as in Bayindir-Upmann ,Raith (2003)):

$$f_L\,(L,E) = w = \alpha_0\alpha_1 L^{\alpha 1\text{-}1}\, E^{\alpha 2} \quad ; \qquad f_E\,(L,E) = p_E = \alpha_0\alpha_2 L^{\alpha 1} E^{\alpha 2\text{-}1} \tag{3}$$

From that we arrive at own price effects for factor demand

$$f_{LL}\,(L,E) = \alpha_0\alpha_1(\alpha_1 - 1)L^{\alpha 1\text{-}2}\, E^{\alpha 2} \quad ; \qquad f_{EE}\,(L,E) = \alpha_0\alpha_2(\alpha_2 - 1)L^{\alpha 1} E^{\alpha 2\text{-}2} \tag{4}$$

where the microeconomic condition of downward sloping factor demand curves is fulfilled: $\frac{\partial L}{\partial w} = \frac{1}{f_{LL}} < 0$ and $\frac{\partial E}{\partial p_E} = \frac{1}{f_{EE}} < 0$.

Explicit factor demand functions can be derived as :

$$L = \left(\frac{w}{\alpha_0\alpha_1}\right)^{\frac{1}{\alpha_1 - 1}} E^{\frac{-\alpha_2}{\alpha_1 - 1}} \quad ; \qquad E = \left(\frac{p_E}{\alpha_0\alpha_2}\right)^{\frac{1}{\alpha 2 - 1}} L^{\frac{-\alpha_1}{\alpha 2 - 1}} \tag{5}$$

As $-\frac{\alpha_2}{\alpha_1 - 1} > 0$ and $-\frac{\alpha_1}{\alpha_2 - 1} > 0$, we get the result, that the *ceteris paribus* impact of labour on energy input is positive, due to a *ceteris paribus* higher output level accompanied with higher labour input. This is just another expression of the fact, that in this framework we can only derive *conditional* factor demand functions, depending on factor prices as well as on the output level. This result could be easily demonstrated by deriving factor demand functions from cost minimization, which is the conventional way to proceed in general equilibrium models and yields functions of the type: $L = l\ (p_E/w\ ,\ f(L,E))$ and $E = e\ (w/p_E,\ f(L,E))$. These factor demand functions are usually implemented in general equilibrium models and combined with a demand model (for example linear expenditure system of consumption and

Armington model of external trade). The equilibrium *level* of factor demand is then given by conditional factor demand as well as equilibrium on the goods market. The model of Bayindir-Upmann ,Raith (2003) remains at the level of partial equilibrium, where factor demand and output are determined simultaneously for given factor prices. Therefore we can proceed to derive f_{EL} and f_{LE} in the Cobb-Douglas case:

$$f_{LE}\,(L,E) = \alpha_0\alpha_1\alpha_2 L^{\alpha 1\text{-}1}\, E^{\alpha 2\text{-}1}\ ; \qquad f_{EL}\,(L,E) = \alpha_0\alpha_2\alpha_1\, L^{\alpha 1\text{-}1} E^{\alpha 2\text{-}1} \tag{6}$$

Again we can reproduce from that the Bayindir-Upmann,Raith result, that ceteris paribus a higher energy input is associated with higher employment, as $\frac{\partial E}{\partial p_E}\frac{\partial p_E}{\partial L} = \frac{1}{f_{EE}}(-f_{LE})$. But we also see from (6), that in the case of two variable inputs these inputs *must* be substitutes with the additional condition of symmetric cross price effects. As f_{LE} and f_{EL} are identical and positive, an increase in each factor price exerts the same positive impact on the demand for the other factor. Therefore in the Cobb-Douglas case we end up with both properties: (i) due to the nature of conditional factor demand, each factor reacts positively to the level of the other factor (this aspect is stressed by Bayindir-Upmann, Raith (2003)) and (ii) for a given output level we observe cross price effects, which are an important additional source for a double dividend. In the 'normal' case, when revenue neutral ecological tax reform has also a neutral impact on the output level, the cross price effects enhance the double dividend of a simultaneous change in both tax rates (under the condition of labour market equilibrium as given in the union wage bargaining case). The essence of the union wage bargaining model used by Bayindir-Upmann, Raith (2003) is that the net consumer wage is constant and the wage reaction due to a change in the labour (income) tax rate is given by :

$$\frac{\partial w}{\partial t_L} = \frac{w}{1-t_L} > 0 \qquad (7)$$

Bayindir-Upmann, Raith (2003) derive the employment impact of ecological tax reform from totally differentiating Q under the condition dQ = (1 – t_L)dw - wdt_L = 0. Here we could proceed to express the total differential of employment under the condition of labour market equilibrium.[1] Combining (4) and (6) with the labour market equilibrium condition (7) we get for the employment effect of ecological tax reform:

$$\frac{dL}{L} = \frac{1}{(\alpha_1 - 1)} \frac{dt_L}{1-t_L} + \frac{dt_E}{\alpha_1 f_E(L,E)} \qquad (8)$$

Here we have taken into account from the first order conditions (3) that $L^{-\alpha_1} E^{1-\alpha_2} = \frac{\alpha_0 \alpha_2}{p_E}$ and $p_E = f_E\,(L,E)$ as well as $L^{1-\alpha_1} E^{-\alpha_2} = \frac{\alpha_0 \alpha_1}{w}$ and $w = f_E\,(L,E)$. This expression is similar to equation (12) in Bayindir-Upmann, Raith (2003), as far as the impact of dt_L on employment is concerned. The second term in (8) depends on the marginal product of energy $f_E\,(L,E)$, which by itself is a positive function of the energy tax rate t_E (via negative output effects of an increase in t_E). The 'pure' cross price effect for a given energy price level would be positive (=1/α_1), but the marginal product $f_E\,(L,E)$ also reacts to dt_E, so that this partial output impact on employment is: $-\frac{[\partial f_E(L,E)/\partial t_E]}{[f_E(L,E)]^2}$. Again we cannot escape the property, that only conditional factor demand can be derived. The *ceteris paribus* effect of a higher energy tax rate on employment therefore is negative, because the negative output effect dominates the cross price effect.

In a similar way the overall environmental effect can be derived as:

$$\frac{dE}{E} = \frac{dt_L}{\alpha_2(1-t_L)} + \frac{dt_E}{(\alpha_2 - 1) f_E(L,E)} \tag{9}$$

Here we face cross price effects (which are the 'normal' case for a Cobb-Douglas production function) in (8) and in (9), whereas Bayindir-Upmann, Raith (2003) have assumed these cross price effects away. Similar to (8) we observe in (9) negative effects on energy (via negative output effects) of an increase in the labour tax rate t_L ,so that the marginal product f_E (L,E) is a positive function of the labour tax rate t_L . The partial output impact on employment is again given by: $-\frac{[\partial f_E(L,E)/\partial t_L]}{[f_E(L,E)]^2}$ and dominates the cross price effect for certain parameter values. These negative output effects are *ceteris paribus* effects for cases, where changes in one tax rate occur. If we assume, that in the case of environmental tax reform (dt_L < 0 and dt_E > 0) the output level would not change, we can treat f_E (L,E) as constant and get the result that the overall factor demand impact is determined by own and cross price effects.

The implications for a revenue neutral ecological tax reform are straightforward and again yield different results than in the Bayindir-Upmann,Raith (2003) paper. Using the public budget constraint $G = R$ and combining the revenue function $R = wLt_L + Et_L$ with (8) and (9) we get for the case, where the initial energy tax is zero ($t_E = 0$):

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[1] The energy price is an after tax price, where a quantity tax is levied on a world market price, so that $\partial p_E/\partial t_E = 1$.

$$\frac{\partial R}{\partial t_L} = \frac{R}{1-t_L}\left(\frac{1-t_L}{t_L} + \frac{1}{\alpha_1 - 1}\right) \tag{10}$$

From that we get the labor tax Laffer curve with a maximum labor tax rate slightly different from Bayindir-Upmann,Raith (2003): $t_L = \bar{t}_1 = (\alpha_1 - 1)/(\alpha_1 - 2)$. The labor tax Laffer curve at $t_E = 0$ can be easily derived, because no negative output effects on the other factor and no cross price effects have to be taken into account. That does not hold for the energy tax Laffer curve at $t_E = 0$:

$$\frac{\partial R}{\partial t_E} = wt_L \frac{\partial L}{\partial t_E} + E \tag{11}$$

As we have seen from (8) the employment effect of energy tax rate increases ($\partial L/\partial t_E$) is negative due to the negative output effect. Therefore revenues can only be raised by introduction of an energy tax if $\frac{\partial L}{\partial t_E} > -\frac{E}{wt_L}$. If total revenues rise despite the negative output effect (which ceteris paribus should reduce revenues), revenue neutrality requires considerable decreases in the labor tax rate, because a lower labor tax has a positive rebound effect on output. This is the main mechanism behind the counter-intuitive result of a lost first dividend in Bayindir-Upmann,Raith (2003). The importance of these results cannot be directly deduced from the partial derivatives of the revenue function, but depends on the whole range of the Laffer curves and on the point, where we start when introducing energy taxes. It is therefore left open to the parameter values and to empirical research, if revenue neutral ecological tax reform increases the use of energy.

A numerical example

An outlined model, which serves to simulate revenue neutral ecological tax reforms with the parameter values given in the numerical example in the Bayindir-Upmann,Raith (2003) paper would consist of the production function, the factor demand equations and the labour market equilibrium condition:

$$f(L,E) = \alpha_0 L^{\alpha 1} E^{\alpha 2} \tag{2}$$

$$L = \left(\frac{w}{\alpha_0\alpha_1}\right)^{\frac{1}{\alpha_1 - 1}} E^{\frac{-\alpha_2}{\alpha_1 - 1}} \quad ; \qquad E = \left(\frac{p_E}{\alpha_0\alpha_2}\right)^{\frac{1}{\alpha 2 - 1}} L^{\frac{-\alpha_1}{\alpha 2 - 1}} \tag{5}$$

$$\frac{\partial w}{\partial t_L} = \frac{w}{1 - t_L} > 0 \tag{7}$$

The impact on public revenues as defined in $R = wLt_L + Et_L$, would be left open in this model and depend on the point on the Laffer curve, where we start when impementing the ecological tax reform. The parameter values from the numerical example in the Bayindir-Upmann,Raith (2003) paper are: $\alpha_0 = 5$, $\alpha_1 = 0.62$, $\alpha_2 = 0.15$, $\alpha_3 = 0.23$. Scaling the fixed capital input $\overline{K}$ with 1,000 we get for $\tilde{\alpha}_0 = 1.0208$. In our setting we see from (10), that the critical value for t_L in order to start still at the increasing part of the Laffer curve is $\bar{t}_1 = 0.2754$. If we assume additionally, that we start from a case, where $t_E = 0$ and normalize $Q = (1 - t_L)w = 1$ as well as $p_E = 1$, we can simulate the introduction of an energy tax. Note that in this case we start from the critical value 0.2754 for the labor tax rate, which marks the maximum of the labor tax Laffer curve as shown in Figure 1.[2]

>>>>*Figure 1: The labor tax Laffer curve*

All non revenue neutral increases in the energy tax reduce energy input and output with implications for tax revenues as shown in Figure 2. We get the result consistent with (11), that for a certain range of energy tax rates total revenues rise, as revenue loss from labor taxation is smaller than revenue gain from energy taxation. The maximum of total revenues can be found at $t_E = 0.25$.

>>>>*Figure 2: Total tax revenues at* $t_L = 0.2754$

The range of $0 < t_E < 0.25$ for the energy tax rate therefore might coincide with the range of the lost first dividend. Within this range very large reductions in the labor taxe rate are needed for revenue neutrality, thereby boosting output and energy input.

This can be seen from simulations of marginal ecological tax reforms, where we gradually increase the energy tax rate t_E and search for the labor tax rate t_L , that leads to revenue

[2] First we can verify that 0.2754 is the critical value for the labor tax rate , when $t_E = 0$ by a simulation, where we change

neutrality. As a result we get indeed that in the range of the energy tax $0 < t_E < 0.25$ we can reproduce the effect of the lost first dividend, if we start from the maximum of the labor tax Laffer curve.

Table 1: Simulation results (numerical example) of ecological tax reform on wages (w), employment (L), output(Y) and energy (E)

Bayindir-Upmann,Raith (2003) argue, that for most European examples of ecological tax reforms t_E does not exceed 20 percent and that these tax reforms are therefore within the dangerous range of loosing the first dividend. It is an open question, if this direct link to practice is consistent with the structure of the Bayindir-Upmann,Raith model. As we know from other studies, energy tax reform implies rather different price schocks for different fuels (given an overall moderate energy price increase) and a considerable part of emission reduction stems from inter-fuel substitution in production as well as in consumption. In the Bayindir-Upmann,Raith-model economic and environmental policy might use ecological tax reform as a device to achieve a certain environmental target about greenhouse gas emissions. Therefore given the information about the parameter values it would be easy to design a revenue neutral tax reform consistent with such a target and leading to a double dividend, as for example in Table 1 an increase of t_E to the value of 0.5. Comparing this major tax reform with a marginal tax reform (for example $t_E = 0.05$), we note that due to the shape of the labor

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t_L in both directions and end up with lower revenues.

tax Laffer curve the additional necessary decrease in the labor tax rate is not very high (an additional 7 percentage points from 23 to 16 percent) compared to the additional increase in the energy tax rate of 45 percentage points.

Figure 1: The labor tax Laffer curve

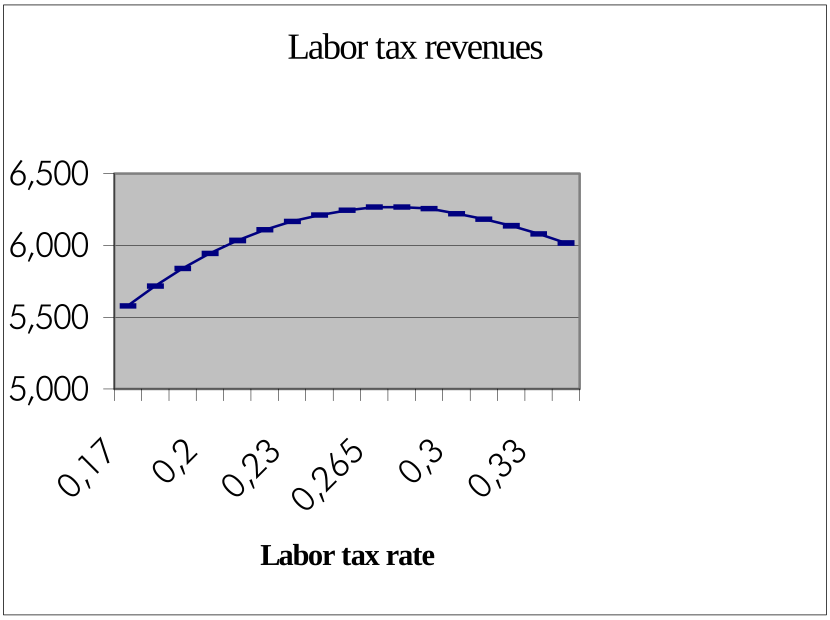

Figure 2: Total tax revenues at t_L = 0.2754

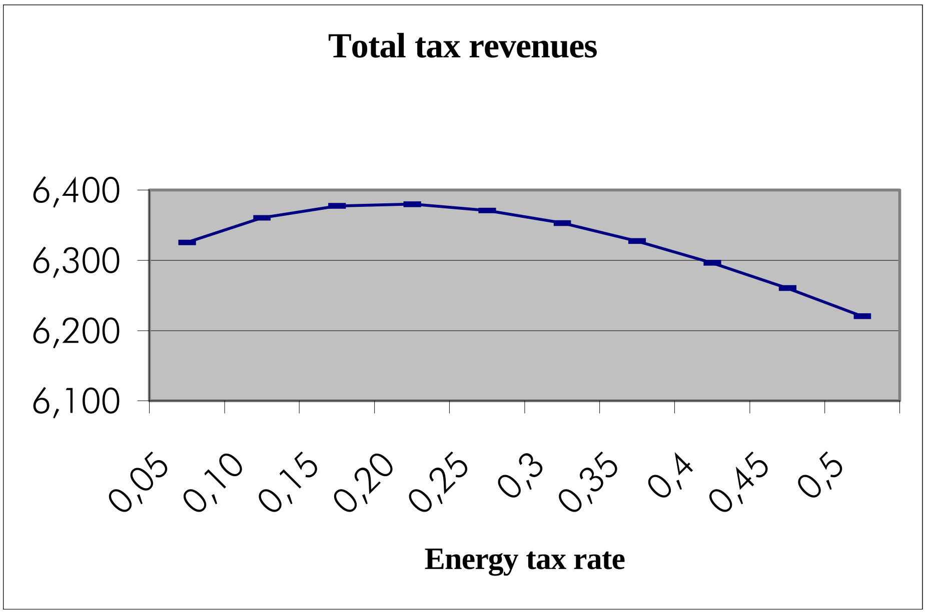

Table 1: Simulation results (numerical example) of ecological tax reform on wages (w), employment (L), output(Y) and energy (E)

t_E	t_L	dw/w	dL/L	dY/Y	dE/E
0	0.275				
0.05	0.229	-0.06	0.22	0.15	0.09
0.10	0.211	-0.08	0.29	0.18	0.08
0.15	0.198	-0.10	0.33	0.20	0.04
0.20	0.187	-0.11	0.36	0.21	0.01
0.25	0.179	-0.12	0.37	0.21	-0.03
0.50	0.161	-0.14	0.32	0.14	-0.24

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