

# Why Governments Should Tax Mobile Capital in the Presence of Unemployment\*

**Erkki Koskela**

University of Helsinki

**&**

**Ronnie Schöb**

University of Munich

## **Addresses:**

Erkki Koskela  
Department of Economics  
University of Helsinki  
P.O. Box 54 (Unioninkatu 37)  
FIN- 00014 University of Helsinki  
Finland  
tel. ++358/9/1918894  
fax ++358/9/1918877  
erkki.koskela@helsinki.fi

Ronnie Schöb  
Center for Economic Studies  
University of Munich  
Schackstrasse 4  
D-80539 Munich  
Germany  
tel. ++49/89/2180-6261  
fax ++49/89/397303  
ronnie.schoeb@ces.vwl.uni-muenchen.de

---

\* An earlier version of this paper has been presented at Economic Policy Research Unit (EPRU) at the University of Copenhagen and on the annual meeting of the Verein für Socialpolitik in Rostock. While we remain responsible for any errors, we are grateful to seminar participants and, in particular, to Jeremy Edwards, Wolfgang Eggert, Andreas Haufler and Søren Bo Nielsen for their helpful comments. We are indebted to the Research Unit on Economic Structures and Growth (RUESG) for financial support. In addition, the second author is grateful to the Economic Policy Research Unit at the University of Copenhagen for its great hospitality.

## Abstract

This paper shows that a small open economy should levy positive source-based taxes on capital income to fight involuntary unemployment and increase welfare. A revenue-neutral tax reform which increases the capital tax rate and reduces the labour tax rate will induce firms to substitute labour for capital. Such a tax reform will lower marginal cost of production, increase output, and reduce unemployment as long as the labour tax rate exceeds the capital tax rate. The result holds even though trade unions might succeed in subsequently increasing the net-of-tax wage rate if the elasticity of substitution between capital and labour is above a critical value which is itself below one. Independent of the elasticity of substitution, the government can promote wage moderation by increasing the personal tax credit instead of reducing the labour tax rate.

*JEL classification: H2, J5*

*Keywords: capital taxation, labour taxation, involuntary unemployment, trade unions.*

## 1. Introduction

In the last decades it has become a common rule in tax policy to tax factors of production if their supply is relatively inelastic but to exempt factors from taxation if their supply is perfectly elastic. Increasing economic integration and the removal of economic borders between countries led to increased international mobility of capital which made it difficult for national tax authorities to tax capital income at source without causing capital flight. Tax competition between countries has consequently led governments to reduce source-based capital tax rates and to rely more and more on taxing internationally immobile labour (cf. Commission of the European Communities 1996 and Table 1 below). Although some countries succeeded in reducing the labour tax rates in absolute terms, the relative importance of labour tax rates has increased in almost all OECD countries over the last 20 years.

In the literature on capital taxation these developments are considered to be beneficial from the viewpoint of a small open economy which faces tax competition. Since capital supply is perfectly elastic, the whole tax burden of a capital tax falls on immobile labour. To avoid the excess burden of capital taxation it is therefore better to tax labour only (cf. e.g. MacDougall 1960, Gordon 1986, Razin and Sadka 1991, or Bucovetsky and Wilson 1991).

These results are driven by the assumption that domestic labour markets are sufficiently flexible for the wage rate to adjust to changes in labour demand and supply so that full employment is sustained. However, many European countries' labour markets are characterized by labour market imperfections. Labour markets are highly unionized and this results in wage rates above the market-clearing level. Furthermore, in such labour markets government intervention contributes significantly to unemployment. In particular, high tax rates on labour income and high social insurance contributions, combined with generous unemployment benefits, distort labour supply, increase wage pressure in the wage negotiations between trade unions and firms and, consequently, increase unemployment (cf. e.g. Lockwood and Manning 1993, OECD 1995, Nickell 1997, Pissarides 1998).

Reducing the share of the tax burden borne by labour in order to fight unemployment is therefore commonly demanded. However, governments find it relatively difficult to reduce

public spending or, because of the stability and growth pact, to increase debt. The question therefore arises of how labour tax cuts should be financed. The figures presented in Table 1 suggest that taxes on capital income may be a good candidate as they are substantially lower than taxes on labour income. Given the labour market imperfections which result in high unemployment rates in most European countries, it seems useful for economies suffering from persistently high unemployment rates, to re-examine the standard result that internationally mobile capital should not be taxed. This paper thus focuses on the question of whether a policy which increases source-based capital taxes and reduces labour taxes can be an efficient instrument for alleviating unemployment and increasing welfare.

*Table 1: Unemployment rates and tax rates on factor incomes for some European countries*

<b>Country</b>	<b>Unemployment rate %</b>	<b>Capital tax rate %</b>	<b>Labour tax rate %</b>
<b>Belgium</b>	8.8	7.4	52.1
<b>Denmark</b>	4.6	15.3	52.1
<b>Finland</b>	12.5	10.7	47.7
<b>France</b>	11.9	7.4	46.6
<b>Germany</b>	9.8	10.7	48.1
<b>Italy</b>	12.1	15.3	52.8
<b>Netherlands</b>	4.0	10.7	51.6
<b>Spain</b>	18.9	19.4	46.2
<b>Sweden</b>	8.6	0	49.7
<b>U.K.</b>	6.4	15.3	40.2

Sources: OECD (1998): *Main Economic Indicators*, Paris; OECD (1991): *Taxing Profits in a Global Economy*, Paris; OECD (1995): *The OECD Jobs Study. Taxation, Employment and Unemployment*, Paris; OECD (1996) *Employment Outlook July 1996*, Paris.

Legend: The unemployment rates are given for the 2nd quarter of 1998. The capital tax rate is given by the formula: cost of capital minus real interest rate, divided by the cost of capital (1991). The labour tax rate measures the marginal labour tax (including employers' and employees' social insurance contributions) on gross wages for a one-earner couple with two children whose wage equals that of an average productive worker (1992).

In the first part of our analysis we consider the benchmark case where unemployment is caused by a constant net-of-tax wage rate which exceeds the market-clearing wage rate. Given net-of-tax factor prices, any shift in the tax burden from labour to capital will lead firms to substitute labour for capital. This will affect the cost of production and thus output supply and input demands will change. Our analysis shows that, as long as the labour tax rate exceeds the capital

tax rate, a marginal revenue-neutral tax reform towards higher capital tax will increase both domestic output and employment and will promote welfare.

However, the net-of-tax wage rate cannot be expected to remain constant when factor taxation is restructured. In the second part of the paper we therefore extend the analysis by allowing wages to be determined endogenously in a bargaining process between a small trade union and a firm which faces monopolistic competition in the output market. The wage negotiations are analysed using a 'right-to-manage' model where the trade union and the firm bargain over wages and the firm then chooses the employment level that maximizes profits.

Our analysis suggests that, if labour can easily be substituted for capital, i.e. if the elasticity of substitution exceeds unity, the net-of-tax wage rate will fall and the employment effect will be stronger than in the case of a constant net-of-tax wage rate. If the elasticity of substitution is smaller than one, however, the net-of-tax wage rate will increase and the net effect on employment becomes ambiguous. Nevertheless, even in the case of a low substitutability between labour and capital, we show that positive employment effects will still occur as long as the elasticity of substitution is not too low. Furthermore, independent of the value of the elasticity of substitution, wage moderation can be promoted if the government increases the workers' personal tax exemption instead of lowering the labour tax rate.

Our results are in contrast to the predominant view in the literature on capital taxation which argues that internationally perfectly mobile capital should not be taxed at source. However, where there is involuntary unemployment because wage rates are too high, it is beneficial for a small open economy to raise a positive tax rate on capital income. The reason is that involuntary unemployment implies that, at least locally, labour supply is also perfectly elastic and there is hence no reason to discriminate between labour income and capital income. On the contrary, as the social marginal cost of labour falls short of private marginal cost, labour income should be taxed at a lower rate than capital income.

The paper is organized as follows. Section 2 presents the basic model. Assuming constant net-of-tax factor prices Section 3 analyses the consequences of a stepwise movement from a *labour tax system*, characterized by a higher tax rate on labour, towards a *capital tax*

*system*, characterized by a higher tax rate on capital. Section 4 extends the analysis to the case where wage negotiations take place between a trade union and the firm and analyses the comparative statics effects of changes in the labour tax rate, the personal tax exemption and the capital tax rate on the negotiated wage. The comparative statics results are then used in Section 5 to discuss the implications of a revenue-neutral tax reform, which increases the capital tax rate and reduces the labour tax rate accordingly. Section 6 examines the relationship between tax progression and employment. Finally, Section 7 relates the results to the existing literature on factor taxation and offers a brief conclusion.

## 2. The model<sup>1</sup>

We consider a small open economy where there are many firms each producing a different good. The goods are sold on the world market. Globally, each firm faces monopolistic competition. The number of domestic firms and the number of firms operating in the world market are fixed.<sup>2</sup> For analytical convenience, we assume that domestic production can be represented by a single monopolistic firm which produces good  $Y$  with capital  $K$  and labour  $L$  as inputs. Capital is assumed to be perfectly mobile between countries and labour to be internationally immobile. The technology is linear-homogenous and is represented by the production function

$$Y = f(L, K). \quad (1)$$

The firm considers the factor prices  $\tilde{r}$  and  $\tilde{w}$  as given. The gross interest rate  $\tilde{r}$  is the net-of-tax interest rate plus a source-based capital tax, i.e.  $\tilde{r} = (1 + t_r)r$  with  $t_r$  denoting the capital

---

<sup>1</sup> A similar model has been used to analyse the impact of a green tax reform, cf. Koskela, Schöb and Sinn (1998).

<sup>2</sup> Alternatively we could allow for free entry. As Eaton and Lipsey (1978) have shown, free entry does not imply that the profits of the incumbent firms fall to zero. They show that a new firm faces a lower demand curve than an incumbent firm. With fixed entry costs, this implies that the new firm's profit will be lower than the average profit of the incumbent firms. Market entry is determined by the zero-profit condition of the new firm. Since its profits are lower than those of incumbent firms, total profits are positive in equilibrium. As the focus of our paper is not on exit-entry decisions of firms, we abstract from fixed entry cost and do not model entry decisions of new firms.

tax rate. The gross wage  $\tilde{w}$  is the net-of-tax wage  $w$ , which is negotiated between a trade union and the firm (see Section 4) plus the labour tax, i.e.  $\tilde{w} = (1 + t_w)w$ , with  $t_w$  denoting the labour tax rate. Linear homogeneity implies that marginal cost is constant in  $Y$  so that the cost function can be written as

$$C(\tilde{w}, \tilde{r}, Y) = c(\tilde{w}, \tilde{r})Y, \quad (2)$$

with  $c(\tilde{w}, \tilde{r})$  denoting unit and marginal cost of production. Marginal cost depends on the gross factor prices only. The monopolistic firm faces output demand  $D(p)$  which is decreasing in the output price  $p$  and is assumed to be isoelastic, i.e.

$$Y = D(p) = p^{-\varepsilon} \quad (3)$$

with  $\varepsilon \equiv -(D(p)/\partial p) \cdot p/Y$  denoting the output demand elasticity. The closer substitutes for good  $Y$  on the world market are, the more elastic output demand becomes. To guarantee a profit maximum, the output demand elasticity must exceed unity, i.e.  $\varepsilon > 1$ , in which case profit maximization implies that the firm will set a price which exceeds the marginal cost  $c(\tilde{w}, \tilde{r})$  by a constant mark-up factor  $\varepsilon/(\varepsilon - 1) > 1$ .

The government requires a fixed amount of tax revenues to finance the public good  $G$  and, in addition, it has to pay unemployment benefits  $b$  to all unemployed workers. Denoting the total number of workers by  $N$ , the number of unemployed workers is given by  $N - L$ . The government levies the labour tax  $t_w$  on wage income and grants a personal tax credit  $a$  to each tax payer. The tax revenues from taxing labour are thus given by  $(t_w w - a)L$ . In addition, the government levies the source-based tax on domestic capital input  $t_r$ , so that the government budget constraint is given by

$$(t_w w - a)L + t_r rK = G + b(N - L). \quad (4)$$

### 3. Labour tax system vs. capital tax system

In a small open economy with free capital mobility, changes in the source-based capital tax rate only affect the gross interest rate  $\tilde{r}$  domestic firms have to pay for capital but leave the world

net interest rate  $r$  constant. In this section, we assume that the net-of-tax wage  $w$  is also fixed. This serves as a benchmark case as this assumption means that the whole tax burden falls on the firm. It will be relaxed in Section 4 when wage negotiations between trade unions and the firm are incorporated into the analysis.

When analysing a marginal reform of factor taxation it is important to know what type of tax system is to be reformed. In the following we therefore distinguish between a labour tax system and a capital tax system. The initial tax system is labelled a *labour tax system* if the labour tax rate exceeds the capital tax rate, i.e.  $t_w > t_r$ , and a *capital tax system* if the capital tax rate exceeds the labour tax rate, i.e.  $t_w < t_r$ .

### 3.1 A marginal revenue-neutral tax reform

In the following we analyse the employment and output effects of a marginal tax reform which leaves the public expenditures for the public good  $G$  unaffected,  $dG = 0$ , and which increases the capital tax rate and lowers the labour tax rate accordingly.<sup>3</sup> To interpret the results, it is appropriate to split the tax reform analytically into two separate steps. First, we consider a reform which keeps output constant, i.e.  $dY = 0$ . This implies a movement along the isoquant, which, as a direct implication of Euler's theorem, guarantees an increase in labour input, while leaving marginal cost constant. If such a reform generates excess tax revenues  $dG > 0$ , the surplus in tax revenues will be rebated in a second step by reducing the two tax rates equiproportionately so that  $dG = 0$  is satisfied. Since marginal costs are linear homogeneous in gross factor prices, an equiproportional tax rate cut reduces marginal cost and increases both output and factor demands. Hence, the whole tax reform will unambiguously increase employment while the effect on capital is *a priori* ambiguous.

To determine the output-neutral tax reform we have to differentiate the production function (1) with respect to the tax rates  $t_w$  and  $t_r$ :

$$dY = 0 = [f_L(K, L)L_{\bar{w}}w + f_K(K, L)K_{\bar{w}}w]dt_w + [f_L(K, L)L_{\bar{r}}r + f_K(K, L)K_{\bar{r}}r]dt_r. \quad (5)$$

---

<sup>3</sup> If the net-of-tax factor prices are given, the quantity of the public good provision is not affected by changes in the tax structure as the net cost of production is given by  $wL^G + rK^G = G$ .



Solving for  $dt_w$  yields the condition for the output-neutral tax reform:

$$\left. \frac{dt_w}{dt_r} \right|_{dY=0} = -\frac{(1-s)(1+t_w)}{s(1+t_r)}, \quad (6)$$

with  $s \equiv \tilde{w}L/cY$  denoting the cost share of labour and  $(1-s) \equiv 1 - \tilde{w}L/cY = \tilde{r}K/cY$  the cost share of capital. The impact such an output-neutral tax reform has on the government budget is given by:

$$dG = [wL + [t_w w + (b-a)]L_{\tilde{w}} w + t_r r K_{\tilde{w}} w] dt_w + [rK + [t_w w + (b-a)]L_{\tilde{r}} r + t_r r K_{\tilde{r}} r] dt_r. \quad (7)$$

As shown in Appendix 1, substituting the condition (6) in (7) yields

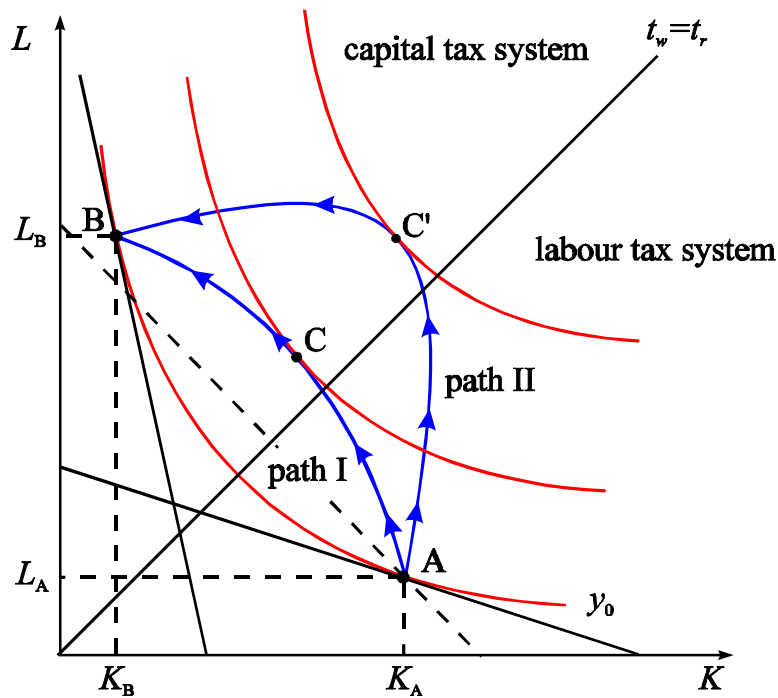
$$\left. \frac{dG}{dt_r} \right|_{dY=0} \begin{cases} > \\ = \\ < \end{cases} 0 \quad \Leftrightarrow \quad \frac{t_w}{(1+t_w)} + \frac{b-a}{(1+t_w)w} \begin{cases} > \\ = \\ < \end{cases} \frac{t_r}{(1+t_r)}. \quad (8)$$

Under the reasonable assumption that the unemployment benefit exceeds the tax credit, i.e.  $b > a$ , condition (8) shows that in a labour tax system, i.e.  $t_w > t_r$ , the first step of the tax reform always yields a budget surplus. There are two reasons for this. First, a move towards more equal tax rates on factor incomes reduces the factor price distortion. For a given output level and hence constant total private cost, this implies that tax revenues increase. In addition, the output-neutral tax reform unambiguously increases employment as labour is substituted for capital. This reduces unemployment benefit payments. Although more workers become eligible for a tax credit  $a$ , public expenditures decrease by  $b - a$  for each additional employee.

Rebating this budget surplus reduces the marginal cost and consequently increases output and factor demands. Figure 1 shows two conceivable paths of consecutive marginal tax reforms. The line through the origin indicates the labour-capital ratio for a non-distorted factor price ratio, i.e.  $t_w = t_r$ . All labour tax systems are located on the left-hand side of this line, because the labour-capital ratio is smaller the higher the factor price ratio  $\tilde{w}/\tilde{r}$ . The loci of capital tax systems is to the right of the path through the origin. Point A indicates the equilibrium for an initial labour tax system, where the labour tax rate exceeds the capital tax rate. Starting from A, both employment and output will increase by a marginal increase in the capital tax rate and a revenue-neutral reduction of the labour tax rate. The same is true as long as we consider a marginal reform of a labour tax system. But even at  $t_w = t_r$ , an output-

neutral tax reform generates a budget surplus because the positive employment effect reduces unemployment benefit payments more than it increases tax credits. Hence, the output maximum can only be reached with a capital tax system, i.e. a tax system where the capital tax rate exceeds the labour tax rate (cf. equation (8)).

Figure 1: Consecutive marginal tax reforms



The maximum output level is indicated by the points C or C', respectively. A further increase in  $t_r$ , however, will result in output reductions and the negative output effect, due to a budget deficit resulting from an output-neutral tax reform, will countervail the substitution effect of moving along the isoquant. If the output demand elasticity is small, the fall in output will be small and the substitution effect will dominate the output effect. This case is represented by path I in Figure 1 where a movement from C to B increases employment but reduces output. If output demand is very elastic, however, as represented by path II, there will be an interval on the path II from C' to B where both output and employment are falling simultaneously. The point B indicates a tax system which, for a given level of the public good  $G$ , yields the same output as the existing tax system A but generates higher employment. Hence, for a marginal reform of the labour tax system, we can formulate the following

PROPOSITION 1: In a labour tax system where the labour tax rate exceeds the capital tax rate, a marginal revenue-neutral tax reform, which increases the capital tax rate and reduces the labour tax rate but leaves the net-of-tax wage rate unaffected, will increase both output and employment.

With respect to output we have shown that, as  $dG > 0$  for  $t_w = t_r$  and  $b > a$ , the following applies:

PROPOSITION 2: Given net-of-tax factor prices, an output maximizing tax system is a capital tax system.

The analysis abstracts from taxes on profits. If profit taxes are available without restriction, it would be beneficial to tax profits only and to abandon taxes on factor incomes. However, even with zero tax rates on both labour and capital income, a marginal revenue-neutral increase in the capital tax rate would increase both employment and output.<sup>4</sup>

Throughout the analysis we have assumed that the full employment level is higher than the unemployment level in C or C', respectively. If full-employment, which is characterized by equality of the net-of-tax wage rate and the marginal willingness to sell labour, is below this level, it can be shown that a further increase in the capital tax rate would result in a reduction in output, capital demand, and profits, without having a positive effect on employment.<sup>5</sup>

### 3.2 Domestic income and welfare

Domestic income consists of labour income, income from unemployment benefits, domestic capital income, profits, which accrue to domestic shareholders, and tax revenue for public good provision. If a marginal revenue-neutral tax reform increases employment, which is the

---

<sup>4</sup> The presence of factor taxes in the existing tax system indicates that the government does not use unrestricted profit taxes, because the maximum tax revenues in this market with fixed net-of-tax factor prices are equal to the monopoly rent if no factor taxes are levied. A 100% profit tax can hence extract all tax revenues. For a discussion why it may not be possible for governments to tax away profits completely see Huizinga and Nielsen 1997.

<sup>5</sup> A complete set of results for this case is available on request.

case when moving from A to C (C') in Figure 1, the sum of net-of-tax labour income and unemployment benefit payments is increasing with employment as the net-of-tax wage rate remains constant. Furthermore, as long as output increases, domestic profits will also rise and domestic shareholders will participate.<sup>6</sup> Hence, increasing the capital tax rate in a labour tax system and lowering the labour tax rate accordingly always increases domestic income. Note that domestic capital owners always obtain  $r$ , regardless of whether they invest in the home country or abroad.

Applying the standard concepts of producer and worker surplus, we can easily derive the welfare effects from changes in domestic income. A movement from a labour tax system towards a capital tax system shows that workers' net-of-tax income increases. Due to involuntary unemployment, the net-of-tax wage rate workers receive exceeds their marginal willingness to sell labour so that each additional worker in the capital tax system receives a labour rent. Since producer surplus is increasing in output, welfare, measured by the sum of producer and worker surplus, is boosted as long as a marginal tax reform increases both employment and output. In addition, the increase in consumer surplus for domestic consumers due to a fall in the output price also has to be taken into account.<sup>7</sup> This leads to

**PROPOSITION 3:** In a labour tax system, a marginal revenue-neutral tax reform, which increases the capital tax rate and reduces the labour tax rate but leaves the net-of-tax wage rate unaffected, will increase domestic welfare.

It may be worth mentioning that an optimal tax system does not maximize output. A marginal tax reform which goes beyond the output maximum leaves profit unaffected but raises employment. Hence, the welfare effect of such a move away from the output maximum is positive.

---

<sup>6</sup> As  $\varepsilon > 1$ , profits, which are given by  $\pi = pY/\varepsilon$ , are decreasing in  $p = \varepsilon/(\varepsilon - 1) \cdot c(\tilde{w}, \tilde{r})$ .

<sup>7</sup> Formally, one can show that the expected utility of a representative worker increases as the probability of being unemployed decreases. Furthermore, it is straightforward to show that the share owners' utility is increasing in profits and the utility of consumers is decreasing in prices.

## 4. Trade unions and wage bargaining

So far we have assumed that the net-of-tax wage rate is not affected by changes in the structure of factor taxation. It is now time to relax this assumption and consider the case where the wage level is determined in wage negotiations between a small trade union and the firm to see how the results derived in Section 3 have to be modified if net-of-tax wages react to changes in the structure of factor taxation.

### 4.1 Wage negotiations between trade union and firm

We consider a small trade union which acts at the firm level. The objective of the trade union is to maximize its  $N$  members' net-of-tax income.<sup>8</sup> Each member supplies one unit of labour if employed, or zero labour if unemployed. The net-of-tax income of a working member depends on the net-of-tax wage rate  $w$  and the personal tax exemption  $a$ , so that the net-of-tax income is given by  $w + a$ . If a trade union member becomes unemployed she is entitled to unemployment benefits  $b$ . The objective function of the trade union can then be written as

$$V^* = (w + a)L + b(N - L). \quad (9)$$

The firm maximizes profits, which is defined by

$$\pi = p(Y)Y - \bar{r}K - \tilde{w}L. \quad (10)$$

The wage rate is determined in a bargaining process between the trade union and the firm and then the firm unilaterally determines employment. This is modelled by using a 'right-to manage' model which represents the outcome of the bargaining by an asymmetric Nash bargaining.<sup>9</sup> The fall-back position of the trade union is given by  $V^0 = bN$ , i.e. if the negotiations break down all members receive their reservation wage equal to the unemployment benefit payments. The fall-

---

<sup>8</sup> In so far as small-scale wage negotiations do not affect the consumer price level, it does not matter whether the trade union maximizes nominal or real income of its members.

<sup>9</sup> This approach can be justified either axiomatically (cf. Nash 1950), or strategically (cf. Binmore, Rubinstein and Wolinsky 1986).

back position of the firm is given by zero profits, i.e.  $\pi^0 = 0$ . Hence, the Nash bargaining maximand can be written as

$$\Omega = (V^* - V^0)^\beta \pi^{1-\beta}, \quad (11)$$

with  $\beta$  representing the bargaining power of the trade union. Using  $V \equiv V^* - V^0$ , the first-order condition with respect to the net-of-tax wage rate is

$$\Omega_w = 0 \Leftrightarrow \beta \frac{V_w}{V} + (1-\beta) \frac{\pi_w}{\pi} = 0. \quad (12)$$

In the following, we assume a CES production technology. This allows us to use an explicit formulation of the wage elasticity of labour demand  $\eta_{L,\tilde{w}} \equiv L_{\tilde{w}} \tilde{w} / L$ , which is useful in understanding the comparative statics. The formula can be derived analogously to the case of perfect competition [cf. Allen (1938) or Hamermesh (1993)]:

$$\eta_{L,\tilde{w}} = -\sigma + s(\sigma - \varepsilon). \quad (13)$$

If  $\sigma > \varepsilon$ , factors are price substitutes and they are price complements if the reverse is true. In the following, we focus on the case where labour and capital are complements.

By using equation (13), equation (12) can be rewritten as

$$\Omega_w = 0 \Leftrightarrow (w + a - b) (\beta \eta_{L,\tilde{w}} + (1-\beta)s(1-\varepsilon)) + w\beta = 0. \quad (14)$$

The second-order condition is assumed to hold throughout, i.e.  $\Omega_{ww} = y + xz < 0$ , with  $y = \beta(1 + \eta_{L,\tilde{w}}) + (1-\beta)(1-\varepsilon)s$ ,  $z = [\beta(\sigma - \varepsilon) + (1-\beta)(1-\varepsilon)]s_{\tilde{w}}(1 + t_w)$  and  $x = w + a - b$ .

Equation (14) defines the negotiated net-of-tax wage from Nash bargaining as a function of the tax policy parameters  $a$ ,  $b$ ,  $t_w$ , and  $t_r$  so that we have  $w = w(a, b, t_w, t_r)$ .

## 4.2 Comparative statics

In the following we focus on the impact that changes in the tax policy parameters have on the negotiated wage rate. To start with, consider an increase in the personal tax credit  $a$ . Implicit differentiation of condition (14) yields

$$w_a = -(y + xz)^{-1}(y - \beta) < 0. \quad (15)$$

Only employed members of the trade union receive the additional benefit of a higher tax credit. An increase in  $a$  can thus be interpreted as an additional subsidy on labour. If the personal tax credit is increased, the trade union will accept a lower net-of-tax wage rate as the gains for new workers from starting to work will increase while the losses for those already employed will remain constant.

A change in the labour tax rate affects both the trade union's and the firm's objective functions. From equation (14) we obtain

$$w_{t_w} = -(y + xz)^{-1} x [\beta(\sigma - \varepsilon) + (1 - \beta)(1 - \varepsilon)] s_{t_w}. \quad (16)$$

For a CES production technology, the partial derivative of the cost share of labour with respect to the labour tax rate is given by

$$s_{t_w} = s_{\bar{w}} w = \frac{s}{(1 + t_w)} (1 - s)(1 - \sigma) \begin{cases} > \\ = \\ < \end{cases} 0 \Leftrightarrow \sigma \begin{cases} < \\ = \\ > \end{cases} 1. \quad (17)$$

Substituting (17) into (16) shows that for  $\sigma < \varepsilon$ , we have

$$w_{t_w} \begin{cases} < 0 & \text{as } \sigma < 1 \\ = 0 & \text{as } \sigma = 1. \\ > 0 & \text{as } \sigma > 1 \end{cases} \quad (18)$$

To interpret this result, it is convenient to look separately at the impact a marginal increase of the labour tax rate has on the trade union's objective function and the firm's objective function. For the trade union, the effect of a labour tax rate change on the wage elasticity of labour demand  $\eta_{L, \bar{w}}$  turns out to play a crucial role in the wage negotiations. It can be seen from the partial derivative of the trade union's objective function  $V_w = L/w \cdot [w + (w + a - b)\eta_{L, \bar{w}}]$  that if the labour demand elasticity is unaffected by a change in the labour tax rate, the arbitrage calculus of the trade union does not change. If the labour demand becomes less elastic, however, fewer workers will be fired because of a net-of tax wage rate increase while the benefits for those employed remain the same. It becomes more profitable for the trade union to demand higher wages. Given a constant elasticity of substitution  $\sigma$ , the partial derivative of the wage elasticity of labour demand is given by

$$\frac{\partial \eta_{L, \bar{w}}}{\partial t_w} = s_{t_w} (\sigma - \varepsilon), \quad (19)$$

As labour and capital are price complements, the sign of equation (19) depends on the sign of  $s_{t_w}$  only, cf. equation (17). If substitutability is low, i.e.  $\sigma < 1$ , the cost share of labour  $s$  increases with the labour tax rate. A larger share  $s$  implies that a one percent change in the wage rate induces a larger increase in total cost and hence a lower output. This will lead firms to lay off more workers. Hence, if  $s$  increases, labour demand elasticity becomes more elastic. This weakens the bargaining position of the trade union as the potential losses of a wage increase go up.

Next consider the firm's bargaining position. If substitutability is low, the cost share of labour  $s$  increases as a consequence of an increase in the labour tax rate and profits will fall at a higher rate. Therefore the firm will oppose wage increases more strongly and demand lower wages. An increase in the labour tax rate weakens the trade union's bargaining position and strengthens the firm's bargaining position at the same time. Hence, both effects work in the same direction and the net-of-tax wage will fall. If, on the contrary, substitutability is high, e.g.  $\sigma > 1$ , the net-of-tax wage rate will rise:<sup>10</sup>

Comparative statics for a capital tax rate change is similar, but opposite in sign, to that of a labour tax rate change as both objective functions are affected. The impact on the trade union's bargaining position depends on how a change in the capital tax affects the wage elasticity of labour demand. As before, if the elasticity of substitution is constant, the labour demand elasticity changes only if the cost share of labour changes. Using the following condition

$$s_{t_r} = -\frac{(1+t_w)}{(1+t_r)} s_{t_w}, \quad (20)$$

it follows immediately that an exogenous increase in the capital tax rate has an effect on the cost share of labour opposite to that of the increase in the labour tax rate. Similarly one can show that an increase in the capital tax rate has an effect on firm's profit opposite to that of an increase in the labour tax rate.

---

<sup>10</sup> If the factors were substitutes, the effects would work into the opposite direction and it would not be possible to *a priori* sign the effect of a labour tax rate increase on the wage negotiations.



Again both effects work in the same direction. If substitutability is low, the trade union's bargaining position becomes stronger while the firm's position becomes weaker due to a capital tax rate increase and vice versa. Depending on the elasticity of substitution we can summarize the total effect of an increase in  $t_r$  as:

$$w_{t_r} \begin{cases} > 0 & \text{as } \sigma < 1 \\ = 0 & \text{as } \sigma = 1. \\ < 0 & \text{as } \sigma > 1 \end{cases} \quad (21)$$

## 5. Substituting the capital tax for the labour tax

The comparative statics results have demonstrated that it is necessary to take account of the effects tax rate changes have on the negotiated wage rate to determine the employment effect of a marginal revenue-neutral tax reform. The condition for a revenue-neutral change in the structure of factor taxation is given by

$$dG = G_{t_w} dt_w + G_{t_r} dt_r = 0, \quad (22)$$

where the effects tax rate changes have on the net-of-tax wage rate have now been taken into account.<sup>11</sup> Using the definition of the tax revenue elasticity with respect to the tax rate  $t_i$   $\tau_{t_i} = G_{t_i} (1+t_i) / G$ , reformulation of the revenue-neutrality condition (22) yields

$$\frac{\tau_{t_r}}{\tau_{t_w}} = - \frac{(1+t_r)}{(1+t_w)} \cdot \frac{dt_w}{dt_r}. \quad (23)$$

The change in employment is given by

$$dL = \frac{L}{(1+t_w)} \eta_{L, \tilde{w}} (1+\omega_{t_w}) dt_w + \frac{L}{(1+t_r)} [\eta_{L, \tilde{w}} \omega_{t_r} + \eta_{L, \tilde{r}}] dt_r, \quad (24)$$

where  $\eta_{L, \tilde{r}} = L_{\tilde{r}} \tilde{r} / L$  denotes the interest rate elasticity of labour demand and  $\omega_{t_w} = w_{t_w} \cdot (1+t_w) / w$  and  $\omega_{t_r} = w_{t_r} \cdot (1+t_r) / w$  describe the net-of-tax wage elasticities with respect to  $t_w$  and  $t_r$ , respectively. Substituting the condition (23) into (24) and rearranging yields the following condition for the change in employment:

---

<sup>11</sup> If the net-of-tax wage rate changes, the cost of public good provision will also change (cf. footnote 2). As we are not interested in changes in public expenditures, this effect is neglected for the time being.

$$\left. \frac{dL}{dt_r} \right|_{dG=0} \begin{cases} > \\ = \\ < \end{cases} 0 \quad \Leftrightarrow \quad \frac{\tau_{t_r}}{\tau_{t_w}} \begin{cases} > \\ = \\ < \end{cases} \frac{\eta_{L,\tilde{w}}\omega_{t_r} + \eta_{L,\tilde{r}}}{\eta_{L,\tilde{w}}(1 + \omega_{t_w})}. \quad (25)$$

If a tax reform increases the gross capital price  $\tilde{r}$  by one percent, the ratio of the left-hand side indicates the percentage by which the gross wage  $\tilde{w}$  has to decrease because of a cut in the labour tax rate in order to keep the public good provision  $G$  constant. The ratio of the right-hand side denotes the percentage the gross wage has to decline to keep the employment level constant. If the revenue-neutrality requirement allows the government to cut the labour tax rate at a higher rate than is necessary to sustain the employment level, wage negotiations will lead to lower wages and will increase employment accordingly. Three different cases can be distinguished depending on the reaction of the net-of-tax wage rate.

*i) Cobb-Douglas production technology*

For the case of a Cobb-Douglas production technology, it can be seen from conditions (18) and (21) that wage negotiations are unaffected by changes in the factor tax rates. Hence, Propositions 1 to 3 from Section 3 carry over to the case of a Cobb-Douglas production technology when the wage rate is negotiated between the trade union and the firm. This may be summarized in

**PROPOSITION 4:** If wages are negotiated between the trade union and the firm and the technology is Cobb-Douglas, a marginal revenue-neutral tax reform, which increases the capital tax rate and reduces the labour tax rate, will leave the net-of-tax wage rate unaffected and increase output, employment, and welfare if the labour tax rate exceeds the capital tax rate.

*ii) The elasticity of substitution exceeds unity*

If the elasticity of substitution exceeds unity, the net-of-tax wage elasticity with respect to  $t_w$ , is positive,  $\omega_{t_w} > 0$ , so that the net-of-tax wage rate is reduced by a cut in the labour tax rate. This effect increases labour demand. As a fall in the net-of-tax wage rate also increases tax revenues,  $G_w < 0$ , and therefore allows for a larger cut of labour taxes, the total employment

effect will be larger than in the case of a constant net-of-tax wage rate.<sup>12</sup> Formally, Appendix 2 shows that the left-hand side of condition (25) is increasing in  $\omega_{t_w}$  :

$$\frac{\partial}{\partial \omega_{t_w}} \frac{\tau_{t_r}}{\tau_{t_w}} > 0. \quad (26)$$

Applying the symmetry condition,  $\omega_{t_r} = -\omega_{t_w}$  (see Appendix 2), and differentiating shows that the right-hand side of (25) is decreasing in  $\omega_{t_w}$  :

$$\frac{\partial}{\partial \omega_{t_w}} \frac{-\eta_{L,\bar{w}}\omega_{t_w} + \eta_{L,\bar{r}}}{\eta_{L,\bar{w}}(1 + \omega_{t_w})} = -\frac{\eta_{L,\bar{w}} + \eta_{L,\bar{r}}}{\eta_{L,\bar{w}}(1 + \omega_{t_w})^2} < 0. \quad (28)$$

These two facts establish that, if employment is increasing when the net-of-tax wage rate is unaffected – which has been shown to hold for  $t_w > t_r$  –, employment is also boosted when the negotiated wage falls due to the revenue-neutral tax reform. This can be summarized in

**PROPOSITION 5:** If the labour tax rate exceeds the capital tax rate, a marginal revenue-neutral tax reform, which increases the capital tax rate and reduces the labour tax rate and induces a reduction in the negotiated net-of-tax wage rate, will increase both output and employment.

*iii) The elasticity of substitution is less than unity*

If substitutability of factors is low, the trade union will succeed in increasing the net-of-tax wage rate. Furthermore, the rise in the net-of-tax wage rate reduces tax revenues and, therefore, allows for smaller tax rate cuts only.<sup>13</sup> Both effects have a negative effect on employment so that the total effect on employment becomes ambiguous.

However, it can be shown that if the elasticity of substitution is sufficiently close to unity, the employment effect will still be positive. It has already been shown that a revenue-neutral tax reform increases employment when  $\sigma = 1$ . Furthermore, it can be shown that at

<sup>12</sup> As  $\varepsilon > \sigma > 1$  it follows that  $\eta_{L,\bar{w}} \leq -1$ . This is a sufficient condition for  $G_w < 0$  to hold.

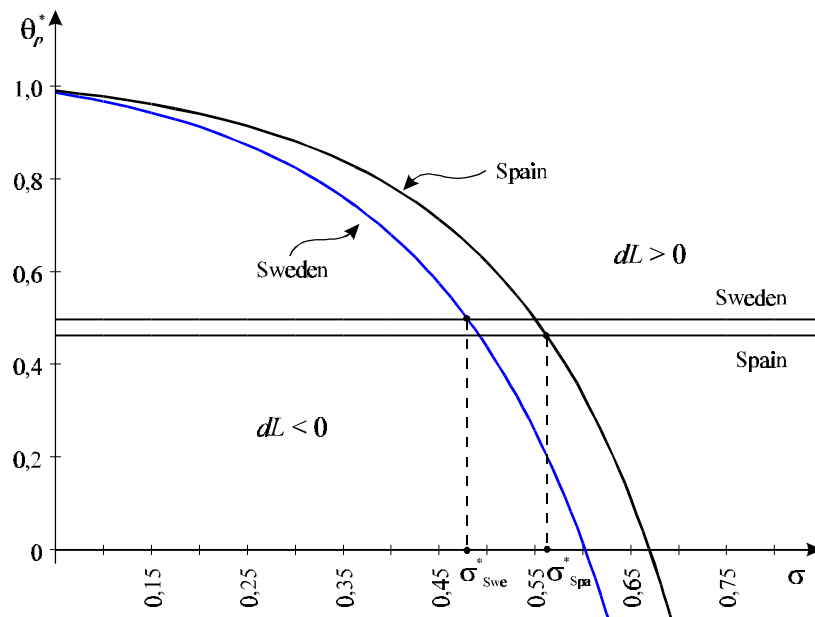
<sup>13</sup> A sufficient condition is  $\eta_{L,\bar{w}} \leq -1$ , which is guaranteed if e.g.  $\varepsilon \geq 1/s$ .

$\sigma = 1$  the positive employment effect is increasing with the elasticity of substitution so that the employment effect is still positive for some values of  $\sigma < 1$ .<sup>14</sup> This result can be summarized in

**PROPOSITION 6:** If the elasticity of substitution between capital and labour is above a critical value  $\sigma^*$  which is itself less than one, a marginal revenue-neutral tax reform, which increases the capital tax rate and reduces the labour tax rate, will reduce unemployment.

As the employment effect cannot be determined qualitatively in the case of a low substitutability, we provide some numerical results for the worst scenario of a monopoly trade union, which show how the sign of the employment effect depends on the initial tax system and the elasticity of substitution.

Figure 2: The employment-neutral labour tax rates for Sweden and Spain



Using the figures presented in Table 1 we consider the case for Spain with the highest capital tax rate, and Sweden with the lowest capital tax rate of zero, and calculate the critical values of the elasticity of substitution which ensure that the marginal tax reform is revenue-neutral. The bold lines in Figure 2 show the combinations of parameter values for the elasticity of

<sup>14</sup> A proof is available on request.

substitution  $\sigma < 1$  and the initial labour tax  $\theta_w^* = t_w^*/(1+t_w^*) < 1$  where the employment effect is zero. The lower line represents Sweden, the upper line represents the geometric loci for Spain. The horizontal lines indicate the present labour tax rates in Sweden and Spain, respectively. The output demand elasticity is assumed to be  $\varepsilon = 2$  for both countries and the cost share of labour  $s = 0,67$ .

In the case of Sweden, it turns out that any elasticity of substitution above  $\sigma^* = 0.48$  would guarantee a positive employment effect. In Spain, where the initial capital tax rate is much higher than it is in Sweden, only an elasticity of substitution above  $\sigma^* = 0.56$  would be sufficient to guarantee a positive employment effect. Further calculations indicate that given the parameter values of the other countries (except for the UK because of the relative low labour tax rate), the critical values for all examples are in the range of  $[0.48; 0.56]$ . If the negative output effect becomes stronger, i.e.  $d\varepsilon > 0$ , the employment-neutral curves shift outward so that the scope for employment improving tax reforms decreases.

## 6. Is tax progression good for employment?

It has been argued in the literature on union bargaining that an increase in the tax progression levied on the members of the trade union moderates the net-of-tax wage, *ceteris paribus*, and thereby boosts employment.<sup>15</sup> This paper has not considered taxes levied on the members of the trade union so that one might ask whether the employment-boosting effect of the tax progression holds in the case of the labour tax levied on the firms. If that is the case, then government can promote wage moderation, and thereby employment, even when the elasticity of substitution between capital and labour is too low for the revenue-neutral tax reform to boost employment. It is therefore of interest to explore whether increasing tax progression by increasing both the labour tax rate levied on firms and the tax credit granted to the members of the trade union will reduce the gross wage and thereby alleviate unemployment.

---

<sup>15</sup> See e.g. Lockwood and Manning (1993) for some theoretical development and empirical evidence from the United Kingdom and Koskela and Vilminen (1996) for a demonstration of the employment boosting effect of income tax progression in three different trade union models.

To consider the revenue-neutral increase in tax progression assume that the government requires a fixed amount of tax revenues to finance public good  $G$  and abstract from changes in the government budget constraint due to changes in unemployment benefit payments and tax revenues from capital income taxation because the net effect on  $G$  is positive if employment increases and negative if employment falls. This gives the following budget constraint

$$G = (t_w w - a)L. \quad (28)$$

The condition for a revenue-neutral change in tax progression is given by  $dG = 0 = G_a da + G_{t_w} dt_w$ . Differentiating (28) with respect to the tax credit  $a$  and the labour tax rate  $t_w$  and taking account of their direct and indirect effects via the net-of-tax wage and employment gives after some manipulations

$$G_a = -L(1 - uw_a), \quad (29)$$

$$G_{t_w} = wL(1 + t_w)^{-1} [1 + u(1 + \omega_{t_w})], \quad (30)$$

where  $u = t_w(1 + (1 - a/t_w w)\eta_{L, \tilde{w}})$ . The comparative statics of the net-of-tax wage with respect to the tax credit  $a$  and the labour tax rate  $t_w$  are given by equations (15) and (16). When the Laffer curve is upward-sloping, i.e.  $G_a < 0$ ,  $G_{t_w} > 0$ , we are now in the position to derive the total effect on the gross wage. The total differential of the gross wage  $\tilde{w} = w(1 + t_w)$  with respect to  $t_w$  and  $a$  can be written as

$$d\tilde{w} = w dt_w + (1 + t_w)w_{t_w} dt_w + (1 + t_w)w_a da = w(1 + \omega_{t_w}) dt_w + (1 + t_w)w_a da. \quad (31)$$

Substituting the tax-revenue-neutrality condition  $da = -G_a^{-1} G_{t_w} dt_w$  for  $da$  in equation (31) gives

$$\left. \frac{d\tilde{w}}{dt_w} \right|_{dG=0} = G_a^{-1} [G_a w(1 + \omega_{t_w}) - G_{t_w} (1 + t_w)w_a]. \quad (32)$$

Now the straightforward substitutions from the equations (29) and (30) give

$$[G_a w(1 + \omega_{t_w}) - G_{t_w} (1 + t_w)w_a] = -wL(1 + \omega_{t_w} + w_a) = -wL[y + xz]^{-1} \beta > 0. \quad (34)$$

As  $G_a < 0$ , this can be summarized in

PROPOSITION 7: A revenue-neutral increase in the labour tax rate compensated by a rise in the tax credit will lower the gross wage and boost employment regardless of the value of the elasticity of substitution.

Proposition 7 suggests that a revenue-neutral increase in the capital tax rate which is accompanied by an increase in the tax credit is more efficient in reducing unemployment than an increase in the capital tax rate which is accompanied by a reduction in the labour tax rate. This result is particularly important in the case of  $\sigma < 1$  as it implies that the employment-neutral value of the elasticity of substitution,  $\sigma^*$ , will be lower if the government increases the tax credit instead of reducing the labour tax rate. This yields

PROPOSITION 8: The employment-neutral value of the elasticity of substitution is lower for a revenue-neutral tax reform which increases the capital tax rate and the tax credit for workers than for a revenue-neutral tax reform which increases the capital tax rate and reduces the labour tax rate.

## 7. Concluding remarks

The preceding analysis has shown that there are good reasons for governments to rely more on source-based capital taxes than they currently do. If a country suffers from persistently high unemployment due to too high wages, a revenue-neutral shift in factor taxation, which increases capital tax rates and cuts labour tax rates, will boost production and alleviate unemployment as long as the labour tax rate exceeds the capital tax rate and the net-of-tax wage rate is not increased by subsequent wage negotiations between a trade union and a firm. If the negotiated net-of-tax wage rate increases as a consequence of a revenue-neutral increase in capital taxation, however, this reduces the efficacy of tax policies to alleviate unemployment. Nevertheless, shifting the labour tax system towards a capital tax system may boost employment provided that substitutability between labour and capital is not too low. But even

if this tax reform fails to boost employment, the government can promote wage moderation by increasing the workers' personal tax exemption instead of reducing the labour tax rate.

The results derived in this paper are in apparently sharp contrast to the conclusions usually found in the literature on capital income taxation in open economies. There, the standard result is that capital should be exempted from source-based taxes (cf. e.g. MacDougall 1961, Gordon 1986, Razin and Sadka 1991, Bucovetsky and Wilson 1991) or even be subsidized (cf. Gordon and Bovenberg 1996). By contrast, our analysis suggests that, in economies with involuntary unemployment due to too high wages, the capital tax should be positive and should not be lower than the labour tax rate. From a pure theoretical perspective one might be inclined to argue that this result holds only for the extreme case when both labour and capital supply are perfectly elastic. Although this argument is correct, it neglects the fundamental fact that involuntary unemployment implies that labour supply is – at least locally – infinitely elastic. Hence, in the presence of involuntary unemployment due to too high wages, there is no reason to discriminate between labour and capital. When the whole tax burden falls on the consumer of domestic output, factor prices should not be distorted. For this reason, labour tax rates and capital tax rate should be equal. However, because the marginal social cost of labour falls short of the net-of-tax market price while the marginal social cost of capital for a small open economy is equal to the interest rate at which the economy can borrow capital, it is beneficial to further substitute labour for capital by going beyond equiproportional factor tax rates.

Some authors have argued that it is optimal to tax capital income when full taxation of profit is not feasible because it is an indirect way of taxing economic profit (cf. Bruce 1992 and Huizinga and Nielsen 1997). Although our analysis assumes restrictions on profit taxation, this assumption is not crucial for our results.<sup>16</sup> Within a modified framework where firms face set-up costs and free entry guarantees zero profits in equilibrium, our results would still hold. The positive capital tax is a direct implication of the elasticity rule of optimal taxation which

---

<sup>16</sup> Positive profits are assumed to model wage negotiations between a trade union and the firm. In the absence of profits, we would have to consider a monopoly trade union instead.



indicates that if the government has to apply factor taxes, it should not discriminate between factors having the same supply elasticity.

If the government could tax profits at 100 percent, it is not necessary in our framework to tax factors at all because the maximum tax revenues in a market with fixed net-of-tax factor prices are equal to the monopoly rent when no factor taxes are levied. It would thus be optimal to set the capital tax rate to zero. In this, our analysis confirms recent results about optimal capital taxation in the presence of monopoly trade unions (cf. Richter and Schneider 1998 or Boeters and Schneider 1998). It also confirms the result that labour should be subsidized if the labour market is monopolized because the social marginal cost of labour falls short of private marginal cost of labour.<sup>17</sup>

When profits occur, however, and are not fully taxed, increasing capital tax rates actually increase profits as long as the tax reform starts in a labour tax system. This positive effect on profit can be of great importance for the location decisions of firms, which have not been considered in our framework. If location decisions of firms were taken into account our results would be strengthened as increasing the capital tax up to the level of the labour tax rate increases profits and therefore the incentive to move into the country.

---

<sup>17</sup> Guesnerie and Laffont 1978 have shown that it is optimal to subsidize price makers. With respect to monopolized labour markets Boeters and Schneider 1998 show that an optimal tax system may require a negative tax on labour.

### Appendix 1: derivation of condition (8)

Applying the factor demand elasticities  $\eta_{L,\tilde{w}} = L_{\tilde{w}}\tilde{w}/L$ , and  $\eta_{K,\tilde{r}} = K_{\tilde{r}}\tilde{r}/K$ , and the cross-factor-price elasticities  $\eta_{K,\tilde{w}} = K_{\tilde{w}}\tilde{w}/K$  and  $\eta_{L,\tilde{r}} = L_{\tilde{r}}\tilde{r}/L$ , equation (7) can be rewritten as:

$$dG = wL \left[ 1 + \frac{t_w + \frac{b-a}{w}}{(1+t_w)} \eta_{L,\tilde{w}} + \frac{t_r}{(1+t_r)} \frac{\tilde{r}K}{\tilde{w}L} \eta_{K,\tilde{w}} \right] dt_w + rK \left[ 1 + \frac{t_w + \frac{b-a}{w}}{(1+t_w)} \frac{\tilde{w}L}{\tilde{r}K} \eta_{L,\tilde{r}} + \frac{t_r}{(1+t_r)} \eta_{K,\tilde{r}} \right] dt_r. \quad (\text{A1})$$

Using the definition of the cost share of labour,  $s$ , and applying Shephard's lemma yields:

$$\eta_{K,\tilde{w}} = K_{\tilde{w}} \frac{\tilde{w}}{K} = C_{\tilde{r}\tilde{w}} \frac{\tilde{w}}{K} = C_{\tilde{w}\tilde{r}} \frac{\tilde{r}}{L} \frac{\tilde{w}L}{\tilde{r}K} = \eta_{L,\tilde{r}} \frac{s}{(1-s)},$$

Equation (A1) can therefore be rewritten as

$$dG = wL \left[ 1 + \frac{t_w + \frac{b-a}{w}}{(1+t_w)} \eta_{L,\tilde{w}} + \frac{t_r}{(1+t_r)} \eta_{L,\tilde{r}} \right] dt_w + rK \left[ 1 + \frac{t_w + \frac{b-a}{w}}{(1+t_w)} \eta_{K,\tilde{w}} + \frac{t_r}{(1+t_r)} \eta_{K,\tilde{r}} \right] dt_r. \quad (\text{A2})$$

Substituting equation (6) in (A2) yields

$$\frac{dG}{dt_r} \Big|_{dY=0} \begin{cases} > \\ = \\ < \end{cases} 0 \quad \Leftrightarrow \quad \frac{t_w + \frac{b-a}{w}}{(1+t_w)} (-\eta_{L,\tilde{w}} + \eta_{K,\tilde{w}}) \begin{cases} > \\ = \\ < \end{cases} \frac{t_r}{(1+t_r)} (-\eta_{K,\tilde{r}} + \eta_{L,\tilde{r}}). \quad (\text{A3})$$

According to Euler's theorem the factor incomes equal total cost of production, i.e.

$$\tilde{w}L + \tilde{r}K = c(\tilde{w}, \tilde{r})Y = \left( \frac{\varepsilon-1}{\varepsilon} \right) pY = \left( \frac{\varepsilon-1}{\varepsilon} \right) Y^{\frac{\varepsilon-1}{\varepsilon}}. \quad (\text{A4})$$

Differentiation of (A4) with respect to the gross wage rate  $\tilde{w}$  yields

$$L + \tilde{w}L_{\tilde{w}} + \tilde{r}K_{\tilde{w}} = \left( \frac{\varepsilon-1}{\varepsilon} \right)^2 (f_L L_{\tilde{w}} + f_K K_{\tilde{w}}) Y^{\frac{1}{\varepsilon}},$$

which, after some manipulations using the definition of the factor demand elasticities and the first order conditions  $((\varepsilon-1)/\varepsilon)pf_L(K, L) = \tilde{w}$  and  $((\varepsilon-1)/\varepsilon)pf_K(K, L) = \tilde{r}$ , can be written as:

$$L(1 + \eta_{L,\tilde{w}} + \eta_{L,\tilde{r}}) = \left( \frac{\varepsilon-1}{\varepsilon} \right) \left( \frac{\tilde{w}}{p} L_{\tilde{w}} + \frac{\tilde{r}}{p} K_{\tilde{w}} \right) Y^{\frac{1}{\varepsilon}}.$$

Applying (3) and the definitions of the cross-price elasticities, we obtain

$$\eta_{L,\tilde{w}} + \eta_{L,\tilde{r}} = -\varepsilon. \quad (\text{A5})$$

Differentiation (A4) with respect to the gross interest rate  $\tilde{r}$  yields analogously

$$\eta_{K,\tilde{r}} + \eta_{K,\tilde{w}} = -\varepsilon. \quad (\text{A6})$$

Substituting (A6) and (A5) in (A3) finally yields condition (8).

## Appendix 2: Net-of-tax wage elasticities

The signs of the net-of-tax wage elasticities are determined by

$$w_{t_w} = -\Omega_{ww}^{-1} \Omega_{wt_w}, \quad w_{t_r} = -\Omega_{ww}^{-1} \Omega_{wt_r}. \quad (\text{A8})$$

Using condition (12) for the labour tax and a similar condition for the capital tax, we have:

$$\begin{aligned} \Omega_{wt_w} &= \frac{\beta}{V^2} (VV_{wt_w} - V_w V_{t_w}) + \frac{(1-\beta)}{\pi^2} (\pi\pi_{wt_w} - \pi_w \pi_{t_w}) \\ &= -\frac{(1+t_r)}{(1+t_w)} \left[ \frac{\beta}{V^2} (VV_{wt_r} - V_w V_{t_r}) + \frac{(1-\beta)}{\pi^2} (\pi\pi_{wt_r} - \pi_w \pi_{t_r}) \right] \\ &= -\frac{(1+t_r)}{(1+t_w)} \Omega_{wt_r}. \end{aligned} \quad (\text{A9})$$

It is straightforward to derive the symmetry condition  $\omega_{t_r} = -\omega_{t_w}$  from (A-9).

To determine the left-hand side of condition (27) we make use of the explicit partial derivatives in (27):

$$G_{t_w} = \frac{wL}{(1+t_w)} \left[ 1 + \left( t_w (1 + \eta_{L,\tilde{w}}) + \frac{b-a}{w} \eta_{L,\tilde{w}} + t_r \frac{rK}{wL} \eta_{K,\tilde{w}} \right) (1 + \omega_{t_w}) \right] \quad (\text{A-10})$$

and

$$G_{t_r} = \frac{rK}{(1+t_r)} \left[ 1 + t_r (1 + \eta_{K,\tilde{r}}) + \left( t_w + \frac{b-a}{w} \right) \frac{wL}{rK} \eta_{L,\tilde{r}} + \omega_{t_r} \left( \left( t_w + \left( t_w + \frac{b-a}{w} \right) \eta_{L,\tilde{w}} \right) \frac{wL}{rK} + t_r \eta_{K,\tilde{w}} \right) \right], \quad (\text{A-11})$$

The partial derivatives of equations (A-10) and (A-11) with respect to the net-of-tax wage elasticity are given by:

$$\frac{\partial G_{t_w}}{\partial \omega_{t_w}} = \frac{wL}{(1+t_w)} \left( t_w (1 + \eta_{L,\tilde{w}}) + \frac{b-a}{w} \eta_{L,\tilde{w}} + t_r \frac{rK}{wL} \eta_{K,\tilde{w}} \right) < 0 \quad (\text{A-12})$$

and

$$\frac{\partial G_{t_r}}{\partial \omega_{t_w}} = -\frac{\partial G_{t_r}}{\partial \omega_{t_r}} = -\frac{rK}{(1+t_r)} \left( \left( t_w(1+\eta_{L,\tilde{w}}) + \frac{b-a}{w} \eta_{L,\tilde{w}} \right) \frac{wL}{rK} + t_r \eta_{K,\tilde{w}} \right) > 0, \quad (\text{A-13})$$

where the signs are unambiguously given if  $\eta_{L,\tilde{w}} < -1$  which always holds if  $\sigma > 1$ . Substituting into the left-hand side of condition (27) shows that the left-hand side is increasing in  $\omega_{t_w}$ .

## References

- Allen, R.G.D. (1938): *Mathematical Analysis for Economists*, Macmillan: London.
- Binmore, Kenneth G. and Ariel Rubinstein and Asher Wolinsky (1986): "The Nash Bargaining Solution in Economic Modelling," *Rand Journal of Economics* 17, pp. 176-188.
- Boeters, Stefan and Kerstin Schneider (1998): *Government versus Union. The Structure of Optimal Taxation in Unionized labor Market*, University of Dortmund, Department of Economics, mimeo. January.
- Bruce, Neil (1992): "A Note on the Taxation of International Capital Flows," *The Economic Record* 68, pp. 217-221.
- Bucovetsky, Sam and John Douglas Wilson (1991): "Tax Competition with Two Tax Instruments," *Regional Science and Urban Economics* 21, S. 333-350.
- Commission of the European Communities (1996): *Task Force on Statutory Contributions and Charges XXI-02. Tableaux de bord prélèvements obligatoires*, Brussels.
- Eaton, B. Curtis and Richard G. Lipsey (1978): "Freedom of Entry and Existence of Pure Profit," *Economic Journal* 88, pp. 455-469.
- Guesnerie, Roger and Jean-Jacques Laffont (1978): "Taxing Price Makers," *Journal of Economic Theory* 19, pp. 423-455.
- Gordon, Roger H. (1986): "Taxation of Investment and Savings in a World Economy," *American Economic Review* 76, pp. 1086-1102.
- Gordon, Roger H. and Lans A. Bovenberg (1996): "Why is Capital so Immobile Internationally? Possible Explanations and Implications for Capital Income Taxation," *American Economic Review* 86, pp. 1057-1075.
- Hamermesh, Daniel S. (1993): *Labor Demand*, Princeton University Press: Princeton NJ.
- Holm, Pasi, Seppo Honkapohja and Erkki Koskela (1994): "A Monopoly Union Model of Wage Determination with Capital and Taxes: An Empirical Application to the Finnish Manufacturing," *European Economic Review* 38, pp. 285-303.
- Huizinga, Harry and Søren Bo Nielsen (1997): "Capital Income and Profit Taxation with Foreign Ownership of Firms," *Journal of International Economics* 42, pp. 149-165.
- Koskela, Erkki, Ronnie Schöb and Hans-Werner Sinn (1998): "Pollution, Factor Taxation and Unemployment", *International Tax and Public Finance* 5, pp.379-396.
- Koskela, Erkki and Jouko Vilmunen (1996): "Tax Progression is Good for Employment in Popular Models of Trade Union Behaviour," *Labour Economics* 3, pp. 65-80.
- Lockwood, Ben and Alan Manning (1993): "Wage Setting and the Tax System," *Journal of Public Economics* 52, pp. 1-29.
- MacDougall, G. D. A. (1960): "The Benefits and Costs of Private Investment from Abroad: A Theoretical Approach," *The Economic Record* 37, S.13-35.
- Nash, John (1950): "The Bargaining Problem," *Econometrica* 18, pp. 155-162.
- Nickell, Stephen (1997): "Unemployment and Labor Market Rigidities: Europe versus North America," *Journal of Economic Perspectives* 11.3, pp. 55-74.
- OECD (1995): *The OECD Jobs Study. Taxation, Employment and Unemployment*, OECD: Paris
- Pissarides, Christopher A. (1998): "The Impact of Employment Tax Cuts on Unemployment and Wages: The Role of Unemployment Benefits and Tax Structure," *European Economic Review* 42, pp. 155-183.
- Razin, Assaf and Efraim Sadka (1991): "International Tax Competition and Gains from Tax Harmonization," *Economic Letters* 37, pp. 69-76.
- Richter, Wolfram and Kerstin Schneider (1998): *Taxing Mobile Capital with Labor Market Imperfections*, University of Dortmund, Discussion Papers in Economics No. 97-08, revised version July.