

Koskela, Erkki; Schöb, Ronnie

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## Optimal Capital Taxation in Economies with Unionised and Competitive Labour Markets

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# OPTIMAL CAPITAL TAXATION IN ECONOMIES WITH UNIONISED AND COMPETITIVE LABOUR MARKETS

ERKKI KOSKELA  
RONNIE SCHÖB

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# OPTIMAL CAPITAL TAXATION IN ECONOMIES WITH UNIONISED AND COMPETITIVE LABOUR MARKETS

## Abstract

According to the existing literature, capital taxes should not be imposed in the presence of optimal profit taxation in either unionised or competitive labour markets. We show that this conclusion does not hold for an economy with both competitive and unionised sectors, where the competitive wage rate provides the outside option for unionised workers. Even with non-distortionary profit taxation it is optimal for such an economy to tax capital if the revenue share of capital in the unionised sector is lower than the revenue share of capital in the competitive sector. This is because taxing capital income reduces employment and lowers the outside option of workers in the unionised sector with the latter effect being stronger. A capital subsidy should be granted if the opposite relationship in terms of revenue shares holds.

JEL Classification: H21, J51, C70.

Keywords: optimal capital taxation, unionised and competitive labour markets, outside option.

*Erkki Koskela*  
*Department of Economics*  
*P.O. Box 54 (Unioninkatu 37)*  
*FIN-00014 University of*  
*Helsinki*  
*Finland*  
*erkki.koskela@helsinki.fi*

*Ronnie Schöb*  
*Dept of Economics and Management*  
*Otto-von-Guericke University*  
*P.O. Box 41 20*  
*39016 Magdeburg*  
*Germany*  
*ronnie.schoeb@ww.uni-magdeburg.de*

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## **1. Introduction**

A fundamental result in the existing literature on capital income taxation is that small open economies should not levy source-based capital taxes if profit taxation is non-restricted. This result holds both in economies with competitive labour markets and economies with unionised labour markets. In the former case, the optimal tax structures includes profit and labour taxes only (cf. e.g. MacDougall 1960, Bucovetsky and Wilson 1991 and for a survey and some generalizations in dynamic general equilibrium models, cf. Atkeson, Chari and Kehoe 1999). In the latter case, i.e. economies where the labour markets are imperfect due to e.g. bargaining power of the trade unions, a capital tax should not be employed as long as profits are high enough so that profit taxes can be used to finance public expenditures and a wage subsidy to correct for the labour market distortions (cf. Koskela and Schöb 2002a and Richter and Schneider 2001). If, however, profit taxation is restricted, it may become optimal to levy a positive capital tax to indirectly tax profits when labour markets are competitive (Huizinga and Nielsen 1997) and to moderate wages in the presence of labour market distortions by affecting the wage elasticity of labour demand via the capital tax (Koskela and Schöb 2002a).

It is tempting to conclude from these well-established results that when capital tax should not be levied in either an economy with a perfectly competitive or an imperfect labour market, it also should not be levied in economies with dual labour markets, where some sectors exhibit competitive labour markets and some unionised labour markets. This paper shows that this conclusion does not hold if these two types of labour markets are interrelated. If workers can be employed in both sectors, the competitive wage rate provides the outside option for unionised workers.<sup>1</sup> The marginal introduction of a capital tax does not distort the competitive labour market but reduces the outside option for workers in the unionised sector. This will moderate wage formation and boost employment and output in the unionised sector

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<sup>1</sup> For an analysis and discussion of the determinants of outside options, cf. Blanchard and Katz (1997).

sector and improve social welfare – as long as the revenue share of capital in the unionised sector is lower than the cost (=revenue) share of capital in the competitive sector. A capital subsidy should be granted if the opposite relationship between the revenue shares holds.

To focus on the interaction between the two different types of labour markets as clearly as possible we abstract from all other reasons that would require a non-zero capital tax rate. Thus, we (i) consider a small open economy that cannot influence the terms-of-trade, (ii) do not impose any restrictions on profit taxation so that the government can always rely on non-distortionary taxes and (iii) assume Cobb-Douglas production technologies to eliminate the effects, factor taxation can have on wage formations by altering the wage elasticity of labour demand. We proceed as follows: Section 2 outlines the model, while Section 3 derives the main results concerning the optimal structure of factor taxes in the presence of unrestricted non-distortionary profit taxation. The results are briefly discussed in the final Section 4.

## 2. The model

We consider a small open economy where there is one unionised sector and one competitive sector. The unionised sector produces the good  $Y^u$  that is sold on the world market at given world market price, which is normalized to unity. Output is produced with three inputs, capital  $K^u$ , labour  $L^u$  and a third fixed input, whose income is considered as profit (or rent).<sup>2</sup> To focus on the effects tax rate changes have on the cost side of production, we assume a constant profit share, i.e. the production function exhibits decreasing returns to scale in capital and labour,

$$Y^u = \left( L^{u^s} \cdot K^{u^{(1-s)}} \right)^{\frac{1}{\epsilon}}. \quad (1)$$

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<sup>2</sup> Alternatively, we can assume that the unionised sector generates profit due to monopolistic competition in the goods market, see e.g. Koskela and Schöb 2002b.

where  $\varepsilon > 1$  describes the degree of decreasing returns to scale. Consequently,  $1/\varepsilon$  denotes the constant profit share,  $s$  the cost share of labour and  $s(\varepsilon - 1)/\varepsilon$  the revenue share of labour, respectively. Capital is assumed to be perfectly mobile between countries while labour is mobile only between sectors within the economy. The firm maximizes profits whereby it considers the gross factor prices  $\tilde{r}$  and  $\tilde{w}^u$  as given. The gross interest rate  $\tilde{r}$  consists of the net-of-tax interest rate and a source-based capital tax, i.e.  $\tilde{r} = (1 + t_r)r$  with  $t_r$  denoting the uniform capital tax rate and  $r$  the (constant) world interest rate. The gross wage  $\tilde{w}^u$  is the net-of-tax wage  $w^u$ , which is negotiated between the trade union and the firm, plus the labour tax, i.e.  $\tilde{w}^u = (1 + t_w)w^u$ , with  $t_w$  denoting the uniform labour tax rate.

All  $N$  workers of the economy are represented by a trade union which maximizes its  $N$  members' net-of-tax income. The net-of-tax wage rate of a working member in the unionised sector is  $w^u$ . The outside option is to work in the competitive sector where the net-of-tax wage rate is given by  $w^c$ . The objective function for the trade union can thus be expressed as:

$$V^0 = w^u L^u + w^c (N - L^u). \quad (2)$$

The wage rate is determined in a bargaining process between the trade union and the firm and the firm then unilaterally determines employment. This 'right-to-manage' approach represents the outcome of the bargaining by an asymmetric Nash bargaining. The fall-back position of the trade union is given by  $V^0 = w^c N$ , i.e. if the negotiations break down, all members will work in the competitive labour sector. Assuming a small trade union, the outside option is constant for the trade union. The fall-back position of the firm is given by zero profits, i.e.  $\pi^0 = 0$ . Using  $V \equiv V^* - V^0$ , the Nash bargaining maximand can be written as

$$\Omega = V^\beta \pi^{1-\beta}, \quad (3)$$

with  $\beta$  representing the relative bargaining power of the trade union. The first-order condition with respect to the net-of-tax wage rate is

$$\Omega_w = 0 \Leftrightarrow \beta \frac{V_w}{V} + (1 - \beta) \frac{\pi_w}{\pi} = 0. \quad (4)$$

Solving the first-order condition (4) explicitly under the assumptions made, we obtain:

$$w'' = \frac{\beta \eta_{L, \tilde{w}}'' (\epsilon(1-s) + s) + (1-\beta)(\epsilon-1)s}{\beta(1 + \eta_{L, \tilde{w}}'') (\epsilon(1-s) + s) + (1-\beta)(\epsilon-1)s} w^c \equiv m w^c, \quad (5)$$

where  $m > 1$  denotes the mark-up between the negotiated and competitive net-of-tax wage rates. It is constant as the definition of the wage elasticity of labour demand,  $\eta_{L, \tilde{w}}'' \equiv L_{\tilde{w}} \tilde{w} / L = -1 + s(1-\epsilon)$ , shows that  $\eta_{L, \tilde{w}}''$  is constant in the case of the Cobb-Douglas production function (1) (cf. Koskela and Schöb 2002b for an explicit derivation). The union-nonunion wage differential can be written as  $d = (w'' - w^c) / w^c = m - 1$ . Hence, the net-of-tax wage  $w''$  as well as the gross wage rate  $w''(1 + t_w)$  are proportional to the net-of-tax wage rate and the gross wage rate, respectively, in the competitive sector.

In the competitive sector, the representative firm produces the good  $Y^c$ , which price is also normalized to unity, with capital  $K^c$  and labour  $L^c$  as the only two inputs. The production technology is assumed to be Cobb-Douglas with constant returns to scale, i.e. we have

$$Y^c = L^{c\sigma} \cdot K^{c(1-\sigma)}, \quad (6)$$

where  $\sigma$  denotes the cost share of labour and  $(1-\sigma)$  the cost share of capital in the competitive sector. Profits are thus zero in the competitive sector – a reason why this sector is not unionised. The price of capital is the same as in the unionised sector, while the net of-tax wage  $w^c$  is determined by the equilibrium condition in the competitive labour market. As all  $N$  workers in the economy prefer to work in the unionised sector as the net-of-tax wage rate exceeds the net-of-tax wage rate in the competitive labour market, the labour supply in the competitive sector is given by  $N - L^u$  and the net-of tax wage rate  $w^c$  is determined by the equilibrium condition  $L^c(\tilde{w}^c, \tilde{r}) = N - L^u(\tilde{w}^u, \tilde{r})$ .

To determine the effects, factor taxes have on the net-of-tax wage rate and the gross wage rate in the competitive sector, we make use of the cost function associated with the production function (6), that is  $C(\tilde{w}^c, \tilde{r}, Y) = c(\tilde{w}^c, \tilde{r}) Y^c = \sigma^{-\sigma} (1-\sigma)^{\sigma-1} \tilde{w}^{c\sigma} \tilde{r}^{1-\sigma} Y^c$ , where  $c(\tilde{w}^c, \tilde{r})$  denotes the constant unit cost of production and thereby the marginal cost as well. As profit maximization requires  $c(\tilde{w}^c, \tilde{r}) = 1$ , the impact of factor taxes on the net-of-tax wage rate can be described as follows

$$\frac{dw^c}{dt_w} \equiv w_{t_w}^c = -\frac{w^c}{(1+t_w)} < 0 \quad (7)$$

and

$$\frac{dw^c}{dt_r} \equiv w_{t_r}^c = -\frac{(1-\sigma)}{\sigma} \frac{w^c}{(1+t_r)} < 0. \quad (8)$$

A higher labour tax decreases the net-of-tax wage rate in the competitive sector such that the gross wage rate remains constant. A higher capital tax also reduces the net-of-tax wage rate such that both the marginal and unit cost remain constant. Naturally, the precise reduction depends on the cost shares of capital and labour.

The government is assumed to require a fixed amount of tax revenues to finance the public good  $G$ . It can levy a profit tax  $t_\pi$ , a labour tax  $t_r$  on wage income and a source-based tax on domestic capital input  $t_r$ , so that the government budget constraint is given by

$$t_\pi \pi^u + t_w (w^u L^u + w^c L^c) + t_r r (K^u + K^c) = G. \quad (9)$$

To focus only on the efficiency aspects of the tax structure, we assume linear preferences and define the total surplus as the social welfare function (cf. Summers, Gruber and Vergara 1993). The total surplus consists of the net-of-tax wage income equal to  $w^u L^u + w^c L^c$ , which accrues to workers, and the net-of-tax profit income  $(1-t_\pi)\pi^u$ . As we hold  $G$  constant we suppress the term  $G$  in the total surplus function. Furthermore, the income from the domestic capital stock is also assumed to be constant and therefore is not explicitly considered in the welfare function either. All domestic profits go to domestic capitalists.<sup>3</sup> Hence, the social welfare function is given by

$$S = w^u L^u + w^c L^c + (1-t_\pi)\pi^u. \quad (10)$$

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<sup>3</sup> For an analysis when foreigners receive a fraction of domestic profits, see Huizing and Nielsen (1997).



### 3. The optimal tax structure

The government is supposed to commit to the choice of an optimal tax structure by choosing tax rates so as to maximize social welfare (10) subject to the government's budget constraint (9) and to wage and employment determination in both the unionised and competitive sector. Defining  $\lambda$  as the Lagrange multiplier for the government budget constraint, the first order condition for the profit tax  $t_\pi$  is:

$$-\pi'' + \lambda\pi'' = 0 \Leftrightarrow \lambda = 1, \quad (11)$$

which shows that the optimal profit tax is non-distortionary. Moreover, and importantly, using the wage bargaining equation (5) for the unionised labour market, the first-order condition with respect to the labour tax rate  $t_w$  can be written as follows

$$\Lambda_{t_w} = 0 \Leftrightarrow mL''[\lambda w^c + (1 + \lambda t_w)w_{t_w}^c] + (N - L'')[w^c + (1 + \lambda t_w)w_{t_w}^c] = 0, \quad (12)$$

where  $\Lambda$  describes the Lagrangian function. Utilizing equation (7) it can easily be shown that (12) also requires  $\lambda = 1$ . Thus, the labour tax rate is as good as the profit tax to finance public expenditures efficiently, i.e. both taxes are non-distortionary in our framework. There are two reasons for this interesting finding. First, the labour tax rate in the competitive sector does only affect the net-of-tax wage of a fixed factor because the labour supply is exogenously determined by the unionised sector's labour demand. Second, as the gross wage rate in the unionised sector is proportional to the gross wage rate in the competitive sector, the labour tax does not affect the outcome of the unionised sector either. This is an application of a well-known neutrality result by Layard, Nickell and Jackman (1991) (see p. 108) according to which labour taxes do not affect the outcome in the unionised sector if the outside option is proportional to the net-of-tax wage paid in the unionised sector. Proposition 1 summarizes.

**PROPOSITION 1 (LABOUR TAX RATE):** A labour tax rate is non-distortionary in both the unionised and competitive sector, if the net-of-tax wage rate of the competitive sector represents the outside option of the trade union and total labour supply in the economy is fixed.

Next we turn to the optimal capital tax rate and first notice that according to the existing literature, the capital tax rate should always be zero if non-distortionary taxes are available. We now ask whether this result holds if unionised and competitive labour markets both exist in an economy and are interrelated because the competitive wage rate is the outside option for the trade union that negotiates the wage rate in the unionised sector.

Maximizing the Lagrangian with respect to  $t_r$  when  $\lambda = 1$ , gives the following formula for the optimal capital tax rate

$$t_r = \frac{(m-1)\epsilon \left( \frac{s(\epsilon-1)}{\epsilon} + \frac{1}{\epsilon} - \sigma \right)}{\left[ \frac{N}{L^u} \frac{(1-\sigma)}{\sigma} + \left( \frac{m\epsilon}{s} - \frac{(\epsilon-1)}{\sigma} \right) (\sigma-s) \right]}. \quad (13)$$

(see Appendix 1 for a detailed derivation of Equation (13)). For a positive markp-up ( $m > 1$ ) the denominator is always positive if  $\sigma - s$  is positive. Furthermore, and importantly, it can also be shown that the denominator is always positive under some additional but rather weak assumptions about the magnitude of  $m$  in the case when  $\sigma - s$  is negative:

$$m < \frac{s}{\sigma} \left( 1 + \frac{1}{\epsilon} \cdot \frac{(1-s)}{(s-\sigma)} \right) \Rightarrow \left[ \frac{N}{L^u} \frac{(1-\sigma)}{\sigma} + \left( \frac{m\epsilon}{s} - \frac{(\epsilon-1)}{\sigma} \right) (\sigma-s) \right] > 0 \quad (14)$$

(see Appendix 2). For instance, if the the profit share  $1/\epsilon$  in the unionized sector is 10 %, i.e.  $\epsilon = 10$ , any union-nonunion wage differential  $m - 1$  being less than 40 % provides a sufficient condition for a positive denominator. This assumption about the union-nonunion wage differential lies in conformity with empirical studies (for surveys, see Booth (1995) and Lewis (1986)). Thus the sign of the capital tax rate is given by the sign of the numerator.

As we show in Appendix 1 (see Equation (A3)), the sign of the numerator is equal to the  $sign(L_r^u r + L_w^u \tilde{w}_{t_r}^c m)$  that describes the employment effect of the capital tax rate in the unionised sector. We can see immediately that if the cost share of labour in the unionised sector  $s$  exceeds the cost share of labour in the competitive sector  $\sigma$ , the optimal tax structure requires a positive capital tax rate. As the numerator of (13) increases in the difference  $(\sigma - s)$  while the denominator decreases, the optimal tax structure is given by

$$t_r \begin{cases} > \\ = \\ < \end{cases} 0 \Leftrightarrow \frac{s(\varepsilon - 1)}{\varepsilon} + \frac{1}{\varepsilon} \begin{cases} > \\ = \\ < \end{cases} \sigma. \quad (15)$$

In equation (14) the left-hand side is equal to the revenue share of labour, which is  $(\varepsilon - 1)/\varepsilon$  times the cost share of labour  $s$ , plus the profit share in the unionised sector  $1/\varepsilon$ . These are the two income shares in the unionised sector that affect social welfare. The right-hand side denotes the cost share of labour in the competitive sector. This is the only income share in the competitive sector. Thus even in the presence of optimal non-distortionary profit tax the capital tax rate should be positive if the welfare-relevant income component increases due to the introduction of a capital tax.

To derive the intuition for this result, we rewrite (15) as the condition for the sign of the capital tax rate in terms of the revenue share of capital:

$$t_r \begin{cases} > \\ = \\ < \end{cases} 0 \Leftrightarrow 1 - \frac{s(\varepsilon - 1)}{\varepsilon} - \frac{1}{\varepsilon} \begin{cases} < \\ = \\ > \end{cases} (1 - \sigma). \quad (16)$$

The optimal capital tax condition (15) can be summarized as

**PROPOSITION 2 (CAPITAL TAX RATE):** The optimal tax structure in an economy, where there are no restrictions on profit taxation, requires a positive capital tax rate if the revenue share of capital in the unionised sector is lower than the cost (= revenue) share of capital in the competitive sector. A capital subsidy should be granted if the opposite relationship holds.

To provide an interpretation, notice first that the allocation of workers between sectors is determined in the unionised sector because the negotiated wage rate there determines labour demand in this sector. A capital tax reduces employment in the unionised sector because labour and capital are price complements, i.e.  $L_{\tilde{r}}^u < 0$ . This effect is the larger, the larger the revenue share of capital is. In the competitive sector, the capital tax rate will lead to a fall in the net-of-tax wage rate so that marginal cost remains constant. The fall in the net-of-tax wage rate in the competitive sector is the larger, the larger the cost share of capital is in this sector. As this affects the outside option of the trade union, the effect countervails the direct effect of a change in the capital tax rate on employment in the unionised sector as it will lead

trade unions to moderate wages. As Proposition 2 shows, the direct effect of the capital tax rate is dominated by the indirect wage moderation effect if the revenue share of capital in the unionised sector is lower than in the competitive sector. Hence, capital should be taxed. But if the direct effect dominates the indirect wage moderation effect, then capital should be subsidised.

Thus, Proposition 2 implies that if a capital tax can shift labour from the competitive to the unionised sector, social welfare will increase. The direct effect is obvious. Those workers who now find a job in the unionised sector are better off as their wage increases. As we can apply the envelope theorem for the marginal introduction of the capital tax, we can see that the income loss of workers in the competitive sector is compensated by the tax revenues from the marginal capital tax rate. In the unionised sector profits will rise by the same amount as tax revenues plus the income loss of incumbent workers. Thus the only welfare relevant effect is the income rise of those workers who change sectors. More precisely, the relationship between the social welfare and a marginal introduction of capital income tax can be presented as follows

$$S_{t_r} = \frac{dL^u}{dt_r} (m-1)w^c \quad (17)$$

(see Appendix 3 for details).

#### 4. Concluding remarks

The existing literature has demonstrated that in the presence of unrestricted profit taxes, source-based capital taxes should not be employed in either an economy with competitive labour market or an economy with unionised labour market. We have shown in this paper that this result does not carry over to the case of an economy where both types of labour markets exist and are interrelated so that the competitive wage rate determines the outside option for unionised workers and where there is a uniform labour tax rate in competitive and unionised labour markets. More precisely, we have shown in Proposition 2 that the relative revenue

shares of capital in the unionised and competitive sector are essential in determining whether a capital tax or capital subsidy should be levied even in the presence of optimal profit taxation.

Of course, our main result holds under strict assumptions about the technology in the two sectors. These strong assumptions were made because the aim of the paper was to isolate an effect that, to our knowledge, has not yet been discussed in the literature. By eliminating all effects that may affect the optimal capital tax rate and have already been identified in the literature, we were able to focus on an important effect capital taxes will have in an economy where parts of the labour markets are unionised while other parts are competitive. In such a dual labour markets economy, the capital tax rate normally affects the allocation of labour between sectors by changing the outside option in the unionised sector labour market via its impact on the wage rate in competitive labour market. It is desirable from a welfare point of view to employ more labour in the unionised sector as the marginal productivity of labour in the unionised sector is higher than in the competitive sector. Hence, the capital tax or the capital subsidy can be used to achieve that when other tax instruments fail to reallocate labour. This is the case with labour taxes when the technology in the unionised sector is Cobb-Douglas.

Apart from the allocative effects, a welfare-improving introduction of either a capital tax or a capital subsidy, depending on the relative size of the revenue shares of capital, will have distributive consequences too. As we have identified the unionised sector as the one where profits are present and thus rent-sharing is possible, a welfare-improving introduction of a capital tax will hurt workers as their income goes down while benefiting the recipients of profit income if the revenue share of capital in the unionised sector is lower than in the competitive one.

## Appendix 1: Derivation of the optimal capital tax formula

Maximizing social welfare (10) subject to government budget constraint (9) and wage and employment determination in the unionised and competitive sectors when the marginal cost of public funds is equal to one allows us to write the Lagrangian function as

$$\Lambda|_{\lambda=1} = m\tilde{w}^c L^u + \tilde{w}^c (N - L^u) \frac{\sigma + t_r}{\sigma(1 + t_r)} + t_r r K^u + \pi^u \quad (\text{A1})$$

Differentiating (A1) with respect to  $t_r$  gives the first-order condition

$$\begin{aligned} \Lambda_{t_r} = 0 \Leftrightarrow & m\tilde{w}^c [L_{\tilde{r}}^u r + L_{\tilde{w}}^u \tilde{w}_{t_r}^c m] + mL^u \tilde{w}_{t_r}^c \\ & + \frac{\sigma + t_r}{\sigma(1 + t_r)} (N - L^u) \tilde{w}_{t_r}^c - \frac{\sigma + t_r}{\sigma(1 + t_r)} \tilde{w}^c [L_{\tilde{r}}^u r + L_{\tilde{w}}^u \tilde{w}_{t_r}^c m] \\ & + \tilde{w}^c (N - L^u) \frac{\sigma(1 - \sigma)}{\sigma^2(1 + t_r)^2} - rK^u - mL^u \tilde{w}_{t_r}^c + rK^u + t_r r [K_{\tilde{r}}^u r + K_{\tilde{w}}^u \tilde{w}_{t_r}^c m] = 0 \end{aligned} \quad (\text{A2})$$

Reformulating, using (8) yields

$$\begin{aligned} & m\tilde{w}^c [L_{\tilde{r}}^u r + L_{\tilde{w}}^u \tilde{w}_{t_r}^c m] - \frac{\sigma + t_r}{\sigma(1 + t_r)} (N - L^u) \frac{(1 - \sigma) \tilde{w}^c}{\sigma(1 + t_r)} - \frac{\sigma + t_r}{\sigma(1 + t_r)} \tilde{w}^c [L_{\tilde{r}}^u r + L_{\tilde{w}}^u \tilde{w}_{t_r}^c m] \\ & + \tilde{w}^c (N - L^u) \frac{\sigma(1 - \sigma)}{\sigma^2(1 + t_r)^2} + t_r r [K_{\tilde{r}}^u r + K_{\tilde{w}}^u \tilde{w}_{t_r}^c m] = \\ & \left[ m - \frac{\sigma + t_r}{\sigma(1 + t_r)} \right] \tilde{w}^c [L_{\tilde{r}}^u r + L_{\tilde{w}}^u \tilde{w}_{t_r}^c m] - \frac{t_r (1 - \sigma) \tilde{w}^c}{\sigma^2(1 + t_r)^2} (N - L^u) + t_r r [K_{\tilde{r}}^u r + K_{\tilde{w}}^u \tilde{w}_{t_r}^c m] = 0 \end{aligned} \quad (\text{A3})$$

Using the factor demand elasticities  $\eta_{L,\tilde{w}}^u = -1 + s(1 - \varepsilon)$ ,  $\eta_{L,\tilde{r}}^u = (1 - s)(1 - \varepsilon)$ ,  $\eta_{K,\tilde{r}}^u = -1 + (1 - s)(1 - \varepsilon)$ ,  $\eta_{K,\tilde{w}}^u = s(1 - \varepsilon)$  (for details cf. Koskela and Schöb 2002b), we can write:

$$L_{\tilde{r}}^u r + L_{\tilde{w}}^u \tilde{w}_{t_r}^c m = \frac{L^u}{1 + t_r} \left[ \eta_{L,\tilde{r}}^u - \eta_{L,\tilde{w}}^u \frac{1 - \sigma}{\sigma} \right] = \frac{L^u \varepsilon}{(1 + t_r) \sigma} \left[ \frac{s(\varepsilon - 1)}{\varepsilon} + \frac{1}{\varepsilon} - \sigma \right] \quad (\text{A4})$$

and

$$K_{\tilde{r}}^u r + K_{\tilde{w}}^u \tilde{w}_{t_r}^c m = \frac{K^u}{1 + t_r} \left[ \eta_{K,\tilde{r}}^u - \eta_{K,\tilde{w}}^u \frac{1 - \sigma}{\sigma} \right] = \frac{K^u \varepsilon}{(1 + t_r) \sigma} \left[ \frac{s(\varepsilon - 1)}{\varepsilon} - \sigma \right]. \quad (\text{A5})$$

Substituting (A4) and (A5) into (A3) yields:

$$\left[ m - \frac{\sigma + t_r}{\sigma(1 + t_r)} \right] \frac{\tilde{w}^c L^u \varepsilon}{(1 + t_r) \sigma} \left[ \frac{s(\varepsilon - 1)}{\varepsilon} + \frac{1}{\varepsilon} - \sigma \right] - \frac{t_r (1 - \sigma) \tilde{w}^c}{\sigma^2(1 + t_r)^2} (N - L^u) + t_r r \frac{K^u \varepsilon}{(1 + t_r) \sigma} \left[ \frac{s(\varepsilon - 1)}{\varepsilon} - \sigma \right] = 0$$

$\Leftrightarrow$

$$\left[ m - \frac{\sigma + t_r}{\sigma(1+t_r)} \right] \tilde{w}^c L^u \varepsilon \left[ \frac{s(\varepsilon - 1)}{\varepsilon} + \frac{1}{\varepsilon} - \sigma \right] - \frac{t_r(1-\sigma)\tilde{w}^c}{\sigma(1+t_r)} (N - L^u) + t_r r K^u \varepsilon \left[ \frac{s(\varepsilon - 1)}{\varepsilon} - \sigma \right] = 0$$

$$\Leftrightarrow$$

$$\left[ m - \frac{\sigma + t_r}{\sigma(1+t_r)} \right] \tilde{w}^c L^u X - \frac{t_r(1-\sigma)\tilde{w}^c}{\sigma(1+t_r)} (N - L^u) + t_r r K^u (X - 1) = 0,$$

where  $X \equiv s(\varepsilon - 1) + 1 - \varepsilon\sigma$ . Thus we have

$$\left[ (1+t_r)m - \frac{\sigma + t_r}{\sigma} \right] \tilde{w}^c L^u X - \frac{t_r(1-\sigma)\tilde{w}^c}{\sigma} (N - L^u) + t_r \tilde{r} K^u (X - 1) = 0$$

and

$$\left[ (1+t_r)m - \frac{\sigma + t_r}{\sigma} \right] X - \frac{t_r(1-\sigma)}{\sigma} \frac{(N - L^u)}{L^u} + t_r \frac{1-s}{s} m (X - 1) = 0.$$

Factoring out with respect to  $t_r$ , we end up with equation

$$\Lambda_{t_r} = 0 \Leftrightarrow t_r \left[ mX + \frac{1-s}{s} m(X-1) - \frac{(1-\sigma)}{\sigma} \frac{(N - L^u)}{L^u} - \frac{X}{\sigma} \right] + [m-1]X = 0. \quad (\text{A6})$$

Substituting the definition of  $X$  into the first-order condition (A6) and reformulating gives equation (13) of the text.

## Appendix 2: Sufficient conditions for positive denominator of equation (13)

*Case A:*  $(\sigma - s) > 0$ . A sufficient condition for the positive denominator is that the term  $[m\varepsilon/s - (\varepsilon - 1)/\sigma]$  is also positive so that  $m\varepsilon\sigma - (\varepsilon - 1)s > 0$ . Using this condition, we have  $m\varepsilon\sigma - (\varepsilon - 1)s > m\varepsilon s - (\varepsilon - 1)s = \varepsilon s(m - 1) + s$ . As  $m > 1$ , it follows immediately that  $m\varepsilon\sigma - (\varepsilon - 1)s > 0$ .

*Case B:*  $(\sigma - s) < 0$ . Let us first rewrite the denominator as follows

$$\frac{N}{L^u} \frac{(1-\sigma)}{\sigma} + \left( \frac{m\varepsilon}{s} - \frac{(\varepsilon - 1)}{\sigma} \right) (\sigma - s) = \frac{1}{\sigma s} \left[ \frac{N}{L^u} (1-\sigma)s + m\varepsilon\sigma^2 - m\varepsilon\sigma s - \varepsilon s\sigma + \varepsilon s^2 + s\sigma - s^2 \right]$$

so that the sign of the denominator is the same as the sign of the terms in square brackets. Furthermore, applying  $(\sigma - s) < 0$ , We can write:

$$\frac{N}{L^u} (1-\sigma)s + m\varepsilon\sigma^2 - m\varepsilon\sigma s - \varepsilon s\sigma + \varepsilon s^2 + s\sigma - s^2 > (1-\sigma)s + m\varepsilon\sigma^2 - m\varepsilon\sigma s - \varepsilon s\sigma + \varepsilon s^2 + s\sigma - s^2$$

Thus, if the right-hand-side is positive, the denominator is also positive:

$$s + m\varepsilon\sigma^2 - m\varepsilon\sigma s - \varepsilon s\sigma + \varepsilon s^2 - s^2 = s(1-s) + m\varepsilon\sigma(\sigma-s) + \varepsilon s(s-\sigma) > 0$$

For  $(\sigma-s) < 0$ , we know that  $\sigma(\sigma-s) < 0$  and  $s(s-\sigma) > 0$ . Thus, the denominator is positive in case B as long as

$$m < \frac{s}{\sigma} \left( 1 + \frac{1}{\varepsilon} \cdot \frac{(1-s)}{(s-\sigma)} \right) \quad (\text{A7})$$

The term in brackets exceeds unity. Assuming that  $\varepsilon$  is a finite number, i.e. monopoly power does exist, a small difference between  $s$  and  $\sigma$  makes the term in brackets very large while a larger difference let the first term increase.

### Appendix 3: The social welfare effect of a marginal introduction of a capital tax

Differentiating social welfare (10), and assuming  $t_r = t_w = 0$ , we obtain

$$S_{t_r} = w_{t_r}^c (mL^u + N - L^u) + (L_r^u r + L_w^u \tilde{w}_{t_r}^c m)(m-1)w^c + (1+t_\pi)\pi^u + \left. \frac{\partial t_\pi}{\partial t_r} \right|_{dG=0} \pi^u \quad (\text{A8})$$

Using (8) and (A4), differentiating the budget constraint (9) with respect to the capital tax and applying

$$\pi_{t_r} = \pi_r^u r + \pi_w^u \tilde{w}_{t_r}^c m = -rK^u + \frac{1-\sigma}{\sigma} L^u \tilde{w}^c m \quad (\text{A9})$$

we can rewrite (A6), using  $rK^c/wL^c = (1-\sigma)/\sigma$

$$\begin{aligned} S_{t_r} &= \frac{dL^u}{dt_r} (m-1)w^c - \frac{1-\sigma}{\sigma} w^c (mL^u + L^c) - rK^u + \frac{1-\sigma}{\sigma} L^u \tilde{w}^c m + r(K^u + K^c) \\ &= \frac{dL^u}{dt_r} (m-1)w^c \end{aligned} \quad (\text{A10})$$

which gives equation (16) of the text.



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