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

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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 dual labour markets, 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 employment effect being stronger. Moreover, a capital subsidy should be granted if the opposite relationship of the revenue shares of capital in the unionised and competitive sectors holds.

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

JEL-classification: H21, J51, C70.

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. in 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 non-distortive 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 should not be levied in economies with dual labour markets, where some sectors exhibit competitive labour markets and some unionised labour markets. This paper, however, shows a new result according to which this conclusion does not hold if these two types of labour markets are interrelated in such a way that if workers can be employed in both sectors, the competitive wage rate provides the outside option for unionised workers.[1] A marginal introduction of a capital tax reduces employment directly in the unionised sector because labour and capital are price complements. While such a marginal introduction of a capital tax

[1] For an analysis and discussion of the determinants of outside options, cf. Blanchard and Katz (1997).

does not distort the competitive labour market, it reduces the outside option for workers in the unionised sector. This will moderate wage formation and thereby boost employment and output in the unionised 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 of capital in the unionised and competititve sector holds. In that case the indirect positive effect of the capital tax rate via the outside option is smaller than the direct negative effect so that subsidizing capital income will improve social welfare.

The main objective of the paper is to identify and elaborate the tax incidence when the the two labour markets are interrelated. Therefore, we abstract from all other well-known reasons that would require a non-zero capital tax rate in a second-best optimal tax framework. 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 result concerning the optimal structure of factor taxes in the presence of unrestricted non-distortionary profit taxation. Our findings are briefly summarized 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).[2] To focus on the effects tax rate changes have on the cost side of production, we assume a constant profit share so that the Cobb-Douglas production function exhibits decreasing

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[2] 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.

returns to scale in capital and labour,

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

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 the two 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 labour 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. The objective function for the trade union can thus be expressed as:

$$V^* = w^u L^u + w(N - L^u). \tag{2}$$

The wage rate is determined in a bargaining process between the labour 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 labour union is given by $V^0 = wN$, i.e. if the negotiations break down, all members will work in the competitive labour sector. Assuming a small labour union, the outside option is constant. 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

$$\Omega = V^\beta \pi^{1-\beta}, \tag{3}$$

with β representing the relative bargaining power of the labour union. The first-order condition with respect to the net-of-tax wage rate is

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

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

$$w^u = \frac{\beta\eta^u_{L,\tilde{w}} + (1-\beta)(1+\eta^u_{L,\tilde{w}})}{\beta(1+\eta^u_{L,\tilde{w}}) + (1-\beta)(1+\eta^u_{L,\tilde{w}})} w = 1 + \frac{\beta}{s(\varepsilon-1)} \equiv mw \,, \tag{5}$$

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, $\eta^u_{L,\tilde{w}} \equiv L_{\tilde{w}}\tilde{w}/L = -1 + s(1-\varepsilon)$, shows that $\eta^u_{L,\tilde{w}}$ is constant in the case of the Cobb-Douglas production function (1) (cf. Koskela and Schöb 2002b for an explicit derivation). The union-non-union wage differential can be written as

$$d = (w^u - w)/w = m - 1 = \frac{\beta}{s(\varepsilon-1)} > 0.$$

Hence, the net-of-tax wage w^u as well as the gross wage rate $(1+t_w)w^u$ 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, the price of which is also normalized to unity, with capital K and labour L as the only two inputs. The production technology is assumed to be Cobb-Douglas with constant returns to scale, i.e. we have

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

where σ denotes the cost share of labour and $(1-\sigma)$ the cost share of capital in the competitive sector. Profits are zero in the competitive sector, because this sector is not unionised. The price of capital is the same as in the unionised sector, while the net of-tax wage w 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 is determined by the equilibrium condition $L(\tilde{w},\tilde{r}) = N - L^u(\tilde{w}^u,\tilde{r})$.

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 $C(\tilde{w},\tilde{r},Y) = c(\tilde{w},\tilde{r})Y = \sigma^{-\sigma}(1-\sigma)^{\sigma-1}\tilde{w}^{\sigma}\tilde{r}^{1-\sigma}Y$, where $c(\tilde{w},\tilde{r})$ denotes the constant unit cost of production and thereby the marginal cost as well. As profit maximization requires $c(\tilde{w},\tilde{r}) = 1$, the impact of factor taxes on the net-of-tax wage rate can be described as follows:

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

and

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

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 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_π, a labour tax t_w on wage income and a source-based tax on domestic capital input t_r, so that the government budget constraint is given by

$$t_\pi \pi^u + t_w(w^u L^u + wL) + t_r r(K^u + K) = G \, . \tag{9}$$

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 $w^u L^u + wL$, 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.[3] Hence, the social welfare function is given by

[3] For an analysis when foreigners receive a fraction of domestic profits, see Huizinga and Nielsen (1997).

$$S = w^u L^u + wL + (1 - t_\pi)\pi^u \,. \tag{10}$$

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 λ as the Lagrange multiplier for the government budget constraint, the first order condition for the profit tax t_π is:

$$-\pi^u + \lambda\pi^u = 0 \quad \Leftrightarrow \quad \lambda = 1, \tag{11}$$

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

$$\Lambda_{t_w} = 0 \Leftrightarrow mL^u\left[\lambda w + (1 + \lambda t_w)w_{t_w}\right] + (N - L^u)\left[w + (1 + \lambda t_w)w_{t_w}\right] = 0\,, \tag{12}$$

where Λ 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.

Of course, under our assumptions the labour tax rate is non-distortionary in both the unionised and competitive sector only if total labour supply in the economy is fixed. If we relax this assumption by endogenising the labour-leisure choice of workers, this result would vanish as it would affect total employment. Nevertheless, the qualitative result concerning the allocation of labour between the two sectors would be unaffected. However, it may be affected by a non-linear labour tax. We will refer back to the implication this would have in our concluding remarks.

Next we turn to the optimal capital tax rate. According to the existing literature, the capital tax rate should always be zero if non-distortionary taxes are available. The question is, 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

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

(see Appendix 1 for a detailed derivation of equation (13)). For a positive mark-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. More precisely, we have

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

(see Appendix 2). For instance, if the profit share $1/\varepsilon$ in the unionized sector is 10 %, i.e. $\varepsilon = 10$, 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, we can conclude that 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 $\text{sign}(L^u_{\tilde{r}} r + L^u_{\tilde{w}} \tilde{w}_{t_r} m)$ 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 σ, then 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

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

In equation (15) 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 non-capital 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:

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

The optimal capital tax condition (16) can be summarized as

> PROPOSITION: *The optimal tax structure in an economy, where 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 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 the proposition 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.

The proposition 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 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 (see Appendix 3 for details)

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

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 demonstrate 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, our new proposition shows 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 is derived 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, a capital tax or capital subsidy can be used to reallocate labour when other tax instruments fail to do so. This is the case with labour taxes when the technology in the unionised sector is Cobb-Douglas. This result is very much in line with the general finding in the literature according to which changes in the tax structure will affect unemployment only if these changes allow the government to shift the tax burden away from unionised labour (cf. Bovenberg 2003). In this particular case, tax policy works by shifting the threat point of the trade union in the wage bargaining process.

Finally, we would like to mention two areas for further research. First, having identified a potentially important effect, the capital tax can play, we could ask in how far this effect can be dealt with by applying other tax instruments, e.g. a non-linear labour tax. Of course, the existence of a non-linear income tax may allow us to treat labour differently in the framework presented here. However, the tax system may allow for different income tax rates for different incomes but it does not so for different sector-specific features of the labour market. We can thus expect that there are restrictions concerning the application of non-linear labour taxes in order to deal with the reallocation of labour and capital taxes may be still necessary to raise efficiency. It is a subject to further research to analyse to what extent capital taxes may be used in dual labour markets to reallocate labour when more complex tax systems are considered.

Second, 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 also have distributive consequences in the case of heterogenous agents. 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.

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

$$\Lambda\big|_{\lambda=1} = m\tilde{w}L^u + \tilde{w}(N - L^u)\frac{\sigma + t_r}{\sigma(1+t_r)} + t_r rK^u + \pi^u . \tag{A1}$$

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

$$\begin{aligned}
&\Lambda_{t_r} = 0 \Leftrightarrow m\tilde{w}\left[L^u_{\tilde{r}} r + L^u_{\tilde{w}}\tilde{w}_{t_r} m\right] + mL^u\tilde{w}_{t_r} \\
&+\frac{\sigma + t_r}{\sigma(1+t_r)}(N - L^u)\tilde{w}_{t_r} - \frac{\sigma + t_r}{\sigma(1+t_r)}\tilde{w}\left[L^u_{\tilde{r}} r + L^u_{\tilde{w}}\tilde{w}_{t_r} m\right] \\
&+\tilde{w}(N - L^u)\frac{\sigma(1-\sigma)}{\sigma^2(1+t_r)^2} - rK^u - mL^u\tilde{w}_{t_r} + rK^u + t_r r\left[K^u_{\tilde{r}} r + K^u_{\tilde{w}}\tilde{w}_{t_r} m\right] = 0.
\end{aligned} \tag{A2}$$

Reformulating, using (8) yields

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

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

$$L^u_{\tilde{r}} r + L^u_{\tilde{w}}\tilde{w}_{t_r} m = \frac{L^u}{1+t_r}\left[\eta^u_{L,\tilde{r}} - \eta^u_{L,\tilde{w}}\frac{1-\sigma}{\sigma}\right] = \frac{L^u\varepsilon}{(1+t_r)\sigma}\left[\frac{s(\varepsilon-1)}{\varepsilon} + \frac{1}{\varepsilon} - \sigma\right] \tag{A4}$$

and

$$K^u_{\tilde{r}} r + K^u_{\tilde{w}}\tilde{w}_{t_r} m = \frac{K^u}{1+t_r}\left[\eta^u_{K,\tilde{r}} - \eta^u_{K,\tilde{w}}\frac{1-\sigma}{\sigma}\right] = \frac{K^u\varepsilon}{(1+t_r)\sigma}\left[\frac{s(\varepsilon-1)}{\varepsilon} - \sigma\right]. \tag{A5}$$

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

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

$$\Leftrightarrow$$

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

$$\Leftrightarrow$$

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

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

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

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

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

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 $\left[m\varepsilon/s-(\varepsilon-1)/\sigma\right]$ 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 the right-hand side 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

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

The term in brackets exceeds unity. Assuming that ε is a finite number, i.e. monopoly power does exist, a small difference between s and σ 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

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

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

$$\pi_{t_r} = \pi^u_{\tilde{r}} r + \pi^u_{\tilde{w}} \tilde{w}_{t_r} m = -rK^u + \frac{1-\sigma}{\sigma} L^u \tilde{w}\, m\,, \tag{A9}$$

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

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

which gives equation (16) of the text.

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