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Optimal capital taxation in economies with unionized 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 unionized or competitive labour markets. We show that this conclusion does not hold for economies with dual labour markets where the competitive wage rate provides the outside option for unionized workers. Even with non-distortionary profit taxation, it is optimal for such economies to tax capital if the revenue share of capital in the unionized sector is lower than in the competitive sector. This is because taxing capital income reduces employment and lowers the outside option of workers in the unionized sector, with the latter employment effect being stronger. A capital subsidy should be granted if the opposite relationship of the revenue shares of capital holds.

Keywords: optimal capital taxation, unionized 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 unionized labour markets. In the former case, the optimal tax structures include profit and labour taxes only (see, e.g., MacDougall 1960, Bucovetsky and Wilson 1991 and, for a survey and some generalizations in dynamic general equilibrium models, see Atkeson *et al.* 1999). In economies with imperfect labour markets due to, for example, 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 both public expenditures and a wage subsidy to correct for the labour market distortions (see Koskela and Schöb 2002a and Richter and Schneider 2001). If 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) or to affect wage elasticity of labour demand in a way that leads to wage moderation when the labour market is unionized (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 a unionized labour market, it should not be levied in economies with dual labour markets where some sectors are competitive and some are unionized. This paper shows that 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 unionized workers.[1] In this case, the fundamental inefficiency in the economy arises from the misallocation of labour between the two sectors since the trade union drives a wedge between marginal labour productivities in the two sectors.

A capital tax may help to reallocate labour if the two sectors exhibit different degrees

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

of capital intensities. To see this, consider the marginal introduction of a capital tax. If labour and capital are price complements, then the direct effect of a capital tax on employment is negative in the unionized sector. This effect is stronger, the higher the capital-intensity in the unionized sector is. In the competitive sector, the higher cost of capital will lead to a fall in the wage rate, which in turn reduces the outside option for workers in the unionized sector. This effect is stronger, the more capital-intensive the competitive sector is. Concerning the allocation of labour between the two sectors, we thus have two countervailing effects whose magnitudes depend on the factor input relation. Reallocating labour away from the competitive sector towards the unionized sector can be achieved with a positive capital tax if the revenue share of capital in the unionized sector is lower than the 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 unionized and competititve sector holds.

The main objective of the paper is to identify and elaborate the tax incidence when 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 for which 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 summarized and interpreted in the final section, 4.

2. The model

We consider a small open economy where there is one unionized sector and one competitive sector. The unionized sector produces the good Y^u that is sold on the world market at a 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). 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 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.[2]

All N workers in the economy are represented by a trade union that maximizes its N members' utility which in turn depends on the net-of-tax income. The net-of-tax wage rate of

[2] Alternatively, we can assume that the unionized sector generates profit due to monopolistic competition in the goods market (see, e.g., Koskela and Schöb 2002b) and that the firms in this sector thus behaves as a price-setter in the global market. If we assume monopolistic competition with an isoelastic demand function $D(p) = p^{-\varepsilon}$, the profit function becomes

$$\pi = pY^A - \tilde{w}^u L^u - \tilde{r}K^u = \left(Y^A\right)^{1-\frac{1}{\varepsilon}} - \tilde{w}^u L^u - \tilde{r}K^u. \tag{A}$$

Comparing this profit function with the profit function for the perfect competition case with one fixed factor,

$$\pi = Y^A - \tilde{w}^u L^u - \tilde{r}K^u = \left((L^u)^s \cdot (K^u)^{(1-s)}\right)^{1-\frac{1}{\varepsilon}} - \tilde{w}^u L^u - \tilde{r}K^u, \tag{B}$$

we can see first that in both cases $1/\varepsilon$ denotes the constant profit share. If we further assume a constant-return-to-scale production function with s being the cost share of labour, we have $Y^A = (L^u)^s \cdot (K^u)^{(1-s)}$. Substituting this production function in (A) shows that, in fact, the profit equation for the monopolistic case with an isoelastic demand function with an output demand elasticity ε is equivalent to the case with perfect competition and a production technology with a third factor whose cost share is equal to $1/\varepsilon$. Thus the analysis can be done in the same way for both type of models that generate profits in the unionized sector.

a working member in the unionized 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**.** When utility depends on wage income only, a utilitarian form for the the objective function for the trade union can be expressed as:

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

where u is assumed to be a concave function of w^u and w (see, e.g., Cahuc and Zylberberg 2004, chapter 7). The union calculates the average utility attained by its employed and unemployed members. The wage rate is determined in a bargaining process between the labour union and the firm, the firm then unilaterally determining employment. This 'right-to-manage' approach represents the outcome of the asymmetric Nash bargaining solution. The fall-back position of the labour union is given by $V^0 = u(w)N$**,** i.e. if the negotiations break down, all the 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 $V = V^* - V^0 = (u(w^u) - u(w))L^u$, 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

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

Henceforth, we shall use a standard HARA-type isoelastic utility function $u(x) = (x^{\gamma}/\gamma)$, where $\gamma \in [0,1]$ is a known exogenously determined constant that ensures risk-aversion and $1-\gamma = -u''(x)x/u'(x) = R < 1$ measures the elasticity of marginal utility of the trade union with respect to x (cf. Merton 1971). For this utility function and the utility function in (1) we can express the negotiated wage rate explicitly. This can be re-expressed as (cf. Appendix 1):

$$w^u = \left[\frac{s(\varepsilon-1)+\beta}{s(\varepsilon-1)+\beta R}\right]^{\frac{1}{1-R}} w = m\, w. \tag{5}$$

For any $\varepsilon > 1$ and $R < 1$, we have a positive union-non-union wage differential, i.e. $m > 1$. Since m is a constant, 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.[3] The case where utility is linear in wage income is represented by $1 - R = \gamma = 1$. In this case, we obtain a mark-up equal to $\overline{m} = \left[s(\varepsilon - 1) + \beta\right] / s(\varepsilon - 1)$. Comparing this mark-up with m in equation (5b) shows that $\overline{m} > m$. If the trade union is risk-averse, i.e. $R > 0$, the mark-up is smaller than in the case of a linear utility function, which implies risk-neutrality. Note that there are two special cases where the mark-up vanishes. First, in the limiting case where trade unions have no bargaining power, we have $\beta = 0$, from which $m = 1$ follows immediately from equation (5b). Second, if the profits in the unionized sector approach zero, i.e. $1/\varepsilon \to 0$, we also obtain $m = 1$.

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 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. Constant returns to scale imply that profits are zero in the competitive sector. This is a sufficient condition for this sector not to be unionized since there is no surplus that could be split between firm owners and workers. The price of capital is the same as in the unionized sector, while the net of-tax wage w is determined by the equilibrium condition in the competitive labour market. Since the net-of-tax wage rate w^u exceeds the net-of-tax wage rate in the competitive labour market, $m > 1$, all N workers in the economy prefer to work in the unionized sector. Thus, 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

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[3] Alternatively, we could also assume a logarithmic utility function $u(x) = \ln x$ that would also provide us with a constant mark-up. Details are available upon request**.**

$L(\tilde{w},\tilde{r}) = N - L^u(\tilde{w}^u,\tilde{r})$.

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. As it turns out, the whole tax incidence of both tax rates falls on labour due to internationally perfectly mobile capital.

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 for the government and define the total surplus as the social welfare function (see e.g. Summers *et al.* 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 is, therefore, not explicitly considered in the welfare function either. All domestic profits go to domestic capitalists.[4] Hence, the social welfare function is given by

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

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 unionized and competitive sector. Defining λ as the Lagrange multiplier for the government budget constraint, we have as the first order condition for the profit tax t_π:

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

which shows that the optimal profit tax is non-distortionary. Moreover, and importantly, using the wage bargaining equation (5b) for the unionized labour market with a constant mark-up m, 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 only affects the net-of-tax wage of a fixed factor because the labour supply is exogenously determined by the unionized sector's labour demand. Second, as the gross wage rate in the unionized sector is proportional to the gross wage rate in the competitive sector, the labour tax does not affect the outcome of the unionized sector either. This is an application of a well-known neutrality result by Layard *et al.* (1991, p. 108) according to which labour taxes do not affect the outcome in the unionized sector if the outside option is proportional to the net-of-

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

tax wage paid in the unionized sector.

Of course, under our assumptions, the labour tax rate is non-distortionary in both the unionized and competitive sector only if total labour supply in the economy is fixed. If we relax this assumption by endogenizing 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. It may, however, 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 analysis of an optimal capital tax rate in our framework. 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 unionized and competitive labour markets both exist in the economy and are interrelated because the competitive wage rate is the outside option for the trade union that negotiates the wage rate in the unionized sector. Maximizing the Lagrangian with respect to t_r when $\lambda = 1$ gives the following formula for the optimal capital tax rate

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

(see Appendix 2 for a detailed derivation of equation (13)). For $m = 1$, it follows immediately that the optimal capital tax rate is zero. As has been shown above, this is the case if either the profits in the unionized sector or the bargaining power of the trade union is zero. In both cases, the model actually reduces to a model with competitive labour markets only. For a positive mark-up $(m > 1)$, the denominator is always positive if $\sigma - s$ is positive, i.e. if the cost share of labour in the competitive sector is higher than in the unionized sector. 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

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

(see Appendix 3). For instance, if the profit share $1/\varepsilon$ in the unionized sector is 10 %, i.e. $\varepsilon = 10$, any union-non-union wage differential $m-1$ being less than 40 % provides a sufficient condition for a positive denominator. This assumption about the union-non-union wage differential lies in conformity with empirical studies (for surveys, see Lewis 1986, Booth 1995, Blanchflower and Bryson 2002). 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 2 (see equation A4), the sign of the numerator is equal to the $\text{sign}(L^u_{\tilde{r}} r + L^u_{\tilde{w}} \tilde{w}_{t_r} m)$, which describes the total employment effect of the capital tax rate in the unionized sector. We can see immediately that if the cost share of labour in the unionized 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 value of the numerator of (13) increases with the difference $(\sigma - s)$ while that of 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 condition (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 unionized sector $1/\varepsilon$. These are the two income shares in the unionized 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 an 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 in both the unionized and competitive sector:

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

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

Proposition 1 The optimal tax structure in an economy with dual labour markets, where there are no restrictions on profit taxation, requires a positive capital tax rate if the revenue share of capital in the unionized 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 see the underlying mechanism at work, notice first that the allocation of workers between sectors is determined in the unionized sector because the negotiated wage rate determines labour demand in this sector. A capital tax reduces employment in the unionized sector because labour and capital are price complements, i.e. $L^u_{\tilde{r}} < 0$. Naturally, this effect is 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 competitive net-of-tax wage rate is larger, the larger the cost share of capital is in this sector. As this affects the trade union's outside option, this effect countervails the direct effect on employment in the unionized sector as it will lead the trade union to moderate the wage. Proposition 1 shows that the direct effect is dominated by the indirect wage moderation effect if the revenue share of capital in the unionized 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 subsidized.

Proposition 1 implies that if a capital tax can shift labour from the competitive to the unionized sector, social welfare will increase. The direct effect is obvious. Those workers who find a job in the unionized 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 unionized 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 4 for details):

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

According to equation (17) a marginal introduction of capital tax (subsidy) will increase social welfare when it raises (decreases) employment in the unionized sector, i.e. when (dL^u / dt_r) is positive (negative).

To gain an idea of the magnitude of the optimal capital tax rate or subsidy, respectively, we provide some numerical calculations. In these calculations, we let the cost shares of labour vary between 0.5 and 0.7 in both sectors. According to Blanchflower and Bryson (2002), the trade union mark-up in 17 OECD countries averages at 12 percent. To be in line with this estimate, we set the profit share at 12.5 percent. This leads to a mark-up in the range of 10 to 14 percent when we vary s between 0.5 and 0.7 (according to equation (5b)). For this parameter range we obtain a maximum capital tax of 9.1 percent (for $s = 0.7$ and $\sigma = 0.57$) and a maximum capital subsidy of 6.1 percent (for $s = 0.5$ and $\sigma = 0.7$). The absolute values of both capital taxes and subsidies rise with the profit share so that lower profit shares would lead to lower optimal capital taxes or capital subsidies, respectively.

4. Concluding remarks

The existing literature shows that in the presence of unrestricted profit taxes, source-based capital taxes should not be employed in either an economy with a competitive or a unionized labour market. This result does not hold for an economy where both types of labour markets exist and are interrelated so that the competitive wage rate determines the outside option for unionized workers. In a model with two types of labour markets, the welfare loss occurs due to the misallocation of labour: there is two little labour employed in the unionized sector. If the government cannot employ sector-specific labour taxes it may use the capital tax to change the inefficient labour allocation between competitive and unionized labour markets. Our new proposition shows that the relative revenue shares of capital in the unionized and competitive sector are essential in determining whether a capital tax or capital subsidy should be levied to reallocate labour from the competitive sector towards the unionized sector to increase social welfare. This result applies 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, had not yet been discussed in the literature. We would like to emphasize that by eliminating all possible effects on the optimal capital tax rate that have already been identified in the literature, we were able to focus on an important effect capital taxes will have in an economy with dual labour markets where parts of the labour markets are unionized while other parts are competitive. Under these circumstances, the capital tax rate normally affects the allocation of labour between sectors by changing the outside option in the unionized sector labour market via its impact on the wage rate in the competitive labour market. Since it is desirable from a welfare point of view to employ more labour in the unionized sector, a capital tax or a 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 unionized sector is Cobb-Douglas. In this case, labour taxes cannot be employed to alter the labour demand elasticity in the unionized sector. Our result is thus 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 unionized 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.

Our analysis easily carries over to the taxation of other internationally traded production factors. A common material or resource with a world market price that cannot be influenced by a small country could be treated in exactly the same way as capital in our framework here. If any of these inputs show differences in how intensively they are used, this fact could be exploited by levying a tax or a subsidy on the material or resource. This becomes even more relevant in cases where such an input is used in only one of the two sectors. If, for example, some materials are used in the competitive sector only, a tax on these inputs would lead to wage moderation in the unionized sector and thus help to reallocate labour in the right direction.

Our analysis shows a classical second-best problem that the government could overcome if it were able to tax labour differently in the two sectors. Of course, the existence of a non-linear income tax may allow us to treat labour differently in the framework presented here, although this would require a regressive tax structure. In practice, however, the tax system may allow for different income tax rates for different incomes but it does not do so for different sector-specific features of the labour market. The government therefore cannot employ sector-specific labour taxes in order to deal with the reallocation of labour. This inability may give a rationale for the use of capital taxes to raise efficiency. It is a subject of further research to analyze the extent to which capital taxes may be used in dual labour markets to reallocate labour when more complex tax systems are considered.

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 in the unionized and competitive sector, will also have distributive consequences in the case of heterogenous agents. As we have identified the unionized sector as the one where profits are present and rent-sharing is thus 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 negotiated wage rate

Equation (4) can be re-expressed as

$$u(w^u)\left(\beta\eta^u_{L,\tilde{w}} + (1-\beta)(1+\eta^u_{L,\tilde{w}})\right) + \beta u'(w^u)w^u = \left(\beta\eta^u_{L,\tilde{w}} + (1-\beta)(1+\eta^u_{L,\tilde{w}})\right)u(w),$$

where the wage elasticity of labour demand is $\eta^u_{L,\tilde{w}^u} = L_{\tilde{w}^u}\tilde{w}^u / L^u = -1+s(1-\varepsilon)$. Henceforth, we shall use a standard HARA-type isoelastic utility function $u(x) = (x^\gamma/\gamma)$, where $\gamma \in [0,1]$ is a known exogenously determined constant and $1-\gamma = -u''(x)x/u'(x) = R < 1$ measures the elasticity of marginal utility of the trade union with respect to x (cf. Merton 1971). For this utility function we can express the negotiated wage rate explicitly as

$$w^u = \left[\frac{\left(\beta\eta^u_{L,\tilde{w}} + (1-\beta)(1+\eta^u_{L,\tilde{w}})\right)}{\left(\beta(1-R+\eta^u_{L,\tilde{w}}) + (1-\beta)(1+\eta^u_{L,\tilde{w}})\right)}\right]^{\frac{1}{1-R}} w = mw, \tag{A1}$$

where $m > 1$ denotes a constant 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) (see Koskela and Schöb 2002b for an explicit derivation). Using the expression for the elasticity of labour demand, equation (A1) can be written as equation (5).

Appendix 2: derivation of the optimal capital tax formula

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

$$\Lambda\big|_{\lambda=1} = m\tilde{w}L^u + \tilde{w}(N-L^u)\frac{\sigma+t_r}{\sigma(1+t_r)} + t_r rK^u + \pi^u. \tag{A2}$$

Differentiating (A2) with respect to t_r gives the first-order condition

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

Reformulating, using (8) yields

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

$$+\tilde{w}(N - L^u)\frac{\sigma(1-\sigma)}{\sigma^2(1+t_r)^2} + t_r r\left[K^u_{\tilde{r}}r + K^u_{\tilde{w}}\tilde{w}_{t_r}m\right] = \tag{A4}$$

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

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

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

and

$$K^u_{\tilde{r}}r + K^u_{\tilde{w}}\tilde{w}_{t_r}m = \frac{K^u}{1+t_r}\left[\eta^u_{K,\tilde{r}} - \eta^u_{K,\tilde{w}}\frac{1-\sigma}{\sigma}\right] = \frac{K^u\varepsilon}{(1+t_r)\sigma}\left[\frac{s(\varepsilon-1)}{\varepsilon} - \sigma\right]. \tag{A6}$$

Substituting (A5) and (A6) into (A4) 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 the equation

$$\Lambda_{t_r}=0\Leftrightarrow t_r\left[mX+\frac{1-s}{s}m(X-1)-\frac{(1-\sigma)}{\sigma}\frac{(N-L^u)}{L^u}-\frac{X}{\sigma}\right]+[m-1]X=0\,. \tag{A7}$$

Substituting the definition of X into the first-order condition (A7) and reformulating gives equation (13) of the text.

Appendix 3: sufficient conditions for the 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 the right-hand side square brackets. Furthermore, applying $(\sigma-s)<0$, we can write:

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

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

$$m<\frac{s}{\sigma}\left(1+\frac{1}{\varepsilon}\cdot\frac{(1-s)}{(s-\sigma)}\right). \tag{A8}$$

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 lets the first term increase.

Appendix 4: 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

$$S_{t_r} = w_{t_r}(mL^u + N - L^u) + (L^u_{\tilde{r}} r + L^u_{\tilde{w}} \tilde{w}_{t_r} m)(m-1)w + (1+t_\pi)\pi^u + \left.\frac{\partial t_\pi}{\partial t_r}\right|_{dG=0} \pi^u . \tag{A9}$$

Using (8) and (A5), differentiating the budget constraint (9) with respect to the capital tax and applying

$$\pi_{t_r} = \pi^u_{\tilde{r}} r + \pi^u_{\tilde{w}} \tilde{w}_{t_r} m = -rK^u + \frac{1-\sigma}{\sigma} L^u \tilde{w}\, m , \tag{A10}$$

we can rewrite (A9), using $rK/wL = (1-\sigma)/\sigma$

$$\begin{aligned} S_{t_r} &= \frac{dL^u}{dt_r}(m-1)w - \frac{1-\sigma}{\sigma} w(mL^u + L) - rK^u + \frac{1-\sigma}{\sigma} L^u \tilde{w} m + r(K^u + K) \\ &= \frac{dL^u}{dt_r}(m-1)w, \end{aligned} \tag{A11}$$

which gives equation (17) of the text.

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