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Optimal Capital Taxation with Labor Unions

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Abstract

In this paper, I examine the nature of optimal capital taxation in an economy where labor unions set wages. Wage contracts are called binding, if they protect investors against immediate expropriation after new machines are installed. I show that in order to maintain aggregate production efficiency the government needs a labor tax only in the presence and taxes on both labor and capital in the absence of binding contracts. In addition, I construct optimal tax rules for the cases of both binding and non-binding wage contracts.

Keywords: labor unions, optimal taxation, capital accumulation

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1 Introduction

This paper considers optimal factor income taxation when the wages determined by collective bargaining. In optimal taxation models with capital accumulation and no inherent distortions, the classical outcome is the Chamley-Judd (hereafter C-J) result: capital income should be taxed at a zero rate in the long run.[1] Because capital appears only in the production but not in the utility function, it should not be taxed, if there are enough instruments to separate consumption and production decisions. Later on, it has been shown that if the goods or asset markets are incomplete, then non-zero capital taxation is in general optimal,[2] and the validity of the C-J result depends sensitively on the set of available tax instruments.[3] This paper attempts to find out the minimum set of tax instruments that supports the C-J result in an economy with collective bargaining.

Domeij (2005) examines optimal factor income taxation with imperfect labor markets. He uses a matching model with the following properties. When workers are unsuccessful in their search for new employment, they end up in unemployment. When there is a successful match, the surplus of the firm is divided through worker-firm bargaining. Domeij's (2005) main result is that if the government is constrained to the taxation of capital and labor income, then the optimal capital income tax is in general non-zero, but if the government has access to other tax instruments, then the C-J result survives.

In Domeij's (2005) matching model, it is implicitly assumed that worker-firm bargaining over the wage is carried out within a single firm after a worker has secured a job. In many European countries, the wages are however determined from outside for a single firm by bargaining between a labor union representing the workers and an employer federation representing the firms in the industry. In that case, wage settlement differs from Domeij's framework in two respects. First, the labor union is interested in total employment in the industry rather than in a single firm. Second, there is a strategic

[1] Cf. Judd (1985), Chamley (1986) and Correia (1996). As a matter of fact, the C-J result is a dynamic counterpart of the result obtained by Diamond and Mirrlees (1971) that intermediate goods should not be taxed.

[2] Cf. Aiyagari (1995), and Judd (1997, 2002).

[3] Cf. Jones, Manuelli and Rossi (1997), Lansing (1999), Coleman (2000), and Judd (1999, 2002).

dependence between investment and wage settlement. In the latter, there are two alternatives:[4]

(i) Wage contracts are called *binding*, if they protect investors against immediate expropriation after new machines are installed. In such a case, there is an institution or a *commitment technology*, through which a labor union can credibly bind itself to a particular sequence of wages.[5]

(ii) Wage contracts are called *non-binding*, if investors must take into account that a union may revise its wages just after new machines have been installed and thus expropriate some of the rent of investment. In such a case, there is *no commitment technology* for a labor union.

In each country, legislation determines the category (case (i) or (ii) above) of collective bargaining institutions. In the Scandinavian countries, where wage contracts are made at the industry level and extended to cover all employers and employees in the industry, institutions correspond to the case (i). With the comparison of cases (i) and (ii), it is possible to examine the implications of labor market institutions for the design of optimal taxation.

Wage bargaining is commonly modeled as a game where two parties make alternately offers to each other to share a "pie" of exogenous size.[6] Unfortunately, because that game cannot be consistently integrated into a model where capital stock and income (the "pie") evolve over time, I must content myself with the special case of a monopoly union. To enable public policy, I assume that there is also a commitment technology through which the government can bind itself to a particular sequence of taxes once and for all.

So far, the literature on optimal capital taxation with labor unions has been very slim.[7] Palokangas (1987 and 2000, Ch. 4) shows that in a static general equilibrium framework, aggregate production efficiency can be maintained in the presence of industrial monopoly unions. This study examines

[4]Cf. Grout (1984), or Palokangas (2000), Ch. 5 and 6.

[5]For the definition of a commitment technology, cf. Chari and Kehoe (1999), p. 1688.

[6]Cf. Binmore et al. (1986).

[7]Aronsson et al. (2001) examine a shift of income taxation from labor to capital. They however assume a wage-setting monopoly union that maximizes the utility of the representative household in the economy. Koskela and von Thadden (2002) show that capital income should be taxed at a non-zero rate. In contrast to this paper, they however do not analyze the strategic dependence between investment and wage settlement.

whether the same result also holds true in a dynamic general equilibrium framework where private agents accumulate capital.

In this study, I use a modification of Chari and Kehoe's (1999) model. The remainder of this paper is organized as follows. Section 2 specifies technology, preferences and taxation. Section 3 establishes a dynamic game in the absence of binding wage contracts. In that case, the strategic order of decisions is taxation, investment, wage settlement and production. Correspondingly, section 4 establishes a dynamic game in the presence of binding wage contracts. The order of decisions is then taxation, wage settlement, investment and production. Both games result in optimal taxation rules.

2 Households, firms and the government

I aggregate all products in the economy into a single good which is chosen as the numeraire. This is used in consumption, investment and public spending. I denote the period t by subscript t, the present by $t = 0$ and assume that all agents (households, firms, unions and the government) observe same number $T > 2$ of periods in the future. Agents can change their control variables only in future $t \in \{1, ..., T\}$. At present $t = 0$, all variables are historically determined and therefore given for all agents. I denote by $\{A_t\}$ the sequence of any variable A_t throughout future $t \in \{1, ..., T\}$. There is an income tax $\tau_t \in (-\infty, 1)$ on labor and an income tax $\theta_t \in (-\infty, 1)$ on capital. I assume that there is a commitment technology through which government can set the sequences of taxes $\{\tau_t, \theta_t\}$ so that the other agents take them as given.

The representative household is subject to the budget constraint

$$B_{t+1} = (1 + r_t)B_t + I_t - C_t \text{ with } I_t \doteq \big(1 - \tau_t\big)w_t L_t + \pi_t \text{ for } t \in \{1, ..., T\}, \tag{1}$$

where B_t is the holdings of government bonds, r_t the interest rate paid to bonds, I_t income and C_t consumption at time t, and w_t is the wage, L_t employment, π_t the profit and $\tau_t \in (-\infty, 1)$ the labor tax at time t. Its utility is a function of consumption C_t and total employment L_t as follows:

$$U = \sum_{t=1}^{T} \rho^t \left[\frac{1}{1-\sigma} C_t^{1-\sigma} - L_t\right], \quad \sigma > 0, \quad \sigma \neq 1, \quad 0 < \rho < 1, \tag{2}$$

where the constant ρ is the discount factor and the constant σ the inverse of the inter-temporal elasticity of substitution. The household maximizes its utility (2) subject to the budget constraint (1) by its sequence of its consumption $\{C_t\}$, taking the sequences of the interest rate $\{r_t\}$, total income $\{I_t\}$ and total employment $\{L_t\}$ as given. This yields the Euler equations

$$\big(C_{t+1}/C_t\big)^{\sigma} = (1 + r_{t+1})\rho \text{ for } t \in \{1, 2, ..., T\}. \tag{3}$$

Given that the utility function (2) is linear in employment, the unit opportunity cost of employment is the inverse of the marginal utility of income $C^{-\sigma}$ and therefore equal to C^{σ}. Effective labor income at time t is then equal to the wages net of taxes, $\big(1 - \tau_t\big)w_t L_t$, minus the total opportunity cost of employment, $C_t^{\sigma} L_t$, at time t:

$$W_t \doteq \big(1 - \tau_t\big)w_t L_t - C_t^{\sigma} L_t. \tag{4}$$

At each time t, the representative firm produces its output Y_t from capital K_t and labor L_t through technology

$$Y_t = F(K_t, L_t), \;\; F_K > 0, \;\; F_L > 0, \;\; F_{LL} < 0, \;\; F_{KL} > 0, \;\; F_{KK} < 0, \tag{5}$$

where subscripts K and L denote partial derivatives with respect to K_t and L_t, respectively. It decides on its labor input before it decides on its investment. Therefore, the firm takes the wage w_t and capital stock K_t as given and maximizes its profit $\Pi = F(K_t, L_t) - w_t L_t$ by labor input L_t at each time t. By duality, this maximization yields

$$\begin{aligned}
&w_t = F_L(K_t, L_t), \quad \Pi(K_t, w_t) = \max_{L_t}[F(K_t, L_t) - w_t L_t],\\
&L_t = L(K_t, w_t) = -\Pi_w(K_t, w_t), \quad \frac{\partial L}{\partial K} = -\frac{F_{KL}}{F_{LL}} > 0, \quad \frac{\partial L}{\partial w} = \frac{1}{F_{LL}} < 0,\\
&\Pi_K(K_t, w_t) = F_K(K_t, L_t) > 0, \quad \Pi_{KK} < 0,
\end{aligned} \tag{6}$$

where subscripts K and w denote partial derivatives with respect to K_t and w_t, respectively. The elasticity of the demand for labor with respect to the wage w_t, when capital K_t is held constant, is given by

$$\varepsilon(K_t, L_t) \doteq \left|\frac{w_t}{L_t}\frac{\partial L}{\partial w}\right| = -\frac{w_t}{L_t}\frac{\partial L}{\partial w} = -\frac{F_L(K_t, L_t)}{L_t F_{LL}(K_t, L_t)} > 0. \tag{7}$$

I assume that the rate of capital depreciation, μ, is constant. Capital stock K_t then accumulates according to

$$K_{t+1} - K_t = (1-\theta_t)\Pi(K_t, w_t) - \pi_t - \mu K_t \ \text{ for } t \in \{0, 1, ..., T\}, \tag{8}$$

where $K_{t+1} - K_t$ is gross investment, $\Pi(K_t, w_t)$ the profit, $\theta_t \in (-\infty, 1)$ the capital tax, π_t dividents and μK_t capital depreciation. Solving for π_t from (8), one obtains the present value of the firm as:

$$P \doteq \sum_{t=1}^{T} \frac{\pi_t}{\prod_{\iota=0}^{t}(1+r_\iota)} = \sum_{t=1}^{T} \frac{(1-\theta_t)\Pi(K_t, w_t) + (1-\mu)K_t - K_{t+1}}{\prod_{\iota=0}^{t}(1+r_\iota)}, \tag{9}$$

where r_t is the interest rate at time t. The firm maximizes its present value (9) by its sequence of capital $\{K_t\}$ subject to accumulation technology (8).

Inserting L_t from (6) into effective labor income (4) yields

$$W_t = W(w_t, C_t, K_t, \tau_t) \doteq \big[(1-\tau_t)w_t - C_t^\sigma\big] L_t(K_t, w_t). \tag{10}$$

All workers of the representative firm are organized in the same labor union. Because both the representative firm and the corresponding union are small relative to the whole economy, it is plausible to assume that they take the sequences of the interest rate $\{r_t\}$ aggregate consumption $\{C_t\}$ as given. The union maximizes the present value of its members' effective labor income (10),

$$\sum_{t=1}^{T} \frac{W(w_t, C_t, K_t, \tau_t)}{\prod_{\iota=0}^{t}(1+r_\iota)}. \tag{11}$$

I assume that public spending at each time t, E_t, is exogenous in terms of the numeraire good. The government's budget constraint is then given by

$$D_{t+1} = (1+r_t)D_t + E_t - \theta_t \Pi(K_t, w_t) - \tau_t w_t L(K_t, w_t) \ \text{ for } t \in \{0, 1, ..., T\}, \tag{12}$$

where D_t is the stock of government bonds and r_t the interest rate at time t. The equilibrium condition for the goods market are given by

$$C_t = Y_t - \big[K_{t+1} + (\mu - 1)K_t\big] - E_t = \Psi(K_{t+1}, K_t, L_t) - E_t \ \text{ with}$$
$$\Psi\big(K_{t+1}, K_t, L_t\big) \doteq F\big(K_t, L_t\big) - K_{t+1} + (1-\mu)K_t \ \text{ for } t \in \{1, 2, ..., T\}, \tag{13}$$

where Y_t is output, E_t public spending, C_t consumption and $K_{t+1}+(\mu-1)K_t$ total investment in capital at time t.

The supply of government bonds, D_t, must be equal to the demand for these, B_t. If the government's budget constraint, (12), and the equilibrium condition of the goods market, (13), hold, then by Walras' law, the households' budget constraint (1) holds true as well.[8] Thus, the households' budget constraint (1) can be ignored in the government planning problem.

3 Non-binding contracts

With *non-binding wage contracts*, the union takes the sequences of aggregate consumption $\{C_t\}$, the interest rate $\{r_t\}$ capital $\{K_t\}$ and the tax $\{\tau_t\}$ as given and maximizes the present value of its members' effective labor income, (11), by the sequence of wages $\{w_t\}$. This is equivalent to the maximization of effective labor income (10) by the wage w_t for given C_t, r_t, K_t and τ_t at each time t. Noting (6), (7) and (10), this leads to the equilibrium conditions

$$w_t = w(C_t, K_t, \tau_t) = \arg\max_{w_t} W(w_t, C_t, K_t, \tau_t) \text{ and } \frac{1-\tau_t}{(1-\tau_t)w_t - C_t^\sigma} = \frac{\varepsilon}{w_t}$$
$$\text{for } t \in \{1, 2, ..., T\}. \tag{14}$$

I define the elasticity of the wage w_t with respect to capital stock K_t, when aggregate consumption C_t and the tax τ_t are kept constant, as follows:

$$\beta(C_t, K_t, \tau_t) \doteq \frac{K_t}{w(C_t, K_t, \tau_t)} \frac{\partial w}{\partial K_t}(C_t, K_t, \tau_t). \tag{15}$$

With non-binding contracts, the firm takes the expected outcome (14) of wage bargaining into account in its investment decisions. Inserting (14) into the present value of the firm, (9), one obtains

$$P = \sum_{t=1}^{T} \frac{1}{\prod_{\iota=0}^{t}(1+r_\iota)} \Big[(1-\theta_t)\Pi\big(K_t, w_t(C_t, K_t, \tau_t)\big) + (1-\mu)K_t - K_{t+1}\Big]. \tag{16}$$

The firm chooses its sequence of capital $\{K_t\}$ to maximize its present value (16), given the sequences of aggregate consumption $\{C_t\}$, the interest rate

[8] Summing up (12) and (13), and noting (5), (6), (10) and $D_t = B_t$, one obtains (1).

$\{r_t\}$ and the taxes $\{\tau_t, \theta_t\}$. Noting (3), (6) and (15), this maximization yields

$$\begin{aligned}
&\left(C_t/C_{t-1}\right)^\sigma/\rho + \mu - 1 = \mu + r_t \\
&= (1-\theta_t)\left[\Pi_K\left(K_t, w(C_t, K_t, \tau_t)\right) + \Pi_w\left(K_t, w(C_t, K_t, \tau_t)\right)\frac{\partial w}{\partial K_t}\right] \\
&= (1-\theta_t)\left[F_K\left(K_t, L_t\right) - \beta w_t L_t/K_t\right] \text{ for } t \in \{1, 2..., T\}.
\end{aligned} \tag{17}$$

Because the equations (17) and $L_t = L(K_t, w_t)$ [Cf. (6)] define a one-to-one correspondence from $\{\theta_t, \tau_t\}$ to $\{K_t, L_t\}$, the taxes $\{\theta_t, \tau_t\}$ can be replaced by employment $\{L_t\}$ and capital $\{K_t\}$ as the control variables of public policy. The government therefore determines the sequences of employment $\{L_t\}$ and capital $\{K_t\}$ to maximize social welfare (2) subject to (13). Noting (6), this yields the first-order conditions

$$\begin{aligned}
&\frac{\partial U}{\partial C_t}\frac{\partial C_t}{\partial L_t} + \frac{\partial U}{\partial L_t} = \frac{\partial U}{\partial C_t}\frac{\partial \Psi}{\partial L_t}\left(K_{t+1}, K_t, L_t\right) + \frac{\partial U}{\partial L_t} \\
&= \rho^t C_t^{-\sigma}\frac{\partial \Psi}{\partial L_t}\left(K_{t+1}, K_t, L_t\right) - \rho^t = \rho^t\left[C_t^{-\sigma}F_L\left(K_t, L_t\right) - 1\right] \\
&= \rho^t\left[C_t^{-\sigma}w_t - 1\right] = 0 \text{ for } t \in \{1, 2, ..., T\},
\end{aligned} \tag{18}$$

$$\begin{aligned}
&\frac{\partial U}{\partial C_t}\frac{\partial C_t}{\partial K_t} + \frac{\partial U}{\partial C_{t-1}}\frac{\partial C_{t-1}}{\partial K_t} \\
&= \frac{\partial U}{\partial C_t}\frac{\partial \Psi}{\partial K_t}\left(K_{t+1}, K_t, L_t\right) + \frac{\partial U}{\partial C_{t-1}}\frac{\partial \Psi}{\partial K_t}\left(K_t, K_{t-1}, L_{t-1}\right) \\
&= \rho^t C_t^{-\sigma}\frac{\partial \Psi}{\partial K_t}\left(K_{t+1}, K_t, L_t\right) + \rho^{t-1}C_{t-1}^{-\sigma}\frac{\partial \Psi}{\partial K_t}\left(K_t, K_{t-1}, L_{t-1}\right) \\
&= \rho^t C_t^{-\sigma}\left[F_K\left(K_t, L_t\right) + 1 - \mu\right] - \rho^{t-1}C_{t-1}^{-\sigma} \\
&= \rho^t C_t^{-\sigma}\left[F_K\left(K_t, L_t\right) + 1 - \mu - \left(C_t/C_{t-1}\right)^\sigma/\rho\right] = 0 \text{ for } t \in \{2, ..., T\}.
\end{aligned} \tag{19}$$

One observes first that the conditions (18) and (19) do not determine the capital tax for the first period, θ_1. This can be used to balance the government's intertemporal budget constraint. Solving for $w_t = C_t^\sigma$ from (18) and inserting this into (14), one obtains:

Proposition 1 *At times $t \in \{1, 2, ..., T\}$, labor should be taxed at the rate $\tau_t = 1/(1-\varepsilon)$, where ε is the wage elasticity of employment [Cf. (7)].*

The labor tax eliminates the effect of union power by changing the slope of the labor demand function so that in equilibrium the marginal product of labor is equal to the opportunity cost of employment, $F_L = C_t^\sigma$.

Inserting (17) into (19) and solving for θ_t, one obtains:

Proposition 2 *At times $t \in \{2, ..., T\}$, capital should be taxed at the rate*

$$\theta_t = 1 - \left(1 - \frac{w_t L_t}{F_K K_t} \beta\right)^{-1},$$

where $w_t L_t/(F_K K_t)$ is the ratio of wages to the total return paid to capital and β is the elasticity of the wage with respect to capital [Cf. (15)*].*

When capital accumulation increases (decreases) the wage w_t – i.e., when $\partial w_t/\partial K_t > 0$ and $\beta > 0$ ($\partial w_t/\partial K_t < 0$ and $\beta < 0$) – capital is below (above) its socially optimal level. To eliminate this departure, capital accumulation must be encouraged by a subsidy $-\theta_t > 0$ (discouraged by a tax $\theta_t > 0$).

Finally, from equations (6), (17), (18) and (19) it follows that $F_K\big(K_t, L_t\big) = r_t + \mu$ and $F_K\big(K_t, L_t\big) = w_t = C^\sigma$. This proves that aggregate production efficiency holds true at the optimum: the marginal product of labor, F_L, is equal to the opportunity cost of employment, C^σ, and the marginal product of capital, F_K, is equal to the marginal cost of maintaining capital, $r_t + \mu$.

4 Binding contracts

With *binding wage contracts*, the firm takes the sequences of wages $\{w_t\}$, aggregate consumption $\{C_t\}$, the interest rate $\{r_t\}$ and the tax $\{\theta_t\}$ as given and maximizes the present value (9) of its dividents by its sequence of capital $\{K_t\}$. Noting (3), this leads to the equilibrium conditions

$$\big(C_t/C_{t-1}\big)^\sigma/\rho + \mu - 1 = \mu + r_t = (1-\theta_t)\Pi_K\big(K_t, w_t\big) \text{ for } t \in \{1, 2, ..., T\}. \tag{20}$$

This defines capital K_t as a function of the wage w_t, the capital tax θ_t and the change in consumption, C_t/C_{t-1}:

$$K_t = K\big(w_t, \theta_t, C_t/C_{t-1}\big) \text{ for } t \in \{1, 2, ..., T\}. \tag{21}$$

The union takes the firm's optimal investment policy (21) into account and maximizes the present value of its members' effective income (11). Given (10) and (21), this target can be written as:

$$\sum_{t=1}^{T} \frac{W_t}{1+r_t} = \sum_{t=1}^{T} \frac{1}{1+r_t} \left[(1-\tau_t) w_t - C_t^{\sigma} \right] L_t \left(K \left(w_t, \theta_t, \frac{C_t}{C_{t-1}} \right), w_t \right). \quad (22)$$

The union sets the sequence of its wage $\{w_t\}$ to maximize (22), given the sequences of the interest rate $\{r_t\}$, the taxes $\{\tau_t, \theta_t\}$ and aggregate consumption $\{C_t\}$. The first-order conditions of the maximization are given by

$$(1-\tau_t) L_t + \left[(1-\tau_t) w_t - C_t^{\sigma} \right] \left[\frac{\partial L_t}{\partial K_t} \frac{\partial K_t}{\partial w_t} + \frac{\partial L_t}{\partial w_t} \right] = 0 \text{ for } t \in \{1, ..., T\}. \quad (23)$$

Because the equations (21) and $L_t = L(K_t, w_t)$ [Cf. (6)] define a one-to-one correspondence from $\{\theta_t, \tau_t\}$ to $\{K_t, L_t\}$, the taxes $\{\theta_t, \tau_t\}$ can be replaced by employment $\{L_t\}$ and capital $\{K_t\}$ as the control variables of public policy. The government therefore determines the sequences of employment $\{L_t\}$ and capital $\{K_t\}$ to maximize social welfare (2) subject to (13). This leads to the same first-order conditions (18) and (19) as in the case of non-binding contracts. Accordingly, the capital taxes for the first period, θ_1, are used to balance the government's intertemporal budget constraint. Solving for $w_t = C_t^{\sigma}$ from (18) and inserting into (14), one obtains that proposition 1 holds also in this case. Equations (6), (19) and (20) yield

$$(1-\theta_t) F_K = (1-\theta_t) \Pi_K = \left(C_t / C_{t-1} \right)^{\sigma} / \rho + \mu - 1 = F_K$$

and $\theta_t = 0$ for $t \geq 2$. This result can be rephrased as follows:

Proposition 3 *In the presence of binding wage contracts, the capital tax θ_t should be zero at times $t \in \{2, ..., T\}$.*

Because the labor tax is sufficient to achieve the optimal production efficiency, the tax rate on capital income, θ_t, should be zero for $t \geq 2$. Any deviation from this zero tax rate distorts aggregate production efficiency.

5 Conclusions

This paper examines optimal taxation in an economy with collective wage bargaining. In each industry workers form a union, which raises their wage above the opportunity cost of employment. The government taxes labor and capital income and finances its deficit by issuing bonds. Two institutional specifications of collective bargaining are compared: (i) there is some institution or technology through which a labor union can commit itself to binding wage contracts, so that investors are protected against immediate expropriation by unions after new machines are installed; and (ii) there is no such commitment technology, so that investors must be prepared for immediate expropriation. The main findings of this paper are the following.

In the steady state, employment should be determined so that the marginal product of labor is equal to the opportunity cost of employment, and capital so that its marginal product is equal to the marginal cost of maintaining capital. Wages must be subsidized at the rate that compels the marginal product of labor equal to the opportunity cost of employment. Zero taxation of capital does not apply in the absence [i.e. in case (ii)], but applies in the presence of binding wage contracts [i.e. in case (i)]. In the absence of binding contracts, investors observe the wage as a function of their investment. Capital stock then converges to the level that is below (above) the social optimum when capital accumulation increases (decreases) the wage. To eliminate this departure, capital accumulation must be encouraged by a subsidy (discouraged by a tax). In the presence of binding contracts, investors take the wage as given. Aggregate production efficiency can then be maintained by a labor tax only and any deviation from zero capital taxation distorts aggregate production efficiency. In both cases, the government budget should be balanced by the capital tax in the first period.

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