Tax Incidence in a Unionised Economy with Tax Evasion

by

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Abstract:
In a unionised labour market, a substitution of a payroll for a income tax will not alter employment if tax obligations are fulfilled. However, if workers or firms can evade taxes this irrelevance result might no longer apply. This will especially be the case if the fine for tax evasion depends on undeclared income or wage payments or if withholding regulations prevent optimal evasion choices. In such instances, tax evasion opportunities make the legal incidence of taxes an important determinant of their economic incidence.

Keywords: economic incidence, legal incidence, penalty, tax evasion, trade union, wedge

JEL-code: H 22, H 26, J 51, J 64

1. Introduction

The legal incidence of a tax is irrelevant for its economic incidence. For the labour market this "most basic theorem of public finance" (Blinder 1988, p. 12) implies that it does not matter for the employment level whether taxes are paid by workers or firms. However, empirically the irrelevance proposition is not always supported (Calmfors 1990, Lockwood and Manning 1993, Tyrväinen 1995). Moreover, there are theoretical arguments why the legal incidence of taxes can affect the economic incidence. If, for example, the tax bases of income and payroll taxes differ, a balanced-budget substitution will alter the progressivity of the tax system. Since changes in tax progression usually affect employment in models of imperfectly competitive labour markets, a tax reform can alter the market outcome.[1] A further explanation for a shift of taxes to influence employment is that the alternative income might depend on one tax rate but not the other (Muysken et al. 1999, Goerke 2000).

In this paper, an additional channel is established by which a shift from a payroll to an income tax can affect employment: tax evasion by workers or firms.[2] In particular, a shift from a linear payroll to a linear income tax will raise employment in an economy in which trade unions set wages, if the penalty for tax evasion by workers not only depends on the evaded tax but also on the undeclared income and if the measure of the workers' absolute risk-aversion is not decreasing too strongly with income. The intuition for the employment effects can best be derived if initially a penalty which depends on evaded taxes instead of undeclared income is considered. In this case, a shift of the tax burden from workers to firms does not alter employment because all the employees' payoffs remain unaffected by the tax reform, while the firms' tax evasion activities are independent of the tax rate and the wage. Hence, the gain from changing the net wage for the trade union is the same as before the variation in the tax structure. Accordingly, the net wage and also labour costs and employment remain constant. However, if the penalty for tax evasion by workers also depends on the undeclared income, a higher income tax rate will not increase the penalty for a given level of wages and tax evasion activities. Therefore, the penalty falls relative to the case of being a function of the evaded tax. Thus, given a constant Arrow-Pratt measure of absolute risk-aversion, an increase in the income tax raises the incentives to evade, relative to the case of the penalty being a function of the evaded tax. Since higher evasion reduces the effective tax burden and because workers are risk-averse, the union's gain from a higher wage declines. The costs of a higher wage owing to the reduction in employment remain the same because of the separability of the firm's employment and evasion decisions. Thus, the wage rises less strongly. As a shift from an income to a payroll tax leaves employment unaffected in a set-up in which the penalty is a function only of the evaded tax, a less pronounced wage increase implies more employment.

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[1] See, inter alia, Holm and Koskela (1996) and Koskela and Schöb (1999). Holmlund (1981) demonstrates the validity of the tax base argument in the context of a competitive labour market.

[2] This finding is foreshadowed by Slemrod and Yitzhaki (2000, p. 34) in their forthcoming *Handbook of Public Economics* article. "Introducing avoidance and evasion ... calls ... into question (that) in the long run the incidence of a tax levy does not depend on which side of the market bears the legal responsibility for remitting the tax." However, this conjecture is not substantiated.

If the measure of absolute risk-aversion is decreasing strongly with income, the optimal degree of tax evasion might fall with higher income tax rates in a set-up in which the penalty depends on undeclared income. In this case the employment effect of a shift from payroll to income taxes can be reversed, but it generally is not zero. The decline in employment can arise as the higher income tax reduces the workers' net income and raises absolute risk-aversion. Thus, the gain from a wage increase goes up and the union might raise its wage demand.

The paper is structured as follows: Section 2 analyses the firm's and the workers' decisions and the trade union's behaviour. While the link between tax evasion and labour supply or participation in the legal sector of the economy has been investigated repeatedly (cf. Pencavel (1979) or Cowell (1985), inter alia), tax evasion in unionised labour markets has not found much attention.[3] Section 3 analyses a shift from a payroll to an income tax for a penalty which depends only on the evaded tax. This tax reform does not change employment. However, the irrelevance proposition will only apply in this setting if evasion choices are optimal. Thus, the final part of Section 3 looks at the impact of withholding regulations. In Section 4, the workers' penalty for evading taxes is a function of the undeclared income instead of the evaded tax. Under this assumption employment can rise, as mentioned above. Section 5 discusses these results.

2. Model

The economy consists of a large number of firms, each of which bargains with a trade union over wages. All potential employees are members of the respective utilitarian trade union. Workers are strictly risk-averse and have to pay a linear income tax of which they are able to evade a fraction. Firms have to pay a linear payroll tax which they can also evade. Linear taxes without exemptions ensure that variations in employment are not caused by changes in tax progressivity. In addition, the alternative income is exempt from taxes, in order to rule out this potential cause of employment effects. The timing of decisions is as follows: first, the government announces the tax rates and parameters of the tax enforcement system, such as the penalty and audit probabilities. As the government can make a credible commitment, firms, unions, and workers take these variables as given. Second, the wage is determined. The trade union takes into account the impact of a wage variation on evasion activities. Third, workers select their optimal degree of tax evasion and firms make employment and evasion choices. Since firms are identical and as all trade unions represent workers with the same preferences, the analysis focuses on one trade union - firm pair. The results can be generalised to the whole economy.

2.1 Firms

Firms or their owners are strictly risk averse. Denoting by S the utility function of the firms' owners, this implies $S' > 0$ and $S'' < 0$. Moreover, non-increasing absolute risk-aversion is presumed, where Θ, $\Theta \equiv - S''/S' > 0$, defines the Arrow-Pratt measure of absolute risk-aversion. Firms sell their

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[3] Lai et. al (1995) represent an exception. They analyse the relationship between tax evasion and revenues.

product in a perfectly competitive output market, such that the output price can be normalised to unity. The sole variable input is labour. The production function f, f = f(n), is strictly concave in employment n, $f' > 0$, $f'' < 0$. The wage is denoted by w. Firms can evade a fraction λ, $0 \leq \lambda \leq 1$, of their payroll tax obligations $w\tau n$. Normalising fixed costs to zero, the firm's profits π^e if not caught evading taxes will be $\pi^e = f(n) - wn(1 + \tau(1 - \lambda))$. With an exogenous probability q firms are detected and have to pay a penalty for tax evasion which - initially - is defined as a multiple G, G > 1, of evaded taxes $wn\tau\lambda$, yielding profits of $\pi^c = \pi^e - Gwn\tau\lambda$. The expected utility E(S, q) of a tax evading firm can be written as:

$$E(S,q) = (1-q)S\left[f(n) - wn(1+\tau(1-\lambda))\right] + qS\left[f(n) - wn(1+\tau(1-\lambda)) - Gwn\tau\lambda\right] \quad (1)$$

The firm chooses employment n and the degree of tax evasion λ, given the wage. The optimal degree of tax evasion is defined by $\partial E(S, q)/\partial\lambda \equiv wn\tau J$, where J is defined by:

$$J \equiv (1-q)S'(\pi^e) + qS'(\pi^c)(1-G) = 0 \quad (2)$$

An interior solution requires $1 < G < 1/q$. This is, henceforth, assumed to be the case.[4] Combining $\partial E(S, q)/\partial n = 0$ with J = 0 yields the standard finding that the employment (or output) decision is separable from the evasion choice. Therefore, the first-order condition implies:[5]

$$K \equiv f'(n) - w(1 + \tau) = 0 \quad (3)$$

This condition for an optimal choice of employment has the usual properties. In particular, $K_\lambda = 0$, $K_n = f''(n) < 0$, $K_w = -(1 + \tau) < 0$, and $K_\tau = -w < 0$. The derivatives of J are:

$$J_\lambda = wn\tau\left[(1-q)S''(\pi^e) + qS''(\pi^c)(1-G)^2\right] = nJ_n/\lambda < 0 \quad (4)$$

Defining a variable C, $C \equiv (1-q)S''(\pi^e) + qS''(\pi^c)(1-G) \geq 0$, where C is non-negative owing to the assumption of non-increasing absolute risk-aversion, yields:[6]

$$J_w = J_\lambda\lambda/w - n(1+\tau)C = \tau J_\tau/w - nC < 0 \quad (5)$$

The changes in employment due to a higher wage w or payroll tax τ are independent of evasion choices and given by $n_w = (1 + \tau)/f'' = n_\tau(1 + \tau)/w < 0$. Using the first-order condition (3), the impact of changes in the wage and the payroll tax rate on the optimal degree of tax evasion are:

$$\frac{d\lambda}{dw} = \frac{K_w J_n}{K_n J_\lambda} - \frac{J_w}{J_\lambda} = -\lambda\frac{(1+\tau)w + f''n}{f''nw} + \frac{n(1+\tau)C}{J_\lambda} = -\lambda\frac{f' + f''n}{f''nw} + \frac{n(1+\tau)C}{J_\lambda} \quad (6)$$

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[4] Blakemore et. al. (1996) show that firms may either fully comply with tax laws or may not pay taxes at all, if the penalty is independent of the employment level and the tax rate. However, such independence seems to be an implausible assumption for a payroll tax.

[5] Marelli (1984) and Marelli and Martina (1988) show that the firm's evasion choices will have no impact on its production if the detection probability is independent of tax declarations. Yaniv (1995) has demonstrated that the separability feature will also apply if the firms' evasion activities are limited by withholding regulations. For further results with respect to the separability under different assumptions about market structure and enforcement parameters see, inter alia, Wang and Conant (1988), Yaniv (1996), Lee (1998), and Panteghini (2000).

[6] Making use of the first-order condition (2), the variable C can be rewritten as:

$$C \equiv -qS'(\pi^c)(1-G)S''(\pi^e)/S'(\pi^e) + qS''(\pi^c)(1-G) = qS'(\pi^c)(1-G)\left[\Theta(\pi^e) - \Theta(\pi^c)\right]$$

Since an interior solution requires G > 1, decreasing absolute risk-aversion ($\Theta(\pi^e) < \Theta(\pi^c)$) implies C > 0.

$$\frac{d\lambda}{d\tau} = \frac{K_\tau J_n}{K_n J_\lambda} - \frac{J_\tau}{J_\lambda} = -\lambda \frac{w\tau + f''n}{f''n\tau} + \frac{wnC}{J_\lambda} = -\lambda \frac{\tau(f' + f''n) + f''n}{f''n\tau(1+\tau)} + \frac{wnC}{J_\lambda} \qquad (7)$$

For a Cobb-Douglas production function, $f = n^{\alpha}$, $0 < \alpha < 1$, $f' + f''n = \alpha^2 n^{\alpha - 1} > 0$ holds. Therefore, the first term in (6) is positive, while the second term is negative, given decreasing absolute risk-aversion. The impact of a higher wage on the optimal degree of tax evasion is ambiguous. A higher payroll tax will decrease tax evasion for a Cobb-Douglas production function, if the tax rate τ or the parameter α are not too high. These findings can be summarised as:

Proposition 1

The firm's employment is independent of the degree of payroll tax evasion. Tax evasion changes in an ambiguous manner with variations in the wage or the payroll tax rate.

While the first part of Proposition 1 is well established (see footnote 5), the second component conflicts with the assertion by Yaniv (1995, p. 114) that "a tax rate increase must always decrease the firm's statement deviation from the true value of its tax base". This differential result is due to Yaniv's assumption that the penalty is independent of employment. While the assumption might be plausible for profit taxes, it does not seem adequate for payroll tax evasion since the required tax payment and the overall level of evasion are linear functions of employment. Accordingly, the relationship between tax evasion and the payroll tax rate is uncertain.

2.2 Workers

All workers are identical ex-ante. If they are employed, they will earn a wage w and be subject to a linear income tax t, $0 < t < 1$. Unemployed workers obtain unemployment benefits $\overline{w}$, $\overline{w} > 0$, which are exempt from income taxes. Employed workers pay a fraction (1 - h) of their tax obligations, $0 \leq h \leq 1$. A worker who is not caught evading taxes obtains an income w^e, $w^e \equiv w(1 - t(1 - h))$. A worker who is caught evading taxes with the exogenous probability p has to pay a fine which is - initially - a multiple F, $F > 1$, of evaded taxes and has an income w^c, $w^c \equiv w^e - Fwth$. Workers exhibit non-increasing absolute risk-aversion and can be characterised by an indirect utility function u, $u' > 0$, $u'' < 0$. The expected utility E(u, p) of a worker is:

$$E(u,p) = (1-p)u\big[w(1-t(1-h))\big] + pu\big[w(1-t(1-h)) - Fwth\big] \qquad (8)$$

Employed workers choose an optimal degree of tax evasion h* which is defined by:

$$H \equiv \frac{1}{wt}\frac{dE(u,p)}{dh} = (1-p)u'(w^e) + pu'(w^c)(1-F) = 0 \qquad (9)$$

A value of h* which is strictly greater than zero but less than unity implies $1 < F < 1/p$. These restrictions are assumed to hold. The second-order condition is given by:

$$H_h = wt\left[(1-p)u''(w^e) + pu''(w^c)(1-F)^2\right] < 0 \qquad (10)$$

For the further derivations it is helpful to compute the impact of changes in the income tax rate t and the wage w on the optimal degree of tax evasion.

$$H_t = -w\left[(1-h)A + hpu''(w^c)(1-F)F\right] \tag{11}$$

$$H_w = A(1-t(1-h)) - pu''(w^c)(1-F)Fth, \tag{12}$$

where A is non-negative due to the assumption of non-increasing absolute risk-aversion:

$$A \equiv (1-p)u''(w^e) + pu''(w^c)(1-F) \geq 0 \tag{13}$$

For $A \geq 0$, the optimal degree of tax evasion unambiguously declines with a higher income tax rate (Yitzhaki 1974). The impact of a change in the wage is uncertain unless the measure of absolute risk-aversion is non-decreasing, implying $A \leq 0$.

2.3 Trade Union

Workers in each firm are represented by a trade union. The individual union takes the behaviour of other unions, firms, and the government as given. For simplicity, a wage setting union is assumed. Given the wage w, the firm selects the employment level n. The trade union has m, $m \geq n$, ex-ante identical workers and maximises the sum of the expected utility of n employed workers who obtain a wage w and are caught evading taxes with probability p, and of m - n unemployed workers who receive benefits $\overline{w}$. Accordingly, the union's objective $\overline{V}$ is:

$$\overline{V} = n(w)\left[(1-p)u(w^e) + pu(w^c)\right] + (m - n(w))u(\overline{w}) \tag{14}$$

Since a utilitarian trade union simply aggregates the utility of its members who adjust their evasion activities to changes in tax rates and wages, optimality of the union's choices requires it to take into account these adjustments in the degree of tax evasion. Maximisation of (14) with respect to the wage w, and assuming a constant labour demand elasticity ε, $\varepsilon = - wn_w/n > 0$, yields after some manipulations $V \equiv - d\overline{V}/dw(w/n)$, where:

$$V = \varepsilon\left[(1-p)u(w^e) + pu(w^c) - u(\overline{w})\right] - w(1-t)\left[(1-p)u'(w^e) + pu'(w^c)\right] = 0 \tag{15}$$

The trade union balances the costs of a wage increase, the first term in (15), measured by the reduction in the number of workers owing to a wage increase and weighted by the utility reduction which each worker will incur if becoming unemployed, against the gain from a higher wage, the second term in (15), which expresses the increase in utility of each employee owing to a higher wage. The second-order condition requires $V_w > 0$, since $d\overline{V}/dw$ has been multiplied by (- w/n) to define the labour demand elasticity. A sufficient requirement for $V_w > 0$ is that the labour demand elasticity is not less than unity, a prerequisite which is independent of the existence of tax evasion. The derivative of V with respect to the payroll tax is zero ($V_\tau = 0$), while the impact of a higher income tax rate is defined by $V_t(1 - t) = - V_w w < 0$ (see appendix 1).[7]

[7] The assumption of a constant labour demand elasticity simplifies the subsequent calculations since it ensures that the wage effect of a higher payroll tax is zero and that wages rise with a higher income tax. However, the restriction does not affect the results with respect to the employment effects of a shift in the tax burden.

3. Shifting the Tax Burden to Workers if the Penalty Depends on the Evaded Tax

A shift of taxes from firms to workers will have no impact on employment in a competitive labour market in the absence of tax evasion either if the wedge between (official) labour costs $w(1 + \tau)$ and the net wage $w(1 - t)$ is held constant or if the tax reform has no budgetary effects. Denote the nominal wedge by γ, $\gamma \equiv (1 + \tau)/(1 - t)$. The wedge which incorporates tax evasion activities is labelled the effective wedge γ^{eff}, $\gamma^{eff} \equiv (1 + \tau(1 - \lambda))/(1 - t(1 - h))$. Finally, a balanced-budget requirement can determine the payroll tax variation. Initially, the extent of the decline in the payroll tax is determined by the requirement of a constant nominal wedge. This constraint is denoted $d\gamma = 0$ and implies $d\tau/dt = - (1 + \tau)/(1 - t)$. Subsequently, it is shown that the same effects will result if either the effective wedge or a balanced-budget requirement determine the adjustment in the payroll tax rate.

3.1 Constant Nominal Wedge

The change in employment per firm owing to a shift from payroll to income taxes, holding constant the nominal wedge is determined by the direct tax effects and the indirect consequences which operate via the wage. From the firm's first-order condition (3) it is known that employment depends on the wage w and the payroll tax rate τ, $n = n(w, \tau)$. The wage which the union sets is influenced by the income tax rate - also due the repercussion via the optimal degree of tax evasion - but independent of the payroll tax rate owing to the assumption of a constant labour demand elasticity. Thus, employment is given by $n = n(w(t, h(t)), \tau)$. Differentiating n with respect to the income tax t and noting that $w_t = -V_t/V_w$, $n_\tau/n_w = w/(1 + \tau)$, and $V_t(1 - t) + V_w w = 0$ hold, the employment change can be computed as:

$$\left.\frac{dn}{dt}\right|_{\substack{d\gamma=0,h=h^*,\lambda=\lambda^* \\ F(\cdot)=Fwth,G(\cdot)=Gwn\tau\lambda}} = n_w w_t + n_\tau \frac{d\tau}{dt} = \varepsilon n \frac{V_t(1-t) + wV_w}{V_w w(1-t)} = 0 \qquad (16)$$

Constant employment entails rigid labour costs $w(1 + \tau)$ and taken in conjunction with the requirement of a constant wedge, this implies an unchanged net wage. Equation (16) yields:

Proposition 2

In an economy with collective wage determination in which firms and workers choose tax evasion optimally and in which the penalty for tax evasion is a function only of the evaded tax, a shift from a linear payroll to a linear income tax which leaves the nominal wedge between labour costs and the net wage unaffected, does not alter labour costs, employment and the net wage.

Proposition 2 shows that the opportunity of workers and firms to evade income taxes does not affect the standard result that employment is independent of the side of the market which is taxed. The intuition for this finding is the following: the employment consequences of a shift from payroll to income taxes are determined solely by the trade union's reaction to the tax variation. This is because the trade-offs between employment and wages (n_w) and employment and payroll taxes (n_τ) are unaffected by variations in the firm's tax evasion behaviour. Thus, the impact of a shift in the tax burden consists of the direct effects on the trade union's payoff and the indirect effects, via changes in income tax evasion owing to tax and wage variations. Changes in the wage w and the income tax rate t alter the union's first-order condition symmetrically. This is because all components of the union's marginal payoff are a function of the wage and the tax. Hence, any fall in the wage has a qualitative impact on trade union utility which is equivalent to the effect of a higher income tax. Effectively, the union's maximisation problem in the presence of optimal evasion activities by workers is the same as in the absence of tax evasion.

3.2 Constant Effective Wedge and Balanced Budget

In the absence of tax evasion, a shift of the tax burden which does not affect the nominal wedge between labour costs and the net wage and which has no employment effects, leaves tax revenues unaffected. For a given level of expenditure, the government's budget remains balanced. In the presence of tax evasion a constant nominal wedge does not have to imply a constant effective wedge and a balanced budget. Accordingly, the question will arise if the absence of any employment effects of the tax reform is due to the specific constraint on the relative tax changes. The impact of a change in the payroll and the income tax rate on the effective wedge γ^{eff} is:

$$\left[1-\lambda-\tau\lambda_\tau\right]\frac{d\tau}{dt}\Big|_{d\gamma^{eff}=0} = \tau\lambda_w w_t - \frac{1+\tau(1-\lambda)}{1-t(1-h)}(1-h-t(h_w w_t + h_t)) \tag{17}$$

Initially, it is investigated whether the change in the payroll tax rate for a constant effective wedge differs from the variation for a constant nominal wedge for two special cases, namely in the absence of either tax evasion by the firm ($\lambda = 0$, $h = h^*$) or workers ($h = 0$, $\lambda = \lambda^*$). These findings can be utilised to analyse the more general case in which firms and workers evade taxes. Assume, therefore, that the firm cannot evade taxes. The difference between the change in the payroll tax rate for a constant effective and a constant nominal wedge is given by:

$$\frac{d\tau}{dt}\Big|_{\substack{d\gamma^{eff}=0\\ \lambda=0}} - \frac{d\tau}{dt}\Big|_{d\gamma=0} = -\frac{1+\tau}{1-t(1-h)}(1-h-t(h_w w_t + h_t)) + \frac{1+\tau}{1-t}$$

$$= \frac{1+\tau}{(1-t)(1-t(1-h))}\left[\frac{hH_h - twH_w - t(1-t)H_t}{H_h}\right] = 0 \tag{18}$$

In deriving this result, use has been made of $V_t(1 - t) = - V_w w$ and of equations (10) to (13). In the absence of evasion activities by firms, a shift from income to payroll taxes, holding constant the effective wedge, does not affect employment since the tax changes imposed by the two constraints of a constant nominal and effective wedge are the same. This can only be the case if the evaded tax wth is not affected by the tax reform, since otherwise the simultaneous constancy of w(1 - t) and w(1 - t(1 - h)) cannot be warranted. [8] If the two constraints have the same impact on the payroll tax variation,

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[8] If neither the nominal wedge $w(1 + \tau)/(w(1 - t))$ nor the effective wedge $w(1 + \tau)/(w(1 - t(1 - h)))$ for $\lambda = 0$ are affected by the tax reform and since a constant level of employment implies that $w(1 + \tau)$ remains the same, $w(1 - t(1 - h))$ will also have to be constant. The constant level of the evaded tax wth is due to the symmetric impact of wages and taxes on the workers' - or trade union's - payoff.

the employment effect of a shift from payroll to income taxes will not be altered by imposing a constant effective wedge in the absence of firm tax evasion instead of a constant nominal wedge.

Assume next that workers do not evade taxes while firms choose evasion activities optimally. The difference between the change in the payroll tax rate for a constant effective and a constant nominal wedge is then given by:

$$\left.\frac{d\tau}{dt}\right|_{\substack{d\gamma^{eff}=0\\ h=0}} - \left.\frac{d\tau}{dt}\right|_{d\gamma=0} = \frac{\tau\lambda_w w_t}{1-\lambda-\tau\lambda_\tau} - \frac{1+\tau(1-\lambda)}{(1-t)(1-\lambda-\tau\lambda_\tau)} + \frac{1+\tau}{1-t}$$

$$= \frac{\tau\lambda_w w_t}{1-\lambda-\tau\lambda_\tau} - \frac{\lambda+(1+\tau)\tau\lambda_\tau}{(1-t)(1-\lambda-\tau\lambda_\tau)} = 0 \qquad (19)$$

From equations (6) and (7) it can be derived that $\lambda + (1 + \tau)\tau\lambda_\tau = \tau w\lambda_w$ holds. Substituting in (19) and simplifying ensures the last equality sign. Since the payroll tax change which is required by the constancy of the effective wedge is exactly the same as imposed by the constraint of a constant nominal wedge, the resulting employment variations are also the same.

Finally, the difference between the effective and the nominal wedge can be investigated for positive degrees of tax evasion by the firm and workers.

$$\left.\frac{d\tau}{dt}\right|_{d\gamma^{eff}=0} - \left.\frac{d\tau}{dt}\right|_{d\gamma=0} = \left(\left.\frac{d\tau}{dt}\right|_{\substack{d\gamma^{eff}=0,\\ h=0}} - \left.\frac{d\tau}{dt}\right|_{d\gamma=0} \right) + \left(\left.\frac{d\tau}{dt}\right|_{\substack{d\gamma^{eff}=0,\\ \lambda=0}} - \left.\frac{d\tau}{dt}\right|_{d\gamma=0} \right)$$

$$- \frac{\tau\lambda}{(1-t)(1-\lambda-\tau\lambda_\tau)} + \frac{\tau\lambda(1-h-t(h_w w_t + h_t))}{(1-t(1-h))(1-\lambda-\tau\lambda_\tau)}$$

$$= -\frac{\tau\lambda(h+t(1-t)(h_w w_t + h_t))}{(1-t)(1-t(1-h))(1-\lambda-\tau\lambda_\tau)} = 0 \qquad (20)$$

Thus, the independence of employment from the legal tax burden also applies for intermediate evasion choices. Moreover, a tax reform which keeps the effective wedge constant does not alter government revenues, that is, taking into account the consequences of tax rate changes on employment (see appendix 2). This is because labour costs, the net wage and the levels of evaded taxes do not change. The balanced-budget result is, hence, independent of whether the impact on fine payments is taken into account or not. These results can be summarised as:

Proposition 3

In an economy with collective wage determination, in which firms and workers choose tax evasion optimally and in which the penalty for evasion is a function only of the evaded tax, a shift from a linear payroll to a linear income tax, which leaves either the effective wedge between labour costs and the net wage or the government's budget balance unaffected, changes neither employment nor the payoffs by workers and firms.

The equivalence of the constraints of a constant effective and nominal wedge is due to the fact that a shift in the tax burden will leave the net wage and labour costs the same if there is not tax evasion.

Moreover, if all determinants of the optimal degree of evasion are influenced both by wages and tax rates, not only the net wage (or labour costs) will remain constant but also the levels of evaded taxes wth and $wn\tau\lambda$. If the levels of evaded taxes do not change, a constant nominal wedge will be equivalent to a constant effective wedge. Therefore, the type of constraint which is imposed on the tax rate variations will not have an impact on the irrelevance of the legal incidence of taxes if the penalty for evasion depends positively only on the evaded tax.

The irrelevance of the legal for the economic incidence also holds in a Nash-bargaining framework. The tax reform which leaves the monopoly union's net wage and the employment level constant induces an adjustment in the degree of tax evasion such that the trade union's first-order condition holds again. Moreover, the level of the union's and the firm's payoffs are not affected. Since, finally, the firm's marginal payoff remains the same, the wage change which warrants the original employment level in the monopoly union model implies that all the components of the Nash-solution are constant.[9] There is no need for additional wage alterations and there continues to be no employment impact of the balanced-budget tax reform. The trade union's bargaining power does not have an effect on the irrelevance characteristic.

3.3 Withholding Regulations

Throughout the analysis it has been assumed that tax evasion choices are optimal. However, in many countries there are regulations according to which the employer has to withhold the employees' taxes and make according payments to the government. On the one hand, such regulations increase evasion opportunities by firms. On the other hand, they restrict or abolish the employees' ability to evade taxes. Given this inability to adjust their tax evasion behaviour, the irrelevance of the legal incidence of taxes for their economic incidence no longer holds.

In order to demonstrate this claim suppose that the firms' tax evasion opportunities are not limited. In this case the employment and the tax evasion choices continue to be independent, irrespective of whether the firm adheres to the withholding obligations or not (Yaniv 1988). Given separability, a convenient way of modelling withholding regulations is to impose a maximum degree of employees' tax evasion h^m, where $0 < h^m < h^*$ before and after the tax reform. Tax revenues B from income and payroll taxes are given by $B = wn[t(1 - h^m) + \tau(1 - \lambda)]$.[10] For a given government expenditure, a

[9] Defining the trade union's (firm's) bargaining power by α $(1 - \alpha)$ and the respective fallback positions by $\hat{V}$ and $\hat{S}$, the Nash-solution can be written as: $\alpha(E(S) - \hat{S})V + (1 - \alpha)(\overline{V} - \hat{V})E(S)_w(-w/n) = 0$. Because E(S), $\overline{V}$, and V, and the fallback levels of utility are unaffected by the tax reform, the only component of the Nash-solution which might change is $E(S)_w(-w/n)$, that is the derivative of the firm's payoff with respect to the wage. Since employment does not vary in the monopoly union model, the focus can be on $-wE(S)_w$:

$$-wE(S)_w = wn[\tau\lambda - w\tau\lambda_w]\{(1-q)S'(\pi^e) + qS'(\pi^c)(1-G)\} + nw(1+\tau)\left((1-q)S'(\pi^e) + qS'(\pi^c)\right)$$

As the term in curly brackets is zero (cf. the first-order condition (2)) and because labour costs $w(1 + \tau)$ have to be unaffected by the tax reform for the employment level to be the same, while profit levels remain constant, the wage which warrants the optimality of the wage demand subsequent to the tax reform in the monopoly union model also guarantees that there is no need to adjust the wage in the Nash-bargaining set-up.

[10] For simplicity, the revenues from fine payments are ignored. Given a fixed degree of employees' evasion and the separability of the firm's employment and evasion decisions, the computation of the balanced-budget effects yields a result which is easier to interpret than for the restriction of a constant nominal wedge.

balanced-budget substitution of the income for the payroll tax implies $dB = B_t dt + B_\tau d\tau = 0$, where B_t, B_τ are assumed to be positive:

$$B_t = w_t(n + n_w w)\left[t(1-h^m) + \tau(1-\lambda)\right] + wn\left[1 - h^m - \tau\lambda_w w_t\right] > 0 \quad (21)$$

$$B_\tau = n_\tau w\left[t(1-h^m) + \tau(1-\lambda)\right] + wn\left[1 - \lambda - \tau\lambda_\tau\right] > 0 \quad (22)$$

Since employees' cannot adjust their tax evasion choices to variations in the income tax rate, the trade union's first-order condition for an optimal wage yields:

$$V = \varepsilon\left[(1-p)u(w^e) + pu(w^c) - u(\overline{w})\right]$$
$$- w\left[(1-p)u'(w^e)(1 - t(1-h^m)) + pu'(w^c)(1 - t(1-h^m) - Fth^m)\right] = 0 \quad (23)$$

The effect due to an increase in the income tax rate t is determined by $w_t = - V_t/V_w$, where:

$$V_w = (\varepsilon - 1)\left[(1-p)u'(w^e)(1 - t(1-h^m)) + pu'(w^c)(1 - t(1-h^m) - Fth^m)\right]$$
$$- w\left[(1-p)u''(w^e)(1 - t(1-h^m))^2 + pu''(w^c)(1 - t(1-h^m) - Fth^m)^2\right] > 0 \quad (24)$$

$$V_t = (1-\varepsilon)w\left[(1-p)u'(w^e)(1-h^m) + pu'(w^c)(1 - h^m + Fh^m)\right]$$
$$+ w^2(1-p)u''(w^e)(1 - t(1-h^m))(1-h^m)$$
$$+ w^2 pu''(w^c)(1 - t(1-h^m) - Fth^m)(1 - h^m + Fh^m) \quad (25)$$

The employment change due to a substitution of the income for the payroll tax, using $wn_w = n_\tau(1 + \tau)$ and the fact that the expression in curly brackets below is zero (cf. appendix 2), is:

$$\left.\frac{dn}{dt}\right|_{\substack{dB=0, F(\cdot)=Fwth, \lambda=\lambda^* \\ h=h^m, G(\cdot)=Gwn\tau\lambda}} = n_w w_t - n_\tau \frac{B_t}{B_\tau}$$

$$= -\frac{nn_\tau}{B_\tau}\left[w_t(t(1-h^m) - 1) + w(1-h^m) - w_t\{w\tau\lambda_w - \lambda - (1+\tau)\tau\lambda_\tau\}\right]$$

$$= -\frac{nn_\tau}{B_\tau V_w}\left[V_t(1 - t(1-h^m)) + V_w w(1-h^m)\right]$$

$$= \frac{nn_\tau Fwph^m}{B_\tau V_w}\left[(\varepsilon - 1)u'(w^c) - wu''(w^c)(1 - t(1-h^m) - Fth^m)\right] \quad (26)$$

A sufficient condition for employment to fall with a substitution of the income for the payroll tax is $1 - t + th^m(1 - F) \geq 0$. Since fines rarely exceed twice the level of the evaded tax (Andreoni et al. 1998, p.

820), a tax rate of less than 50% and a maximum degree of evasion also of less than 50% guarantee the negative employment effects.[11] The result can be summarised as:

Proposition 4

If tax evasion choices are restricted, a balanced-budget shift in the tax burden will alter employment. In particular, in an economy with a wage setting trade union, in which the penalty for evasion is a function only of the evaded tax and evasion activities by firms are unrestricted while workers cannot attain their optimal degree of evasion, a balanced-budget shift from a linear payroll to a linear income tax will reduce employment if $1 - t + th(1 - F) \geq 0$ holds.

Withholding regulations or, more generally, restrictions on evasion choices destroy the symmetric impact of wage and tax rate variations on the employees' payoff. Thus, variations in wages and income taxes alter the trade union's objective in a different way than it is the case for unrestricted evasion choices. In the absence of restrictions on tax evasion activities, a balanced-budget substitution of an income for a payroll tax will have no employment effects if the penalty is a function of the evaded tax. A fixed degree of income tax evasion implies that a given income tax increase raises tax revenues by less than in the case of unrestricted evasion activities because higher tax rates reduce optimal evasion (cf. equation (11)). Since the budgetary effects of a given decrease in the payroll tax are unaffected by evasion - due to the separability feature - a substitution of the income for the payroll tax which leaves the government's budget unaffected in a world of unrestricted tax evasion choices will induce a decline in tax revenues if the workers' evasion possibilities are limited. In order to balance the budget, the income tax has to be raised further. In comparison to the set-up in which evasion choices are unrestricted and employment remains constant, the more pronounced income tax increase induces a further wage rise and an employment reduction. If, however, the penalty is sufficiently high, the budget might experience a surplus due to the rise in evaded taxes, such that the increase in the income tax rate can be less pronounced than for an unrestricted evasion choices.

4. Employment Effects if the Penalty Depends on Undeclared Income

Suppose the penalty which has to be paid in the case of being detected is not determined solely by the amount of evaded taxes but also influenced by the level of undeclared income. Under this assumption, a shift from payroll to income taxes, holding constant the nominal wedge between labour costs and the net wage, is likely to raise employment. It has been shown above that the firm's employment decision is independent of its evasion activities. This independence result will also apply if the penalty paid by the firm is a function of undeclared wage payments (see appendix 3). Thus, the trade-offs between wages or payroll taxes and employment are independent of the nature of the firm's fine. Accordingly, the focus of the subsequent analysis is on workers. Since already a shift of the tax burden in the

[11] If the payroll tax rate change is determined by a constant nominal wedge, the restriction $1 - t + th^m(1 - F) \geq 0$ will not suffice to guarantee an employment increase. However, the employment variation is generally non-zero.

presence of a constant nominal wedge has employment effects, this is also the case for the alternative constraints of a constant effective wedge or a balanced-budget requirement.

Assume that the workers' penalty for evasion increases with the evaded tax and the undeclared income, where the parameter β measures the importance of the two determinant. The penalty can then be expressed as $Fwh(\beta t + 1 - \beta)$, $0 \le \beta \le 1$. To simplify the subsequent analysis, $\beta = 0$ is assumed. The employment effects for $\beta > 0$ can be modelled by a combination of the impact for the case in which the penalty is a function of evaded tax and in which it depends on undeclared income. For a value of $\beta = 0$, the workers' optimal degree of tax evasion is defined by:

$$H \equiv (1-p)u'(w^e)t + pu'(w^c)(t-F) = 0, \tag{27}$$

where the wage if caught evading taxes will be defined by $w^c \equiv w(1 - t(1 - h) - Fh))$. An interior solution requires $t < F < t/p$. Using a variable M, $M \equiv (1 - p)u'(w^e) + pu'(w^c) > 0$, the derivatives of H are given by:

$$H_h = w\left[(1-p)u''(w^e)t^2 + pu''(w^c)(t-F)^2\right] < 0 \tag{28}$$

$$H_w = (1-p)u''(w^e)t(1-t(1-h)) + pu''(w^c)(t-F)(1-t(1-h)-Fh) \tag{29}$$

$$H_t = M - w(1-h)\left[(1-p)u''(w^e)t + pu''(w^c)(t-F)\right] \tag{30}$$

The first-order condition of the trade union's maximisation problem is given by equation (15), where w^c is redefined accordingly. The change in employment owing to a shift from the payroll to the income tax, holding constant the nominal wedge γ is defined by equation (16). Substituting for V_t and $V_w > 0$ one obtains (see appendix 4 for a derivation):

$$\left.\frac{dn}{dt}\right|_{\substack{d\gamma=0,G(\cdot)=Gwn\tau\lambda \\ h=h^*,\lambda=\lambda^*,F(\cdot)=Fwh}} = -\frac{n_w}{(1-t)V_w}\left[V_t(1-t) + wV_w\right]$$

$$= \frac{\varepsilon N}{V_w H_h}\left[MQ - w^2(1-t)(1-p)u''(w^e)pu''(w^c)h(t-(t-F)F)\right], \tag{31}$$

where $$Q \equiv \varepsilon h H_h + w(1-t)\left[(1-p)u''(w^e)t + pu''(w^c)(t-F)\right] \tag{32}$$

Since $H_h < 0$, while the expression is brackets in (32) will be positive (zero) if workers exhibit decreasing (constant) absolute risk-aversion, Q has an ambiguous sign (is negative). This yields:

Proposition 5

If the measure of the workers' absolute risk-aversion is not decreasing too strongly with income, a shift from payroll to income taxes, holding constant the nominal wedge between labour costs and the net wage, will increase employment in an economy with a wage setting trade union and optimal evasion activities, provided the workers' penalty for tax evasion depends at least marginally on undeclared income.[12]

The intuition for the positive employment effect is the following: assume for the sake of the argument that the Arrow-Pratt measure of absolute risk-aversion is constant, implying an employment expansion of the tax reform. This expansion occurs because a higher income tax rate will unambiguously increase the optimal degree of tax evasion if the penalty depends on the undeclared income while it will reduce evasion activities if the fine is a function of evaded taxes (cf. equations (10) to (13) and (28) and (30)). If the penalty depends on undeclared income and the optimal degree of tax evasion rises, the trade union's payoff from raising the wage will decrease, relative to a situation in which the penalty for evasion is a function of evaded taxes and the optimal degree of evasion has fallen, since the effective net wage has gone up and workers are risk-averse. Since, moreover, the decline in employment due to a given wage rise is not altered, the incentives to raise wages will be lower if the penalty is a function of the undeclared income instead of the evaded tax. Thus, employment will rise if the measure of absolute risk-aversion is constant. If this measure is strongly decreasing with income, the optimal degree of tax evasion might also decline with a higher income tax rate (cf. equation (30)). If this is the case, the employment effects of a shift from payroll to income taxes can be negative.

If the firm's penalty for evasion depends on the amount of undeclared wage payments, the trade-offs between employment and wages or the payroll tax rate will remain unaffected. Thus, the firm's evasion activities continue to have no impact on the employment decision. Moreover, the impact of a higher wage on the firm's degree of tax evasion λ is qualitatively unaffected by the fine structure and continues to be given by equation (6), where the change in J_λ owing to the alternative fine is taken into account. However, the impact of a higher payroll tax rate on the optimal degree of tax evasion, that is λ_τ, will vary in comparison to (7) if the penalty changes with undeclared wage payments (cf. appendix 3). This implies that a shift in the tax burden which leaves the effective wedge γ^{eff} constant induces a quantitatively different wage change than for a constant nominal wedge. Accordingly, employment changes. Thus, assuming a penalty for evasion for firms which depends on undeclared wage payments will only alter the irrelevance of the legal for the economic incidence if the tax reform is combined with a requirement of a constant effective wedge or of a balanced budget. If, however, the nominal wedge is held is constant, employment will not be affected by a shift in the tax burden, irrespective of whether the firm's penalty depends only on the evaded tax or also on the undeclared wage payment.

5. Conclusions

[12] If the constraint on the payroll tax change is not determined by a constant nominal wedge but by a balanced-budget restriction, a sufficient condition for employment to fall will be a constant Arrow-Pratt measure of absolute risk-aversion. Since the underlying computations are basically analogous to but more elaborate than those on which Proposition 5 is based, only the more straightforward case of a constant nominal wedge is analysed here.

The results of this paper may be summarised as follows: in the presence of tax evasion by firms and workers a change in the legal incidence of taxes is likely to have consequences for the economic incidence. Accordingly, the existence of tax evasion opportunities can invalidate one of the 'most basic theorems of public finance'. This assertion will hold true in a unionised labour market either if the penalty for evasion depends on the level of undeclared income while evasion activities are chosen optimally or if evasion opportunities are restricted. In particular, this paper shows that a shift from payroll to income taxes can raise employment if the penalty for tax evasion depends on undeclared income. However, if the penalty for evasion is a function only of the evaded tax and evasion activities by firms are unrestricted while workers cannot attain their optimal degree of evasion, a balanced-budget shift from a linear payroll to a linear income tax can lower employment. Thus, the direction of the employment change depends on whether evasion choices by workers are restricted or not, the specification of the penalty structure and on the type of constraint which determines relative tax changes.

In assessing the relevance of these findings, a number of further issues are worth discussing. They include the prevalence of unionised labour markets and the adequacy of the tax evasion model. In OECD countries union density often exceeds 30%, while collective bargaining coverage might easily reach 70% to 90% (OECD 1997, table 3.3). Therefore, the findings of this paper are relevant for a substantial part of labour markets. Moreover, it can be conjectured that they are not restricted to unionised labour markets, as long as the wage determination process exhibits the same qualitative features as in a collective bargaining set-up. Another relevant aspect for an evaluation of the above findings is the model of tax evasion. The employment effects of a substitution of an income for a payroll tax if the penalty also depends on the undeclared income will be caused by the asymmetric impact of wage and tax changes on the penalty for evasion and the effective net wage. Thus, it can be conjectured that the irrelevance hypothesis does not hold for any model of tax evasion in which wages and tax rates affect evasion choices non-symmetrically. While the direction of the employment change may be sensitive to the exact specification of the tax evasion model, it seems that the pure tax evasion model is not required for a refutation of the irrelevance hypothesis.

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7. Appendix

1. Second-order Condition for the Trade Union's Maximisation Problem

Making use of M, $M \equiv (1 - p)u'(w^e) + pu'(w^c) > 0$, the second-order condition is found to be:

$$V_w = (\varepsilon-1)(1-t)M - w^2(1-t)t\Big[(1-p)u''(w^e) + pu''(w^c)(1-F)\Big]h^*_w$$
$$- w(1-t)^2\Big[(1-p)u''(w^e) + pu''(w^c)(1-F) + pu''(w^c)F\Big]$$
$$- w(1-t)th\Big[(1-p)u''(w^e) + pu''(w^c)(1-F)\Big] \qquad (7.1)$$

Equation (7.1) can be simplified, employing $A \geq 0$ as defined by (13):

$$V_w = (\varepsilon-1)(1-t)M - w(1-t)^2 pu''(w^c)F - w(1-t)A\big[1-t+th-wtH_w / H_h\big] \qquad (7.2)$$

The term in square brackets can be manipulated, using (10) and (13). This yields:

$$V_w = (\varepsilon-1)(1-t)M - w(1-t)^2 pu''(w^c)F + Apu''(w^c)(1-F)Fw^2t(1-t)^2 / H_h$$
$$= (\varepsilon-1)(1-t)M - w(1-t)^2 pu''(w^c)F\big[1-A(1-F)wt / H_h\big]$$
$$= (\varepsilon-1)(1-t)M - w^2(1-t)^2 F^2 t(1-p)u''(w^e)pu''(w^c) / H_h \qquad (7.3)$$

The change in V due to a higher income tax rate t is defined by:

$$V_t = -(\varepsilon-1)wM - w^2(1-t)t\Big[(1-p)u''(w^e) + pu''(w^c)(1-F)\Big]h^*_t$$
$$+ w^2(1-t)\Big[(1-p)u''(w^e)(1-h) + pu''(w^c)(1-h+Fh)\Big] \qquad (7.4)$$

Substituting for h^*_t and A (cf. equations (11) and (13)), (7.4) can be rewritten as:

$$V_t = -(\varepsilon-1)wM - A\Big[(1-p)u''(w^e)(1-h) + pu''(w^c)(1-F)(1-h+hF)\Big]w^3t(1-t)/H_h$$
$$+ w^2(1-t)\Big[(1-p)u''(w^e)(1-h) + pu''(w^c)(1-h+hF)\Big] \qquad (7.5)$$

Simplification shows that $V_t(1 - t) + V_w w = 0$ holds, since:

$$V_t = -(\varepsilon-1)wM + w^3(1-t)F^2t(1-p)u''(w^e)pu''(w^c) / H_h \qquad (7.6)$$

2. Budgetary Effects and Constancy of Expected Payoffs

Ignoring government expenditure, and using the definition of γ^{eff}, B can be expressed as:

$$B = wn(1-t(1-h))(\gamma^{eff} - 1) + wn(pFth + qG\tau\lambda) \tag{7.7}$$

Differentiating B with respect to the income tax t and taking into account $\tau = \tau(t)$ yields:

$$\frac{dB}{dt}\Big|_{d\gamma^{eff}=0} = (\gamma^{eff} - 1)n\left[w_t(1-t(1-h)) - w(1-h-t(h_w w_t + h_t)\right]$$

$$+ npF\left[w_t th + wh + wt(h_w w_t + h_t)\right] + nqG\tau w_t\left[w\lambda_w + \lambda\right] + nqGw\left[\lambda + \tau\lambda_\tau\right]\frac{d\tau}{dt} \tag{7.8}$$

Simplification and substitution using $w_t(1 - t) = w$ and $d\tau/dt = -(1 + \tau)/(1 - t)$, irrespective of whether the nominal or the effective wedge is held constant (cf. equation (20)), gives rise to:

$$\frac{dB}{dt}\Big|_{d\gamma^{eff}=0} = \frac{wn}{1-t}\left(\gamma^{eff} - 1 + pF\right)\left[h + (1-t)t(h_w w_t + h_t)\right]$$

$$+ wnqG\left\{w\tau\lambda_w - \lambda - (1+\tau)\tau\lambda_\tau\right\}/(1-t) = 0 \tag{7.9}$$

From equation (18) it is known that the expression in square brackets in (7.9) is zero. Substituting in accordance with (19) shows that the term in curly brackets is also zero. Moreover, the trade union's and the firm's payoffs do not change. The union's utility is given by equation (14). The alternative income $\overline{w}$ is fixed and employment remains constant. It has been shown above that neither w^e nor w^c change. Thus, union utility is unaffected. Formally, the constancy of w^e and w^c can be demonstrated by differentiating w^e and w^c with respect to t and using $w_t(1 - t) = w$ and the calculations on which equation (18) is based.

Profits are given by $\pi^e = f(n) - wn(1 + \tau(1 - \lambda))$ and $\pi^c = \pi^e - Gwn\tau\lambda$. Profits will only be influenced by the tax reform if labour costs vary since employment is not affected and because the fine $Gwn\tau\lambda$ can be shown to be constant, using $\lambda + (1 + \tau)\tau\lambda_\tau = \tau w\lambda_w$.

$$\frac{d(Gwn\tau\lambda)}{dt}\Big|_{d\gamma^{eff}=0} = Gn(w_t\tau\lambda + w\tau\lambda_w w_t + w\left[\lambda + \tau\lambda_\tau\right]\frac{d\tau}{dt})$$

$$= Gwn\left[\tau\lambda + w\tau\lambda_w - (\lambda + \tau\lambda_\tau)(1+\tau)\right]/(1-t) = 0 \tag{7.10}$$

The change in actual labour costs due to a rise in the income tax rate t, taking into account $\tau = \tau(t)$, and making use of the same equality as in (7.10) is given by:

$$\frac{d(w(1+\tau(1-\lambda)))}{dt}\Big|_{d\gamma^{eff}=0} = w_t(1+\tau(1-\lambda)) - w\tau\lambda_w w_t + \left[w(1-\lambda) - w\tau\lambda_\tau\right]\frac{d\tau}{dt}$$

$$= w\left[1 + \tau(1-\lambda) - \lambda - (1+\tau)\tau\lambda_\tau - (1-\lambda)(1+\tau) + \tau\lambda_\tau(1+\tau)\right](1-t) = 0 \tag{7.11}$$

Since none of the components of profits change, expected utility also remains unaffected.

3. Evasion Choices by Firms if the Penalty Depends on Undeclared Wage Payments

If the firm's penalty is a multiple G of undeclared wage payments $wn\lambda$, the firm's optimal degree of tax evasion will be defined by $\partial E(S, q)/\partial\lambda \equiv wnJ$, where J is given by:

$$J \equiv (1-q)S'(\pi^e)\tau + qS'(\pi^c)(\tau - G) = 0 \tag{7.12}$$

The maximisation of E(S, q) with respect to employment yields (3). The derivatives of J are:

$$J_\lambda = wn\left[(1-q)S''(\pi^e)\tau^2 + qS''(\pi^c)(\tau - G)^2\right] = nJ_n / \lambda < 0 \qquad (7.13)$$

Defining a variable C, $C \equiv (1-q)S''(\pi^e)\tau + qS''(\pi^c)(\tau - G) \geq 0$, where C is non-negative owing to the assumption of non-increasing absolute risk-aversion, one obtains:

$$J_w = J_\lambda \lambda / w - nC < 0 \qquad (7.14)$$

$$J_\tau = (1-q)S'(\pi^e) + qS'(\pi^c) - w(1-\lambda)nC \qquad (7.15)$$

The changes in employment owing to a higher wage w or a higher payroll tax rate τ are independent of the evasion choices. The consequences of changes in the wage on the optimal degree of tax evasion are defined by (6). The impact of a rise in the payroll tax is found to be:

$$\frac{d\lambda}{d\tau} = -\frac{w\lambda}{f''n} - \frac{(1-q)S'(\pi^e) + qS'(\pi^c)}{J_\lambda} + \frac{wn(1-\lambda)C}{J_\lambda} \qquad (7.16)$$

4. Penalty as a Function of Undeclared Income

The derivatives of the union's first-order condition (23) with respect to wages and the income tax rate are:

$$V_w = (\varepsilon - 1)(1-t)M - w^2(1-t)\left[(1-p)u''(w^e)t + pu''(w^c)(t-F)\right]h_w^*$$
$$- w(1-t)\left[(1-p)u''(w^e)(1-t(1-h)) + pu''(w^c)(1-t(1-h)-Fh)\right] > 0 \qquad (7.17)$$

$$V_t = (1-\varepsilon(1-h))wM - w^2(1-t)\left[(1-p)u''(w^e)t + pu''(w^c)(t-F)\right]h_t^*$$
$$+ w^2(1-t)(1-h)\left[(1-p)u''(w^e) + pu''(w^c)\right] \qquad (7.18)$$

The employment change due to a shift of the tax burden is determined by equation (31), where:

$$V_t(1-t) + V_w w = Mw(1-t)\varepsilon h - w^2(1-t)(1-p)u''(w^e)\left(h + t\left\{h_t^*(1-t) + wh_w^*\right\}\right)$$
$$- w^2(1-t)pu''(w^c)\left(h(1-F) + (t-F)\left\{h_t^*(1-t) + wh_w^*\right\}\right) \qquad (7.19)$$

Substituting for the derivatives of h (cf. equations (28) to (30)) shows:

$$h + t\left\{h_t^*(1-t) + wh_w^*\right\} = -(1-t)\frac{pu''(w^c)(t-F)whF + tM}{H_h} \qquad (7.20)$$

$$h(1-F) + (t-F)\left\{h_t^*(1-t) + wh_w^*\right\} = (1-t)\frac{(1-p)u''(w^e)wth - (t-F)M}{H_h} \qquad (7.21)$$

Combining equations (7.19) to (7.21) gives rise to equation (31) in the text.