The Structure of Labour Taxation and Unemployment in Efficiency Wage Models

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Abstract

We use an efficiency wage framework to analyze tax reforms that leave the tax wedge unaffected both in the case of constant and endogenous outside options. An increase in the wage tax rate and a reduction of the payroll tax such that the ratio of gross wage rate to net-of-tax wage remains constant, does not affect the labour market allocation. But an increase in the wage tax rate and a reduction of the payroll tax such that the sum of the tax rates remains unaffected, lowers employment and in the long-run Nash equilibrium with endogenous outside option the policy reform also lowers effort.

JEL Classification: H22, J41, J48.

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1. Introduction

The “most basic theorem of public finance” (see e.g. Blinder 1988) states that the incidence of labor taxes is independent of whether the tax is levied on employers or employees meaning that it is the overall burden rather than the formal composition of the burden that matters. This theorem has recently been questioned for several reasons. First, it is emphasized that when payroll taxes and wage taxes have a different tax base due to tax exemptions, the composition of labor taxes matter (Koskela and Schöb 1999). Second, non-linear taxes may affect the incidence of payroll taxes and wage taxes in different ways (Picard and Toulemonde 2002). Third, when unemployment benefit payments are subject to income taxes, the composition of labor taxes also affects the labor market outcome (Goerke 2000).

In this paper we abstract from these sources of non-equivalence by focusing on a linear ad valorem payroll tax $s$ and a linear ad valorem wage tax $t$, which both have the same tax base. The gross wage rate is $w^g = w(1+s)$ and the net-of-tax wage is $w^n = w(1-t)$. The difference between gross wage and net-of-tax wage, $w(t+s)$, determines the tax wedge. Often, however, it is the sum of the tax rates $t+s$, which is used to define the tax wedge. For instance, Nickell and Layard (1999, p. 3037) “expect the labor market consequences of taxation to operate via the sum of the three$^1$ tax rates” (also see Nickell 2003). Goerke (2000), by contrast defines the wedge as the ratio of gross wages and net-of-tax wage, i.e. as $(1+s)/(1-t)$. We will show that in an efficiency wage framework, only the latter definition will sustain the equivalence result. The composition of labor taxes matters when focusing on the sum of labor tax rates. In this case a tax system with higher income tax and lower payroll taxes will generate higher unemployment and less work effort.

The following section sets up the model. In section 3 we analyze tax reforms that leave the tax wedge unaffected for both definitions of the tax wedge. We distinguish between the reaction in case of constant outside options and the case of endogenous outside options. Section 4 concludes.

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$^1$ They also include a consumption tax rate, which we do not consider here.
2. Model framework and comparative statics

We consider a standard efficiency wage model where firms can determine both wages and employment. The time sequence of decisions is shown in figure 1. The government behaves as a Stackelberg leader, which sets the \textit{ad valorem} payroll tax rate $s$ and the \textit{ad valorem} wage tax $t$ in the first stage. Since we do not allow for tax exemptions the tax base $w$ is the same for both tax rates.

\begin{align*}
\text{1st stage} & \quad \text{2nd stage} & \quad \text{3rd stage} \\
\text{Tax policy} & \quad \text{Wage setting ($w$) and labour demand ($L$)} & \quad \text{Effort determination ($e$)}
\end{align*}

When the tax policy is announced in the first stage, firms behave as Stackelberg leaders with respect to workers. They decide in the 2\textsuperscript{nd} stage on the wage rate $w$ and the employment level $L$, taken the tax parameters as given. When the net-of-tax wage rate exceeds the outside option of workers, $w^n - b > 0$, workers accept any job offered at the wage rate $w$. On the job, they can decide upon the effort $e$ they put into their work. As effort increases the disutility of working, workers have an incentive to shirk in the work place. Firms face the problem that they cannot perfectly monitor effort, but they can offset the incentive to shirk by paying higher wages, since this raises the penalty for shirking workers who are caught and fired.

We proceed by using backward induction and start our analysis with the 3\textsuperscript{rd} stage of the game, in which the wage rate, employment, and taxes are already determined.

\textit{Effort determination}

The preferences of the representative worker can be described by a utility function $U$ that is additively separable and quasi-linear, $U = (1 - d(1 - e))w(1 - t) + d(1 - e)b - g(e)$, where $d$ denotes the exogenously given probability of monitoring workers, $b$ denotes the workers’ outside option, which is explained in more details below, and $g(e)$ denotes the disutility from effort. Total working time per worker is fixed and normalized to unity. Effort is normalized such that we have $e \in [0, 1]$. For $e = 1$ we do not observe any shirking and thus have a zero
probability of being laid off, i.e. \( d(1-e) = 0 \). The utility function then simplifies to \( U = w(1-t) - g(l) \).

We assume that the disutility of effort is a convex function, i.e. \( g'(e), g''(e) > 0 \). The first-order condition for effort is then \( U_e = d(w^n - b) - g'(e) = 0 \). Using the parameterization \( g(e) = e^\theta \), \( \theta > 1 \) yields the following effort function

\[
e = A(w^n - b)^\alpha,
\]

where \( A = (d/\theta)^{1/(\theta - 1)} \) is constant, \( \alpha = 1/(\theta - 1) \), and \( w^n = w(1-t) \). Effort is a concave function of the difference between the net-of-tax wage rate and the workers’ outside option so that we have \( \alpha < 1 \). The comparative statics of the effort function is straightforward. Effort is increasing in the net-of-tax wage rate so that we have \( e_t < 0 \) and \( e_w > 0 \), and decreasing in the outside option \( e_b < 0 \).²

**Wage setting and labor demand**

In the 2\(^{nd}\) stage of the game, each firm takes the tax parameters as given and decides about the wage rate \( w \) and labor demand \( L \). Production depends on effective labor input \( eL \) so that the production function for the representative firm can be written as \( f(eL) \) with \( f'(eL) > 0 \) and \( f''(eL) < 0 \). The output price is normalized to unity and profits are defined by \( \pi = f(eL) - w(1+s)L \). Profit maximization subject to the effort function (1) yields the well-known Solow-condition (Solow 1979) \( e_n w/e = 1 \), according to which the wage elasticity of effort is equal to one, i.e. the condition also applies in the presence of wage and payroll taxes.

The outside option \( b \) of the worker is determined by the average net-of-tax wage rate \( \bar{w}(1-t) \) in the economy, the unemployment benefit payments \( \bar{b} \), and the probability with which a fired worker finds employment or stays unemployed. The unemployment benefits normally consist of a component that is related to the wage income and a component not related to wage income. Only the former may be subject to income taxation. This is the case analyzed by Goerke (2000). For the sake of the argument we set the proportional part equal to

² We can allow for a more general utility function that is concave in terms of rents and convex in terms of disutility of effort. Results are qualitatively similar and available upon request.
zero and only focus on exogenously given unemployment benefit payments. Following the standard approach in the efficiency wage models (cf. e.g. Summers 1988), the probability of finding a job equals the employment rate \((1-u)\), where \(u\) defines the unemployment rate in the economy. In what follows we consider the case of \(k\) identical firms. By normalizing total labor supply to unity, the unemployment rate is given by \(u = 1 - kL\). Thus the outside option of the representative firm becomes \(b = \overline{w}(1-t)(1-u) + ub\). From the viewpoint of a single firm, the outside option of its respective workers is not affected by its wage setting behavior. From the effort function (1), we can thus derive an explicit solution for the optimal wage rate set by the single firm:

\[
(2) \quad w = \frac{b}{(1-t)(1-\alpha)}.
\]

The comparative statics of the wage function shows that the wage rate \(w\) is affected by the outside option and the wage tax, \(w_b > 0\) and \(w_t > 0\), but is not directly affected by the payroll tax \(s\). For the labor demand function, we use the parametric specification \(f(eL) = \varepsilon^{-1}(eL)^\varepsilon\) with \(\varepsilon < 1\) denoting the revenue share of labor and \((1-\varepsilon)\) the profit share, respectively. The labor demand function is given by

\[
(3) \quad L = [w(1+s)]^{1-\delta}\varepsilon^{1-\delta},
\]

where \(\delta \equiv 1/(1-\varepsilon) > 1\) and \(\delta - 1 \equiv \varepsilon/(1-\varepsilon) > \varepsilon\). The comparative statics of labor demand shows that the wage tax \(t\) only affects labor demand via the effort determination. Changes in the payroll tax \(s\) do not affect effort but affect the gross wage rate. The wage rate \(w\) affects labor demand in two different ways: there is a negative direct effect of the wage rate and a positive indirect effect of the wage rate via effort. The former effect dominates so that a higher wage rate \(w\) cet. par. unambiguously decreases labor demand:

\[
(4) \quad L_w = -\delta (1+s)[w(1+s)]^{-\delta-1}e^{\delta-1} + [w(1+s)]^{-\delta}e^{\delta-2}(\delta-1)e_w = -\frac{L}{w} < 0.
\]

The optimal employment level is such that the labor demand elasticity is equal to \(-1\). To derive the general equilibrium result we use the fact that with symmetric firms, the average wage rate equals the wage rate each single firm sets. The general equilibrium condition is:
Substituting the labor demand function in the definition of the unemployment rate, we have

\[ 1 - u - k \left( w(1+s) \right)^{\delta} e^{\delta-1} = 0. \]

Together with the effort function (1) we thus have three equations (1), (5) and (6), and three unknown variables \( e, w, \) and \( u. \)

3. Changing the tax wedge structure

In what follows we consider two different changes in the composition of the tax wedge that leaves the marginal tax wedge constant. First we follow the definition of Goerke (2000) and consider a reform that leaves the ratio of gross wage rate and net-of-tax wage rate unaffected. This is the case when

\[ dt = ts - ds. \]

To show that such a change in the composition of labor taxes leaves the allocation unaffected, we look at the case where firms consider an exogenous outside option \( b. \) From (2) we get \( w_\gamma = w/(1-t) \) so that the net-of-tax wage remains constant, \( dw^n = [w_\gamma(1-t) - w] dt = 0 \) and work effort remains unchanged. The gross wage rate also remains constant, since \( dw^g = w_\gamma(1+s) - w_\gamma(1+s)/(1-t) = 0 \) so that employment does not change. This, in turn ensures that the outside option \( b \) does not change so that the initial allocation establishes a new Nash-equilibrium.

RESULT 1 (CONSTANT RATIO): An increase in the wage tax rate \( t \) and a reduction of the payroll tax \( s \) such that the ratio of gross wage rate to net-of-tax wage remains constant, does not affect the labor market allocation. From result 1, it follows immediately that for \( G = (t + s) wkL - (1 - kL) \bar{b} \) the tax reform is revenue-neutral so that we can state the following corollary:

COROLLARY 1: A revenue-neutral increase in the wage tax rate \( t \) and a reduction of the payroll tax \( s \) does not affect the labor market allocation.
Next we turn to the second definition of the tax wedge, i.e. that the tax wedge is determined by the sum of the tax rates. According to this definition, a tax reform that leaves the wedge constant is given by \( dt = -ds \). To compare the results with the previous one, we also start with the case where the firms consider a constant outside option.

**Constant outside option**

As before, the wage tax \( w \) is only affected by the wage tax rate so that we have \( w_t = w/(1-t) \) and consequently \( dw^w = [w_t(1-t) - w] dt = 0 \). Hence, for a constant outside option, effort is not affected at all, i.e. \( de/dt \bigg|_{ds=-dt} = 0 \). The gross wage unambiguously rises since the reduction of \( s \) is lower than in the first case:

\[
\left. \frac{dw^s}{dt} \right|_{ds=-dt} = w_t(1+s) - w = w \left( \frac{s + t}{1-t} \right) > 0 .
\]

Since effort does not change, the only effect on the firm-specific employment level is the increase of the gross wage rate. The employment effect is given by:

\[
\left. \frac{dL}{dt} \right|_{ds=-dt} = L_t + L_\eta w_t - L_t = -L \delta \frac{(s + t)}{(1-t)(1+s)} < 0.
\]

**RESULT 2 (CONSTANT SUM):** For given outside option, an increase in the wage tax rate \( t \) and a reduction of the payroll tax \( s \) such that the sum of the tax rate remains unaffected, lowers employment but leaves the effort level unaffected.

The outside option does not remain constant in the long run since unemployment rises and, for a constant net-of-tax wage rate in other firms, the outside option falls. Result 2 does not establish a Nash-equilibrium so that we have to further investigate the tax reform by looking at the general equilibrium in which the outside option is determined endogenously.

**General equilibrium analysis**

When a firm determines its optimal employment level, it takes the unemployment rate \( u \) as given. A higher unemployment rate, however, lowers the outside option. This increases effort and reduces the wage set by the firm. To analyze the total effect, including these feedback
effects, we investigate the equation system (1), (5), and (6). The determinant $D$ of the equation system is always negative (see Appendix). We can sign the following effects. First, the unemployment unambiguously rises due to the reform:

\[
(9) \quad \left. \frac{du}{dt} \right|_{dt=-ds} = -D^{-1}[w_i(u_u + u_ue) + u_ue_e - u_e] > 0.
\]

The effort of worker decreases:

\[
(10) \quad \left. \frac{de}{dt} \right|_{dt=-ds} = D^{-1}[w_i(u_u + e_u) - e_i - w_ue_e + e_u(u_e - w_u)] < 0.
\]

For the wage rate $w$, we have the following condition:

\[
(11) \quad \left. \frac{dw}{dt} \right|_{dt=-ds} = -D^{-1}w_i + D^{-1}[w_ue_e + w_e(u_e - w_u)] > 0.
\]

The direct effect is positive. If $(1-t)/(1+s) > \alpha$, the second term that covers the indirect effect of unemployment via wage formation and effort, is positive as well. The result is summarized in the second result:

RESULT 3 (ENDOGENOUS SUM): In the long-run Nash equilibrium, an increase in the wage tax rate $t$ and a reduction of the payroll tax $s$, such that the sum of the tax rate remains unaffected, lowers employment and work effort.

For a constant outside option, the net-of-tax wage rate and effort are not affected by the reform. Taking the change in the outside option into account, however, the effect on unemployment becomes important. First, we can show that the net-of-tax wage rate falls:

\[
(12) \quad \left. \frac{dw}{dt} \right|_{dt=-ds} = \left[ w_i + w_u \left. \frac{du}{dt} \right|_{dt=-ds} \right] (1-t) - w = (1-t)w_u \left. \frac{du}{dt} \right|_{dt=-ds} < 0.
\]

While the direct effects cancel out, the indirect effect due to the change in the unemployment rate ensures that the net-of-tax wage rate falls. The outside option $b$ also falls since both the unemployment rate rises and the net-of-tax wage rate falls. Effort, however, will only fall if the difference between the net-of-tax wage rate and the outside option decreases. Rewriting

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Note that $\alpha$ is always smaller than the unemployment rate. For mark-ups below 30 percent, it can be deduced from equation (6) that $\alpha$ is only a fourth of the unemployment rate or even less.
equation (2) as \( w(1-t) - b = \alpha w(1-t) \), it can be seen immediately that the difference is proportional to the net-of-tax wage rate so that the difference between the net-of-tax wage rate and the outside option also falls. When effort falls, cet. par. employment falls since the marginal productivity of workers becomes smaller. The total employment effect is even stronger since the gross wage also rises, i.e. we have \( \frac{d w^t}{ds} \bigg|_{ds=-dt} > 0 \). The main reason for this apparently paradox result is the following. Even though we keep the sum of the tax rate \((t+s)\) constant, the total wedge between the gross wage and the net-of-tax wage rate, \( w(t+s) \), increases since the tax base \( w \) increases.

Finally we turn to the government budget constraint, which is given by \( G = (t+s)w k L - (1-kL)b \), where \( (1-kL)b = u \). Now the total differentiation yields \( dG = (dt+ds)wk L + (t+s)k((L+wL_w)dw + w(L_dt + L_ds)) + k \bar{b}(L_w dw + w(L_dt + L_ds)) \). The first term is zero and we know from the first-order condition of the firm that \( L + wL_w = 0 \).

Thus the total effect on the budget constraint is given by:

\[
\left. \frac{dG}{dt} \right|_{ds=-dt} = (t+s)kw + k \bar{b})(L - L_s) - \frac{k \bar{b} L}{w} \left. \frac{dw}{dt} \right|_{ds=-dt} = -(G + \bar{b}) \left( \delta (t+s) - (1+s) \right) - \frac{k \bar{b} L}{(1-t)(1+s)} \cdot
\]

The term \((1+s)/(t+s)\) is below 2 in most cases. Since \( \delta \equiv 1/(1-\varepsilon) > 1 \), where \( \varepsilon \) indicates the cost share of labor, empirically, \( \delta \) is larger than 2 so that the first term of the right-hand side will likely to be negative. The second term is always negative and will be the larger in absolute terms the larger the unemployment benefit payments are. Thus we can expect public revenues to fall.\(^4\)

4. Concluding remarks

In an efficiency wage framework, we analyzed tax reforms that leave the tax wedge unaffected by distinguishing between the reaction in the case of constant outside options and the case of endogenous outside options. A tax reform that keeps the ratio of gross wage rate to net-of-tax wage constant, does not affect the labor market allocation. A reform that keeps the sum of the labor tax rate constant, however, lowers employment and effort in the long-run Nash

\(^4\) Note that we would obtain the same condition for the case of exogenous outside option.
equilibrium. The reason is that the tax reform, which leaves the sum of tax rates constant, changes the marginal incentives for firms and workers and therefore affects wage formation. This in turn changes the tax base for the two tax rates. The constant-ratio definition of the wedge takes this tax base change into account and therefore correctly measures the tax wedge. The constant-sum definition ignores this effect and therefore does not yield the basic theorem of public finance that the incidence of labor taxes is independent of whether the tax is levied on employers or employees. The precise definition therefore is important for both analytical and empirical research in determining the impact the structure of labor taxation has on wage formation and employment and to focus on the potential reasons such as different tax bases, non-linear tax schedules and the taxation of unemployment benefit payments.

5. References
Appendix

The effort function (1), the wage rate function (5) and the unemployment function (6) provide the equation system in the general equilibrium case. The determinant is

\[
D = \begin{vmatrix}
1 & 0 & -w_u \\
-e_w & 1 & -e_e \\
u_w & u_e & -1
\end{vmatrix} = -1 - \frac{\alpha \delta (1-u) [1 + (\delta - 1)(1-u)]}{u(u-\alpha)} < -1.
\]

In terms of changes in \( t \) and \( s \), we have the following equation systems, respectively:

\[
(A2) \quad \begin{bmatrix}
1 & 0 & -w_u \\
-e_w & 1 & -e_e \\
u_w & u_e & -1
\end{bmatrix} \begin{bmatrix}
\frac{dw}{dt} \\
\frac{de}{dt} \\
\frac{du}{dt}
\end{bmatrix} = \begin{bmatrix}
\frac{w_t dt}{e_t} \\
\frac{e_t dt}{e_t} \\
0
\end{bmatrix}, \quad \begin{bmatrix}
1 & 0 & -w_u \\
-e_w & 1 & -e_e \\
u_w & u_e & -1
\end{bmatrix} \begin{bmatrix}
\frac{dw}{ds} \\
\frac{de}{ds} \\
\frac{du}{ds}
\end{bmatrix} = \begin{bmatrix}
0 \\
0 \\
-u_ds
\end{bmatrix}
\]

By using Cramer’s rule, we obtain the following results

\[
(i) \quad \frac{dw}{dt} = D^{-1}[-w_t (1-e_u u_e - u_e e_w)], \quad \frac{dw}{ds} = D^{-1}[-w_u u_s],
\]

\[
(ii) \quad \frac{de}{dt} = D^{-1}[-e_t (1-w_u u_w - w_e u_w + e_w)], \quad \frac{de}{ds} = D^{-1}[-e_s (e_u w_u + e_w)],
\]

\[
(iii) \quad \frac{du}{dt} = D^{-1}[-w_t (u_w + u_e e_w) - u_e e_t], \quad \frac{du}{ds} = D^{-1}[-u_s].
\]

Thus the total effects for \( dt = -ds \) can be expressed as

\[
(i) \quad \frac{dw}{dt} \bigg|_{dt=-ds} = D^{-1}[-w_t (1-u_e e_w) + w_e (u_s - u_e e_t)],
\]

\[
(ii) \quad \frac{de}{dt} \bigg|_{dt=-ds} = D^{-1}[-w_t (u_s e_w + e_u) - e_t - w_e e_w + e_u (u_s - w_u)],
\]

\[
(iii) \quad \frac{du}{dt} \bigg|_{dt=-ds} = D^{-1}[-w_t (u_w + u_e e_e) - u_e e_s + u_s].
\]

The gross wage increases since

\[
dw^g = w_t (1+s) dt + wds = w \left( \frac{s + t}{(1-t)(1+s)} \right) dt.
\]

Therefore unemployment raises accordingly as

\[
\frac{du}{dt} \bigg|_{dt=-ds} = u_w \frac{dw}{dt} \bigg|_{dt=-ds} - u_s = \frac{\delta (1-u)(s + t)}{(1-t)(1+s)} > 0.
\]