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OF PROGRESSIVE TAXATION

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# Efficiency Wages and the Long-Run Incidence of Progressive Taxation*

Bo Sandemann Rasmussen†

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**Abstract**

Progressive income taxation has for some time been recognized to provide incentives for wage restraint in models with imperfectly competitive labour markets. Recent research has established that bargaining over individual working hours may reverse the wage restraining effect such that increased tax progression may reduce employment. In the present paper an alternative explanation for such adverse employment effects is suggested. Using an efficiency wage model it is shown that long-run adjustment in the number of firms to changes in profits may imply that an increase in tax progression has adverse employment effects when all the budgetary effects of the tax reform are taken into account.

*Keywords*: Efficiency wages, employment, progressive taxation, balanced-budget tax reforms, long-run equilibrium.

*JEL*: J41, H22.

## 1 Introduction

The early theoretical literature on the effects of progressive taxation in equilibrium models of unemployment showed that progressive taxation seems to

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provide the right incentives in wage formation for obtaining high levels of employment in labour markets with imperfect competition (see e.g. Hoel (1990), Koskela and Vilmunen (1996), Lockwood and Manning (1993), Malcomson and Sartor (1987)). The most forceful conclusion within that literature is probably due to Pissarides (1998) suggesting that "*...a reform of the employment tax structure from regressive to progressive can be one of the very few 'free lunches' that one encounters in the analysis of economic policy*" (Pissarides (1998), p. 177). Along a similar vein Lockwood and Manning (1993) argued that the "optimal" tax schedule is progressive in a bargaining model of the labour market (see also Sørensen (1999) for an explicit analysis of the optimal degree of tax progression). The positive employment effects of progressive taxation in imperfectly competitive markets stand in sharp contrast to the effects in perfectly competitive labour markets where progressive taxes distort labour supply decisions and reduce employment (see e.g. Pissarides (1998)).

One interpretation of the desirability of progressive taxation in imperfectly competitive labour markets is that it is simply a second-best result: Adding a distortion to an economy may alleviate the harmful effects of already existing distortions. Although there is no guarantee that *any* new distortion will alleviate existing distortions the literature cited above seems to suggest that it could be rather difficult to obtain harmful employment effects of progressive taxation in imperfectly competitive labour market models.

More recently, however, successful attempts have been made to show that progressive taxation may not be good for employment even under imperfectly competitive conditions. Hansen *et al.* (1995) and Fuest and Huber (2000) use trade union bargaining models of the labour market where individual hours are endogenously determined either by the individual workers themselves or through bargaining between the union and the firm. It turns out that the standard result goes through as long as individual hours are determined by the individual worker. However, if individual hours are determined through bargaining between the union and the firm the employment effect of an increase in tax progression is generally ambiguous.[1] Andersen and Rasmussen (1999) show in a model where workers may choose between a high and a low effort level that an increase in tax progression may have adverse effects by reducing the likelihood that high effort equilibria prevail.[2]

[1] Hansen (1999) makes the same kind of analysis in an equilibrium search model but obtains the standard result even if individual working hours are determined through bargaining. Thus, it is not a general result that bargaining over individual hours leads to ambiguous employment effects of increased tax progression.

[2] See also Fuest and Huber (1998) who in an efficiency wage model show that an increase in the marginal tax rate may lead to lower employment if the actual tax payment of the

The purpose of the present paper is to provide an alternative explanation for possibly adverse employment effects of progressive taxation by introducing long-run adjustment through responses in the number of firms to changes in profits. To this end we set up a generalized version of the Shapiro-Stiglitz (1984) shirking model of efficiency wages allowing workers to choose work effort at a continuous scale. Firms cannot observe effort costlessly but can monitor the work force at a cost. Following Altenburg and Straub (1998) and Bulkley and Myles (1996) firms offer to their workers a contract consisting of an effort norm and a wage, and workers observed providing less effort than required by the norm are sacked. Thus, in contrast to the original Shapiro-Stiglitz model and the efficiency wage model in Pissarides (1998) where wages are determined in a "quasi-Walrasian" fashion to equate labour demand and a no-shirking condition, firms are explicitly wage-setters.[3]

Regarding taxation, it is assumed that labour income is taxed progressively and that the various tax reforms to be considered amount to changes in the degree of tax progression. Two types of tax reforms are considered. First, a pure increase in tax progression where the marginal tax rate is increased holding the average tax on the initial wage income level constant. Secondly, a balanced-budget tax reform is considered where the degree of tax progression is increased such that the net tax revenue is unaffected by the reform.

The results reveal that we cannot rule out that an increase in tax progression leads to a reduction in long-run employment when all the budgetary effects of the tax reform are taken into account. It is shown that it is the combination of a long-run equilibrium analysis and a balanced-budget tax reform that accounts for the possible adverse effects on employment. Moreover, it turns out that the size of the marginal tax rate has qualitative implications for the employment effect of an increase in tax progression as the

employed workers is kept constant. Notice, however, that this is not a balanced-budget tax reform as long as the equilibrium employment level changes (and if employment falls so does the total tax revenue).

[3]In principle, firms choose employment, wages and the effort norm subject to an incentive compatibility constraint stating how wages and the effort norm must be related for workers to comply with the effort norm (i.e. a no-shirking condition). However, given the incentive compatibility constraint once wages are set the effort norm become residually determined (or vice versa), implying that we can model firms as setting either employment and wages or employment and the effort norm. We choose the former, but nothing would change if the other specification were chosen. The main implication of effort being a continuous variable is that the qualitative properties of our efficiency wage model become identical to those of the bargaining models in Pissarides (1998) for which the tax structure generally matters, in the sense that the optimal choice of wage offer by the firms depends on the progressiveness of the tax system (see also Hoel (1990)).

likelihood of getting an adverse employment effect rises with the level of the marginal tax rate. This implies that, in principle, it is possible to determine the employment-maximizing degree of income tax progression within this model (although an actual calculation of that degree of tax progression would require that a fully parameterized version of the model be specified).

The paper is organized as follows. In section 2 the basic efficiency wage model of the shirking-type is stated. The various tax reform analyses are presented in section 3 while the generality of the results is discussed in section 4. Finally, some concluding remarks are offered in section 5.

# 2 The Model

The model captures a small open economy where a large number of competitive firms produce a homogeneous tradable good whose price is fixed from the world market and normalized at unity. Labour acts as the only productive input. The government provides, in excess of benefits to the unemployed, an exogenously given level of public goods financed by taxation of labour income. We use the generalization suggested by Altenburg and Straub (1998) and Bulkley and Myles (1996) of the standard Shapiro-Stiglitz efficiency wage model where firms offer a wage-effort package to their workers stating a required effort level and a wage. Effort cannot be costlessly observed but the firm can, at a cost, monitor the effort of its employees. The firm renews the contract with a worker unless the worker is observed not complying with the effort norm. Workers who are fired by a firm subsequently seek employment in other firms. There is free entry and exit of firms such that the equilibrium number of firms is determined by a zero pure profit condition.

## 2.1 Households

Let there be $H$ households[4] in the economy. Household utility depends positively on consumption of goods and negatively on the amount of effort put forth when working.[5] Since all income is spent on the single consumption good we can generally express the utility function as depending on post-tax income, $m$, and effort, $e$. In contrast to the original Shapiro-Stiglitz model, but in accordance with e.g. Altenburg and Straub (1998), Bulkley and Myles (1996), Hoel (1990), Pisauro (1991) and Rasmussen (1998), effort

[4] Throughout the paper we use the terms "households" and "workers" interchangeably.

[5] Utility may also depend on the level of the publicly provided good, $g$, but since that level is kept fixed throughout the analysis, $g$ is suppressed in the utility function.

is a continuous variable. An implication of specifying effort as a continuous variable is that the equilibrium effort level generally becomes dependent on the structure of taxation whereby the private sector response to tax reforms is enriched compared to efficiency wage models that are based more strictly on the original Shapiro-Stiglitz model, as in Pissarides (1998), where effort is constrained to take on a fixed value independently of the structure of taxation.

The instantaneous utility function of a household (time subscripts are left out since we concentrate on steady state equilibria)[6] is

$$U = u(m) - \gamma e,$$

assumed to be separable in income and effort and linear in effort (as in Pisauro (1991)) with $u'(m) > 0$, $u''(m) \leq 0$, and $\gamma > 0$ being the marginal disutility of effort.

Income taxes are progressive as taxes paid by workers earning a pre-tax wage $w$ amount to $T = tw - a$, where $t > 0$ is the marginal tax rate while $a > 0$ is a subsidy making the overall tax progressive.[7] Hence, post-tax wage income is $\omega = w - T = w(1-t) + a$. Unemployed workers receive unemployment benefits with a post-tax value of $\beta$.[8]

The representative firm chooses a wage, $w^j$, and a required effort level, $e^j$, and workers detected supplying effort below this threshold level are fired.[9] For simplicity, we assume that a firm's monitoring expenditures are constant (similar assumptions are found elsewhere in the efficiency wage literature e.g. in Altenburg and Straub (1998), Bulkley and Myles (1996) and Pisauro (1991)),[10] implying that a worker supplying less effort than the norm, $e^j$, is being detected at an exogenously given rate, $q > 0$.

[6] See Rasmussen (2000) for a description of the dynamic behaviour of agents in this model. In the present paper we specify an atemporal model since that is sufficient when only steady state equilibria are considered.

[7] The coefficient of residual income progression, $R = \frac{1-T'(w)}{1-\frac{T(w)}{w}}$, is an often used measure of the degree of tax progression with $R < 1$ reflecting a progressive tax schedule. In our case we have $R = \frac{1-t}{1-t+\frac{a}{w}} < 1$.

[8] In our main analyses it is assumed that the post-tax value of unemployment benefits, $\beta$, is kept constant, implying that the pre-tax benefit rate, $b$, is adjusted to keep $\beta$ constant. Thus, as $\beta = b(1-t) + a$, this amounts to changing $b$ according to $db = \frac{b \cdot dt - da}{1-t}$ when the tax reform is undertaken. Alternatively, it could be assumed that the (post-tax) replacement ratio, $c = \frac{\omega}{\beta}$, is kept constant. The implications hereof for our results are briefly discussed in section 4.

[9] Since only a fraction of the work force of the firm is monitored at a given point in time wages cannot be conditioned on effort, and all workers must be paid the same wage (this is the basic premise in efficiency wage models, see e.g. Milgrom and Roberts (1992)).

[10] Taking the level of monitoring as exogenous is obviously a short cut for a more complete description of the behaviour of firms when effort is only observable at a cost. In general

Let $V^{Nj}$ and $V^{Sj}$ denote the expected discounted lifetime utilities of an employed worker who chooses not to shirk and to shirk, respectively, in the representative firm. The asset equations of a non-shirking worker and a shirking worker follow in the usual way

$$\theta V^{Nj} = u(\omega^j) - \gamma e^j + s\left(V^U - V^{Nj}\right) \quad (1)$$

$$\theta V^{Sj} = u(\omega^j) + (s+q)\left(V^U - V^{Sj}\right) \quad (2)$$

where $\theta > 0$ is the subjective discount rate, $s > 0$ is an exogenous separation rate and $V^U$ is the expected discounted utility of being unemployed. It follows implicitly from the specification of the asset equations that a worker not complying with the effort norm chooses to supply zero effort.

## 2.2 Firms

The production function of the representative firm depends on labour input measured in efficiency units:

$$y^j = f(e^j n^j),$$

where $f' > 0$ and $f'' < 0$.[11] Profits of the representative firm are

$$\Pi^j = f(e^j n^j) - w^j n^j$$

The representative firm chooses the wage, $w^j$, the required effort level, $e^j$, and firm level employment, $n^j$. To ensure positive levels of production, the firm must offer a wage-effort package such that $V^{Nj} \geq V^{Sj}$ and to be profit maximizing for the firm this incentive compatibility constraint (or no-shirking condition) must hold as an equality, $V^{Nj} = V^{Sj}$. Using equations 1 and 2 the incentive compatibility constraint can be written as

$$qu(\omega^j) - (\theta + q + s)\,\gamma e^j - \theta q V^U = 0.$$

The value of being unemployed, $V^U$, follows from combining the asset equations for non-shirkers and shirkers in all other firms with the asset equation

the firm has to trade off the amount of resources devoted to monitoring and the direct costs of offering a higher wage to elicit more effort of workers.

[11] This holds at the equilibrium employment level. For our model to be consistent with zero long-run pure profits it is assumed that for small values of $e^j n^j$ we have increasing returns to labour, $f''(e^j n^j) > 0$. Hence, we have U-shaped cost curves that allow for zero pure profits at an interior solution. Alternatively, a production function with a fixed labour input requirement, $y^j = f(e^j n^j - \zeta)$, could be specified.

for an unemployed worker

$$\begin{aligned} \theta V^N &= u(\omega) - \gamma e + s\left(V^U - V^N\right) & (3)\\ \theta V^S &= u(\omega) + (q+s)\left(V^U - V^S\right) & (4)\\ \theta V^U &= u(\beta) + \psi(N)\left(\max\left\{V^N, V^S\right\} - V^U\right), & (5)\end{aligned}$$

where the variables related to all other firms are without the $j$-superscript, and $\psi = \psi(N)$ is the exit rate from unemployment depending positively on aggregate employment, $N$, i.e. $\psi'(N) > 0$.[12] In equilibrium all other firms offer wage-effort contracts that are just sufficient to make workers supply the required effort level such that $V^N = V^S$. Solving for the value of being unemployed using equations 4 and 5 yields[13]

$$V^U = \frac{\psi(N)u(\omega) + u(\beta)}{\theta\left(\theta + q + s + \psi(N)\right)}.$$

Inserting this in the incentive compatibility constraint of firm $j$ yields effort in firm $j$ as an implicit function of the wage in firm $j$, the wage in all other firms, the rate of unemployment benefit and aggregate employment:

$$\varphi(\omega^j, e^j; \omega, \beta, N) \equiv qu(\omega^j) - (\theta + q + s)\gamma e^j - \frac{q\psi(N)u(\omega) + qu(\beta)}{\theta + q + s + \psi(N)} = 0. \quad (6)$$

We can without loss of generality model the firm as choosing either wages or the effort norm. Letting the firm set wages we can think of equation 6 as defining effort in firm $j$ as an implicit function of the firm-specific after-tax wage, $\omega^j$, and aggregate variables that a single firm takes as exogenously given i.e., $e^j = e^j(\omega^j; \omega, \beta, N)$. Using 6 it is straightforward to show that $e^j_\omega \equiv \frac{\partial e^j}{\partial \omega^j} > 0$, and $e^j_{\omega\omega} \equiv \frac{\partial^2 e^j}{\partial (\omega^j)^2} < 0$ (see the appendix for details). Thus, instead of wages being determined in a "quasi-Walrasian" fashion (cf. Pissarides (1998) and Shapiro and Stiglitz (1984)) adjusting to equalize a no-shirking condition and the demand for labour from firms, wages are choice variables of firms. The important differences between our set-up and that of Shapiro

[12] In a steady state equilibrium where the flows into and out of unemployment are equal the exit rate from unemployment is determined by the flow condition $(q+s)N = \psi \cdot (H - N)$, such that $\psi = \psi(N) = \frac{(q+s)N}{H-N}$, with $\psi'(N) = \frac{(q+s)H}{(H-N)^2} > 0$.

[13] Of course, we could also have used equations 3 and 5 to solve for $V^U$ in which case the effort norm of the other firms, $e$, would have entered the expression for $V^U$. The point is that there is a unique relation between the wage in the other firms, $w$, and their effort norm, $e$, as given by the incentive compatibility constraint, implying that we can substitute out the effort norm to get an expression including only the wage of the other firms.

and Stiglitz (1984) is the endogeneity of the equilibrium effort level present in our model whereas is does not matter for our results whether we let wages or the effort norm be the choice variables of firms.

The first-order conditions read

$$\begin{aligned} \frac{\partial \Pi^j}{\partial w^j} &= f' e^j_\omega \left(1-t\right) n^j - n^j = 0 \qquad (7) \\ \frac{\partial \Pi}{\partial n} &= f' e^j - w^j = 0. \qquad (8) \end{aligned}$$

The second-order condition can easily be shown to be satisfied due to $f'' < 0$ and $e^j_{\omega\omega} < 0$. Using 8 to eliminate $f'$ from 7 yields

$$e^j_\omega w^j \left(1-t\right) - e^j = 0, \qquad (9)$$

which is a "modified" version of the familiar Solow condition. It is the presence of progressive taxes that makes it a "modified" Solow condition since the equilibrium wage elasticity of effort exceeds unity when the tax schedule is progressive:

$$\frac{e^j_\omega \omega^j}{e^j} = \frac{w^j(1-t)+a}{w^j(1-t)} > 1.$$

## 2.3 Equilibrium

Since firms are identical the equilibrium will be symmetric with all firms choosing the same wage rate and the same effort norm. With a (slight) abuse of notation we denote the symmetric equilibrium values of the wage, effort and firm level employment by $w$, $e$ and $n$, respectively. The equilibrium effort function relates the economy-wide effort level to the economy-wide wage rate, the unemployment benefit rate and aggregate employment. Thus, using equation 6 with $\omega^j = \omega$ and $e^j = e$ the equilibrium effort function is determined implicitly as

$$\begin{aligned} \Phi\left(\omega, e, \beta, N\right) &\equiv \varphi(\omega, e, \omega, \beta, N) \\ &= \frac{q\left(\theta+q+s\right)u(\omega) - qu(\beta)}{\theta+q+s+\psi(N)} - \left(\theta+q+s\right)\gamma e = 0, \qquad (10) \end{aligned}$$

or (suppressing the dependence of effort on the level of unemployment benefit) $e = e(\omega, N)$, where it is easy to show that $e_\omega > 0$, $e_{\omega\omega} < 0$, $e_N < 0$, and $e_{\omega N} < 0$ (see the appendix for details). Notice that the effect on effort of an economy-wide increase in the wage is smaller than the effect on effort in a single firm of changing its own wage, only:

$$e_\omega \equiv \frac{\partial e}{\partial \omega} = \frac{qu'(\omega)}{\theta + q + s + \psi(N)} = \frac{\theta + q + s}{\theta + q + s + \psi(N)} e_\omega^j < e_\omega^j,$$

reflecting the negative externality among firms in wage-setting.

As in Albrecht and Vroman (1999) a long-run equilibrium obtains through free entry and exit of firms, implying that aggregate employment, $N$, be determined by the zero pure profit condition,[14]

$$\Pi = f(e(\omega, N)\, n) - wn = 0.$$

Notice that a perturbation of equilibrium leading to positive profits will result in an increase in the number of firms and thereby a higher level of employment. This induces workers to lower their effort as $e_N < 0$, whereby profits are reduced and the adjustment process is stable. $N < H$ is assumed for the analysis to be of interest.

We have three equilibrium conditions to determine wages, $w$, employment at the firm level, $n$, and aggregate employment, $N$. Thus, using that $w^j = w$, $e^j = e$, and $n^j = n$ while $e_\omega^j = \frac{\theta+q+s+\psi}{\theta+q+s} e_\omega$ the equilibrium conditions become

$$\begin{aligned} e_\omega(\omega, N)\, w\,(1-t)\,\frac{\theta + q + s + \psi(N)}{\theta + q + s} - e(\omega, N) &= 0 && (11)\\ f'(e(\omega, N)n)e(\omega, N) - w &= 0 && (12)\\ f(e(\omega, N)\, n) - wn &= 0. && (13) \end{aligned}$$

The determinant of the Jacobian $|J|$, is non-zero (see the appendix for details):

$$|J| = e_{\omega\omega} w(1-t)^2 f'' e^2 f' e_N n \frac{(\theta + q + s + \psi(N))}{(\theta + q + s)} < 0,$$

implying that the three equilibrium conditions define equilibrium levels of $w$, $n$ and $N$ as functions of the tax parameters.[15]

[14] An alternative way of specifying the long-run would be two include capital as a productive input with a given long-run return. Then if the production function exhibits constant returns to scale, the effective wage would be uniquely determined by the zero pure profit condition, and the firms would be unable to use the wage to enhance labour efficiency. In that case the efficiency wage model degenerates and we are back in a perfectly competitive model where progressive taxes are known to reduce employment.

[15] We are as such not interested in the effects on firm level employment, $n$, but we cannot, of course, leave out the equilibrium condition determining $n$, since it generally will affect the equilibrium responses of the variables of interest, $w$ and $N$, to the tax reforms.

## 2.4 Government

The government collects wage income taxes to cover the provision of the publicly provided good, $g$, and the (net) expenditures on unemployment benefits, $(H-N)\beta$. Thus, the government budget constraint reads

$$BS = (tw - a)N - (H-N)\beta - g = 0.$$

When we consider balanced-budget tax reforms the tax parameters $(t,a)$ are changed such that $g$ can be kept constant, $dg = 0$. On the other hand, in case of tax reforms holding the average tax on wage income constant, there will either be a deficit or a surplus on the government's accounts. It can therefore be argued that only balanced-budget tax reforms include all the relevant effects of the changes in taxation.

# 3 Tax Reform Analysis

We model tax reforms as changes in the tax parameters $(t,a)$ such that the income tax becomes more progressive (at any income level). This can be accomplished by increasing either of the tax parameters as can be seen from the effects on the coefficient of residual income progression, $R = \frac{1-t}{1-t+\frac{a}{w}}$:

$$\begin{aligned}\frac{\partial R}{\partial t} &= \frac{-a}{w\left(1-t+\frac{a}{w}\right)^2} < 0 \\ \frac{\partial R}{\partial a} &= \frac{-(1-t)}{w\left(1-t+\frac{a}{w}\right)^2} < 0.\end{aligned}$$

Notice that since the equilibrium wage typically changes as a result of a tax reform, the coefficient of residual income progression evaluated at the equilibrium wage is purely endogenous. Thus, even though $R$ is reduced at any wage level the value of $R$ evaluated at the *equilibrium* wage may increase if e.g. the tax reform leads to a lower wage.[16]

Two types of tax reforms are considered. Following most of the literature on the effects of progressive income taxation we first consider a "pure increase in tax progression" which amounts to increasing the marginal tax rate holding the average tax at the pre-tax reform wage level constant. That is, increasing $t$ and $a$ such that

$$dT = wdt - da = 0.$$

[16] It turns out, however, that in our model the coefficient of residual income progression evaluated at the equilibrium wage always falls when the income tax is made more progressive at any income level.

If, however, equilibrium wages and employment are affected by the tax reform a pure change in tax progression is not the end of the story since the government budget is affected. Hence, to consider the full effects of the tax reform a "balanced-budget increase in tax progression" should be analyzed. This amounts to increasing $t$ and $a$ such that

$$dg = (tw - a + \beta)\, dN + tNdw + wNdt - Nda = 0,$$

where $dN$ and $dw$ are the endogenous changes in employment and wages following the tax reform. Since we generally can state the equilibrium conditions for $w$ and $N$ as

$$\begin{aligned} w &= w(t, a) \\ N &= N(t, a), \end{aligned}$$

the employment effect of a pure increase in tax progression follows straightforwardly

$$\left.\frac{dN}{dt}\right|_{dT=0} = w\frac{\partial N}{\partial a} + \frac{\partial N}{\partial t}.$$

To obtain the effects of a balanced-budget tax reform is a little more cumbersome. The marginal rate of substitution of the two tax parameters is

$$\left.\frac{da}{dt}\right|_{dg=0} = \frac{wN + (tw - a + \beta)\frac{\partial N(t,a)}{\partial t} + tN\frac{\partial w(t,a)}{\partial t}}{N - (tw - a + \beta)\frac{\partial N(t,a)}{\partial a} - tN\frac{\partial w(t,a)}{\partial a}},$$

which is positive under the (reasonable) assumption that a higher tax rate generates a surplus on the government's accounts, $\frac{\partial BS}{\partial t} > 0$, while a higher tax subsidy makes the government accounts go into deficit, $\frac{\partial BS}{\partial a} < 0$.[17] The balanced-budget employment effect then becomes

$$\left.\frac{dN}{dt}\right|_{dg=0} = \frac{N\left[w\frac{\partial N(t,a)}{\partial a} + \frac{\partial N(t,a)}{\partial t}\right] + tN\left[\frac{\partial N(t,a)}{\partial a}\frac{\partial w(t,a)}{\partial t} - \frac{\partial N(t,a)}{\partial t}\frac{\partial w(t,a)}{\partial a}\right]}{-\frac{\partial BS}{\partial a}}. \tag{14}$$

## 3.1 A Pure Increase in Tax Progression

In the standard short-run model with a fixed number of firms a pure increase in tax progression has an unambiguously positive effect on employment (even

[17] Thus, we basically assume that we are on the rising part of the income tax Laffer-curve. Notice that this assumption also implies that a balanced-budget tax reform that increases $t$ unambiguously increases the degree of tax progression since $a$ increases along with $t$.

if individual working hours are endogenously determined as in Fuest and Huber (2000)). With free entry and exit of firms the positive employment effect remains intact.

**Proposition 1** *There is a positive employment effect of a pure increase in tax progression.*
***Proof.*** *Differentiating the equilibrium conditions, equations 11-13, implicitly with respect to the tax parameters $(t, a)$ and solving for the effects on wages and employment (see the appendix for details) yields:*

$$\frac{\partial w}{\partial t} = \frac{e_\omega}{e_{\omega\omega}(1-t)^2} + \frac{w}{1-t} \tag{15}$$

$$\frac{\partial w}{\partial a} = -\frac{1}{(1-t)} \tag{16}$$

$$\frac{\partial N}{\partial t} = \frac{e_\omega w(\theta+q+s+\psi(N))}{e_N(\theta+q+s)} + \frac{e_\omega^2 \psi(N)}{e_N e_{\omega\omega}(1-t)(\theta+q+s)} \tag{17}$$

$$\frac{\partial N}{\partial a} = -\frac{e_\omega(\theta+q+s+\psi(N))}{e_N(\theta+q+s)}. \tag{18}$$

*Hence, increasing the tax parameters to keep the average tax at the pre-tax reform wage level constant, $da = wdt$, the employment effect of the tax reform is positive*

$$\left.\frac{dN}{dt}\right|_{dT=0} = \frac{e_\omega^2 \psi(N)}{e_N e_{\omega\omega}(1-t)(\theta+q+s)} > 0,$$

*since $e_N < 0$ and $e_{\omega\omega} < 0$.* ■

## 3.2 A Balanced-Budget Increase in Tax Progression

Since the government budget is generally affected under a pure increase in tax progression it is important to take the full budgetary effects of the tax reform into account. It turns out that this may be sufficient to reverse the positive employment effect of a pure increase in tax progression.

**Proposition 2** *The employment effect of a balanced-budget increase in tax progression is generally ambiguous.*
***Proof.*** *Using equations 15-18 for the effects on wages and employment of changes in the tax parameters and the general expression for the employment effect of a balanced-budget tax change, equation 14, it follows that*

$$\left.\frac{dN}{dt}\right|_{dg=0} = \frac{e_\omega^2 N\left[t(\theta+q+s) - \psi(N)(1-t)\right]}{e_N e_{\omega\omega}(1-t)^2(\theta+q+s)\frac{\partial BS}{\partial a}} \lesseqgtr 0, \tag{19}$$

*due to the expression inside the brackets being of an ambiguous sign.* ■

Thus, when all the budgetary effects of the tax reform is taken into account and free entry and exit of firms is allowed for it is possible to get the opposite of the usual short-run result: Tax progression may be bad for employment. An interesting property of the employment effect is that the sign of it depends explicitly on the marginal tax rate, $t$. If we e.g. start with no taxation at all, $t = 0$, and introduce a small progressive income tax (which by construction must be purely redistributive since $g = 0$ must hold both before and after the tax reform), the employment effect is strictly positive

$$\left.\frac{dN}{dt}\right|_{t=g=dg=0} = -\frac{e_{\omega}^{2} N \psi(N)}{e_N e_{\omega\omega} \left(\theta + q + s\right) \frac{\partial BS}{\partial a}} > 0,$$

since $e_N < 0$ , $e_{\omega\omega} < 0$ and $\frac{\partial BS}{\partial a} < 0$. This result is stated in the following corollary.

**Corollary 1** *A small purely redistributive progressive income tax has a strictly positive employment effect.*

However, as the marginal tax rate increases the first term inside the square brackets in the numerator of equation 19 becomes larger while the second term becomes smaller,[18] and eventually the employment effect may be reversed. In fact, assuming that we stay on the upward sloping part of the income tax Laffer-curve it is possible to determine the employment maximizing income tax by setting 19 equal to zero, i.e. when $t^* = \frac{\psi(N)}{(\theta+q+s+\psi(N))}$ (the corresponding employment maximizing value of the subsidy, $a^*$, is then determined by the government's balanced budget requirement). However, since $t^*$ depends on aggregate employment through $\psi(N)$ we cannot obtain a specific value of $t^*$ without solving for the equilibrium levels of the endogenous variables[19] (and that would require a full parametric specification of the model and presumably numerical simulations). An implication of this inverse relation between the employment effect and the level of the marginal tax rate is that tax reforms aimed at promoting employment may be successful at low

[18] Two comments are in order here. First, since the exit rate from unemployment is an increasing function of aggregate employment, $\psi(N)$ increases with $t$ as long as the employment effect is positive. However, unless the employment effect of increasing tax progressivity is very big that effect is likely to be dominated by the fall in $(1 - t)$. Second, as we increase the marginal tax rate we may approach the decreasing part of the income tax Laffer-curve along which $\frac{\partial BS}{\partial a} > 0$. Hence, our argument here is only valid as long as we stay on the rising part of the income tax Laffer-curve.

[19] This is akin to the "optimum tariff" in international trade theory being determined by the (inverse of the) price elasticity of foreign export supply which itself is an endogenous variable.

levels of the degree of tax progression and yet counterproductive at higher levels of tax progression.

To understand intuitively why the balanced-budget effects of the increase in tax progression may differ qualitatively from the effects of a pure increase in tax progression one should note that following a pure increase in tax progression aggregate employment goes up while the wage goes down:

$$\left.\frac{dw}{dt}\right|_{dT=0} = \frac{e_\omega}{e_{\omega\omega}\,(1-t)^2} < 0,$$

implying that tax revenues may rise or fall. If tax revenues fall the average tax must subsequently be increased leading to a reduction in firms' profits and that may eventually reverse the positive employment effect. Thus, it is inclusion of the balanced-budget constraint of the government that is responsible for the possible adverse long-run employment effects of progressive taxation.

# 4 Discussion of the Results

Obviously, our results reveal that taking the full budgetary effects of the tax reforms and the long-run responses of firms to the reforms into account may be crucial to the conclusions to be drawn from the analyses. Since these results have been obtained through some specific modelling assumptions, we will briefly discuss the degree of generality of our results.

As a general point the model we have presented is basically a partial equilibrium model. However, at least for bargaining models the adoption of a general equilibrium specification does not seem to influence the effects of progressive taxation qualitatively, see e.g. Hansen *et al.* (1995).

## 4.1 Other Efficiency Wage Models

The results have been derived within a specific efficiency wage model of the shirking-type based on an extension of the celebrated Shapiro-Stiglitz model. The main properties of our model that are important for the results are that equilibrium effort is related to the wage level and aggregate employment such that $e_\omega > 0$, $e_{\omega\omega} < 0$, and $e_N < 0$. Thus, effort should increase, at a decreasing rate, with the wage and decrease with aggregate employment. These are quite general (and reasonable) properties that should hold in most (if not all) efficiency wage models. Hence, our results should be quite robust against alternative specifications of the efficiency wage effects.

## 4.2 Constant Replacement Ratio

Throughout the analyses we have assumed that the income of the unemployed workers is unaffected by the tax reforms, since that is the most commonly applied assumption in the literature (see e.g. Fuest and Huber (2000) and Lockwood and Manning (1993)). It is, however, perfectly possible to let the post-tax benefit rate react to changes in the post-tax wage rate by holding the replacement ratio constant. This may make sense since a tax reform that e.g. reduces the post-tax wage for a constant post-tax benefit rate is effectively changing the relative incomes of employed and unemployed workers. Obviously, if the tax reform reduces the post-tax wage level, the consequence of holding constant the replacement ratio instead of the post-tax benefit rate throughout the tax reform should be that a higher employment level is generated. Intuitively, the cut back in the post-tax benefit rate induces workers to exert more effort leading to higher profits and an increase in the number of firms. This is exactly what happens in the present model implying that the strictly positive employment effects of a pure increase in tax progression is strengthened while the sign of the employment effect of a balanced-budget increase in tax progression is still ambiguous (but a positive effect is now more likely to materialize, *ceteris paribus*).

## 4.3 Government Production

It could be argued that government consumption, $g$ in our model, to a large extent consists of services produced by domestic labour input. Hence, when a more progressive income tax lowers the wage level the revenue requirement is also lowered. Assuming that all government expenditures consist of labour input services the government budget constraint becomes

$$BS = (tw - a)(N + N^g) - (H - N - N^g)\beta - wN^g,$$

where $N^g$ is public employment assumed to be paid the market wage, $w$. A balanced-budget tax reform is now represented by changes in the tax parameters $(t, a)$ that keep $N^g$ constant. It is fairly straightforward to show that the employment effect of such a balanced-budget tax reform is generally ambiguous, such that our main result is not changed qualitatively.[20]

[20] See Rasmussen (2000) for an explicit derivation of this result in a slightly different model.

# 5 Concluding Remarks

The main purpose of this paper has been to present an additional explanation for how an increase in income tax progression may lead to a reduction in employment in an imperfectly competitive labour market. The mechanism presented included the long-run adjustment in the number of firms to changes in profits when all the budgetary effects of the tax reform were accounted for. Given the general ambiguity of the sign of the employment effect following an increase in tax progression in theoretical models, progressive taxes are not necessarily bad for employment in imperfectly competitive labour markets from a theoretical perspective. Instead, more empirical work in this area is needed.[21] One implication of our findings is that it may be important for the empirical modelling to take the full budgetary effects of the tax reforms into account and to distinguish short-run from long-run responses in a systematic way.

Another interesting implication of the analysis is that the sign of the employment effect of an increase in tax progression seems to depend on the size of the marginal tax rate such that a positive employment effect is likely to be present at low marginal tax rates (and hence at low degrees of tax progression) while a negative employment effect may follow for relatively high marginal tax rates. If tax policies are aimed at promoting employment this obviously limits the degree of tax progression policy-makers should contemplate establishing.

# 6 Appendices

## 6.1 The Effort Function for the Representative Firm

Using implicit differentiation of equation 6 the partial derivatives of the effort function for the representative firm are:

$$\begin{aligned} e_{\omega}^{j} &= -\frac{\varphi_{\omega^{j}}}{\varphi_{e^{j}}} = \frac{qu'(\omega^{j})}{\gamma(\theta+q+s)} > 0 \\ e_{\omega\omega}^{j} &= \frac{qu''(\omega^{j})}{\gamma(\theta+q+s)} < 0. \end{aligned}$$

[21] For empirical results on this literature see e.g. Hansen *et al.* (1995), Holmlund and Kolm (1995), Lockwood and Manning (1993) and Lockwood *et al.* (2000).

## 6.2 The Aggregate Effort Function

Using implicit differentiation of equation 10 the partial derivatives of the aggregate effort function become:

$$
\begin{aligned}
e_\omega &= -\frac{\frac{\partial \Phi}{\partial \omega}}{\frac{\partial \Phi}{\partial e}} = \frac{qu'(\omega)}{\gamma\left(\theta + q + s + \psi(N)\right)} > 0 \\
e_{\omega\omega} &= \frac{qu''(\omega)}{\gamma\left(\theta + q + s + \psi(N)\right)} < 0 \\
e_N &= -\frac{\frac{\partial \Phi}{\partial N}}{\frac{\partial \Phi}{\partial e}} = -\frac{q\psi'(N)\left[u(\omega) - \gamma e - u(\beta)\right]}{\gamma\left(\theta + q\right)\left(\theta + q + s + \psi(N)\right)} < 0 \\
e_{\omega N} &= -\frac{q\psi'(N)u'(\omega)}{\gamma\left(\theta + q + s + \psi(N)\right)^2} < 0.
\end{aligned}
$$

## 6.3 Equilibrium Analysis

The equilibrium conditions are

$$
\begin{aligned}
\Lambda^1(w, n, N, t, a) &\equiv e_\omega(\omega, N)\, w\, (1 - t)\, \frac{\theta + q + s + \psi(N)}{\theta + q + s} - e(\omega, N) = 0 \\
\Lambda^2(w, n, N, t, a) &\equiv f'(e(\omega, N)n)e(\omega, N) - w = 0 \\
\Lambda^3(w, n, N, t, a) &\equiv f(e(\omega, N)\, n) - wn = 0.
\end{aligned}
$$

Using the implicit function theorem the effects on wages and employment of a change in a tax parameter, say $t$, are:

$$
\begin{bmatrix} \Lambda^1_w & \Lambda^1_n & \Lambda^1_N \\ \Lambda^2_w & \Lambda^2_n & \Lambda^2_N \\ \Lambda^3_w & \Lambda^3_n & \Lambda^3_N \end{bmatrix}
\begin{bmatrix} \frac{\partial w}{\partial t} \\ \frac{\partial n}{\partial t} \\ \frac{\partial N}{\partial t} \end{bmatrix}
= -\begin{bmatrix} \Lambda^1_t \\ \Lambda^2_t \\ \Lambda^3_t \end{bmatrix},
$$

where

$$
\begin{aligned}
\Lambda^1_w &= e_{\omega\omega} w (1 - t)^2 \frac{\theta + q + s + \psi(N)}{\theta + q + s} + \frac{e_\omega (1 - t)\psi(N)}{\theta + q + s} \\
\Lambda^1_n &= 0 \\
\Lambda^1_N &= -e_N \\
\Lambda^1_t &= -e_{\omega\omega} w^2 (1 - t) \frac{\theta + q + s + \psi(N)}{\theta + q + s} - \frac{e_\omega w \psi(N)}{\theta + q + s} \\
\Lambda^2_w &= f'' e_\omega (1 - t) en - \frac{f' e_\omega (1 - t)\psi(N)}{\theta + q + s} \\
\Lambda^2_n &= f'' e^2
\end{aligned}
$$

$$\begin{aligned}
\Lambda_N^2 &= e_N(1-\sigma)f'; \quad \sigma = -\frac{f''en}{f'} \\
\Lambda_t^2 &= -e_\omega w(1-\sigma)f' \\
\Lambda_w^3 &= -\frac{f'e_\omega n(1-t)\psi(N)}{\theta+q+s} \\
\Lambda_n^3 &= 0 \\
\Lambda_N^3 &= f'e_N n \\
\Lambda_t^3 &= -f'e_\omega wn.
\end{aligned}$$

Solving this linear system of equations yields the results stated in the main text.

# References


[1] Albrecht, J.W. and S.B. Vroman, 1999, Unemployment Compensation Finance and Efficiency Wages, *Journal of Labor Economics* **17**, 141-167.

[2] Altenburg, L. and M. Straub, 1998, Efficiency Wages, Trade Unions, and Employment, *Oxford Economic Papers* **50**, 726-746.

[3] Andersen, T.M. and B.S. Rasmussen, 1999, Effort, Taxation and Unemployment, *Economics Letters* **62**, 97-103.

[4] Bulkley, G. and G.D. Myles, 1996, Trade Unions, Efficiency Wages, and Shirking, *Oxford Economic Papers* **48**, 75-88.

[5] Fuest, C. and B. Huber, 1998, Efficiency Wages, Employment and the Marginal Income-Tax Rate : A Note, *Journal of Economics* **68**, 79-84.

[6] Fuest, C. and B. Huber, 2000, Is Tax Progression Really Good for Employment? A Model with Endogenous Hours of Work, *Labour Economics* **7**, 79-93.

[7] Hansen, C.T., 1999, Lower Tax Progression, Longer Hours and Higher Wages, *Scandinavian Journal of Economics* **101**, 49-66.

[8] Hansen, C.T., L.H. Pedersen and T. Sløk, 1995, Progressive Taxation, Wages and Activity in a Small Open Economy, Working Paper 1995-21, Economic Policy Research Unit, Copenhagen Business School.

[9] Hoel, M., 1990, Efficiency Wages and Income Taxes, *Journal of Economics* **51**, 89-99.

[10] Holmlund, B. and A.S. Kolm, 1995, Progressive Taxation, Wage Setting and Unemployment - Theory and Swedish Evidence, *Swedish Economic Policy Review*, 423-460.

[11] Johnson, G.E. and P.R.G. Layard, 1986, The Natural Rate of Unemployment: Explanation and Policy, in O. Ashenfelter and R. Layard, eds., *Handbook of labor economics, Vol. II* (North-Holland, Amsterdam) 921-999.

[12] Koskela, E. and J. Vilmunen, 1996, Tax Progression Is Good for Employment in Popular Models of Trade Union Behaviour, *Labour Economics* **3**, 65-80.

[13] Lockwood, B. and A. Manning, 1993, Wage Setting and the Tax System: Theory and Evidence for the U.K., *Journal of Public Economics* **52**, 1-29.

[14] Lockwood, B., T. Sløk and T. Tranæs, 2000, Progressive Taxation and Wage Setting: Some Evidence for Denmark, *Scandinavian Journal of Economics* **102**, 707-723.

[15] Malcomson, J.M. and N. Sartor, 1987, Tax Push Inflation in a Unionized Labour Market, *European Economic Review* **31**, 1581-1596.

[16] Milgrom, P. and J. Roberts, 1992, *Economics, Organization, and Management* (Prentice-Hall, New Jersey).

[17] Pisauro, G., 1991, The Effect of Taxes on Labour in Efficiency Wage Models, *Journal of Public Economics* **46**, 329-345.

[18] Pissarides, C.A., 1998, The Impact of Employment Tax Cuts on Unemployment and Wages: the Role of Unemployment Benefits and Tax Structure, *European Economic Review* **42**, 155-183.

[19] Rasmussen, B.S., 1998, Long-run Effects of Employment and Payroll Taxes in an Efficiency Wage Model, *Economics Letters* **58**, 245-253.

[20] Rasmussen, B.S., 2000, Balancing the Budget: Short-Run and Long-Run Effects of Progressive Taxation, Working Paper, Department of Economics, University of Aarhus.

[21] Shapiro, C. and J.E. Stiglitz, 1984, Equilibrium Unemployment as a Worker Discipline Device, *American Economic Review* **74**, 433-444.

[22] Sørensen, P.B. (1999), "Optimal Tax Progressivity in Imperfect Labour Markets", *Labour Economics*, **6**, 435-452.

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