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Balancing the Budget: Long-Run Adverse Effects of Progressive Taxation*

Bo Sandemann Rasmussen†

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Abstract

Progressive taxation is known to provide incentives for wage restraint and thereby lead to a higher level of employment in various models of equilibrium unemployment based on imperfectively competitive labour markets. It is shown in an efficiency wage model that although an increase in tax progression holding the average tax unchanged leads to a higher level of employment in the short run, once the full budgetary effects of changing tax progression is taken into account and free entry and exit of firms is allowed for in the long run, increasing tax progression leads to the opposite result, *viz.* a lower level of equilibrium employment.

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

JEL: J41, H22.

1 Introduction

Recent theoretical studies of the effects of progressive taxation in various equilibrium models of unemployment, e.g. efficiency wage models, trade union models and search models, have concluded that progressive taxation

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seems to provide the right incentives in wage formation for obtaining high levels of employment (see e.g. Bovenberg and van der Ploeg (1994), Hoel (1990), Koskela and Vilmunen (1996), Lockwood and Manning (1993), Malcomson and Sartor (1987) and Pissarides (1998)).[1] In fact, Pissarides forcefully concludes 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) argues that the "optimal" tax schedule is progressive (see also Sørensen (1997) for an explicit analysis of the optimal degree of tax progression).

From an economic policy point of view the implication of the tax structure, i.e. the degree of tax progression, for employment outcomes is of vital importance when tax reforms are considered. In particular, the possibility that improved employment performance can be obtained by changing the tax structure without reducing the overall tax burden seems almost too good to be true for any minister of finance having difficulties cutting government expenditures.

The purpose of the present paper is to investigate the robustness of these results on two accounts. First, most studies of the effects of progressive taxation model an increase in tax progression as a higher marginal tax rate, holding the average tax on the pre-tax reform wage level constant. However, whenever employment or wages are affected by the tax reform the government's budget is affected, as well. Therefore, further changes in taxation is needed to take all relevant effects into account. Secondly, most (presumably all) studies consider short-run effects only by not allowing for entry and exit decisions of firms in response to changes in taxation. However, tax reforms will generally affect the profits of firms, and taking this aspect into account seems not only natural but rather essential since tax reforms of the kind considered here presumably reflect long run policy objectives like allocative efficiency, distributional objectives etc. rather than short-run stabilizational objectives. To this end we set up a generalized version of the Shapiro-Stiglitz (1984) shirking model of efficiency wages where workers are allowed to choose work effort continuously within the unit interval. Firms cannot observe effort costlessly but can monitor part of the work force at a cost. With effort being a continuous variable chosen optimally by workers the firms have an incentive to offer a wage that induces workers not to shirk "too much". Thus, in contrast to the original Shapiro-Stiglitz model and the efficiency wage model

[1] Andersen and Rasmussen (1999) provide one of the few examples of possible adverse effects of progressive taxation due to increasing average tax rates, making high effort equilibria less likely to prevail. See also Hansen *et al.* (1995).

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. As a consequence, our efficiency wage model possesses properties of a qualitatively same nature as the bargaining models in Pissarides (1998) for which the tax structure generally matters. The optimal choice of wage offer by the firms depends on the characteristics of the tax system. Labour income is taxed progressively and the various tax reforms to be considered amount to changes in the degree of tax progression. In the short run the number of firms is exogenously given while free entry and exit of firms determines the long-run equilibrium. Two types of tax reforms are considered. First, holding constant the average tax on the initial wage income level, the tax is made more progressive through increasing the marginal tax rate. 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 from a short-run perspective a more progressive tax structure does seem to boost employment. Thus, in the short-run we seem to able to replicate the results obtained in various equilibrium models of unemployment. Furthermore, compared to Pissarides (1998) we generalize the results from the efficiency wage model to become compatible with his results obtained in bargaining models. As mentioned above, this is due to our modelling of wage formation as an explicit Nash game in wages among firms, instead of wages being determined in a quasi-Walrasian fashion. More strikingly, when we turn to the long-run aspects of the tax reforms, the results reveal that the long-run effects may differ sharply from the short-run effects. In fact, even though the well-known positive employment effect of an increase in tax progression is valid in the short run, it is turned into a negative employment effect in the long run when all the budgetary effects of the tax reform is 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 adverse effects on employment.

The paper is organized as follows. In section 2 we present the basic efficiency wage model of the shirking-type and show the differences between the short-run and the long-run version of the model. 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 consisting of a large number of competitive firms producing 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 a generalized version of the shirking models in Shapiro and Stiglitz (1984), Johnson and Layard (1986), Moene (1995) and Pisauro (1991) where a firm makes continuous wage offers to workers in an infinite horizon framework. If the wage offer is accepted the workers choose how much effort to provide. 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 an unsatisfactory level of effort has been observed. In the short run the number of firms is fixed while in the long run there is free entry and exit of firms so that the number of firms is determined by a zero pure profit condition.

2.1 Households

Let there be H households in the economy. Households[2] derive utility from consumption of goods and leisure.[3] Each household is endowed with one unit of leisure. 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 leisure $1-e$, e being the effort provided by the household. In contrast to the original Shapiro-Stiglitz model, but in accordance with e.g. Bulkley and Myles (1996), Hoel (1990) and Pisauro (1991), effort is a continuous variable defined on the unit interval, $e \in [0,1]$. One interpretation of our set up is that effort at any point in time must be either zero or one as in Shapiro-Stiglitz. However, since monitoring is random a worker may choose to vary effort throughout the workday, such that e becomes average effort supplied during a workday. Thus, seen from the firm's point of view e measures at a given point in time the proportion of the work force choosing not to shirk, while a worker regards e as the proportion of the work day where full effort is put forth. Then, by assuming that the workers' choices of when to shirk are random and distributed independently of each other, the two notions of e will coincide. This may even be a more satisfactory interpretation of notion of shirking, making partial shirking a perfectly valid option for the

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

[3] Utility may also depends 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.

worker.[4] The purpose of specifying effort as a continuous variable is for the structure of taxation to matter in the standard short-run specification of the model whereby our efficiency wage model becomes more closely related to the bargaining models in Pissarides (1998) than to his efficiency wage model that is based more strictly on the original Shapiro-Stiglitz model with effort taking either a value of zero or one. The firm reacts to the monitoring problem by offering the same wage w to all workers while firing workers observed shirking. Hence, a worker choosing effort level e faces a probability $q = q(e)$ of being fired with $q^{'}(e) < 0$ and $q^{''}(e) \geq 0$.[5]

In an infinite horizon framework households maximize at time t the expected present discounted value of utility, V_t,

$$V_t = E\left(\int_{s=t}^{\infty} e^{-\theta(s-t)} U_s ds\right), \tag{1}$$

where $\theta > 0$ is the subjective discount rate, E is the expectations operator and U_t is the (instantaneous) utility function of a household (time subscripts are left out from now on whenever possible)[6]

$$U = U(m, 1-e), \tag{2}$$

where $\frac{\partial U(m,1-e)}{\partial m} > 0$, $\frac{\partial^2 U(m,1-e)}{\partial m^2} < 0$, $\frac{\partial U(m,1-e)}{\partial (1-e)} > 0$, and following Pisauro (1991) we assume weak separability between income and leisure, and linearity of utility in effort, implying that $\frac{\partial^2 U(m,1-e)}{\partial m \partial (1-e)} = \frac{\partial^2 U(m,1-e)}{\partial (1-e)^2} = 0$. 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

[4] One way of thinking about shirking within this interpretation is that it amounts to taking too many (or too long) breaks through a workday.

[5] 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)). Taking the probability of being fired as some exogenously specified function of effort 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 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. For simplicity, we assume that the level of monitoring is exogenously given (a similar assumption is found elsewhere in the efficiency wage literature e.g. in Pisauro (1991)).

[6] Notice, that we implicitly assume $e = 1$ to be the maximum effort that can be provided. Throughout we assume an interior solution, $0 < e < 1$, applies. This just requires sufficient concavity of the utility function with respect to income, see Pisauro (1991) for further details.

[7] The coefficient of residual income progression, $R = \frac{1-T'(w)}{1-\frac{T(w)}{w}}$, is an often used measure

is $\omega = w - T = w(1-t) + a$. Unemployed workers receive unemployment benefits with a post-tax value of β. In all the tax reforms to be considered we disregard the predictable employment effects of changing the post-tax value of unemployment benefits by assuming that the pre-tax benefit rate is changed simultaneously to keep the after-tax value of unemployment benefits constant. Hence, none of our results hinge on effects following from changing the post-tax income of the unemployed. Notice that

$$\frac{dV}{dt} = \theta E\left(\int_{s=t}^{\infty} e^{-\theta(s-t)} U_s ds\right) - E(U) = \theta V - E(U), \tag{3}$$

such that by defining V^E (V^U) as the value of V for an employed (unemployed) worker, respectively, we can state the asset equations of an employed and an unemployed worker, respectively,

$$\theta V^E = U(\omega, 1-e) + (q(e)+s)\left(V^U - V^E\right) \tag{4}$$

$$\theta V^U = U(\beta, 1) + \psi(N)\left(V^E - V^U\right), \tag{5}$$

where $\psi = \psi(N)$ is the exit probability from unemployment that depends positively on aggregate employment, N, i.e. $\psi'(N) > 0$ (see details below) and $s > 0$ is an exogenous separation rate. It follows implicitly from the specification of the asset equations that a worker starting out being unemployed receives unemployment benefits, β, and obtains a job with probability $\psi(N)$. Solving the asset equations for V^E we obtain

$$V^E = \frac{(\theta + \psi(N))\, U(\omega, 1-e) + (q(e)+s)\, U(\beta, 1)}{\theta\,(q(e) + \theta + \psi(N) + s)}. \tag{6}$$

Maximizing V^E with respect to e we get (after some simple manipulations)

$$\frac{q'(e)\,(U(\omega, 1-e) - U(\beta, 1))}{q(e) + \theta + \psi(N) + s} + \frac{\partial U(\omega, 1-e)}{\partial(1-e)} = 0, \tag{7}$$

defining effort as an implicit function of the after-tax wage rate and aggregate employment, $e = e(\omega, N)$. Using 7 it is straightforward to show that $e_\omega \equiv \frac{\partial e(\omega,N)}{\partial \omega} > 0$, $e_N \equiv \frac{\partial e(\omega,N)}{\partial N} < 0$, $e_{\omega\omega} \equiv \frac{\partial^2 e(\omega,N)}{\partial \omega^2} < 0$ and $e_{\omega N} \equiv \frac{\partial^2 e(\omega,N)}{\partial \omega \partial N} = 0$.[8]

of the degree of tax progression with $R < 1$ reflecting a progressive tax schedule. In our case we have $R = \frac{1-t}{1-t+\frac{a}{w}} < 1$. That we choose labour taxes to be levied on households and not on firms as in Pissarides (1998) is fully innocuous as the incidence of the tax is independent of which side it is levied on (given no nominal rigidities or other imperfections), cf. Lockwood and Manning (1993).

[8] $e_{\omega N} = 0$ follows from the assumption of utility being linear in leisure (effort). With decreasing marginal utility of leisure $e_{\omega N}$ would be negative, and we would not be able to sign the determinant of the Jacobian of equations 15 and 16 (see below).

2.2 Firms

The production technology is the same in all periods depending on labour input measured in efficiency units:

$$y = f(en), \tag{8}$$

where $f^{'}(en) > 0$ and $f^{''}(en) < 0$.[9] Profits of the representative firm are

$$\Pi = f(en) - wn. \tag{9}$$

With effort being a continuous variable it makes sense to model wage formation as explicit wage-setting by firms taking the induced effect on effort, $e(\omega, N)$, into account. Thus, in accordance with Albrecht and Vroman (1998) the equilibrium is explicitly Nash, and not a "quasi-Walrasian" equilibrium as in Pissarides (1998) and Shapiro and Stiglitz (1984) where wages adjust to equalize a "no-shirking condition" and the demand for labour from firms.[10] The first-order conditions read

$$\frac{\partial \Pi}{\partial w} = f' e_{\omega} (1-t) n - n = 0 \tag{10}$$

$$\frac{\partial \Pi}{\partial n} = f' e - w = 0. \tag{11}$$

The second-order condition can easily be shown to be satisfied due to $f'' < 0$ and $e_{\omega\omega} < 0$. Using 11 to eliminate f' from 10 yields

$$e_{\omega} w (1-t) - e = 0, \tag{12}$$

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

[9] 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 en we have increasing returns to labour, $f^{''}(en) > 0$. Hence, we have U-shaped cost curves that allow for zero pure profits at an interior solution.

[10] Also, as noted by Albrecht and Vroman (1998), even though the quasi-Walrasian equilibrium in Shapiro and Stiglitz (1984) is in fact a Nash equilibrium, once the basic Shapiro-Stiglitz model is extended the equivalence between the two notions of equilibrium needs not hold. This is indeed the case in our model where the wage-setting behaviour of firms causes the structure of taxation to matter for equilibrium employment in contrast to what Pissarides (1998) obtains in his quasi-Walrasian model of efficiency wages. Therefore, the importance of the structure of taxation that is generally found in our model is more akin to the results in the wage bargaining models of Pissarides (1998) (trade union and search models).

the equilibrium wage elasticity of effort exceeds unity when the tax schedule is progressive:

$$\frac{e_\omega \cdot \omega}{e} = \frac{w(1-t)+a}{w(1-t)} > 1. \tag{13}$$

2.3 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

$$BS = (tw-a)\,N - (H-N)\,\beta - g = 0. \tag{14}$$

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.

2.4 Short-Run Equilibrium

In the short run the number of firms is fixed implying that in a symmetric equilibrium the aggregate equilibrium level of employment, N, is just a multiple of n such that by normalizing the short-run number of firms to one, we can express the equilibrium conditions for w and N as

$$\begin{aligned} e_\omega(\omega,N)\,w\,(1-t) - e(\omega,N) &= 0 & (15)\\ f'(e(\omega,N)N)e(\omega,N) - w &= 0. & (16) \end{aligned}$$

Obviously, for the analysis to be of interest we must assume that unemployment prevails in equilibrium, i.e. $N < H$. Since the determinant of the Jacobian of equations 15 and 16, $\left|J^{SR}\right|$, is strictly positive,[11]

$$\left|J^{SR}\right| = \left[f''\,(e+e_N N)\,e + e_N f'\,(1-t)^2\right] e_{\omega\omega} w + f'' e_\omega e_N e\,(1-t) > 0, \tag{17}$$

15 and 16 define short-run equilibrium levels of w and N as functions of the tax parameters:

$$\begin{aligned} w^{SR} &= \phi_1(t,a) & (18)\\ N^{SR} &= \phi_2(t,a). & (19) \end{aligned}$$

[11] As in Pisauro (1991) we assume that an increase in aggregate employment also leads to an increase in aggregate effective labour input, i.e. that $\frac{d(e(\omega,N)N)}{dN} = e + e_N N > 0$.

2.5 Long-Run Equilibrium

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

$$\Pi = f(e(\omega, N)\, n) - wn = 0. \tag{20}$$

Notice that starting from a short-run equilibrium with positive profits an increase in the number of firms raises aggregate employment. This induces workers to lower their effort as $e_N < 0$, whereby profits are reduced. Hence, the adjustment process is stable.

Again we need to assume $N < H$ for the analysis to be of interest. In this long-run version of the model it makes sense to consider steady state equilibria where the flows into and out of unemployment are equal. Hence, in that steady state the probability of leaving unemployment, ψ, will be determined by the flow condition

$$q(e)\, N = \psi \cdot (H - N), \tag{21}$$

such that

$$\psi = \psi(N) = \frac{q(e)\, N}{H - N}, \tag{22}$$

with $\psi'(N) = \frac{q(e)H}{(H-N)^2} > 0$ as claimed above.

In the long-run equilibrium we have three equilibrium conditions to determine wages, w, employment at the firm level, n, and aggregate employment, N. Thus, the long-run equilibrium is determined by

$$\begin{aligned} e_\omega(\omega, N)\, w(1-t) - e(\omega, N) &= 0 && (23)\\ f'(e(\omega, N)n)e(\omega, N) - w &= 0 && (24)\\ f(e(\omega, N)\, n) - wn &= 0. && (25) \end{aligned}$$

The determinant of the Jacobian for this long-run model, $\left|J^{LR}\right|$, is non-zero

$$\left|J^{LR}\right| = e_{\omega\omega} w (1-t)^2 f'' e^2 f' e_N n < 0, \tag{26}$$

such that the three equilibrium conditions define long-run equilibrium levels of w, n and N as functions of the tax parameters:[12]

$$w^{LR} = \Phi_1(t, a) \tag{27}$$

[12] 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 by the variables of interest, w and N, to the tax reforms.

$$n^{LR} = \Phi_2(t,a) \tag{28}$$
$$N^{LR} = \Phi_3(t,a). \tag{29}$$

3 Tax Reform Analysis

We model tax reforms as changes in the tax parameters (t,a) such that the income tax becomes more progressive. 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, $R = \frac{1-t}{1-t+\frac{a}{w}}$:

$$\frac{\partial R}{\partial t} = \frac{-a}{w\left(1-t+\frac{a}{w}\right)^2} < 0 \tag{30}$$
$$\frac{\partial R}{\partial a} = \frac{-(1-t)}{w\left(1-t+\frac{a}{w}\right)^2} < 0. \tag{31}$$

Two types of tax reforms are considered. Following most of the recent 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-reform wage level constant. That is, increasing t and a such that

$$dT = wdt - da = 0. \tag{32}$$

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

$$(tw - a + \beta)\, dN + tNdw + wNdt - Nda = 0, \tag{33}$$

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

$$w = w(t,a) \tag{34}$$
$$N = N(t,a), \tag{35}$$

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

$$\left.\frac{dN}{dt}\right|_{dT=0} = w\frac{\partial N}{\partial a} + \frac{\partial N}{\partial t}. \tag{36}$$

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

$$\left.\frac{da}{dt}\right|_{dg=0} = \frac{wN + (tw - a + \beta)\frac{\partial N(t,a)}{\partial t} + tN\frac{\partial w(t,a)}{\partial t}}{N - (tw - a + \beta)\frac{\partial N(t,a)}{\partial a} - tN\frac{\partial w(t,a)}{\partial a}}, \tag{37}$$

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, $\frac{\partial BS}{\partial a} < 0$.[13] The balanced-budget employment effect then becomes

$$\left.\frac{dN}{dt}\right|_{dg=0} = \frac{N\left[w\frac{\partial N(t,a)}{\partial a} + \frac{\partial N(t,a)}{\partial t}\right] + tN\left[\frac{\partial N(t,a)}{\partial a}\frac{\partial w(t,a)}{\partial t} - \frac{\partial N(t,a)}{\partial t}\frac{\partial w(t,a)}{\partial a}\right]}{-\frac{\partial BS}{\partial a}}. \tag{38}$$

Of course, the tax incidence will differ in the short run (with a fixed number of firms) and the long run (with free entry and exit). We therefore consider the tax reform effects in the short-run model and the long-run model separately.

3.1 Short-Run Effects of Pure Increase in Tax Progression

This is what most recent studies of progressive taxation have considered: In a short-run equilibrium model of an imperfectly competitive labour market the effect of increasing the marginal tax rate, holding the average tax rate constant, is analyzed (e.g. Bovenberg and van der Ploeg (1994), Lockwood and Manning (1993), Malcomson and Sartor (1987)). Our model fully replicates the employment boosting effect of such a tax reform, as stated in the following proposition.

Proposition 1 *Employment increases in the short run following a pure increase in tax progression.*

Proof. *Differentiating the short-run equilibrium conditions 15 and 16 implicitly with respect to the tax parameters (t, a) and solving for the effects on wages and employment yields*

$$\frac{\partial w^{SR}}{\partial t} = \frac{e_{\omega\omega}w^2(1-t)\left[f''(e + e_N N)e + f' e_N\right] + e_N e_\omega w\left(f'' eN + f'\right)}{|J^{SR}|} \tag{39}$$

[13] 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.

$$\frac{\partial w^{SR}}{\partial a} = -\frac{e_N e_\omega w\left(f^{''} eN + f^{'}\right)}{|J^{SR}|} - \frac{\left(e_{\omega\omega} w\left(1-t\right) - e_\omega\right)\left[f^{''}\left(e + e_N N\right)e + f^{'} e_N\right]}{|J^{SR}|} \tag{40}$$

$$\frac{\partial N^{SR}}{\partial t} = \frac{e_{\omega\omega} w^2 \left(1-t\right)^2 e_\omega f^{'}}{|J^{SR}|} < 0 \tag{41}$$

$$\frac{\partial N^{SR}}{\partial a} = -\frac{e_\omega\left(1-t\right)\left[e_{\omega\omega} w\left(1-t\right) f^{'} + eNf^{''} e_\omega\right]}{|J^{SR}|} > 0 \tag{42}$$

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

$$\left.\frac{dN^{SR}}{dt}\right|_{dT=0} = \frac{-e_\omega^2 w\left(1-t\right) f^{''} eN}{|J^{SR}|} > 0, \tag{43}$$

which obviously is positive. ■

Hence, our model is capable of explaining the result usually found in the recent literature cited above. The interpretation of the result is straightforward. A higher marginal tax rate makes the post-tax wage less responsive to changes in the pre-tax wage, implying that for a given cost to firm of offering a higher wage, the benefit to the firm of eliciting more effort of its workers is smaller the more progressive the tax system is. As a consequence, a lower wage is offered and more workers become employed.

3.2 Short-Run Effects of Balanced-Budget Increase in Tax Progression

Obviously, a pure change in tax progression that affects either employment or wages cannot be the end of the story since the government budget constraint is affected. It is therefore of interest to analyze a balanced-budget tax reform that takes all of these effects into account. Perhaps somewhat surprisingly, we can no longer sign the employment effect of the tax reform.

Proposition 2 *The employment effect of a balanced budget increase in tax progression is ambiguous in the short run.*

Proof. *Using equations 39-42 and the general expression for the employment effect of a balanced-budget tax change, equation 38, it is straightforward, but cumbersome, to show that in general the overall effect on employment cannot be signed. However, if $\left(f^{''} en + f^{'}\right) < 0$ is assumed to hold (as it does*

for a Cobb-Douglas production function), the overall employment effect is positive. ■

Intuitively, since we know that following a pure increase in tax progression the wage goes down and employment goes up, the effect on the tax base (total labour income) is ambiguous. If the tax base increases a lower average tax is needed which tends to increase employment further. However, if the tax base falls a higher average tax is needed and the employment effect is reduced or even negated. Therefore, we cannot sign the employment effect without imposing additional assumptions on technology and preferences.[14]

3.3 Long-Run Effects of Pure Increase in Tax Progression

Even though short-run results are not unimportant it is a critical assumption to take the number of firms to be unaffected by the change in tax policy. If starting from a long-run equilibrium a tax reform leads to negative pure profits, firms will go out of business and the long-run employment effect will differ from the short-run effect. As the following two propositions show this is indeed the case in our model.

Proposition 3 *There is no long-run effect on employment of a pure increase in tax progression.*

Proof. *Differentiating the long-run equilibrium conditions, equations 23-25, implicitly with respect to the tax parameters* (t, a) *and solving for the effects on wages and aggregate employment yields:*

$$\frac{\partial w^{LR}}{\partial t} = \frac{e_{\omega\omega} w (1-t) + e_{\omega}}{e_{\omega\omega} (1-t)^2} \tag{44}$$

$$\frac{\partial w^{LR}}{\partial a} = -\frac{1}{(1-t)} < 0 \tag{45}$$

[14] This is exactly what Pissarides (1998) does when he simulates various short-run equilibrium unemployment models to quantify the effects of changes in tax structure. Therefore, our result is compatible with the positive employment effects obtained by Pissarides. The reason he does not obtain any effects of changes in the tax structure in the efficiency wage model is his assumption of effort being a dichotomous variable, implying that wages are determined in a "quasi-Walrasian" fashion adjusting to equalize a "no-shirking condition" and the demand for labour from firms. Once wages are set by firms the structure of taxes influence wages and employment in the same direction as in bargaining models (see e.g. Bovenberg and van der Ploeg (1994)). Therefore, our short-run results is immediately more comparable to the wage bargaining results obtained by Pissarides (1998).

$$\frac{\partial N^{LR}}{\partial t} = \frac{e_\omega w}{e_N} < 0 \tag{46}$$

$$\frac{\partial N^{LR}}{\partial a} = -\frac{e_\omega}{e_N} > 0. \tag{47}$$

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

$$\left.\frac{dN^{LR}}{dt}\right|_{dT=0} = 0, \tag{48}$$

implying long-run neutrality of the progressive income tax for a given average tax level. ■

Thus, in the long run any initial positive employment effect vanishes. To understand why the positive short-run effect vanishes in the long-run notice that long-run employment is determined by the zero pure profit condition

$$f(e(\omega, N)\, n) - wn = 0. \tag{49}$$

However, by construction a pure increase in tax progression leaves the post-tax wage unchanged, $d\omega = -wdt + da = 0$, for a given pre-tax wage, implying that there are no first-order effects on profits.[15] As a consequence, the zero pure profit condition is unaffected by the tax reform and so is aggregate employment.

3.4 Long-Run Effects of Balanced-Budget Increase in Tax Progression

An even more remarkable change in results follows when the full budgetary effects of the tax reform is taken into account.

Proposition 4 *Employment falls in the long run following a balanced budget increase in tax progression.*

Proof. *Using equations 44-47 for the long-run 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 38, it follows that*

$$\left.\frac{dN^{LR}}{dt}\right|_{dg=0} = \frac{tNe_\omega^2}{e_N e_{\omega\omega}(1-t)^2 \frac{\partial BS}{\partial a}} < 0, \tag{50}$$

since $\frac{\partial BS}{\partial a} < 0$. ■

[15] Of course, the wage will generally respond to the tax change, but due to the envelope theorem this will have no first-order effects on profits.

Thus, when all the budgetary effects of the tax reform is taken into account and free entry and exit of firms is allowed for a long-run equilibrium to materialize we get exactly the opposite of the usual result: Tax progression is bad for employment.[16] Intuitively, holding the average tax constant there is no effect on employment. However, the wage rate goes down

$$\left.\frac{dw^{LR}}{dt}\right|_{dT=0} = \frac{e_{\omega}}{e_{\omega\omega}\left(1-t\right)^{2}} < 0, \tag{51}$$

implying that the tax base deteriorates.[17] As a consequence, the average tax must be increased. Raising the average tax has a first-order effect on the profits of the firms through the workers' choice of effort, and a higher average tax depresses both effort and profits. Therefore, some firms go out of business and aggregate employment falls.[18]

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. What remains is, among other things, to establish the degree of generality of our results. First, the same kind of analysis should be extended to other equilibrium models of unemployment (bargaining models, primarily). This may not be an easy task at the methodological level where e.g. a long-run equilibrium condition of zero pure profits would render trade unions without any bargaining power in the long run. On the other hand, in search models with wage bargaining a zero pure profit condition (on the value of opening a vacancy) is typically imposed making it rather straightforward to extend our analysis to such a setting (see e.g. Hansen (1999)). Secondly, 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 results qualitatively, see e.g. Hansen *et al.* (1995). As a third point it could be argued that government consumption, g in our model, to a large

[16] A somewhat similar result is obtained in Rasmussen (1998) in terms of changing the tax structure on firms, although that model assumes constant returns to labour and not decreasing returns as in the present model.

[17] Notice the difference between the effects of this wage change on firms and the government: The profits of the firms are unaffected due to the wage being optimally chosen before the tax reform, while the wage change has a first-order effect on tax revenues.

[18] As mentioned above, the fall in employment elicits more effort from workers restoring profits at their original (zero) level.

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

$$BS = (tw - a)(N + N^g) - (H - N - N^g)\beta - wN^g, \tag{52}$$

where N^g is public employment assumed to be paid the market wage, w.[19] A balanced-budget tax reform is now changes in the tax parameters (t, a) keeping N^g constant. The long-run employment effect of such a balanced-budget tax reform can be shown to be

$$\left.\frac{dN^{LR}}{dt}\right|_{dN^g=0} = \frac{e_\omega^2 \left[a(N + N^g) + (H - N - N^g)\beta\right]}{e_N e_{\omega\omega} w (1-t)^2 \frac{\partial BS}{\partial a}} < 0, \tag{53}$$

such that the result is not changed qualitatively.

5 Concluding Remarks

Two main conclusions can be derived from our analysis. First, it is important to take the full budgetary effects of tax reforms into account when changes in tax structures are analyzed. This is much like considering a general equilibrium analysis instead of a partial analysis. Secondly, long-run effects may differ sharply from short-run effects and since tax reforms usually are used for long-term policy purposes aimed at allocative efficiency, as opposed to short-term policies directed at business cycle fluctuations, the longer term results are presumably the more important ones.

The more specific results obtained seem to cast serious doubt on recent praising of having progressive tax schedules (see Lockwood and Manning (1993) and Pissarides (1998)). In the short run there may be some beneficial effects of increasing tax progression, but in the longer run the impact on the profits of firms from a balanced-budget increase in tax progression causes an adjustment in the number of firms that ultimately reverses the effect on aggregate employment.

Finally, it should be noticed that our results may be fully consistent with recent empirical evidence on the effects on progressive taxation (see e.g. Malcomson and Sartor (1987), Lockwood and Manning (1993), Holmlund and Kolm (1995) and Hansen *et al.* (1995)) that tends to support the wage

[19] By assumption, aggregate employment, $N + N^g$, is less than aggregate labour supply, H, in equilibrium.

moderating and employment enhancing effects (at least for unskilled workers) since our model replicates that result in the short run. However, some empirical work directed on the long-run effects of progressive taxes seems warranted.

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