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Can Tax Progression Raise Employment? A Study of Four European Countries

by

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Abstract

This paper shows that increases in direct tax progression tend to reduce wages and increase welfare and employment, even in a model allowing for labour supply effects. The employment effect is reversed when benefit levels are low, however. The model shows the different impacts on full and parttime workers, and on men and women. The countries modelled are France, Germany, Italy and the UK. An efficiency wage sector with training costs generates unemployment effects. Households choose between an efficiency wage sector and a market-clearing sector.

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1 Introduction

A principal objection to progressive income taxation is that it discourages the supply of effort and labour, and so reduces economic efficiency. Blum and Kalven (1953) set out the traditional arguments, including those relating to equity, the benefit principle and macro-economic stabilisation; for a recent review see Myles (1995, Chapter 5). The effect of the efficiency loss typically shows up in the form of reduced output, employment and welfare indicators. In the general equilibrium analysis of tax policy it will therefore tend to be eliminated in favour of fairly uniform indirect taxes unless the analyst's model permits distributional criteria or, crucially, allows for pre-existing distortions. When we introduce non-clearing labour markets, the role of progression is much less obvious. Whether unemployment is a by-product of trade union activity (bargaining models) or missing markets (efficiency wage models) or uncertainty (search models), progression tends to reduce pretax wages, and hence stimulate the demand for labour. See e.g. Hoel (1990), Lockwood and Manning (1993), Goerke (1999) and Sorensen (1997a), who also provides a review of the empirical evidence. The net outcome for employment is therefore not clear *a priori.*

An increase in progression at a point in the wage distribution can be achieved either by increasing the marginal rate, or reducing the average rate at that point; in practice, we often wish to refer to some overall measure, and consider the rates experienced by some representative worker. If more progression increases employment, average rate and marginal rate increases have, respectively, negative and positive effects: the first proposition is not contentious, but the second is.

In a wide-ranging review of the possibilities of increasing employment through tax reform, OECD (1995) emphasised the negative employment effects of increasing average rates of labour income taxation, but recommended measures to reduce the burden of taxation on low-income families even at the cost of increasing the burden further up the scale. The damaging effects of marginal rates on human capital formation, tax compliance and entrepreneurship are noted, indicating that there are strict limits on what is possible. The idea of reducing rates of tax on low earners was to encourage participation, rather than that the increased progression would reduce wage rates. Nevertheless, there was some cautious endorsement of the idea that more progression may be recommended. And in a recent a.g.e. study of the Netherlands, Graafland and de Mooij (1999) find that the best policies for reducing unemployment work by reducing the average rate and the replacement rate (of wages by unemployment benefit), even although this means raised marginal rates for most workers: In this paper, however, we focus solely on the effects of progression on employment via wage rates

It is clear that the presence of unemployment can sometimes reverse normal policy conclusions. For example, in the different context of international policy coordination, Fuest and Huber (1999) have recently shown that coordination in setting direct taxes can be welfare-reducing if the labour market is less than perfectly competitive. These results are derived from a theoretical model where unemployment can arise through wage-bargaining, and in which government can choose single capital and labour income tax rates. The question of progression does not arise, but their results provide another example of how the presence of unemployment can reverse results obtained in a competitive setting[1].

Thus it has recently become clear that in more realistic models, one can sometimes make second-best arguments in favour of progression and other forms of distortionary taxation. In the next section we develop a simple efficiency wage model in the style of Phelps (1994) to explore this issue. This model introduces training costs (representing also a range of related costs) incurred by employers depending on labour turnover. We will show that progression can indeed raise employment, but that when labour is not in fixed supply and when the benefit system is less generous, the effect can be reversed. In subsequent sections we pursue the same issues for fully calibrated general equilibrium models of several European economies. In section 3 we describe the main features of our simulation model, putting particular emphasis on the labour market structure, while also briefly discussing the parametrisation of the model. We also show how we calculate alternative

[1] As a further example, Duncan, Hutton, Laroui, and Ruocco (1998) show in a simulation study that indirect tax harmonisation can be welfare-reducing in the presence of unemployment.

equivalent variations in order to measure the welfare effects of the policies at issue. Section 4 describes the policies analysed and presents the results obtained in simulation and their economic interpretation. Section 5 concludes with some further discussion and a summary of the main findings.

2 An efficiency wage model of the effect of tax progression on the labour market

We first consider a model of a single input, single output competitive firm, designed to be parameterised to explore subsequent full model properties. The firm employs only labour, but new workers are less productive and require training. Existing trained workers are liable to be tempted away by the prospect of higher wages in competing firms, especially when the labour market is tight and the prospect of re-employment is good. This provides our firm with an incentive to raise wages to deter quits and thus reduce its training and other labour turnover costs. Initially we assume that all workers participate in the labour market, so labour supply is fixed. Workers have fixed hours and pay income tax on their wages, and in the model the structure of the income tax affects the ability of the employer to use wages to reduce labour turnover. This efficiency wage model is based on that in Phelps (1994) and Campbell and Orszag (1998). For a review of efficiency wage, bargaining and search models with similar predictions see Sorensen (1997b) and Sorensen (1997a).

The firm maximises the present value of profits at time t_0,

$$V_{t_0} = \int_{t_0}^{\infty} e^{-\rho(t-t_0)}[f(L_t) - w_t L_t - Tg(h_t)L_t]dt$$

subject to the dynamic constraint

$$\frac{\dot{L}}{L} = h - q(w^*, w_A^*, R)$$

where L is employment and economy-wide average employment is R, $\dot{L}$ the rate of change of L, h the hiring rate, $f(L)$ the production function, w the firm's wage rate, w^* the firm's net of tax wage rate, w_A^* the economy-wide net of tax average wage rate, Tg training costs (narrowly, the cost of using existing workers to train new workers, but representing all turnover costs), and q is the quit rate. The net of tax wage rate is

$$\begin{aligned} w^* &= w(1-a), \text{ where } a = t(w)/w \text{ is the average tax rate, } t(w) \text{ is the} \\ & \quad \text{tax function and} \\ m &= \frac{\partial t(w)}{\partial w} \text{ is the marginal tax rate.} \end{aligned}$$

We assume that hours are fixed, so L corresponds to the number of employees as well as the total input of labour, and the tax is therefore levied on labour income rather than just on the wage rate. The quit rate depends on the firm net of tax wage, the economy net of tax average wage, the unemployment benefit level, and economy-wide average employment R. LS is the labour force, so $(LS - R)/LS = u$, the unemployment rate.

Firms behave in a Nash manner, treating economy-wide averages as given, but in equilibrium wages and employment are equated across firms.

To solve the firm's problem, set up the current value Hamiltonian:

$$H_t = f(L_t) - w_t L_t - Tg(h_t)L_t + \lambda_t[h_t - q(w_t^*, w_{A,t}^*, R_t)]L_t.$$

The first-order conditions are

$$\begin{aligned} \frac{\partial Tg(h_t)}{\partial h_t} &= \lambda_t & (1) \\ -\lambda_t \frac{\partial q}{\partial w_t} &= 1 \\ \text{i.e.} -\lambda_t \frac{\partial q}{\partial w_t^*}\frac{\partial w_t^*}{\partial w_t} &= 1 \\ -\lambda_t \frac{\partial q}{\partial w_t^*}(1-m) &= 1 & (2) \\ \dot{\lambda}_t &= \rho\lambda_t - \frac{\partial H_t}{\partial L_t} \\ \text{i.e } \dot{\lambda}_t &= \rho\lambda_t - [\frac{\partial f(L_t)}{\partial L_t} - w_t - Tg(h_t)] & (3) \end{aligned}$$

Equation (1) equates marginal training costs with the shadow value of an additional worker. Equation (2) sets the wage to balance the effect of the wage on replacement costs with the effect of a change in the wage on the total wage bill. Imposing the necessary transversality condition, integrating equation (3) expresses the shadow value of an additional worker in terms of the present discounted value of future cash flows from hiring an additional worker:

$$\lambda_t = \int_t^\infty e^{-\rho(n-t)} \left[\frac{\partial f(L_n)}{\partial L_n} - w_n - Tg(h_n) \right] dn. \qquad (4)$$

2.1 The wage curve

The next stage is to derive the wage curve, assuming that $q(.)$ and $Tg(.)$ are, respectively, constant elasticity and quadratic functions. Assume the potential quitter compares his actual net-of-tax wage w^* with the expected alternative net-of-tax wage $w_A^*(1-u) + b.w_A^*.u = w_A^*(1-u(1-b))$, where u is interpreted as the probability of remaining unemployed, and $b.w_A^*$ is the benefit level or unemployment income. Then, assuming a constant elasticity function,

$$q(w^*, w_A^*, u) = B \left[\frac{w^*}{w_A^*(1-u(1-b))} \right]^{-\eta} \qquad (5)$$

Assume that training costs increase with the hiring rate (following Campbell and Orszag (1998)) , so that

$$Tg(h) = \frac{A}{2} h^2. \qquad (6)$$

The first-order conditions (1) and (2) now become

$$\begin{aligned} Ah_t &= \lambda_t, && (7) \\ \text{and } -\lambda_t \frac{\partial q_t}{\partial w_t^*}(1-m) &= 1 \\ \text{i.e. } \lambda_t B\eta (w_t^*)^{-\eta-1}(w_{A,t}^*)^\eta (1-u_t(1-b))^\eta (1-m) &= 1. && (8) \end{aligned}$$

In equilibrium, $w = w_A$, and $w^* = w_A^* = w(1-a)$, so equation (8) becomes

$$\begin{aligned} \frac{\lambda B\eta(1-u(1-b))^\eta(1-m)}{w(1-a)} &= 1 \\ \text{i.e. } w &= \frac{1-m}{1-a} \lambda B\eta(1-u(1-b))^\eta. && (9) \end{aligned}$$

Substituting equations (5) and (7) into equation (9), and imposing the steady-state condition that $h = q$, yields

$$w = \left(\frac{1-m}{1-a} \right) AB^2\eta(1-u(1-b))^{2\eta}. \qquad (10)$$

This is the wage curve. Taking logarithms as is conventional,

$$\log(w) = \log\left(\frac{1-m}{1-a}\right) + \log(AB^2\eta) + 2\eta\log(1-u(1-b)). \qquad (11)$$

Note that increasing progression (i.e. decreasing $\frac{1-m}{1-a}$) will shift the wage curve down, and that increasing the value of benefits through the replacement rate b will flatten the wage-curve. Blanchflower and Oswald (1994) review the theory and evidence concerning this type of relationship, and suggest that an elasticity of w with respect to u of -0.1 is a robust empirical finding.

2.1.1 Preliminary comments on the wage curve

The term $\frac{1-m}{1-a}$ is the well-known index of residual progression, the elasticity of after-tax income to pretax income: see Lambert (1993) on the redistributive implications of a change on this index[2]. Similar functional forms for the wage curve, complete with the residual progression index, can be derived from the various models set out in Lockwood and Manning (1993) and Sorensen (1997a). It therefore appears that the index of progression should be included as a matter of course in empirical wage curve studies, since this form of equation is consistent with the leading theories of equilibrium unemployment.

The intuition of the result is that a rise in the marginal tax rate reduces the benefit to a worker of working for an employer who pays above the market rate to reduce the quit rate; the worker will therefore be more likely to quit. The employer therefore lowers the wage and accepts a higher quit rate. This mechanism is independent of the level of unemployment, so the wage curve shifts down.

The other notable feature of this wage curve is that the effect of a higher benefit rate, b, is to reduce the slope of (i.e. flatten) the wage curve. This is because generous benefits reduce the costs of unsuccessful job search, damping the effects of unemployment on quit-and-search activity. In the limit, if benefits equal wages, the latter are set by the former and wages are exogenous.

[2]The Jacobsson-Kakwani Theorem shows that an decrease in this index for all incomes will result in a distribution which Lorenz-dominates the pre-change distribution.

This analysis suffers from some obvious defects. First, labour supply is fixed. Second, the progression index is assumed independent of the wage rate. We attempt to remedy both defects in the next section, by specifying both the household utility function and the form of the income tax schedule. A third defect, the partial nature of the analysis, is addressed later in the country simulations.

2.2 Variable labour supply

To allow a variable labour supply, but with workers having fixed hours so that the tax liability still depends on the wage rate, we will assume that supply varies with the proportion of members of an aggregate household deciding to participate[3]. Assuming a household Cobb-Douglas utility function[4] of consumption and leisure, $u = c^{\theta_1} l^{\theta_2}$, and budget constraint $c = w(1-m)(E-l) + mZ$, we derive labour supply $Ls = E - l$. Thus

$$Ls = \theta E - \frac{(1-\theta)mZ}{(1-m)w} \tag{12}$$

where $\theta = \theta_1/(\theta_1 + \theta_2)$, E is time endowment and Z the level of tax-free allowance in a linear-progressive tax with constant marginal rate m. The average tax rate is now $a = \frac{mwL - mZ}{wL} = m - \frac{mZ}{wL}$. So the index of residual progression now depends on the wage rate, and is

$$\frac{1-m}{1-a} = \frac{1-m}{1-(m-\frac{mZ}{wL})} = \frac{(1-m)wL}{(1-m)wL + mZ}.$$

Now $(1-u) = L/Ls$, so the wage-curve (11) can be expressed as

$$\begin{aligned} \log(w) &= \log\left(\frac{(1-m)wL}{(1-m)wL + mZ}\right) + \log(AB^2\eta) \\ &\quad + 2\eta \log(b + (1-b)(L/Ls)) \end{aligned} \tag{13}$$

[3]This argument is further elaborated below in the AGE model in discussing the full-time/parttime choice.

[4]In the full general equilibrium model later, we uses a nested CES utility structure, but the simpler Cobb-Douglas form is quite suitable at this stage.

Substituting for Ls from (12),

$$\begin{aligned}\log(w) &= \log\left(\frac{(1-m)wL}{(1-m)wL+mZ}\right)+\log(AB^2\eta) \\ &\quad +2\eta\log\left(b+\frac{(1-b)L}{\theta E-\frac{(1-\theta)mZ}{(1-m)w}}\right). \qquad (14)\end{aligned}$$

This equation has been left in implicit form for practical reasons and to retain its family resemblance to equation (11) above. This is now a wage-setting equation (WS) or pseudo labour supply schedule rather than a wage curve, since it combines the household labour supply with the wage curve. When labour supply is fixed, WS and the wage curve coincide.

Considering the properties of this wage-setting equation, notice that a rise in the marginal tax rate m will now have opposing effects. First, reducing the residual progression index will tend to shift WS down. But second, reducing labour supply Ls will tend to shift WS up. So it seems possible that a more elastic labour supply can reverse the effect of progression on the WS. Whether this happens can be influenced by the generosity or otherwise of the benefit system. If b is high (e.g. 0.8, say), the effects of changes in labour supply are strongly damped (see equation (13)), so in this case the possibility that labour supply effects will reverse the effect of progression is also strongly damped. Conversely, with low unemployment benefits, labour supply effects could give us the result that an increase in progression raises wages and reduces employment, thus restoring what one expects in fully market clearing models.

There are, however, also demand side effects of progression to be considered. Training costs negatively affect the demand for labour, and the rate of progression affects the quit rate and hence training costs. An increase in progression, *cet.par.*, will increase the quit rate and training costs, reducing demand for labour; this effect is again damped for high b. For high b, therefore, an increase in progression will shift both supply and demand down, reducing wages but with an uncertain effect on employment. For low b, the negative demand shift will be greater, making it more likely that employment will fall.

The next sections illustrate these possibilities.

2.3 Labour market equilibrium

With fixed labour supply, the wage curve plays the role of labour supply curve. To complete the model of the labour market we solve equation (3) for $\dot{\lambda}_t = 0$, the steady-state condition. From 7 $\lambda = Ah$. We also set $h = q = B[1 - u(1-b)]^\eta$ for $w^* = w_A^*$ (see equation(5)). The result is

$$-\frac{\partial f(L)}{\partial L} + w + \frac{AB^2}{2}(1 - u(1-b))^{2\eta} + \rho AB[1 - u(1-b)]^\eta = 0.$$

To solve in terms of w and L, express u as $1 - L/Ls$, and choose a parametric form for the production function: let

$$f(L) = CL^\alpha, \text{ for } 0 < \alpha < 1.$$

Hence the demand curve is (simplifying by taking the static case , or $\rho = 0$)

$$w = \alpha C(L)^{\alpha-1} - \frac{AB^2}{2}(1 - u(1-b))^{2\eta} \quad (15)$$

$$w = \alpha C(L)^{\alpha-1} - \frac{AB^2}{2}(b + \frac{L(1-b)}{\theta E - \frac{(1-\theta)mZ}{(1-m)w}})^{2\eta} \quad (16)$$

The wage equals the marginal product less the marginal cost of training at the equilibrium hiring rate. Labour supply effects enter the demand curve via training costs, since any change in labour supply affects unemployment and so quits and so training costs. A rise in m therefore will tend to raise training costs and reduce the demand for labour.

2.4 Numerical examples

To illustrate numerically, we choose parameters to yield a wage curve elasticity of about -0.1 (see comments above on this), and measures of progression and labour supply elasticity comparable with calibrated AGE models. Let $A = B = 1$, $C = 3$, $\alpha = 0.75$, $\eta = 2.5$, $b = 0.8$, $m = 0.4$ and 0.3, $\rho = 0.0$, $\theta = 0.5$, $Z = 1$, and $E = 4$.

2.4.1 Fixed labour supply case

Figures 1 and 2 plot equations (16) and (13) with Ls fixed, showing the wage rate w against relative employment L/Ls. The figures differ in the level of benefits.

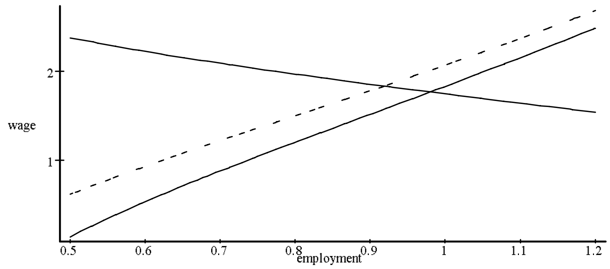

Figure 1: Progressive taxes with fixed labour supply and b = 0.8; dotted lines less progressive. Demand and wage-setting curves shown.

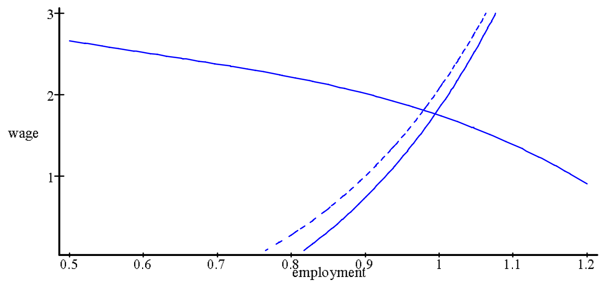

Figure 2: Progressive taxes with fixed labour supply and b = 0; dotted lines less progressive. Demand and wage-setting curves shown.

Changes in progression can easily be seen to have the following consequences: an increase in marginal rate of tax, for given allowances, will shift down the wage-curve, reducing the wage rate and the unemployment rate; changes in the average rate will have the opposite effects. In the diagram, the upper wage curve corresponds to $m = 0.3$, the lower to $m = 0.4$. Since labour supply is fixed, progression changes have no effect on labour demand. The effect of a low (zero in this case) level of benefits is to steepen the curves and to reduce the employment gain of increased progression: the effect is still positive.

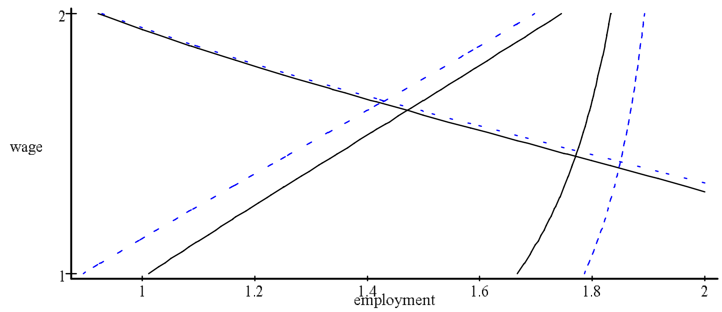

Figure 3: Progressive taxes with variable labour supply and b = 0.8; dotted lines less progressive. Demand, supply and wage-setting curves shown.

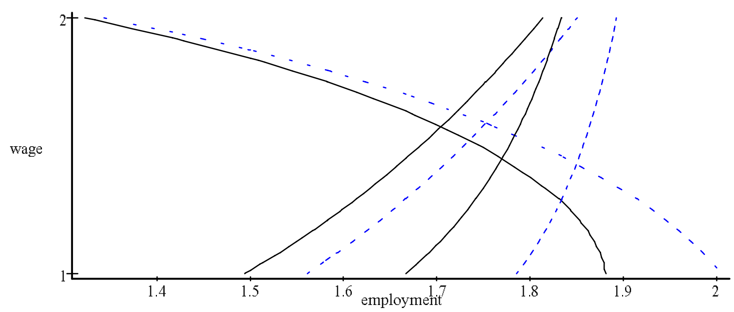

Figure 4: Progressive taxes with variable labour supply and b = 0; dotted lines less progressive. Demand, supply and wage-setting curves shown.

2.4.2 Variable labour supply case

The next examples introduce variable labour supply as set out above, with a linear-progressive tax and Cobb-Douglas utility function. We again compare high and low benefit regimes.

In Figure 3, we can see the effects of including variable labour supply into the analysis. Again, the dotted lines show the less progressive case with marginal rate $m = 0.3$, and the more progressive case has $m = 0.4$. The maximum labour supply is 2 (since $T = 4$ and $\theta = 0.5$). The figure shows both the supply schedules and the wage-setting schedules: the latter are shifted to the left, and the gap between them is involuntary unemployment.

The effect of increased progression is to move the supply schedule and the wage-setting schedule closer together, reducing unemployment. The more progressive case has higher employment, but the demand schedule also shifts down damping the employment effect and further reducing wages. This shift in the demand curve is a feature of the variable labour supply model: the variable labour supply changes the relation between employment, unemployment and hence employers' training costs. In this example, however, the demand shift does not reverse the positive employment effect of an increase in progression.

In the example discussed above, the residual progression index ($\frac{1-m}{1-a}$) is 0.78 and the elasticity of labour supply is 0.12 at the equilibrium with the progressive tax. These figures correspond quite closely to measures reported in the literature (see e.g. Sorensen (1997b)) and to those in our calibrated models of Germany, France, Italy and the UK discussed below.

We now illustrate the effect of reducing the benefit level. Figure 4 shows the effect of setting $b = 0$. This time, with higher progression the supply schedule is shifted further to the left, so that the wage-setting schedule is also shifted to the left; since the gap between them is reduced, unemployment falls as well as employment. Two quite distinct effects on employment can be seen. First, reducing benefits increases the level of employment. Comparing Figures 3 and 4, it can be seen that with $m = 0.4$ (for example) the level of employment has risen from about 1.5 to 1.7. Second, however, the more progressive tax has in the zero benefit case both lower demand and lower wage-setting curve, clearly reducing employment. The effect on wages is also slightly negative in this case. So when benefits are zero, the effect of increased progression on employment is reversed. On the other hand, it is still true that increased progression reduces unemployment.

Thus, if the policy-maker starts from a position of high benefit levels, he/she can increase employment by increasing progression, reducing benefits, or both. Since each of these options has quite different distributional consequences, equity considerations might determine the choice. By contrast, if benefits are initially low, there will be less scope for increasing employment by fiscal manipulation, and reducing benefits and/or reducing progression will be the choice: in this case all choices will tend to increase inequality. It may be, therefore, that there is some limit to the degree to which employment can be stimulated in this way before equity considerations become dominant.

These examples show that the effects of progression on employment in this variety of efficiency wage model depend crucially on the benefit level, and work through both demand and supply in the labour market. In a general equilibrium setting, the product market and public sector would provide further feedback. To yield any policy recommendations therefore, it is desirable to incorporate these wider effects, and to calibrate the resulting general equilibrium for the country under consideration. It is already clear that calibration can affect the direction as well as the extent of the consequences of tax reform.

3 Extensions to the theoretical model and A.G.E. model description

The model set out in the previous section is inadequate in several ways that we can remedy by making use of an applied general equilibrium model. In a multi-country, multi-sector model, with a variety of types of labour, various direct and indirect taxes, and terms of trade effects, the intuition from simple examples must be confirmed. And using a model calibrated to national data, we can obtain quantified estimates of the effects of changes in tax design, and thus judge whether the effects seem trivial or potentially important.

The model described here corresponds in most of its features to that used in Hutton and Ruocco (1999), so we will focus mainly on the innovations of this paper. It is a multicountry applied general equilibrium (A.G.E.) model, representing 6 groups of European Union countries. Some of these represent single states while others represent groups as follows: 1. Belgium & Luxembourg -Denmark - Netherlands, 2. Germany , 3. Spain - Greece-Ireland - Portugal, 4. France, 5. Italy, 6. United Kingdom. The Rest of the World (ROW) completes this setting. Aggregating some of the countries will not undermine our simulation results as we concentrate our attention on Germany, France, Italy and the UK.

3.1 The household sector

Formally, the preferences of households are represented by a nested utility function, a formulation implying Hicksian separability, and multi-stage budgeting. Given that the countries differ only in the parametrisation of the functional forms, we will not index the variables by country in what follows. For each country we have modelled a representative household composed of two groups of individuals identifiable by gender, each with distinct time endowments, acting as if maximising a single utility function subject to a household budget constraint. The arguments of the utility function are leisure and aggregate present consumption. On the one hand the household decides consumption, by choosing different consumption goods, then distinguishing between imported and domestic commodities and finally, between imported consumption goods from different source countries. Collective goods are provided free of charge and enter the utility function in an additively separable manner (and consequently can be omitted). On the other hand, leisure decisions are distinguished by family member, yielding distinct mens' and womens' labour supplies. In addition, we allow each family member to choose her/his optimal combination of full- and part-time labour supply, distinguishing between the preferences of men and women. The figure in Appendix A provides an overview of the household sector hierarchy. A much more ambitious household model, disaggregated in to 40 household types and several categories of labour is developed within the MIMIC model, in e.g. Graafland and de Mooij (1999). The model presented here has some similar features, including the choice of full vs. parttime work. We will assume that the parttime market is "legitimate" but clears competitively, while in MIMIC there is a competitive "black" labour market.

The difference between the level of the total time endowment and the leisure demand for each group yields the total labour supply for men (L_m^T) and for women (L_w^T). Conditional on the total labour supply for each gender, women and men must still decide whether to work full or part-time, so the household will offer a combination of full and part-time work. This choice is taken by each group maximising a homothetic CET preference function subject to a net income constraint. The model differs from our previous work in that we allow the household to take into account, while making its decision, of the risk of being unemployed.

Formally, each gender i solves the problem:

Maximise

$$CET(L_{f,i}^T/L_i^T, L_{p,i}^T/L_i^T) = -\left[{\beta_{f,i}}^{1/\delta_2}\ \left(L_{f,i}^T/L_i^T\right)^{\pi_2} + {\beta_{p,i}}^{1/\delta_2}\ \left(L_{p,i}^T/L_i^T\right)^{\pi_2}\right]^{\frac{1}{\pi_2}} \tag{17}$$

subject to

$$L_{f,i}^T/L_i^T + L_{p,i}^T/L_i^T = 1 \tag{18}$$

$$\begin{aligned}(1-u)(L_{f,i}^T/L_i^T)w_f\ (1-t_f) + u.b.(L_{f,i}^T/L_i^T)w_f\ (1-t_f) \\ + (L_{p,i}^T/L_i^T)w_p(1-t_p) = w_i\end{aligned} \tag{19}$$

$$\begin{aligned}\text{i.e.}\qquad (L_{f,i}^T/L_i^T)w_f\ (1-t_f)((1-u(1-b)) \\ +(L_{p,i}^T/L_i^T)w_p(1-t_p) = w_i\end{aligned} \tag{20}$$

$$\text{or}\qquad (L_{f,i}^T/L_i^T)\widetilde{w_f}\ (1-t_f) + \ (L_{p,i}^T/L_i^T)w_p(1-t_p) = w_i \tag{21}$$

where the notation is as follows:

δ_2	elasticity of substitution ($\delta_2 < 0$)
π_2	$\frac{\delta_2 - 1}{\delta_2}$
$\widetilde{w_f}$	"risk-adjusted" full-time wage $w_f\ (1-u(1-b))$
t_j	marginal tax rates for f and p labour
$L_{j,i}^T$	Total f and p labour supply for gender i
$\beta_{j,i}$	share parameters for f and p labour supply for gender i.
i	index for gender (m, w)
j	index for full and part-time labour (f, p)
w_i	composite net of tax wage rates for gender i
w_j	gross wage rates for f and p labour

The share parameters ($\beta_{j,i}$) together with the elasticity of substitution (δ_2) determine the shape of the CET function (see Hutton and Ruocco (1999) for details). The budget constraint equation (19) has three components: full-time wages from employment, benefit from unemployment in the full-time market, and part-time wages. Therefore any variation in unemployment will induce changes in the full-time/part-time choice: increased unemployment reduces the relative attraction of the full-time market, and moves some workers into the part-time market.

For arbitrary values of w_i, w_f and w_p, the full-time and part-time shares would not sum to unity: the general equilibrium set of wages and prices must therefore satisfy equation (18).

The solution to this problem, therefore, determines the optimal choice of the household, given net wages, the benefit level, unemployment and preferences over full or part-time work. Each gender's labour supply is

$$L_i^T = L_{f,i}^T + L_{p,i}^T \text{ for } i = m, w \tag{22}$$

Our modelling of household choice between full and part-time labour is also consistent with a distribution of preferences over mode of work. In this case the threshold value of relative wages is a random variable: i.e. $0 \leq L_{f,i}^T / L_i^T = F\left(\frac{\widetilde{w_f}\ (1-t_f)}{w_p\ (1-t_p)}\right) \leq 1$. Each member of the labour force has a threshold value of $\left(\frac{\widetilde{w_f}\ (1-t_f)}{w_p\ (1-t_p)}\right)$, above which he/she decides to switch from part-time to full-time work, according to individual preferences. To be consistent with the CET function in (17), these threshold values are distributed according to the log-logistic distribution function, which yields the proportion of the population whose threshold lies below the value $\frac{\widetilde{w_f}\ (1-t_f)}{w_p\ (1-t_p)}$.

3.2 The production sector

The other features of the model are fairly standard in the tradition of Shoven and Whalley (*op. cit.*): the reader can refer to Fehr, Rosenberg, and Wiegard (1995), and to Ruocco (1996) for a more detailed description. In this section we will, therefore, report the main differences between our model and the original model of Fehr, Rosenberg, and Wiegard (1995). Three primary factors of production (capital, full-time and part-time labour) and 11 commodities are identified for each country. Firms do not distinguish between full-time labour offered by men or by women. The different observed market wage rates of women and men depend solely on the fraction of full or part-time work provided by women and men respectively. This assumption does not necessarily rule out some degree of discrimination [5].

Full-time (L_f^D) and part-time (L_p^D) labour form a Cobb-Douglas nest within a CES value-added production function with aggregate labour and capital as arguments. The gross production function is the usual Leontief-type, depending on value-added and m composite intermediate inputs. The introduction of training costs for full-time employees is the major difference between this model and that in Hutton and Ruocco (1999). Appendix A displays the production tree schematically.

3.3 The public sector

We now consider the expenditure side of the government budget. There are two expenditure categories: lump-sum payments to the representative consumer and government outlays for the provision of public goods. Because firms pay for the use of the public good as an intermediate input, only net public expenditures (provided free of charge to the consumer) have to be financed by taxes. Transfers are a linear function of the level of unemployment

$$T = \gamma_0 + \gamma_1 \; u \sum_i L_{f,i}^T \tag{23}$$

The parameter γ_1 is the cost in benefits of an additional unemployed person, i.e. $\gamma_1 = b.w_f(1 - t_f^A)$ The intercept of the transfers function γ_0 corresponds to those transfer payments which the government makes independent of the level of unemployment (i.e. pensions) is calibrated to the value of unemployment compensation in the respective countries under consideration.

On the revenue side of the budget, the government collects various taxes: full-time labour income tax, part-time labour income tax (in principle but not in practice), capital income tax, value added taxes, tariffs and production taxes. Taxes on capital and labour income are modelled as linear progressive taxes: we assume single marginal tax rates applicable to income

[5] Discrimination may still take the form of e.g. non–employment or non-promotion, rather than paying a lower wage for identical work.

above a threshold. As noted below, capital income tax is levied according to ownership of capital, not the location where the capital is employed, and since this is a static model with the return on capital determined internationally, capital income is in effect exogenous and so capital income tax is like a lump sum tax.

3.4 Labour market equilibrium in the AGE model

The form of the wage curve in this study is a departure from our previous work and has been derived above as equaton (11). Adapting the notation, this now appears as:

$$\log\left(\frac{w_f}{Q}\right) = \log\left(\frac{1-t_f}{1-t_f^A}\right) + \log(AB^2\eta) + 2\eta\log(1-u(1-b)) \tag{24}$$

where we use the following notation:

t_f^A average full-time labour income tax rate

Q consumer price index.

The demand for full-time labour is derived along the lines of equation (16) above, the demand for full-time labour is L_f^D, solved from

$$\frac{\partial VA}{\partial L^D}\frac{\partial L^D}{\partial L_f^D} = \frac{w_f}{Q} + \frac{AB^2}{2}(1-u(1-b))^{2\eta} + \rho AB[1-u(1-b)]^{\eta} \tag{25}$$

where VA is the value added function.

The second and third terms on the RHS of (25) are the full marginal cost of training, acting like a wage tax. Comparing (25) and (24), the marginal cost of training can be solved out as

$$MCT = \frac{w_f}{Q}\left[2\eta\left(\frac{1-t_f}{1-t_f^A}\right)\right]^{-1} + \rho\,(2A)^{0.5}\left[\frac{w_f}{Q}\left[2\eta\left(\frac{1-t_f}{1-t_f^A}\right)\right]^{-1}\right]^{0.5}$$

The second part of this expression is very small, so MCT can be approximately measured by the first term. For calibration purposes, we start from the estimated wage curve elasticity of $\partial\log(w_f/Q)/\partial\log(u) = -0.1$.

Thus, for an unemployment rate of $u = 0.1$ and a benefit level of $b = 0.8$, say, we can derive a value of η by solving $\partial[2\eta \log(1 - u(1 - b))]/\partial \log(u) = -\frac{2u(1-b)\eta}{1-u(1-b)} = -0.1$. This yields $\eta = 2.5$. For a residual progression index value of $\left(\frac{1-t_f}{1-t_f^A}\right) = 0.8$, training (and other turnover-related) costs can be solved out as $MCT = 0.25(\frac{w_f}{Q})$. This example illustrates the orders of magnitude implied in the modelling.

In the full-time labour market, we have unemployment equalling the difference between the level of leisure that the consumer (of each sex) would choose at the equilibrium wage rate (ℓ_m or ℓ_w) and the level of leisure that the consumer is forced to choose (ℓ_i^*), thus:

$$\ell_i^* = \ell_i + u \ L_{f,i}^T. \tag{26}$$

Unemployment therefore corresponds to excess leisure consumption. The market equilibrium condition for the full-time labour market is:

$$\sum_n L_{f,n}^D = (L_{f,m}^T + L_{f,w}^T)(1 - u),$$

where $\sum_n L_{f,n}^D$ is the demand for full-time labour (summed over production sectors). In the part-time market the conventional clearing condition holds:

$$\sum_n L_{p,n}^D = L_{p,m}^T + L_{p,w}^T.$$

3.5 Policy evaluation

To evaluate policy changes, we need appropriate indicators of their welfare effects. A welfare function which represents the economy as a whole in a world with a single consumer and without rationing is straightforward: the welfare function coincides with the utility function of the representative consumer (U) . When some individuals are unemployed, however, this approach is not so satisfactory, since unemployed individuals are forced off their optimal leisure/goods choice. We wish to choose an index which represents the costs of unemployment in a reasonable manner.

We therefore calculate equivalent variations in two ways. The first translates directly from the analysis of the single representative household in unconstrained full employment, comparing utility as a function of consumption and leisure. The second recognises that excess leisure consumption in the form of unemployment for some households will contribute less utility at the margin than freely chosen leisure. The two measures are $EV_{C,l+u}$ and $EV_{C,l}$, based on utility evaluated using, respectively, total leisure consumed and total leisure demanded. Thus in the second, we assign zero utility to excess leisure in the form of unemployment. For details see Hutton and Ruocco (1999).

4 The Simulations

4.1 Simulation design

To investigate the size of the effects of changes in income tax progression, we conducted some simple experiments on the multi-country model. We measure the effects of increases in the marginal income tax rate, maintaining constant the average income tax rate by varying the level of personal allowances. Since these changes in marginal rates will affect wages and thus the rest of the economy, the government budget constraint will be disturbed. To offset this, we allow the capital income tax rate to vary endogenously. The advantage of using this device is that the capital income tax in this model is in effect a lumpsum tax, since it is levied on domestic income from capital ownership and the domestic supply of capital is fixed (although the domestic capital stock can vary through capital flows). Each experiment is repeated for different levels of unemployment benefit, with and without variable labour supply.

We first, however, construct a full-employment version of the model, by eliminating training costs and hence the wage curve from the full-time market. The tax experiments on this model are necessary to confirm that the progression effects in which we are interested do really depend on the presence of unemployment, and are not the result of some basic misspecification. The results conform to traditional theory: in brief, an increase in marginal rate, with average rate held constant, raises wages and reduces employment and welfare, while an increase in the average rate, with marginal rate constant (achieved by varying either allowances or capital taxation), has similar effects. The question of changing benefit levels does not arise in an interesting way in the absence of unemployment: more generous transfers to households tends to reduce labour supply, with the final effect depending on how the transfer increase is financed. These simulation results are not reported but are available on request.

We now turn to the model with involuntary unemployment. In the presence of unemployment, we conduct the two experiments above (changing marginal and average rates), and investigate the effect of benefit level and labour supply elasticity as sensitivity exercises. Raising the average rate has similar effects with or without unemployment, as expected, and we do not report these results here. We now, however, expect the marginal rate increase (as described above) to reduce wage rates in the full-time market and so tend to encourage full-time employment. Whether employment actually does increase depends also on demand side effects, since as we saw above with the small model, when benefits are low and labour supply variable, the employment effect may be reversed. But since increased progression reduces the wage curve, we can expect unemployment to be reduced in all cases.

Because men are more likely to work full-time, they should be more affected than women. The effect on the part-time market is more difficult to predict. The reduced unemployment rate will encourage workers to switch from the part-time to the full-time market, reducing part-time employment; but on the other hand, the lower full-time wage will have the opposite effect. If the latter effect is stronger, we expect part-time wages to be driven down and part-time employment to increase. Since women have a higher share of part-time work, the effects on women may therefore be smaller than on men.

Repeating the experiment , but with a zero benefit level, will steepen the wage curve and generally increase the effects of progression changes on wage rates and so on workers' and employers' decisions. Labour supply effects will be more important: if fulltime employment is reduced by higher progression, employers will tend to substitute parttimers, so womens' employment should

	Germany	France	Italy	UK
marginal tax rate	42.0	28.1	32.7	34.0
average tax rate	30.5	21.8	20.4	19.2
social security paid by employers	18.2	35.3	45.9	10.4
I^{PR}(resid. prog.)	0.83	0.92	0.85	0.82

Sources: OECD (1995) p.147, 151, 155, 179. *N.b.* tax rates include employees' social security contributions.

Table 1: Direct tax rates modelled in 1992 benchmark

benefit. Finally, as a check for nonlinearity, we repeat the experiments using 3 instead of 1 percentage changes in tax rates.

4.2 Simulation results

Table 1 shows the main direct tax rates in our benchmark data set for 1992. The residual progression indices show that France has the least progressive, Italy and Germany the most progressive income tax systems, excluding social security contributions. The values shown for the marginal tax rates refer to a two-earner couple with two children. We actually use the tax rates of the principal earner as tax rates on full and part-time labour, where the percentage of the APW (average production worker) income principal/secondary earner is 100/33.

4.2.1 The German case in more detail

Table 2 shows the effects of increasing the marginal rate by one percentage point for Germany, as a typical example of the results. Details of all simulations are shown in the Appendix tables, with 1 and 3 percentage changes in marginal rates, and also for France, Italy and UK.

The first column of figures shows that for fixed labour supply, with full benefit level of 0.78, the largest employment effects are obtained, together with a 0.62 reduction in the percentage unemployment rate (confined by assumption to full-time workers). Parttimers do not benefit, however, since

Effects of increased progression on employment and unemployment: Germany (1992 benchmark)

Marginal rate increased by 1%, average rate constant via variations in allowances.				
Benefit level	0.78		0.00	
Labour supply	Fixed	Variable	Fixed	Variable
%Δ employment level	0.57	0.24	0.23	-0.14
%Δ male employment	0.65	0.33	0.26	-0.10
%Δ female employment	0.46	0.11	0.18	-0.19
%Δ fulltime employment	0.67	0.33	0.26	-0.10
%Δ parttime employment	0.00	-0.29	0.00	-0.41
Δ% unemployment rate	-0.62	-0.95	-0.24	-0.32
Welfare measures (% equivalent variation)				
$EV_{c,l+u}$	0.48	0.16	0.18	-0.07
$EV_{c,l}$	0.48	0.40	0.18	0.03

Table 2: Germany

the impact of increased progression is to reduce the fulltime wage, encouraging employers to substitute full-time for part-time workers; and because women are more likely to work part-time, women benefit less than men.

The second column shows some interesting contracts with column one. When labour supply is variable, the tax rise will reduce supply, and all employment effects are less positive. Part-time employment is now reduced by 0.29%. Because fulltime employment has risen while labour supply has fallen, however, the reduction in the unemployment rate is much larger than in the previous case of fixed labour supply: a reduction of 0.95 percentage points is obtained. A further influence on parttime employment is the fall in the unemployment rate making full-time employment more attractive, for given wage rates, so the share of parttime labour in the total labour supply also falls.

Columns three and four repeat the exercise, but with zero benefits for unemployed workers. It is necessary to be clear about this experiment: we have set zero benefits into the benchmark, together with the same benchmark level of unemployment as in the other cases. Thus, although we can predict than reducing benefit levels would also raise employment, as in section 2 above, employment effects from changing progression are still comparable. If we had shown progression effects relative to employment levels already increased by zero benefits, lower gains would be observed as in Figures 3 and 4. Column 3 still shows employment gains for the fixed supply case, though the gains are much less because the flatter wage curve induces smaller wage reductions. When labour supply is variable, the zero benefit case yields employment losses for all categories of worker, especially parttimers. The unemployment rate is still reduced, however, as the labour supply has reduced by more than labour demand. Thus the predictions from the simple partial model of section 2 are reproduced here.

The effects on parttime work are worth a further comment. Where income taxation is levied on individual incomes, it is sometimes argued (in e.g. **?**) that more progression would encourage parttime work. We do not replicate this effect since we assume that all workers pay the same marginal rate of tax, so there is no incentive to minimise family tax liability by sharing the work more equally. Our results mainly derive from our modelling the parttime market as competitive, so that the normal disincentive effects on labour supply are obtained.

The welfare measures each tell a different story. The first, "naive", measure $EV_{c,l+u}$, in which all leisure is treated in the same way shows positive effects particularly for the fixed labour supply cases, but is negative for the fourth column in which employment falls together with unemployment. The second measure, $EV_{c,l}$, which removes any welfare benefits from excess leisure consumption through unemployment, is identical for the fixed supply cases since leisure is not a variable, but is more positive for the variable supply cases than $EV_{c,l+u}$. This second measure is still positive for the fourth column. Thus the arguably more realistic measure shows consistently greater benefits from greater progression, remaining positive even when this means lower employment. The reason for the significant discrepancy in the fourth column is that in this case there is a sizeable shift within total leisure $(l+u)$ from forced consumption (u) to chosen consumption (l). Interpretation of these measures is complicated, however, since leisure is not treated as a good when computing utility in the fixed supply case, with the effect that the EV figures will be smaller in absolute value for the fixed case[6].

With some variations in the details, the same qualitative results are obtained for all other cases considered: see the Appendix. Changing the marginal income tax rate by three instead of one point simply increases all the effect by approximately a multiple of three, indicating the local linearity of the model. The case of Italy is notable in that the1992 benefit benchmark is only 0.5, reducing the contrast from dropping to zero benefit. The same pattern is observed, however, with zero benefits reversing the employment gains from extra progression. But in Italy, the lower benefit level means that the impact of progression in employment is less. In the central case, with benefit parameter $b = 0.5$, and variable labour supply, a one percentage point change in m reduces the percentage unemployment rate by 0.58 compared to 0.95 in Germany, and employment increases by 0.12% compared to 0.24% in Germany. The figures for France and the UK are quite similar to those for Germany.

5 Conclusions

5.1 Employment effect of progression

The numerical results we have obtained are quite consistent with the qualitative predictions of the small theoretical model initially set out. Increased progression above current levels does reduce unemployment; and when unemployment benefit levels are at observed levels, increased progression also increases employment and welfare. Lower levels of benefit would, however, reverse the employment effects, with more progression reducing employment. It also seems that the size of the effects obtained are not trivial, and that there are positive employment and welfare effects from increasing progression in all the cases considered, of France, Germany, Italy and the UK. These conclusions are, of course, subject to some reservations. It should be clear that assuming higher levels of supply responsiveness will tend to reverse the

[6]Because when leisure is a good, full income exceeds money income; and the EV equals the % change in utility times the ratio of full income to money income.

results for employment (but not for unemployment), as would increasing progression from much higher levels than currently observed. Diminishing returns must set in at some point, though our simulations do not pick up any strong signs of nonlinearity when comparing 1% and 3% changes. The results for parttime workers are different, because in our model the market for parttime workers is fully competitive and is cleared by the parttime wage. The normal negative effect of progression on employment is therefore to be expected, but other mechanisms work in the same direction: more progression tends to reduce fulltime wages and encourage substitution from parttime working; and reduced unemployment makes fulltime work more attractive to workers. Women are more likely to work parttime, so they benefit less than men.

5.2 Distributional effects

Another aspect of these results which calls for some comment is their distributional implications. We have assumed away distributional issues with the representative household, but we can speculate on the implications of allowing a range of households of different types/skills and different wages. We have assumed a linear-progressive tax schedule, whose index of residual progression will increase with income (n.b. this means, perversely, that progression as usually understood reduces with income). A given percentage change in the marginal rate will have a bigger effect on residual progression at low incomes, and therefore a bigger effect on the pre-tax wage at low levels. So a rise in the marginal rate will tend to reduce low pre-tax wages proportionately more than high pre-tax wages, and thus increase pre-tax inequality indices such as the Gini. Post-tax inequality will depend on the average rate structure: average rates must rise at the top end, and fall at the bottom, if the overall average rate is unchanged. Thus the average rate structure will tend to reduce post-tax inequality. The net effect is not clear, but a simple example is suggestive.

Assume there are two classes of labour in equal and fixed supply, sharing the same wage-curve, but with different levels of demand yielding different wage rates. The model in Section 2 above yields the result that

$$\log(w) = \log(\frac{1-m}{1-a}) + \text{cons}\tan\text{t} + f(u). \tag{27}$$

To evaluate the proportionate effect of a given change in m, conditional on u, use the definition

$$\frac{d\log(w)}{dm} = \frac{\partial\log(w(1-a))}{\partial m} - \frac{\partial\log(1-a)}{\partial m} \tag{28}$$

And from (27)

$$\begin{aligned} \frac{d\log(w)}{dm} &= \frac{\partial\log(1-m)}{\partial m} - \frac{\partial\log(1-a)}{\partial m} \\ &= -\frac{1}{1-m} + \frac{1-Z/w}{1-a}. \end{aligned} \tag{29}$$

This is the effect on the gross wage. And combining (28) and (29),

$$\frac{\partial\log(w(1-a))}{\partial m} = -\frac{1}{1-m} \tag{30}$$

is the effect on the net wage.

The average rate a is higher and Z/w lower for high w, so the second term in (29) is larger for high w than low w. The whole expression is therefore less negative for high w, and so more progression is disequalising, provided we assume equal elasticity of demand for each class of labour. The effect on the post-tax distribution is equi-proportional, however, since the marginal effect on $\log(w(1-a))$ is $-\frac{1}{1-m}$ in (30), which is independent of w. Thus, in this case, progression has no effect on the post-tax distribution, while the pre-tax distribution is made less equal by increased progression.

5.3 Other models

Efficiency wage models can be motivated in a number of different ways. Our training model is one possibility, while "shirking" models associated with Shapiro and Stiglitz (1984) suggest a different mechanism but with similar predictions. The essential message of these latter models has been expressed by Sorensen (1997b):

> ....a higher marginal tax rate implies that a rise in the relative wage will generate a smaller net gain for the individual workers. A higher pre-tax wage will thus become less effective as a means of raising labour productivity. From the viewpoint of each employer, the optimal level of firm's relative wage rate will therefore go down, and in the new general equilibrium, employment will be higher as a result of lower wages. By contrast, if the average tax rate on labour is raised and tax progressivity as well as after-tax unemployment benefits are unchanged, the discipline and productivity-enhancing effects of unemployment will be weakened because the unemployment option becomes relatively more attractive. In order to (partially) restore productivity, employers therefore bid up the level of wages, resulting in higher equilibrium unemployment.

Sorensen (1997a)'s efficiency wage model assumes fixed hours but variable effort: more progression reduces effort levels, and employment increases with progression; in a search model, similar results flow from the same fixed-wage assumption. In a bargaining model, however, Sorensen shows that the effect on wage rates of increased progression can be offset by reduced hours, but in his model this tends to increase employment (numbers of workers). The net effect is that he finds that progression always increases employment. We have assumed fixed hours for each mode of work, with households adjusting the mix of full and parttime work, and obtain rather different results.

The different versions have similar properties, but the version we have adopted has its own characteristic features, such as the role of training costs on the demand for labour. This will yield different quantitative properties from alternative efficiency wage, or bargaining models, motivating the wage curve. The mechanisms we have highlighted, however, will exist in any version: the more elastic supply of labour must offset the employment generating feature of progression in any model with a wage curve, and the benefit system must have broadly the same impact as we have demonstrated.

5.4 Summary

The main messages of our paper can be summarised as follows:

1. Simulations suggest that increased progression in the European economies studied would increase employment and welfare, especially for fulltime workers i.e. mostly men. Reducing unemployment by this means could even reduce parttime employment.

2. In the efficiency wage model adopted here, the level of unemployment is a function of training (and other turnover-related) costs.

3. The more generous the benefit system, the more unemployment will exist and the more effective is progression in raising employment. When unemployment benefit is sufficiently low, more progression would reduce employment and welfare, but from a higher level. Therefore the distributional consequences of employment policies must be addressed by policy-makers.

4. The model suggests that increased progression may have little or no effect on the post-tax distribution of income, while the pre-tax distribution might become more unequal.

5. The general equilibrium model, calibrated for France, Germany, Italy and the UK showed that the partial equilibrium results hold even in the context of a highly distorted general equilibrium, with international trade, tariffs and various other taxes and subsidies. The numerical effects are similar across countries, and sufficiently large to be relevant for policy.

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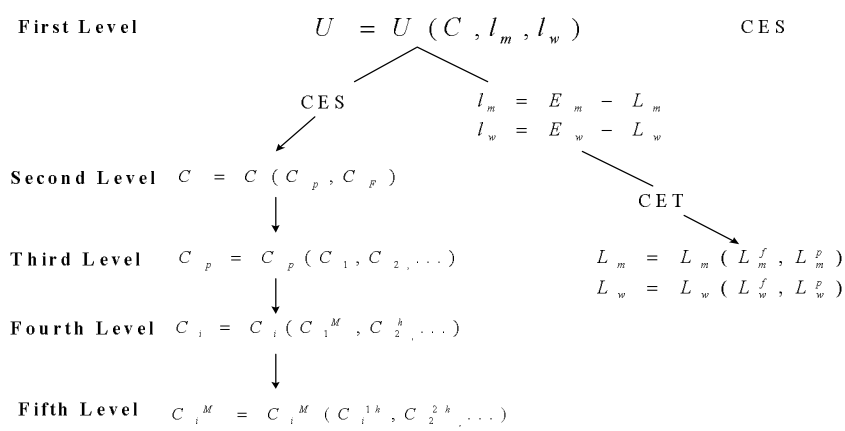
A Appendix: Utility and production structures

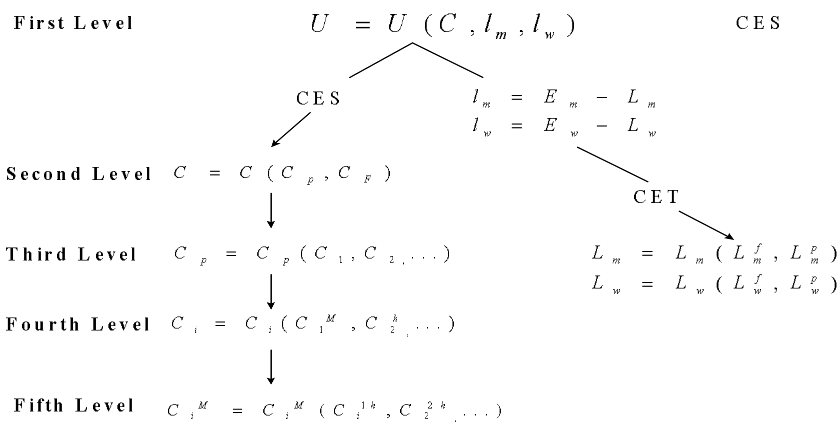


Utility tree

At the *first level*, our representative household chooses between an aggregate consumption commodity C and leisure demand l_m for male and l_w for female family members. The utility function $U(\cdot)$ is of the constant elasticity of substitution (CES) type. In the utility tree we now distinguish between the determination of commodity demands in the left-hand part and labour supply in the right-hand part of the diagram. Let us start with the latter branch of the utility tree. Each family member is endowed with a given time endowment E_m and E_w, respectively. The differences between time endowments and leisure demands yield labour supplies L_m and L_w of the different genders. Following Hutton and Ruocco (1999) we introduce at the *second level* an additional labour/leisure choice allowing each family member to choose his or her optimal combination of full and part-time labour supply L_m^f and L_m^p for men and L_w^f and L_w^p for women.

The left-hand side of the utility tree illustrates the partition of consumer choices. On the *second level* of the utility tree the consumer decides on the demand for different aggregate consumption categories C_i such as, for example, cars or food. The *third level* divides each aggregate consumption commodity into domestic consumption component C_i^h and a composite import component C_i^M. Hence, at this stage the household decides, whether to purchase an imported or a domestically produced commodity. Finally, at the *fourth* and last stage, the decision is about where to buy consumption imports. For example, a German household decides whether to buy an imported car from Italy or from France. Here, C_i^{Fh} and C_i^{Ih} denote the imports from France (F) and Italy (I) of commodity i to country $h \neq F, I$.

As functional forms we have chosen CES functions for the consumption branch of the utility tree.



Production tree

The production function at the *first level* of the firm's cost minimisation problem is a Leontief-technology. Total output of commodity i, Q_i, depends on value added, VA_i, and on the intermediate use of composite commodities, $j = 1, .., 11$ in the production of commodity i, V_{ji}. The left-hand side of the production tree decomposes value added, whereas the right-hand side illustrates the composition of intermediate products.

Starting with the value added branch, sector i decides at the *second level* how much capital, K_i, and aggregate labour, L_i, it needs in production. At the *third level* aggregate labour demand is decomposed into full-time labour, L_i^f ,and part-time labour L_i^p. Turning to the left-hand branch of Figure 3, the *second level* disaggregates composite intermediate products V_{ji} into domestically produced inputs, V_{ji}^h, and an aggregate of imported intermediate inputs, V_{ji}^{M}. At the *third level* of the hierarchical cost minimization problem the representative firm in sector i decides in which country to purchase its imported intermediates. Here V_{ji}^{kh} denotes the intermediate use of commodity j, originating from country k, in the production of commodity i in country h. At the second level of the production tree we employ CES functions in the value added and the intermediate product branches, while Cobb-Douglas functions are used at the third level.

B Appendix: Tables

Note: in tables below, the EV measures for the variable labour supply cases indicate % equivalent variations in disposable money income. For fixed cases, leisure does not enter computed utility, so figures indicate % change in utility: these figures will tend to understate EV, but signs will not change.

Table 1a. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

GERMANY

	Increase of 1 percentage points of the marginal tax rate			
	benchmark benefit level = 0.78		benchmark benefit level = 0	
Labour supply	Fixed	Variable	Fixed	Variable
%Δ employment level	0.57	0.24	0.23	-0.14
%Δ male employment	0.65	0.33	0.26	-0.10
%Δ female employment	0.46	0.11	0.18	-0.19
%Δ full-time employment	0.67	0.33	0.26	-0.10
%Δ part-time employment	-	-0.29	-	-0.41
Δ unemployment rate	-0.62	-0.95	-0.24	-0.32
Welfare measures				
$EV_{c,l+u}$	0.48	0.16	0.18	-0.07
$EV_{c,l}$	0.48	0.40	0.18	0.03
Terms of Trade	1.03	1.03	1.03	1.03
Residual Income Elasticity	0.82	0.82	0.82	0.82

Table 1b. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

GERMANY

	Increase of 3 percentage points of the marginal tax rate			
	benchmark benefit level = 0.78		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	1.75	0.69	0.69	-0.44
%Δ male employment	1.99	0.98	0.79	-0.32
%Δ female employment	1.42	0.29	0.56	-0.60
%Δ full-time employment	2.04	0.96	0.81	-0.30
%Δ part-time employment	–	-0.92	-	-1.25
Δ unemployment rate	-1.88	-2.92	-0.74	-0.97
Welfare measures				
$EV_{c,l+u}$	1.45	0.48	0.55	-0.22
$EV_{c,l}$	1.45	1.19	0.55	0.07
Terms of Trade	1.03	1.03	1.03	1.03
Residual Income Elasticity	0.79	0.79	0.79	0.79

Table 2a. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

FRANCE

	Increase of 1 percentage points of the marginal tax rate			
	benchmark benefit level = 0.8		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	0.49	0.24	0.19	-0.10
%Δ male employment	0.54	0.30	0.21	-0.07
%Δ female employment	0.42	0.16	0.16	-0.13
%Δ full-time employment	0.56	0.31	0.22	-0.06
%Δ part-time employment	-	-0.22	-	-0.33
Δ unemployment rate	-0.50	-0.78	-0.19	-0.25
Welfare measures				
$EV_{c,l+u}$	0.46	0.18	0.17	-0.06
$EV_{c,l}$	0.46	0.41	0.17	0.04
Terms of Trade	1.01	1.01	1.01	1.01
Residual Income Elasticity	0.91	0.91	0.91	0.91

Table 2b. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

FRANCE

	Increase of 3 percentage points of the marginal tax rate			
	benchmark benefit level = 0.8		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	1.49	0.72	0.58	-0.33
%Δ male employment	1.65	0.90	0.64	-0.22
%Δ female employment	1.29	0.47	0.50	-0.39
%Δ full-time employment	1.71	0.92	0.66	-0.19
%Δ part-time employment	-	-0.68	-	-1.02
Δ unemployment rate	-1.53	-2.38	-0.59	-0.77
Welfare measures				
$EV_{c,l+u}$	1.39	0.52	0.52	-0.19
$EV_{c,l}$	1.39	1.24	0.52	0.11
Terms of Trade	1.01	1.01	1.01	1.01
Residual Income Elasticity	0.88	0.88	0.88	0.88

Table 3a. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

ITALY

	Increase of 1 percentage points of the marginal tax rate			
	benchmark benefit level = 0.5		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	0.42	0.12	0.26	-0.03
%Δ male employment	0.43	0.14	0.27	-0.02
%Δ female employment	0.39	0.09	0.25	-0.05
%Δ full-time employment	0.45	0.15	0.28	-0.01
%Δ part-time employment	-	-0.35	-	-0.39
Δ unemployment rate	-0.41	-0.58	-0.25	-0.33
Welfare measures				
$EV_{c,l+u}$	0.34	0.09	0.19	-0.03
$EV_{c,l}$	0.34	0.25	0.19	0.07
Terms of Trade	1.04	1.04	1.04	1.04
Residual Income Elasticity	0.83	0.83	0.83	0.83

Table 3b. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

ITALY

	Increase of 3 percentage points of the marginal tax rate			
	benchmark benefit level = 0.5		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	1.28	0.36	0.80	-0.11
%Δ male employment	1.32	0.41	0.83	-0.08
%Δ female employment	1.21	0.26	0.75	-0.17
%Δ full-time employment	1.36	0.45	0.85	-0.04
%Δ part-time employment	-	-1.08	-	-1.19
Δ unemployment rate	-1.24	-1.77	-0.77	-1.02
Welfare measures				
$EV_{c,l+u}$	1.04	0.27	0.57	-0.09
$EV_{c,l}$	1.04	0.74	0.57	0.20
Terms of Trade	1.05	1.05	1.04	1.05
Residual Income Elasticity	0.81	0.81	0.81	0.81

Table 4a. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

UK

	Increase of 1 percentage points of the marginal tax rate			
	benchmark benefit level = 0.77		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	0.47	0.18	0.19	-0.13
%Δ male employment	0.58	0.30	0.23	-0.08
%Δ female employment	0.34	0.03	0.14	-0.19
%Δ full-time employment	0.62	0.31	0.25	-0.06
%Δ part-time employment	-	-0.26	-	-0.36
Δ unemployment rate	-0.56	-0.81	-0.22	-0.28
Welfare measures				
$EV_{c,l+u}$	0.46	0.15	0.17	-0.07
$EV_{c,l}$	0.46	0.39	0.17	0.04
Terms of Trade	1.05	1.05	1.05	1.05
Residual Income Elasticity	0.80	0.80	0.80	0.80

Table 4b. Increase in tax progression, by increasing the marginal tax rate keeping the average constant and letting allowances vary

UK

	Increase of 3 percentage points of the marginal tax rate			
	benchmark benefit level = 0.77		benchmark benefit level = 0	
Labour Supply	Fixed	Variable	Fixed	Variable
%Δ employment level	1.44	0.52	0.57	-0.39
%Δ male employment	1.76	0.88	0.70	-0.24
%Δ female employment	1.04	0.06	0.41	-0.59
%Δ full-time employment	1.88	0.92	0.75	-0.18
%Δ part-time employment	-	-0.81	–	-1.10
Δ unemployment rate	-1.69	-2.49	-0.67	-0.84
Welfare measures				
$EV_{c,l+u}$	1.38	0.44	0.52	-0.21
$EV_{c,l}$	1.38	1.17	0.52	0.10
Terms of Trade	1.05	1.05	1.05	1.05
Residual Income Elasticity	0.78	0.78	0.78	0.78