CENTRE FOR ECONOMIC PERFORMANCE

DISCUSSION PAPER NO. 361

August 1997

THE IMPACT OF EMPLOYMENT TAX CUTS ON UNEMPLOYMENT AND WAGES: THE ROLE OF UNEMPLOYMENT BENEFITS AND TAX STRUCTURE

C. PISSARIDES

ABSTRACT

I model and simulate the effects of employment tax cuts on unemployment and wages in four equilibrium models: competitive, union bargaining, search and efficiency wages. I find that if the ratio of unemployment compensation to wages is fixed, the effect of the tax cut is mainly on wages. But if income out of work is fixed in real terms, there are substantial employment effects. When wages are determined by bargaining, revenue-neutral reforms that make the tax more progressive also reduce unemployment. Thus, policy towards unemployment compensation and tax structure are key influences on the effect of taxes on unemployment.

This paper was produced as part of the Centre's

National Economic Performance Programme

THE IMPACT OF EMPLOYMENT TAX CUTS ON UNEMPLOYMENT AND WAGES: THE ROLE OF UNEMPLOYMENT BENEFITS AND TAX STRUCTURE

C. PISSARIDES

AUGUST 1997

Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London
WC2A 2AE

ISBN 085328 754 6

THE IMPACT OF EMPLOYMENT TAX CUTS ON UNEMPLOYMENT AND WAGES: THE ROLE OF UNEMPLOYMENT BENEFITS AND TAX STRUCTURE

C. PISSARIDES

Page

The Centre for Economic Performance is financed by the Economic and Social Research Centre.

ACKNOWLEDGEMENTS

This study was financed by the European Commission (DGII) who should not be implicated by the views expressed. I am grateful to Mathias Mors of DGII for suggestions and to Etienne Wasmer for carrying out the simulations. I have also benefited from comments received at seminars at the Centre for Economic Performance and the University of Cambridge and from the suggestions of two referees.

THE IMPACT OF EMPLOYMENT TAX CUTS ON UNEMPLOYMENT AND WAGES: THE ROLE OF UNEMPLOYMENT BENEFITS AND TAX STRUCTURE

C. PISSARIDES

High unemployment rates have been a feature of European labour markets for many years, despite the high priority attached to the problem by the European Commission and national governments and despite the many pieces of policy advice available. One piece of policy advice that appears to command universal support is reform of the employment tax system, with the aim of reducing the tax burden on employers. For instance, the European Commission's White Paper on *Growth, Competitiveness, Employment*, advised governments to "set themselves **the target of reducing non-wage labour costs by an amount equivalent to 1% to 2% of GDP**", "in order to help maintain employment and create new jobs without reducing wage levels".[1] My objective in this paper is to evaluate the impact of the structure and level of employment taxes on equilibrium unemployment, in the light of recent theoretical work on labour markets.

Of course, there is plenty of theoretical modelling and empirical estimation addressed to the question of employment taxes.[2] My reasons for writing yet another paper are two. First, the literature addressed the issue in a variety of models but has not attempted to say how much quantitative difference it really makes to have one model rather than another. Second, the implications of the structure of taxation are seldom made explicit, though the literature often compares and evaluates different types of taxes (eg employment, income or expenditure taxes), a question not addressed in this paper.[3]

The first point is important because we do not yet have a definitive model for the European labour market. I examine how much difference it makes when different models are used to evaluate the impact of policy, by simulating the effects of tax changes in four partial equilibrium models: a competitive model, a union model where wages are determined by a bargain between firms and unions, a search model where wages are also determined by a bargain but now between firms and individual workers and an efficiency wage (shirking) model.

The second point is also important because, as we discover in this paper, changes in the structure of taxation that are revenue-neutral can sometimes have a bigger impact on employment than a general tax cut that substantially reduces overall tax revenue. It turns out, however, that this is the case in some models but not in others, so whether the reform is likely to be effective or not depends on the predominant method of wage determination in the labour market in question. I investigate and discuss this point with reference to simulation results with the same four models.

The four models are partial equilibrium ones in the sense that capital is ignored and the disincentives of taxation in other areas of economic activity, such as the emergence of a black economy or the migration of labour or capital to low-tax countries, are ignored. They are, however, "equilibrium" models, in the sense that both wages and employment are determined within the models at the micro level. A useful common framework that links the four models is one where employment and wages are determined at the intersection of two curves, a conventional labour demand curve and a wage-setting function (which in the competitive model is a labour supply curve). The intersection is at a point to the left of maximum desired labour supply, so there is unemployment in equilibrium.

A cut in employment taxes in this framework shifts the labour demand curve to the right. Both real wages and employment rise but how much is the impact on employment depends on the slope of the wage-setting function. If it is flat there is "real wage resistance" (see, for example, Tyrvainen, 1995), and employment rises by a lot. But if the wage-setting function is steep, wages rise sufficiently to absorb the tax cut and employment does not change. Thus, the issue that needs to be quantified in the simulations is the slope of the wage-setting function.

The key finding of this paper is that the slope of the wage-setting function depends crucially on the relation between taxes and unemployment benefits and on the structure of taxation. Thus, I find, first, that if unemployment benefits are indexed to wages, real wages are flexible and they absorb tax changes without much impact on employment or unemployment. But if unemployment benefits are held constant in real terms when taxes are changed, real wages are more rigid. In other words, the wage-setting function is steeper when unemployment benefits are indexed to wages and flatter when they are indexed to prices. Consequently, all models imply that across-the-board tax cuts that do not change the ratio of unemployment benefits to the post-tax wage are not likely to have much of an impact on employment. But if the tax cuts are allowed to change the ratio of unemployment benefits to the post-tax wage, the four models imply that the impact on employment can be large.

Second, changes in the structure of taxation (ie whether taxes are made more of less progressive) can have dramatic effects on unemployment even if their average level is held fixed. This is true, however, only in bargaining models. A more progressive employment tax shifts the wage-setting function to the right. Thus, if employment tax cuts are targeted so as to make the tax system more progressive, then in models where wages are determined by a bargain, as they are in the union and search models, the impact on employment is large. But if wages are determined competitively or as in the shirking efficiency wage model, the structure of taxation is irrelevant to the impact of the tax cuts. In this respect, the four models studied here have different implications for policy.

In Section 1, I describe the tax structure that I study. In Section 2, I discuss the demand for labour, which is similar across the four models. In Sections 3, 4, 5 and 6, I respectively consider the role of the tax in a competitive, union, search and efficiency-wage framework. I study labour market equilibrium under specific functional forms and I also discuss the numerical values of some key parameters. In Section 7, I report the results of simulations and show first, the importance of the structure of the tax and second the role of unemployment benefits in employment determination. The main conclusions are collected in Section 8.

1. PRELIMINARIES

A general structure for a tax on employment that subsumes proportional, progressive and regressive taxation is the linear tax,

$$T = a + tw, \tag{1}$$

where T stands for the tax collected from the firm per employee, w is the firm's wage rate and a and t are the tax instruments. I assume that t is either positive or zero but a can also be negative. If it is negative, it is equivalent to an employment subsidy and when combined with a positive t, it implies that the overall employment tax is progressive. If a is zero, the tax is proportional to wages and if it is positive the overall tax is regressive.

In order to isolate the effects of employment taxes, I derive employment and wage equations in the four models that I study without imposing constraints on the overall tax revenue.[4] Also, I assume that the taxes levied on a particular firm are unrelated to any social security benefits that accrue to its workers, such as benefits in the event of unemployment or retirement pensions.

As already indicated, an important modelling issue concerns the government's unemployment compensation policy. Results depend on whether the government's policy is to fix the ratio of benefits to wages or the real level of benefits. Of course, in a long-run equilibrium with real wage growth, if benefits are not raised along with wages the unemployed would be suffering a continual drop in their relative living standards (though not in their absolute standards), so it is not likely to be a feasible political equilibrium. The relevant question here, however, is whether when taxes are reduced and wages rise, unemployment benefits are also raised to compensate the unemployed for a once-for-all deterioration in their relative living standards. The answer to this question depends on the nature of government policy. Because of the importance of this issue for the employment tax, I work out the effects of employment taxes both when the policy variable is the *ratio* of benefits to wages and when it is the level of *real* unemployment benefit.

2. THE DEMAND FOR LABOUR

Labour demand in all models is derived from the maximisation of profit under price-taking behaviour. The production function is assumed to be CES,

$$y = A\left[\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha) n^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where y is output, k is the capital stock, n is employment, A is a technology parameter, α is a parameter between zero and one and $\sigma > 0$ is the elasticity of substitution between labour and capital. If $\sigma = 1$ the production function becomes Cobb-Douglas. It is convenient to think of the magnitudes in (2) as ratios to an exogenous labour supply, or alternatively to think of n as constrained from above by unity.

Normalising the price of output to unity and assuming that the firm has to pay taxes $a + tw$ per employee, profit maximisation with respect to n gives the condition,

$$(1-\alpha) A^{\frac{\sigma-1}{\sigma}} \left(\frac{y}{n}\right)^{\frac{1}{\sigma}} = (1+t)w + a. \tag{3}$$

The two-equation system, (2) and (3), is solved for the supply of output and the demand for labour for a given wage rate and is referred to as the demand side of the labour market.

Employment taxes shift the labour demand curve down by increasing the cost of labour. The structure of taxation does not matter for the demand for labour, once the wage rate has been determined. The demand parameters that matter for the effect of taxes on employment are the ones that determine the shift of labour demand in response to a change in costs, ie the wage elasticity of the demand for labour.

Inspection of (3) shows that the two parameters that influence the wage elasticity are s and a. Some experimentation with s showed that the results are not sensitive to small variations in its value. I adopted s =0.7 as the benchmark, though results with s =1 were similar to the ones reported. For a, which approximates the share of capital, I took 0.3 as the benchmark. Since the models that I study do not endogenise either capital or technology, the parameters A and k are free and set at A=k=1. Their status is that of normalising constants in this analysis and the implication of unit choice is that at zero unemployment, y=n=1.

3. COMPETITIVE LABOUR MARKETS

The key assumption in the competitive model is that both firms and workers are price takers in labour markets and wages are set at the level where the aggregate demand for labour is equal to the aggregate supply. Unemployment is treated as time off work during which the worker enjoys some return which is less than the wage rate. It is the difference between some exogenous endowment of labour (the level of potential labour supply) and the level of labour supply generated by the model. What is a little different in our model from more conventional competitive models is that we assume that the difference between the endowment of time and the supply of labour generates both some leisure value and some income, which we call unemployment benefit. In the modelling, the exogenous level of potential labour supply is normalised to unity. In simulations, the free parameters in the utility function are chosen such that the unemployment generated by the model corresponds to actual unemployment in some baseline situation.

The utility function is defined over a composite good and leisure and it is of the CES variety. The model is a static equilibrium one so the period of analysis should be thought of as a sufficiently long period (say a year) during which adjustment to the desired equilibrium is complete. The utility function is

$$U = B[\beta C^{\frac{?-1}{?}} + (1-\beta)(1-n)^{\frac{?-1}{?}}]^{\frac{?}{?-1}} \qquad (4)$$

where C is the composite consumption good and n is working time. B, ß and ? are all positive parameters, with 0<ß<1. The important parameter in the simulations of tax changes is ?, which we discuss later. B and ß are free taste parameters. B drops out of the final expressions whereas ß turns out to be an important determinant of the level of equilibrium employment but not of the proportional effects of taxes on it. I set its value in the simulations such that the equilibrium unemployment rate in the absence of taxation is 6%.[5] This value, given the other parameters of the model, turns out to be ß=0.964.

A reasonable assumption is that savings and wealth do not influence labour supply (except in a long-run growth situation, which we do not consider here), so the budget constraint facing the worker may be simply specified as $C = nw+(1-n)b$, where w is the real wage rate received by the worker and $b<w$ is the level of real unemployment benefit. In competitive equilibrium the worker chooses labour supply to maximise

$$U = B[\beta(nw + (1-n)b)^{\frac{?-1}{?}} + (1-\beta)(1-n)^{\frac{?-1}{?}}]^{\frac{?}{?-1}}. \qquad (5)$$

Time off work (“unemployment”) yields leisure but is costly to the worker because work yields higher income.

Differentiation with respect to n gives the first-order maximisation condition,

$$\beta(w-b)[nw+(1-n)b]^{-\frac{1}{?}} - (1-\beta)(1-n)^{-\frac{1}{?}} = 0. \qquad (6)$$

Second-order conditions are satisfied at all values of n between 0 and 1, which we impose as a time constraint.

We derive two supply functions from (6), one for a fixed ratio of benefits to wages (the replacement ratio), denoted by ?, and one for fixed real unemployment benefits, *b*. Letting n^s denote labour supply we derive from (6), for the case where the policy parameter is ?,

$$\frac{n^{s}}{1\&n^{s}} \ ' \ (\frac{ß}{1\&ß})^{?} (1\&?)^{?} w^{?\&1} \ \& \ ?. \qquad (7)$$

If the policy parameter is *b*, (7) is transformed by replacing ? by *b/w* to give,

$$\frac{n^{s}}{1\&n^{s}} \ ' \ [(\frac{ß}{1\&ß})^{?} (w\&b)^{?} \ \& \ b]/w. \qquad (8)$$

Our first important result is already apparent in these two supply functions. The function with fixed real benefits, (8), is flatter at all wage levels than the function with fixed replacement ratio, (7). Therefore, a shift in the labour demand curve caused by tax changes will have a bigger impact on employment and less impact on wages when real benefits are fixed than when the replacement ratio is fixed. The intuition behind this result is simple. Say labour demand shifts up, bidding up real wages. If real benefits are fixed, wages rise relative to unemployment income, making unemployment a relatively less attractive state than previously. So, the supply of labour rises, resulting in an increase in employment. But if the replacement ratio is the policy parameter — as wages rise, unemployment benefits are also increased reducing the incentive to substitute work for unemployment at the new higher wages.

The CES functional forms are such that if ? = 1, the income and substitution effects on labour supply offset each other exactly in the case of a fixed ?, and the labour supply curve is vertical.[6] ?>1 implies that the substitution effect dominates the income effect and the labour supply curve has a positive slope. If ?<1, the labour supply curve is 'backward bending'. If *b* is the policy parameter, however, labour supply slopes up at values of ? exceeding some number strictly less than 1-?. So the range of values of ? which give positive employment effects of tax cuts is increased.

Empirical evidence shows that ? is always less than 1 for men but above 1 for women.[7] Moreover, whereas for men ? might drop to 0.8 or 0.7 or even further below, for women it is rarely above 1.5. So taken at face value, the competitive model for the whole economy must have a ? either close to 1 or below it. For constant ?, this would give a backward-bending labour supply curve and perverse effects of taxes on employment but for constant *b* the effects of tax cuts on employment might still be strong. To illustrate the effects of taxes in the competitive framework, I simulated the solution for ?=1.2; the simulations will show that even at this ? the real wage absorbs virtually the entire tax in cases where the policy parameter is the replacement ratio.

Another interesting feature of the competitive model is that the structure of taxation does not matter for equilibrium. What matters is only the total amount that taxation adds to the firm's wage costs. This confirms our claim that in models without bargaining, changing the structure of taxation does not influence unemployment.

4. UNION WAGE BARGAINING

Suppose now that workers are organised into trade unions and wages are determined after a bargain between the firm and the union. We consider labour market equilibrium when there are many independent decentralised trade unions.[8] Each firm negotiates with a single union which assumes that it is too small to influence the outcome of the market.

I specify the equilibrium with unions by assuming that the demand side of the model is the same as in the competitive case but the supply side is replaced by a union utility function and a negotiated outcome for wages. The union model that I use is that of the 'right to manage', where the union and the firm bargain over wages but the firm chooses employment to maximise profit, by taking the negotiated wage as given (see Nickell and Andrews, 1983; and Farber, 1986).

Equilibrium is described by three equations, the production function (2), the labour demand (3) and the wage equation, to be derived.

The union utility function and the wage bargain introduce more parameters into the wage equation, which now plays the role that the supply of labour equation played in the competitive model. For convenience, I assume that in the absence of unions the full employment equilibrium is independent of policy and defined by n=1. For the union equilibrium to be feasible, the wage curve derived from the bargain has to lie everywhere to the left of the competitive labour supply curve, otherwise labour supply will constrain union choices. This is always satisfied for as long as the union equilibrium is constrained by n # 1.

There is still no consensus about the best union utility function to use.[9] Functions that have proved popular are the ‘utilitarian’ one (Oswald, 1982; Layard *et al*, 1991) and the Stone-Geary one (Dertouzos and Pencavel, 1980). In what follows I use the utilitarian approach, which has proved the most popular one in the analysis of labour market equilibrium with unions. Some of the results obtained with this utility function are, however, too restrictive and further work on union preferences is likely to prove fruitful.

The function that I use for union i is,

$$V_i \;\; ' \;\; n_i \frac{w_i^{1\&?}}{1\&?} \;\; \% \;\; (m_i \& n_i)[u \frac{b^{1\&?}}{1\&?} \;\; \% \;\; (1\&u)\frac{w^{1\&?}}{1\&?}], \qquad (9)$$

where n_i is union employment, m_i is union membership, assumed for convenience to be always greater than union employment, w_i is the wage rate negotiated by the union, w is the wage rate elsewhere, u is the unemployment rate and b is the unemployment benefit. The union is assumed to be risk averse with coefficient of risk aversion ?>0.[10] Most macroeconomic treatments of union models assume risk neutrality (?=0) but as I shall argue, risk aversion introduces an interesting dimension into the final solution.

The assumption underlying (9) is that the union members who do not get employment in the union firm seek employment elsewhere with a positive probability of finding a job paying *w* and a positive probability of unemployment on benefit. As an approximation, and to avoid an explicitly dynamic model, the probabilities are taken to be the rate of employment and the rate of unemployment respectively. The utility function in (9) does not distinguish between one union member and another: all carry the same weight in union decisions and all are exposed to the same unemployment risk. Thus, both seniority considerations and membership dynamics are ignored in this analysis.

A decentralised union cannot influence either *u* or *w*. In equilibrium, however, all decentralised unions will negotiate the same wage and employment for their members, so w_i=*w* and *u*=1-n_i. The union and the firm bargain over wages, given (2) and (3). The wage rate maximises the product $(V_i ! V)^{\mathrm{d}} ?_i^{(1!\mathrm{d})}$, where d is a parameter between 0 and 1 showing union bargaining strength, *V* is the utility gained by union members if employment at the firm is zero (obtained by substituting n_i=0 in (9)) and $?_i$ is the profit of the firm, defined by

$$?_i \;\; ' \;\; y_i \;\; \& \;\; (1\%t)w_i n_i \;\; \& \;\; an_i. \tag{10}$$

If d=1, we have the simple monopoly union model, with the union choosing the wage and the firm choosing employment.

We maximise the product of union utility and firm profit subject to (2) and (3) and then impose symmetry on the outcome to obtain the wage equation,

$$\mathrm{d}[y\&(1\%t)wn\&an]w^{\&?} \;\;\&\;\; [\frac{\mathrm{ds}\,(1\%t)(1\&n)}{(1\%t)w\%a} \;\;\%\;\; (1\&\mathrm{d})(1\%t)n(1\&n)]\frac{w^{1\&?}\&b^{\;1\&?}}{1\&?} \;\; ' \;\; 0. \tag{11}$$

For fixed *b*, this equation, (2) and (3) are solved for the endogenous variables *y*, *n* and *w*. If *b* were fixed in terms of the wage rate, we replace *b* by ?*w* in (11) and then solve the system (2), (3) and (11).

I discuss the properties of the solution by making the ? substitution and also by writing the intercept of the tax schedule, *a*, as a fraction *z* of the equilibrium wage rate.[11] I also introduce the notation $?=(1!?^{1!?})/(1!?)$ and use the demand condition (3) to get rid of *y* from (11). ? is the loss in income, measured in utility terms, that union members suffer when they remain unemployed instead of getting a union job. As risk aversion rises, this loss also rises, because the uncertainty of whether the union member will end up with a job or unemployed is costlier. But as the level of unemployment benefit rises this loss falls.

The substitutions made above give the wage equation,

$$\begin{aligned} &\delta[A^{1-\sigma}(1-\alpha)^{-\sigma}(1+t+z)^{\sigma-1}w^{\sigma-1}-1](1+t+z) \\ &-[\delta\sigma A^{1-\sigma}(1-\alpha)^{-\sigma}(1+t+z)^{\sigma-1}w^{\sigma-1}+(1-\delta)]?(1+t)(1-n) = 0. \end{aligned} \tag{12}$$

A much simpler version of this equation is obtained when the elasticity of substitution between labour and capital is unity. In that case, (12) can be uniquely solved for the unemployment equilibrium,

$$u = 1-n = \frac{\alpha\delta(1+t+z)}{?(1-\alpha+\alpha\delta)(1+t)}. \tag{13}$$

Unemployment exists in equilibrium (over and above any competitive level) because it acts as a discipline on union wage demands. Unions bargain over the wage by taking other unions' actions as given: they try to beat an average that is ultimately made up of the actions of similar unions. When they push up the wage they create unemployment, which eventually raises the chances that their members who do not get a job with their own firm will remain on benefit to such a level that makes any higher wage undesirable.

In contrast to the competitive case, employment taxes shift both the wage equation and the labour demand equation. Taxes shift the wage equation because firms and unions perceive that the tax they pay depends on their wage choices: by not conceding a wage rise of one unit to the union, both firm and union jointly save t units. Unions perceive this saving, so they agree to settle for a lower wage. This saving does not arise with respect to the intercept a (or z), so a given tax revenue raised through the a part of the tax is likely to have a larger employment cost than when raised through the t part. It is for this reason that the structure of taxation matters for equilibrium wages and unemployment when there is wage bargaining. In the competitive model, neither workers nor firms have any choice over the wage rate and so both *a* and *t* have a similar effect on wages and employment.

Now, higher unemployment benefit implies higher unemployment in equilibrium because the cost of unemployment is less, but more risk aversion implies lower equilibrium unemployment because the risk of income loss associated with unemployment is costlier. Interestingly, however, when the policy parameter is ?, proportional taxation (ie, z=0) does not affect equilibrium unemployment, regardless of whether s =1 or s …1. The labour demand and wage equation shift down by the same amount in this case, and so taxes are absorbed by wages with no effect on employment. But if, when wages fall in response to taxation, benefits are not adjusted downwards, unemployment is higher when taxes are higher even when taxation is proportional.

Other things equal, regressive taxation (z>0) implies higher unemployment and progressive taxation (z<0) lower unemployment. Changing the structure of taxation by switching from the taxation of employment to the taxation of wages, ie by switching from z to t, reduces unemployment.[12]

In terms of parameters, the union bargain introduces two new ones, d and ?. d is a free parameter but it turns out from (12) and (13) that for s =0.7 or s =1, the solution for equilibrium unemployment, 1 ! n, is proportional to d. This is reassuring because there is no microeconomic evidence on d. The fact that the solution is proportional to d implies that the proportional effects of taxes on employment are independent of d. I therefore chose a value of d to give 6% unemployment in the absence of taxes, and so make the simulation results of the union model easier to compare with those of the competitive model.[13] The required value of d turned out to be d=0.074.

For the other parameter, ?, there is some evidence. Farber (1986, p.1063) reports that for Great Britain an estimate for the coefficient of risk aversion, obtained by Carruth and Oswald for mine workers, is 0.8. I use this value in the simulations. When ?=0.6, this risk aversion approximately gives ?=0.5, so it is equivalent to 10 percentage points off the replacement ratio. Since the estimate of ? may not be generally applicable, I also obtained solutions for ?=0.4 and ?=0.6, with similar results for the proportional effects of taxes.

5. SEARCH EQUILIBRIUM

The key departure of search equilibrium models from the competitive one is that there are heterogeneities (or mismatches) in the labour market that make it costly for a worker or a firm to find a partner with whom they can produce sufficiently high returns. The heterogeneities are assumed to lead to a transaction cost which plays a key role in equilibrium. Because of this transaction cost, unemployment arises more naturally in the search model than in the competitive one, with a definition that exactly matches its international survey-based definition. Also because of the transaction cost, there are local monopoly rents associated with each job, so apart from compensating workers for the value of their marginal product, wages also have to share a surplus that is not driven to zero by competitive forces. The solution adopted for wages is usually a solution to an implicit bargain, although the structure of the model does not change significantly if wages are determined by the firm acting as a monopsonist. What is more important for the empirical relevance of search models is whether the transaction costs are sufficiently large to generate monopoly rents that actually make a difference to the functioning of the labour market. I will show at the end of this section that even moderate transaction costs can lead to unemployment that is comparable to those in the models of the preceding two sections of the paper.

Labour market heterogeneities in aggregate search models are summarised in the matching function. The underlying assumption is that because of many potential mismatches in the labour market, workers seeking a new job and employers seeking a new worker have to spend some time looking for partners with whom they are well matched. The matching function gives the rate at which good matches are formed in the market. In its simplest form it depends only on two variables, the number of vacant jobs, *v*, and the number of job seekers, which is in turn approximated by the unemployment rate, *u*.

Let the matching function be,

$$m = m(v,u), \tag{14}$$

with positive first partial derivatives, negative second derivatives and constant returns to scale. Thus, the properties of the matching function are similar to those of an aggregate production function and it should be interpreted in a similar light: it shows the rate of meetings taking place in the labour market given the institutional structure of transactions and the heterogeneities in the composition of jobs and workers. Any change in either the institutional structure of transactions (eg if government takes a more or a less active role in matching firms to workers) or in the composition of the labour force or jobs will shift the matching function. The usefulness of the function, however, depends on its stability over reasonably long periods of time.

Empirically it is found that a stable matching function of a few variables exists for many countries that have the appropriate vacancy data. The variables that are found significant, besides *v* and *u*, are variables related to the incentives that firms and workers have to look for a job, such as the level of unemployment benefit and length of eligibility, the proportion of long-term unemployment, the incentives offered by the state as part of 'active' labour market policies etc and variables that measure mismatch, such as the geographical distribution of vacancies and unemployment. Both sets of variables, however, tend to be quantitatively unimportant, with the possible exception of the length of time that unemployment benefits are available.[14] I will ignore them in what follows, so the disincentive effects of unemployment benefits that I consider work only through wages. Empirically, a reasonable approximation to the matching function in (14) is a Cobb-Douglas function, with the index on each variable not far from 0.5.[15] This is the function that I shall use in the simulations:

$$m = \mu u^{?} v^{1-?}, \qquad \mu>0, \quad 0<?<1. \tag{15}$$

Apart from the introduction of the matching function, the search equilibrium model is deliberately specified as a competitive model. The matching function, however, necessitates several departures from the competitive model in important directions, the most important of which is in wage determination. Another important departure is that idiosyncratic shocks that necessitate worker reallocation between firms now have to be explicitly modelled, because the cost of making new matches implies that the frequency of such shocks will be one of the determinants of equilibrium employment. These departures have implications for the role of employment taxes in the determination of employment.

I assume that negative idiosyncratic shocks arrive at constant rate s. Negative shocks lead to the destruction of the job and the entry of the worker into the unemployment pool. The assumption of constant s is reasonable in a long-run equilibrium setting, as in this paper, though it is less appropriate for the cyclical analysis of job flows.[16]

The matching function implies that during a short period of time a worker looking for a new job finds one with probability less than one, even if there are enough jobs to satisfy all workers. On average, a worker finds a job in a period of unit length with probability $m(v,u)/u$ and a firm seeking a worker finds one with probability $m(v,u)/v$. Under the assumption of constant returns to scale, we define a new variable $? / v/u$, and write each probability as,

$$q(?) \;/\; m(v,u)/v \;'\; \mu ?^{\&?}, \qquad ?q(?) \;/\; m(v,u)/u \;'\; \mu ?^{1\&?}. \quad (16)$$

To derive first the demand for labour for given wage, we note that recruitment takes place when the firm posts a vacancy and a worker arrives to take the job. The firm that posts v_i vacancies gets a flow of $q(?)v_i$ workers and if its current employment level is n_i, it loses workers at the rate s. Therefore employment satisfies the dynamic constraint,

$$?n_i \;'\; q(?)v_i \;\&\; sn_i. \quad (17)$$

Posting a vacancy costs the firm c per unit period. Since with a worker flow of $q(?)$ per period the average duration of each vacancy is

1/*q*(?), the average recruitment cost per worker is *c*/*q*(?). The demand for labour in the search model is modified to take account of this cost. With constant rate of discount *r* and constant rate of separation *s*, the cost of labour to the firm now becomes equal to the wage rate plus taxes plus the capitalised recruitment cost, (*r*+*s*)*c*/*q*(?). Therefore, the demand for labour in the economy as a whole is,

$$(1\&\mathrm{a})A^{\frac{\mathrm{s}\&1}{\mathrm{s}}}(\frac{y}{n})^{\frac{1}{\mathrm{s}}} \;\&\; w(1\%t) \;\&\; a \;\&\; \frac{(r\%s)c}{q(?)} \;'\; 0. \qquad (18)$$

For the Cobb-Douglas matching function and the assumption that *a*=*zw*, (18) becomes,

$$(1\&\mathrm{a})A^{\frac{\mathrm{s}\&1}{\mathrm{s}}}(\frac{y}{n})^{\frac{1}{\mathrm{s}}} \;'\; (1\%t\%\mathrm{z})w \;\%\; \frac{r\%s}{\mu}c?^{?} \qquad (19)$$

The dynamic constraint (17) can be aggregated to the level of the economy as a whole, *n* replaced by 1-*u*, and ? replaced by *v/u*, to yield the Beveridge equation,

$$?u \;'\; s \;\&\; vq(v/u)\&su. \qquad (20)$$

The steady-state version of the Beveridge equation for the Cobb-Douglas matching function is,

$$1 \;\&\; n \;'\; \frac{s}{s\%\mu?^{1\&?}}. \qquad (21)$$

The production function (2), demand for labour (19) and Beveridge curve (21) can be solved uniquely for the three unknowns, *y*, *n* and ?, given the wage rate. Unemployment and vacancies are then obtained from the conditions *u*=1-*n* and ?=*v/u*.

The final equation needed to close the model is the wage equation. Wage determination in search equilibrium cannot be derived from an equality between appropriately defined supply and demand functions, because the firm and worker who are together have a net advantage over those outside. They have already undergone a costly process of search to find a good match. The sum of the costs of the two sides corresponds to a local monopoly rent that has to be shared. In the Appendix I derive the wage equation from the leading approach in the search literature, which assumes that wages are determined as the solution to a Nash bargaining problem.[17]

In the full solution, the firm and the worker choose the wage rate after they meet by taking into account the fact that if they do not agree to form the job, their best alternative is to search for alternative partners. Thus, the solution is dynamic and it depends on the ease with which each side can find alternative partners. The ease with which firms find alternative partners relative to the ease with which workers find alternative partners depends on the ratio of the rate at which workers arrive to firms to the rate at which job offers arrive to workers, *q*(?)/?*q*(?) = 1/?. The wage rate depends inversely on this ratio, ie it depends positively on ?. The wage rate also shares the output produced by the worker (his marginal product) after it compensates the worker for giving up income *b* during unemployment to accept the job. If the share that goes to the worker is ß, the full wage equation is (see the Appendix for formal derivation),

$$w \;\&\; b \;'\; ß[\frac{(1\&\mathrm{a})A^{\frac{s\&1}{s}}(y/n)^{\frac{1}{s}}\&a\%c?}{1\%t} \;\&\; b]. \qquad (22)$$

Wages depend positively on the worker's marginal product and on unemployment income. They depend negatively on the fixed component of the tax, *a,* because it reduces the surplus from the job. They also depend negatively on the marginal tax *t* but as in the union model, the marginal tax reduces wages partly because it reduces the surplus from the job and partly because by agreeing to keep the wage lower, the firm and worker reduce the amount of tax they pay. Thus, again as in the union model, the marginal employment tax influences the slope of the wage curve but the intercept influences only its position.

Equations (22), (19) and (20) give a complete description of search equilibrium, as they can be solved in the three unknowns, *w, n* and v for some initial n_0, given the production function and noting the definitional relations $u = 1 ! n$ and $v = ?u$. Writing (once again) unemployment benefits as a constant fraction ? of the net wage, and making use of (19), we write the wage equation (22) as,

$$w \;' \; \frac{ßc}{(1\&ß)(1\%t)(1\&?)}\,(\frac{r\%s}{µ}\,\%\,?^{1\&?})?^{?}. \qquad (23)$$

The equilibrium equations of the model with fixed replacement ratio are (2), (19), (23) and (21) in y, n, w, and ?. For the simulations, the parameters of the production function are assumed to be the same as before, A=k=1, a=0.3, s=0.7. The real interest rate r is taken to be 0.1. The separation rate s is the inverse of the average duration of a job, and with the year as the length of the period, it is taken to be s=1/5=0.2. The elasticity ? is chosen to be 0.5, which is the average of the elasticities estimated for the United Kingdom and the United States, and the share of labour ß is also taken to be 0.5, as assumed by the symmetric Nash bargain solution. The constant µ is free and chosen to yield a plausible value for the duration of unemployment, bearing in mind that the inverse of $µ?^{1!?}$ is the average duration of unemployment. I use µ=3.3, giving a duration of unemployment of just over 5 months at ?=0.5 and of 3.6 months at ?=1.

As in the union and competitive models, I set 1 ! ?=0.4 and then choose c so as to get the same equilibrium solution for unemployment at zero tax that was obtained for the other two models, 6%. The required value of c turns out to be 0.4w, and gives a v/u ratio of 0.9 and duration of vacancies of 0.287 years. Since the assumed average duration of a job is 5 years, our parameters imply that on average the firm spends on each job 0.287 years paying recruitment costs 0.4w and 5 years paying wage costs w. Thus the total recruitment cost per job required to generate 6% unemployment in this model is only 2% of the total wage cost per job.

6. EFFICIENCY WAGES

This section considers another method of wage determination, ‘efficiency wages’. Several apparently distinct models of labour market equilibrium are often included under this heading, ranging from fairly conventional models where the supply of labour to the firm depends on the firm’s wage offer, to models of individual behaviour inspired by work in the other social sciences. The unifying theme of these models is that the wage rate is chosen by the firm and that the constraint facing the firm, which stops it short from pushing wages down to each worker’s reservation wage, is that a higher wage extracts more labour input from the firm’s workforce. For this reason, the term favoured by Phelps (1994), ‘incentive wages’, is a more accurate description of the role of wages in these models than the more conventional ‘efficiency wages’.

Models which build on the idea of efficiency wages include the early work in search theory by Phelps (in Phelps *et al*, 1970) and others, as recently refined and adapted to the OECD context by Phelps (1994); the more straightforward and simple assumption that higher wages bring about more effort from employees, first put forward by Solow (1978); the assumption that higher wages attract better quality workers due to Weiss (1991); and the assumption that high wages discourage workers from shirking due to to Shapiro and Stiglitz (1984). Summaries of efficiency wage models appear in Johnson and Layard (1986), Weiss (1991) and Phelps (1994).

Although different models of efficiency wages do give rise to different results about labour market equilibrium, the main message is fairly general. The basic result is that wages in macro equilibrium end up being higher than the competitive wage because firms try to motivate their employees by offering them a premium over the market average. Since the market average is made up of their own wage offers, they cannot beat each other in equilibrium. The premium they offer results in too high a wage and so to unemployment. Thus, the incentives firms try to offer by making the inside job offer more attractive are eventually provided through a deterioration of the worker’s outside options.

The model that I formalise here is due to Shapiro and Stiglitz (1984), which can be developed in an environment similar to that of the search model in the preceding section.[18] There are two main differences between the model of the preceding section and the model of this section. The first difference is in the method of wage determination and it is what makes this model an 'efficiency wage' one. The second difference is that there are no matching frictions in this model but there is unemployment, so the firm can recruit instantaneously, whereas workers have to wait until they are called to a job. I assume that the allocation of jobs to workers is done randomly. The fact that there are no frictions and there is always unemployment in equilibrium ensures that the firm can get all the surplus generated by the job, once the worker is compensated for his work effort. This is a limitation of the model and an extension to a matching framework can enrich the results by making wages depend on insider variables as well.

The role of unemployment in this model is to discipline workers into not shirking on the job, in contrast to the preceding models where the role of unemployment was to discipline wage demands. In this model, as firms try to offer a premium over what other firms are offering they push average wages too high, and so generate unemployment which disciplines workers by increasing the costs of a dismissal in the event of detection.

To formalise the idea, suppose as before that the equilibrium unemployment rate is u and that there is exogenous job destruction at the rate s. In stationary equilibrium, the hiring rate in the economy must be equal to sn, and since those hirings take place from the pool u, the rate at which unemployed workers find jobs is sn/u. Therefore, the returns of an unemployed worker, U, satisfy,

$$rU = b + \frac{sn}{u}(E - U), \tag{24}$$

with the notation the same as before: b is unemployment compensation and E the expected returns from a job.

A worker has the choice of supplying work effort e or not supplying any effort and being detected and fired with probability (in unit time), q. If the worker supplies effort or if he shirks but is not detected, he earns wage w_i. The worker will supply effort if the wage he gets raises the returns from supplying it to those from shirking. The returns from supplying effort, E_i^{ns}, satisfy,

$$rE_i^{ns} = w_i - e - s(E_i^{ns} - U), \tag{25}$$

and the returns from shirking, E_i^{s}, satisfy,

$$rE_i^{s} = w_i - (s+q)(E_i^{s} - U). \tag{26}$$

The firm has to offer a wage that makes workers supply effort, but in this environment, it has no incentive to offer anything more than the minimum required. Therefore the wage equation satisfies,

$$E_i^{ns} = E_i^{s} \equiv E. \tag{27}$$

Upon substitution from (25) and (26), and imposing symmetry, we get the wage equation,

$$w = rU + \frac{r+s+q}{q}e. \tag{28}$$

The worker gets a premium over his reservation wage but the premium is not related to his productivity.[19] It exists only because of the firm's inability to perfectly monitor the supply of effort. For our purposes, the most important implication of this wage equation is that given unemployment income, taxes do not influence the wage offer. In this respect the shirking model is closer to the competitive model than to the search or union models.

In order to complete the specification of the model we need to solve for the return from unemployment, U. Substituting from (24) and (25) into (28) and noting the definition u=1-n, we get,

$$w = b + \frac{r+s+q}{q}e + \frac{n}{1-n}\frac{se}{q}. \tag{29}$$

This wage equation has the desirable property that wages depend negatively on equilibrium unemployment, even with a constant *b/w* ratio.

Equation (29) is combined with the demand side of the competitive and union models, (2) and (3), to give unique solutions for wages, employment and output. As in the competitive model, taxes reduce employment by shifting the labour demand curve down, so only the total tax paid influences equilibrium, not the structure of taxation. What the efficiency wage assumption buys is a flatter 'labour supply curve', (29), which Shapiro and Stiglitz call the "no shirking condition".

The new parameters in this model are q and e. There is no empirical evidence on either, which is a serious limitation of the model in the simulations because with two free parameters, the condition that we used before, a 6% unemployment rate at a zero-tax equilibrium, is not enough to tie down the model. Using the assumption of 6% unemployment at the zero-tax equilibrium gives the following constraint on the parameters,

$$e = 0.287 - 3.433\frac{e}{q}. \tag{30}$$

This gives a feasible range for the parameters, since both e and q have to be positive, but the range is still large. If we use the utility function of the competitive model and we literally assume that a shirker gets as much utility out of his time as a non-participant (which is unlikely because the shirker still has to show up at work), then the utility parameters at ?=1 imply e=0.1. Substituting this value into (30) gives q=1.835, ie a shirker is on average detected after 6 to 7 months. But then the elasticity of labour supply at the zero-tax equilibrium implied by these numbers (when ? is constant) is 0.12, which contrasts sharply with that obtained from the competitive model at ?=1.2, which is 0.013. The value of ? required to raise the elasticity of labour supply in the competitive model to 0.12 is approximately ?=1.65, which is much higher than a large number of empirical estimates.

In one sense, the calculations in the preceding paragraph show the power of the no-shirking condition: even when monitoring is such that a shirker is caught on average after 6 months, the no-shirking condition is ten times as elastic as the competitive labour supply curve (or more precisely, the competitive model that replicates the shirking model needs an elasticity of substitution between consumption and leisure of 1.65, in contrast to the estimated values around one or even below). But the assumption that the leisure that the shirker gets out of idleness is as much as the leisure that he gets from not going to work is extreme. In the absence of better information, I have taken half of the calculated utility gain as the benchmark, ie, I simulated the efficiency wage model for *e*=0.05 and *q*=0.723 (the value of ? required to make the competitive supply curve as flat as the no-shirking condition at *e*=0.05 is ?=1.57). The results should, however, be treated with caution, because sensitivity analysis shows that they are sensitive to the values of *e* and *q* chosen.

7. SIMULATION RESULTS

The four models are simulated for the parameters chosen in the text. Two sets of simulations are undertaken, one for a fixed ? and one for a fixed *b* (=?*w*). In the latter case the *b* is fixed at the point where ?=0.6 at zero taxation and 6% unemployment. The equations and parameters are reproduced here for convenience, with the same equation number as they appear in the text:

1. *Competitive*

$$y = A\left[\alpha k^{\frac{\sigma-1}{\sigma}} + (1-\alpha)n^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \qquad (2)$$

$$(1\&a)A^{\frac{s\&1}{s}}(\frac{y}{n})^{\frac{1}{s}} \ \text{'} \ (1\%t)w \ \% \ a. \tag{3}$$

$$\frac{n^{s}}{1\&n^{s}} \ \text{'} \ (\frac{ß}{1\&ß})^{?}(1\&?)^{?}w^{?\&1} \ \& \ ?. \tag{7}$$

Unknowns *y*, *n*, *w*, parameter values:
A=*k*=1, a=0.3, s=0.7, *a*=*zw*, ?=0.6 or ?=0.431/*w*, ?=1.2, ß=0.964.

2. *Unions*

$$y \ \text{'} \ A[ak^{\frac{s\&1}{s}} \ \% \ (1\&a)n^{\frac{s\&1}{s}}]^{\frac{s}{s\&1}} \tag{2}$$

$$(1\&a)A^{\frac{s\&1}{s}}(\frac{y}{n})^{\frac{1}{s}} \ \text{'} \ (1\%t)w \ \% \ a. \tag{3}$$

$$\begin{aligned} &d[A^{1\&s}(1\&a)^{\&s}(1\%t\%z)^{s\&1}w^{s\&1}\&1](1\%t\%z) \\ &\& \ [dsA^{1\&s}(1\&a)^{\&s}(1\%t\%z)^{s\&1}w^{s\&1}\%(1\&d)]?(1\%t)(1\&n) \ \text{'} \ 0. \end{aligned} \tag{12}$$

For this model, ?=(1-?$^{1-?}$)/(1-?). Unknowns *y*, *n*, *w*, parameter values:
A=*k*=1, a=0.3, s=0.7, *a*=*zw*, ?=0.6 or ?=0.431/*w*, ?=0.8, d=0.074.

3. *Search*

$$y \ \text{'} \ A[ak^{\frac{s\&1}{s}} \ \% \ (1\&a)n^{\frac{s\&1}{s}}]^{\frac{s}{s\&1}} \tag{2}$$

$$(1\&a)A^{\frac{s\&1}{s}}(\frac{y}{n})^{\frac{1}{s}} \ \text{'} \ (1\%t\%z)w \ \% \ \frac{r\%s}{µ}c?^{?} \tag{19}$$

$$w = \frac{ßc}{(1-ß)(1+t)(1-?)}\left(\frac{r+s}{\mu} + ?^{1-?}\right)?^{?}. \qquad (23)$$

$$1 - n = \frac{s}{s + \mu ?^{1-?}}. \qquad (21)$$

Unknowns *y*, *n*, *w*, and ?, parameter values:

A=k=1, a=0.3, s=0.7, a=zw, ?=0.6 or ?=0.431/w, r=0.1, ß=?=0.5, s=0.2, µ=3.3, c=0.28.

4. *Efficiency wages*

$$y = A\left[\mathrm{a}k^{\frac{\mathrm{s}-1}{\mathrm{s}}} + (1-\mathrm{a})n^{\frac{\mathrm{s}-1}{\mathrm{s}}}\right]^{\frac{\mathrm{s}}{\mathrm{s}-1}} \qquad (2)$$

$$(1-\mathrm{a})A^{\frac{\mathrm{s}-1}{\mathrm{s}}}\left(\frac{y}{n}\right)^{\frac{1}{\mathrm{s}}} = (1+t)w + a. \qquad (3)$$

$$w = b + \frac{r+s+q}{q}e + \frac{n}{1-n}\frac{se}{q}. \qquad (29)$$

Unknowns *y*, *n*, *w*, parameter values:

A=k=1, a=0.3, s=0.7, a=zw, b=0.6w or b=0.431, r=0.1, s=0.2, e=0.05, q=0.723.

Table 1 reports the results of the simulations for the case of a constant replacement ratio. Recall that what this implies is that as the employment tax is cut and wages rise to reflect the higher demand for labour, unemployment benefits are increased so as to maintain the ratio of benefits to the post-tax wage rate.

The simulation results in Table 1 confirm that in the competitive model, where the structure of taxation does not matter, there are very small effects from a tax cut. Even a tax worth 60% of the wage bill, shown in the bottom row of the Table, costs only about half of one percentage point of unemployment. The tax is absorbed almost entirely by the wage rate.

The same is not, however, true of the efficiency wage model, where the structure of taxation also does not matter. Equilibrium wages in the two models differ at most only by about 1 to 2% at all levels of taxes, but unemployment in the efficiency wage model is almost double, at 10.9%, when there is a 60% tax. In this model, a reduction of the tax rate from say 40 to 20% of the wage rate can reduce unemployment by 1.6 percentage points and increase wages by about 15%. These differences between the competitive and efficiency wage models reflect the fact that the no-shirking condition is considerably flatter than the labour supply curve, but as warned in the preceding section, these results should be treated with caution because of too many free parameters in the efficiency wage model, and also because they imply far larger employment effects than any of the other models.

In the union model, proportional taxes are absorbed entirely by wages. The key in this model then is not the total amount of the tax but its structure. A revenue-neutral change of the tax system from a 20% lump sum to 20% proportional has the same employment effect as the abolition of the tax. Unemployment falls by 1.16 points, with virtually no change in the real wage. A similar implication about the benefits from reform of the tax structure is shown in the first row of the Table. A progressive tax with zero revenue has no employment or wage effects in the competitive and efficiency wage models, but reduces unemployment by almost a full point in the union model, for virtually no wage change. The results with the union model show that at least when the ratio of unemployment benefit to the post-tax wage is fixed, any concern with the total amount of the tax is misplaced. Structure is far more important and 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. The key property of the model that policy exploits in this case is the flatness of the labour demand curve, implied by s =0.7 and no adjustment costs. When the wage curve shifts in response to the change in the structure of taxation, the flatness of the labour demand curve gives rise to a large increase in the demand for labour and a small fall in real wages. A 0.5% fall in the wage buys a 1% increase in employment (and so a one percentage point reduction in unemployment).

The search model behaves very much like the union model, and for similar reasons, except that the magnitude of the employment effects is more subdued. Proportional taxation has no employment effects. The gain from changing a zero tax to a progressive 20% tax with no net tax revenue is half of 1% instead of a full point, for a wage fall of just over half of 1%. The gain from reforming the system from a 20% lump sum tax to 20% proportional is also about half of what it is in the union model.

Table 2 shows the implications of the same tax rates for employment and wages when unemployment benefits are not adjusted each time the wage rate changes in response to tax cuts. The resulting equilibrium is vastly different from the earlier one. When taxes are cut from 40 to 20% of the wage, even in the competitive model there is a gain of about 6 percentage points of unemployment. In the efficiency wage model the gain is 10 points and even a proportional tax cut in the union model gives a gain of close to 5 percentage points. The odd model out in these simulations is the search model, where the existence of the matching function and the Beveridge curve mitigates the effects of any exogenous change on employment. A close look at the Beveridge equation (21) shows that even very low values of the vacancy-to-unemployment ratio imply modest unemployment rates (for example, at tax rates z=0.4 and t=0.2, ? falls to 0.17, implying a mean duration of vacancies of 1.5 months and a mean duration of unemployment of nearly 9 months). As a result, the gain from a tax cut from 40 to 20% in the search model is a modest 1.7 points of unemployment, even with fixed real benefits. Note, however, that the assumption of a fixed benefit implies that at 40% tax the replacement ratio is 80% whereas at 20% tax it is 70%.[20]

8. CONCLUSIONS

The analysis of the four equilibrium models of employment determination has brought out an important fact. Although there are forces on the supply side of the labour market that stop wages from fully absorbing the employment taxes, once unemployment benefits are indexed to the post-tax wage these forces are too weak to introduce much 'real wage resistance'. So across-the-board tax cuts are not likely to have much of an impact on employment: real wages are likely to absorb the tax changes if unemployment benefits are increased in proportion to the wage rate when the taxes are cut.

But if unemployment benefits are not indexed to wages (and are held fixed in real terms), the employment effects of the tax cut can be sizeable. I estimated that a 10% cut in the taxes levied on employers could reduce equilibrium unemployment by up to 1 percentage point. It would also increase wages by about 3% and so reduce the unemployment replacement ratio by about 2 percentage points.

The results derived under the assumptions of union wage bargaining and search, where there are monopoly rents and wages are determined by a bargain between employers and employees, point to another issue which is as important in the design of policy. Proportional and progressive taxes in the presence of monopoly have much less of an impact on employment than regressive taxes. In countries where there is a regressive tax (that usually takes the form of a fixed component in the tax levied on employers, or of a ceiling on social security contributions), a revenue-neutral reform of the tax system to a proportional or progressive tax can have bigger employment effects than an across-the-board reduction in the marginal tax rate. Moreover, the gains from revenue-neutral reform come close to a 'free lunch', since a small drop in real wages of about half of 1%, even when combined with indexed unemployment benefits, could save more than a full point of unemployment.

The models that we simulated are all 'representative agent' models, so they can not be used to analyse the impact of targeted reductions in taxes. But since when tax cuts are concentrated on the low-paid the whole structure of the tax becomes more progressive, when wages are determined by bargaining the models imply that tax cuts targeted on low incomes have bigger employment effects than general tax cuts.[21]

In terms of similarities and differences, the models differ in a variety of ways, though they have similar implications about the interaction between unemployment benefits and tax cuts. In general, tax cuts have smaller employment effects in the competitive model and larger ones in the efficiency wage model (both of which imply that the structure of taxation is irrelevant).[22] When the replacement ratio is fixed, there are only small differences between the predictions of the competitive, union and search models, except that structure has a large impact in the last two. Perhaps surprisingly, it turns out that when real unemployment benefits are held fixed, tax cuts have their smallest impact in the search model (because the number of vacancies absorbs some of the shocks), with the other three models having similar predictions.

ENDNOTES

1. See European Commission (1994), p.155 (emphasis in the original).

2. See, for example, Layard *et al* (1991), Phelps (1994), Pissarides (1990), Symons and Robertson (1990), OECD (1994) and the survey by Tyrvainen (1995).

3. A large number of studies discusses the interaction between employment subsidies and wage taxation, which is closely related to the question of tax structure (see above, Sections 1 and 4). Two papers that explicitly discuss the influence of the structure of taxation on labour costs are Lockwood and Manning (1993) and Holmlund and Kolm (1995).

4. The implications of revenue-neutral switching from employment to anti-pollution taxes have been examined in a number of papers, eg Bovenberg and van der Ploeg (1994) and Barker and Gardiner (1995). See also Analytical Study No. 3 in the 1994 issue of *European Economy*.

5. The number 6% is not important for the results. In each model I choose the values of the free parameters so as to give me the same unemployment rate in the absence of taxation. What these models mostly determine is the proportional effect of the tax, with the baseline value playing a minor role.

6. If we had a dynamic model of labour supply, wages could still influence labour supply with ? = 1, provided the change in the wage rate was perceived to be temporary. This difference between the effects of temporary and permanent changes in wages is what underlies the intertemporal substitution theory of labour supply, which is the dynamic generalisation of the static model described here. See Sargent (1979, chapter 16) for an analysis of the dynamic case.

7. See for example the surveys by Pencavel (1986) and Killingsworth and Heckman (1986). Zabalza *et al* (1980), estimated ? with British data for older men and women and found ?=0.25 for men and ?=1.3 for women.

8. Our models imply that with a centralised union there is always full employment.

9. See Farber (1986) for a good summary of union preferences.

10. If ?=1, a limiting argument can show that the utility function becomes logarithmic. I will assume throughout that ? is different from 1 to avoid technical complications. There is, of course, continuity of the solution in the neighbourhood of 1.

11. Of course, this does not change the nature of the tax schedule, as progressive when $z<0$ and regressive when $z>0$, because a is treated as independent of the negotiated wage by both the firm and the union and indexed to the wage *ex post*.

12. The case where employment is subsidised ($z<0$) and a wage tax is used to finance the subsidy was advocated by Layard (1982) as an incentive-based incomes policy to reduce equilibrium unemployment. His recommendation obviously works in our model (and in the search model that follows), since the net effect of the policy can be obtained by writing $t=!z>0$ in the final solutions.

13. Recall that in a competitive situation, with powerless unions, d is equal to 0. In that case the solution is full employment, since (12) implies $n=1$ for any set of parameters. Any value of d above zero indicates the existence of some union monopoly power and lower employment.

14. See Atkinson and Micklewright (1991) for evidence of the unimportance of the disincentive effects of unemployment benefits and Layard *et al* (1991) for the importance of the duration of benefits.

15. See Pissarides (1986) and Blanchard and Diamond (1989). The statement in the text has been left deliberately vague because there are no precise estimates to match those of the production function. Pissarides (1986) finds 0.7 for unemployment and 0.3 for vacancies in Britain, an estimate also found for a different data period by Layard *et al* (1991). Blanchard and Diamond find 0.4 for unemployment and 0.6 for the help-wanted index in the United States.

16. Recently, there has been a lot of research into the determinants of the job destruction rate and its variability over the business cycle. Our assumption of a constant *s* corresponds to the assumption of a constant destruction rate. See Mortensen and Pissarides (1994) for an endogenous treatment of job destruction along the lines of the model in the text and Davis and Haltiwanger (1992), OECD (1993) for a discussion of data issues.

17. See Pissarides (1990) for a discussion of this and other issues related to search equilibrium

18. Hoon and Phelps (1995) consider the effects of taxes in an efficiency wage model that assumes that the firm uses its wage offer as a tool to discourage quits.

19. In contrast to the search model, where it does. See Appendix equation (37).

20. The European Commission in its White Paper recommended reducing taxes by about 1 to 2% to GDP, which would correspond to a reduction of the employment tax by about 7 to 14%, depending on the base. In our models, reductions of this magnitude would have very small employment effects if the replacement ratio was the same before and after the tax change, but would reduce unemployment by 0.5 (in the competitive model) to 1 percentage point (in the union model) if unemployment benefits were fixed in real terms. If the reductions in the employment tax were concentrated on low wage earners, also recommended in the White Paper, they would have bigger effects in the

union and search models, because they would make the tax more progressive.

21. Another reason that targeted tax cuts might have bigger employment effects is that workers on low incomes are likely to have higher supply elasticities.

22. The efficiency wage model is, however, the least reliable model in the simulations.

TABLE 1

Simulation of Tax Changes
Constant Replacement Ratio

		Competitive		Unions		Effic Wages		Search	
Tax Rates		Umpl	Wage	Umpl	Wage	Umpl	Wage	Umpl	Wage
z	t	u	w	u	w	u	w	u	w
-0.2	0.2	6.00	0.719	5.02	0.716	6.00	0.719	5.51	0.690
-0.2	0.4	6.22	0.599	5.16	0.597	7.51	0.603	5.58	0.576
0.0	0.0	6.00	0.719	6.00	0.719	6.00	0.719	6.00	0.694
0.0	0.2	6.22	0.599	6.00	0.599	7.51	0.603	6.00	0.579
0.0	0.4	6.40	0.514	6.00	0.513	9.14	0.521	6.00	0.496
0.2	0.0	6.22	0.599	7.16	0.602	7.51	0.603	6.55	0.582
0.2	0.2	6.40	0.514	6.97	0.516	9.14	0.521	6.46	0.498
0.2	0.4	6.57	0.450	6.83	0.451	10.9	0.459	6.40	0.436

TABLE 2

Simulation of Tax Changes
Constant Real Unemployment Benefits

		Competitive		Unions		Effic Wages		Search	
Tax Rates		Umpl	Wage	Umpl	Wage	Umpl	Wage	Umpl	Wage
z	t	u	w	u	w	u	w	u	w
-0.2	0.2	6.00	0.719	5.06	0.716	6.00	0.719	5.52	0.691
-0.2	0.4	9.09	0.607	7.62	0.603	11.1	0.613	6.56	0.582
0.0	0.0	6.00	0.719	6.00	0.719	6.00	0.719	6.00	0.694
0.0	0.2	9.09	0.607	8.73	0.606	11.1	0.613	7.02	0.584
0.0	0.4	15.0	0.535	13.7	0.532	21.4	0.552	8.74	0.508
0.2	0.0	9.09	0.607	10.2	0.610	11.1	0.613	7.61	0.588
0.2	0.2	15.0	0.535	15.3	0.536	21.4	0.552	9.32	0.510
0.2	0.4	25.5	0.494	24.1	0.490	36.8	0.525	12.9	0.457

APPENDIX

In this Appendix, I derive the wage equation (22) as the solution to a Nash bargain problem. For this it is necessary to write down the expected returns for each job and worker. The final solution corresponds to a competitive solution with dynamic transaction costs. We write down four equations, derived from dynamic programming, one each for the expected returns from a vacant job, a filled job, an unemployed job seeker and an employed worker.

The expected returns from a vacant job are denoted by V and satisfy,

$$rV = -c + q(?)(J - V). \tag{30}$$

There is an underlying assumption of a perfect capital market with interest rate r. c is the cost of keeping an active job vacancy and J is the expected return from a filled job. Equation (30) says that with a perfect capital market, the capital market cost of a vacant job, rV, has to equal the labour market return: a cost c and a capital gain equal to J-V, received with probability $q(?)$.

In competitive equilibrium and without restrictions on job creation, firms will create jobs until the expected net return from one more vacant job is driven to zero. Therefore, the equilibrium condition on job creation is V=0, which, after substitution into (30) becomes,

$$J = \frac{c}{q(?)}. \tag{31}$$

Since $1/q(?)$ is the expected duration of a vacancy, (31) states that in equilibrium, the expected profit from a job has to cover the expected cost of a vacancy. The right-hand side of (31) corresponds to a recruitment cost borne by the firm.

The expected returns from a filled job satisfy

$$rJ = y^{)} - (1+t)w - a - s(J-V). \tag{32}$$

The interpretation of this equation is similar to that in (32). The labour market return from a filled job is the worker's marginal product, which

I write for convenience as y', less the total labour cost $(1+t)w+a$, less the loss from an idiosyncratic shock that leads to the destruction of the job. The worker's expected returns from unemployment satisfy

$$rU = b + \theta q(\theta)(E-U), \tag{33}$$

where U stands for the unemployed worker's expected returns, b for (an indefinitely available) unemployment income and E for the expected returns from a job.

Finally, the employed worker's expected returns satisfy

$$rE = w - s(E-U), \tag{34}$$

with the notation already defined.

The wages of a meeting pair of firm and worker i are obtained from the solution to the following maximisation problem,

$$w_i = \arg\max \, (E_i - U)^{\beta}(J_i - V)^{1-\beta}, \tag{35}$$

where β is a parameter between zero and one (normally taken to be 0.5 in symmetric situations, with firm and worker using the same rates of discount) and the index i distinguishes the insider job from the average job outside. Since, however, we assume that all job matches are equally productive — the natural extension of the assumption of a representative agent to this context — the solution for wages will be the same in all jobs. Carrying out the maximisation gives rise to the first order condition,

$$E - U = \frac{\beta}{(1-\beta)(1+t)} J. \tag{36}$$

The Nash bargain solution implies that the share of the worker from the surplus that the job creates is influenced by the marginal tax rate. The reason is that as more of the share is shifted from the firm to the worker the pair pay more taxes, which is a net loss to both. In contrast, the fixed component a does not influence the share, because how much the pair pay is independent of their wage choices.

Making use now of the value equations, the maximisation condition and the equilibrium condition V=0, we get the wage equation,

$$w = rU + \beta\left[\frac{y' - a}{1+t} - rU\right]. \tag{37}$$

Equation (37) states that the worker gets his ‘reservation wage’ rU, plus a fraction β of the net output that is created when he gives up the state of unemployment to take a job. rU is the reservation wage because U is the value of unemployment and so rU is the permanent income of the unemployed. Equation (37) is the basis of an empirical wage equation derived from the search model. In general terms, it says that the wage rate should be a weighted average of the worker’s reservation wage (the outside factors) and the net marginal product of labour (the inside factors). A semi-reduced form equation for wages is derived by substituting rU out of (37) by making use of (33) and the maximisation conditions (36) and (31), to obtain equation (22) of the text.

REFERENCES

Atkinson, A. and Micklewright, J., (1991) 'Unemployment Compensation and Labor Market Transitions: A Critical Review', Journal of Economic Literature, 29, pp.1679-1727.

Barker, T. and Gardiner, B., (1995) 'Employment, Wage Formation and Pricing in the European Union: Empirical Modelling of Environmental Tax Reform, Economics, Energy, Environment', Working Paper No.53.95, Fondazione Eni Enrico Mattei.

Blanchard, O. and Diamond, P., (1989) 'The Beveridge Curve', Brookings Papers on Economic Activity, 1:1989, 1-60.

Bovenberg, A. and van der Ploeg, F., (1994) 'Consequences Of Environmental Tax Reform for Involuntary Unemployment and Welfare', mimeo.

Davis, S. and Haltiwanger, J., (1992) 'Gross Job Creation, Gross Job Destruction and Employment Reallocation', Quarterly Journal of Economics, 107, pp.819-864.

Dertouzos, J. and Pencavel, J., (1980) 'Wage and Employment Determination Under Trade Unionism: The International Typographical Union', Journal of Political Economy, 89, pp.1162-1181.

European Commission (1994) 'Growth, Competitiveness, Employment: The Challenges and Ways Forward into the 21st Century', White Paper (Office for Official Publications of the European Community: Luxembourg).

Farber, H., (1986) 'The Analysis of Union Behavior', in O. Ashenfelter and R. Layard, eds, *Handbook of Labor Economics, Vol. II* (North-Holland: Amsterdam).

Holmlund, B. and Kolm, A-S., (1995) 'Progressive Taxation, Wage Setting and Unemployment — Theory and Swedish Evidence, Tax Evaluation', Report No.15 (National Institute of Economic Research, Economic Council: Stockholm).

Hoon, H. and Phelps, E., (1995) 'Taxes and Subsidies in a Labor-Turnover Model of the 'Natural Rate'', mimeo.

Johnson, G. and Layard, R., (1986) 'The Natural Rate Of Unemployment: Explanation and Policy', in O. Ashenfelter and R. Layard, eds, *Handbook of Labor Economics, Vol. II* (North-Holland: Amsterdam).

Killingsworth, M. and Heckman, J., (1986) 'Female Labor Supply: A Survey', in O. Ashenfelter and R. Layard, eds, *Handbook of Labor Economics, Vol. I* (North-Holland: Amsterdam).

Layard, R., (1982) 'Is Incomes Policy the Answer to Unemployment?', Economica, 49, pp.219-240.

Layard, R., Nickell, S. and Jackman, R., (1991) *Unemployment* (Oxford University Press: Oxford).

Lockwood, B. and Manning, A., (1993) 'Wage Setting and the Tax System: Theory and Evidence for the UK', Centre for Economic Performance, Discussion Paper No.115 (London School of Economics: London).

Mortensen, D. and Pissarides, C., (1994) 'Job Creation and Job Destruction in the Theory of Unemployment, Review of Economic Studies, 61, pp.397-415.

Nickell, S. and Andrews, M., (1983) 'Unions, Real Wages and Employment In Britain 1951-79', Oxford Economic Papers, 35 (Supplement), pp.183-206.

OECD, (1993) *Employment Outlook* (Paris).

OECD, (1994) *The OECD Jobs Study* (Paris).

Oswald, A., (1982) The Microeconomic Theory of the Trade Union, Economic Journal, 92, pp.576-596.

Pencavel, J., (1986) 'Labor Supply of Men: A Survey', in O. Ashenfelter and R. Layard, Eds, *Handbook of Labor Economics, Vol. I* (North-Holland: Amsterdam).

Phelps, E., (1994) *Structural Slumps* (Harvard University Press, Cambridge: Mass).

Phelps, E. *et al*, (1970) *Microeconomic Foundations of Employment and Inflation Theory* (Norton: New York).

Pissarides, C., (1986) 'Vacancies and Unemployment in Britain', Economic Policy, 3, pp.499-559.

Pissarides, C., (1990) *Equilibrium Unemployment Theory* (Blackwell: Oxford).

Sargent, T., (1979) *Macroeconomic Theory*, (Academic Press: New York).

Shapiro, C. and Stiglitz, J., (1984) 'Unemployment as a Worker Discipline Device', American Economic Review, 74, pp.433-444.

Solow, R., (1978) 'Another Possible Source of Wage Stickiness', Journal of Macroeconomics, 1, pp.79-82.

Symons, J. and Robertson, D., (1990) 'Employer Versus Employee Taxation: The Impact on Employment', in *OECD Employment Outlook* (OECD: Paris).

Tyrvainen, T., (1995) 'Real Wage Resistance and Unemployment: Multivariate Analysis of Cointegrating Relations in 10 OECD Countries', The OECD Jobs Study Working Papers Series, No. 10 (OECD: Paris).

Weiss, A., (1991) *Efficiency Wages* (Princeton University Press, Princeton: NJ).

Zabalza, A., Pissarides, C. and Barton, M., (1980) 'Social Security and the Choice between Full-time Work, Part-time Work and Retirement', Journal of Public Economics, 14, pp.245-276.