DISCUSSION PAPER SERIES

No. 2541

MEASURING THE EQUILIBRIUM EFFECTS OF UNEMPLOYMENT BENEFITS DISPERSION

Aico van Vuuren, Gerard J van den Berg and Geert Ridder

LABOUR ECONOMICS

Centre for **E**conomic **P**olicy **R**esearch

www.cepr.org

ISSN 0265-8003

MEASURING THE EQUILIBRIUM EFFECTS OF UNEMPLOYMENT BENEFITS DISPERSION

Aico van Vuuren, Vrije Universiteit Amsterdam
Gerard J van den Berg, Vrije Universiteit Amsterdam and CEPR
Geert Ridder, Johns Hopkins University

Discussion Paper No. 2541
August 2000

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

This Discussion Paper is issued under the auspices of the Centre's research programme in **Labour Economics**. Any opinions expressed here are those of the author(s) and not those of the Centre for Economic Policy Research. Research disseminated by CEPR may include views on policy, but the Centre itself takes no institutional policy positions.

The Centre for Economic Policy Research was established in 1983 as a private educational charity, to promote independent analysis and public discussion of open economies and the relations among them. It is pluralist and non-partisan, bringing economic research to bear on the analysis of medium- and long-run policy questions. Institutional (core) finance for the Centre has been provided through major grants from the Economic and Social Research Council, under which an ESRC Resource Centre operates within CEPR; the Esmée Fairbairn Charitable Trust; and the Bank of England. These organizations do not give prior review to the Centre's publications, nor do they necessarily endorse the views expressed therein.

These Discussion Papers often represent preliminary or incomplete work, circulated to encourage discussion and comment. Citation and use of such a paper should take account of its provisional character.

Copyright: Aico van Vuuren, Gerard J van den Berg and Geert Ridder

CEPR Discussion Paper No. 2541

August 2000

ABSTRACT

Measuring the Equilibrium Effects of Unemployment Benefits Dispersion*

We analyse the impact of unemployment benefits and minimum wages using an equilibrium search model, which allows for dispersion of benefits and productivity levels, job-to-job transitions, and structural and frictional unemployment. The estimation method uses readily available aggregate data on marginal distributions of unemployment durations as well as wages and benefit levels. Different causes of structural and frictional unemployment are investigated. We investigate the efficiency of the imposition of a single benefit level for all household types and the introduction of an Earned Income Tax Credit.

JEL Classification: C41, E24, J31 and J64
Keywords: benefit levels, equilibrium search, minimum wages, wages and welfare

Aico van Vuuren
Department of Economics
Vrije Universiteit
De Boelelaan 1105
NL-1081 HV Amsterdam
HOLLAND
Tel: (31 20) 444 6120
Fax: (31 20) 444 6005
Email: vuuren@tinbergen.nl

Gerard J van den Berg
Department of Economics
Vrije Universiteit
De Boelelaan 1105
NL-1081 HV Amsterdam
HOLLAND
Tel: (31 20) 444 6132
Fax: (31 20) 444 6020
Email: gjvdberg@xs4all.nl

Geert Ridder
Department of Economics
The Johns Hopkins University
Baltimore
MD 21218-2685
USA
Tel: (1 410) 516 7614
Fax: (1 410) 516 7600
Email: gridder@jhu.edu

*We thank Audra Bowlus, Maarten Lindeboom and participants at the Journal of Applied Econometrics Conference on Inference and Decision Making, in particular our discussant John Rust, for very useful comments.

Submitted 25 July 2000

NON-TECHNICAL SUMMARY

This Paper analyses the impact of unemployment benefits and minimum wages using an equilibrium search model, which allows for dispersion of benefits and productivity levels, job-to-job transitions, and structural and frictional unemployment. We use a model of a labour market with imperfect information, where workers and employers search optimally for a suitable match. Previous research finds that the impact of the minimum wage and the unemployment benefits system on social welfare depends highly on the particular assumptions being made. Our model is quite general, where we use a framework of **equilibrium on-the-job search** in combination with both **between market heterogeneity in productivity** and **within market heterogeneity in unemployment income**. This model allows for three types of unemployment that react differently to changes in the minimum wage: frictional unemployment that is independent of both the minimum wage and unemployment benefits, structural unemployment due to a high minimum wage, and 'voluntary' unemployment that increases with the level of unemployment benefits, but decreases with an increase in the minimum wage. Hence, the effect of an increase in the minimum wage on the level of unemployment is indeterminate and only empirical research can determine which effect dominates. The sign and size of the effect are determined by a few parameters and the main goal of this Paper is to estimate these parameters in order to assess the importance of the various types of unemployment and the likely effect of changes in the minimum wage and the unemployment benefits system.

Since we allow for unemployment benefits dispersion and we intend to examine counterfactual benefits distributions, we have to be specific about the benefits system and the determinants of the individual benefits level. Over the years the unemployment benefits system has become a complicated system of income protection for workers who have lost their job. Its core is the unemployment insurance system that was introduced after World War II. Unemployment insurance benefits protect workers, in particular workers with insufficient savings, during their search for a new job. Without this protection workers would be forced to accept jobs at a much lower wage than they earned in their last job. In the wage posting model that is the basis for our empirical work, unemployment insurance benefits increase the correlation between the wage in the new job and the value of the (marginal) product of the worker.

We use our model to evaluate the unemployment benefits and tax system of the United Kingdom. In the United Kingdom, unemployment insurance benefits are independent of income in the last job and this simplifies the empirical analysis. An additional interesting feature of the system in the United Kingdom is the presence of the Family Credit. This is an in-work benefits

system depending on the number of children, the age of the children and net income. We find that, due to the Family Credit, parents have relatively high incentives to accept jobs. This implies that these individuals should have shorter unemployment spells, which is confirmed by recent research in duration models for the United Kingdom.

We obtain good results from our stylized model. There are many unrealistic aspects, but it is hard to think of any model that is not unrealistic in many respects. We find that 80% of total unemployment is due to search frictions. The remaining part results from the mandatory minimum wages and unemployment benefits, where the latter is most important. We find that the unemployment rate of households with children is only determined by the mandatory minimum wage. Hence, marginal increases of the unemployment benefits of these households as well as their in-work benefits do not change unemployment rates. From our policy simulations, we also find that changes in the unemployment benefits to their average level have quite important positive effects on social welfare. This is mainly due to the fact that such a policy decreases the reservation wage of households without children. Other policy simulations involving benefits, like changing all unemployment benefits with a fixed percentage or an increase in benefits to the highest level, have a smaller effect on social welfare, even if they change the system considerably. Increasing the mandatory minimum wage affects the level of social welfare by increasing structural unemployment among parents. The unemployment rates among households without children are not affected.

We evaluate the present system of the Family Credit by comparing it with our predictions in the situation that it does not exist. We find that such a policy increases both structural and total unemployment and that social welfare is reduced. Although the costs of the present Family Credit are high, these are outweighed by the decrease in unemployment benefits. Since we find that households with children already have sufficient incentives to accept jobs at the minimum wage, extending the present system to these households does not improve social welfare. Social welfare is increased by a lower minimum wage for households with children, if such a selective minimum wage were possible.

1 Introduction

The effect of minimum wages and unemployment benefits on the level and composition of unemployment is one of the most intensively researched issues in labor economics. In this article we contribute to the extensive literature on this effect by developing a new empirical approach that has important advantages over existing methods, because (1) it is based on a structural model that assumes that workers and employers make optimal decisions (2) the structural model is an equilibrium model of the labor market (3) the model allows for an interaction effect of changes in unemployment benefits and minimum wages (4) the model can be estimated using readily available aggregate data. In many models that are used to estimate the effect of minimum wages and unemployment benefits, the sign of the effect is given. Examples are the standard competitive model of the labor market, in which an increase in the minimum wage decreases employment, and the standard partial equilibrium job search model that predicts that an increase in unemployment benefits lengthens the duration of unemployment. Our empirical model nests the standard competitive model (but not the partial job search model), so that we can assess the deviation from the competitive model and the associated deviation from the predicted effect.

Our model is a model of a labor market with imperfect information, where workers and employers search optimally for a suitable match[1]. Initially search models focused on worker behavior, i.e. on labor supply (see the surveys of Devine and Kiefer, 1991, Layard, Nickell and Jackman, 1991, and Wolpin, 1995). In these models wage offers are draws from a wage offer distribution that is exogenous and invariant to changes in policy variables. Because the optimal search strategy of job seekers is given by a reservation wage and wages are set by employers or by bargaining between employers and job seekers, the partial equilibrium model implicitly assumes that employers ignore the reservation wage(s) when setting wage offers. In a seminal contribution Diamond (1971) showed that in a labor market where both workers and firms are identical and only the unemployed search for a job, the unique equilibrium wage offer distribution is degenerate in the common opportunity cost of employment, which is the wage that would prevail if there were a single monopsonist. In this equilibrium all job offers are acceptable to the unemployed, and the unemployment rate is independent of the opportunity cost of employment and, in particular, of unemployment benefits.

Diamond's result suggested that in equilibrium wage offers are not dispersed.

[1] Mortensen (1986) and Mortensen and Pissarides (1999) survey search models of labor markets.

This led researchers to formulate models in which the equilibrium wage offer distribution is not degenerate. Diamond assumed that workers and firms are identical and that only the unemployed search. Albrecht and Axell (1984) showed that the equilibrium wage offer distribution is nondegenerate if workers differ with respect to the opportunity cost of employment and employers with respect to average productivity. Eckstein and Wolpin (1990) estimate this model on the assumption that there is a finite number of worker types (characterized by their opportunity cost of employment). In their model the support of the equilibrium wage offer distribution coincides with the reservation wages of the worker types. They infer the number of types and their opportunity cost of employment from the observed distributions of unemployment spells and accepted wages. Because the observed distribution of accepted wages is not discrete, they assume that wages are measured with error to obtain an acceptable fit to the data. They find that the number of types is small (seven), and that the opportunity costs of employment are small and close together (the largest is 9.5% larger than the smallest), so that the reservation wages are all located in the left tail of the distribution of accepted wages. As a consequence most of the variation in the observed accepted wages is explained by the measurement error. We avoid some of these problems by equating non-employment income to unemployment benefits and by using the rules of the benefits system to impute the distribution of the opportunity cost of employment.

A second problem is that in the Albrecht-Axell-Eckstein-Wolpin model an increase in the minimum wage decreases unemployment and increases employment, if the minimum wage exceeds the reservation wage of the workers with the lowest opportunity cost of employment. The reason is that an increase in the minimum wage forces low productivity employers to close down and the upward shift in the wage offers of the remaining employers increases the probability that a wage offer is acceptable to a job seeker. Although there is weak empirical evidence that in some labor markets an increase in the minimum wage may lead to a higher level of employment (Card and Krueger (1995)), most empirical studies find negative effects. In the Albrecht-Axell-Eckstein-Wolpin model an increase in unemployment benefits has two effects. First, just as an increase in the minimum wage, it forces low productivity employers out. However, if the increase is general, it also raises the reservation wages of workers with a relatively high non-employment income. Some employers can no longer afford these workers and switch to a lower wage offer. The relative size of these effects, which is determined by the shape of the productivity distribution, determines the sign of the effect of unemployment benefits on unemployment. Albrecht and Axell show that if the density of the productivity distribution is increasing, then the second effect dominates and an increase in unemployment benefits increases the unemployment rate. If all employers have the same average productivity, the model becomes a standard monopsony model with a single profit maximizing wage offer, in which an increase in the minimum wage has no effect on unemployment (it just redistributes rents from firms to workers) and an increase in unemployment benefits only leads to unemployment if these benefits exceed the average productivity.

Mortensen (1990) and Burdett and Mortensen (1998) generalized the assumption that only the unemployed search. If moving to another job is costless, the reservation wage of employed workers is equal to their current wage. Together with the fact that the profit per worker is a continuous function of the wage, this implies that the equilibrium wage offer distribution is dispersed. In the simplest version of this model all workers and firms are identical. In that case all wage offers are acceptable to the unemployed and the level of unemployment is independent of unemployment benefits, if non-employment income is below the value of production per worker. The same is true for the minimum wage. An interesting feature of the model is that is nests both the pure monopsony model of Diamond and the competitive model as special cases.

The assumption that all workers and firms are identical is clearly counterfactual and in empirical studies that estimate this model either worker or firm heterogeneity or both are introduced (see Ridder and Van den Berg, 1997, for an overview). Worker and firm heterogeneity not only improve the fit of the model to the data, they also imply nontrivial policy effects. As in the Albrecht-Axell-Eckstein-Wolpin model we distinguish between variation in the productivity of firms and variation in nonemployment income. Productivity heterogeneity may be due to differences in the production technology of firms or to the fact that firms employ different types of workers. In the first case it is natural to assume that there is a single labor market with identical workers. Bontemps, Robin, and Van den Berg (2000) propose and estimate such a model with within (the single) labor market heterogeneity. In that model the minimum wage and unemployment benefits have no effect on unemployment. An increase of the minimum wage makes low productivity firms unprofitable and their employees move to more productive and higher paying firms. If workers differ in productivity, the assumption that they operate on separate labor markets is more attractive[2]. With this assumption the minimum wage may have a positive effect on the level of unemployment and a negative effect on employment, because employees of firms that become unprof-

[2]The intermediate case is most likely closer to the truth, but with the type of data used in this study we can not infer the structure of the labor market

itable, will not be employed by other firms. Hence, the model allows for both structural and frictional unemployment. Because the unemployed still accept all job offers, the level of unemployment is independent of unemployment income, as long as it is below either the minimum wage or the lowest productivity. This is the model estimated by e.g. Van den Berg and Ridder (1998).

Mortensen (1990) and Bontemps, Robin, and Van den Berg (1999) extend the model with within market heterogeneity in productivity with within market heterogeneity in the level of unemployment income. The latter assumption is natural, because an important source of variation, unemployment benefits, is mainly due to social considerations that are only weakly related to differences in productivity. With this type of heterogeneity some unemployed reject a fraction of the job offers and this leads to unemployment due to high reservation wages. As in the Albrecht-Axell-Eckstein-Wolpin model an increase in the minimum wage decreases the level of unemployment, because it increases the fraction of job offers that are acceptable to the unemployed.

In this paper we combine between market heterogeneity in productivity with within market heterogeneity in unemployment income. This model allows for three types of unemployment that react differently to changes in the minimum wage: frictional unemployment that is independent of both the minimum wage and unemployment benefits, structural unemployment due to a high minimum wage, and 'voluntary' unemployment that increases with the level of unemployment benefits, but decreases with an increase in the minimum wage. Hence, the effect of an increase in the minimum wage on the level of unemployment is indeterminate and only empirical research can determine which effect dominates. The sign and size of the effect are determined by a few parameters and the main goal of this paper is to estimate these parameters in order to assess the importance of the various types of unemployment and the likely effect of changes in the minimum wage and the unemployment benefits system.

Since we allow for unemployment benefits dispersion and we intend to examine counterfactual benefits distributions, we have to be specific about the benefits system and the determinants of the individual benefits level. Over the years the unemployment benefits system has become a complicated system of income protection for workers who have lost their job. Its core is the unemployment insurance system that was introduced after World War II. Unemployment insurance benefits protect workers, in particular workers with insufficient savings, during their search for a new job. Without this protection workers would be forced to accept jobs at a much lower wage than they earned in their last job. In the wage posting model that is the basis for our empirical work, unemployment insurance benefits increase the correlation between the wage in the new job and the value of the (marginal) product of the worker.

The unemployment insurance systems differ considerably between countries. The main differences are in the eligibility, the duration of benefits, and the replacement rate, i.e. the ratio of the benefits to income in the job that was lost. In most countries these benefits support job search up to a year. The replacement rate is at most 70% of previous income, but in many cases much lower. In some countries the replacement rates are needs based, being higher for couples with a single earner, and in most countries unemployment insurance benefits are supplemented by other types of benefits. Many countries have unemployment assistance benefits for unemployed who exhaust their unemployment insurance benefits. These are usually not a fraction of previous income and often means tested. Often supplements are paid to single-earner households and/or households with children and this increases the replacement rates for these households. In some countries the supplements are paid as housing benefits. An additional complication is that some countries also have a social assistance program that supports individuals and households that do not qualify for unemployment insurance or assistance benefits, and social assistance benefits usually act as a lower bound on unemployment benefits.

This complicated system of income protection for the unemployed leads to a substantial variation in replacement rates between types of households, but surprisingly not between countries (with a few exceptions) and over the duration of the spell of unemployment. In a comparison of 18 countries, the OECD found that at the average wage, unemployment insurance benefits replaced on average 52% of previous gross earnings (OECD, 1997). The net (of tax) replacement rates including supplemental benefits for a couple with children was on average 73% in the first month of unemployment and 67% after 5 years of unemployment[3]. The decline in the replacement rate during the unemployment spell is larger for couples without children and single-person households, but smaller for couples with children who earned a wage below the average.

We conclude that (i) although the unemployment insurance benefits decline during the spell of unemployment, the supplemental benefits make this decline less pronounced, and (ii) replacement rates differ between household types. In fact, we will assume that, for a given household type, the unemployment income is essentially constant during the spell of unemployment. Van den Berg (1990) shows that it is optimal for unemployed workers to anticipate a future decline of the benefits level by reducing the reservation wage before the actual decline. As

[3]The exception is Italy with a 11% replacement rate after 5 years.

a result, the optimal reservation wage path declines less than might be expected on the basis of the magnitude of the benefits declines. The reservation wage is generally close to the constant reservation wage level in a stationary model where the benefits level is an average of the actual successive levels during a spell[4].

We should note that in general a constant benefits level does not correspond to the socially optimal outcome. For example, in the context of a frictional labor market, Hopenhayn and Nicolini (1997) show that an optimal benefits system entails that benefits decline during unemployment. However, investigations of the effects of decreasing benefits and the socially optimal system are beyond the scope of this paper.

In our empirical work we take account of the variation of benefits between household types. In many countries the unemployment insurance (but not the unemployment or social assistance) benefits are related to the income in the last job. This provides a second source of variation in unemployment benefits. In our model we ignore this type of variation. We shall argue that this variation may influence wage setting at higher wages. However, we want to concentrate on the lower end of the labor market where the disincentive effects of the benefits system are more important. To avoid biases, we estimate the model for a country, the UK, in which the unemployment insurance benefits are not related to previous earnings.

The high replacement rates for particular types of households have led to concern that work is hardly attractive to members of such households. Such households are caught in an unemployment trap, which may become a poverty trap. An important contribution of this paper is to quantify this unemployment trap. It is important to do this in an equilibrium model of the labor market, because this allows us to distinguish between the case that job seekers turn down offers and the case that it is not profitable for firms to employ workers at their reservation wage. The unemployment trap refers to the first case, because in the latter the unemployed do not receive any job offers. If this case applies, the jobs "just are not there", as often stated by frustrated job seekers.

A policy intervention that makes work more attractive is the introduction of

[4]In principle, it would be preferable to incorporate any benefits declines into the equilibrium model. Due to their complexity, such models have not been analyzed in the literature. The path of the optimal reservation wage follows a differential equation that cannot be solved analytically except for special functional forms for the wage offer distribution. The labor supply of a firm at a given point of time is affected by the cross-sectional distribution of reservation wages across unemployed individuals who are at different stages of their spells. It is not clear what the equilibrium properties are. Perhaps more importantly, from a computational point of view, the empirical analysis of such models seems extremely complicated.

benefits that are conditional on employment. Examples are the Earned Income Tax Credit in the US and the Family Credit in the UK. As we shall show, in a wage posting model these benefits have the same effect as a reduction in the unemployment benefits. In our empirical work, we shall estimate the effect of the Family Credit on labor market outcomes, taking account of the responses of employers. Hence, our work supplements earlier studies of the FC that only considered labor supply responses (Scholz, 1996). When the FC was introduced some critics expressed concern that it would be an implicit wage subsidy to low-wage employers (OECD, 1997). We shall quantify this effect.

Full estimation of equilibrium search models with longitudinal labor force survey data is a non-trivial task and requires data of high quality covering long time spans, as is obvious from the empirical studies above. Such data are not readily available for every country. In this paper we show that the structural model parameters can be estimated from cross-sectional data that are obtained from yearly cross-sectional surveys (such as the US Current Population Survey (CPS) and the EC Labor Force Surveys (LFS); these aggregate data are obtained from readily available OECD and EUROSTAT publications). This may come as a surprise, since equilibrium search models deal with interrelations between duration and wage variables, while aggregate data only contain information on the marginal distributions of wages, benefits, and durations.

The paper is organized as follows. The next section presents the theoretical model. Section 3 describes the institutional aspects of the benefits and income tax system, and it discusses the data. The empirical implementation is discussed in section 4 and the estimation results are in section 5. Section 6 discusses the policy simulations of our paper. Finally, section 7 summarizes our main findings.

2 The equilibrium search model

2.1 Submarkets

We assume that the labor market can be segmented into a large number, to be precise a continuum, of submarkets. In a submarket workers with a common marginal value product, denoted by p interact with firms that are identical, except for the size of their workforce. The distribution of productivity levels over the submarkets is given by the cdf Γ. We assume that workers and firms stay in their submarket. Hence, we may think of p as an endowment, e.g. related to specific skills of workers that are required by a specific group of firms or the level of productivity at a particular location, and not as a characteristic that can be changed by investment by either the worker, e.g. in schooling, or the firm, e.g. in capital goods. Alternatively, we may think of p as a characteristic that can be changed by investment. In that case, we assume that all investment decisions have been made, and no further investment takes place. In our empirical work, we do not relate p to observed characteristics of workers and/or firms, so that the distinction is moot.

2.2 Workers

Every worker in a particular submarket is either unemployed or employed. If unemployed he or she receives unemployment benefits that depend on the type of household that he or she belongs to. Household types are denoted by $h = 1, \ldots, H$ and the unemployment benefits of a worker in household type h is denoted by b_h. The income tax rate also depends on h and b_h is the after-tax benefit. The household type is not related to any other characteristic of the worker or firm in the model. In particular, we assume that the distribution of p is the same for workers belonging to different household types. If the total mass of workers is normalized to 1, then m_h, $h = 1, \ldots, H$ is the fraction of workers who belong to household type h. Without loss of generality we order household types by increasing net unemployment benefits.

The assumption of independence between the productivity and household type is made for convenience. In particular, the use of aggregate data makes an assumption like this necessary if we do not have information about wages and unemployment spells of individuals in particular household types. There is some evidence that this assumption does not hold for some types of households. For example, Bartholomew, Hibbet and Sidaway (1992) find that single mothers are on average less qualified than married mothers.

Job offers arrive according to a Poisson process, with arrival rate λ that is the same for employed and unemployed workers. The assumption that the job offer arrival rate is the same in employment and unemployment deserves some discussion. If we relax this assumption then the model becomes empirically intractable, because then the unemployed workers' reservation wages depend on all structural determinants (see Mortensen, 1990). Moreover, the currently available aggregate data are not informative on the job offer arrival rate of the employed (Ridder and Van den Berg, 1999). Of course, this assumption is restrictive. Other empirical studies based on equilibrium search models either find that the arrival rates are of similar magnitude (see e.g. Van den Berg and Ridder, 1998) or that the arrival rate of job offers of employees is an order of magnitude smaller than that of unemployed job searchers (Kiefer and Neumann, 1993, and Bontemps, Robin and Van den Berg, 2000). The only other studies in which equilibrium search models with benefits dispersion have been estimated assume either that employed workers receive offers at the same rate as the unemployed (Bontemps, Robin and Van den Berg, 1999) or that they do *not* receive alternative offers (Eckstein and Wolpin, 1990). The offer arrival rate is a technology parameter in this model. An implication of the model is that in equilibrium firms make positive profits. This could lead to the entry of additional firms, provided that there is no fixed cost of entry. This may increases the offer arrival rate, because more firms are looking for workers. Zero profits correspond to an infinite arrival rate, and in that case the wage is equal to the marginal product of the workers. In practice, there is an upper limit to the arrival rate, because there are informational frictions.

Employed workers become unemployed at a rate δ. In the remainder of this paper, we write κ for the ratio λ/δ. This parameter can be interpreted as the average number of job offers during a spell of employment. Workers maximize their expected future wealth, discounted at a rate ρ. Because we consider a steady state the parameter δ is not a control variable of the firm in the adjustment of its workforce. It is more appropriate to think of this parameter as reflecting individual idiosyncratic unemployment risk. Models in which both the arrival rate, determined by a matching function, and the job destruction rate are endogenous are reviewed by Pissarides (1990).

When a job is offered to a worker, he or she has to decide whether to accept or reject the job. Since jobs have just one characteristic, the wage level, the optimal strategy depends only on the wage and has the reservation wage property. If there are no job mobility costs, the reservation wage of employed individuals is equal to the wage in their current job[5]. Transition costs for the unemployed and the employed increase their reservation wage because workers have to be compensated for the costs associated with the expected number of future transitions. The transition costs also enter the equilibrium wage offer distribution. Because employers can more easily hold on to their employees, their monopsony power increases and the wage offers will be lower. As a result the structural unemployment associated with the minimum wage increases, as does the unemployment due to rejected wage offers. There is no effect on frictional unemployment. We conjecture that these effects are small.

Because the offer arrival rate of an unemployed worker remains the same if

[5]This assumption is maintained in the paper. The model becomes empirically intractable if there are positive transition costs for the employed. See Van den Berg (1992) for a partial job search model with transition costs.

he or she accepts a job, the after-tax reservation wage is equal to the after-tax unemployment benefits. The computation of the before-tax reservation wage is complicated by employment-conditional benefits as the Earned Income Tax Credit (EITC) in the US and the Family Credit (FC) in the UK. These are determined by the net income in the job. If the reservation wage is denoted by ξ_h, then the net reservation wage is equal to $\xi_h - \tau_h(\xi_h)\xi_h$ with $\tau_h(.)$ the tax schedule. The corresponding tax credit is denoted by d_h. The net income in the marginal job is the sum of these components, and also equal to net income while unemployed b_h. Hence, the reservation wage is the solution of $\xi_h - \tau_h(\xi_h)\xi_h + d_h = b_h$.

Note that an employment-conditional tax credit is equivalent to the reduction of the after-tax unemployment benefits by the value of the tax credit. The reservation wage decreases with the tax credit and in this sense the introduction of the credit can be seen as a painless (to the unemployed) reduction of the unemployment benefits. If the marginal tax rate is less than 100%, then it always pays to accept a job with a higher wage. Because in our model we do not consider the hours decision and workers always supply either zero or a fixed number of hours, the behavior of employed workers is unaffected by the tax system. For that reason, it is convenient to use before-tax quantities in the model. The only place where the tax system plays a role is in the determination of the reservation wage of the unemployed.

2.3 Firms

We define $l(w|p)$ as the steady-state workforce of a firm that offers a gross wage w, given that it operates in the submarket with productivity level p. The gross wage is the before-tax wage, but after social security contributions. The latter is innocuous, if we interpret p as the value product after deduction of this contribution. An increase in this contribution shifts the distribution of p and could lead to a higher level of structural unemployment as defined below. We do not consider social security contributions in the sequel. Employers are assumed to maximize their steady-state profit flow

$$\pi(w|p) = (p - w)\, l\,(w|p) \tag{1}$$

We make the assumption that a firm offers the same wage to all its potential employees. This assumption deserves some discussion in the light of the fact that potential employees have different reservation wages. If firms observe the values of b, they could exploit this by offering lower wages to applicants with a lower non-employment income. We thus have to assume that firms are not able to observe the values of b of job applicants, or that they are not allowed to pay different wages to individuals with different b values, or that the costs involved in paying different wages to individuals with different b values are too high (Bontemps, Robin and Van den Berg, 1999).

The employers' optimal strategy has two stages. First, they decide whether to participate or not and next, if they decide to participate, they make a wage offer. For the moment, we assume that there is no mandatory minimum wage. It is obvious that $l(w|p) = 0$, whenever $w < \xi_1$, i.e. below the lowest reservation wage of the unemployed, and firms offering wages below ξ_1 do not participate in their labor submarket. Hence, the optimal strategy is to participate if and only if the productivity level is higher than the lowest reservation wage. The distribution of the wages offered in a submarket is given by a distribution function $F(w|p)$. The support of the wage offer distribution is equal to the set of profit maximizing wages, which we denote by $\mathcal{W}(p)$. The infimum and supremum of the support are denoted by $\underline{w}(p)$ and $\overline{w}(p)$. The lowest wage offered in a submarket is equal to the reservation wage of some type of worker. As shown by Mortensen, the type is given by $\arg\max_{h=1,\ldots,H}\left\{(p-\xi_h)\sum_{k=1}^{h} m_k\right\}$, i.e. the type that maximizes profits if the supply consist of all workers that accept ξ_h if they were unemployed. Note that the strategy of the firms is a pure strategy if and only if $F(w|p)$ is degenerate.

2.4 Equilibrium in a submarket

For a particular submarket, is a special case of Mortensen's (1990) model. We assume that there is no productivity dispersion in submarkets and that the job offer arrival rates are the same for employed and unemployed workers. The equilibrium is a steady-state equilibrium in which worker flows to and from unemployment and to and from firms that pay a wage w are equal. Moreover all firms in a submarket have equal profits. The equal profit condition defines the equilibrium wage offer distribution.

The equality of worker flows relates the wage offers to the wages earned by a cross-section of workers in a submarket. The latter distribution is the earnings distribution, and is denoted by $G(w|p)$. The steady state unemployment rate of workers of type h in submarket p is

$$u_h(p) = \frac{1}{1+\kappa\overline{F}(\xi_h|p)} \tag{2}$$

and the total unemployment rate is

$$u(p) = \sum_{h=1}^{H} m_h u_h(p) \tag{3}$$

If we consider employees with a wage less than or equal to w, their number is $G(w)(1-u(p))$, then their outflow rate is equal to the sum of $\lambda\overline{F}(w \mid p)$, the outflow to better paying jobs, and δ, the outflow to unemployment. The inflow consists of unemployed workers with a reservation wage that is less than or equal to w, and who receive a wage offer that does not exceed w. Hence this inflow is equal to $\sum_{\xi_h \leq w} \lambda(F(w \mid p) - F(\xi_h \mid p))u_h(p)$. If we equate inflow to outflow, we obtain the following relation between G and F

$$G(w|p) = \frac{\kappa \sum_{w \geq \xi_h} m_h u_h(p) \left(F(w|p) - F(\xi_h|p)\right)}{\left(1 + \kappa\overline{F}(w|p)\right)(1 - u(p))} \tag{4}$$

Taking the derivative we have

$$g(w|p) = \frac{\kappa \sum_{w \geq \xi_h} m_h f(w|p)}{(1 + \kappa\overline{F}(w|p))^2 (1 - u(p))} \tag{5}$$

Because the number of firms that pay a wage w is equal to $f(w)dw$ and the number of workers that earn this wage is $g(w)(1-u(p))dw$, the number of employees at a firm that pays w is the ratio

$$l(w|p) = \frac{\kappa \sum_{w > \xi_h} m_h}{(1 + \kappa\overline{F}(w|p))^2} \tag{6}$$

In equilibrium all firms in a submarket are equally profitable. In particular, the profit rate is equal to that of the firm that offers the lowest wage $\underline{w}(p)$. From equation (6) it is easily seen that the equilibrium profit rate is

$$\pi(w) = \pi(\underline{w}(p)) = (p - \underline{w}(p)) \frac{\kappa}{(1+\kappa)^2} \sum_{\underline{w}(p) \geq \xi_h} m_h \tag{7}$$

Mortensen (1990) shows that the resulting equilibrium wage offer distribution is given by

$$F(w|p) = \min_{x \geq w} \varphi(x|p) \tag{8}$$

with

$$\varphi(w|p) = \frac{1+\kappa}{\kappa}\left(1 - \sqrt{\frac{(p-w)\sum_{w\geq\xi_h} m_h}{(p-\underline{w}(p))\sum_{\underline{w}(p)\geq\xi_h} m_h}}\right) \tag{9}$$

The density of the wage offer distribution is equal to

$$f(w|p) = \begin{cases} \varphi'(w|p) & \text{if } w \in \mathcal{W}(p) \\ 0 & \text{otherwise} \end{cases} \tag{10}$$

where $\mathcal{W}(p) = \{w|\varphi(w|p) \leq \varphi(x|p), w \leq x \leq \overline{w}(p)\}$ and $\varphi'(w|p)$ is the derivative of the function φ

$$\varphi'(w|p) = \frac{1+\kappa}{2\kappa}\frac{1}{\sqrt{(p-w)(p-\underline{w}(p))\sum_{w\geq\xi_h} m_h \sum_{\underline{w}(p)\geq\xi_h} m_h}} \tag{11}$$

Because the labor supply has positive discontinuous jumps at the reservation wages of the worker types (see equation (6)), employers who offer a wage in an interval below the reservation wage of a particular type of workers, can increase their profits by offering a wage equal to that reservation wage. This implies that there will be no wage offers in an interval below each reservation wage and the density $f(w|p)$ is 0 on that interval.

Closed form expressions can be derived for the conditional distributions $F(w|p)$ and $G(w|p)$. See the Appendix for more details.

The preceding discussion did not allow for a mandatory minimum wage. A few comments are in order. First, we use the notation w_{min} for the minimum wage and $\overline{\xi}_h := \max\{w_{min}, \xi_h\}$. Second, with a minimum wage firms in a labor market segment only participate if their productivity is at least as high as $\overline{\xi}_1$. Third, the new wage offer distribution first order stochastically dominates the wage offer distribution before the introduction of a minimum wage. Fourth, even if the minimum wage is binding in the sense that $\underline{w}(p) < w_{min}$ before its introduction, it is possible that this minimum wage is not in the support of the wage offer distribution. In that case the introduction of the mandatory minimum wage makes the lowest wage equal to the smallest reservation wage above the minimum wage. Finally, the introduction of a minimum wage does not have any effect if it is below the lowest reservation wage.

Note that an increase in the minimum wage has two effects. If the minimum wage is binding but stays below p, the increase shifts the wage offer distribution to the right. The fraction of unacceptable job offers decreases, so that the

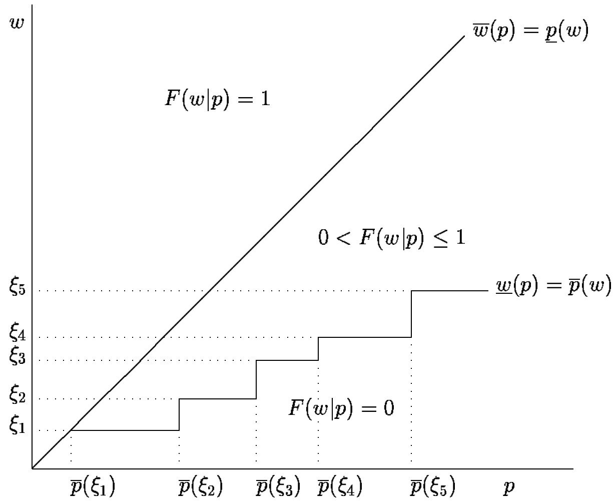

Figure 1: Support of the wage offer distribution by productivity level

high-reservation wage unemployment decreases. However, if the minimum wage exceeds p, then the labor market segment becomes unprofitable and the workers in it become (permanently) unemployed.

2.5 Aggregation over submarkets

The aggregate wage offer distribution is derived by integration over the distribution of p (*cf.* Koning, Ridder and Van den Berg, 1995)

$$\begin{aligned} F(w) &= \int_{\overline{\xi}_1}^{\overline{p}(w)} F(w|p) d\Gamma\left(p|p \geq \overline{\xi}_1\right) \\ &= \int_{\underline{p}(w)}^{\overline{p}(w)} F(w|p) d\Gamma\left(p|p \geq \overline{\xi}_1\right) + \Gamma\left(\underline{p}(w)|p \geq \overline{\xi}_1\right) \end{aligned} \tag{12}$$

The function $\underline{p}(w)$ is the inverse of the upper bound of the support of the wage offer distribution $\overline{w}(p)$ seen as a function of p (analogously $\overline{p}(w)$ is the inverse of the lower bound of the support $\underline{w}(p)$). Because the cdf of the wage offer distribution is equal to 1 if the wage is above this upper bound, integration over those values of p gives the second term (see figure 1).

The aggregate wage offer density function f is given by

$$f(w) = \int_{\underline{p}(w)}^{\overline{p}(w)} f(w|p) d\Gamma(p|p \geq \overline{\xi}_1) \tag{13}$$

The aggregate unemployment rate is given by (we split the integration interval; see figure 1)

$$u = \sum_{h=1}^{H} \int_{p \geq \bar{\xi}_1} \frac{m_h}{1+\kappa \overline{F}(\xi_h|p)} d\Gamma(p) = \sum_{h=1}^{H} m_h \Gamma(\underline{p}(\overline{\xi}_h)) + \tag{14}$$

$$\sum_{h=1}^{H} \int_{\underline{p}(\overline{\xi_h})}^{\overline{p}(\overline{\xi}_h)} \frac{m_h}{1+\kappa \overline{F}(\xi_h|p)} d\Gamma(p) + \frac{1}{1+\kappa} \sum_{h=1}^{H} m_h \overline{\Gamma}(\overline{p}(\overline{\xi}_h))$$

The third term on the right-hand side gives the unemployment in submarkets in which all offered wages are acceptable to the unemployed. The second term refers to submarkets where some but not all offers are acceptable to the unemployed, while the first term is for submarkets where none of the wage offers are acceptable.

As noted, all submarket wage offer distributions have intervals with zero density below the reservation wages. Because these reservation wages are independent of p, the aggregate wage offer distribution has the same property. This is clearly a less attractive feature of the equilibrium distribution. We will not try to mask it by introducing measurement error in the wages.

2.6 A decomposition of unemployment

The unemployment rate can be decomposed into a structural and frictional part. This decomposition is implicit in equation (14). The first component on the right-hand side of (14), can be decomposed as

$$\sum_{\xi_h < w_{min}} m_h \Gamma(\underline{p}(w_{min})) + \sum_{\xi_h \geq w_{min}} m_h \Gamma(\underline{p}(\xi_h)) \tag{15}$$

The first component is the structural unemployment due to a high minimum wage. This component is equal to zero if $\xi_1 \geq w_{min}$, i.e. if the lowest reservation wage exceeds the minimum wage. The second component consists of unemployment due to high reservation wages, i.e. firms with a productivity below the reservation wage of some group of unemployed workers make offers that are not acceptable to these workers who prefer to remain unemployed. We denote these two components of unemployment by $u_{w_{min}}$ and u_b. These components are not independent: a lower minimum wage gives less unemployment due to a high minimum wage, but more unemployment due to high reservation wages.

The frictional component of unemployment is equal to the sum of the first two terms on the right-hand side of (14)

$$\frac{1}{1+\kappa}\sum_{h=1}^{H} m_h \overline{\Gamma}(\overline{p}(\overline{\xi}_h)) + \sum_{h=1}^{H} \int_{\underline{p}(\overline{\xi}_h)}^{\overline{p}(\overline{\xi}_h)} \frac{m_h}{1+\kappa \overline{F}(\overline{\xi}_h|p)} d\Gamma(p) \tag{16}$$

The first component consist of unemployment in submarkets where the unemployed of various types accept all job offers. The second component corresponds to submarkets where some of the unemployed turn down job offers.

3 Institutions and data

3.1 Unemployment benefits and income taxes

The structural model developed in section 2 is estimated for the United Kingdom. In the United Kingdom, unemployment insurance benefits are independent of income in the last job, and this simplifies the empirical analysis. If an unemployed worker is eligible for UI benefits, he or she receives these benefits for 1 year after a waiting period of 3 days. The benefit amount depends on the household situation and is 201 pounds per month for individuals and single parents and 325 pounds per month for couples.

There is no unemployment assistance for unemployed who exhaust their UI benefits. However, there is a social assistance system, Income Support (IS), for all households whose net income falls below a minimum level and whose members do not work more than 16 hours per week. In the calculation of the benefit amount the net income of the household from labor and other sources is taken into account. The maximum benefits are 201 pounds per month for single individuals and 316 pounds per month for couples. Supplements are paid for dependent children, depending on the age of the child. These supplements vary from 69 pounds per month for a child under 11 to 159 pounds per month for a dependent child above 18 years of age.

In addition the household receives housing benefits that are equal to the rent for those households who are eligible for IS. For non-eligible households, housing benefits are equal to the rent minus 65 percent of the difference between net income and the maximum benefit.

Finally, family benefits are paid to households with children below 15 years of age or below 19 if they are still in full-time non-advanced education. The benefits are equal to 45 pounds per month for the eldest child and 37 pounds per month for each additional child.

Household members are taxed individually. The marginal tax rate is progressive and varies from 20 to 40 percent. An important feature of the tax system in the United Kingdom is the existence of an earned income tax credit for adults, the Family Credit (FC). The actual payments from this in-work benefits system depend on the number of children, the age of the children and net income. For adults with two children (one below 11 and one between 11 and 15), the payments are equal to 292 pounds per month at the level of the minimum wage. This is quite a large amount compared to the level of unemployment benefits in the United Kingdom.

3.2 The data on unemployment durations and wages

The unemployment data are from the UK Labor Force Survey (LFS), which is part of the EUROSTAT LFS, and is held every quarter. From 1992, the methods and definitions of the surveys are harmonized across countries (see EUROSTAT, 1996b, for a summary). We therefore restrict attention to data from the years 1992 to 1996[6]. EUROSTAT publishes the results of the surveys in their annual report (see for example EUROSTAT, 1996a). For the UK, the annual report uses data from the Labor Force Survey of the second quarter of the year. These are not corrected for seasonal effects. The sample size of the Survey differs from period to period, but is on average equal to about 65,000 households. The LFS-UK is a rotating panel with a five wave rotation scheme. Respondents are interviewed five times at 13 week intervals and a fifth of the sample is replaced each quarter. The LFS in the UK consists of three different surveys to cover representativeness. First, there is a survey that covers Great Britain. The sampling unit for this survey is the postal address. This survey contains 16,600 addresses for each of the quarterly waves. Second, there is a survey for the far north of Scotland that has a very low population density. The small size of this survey makes it unimportant for the final results. Third, there is a separate survey for Northern Ireland, which is based on three different strata. The samples within these strata are randomly drawn and contain 5,200 addresses in total. The annual sampling fraction is larger for Northern Ireland than for Great Britain (approximately 1% as compared with 0.36%). The results of the combined survey are weighted to undo this regional imbalance. Moreover, weights are used to reproduce the known

[6]Ridder and Van den Berg (1999) show that the changes in definition had a major impact on the distribution of e.g. the unemployment spells

age and gender composition of the UK population.

We use unemployment rate data from these annual EUROSTAT reports. The corresponding unemployment definition is based on the ILO definition (i.e., self-reported: without work, actively searching, and immediately available for work). We also use the unemployment duration data from these annual reports. These concern the elapsed durations of currently unemployed individuals. Specifically, the durations are grouped into eight duration classes: < 1 month, $1-3$, $3-6$, $6-12$, $12-18$, $18-24$, and ≥ 24 months, and we observe the number of individuals who are in a certain duration class [7]. The duration is defined as the minimum of the duration of search for a job and the length of the period since the last job was held.

Data on earnings are based on the annual New Earnings Survey, conducted by the British Central Statistical Office. The survey is a 1% random sample of employees in Pay As You Earn (PAYE) schemes. This gives about 180,000 records in each year of our reference period. The data that we use are grouped, and they concern gross earnings of full-time employees. These gross earnings include occasional payments but exclude employer labor taxes. Earnings are classified into 24 earnings classes that range between 475 and 3500 pounds per month in 1994. The other years use similar classifications.

The tax rates for different wage levels are from OECD (1997). These tax rates refer to income taxes plus social security contributions minus benefits provided to employees, such as housing benefits and family benefits. We take the differences between household types into account. Figure 2 illustrates the calculated average tax rates.

Table 1 provides some descriptive statistics for the year 1994. As there was no mandatory minimum wage in the UK in the period of analysis, we use the smallest of the minimum wages that are set by the wage councils in the year 1993. These wage councils were independent bodies, made up of equal numbers of employer and union representatives and independent members. Since then the wage councils have been abolished. Instead, the UK now has a mandatory minimum wage that is identical for all industries.

Structurally unemployed individuals may be underrepresented in the unemployment data, because they may classify themselves as a nonparticipant or disabled. As a result, the unemployment rate in the data may underestimate the total unemployment rate, and the estimated structural unemployment may be

[7] We took the sum of the individuals with elapsed unemployment durations between 24 and 48 months and with 48 months and more to avoid the problems due to measurement errors for those individuals with long unemployment durations.

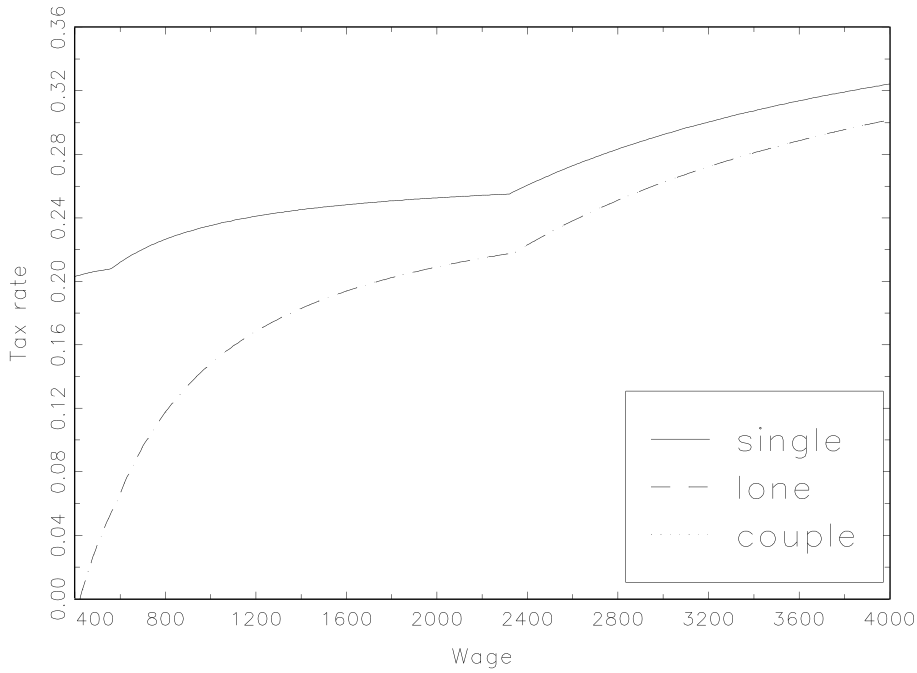

Figure 2: Average tax rates at different wage levels

downward biased. This problem cannot be solved by adding all nonparticipants to the unemployed, because the state of nonparticipation also includes individuals who do not participate by choice, e.g. homemakers. The current data do not enable a distinction between individuals who do not participate by choice and individuals who would participate if the wage floor were not binding. Previous empirical research found that the group of non-participants is quite heterogeneous and these individuals differ from the unemployed with respect to their transition rate to employment (Flinn and Heckman, 1983, Gönül, 1992, and Jones and Riddell, 1999). We report the UK non-participation rate in Table 1. This rate is high in comparison to other countries. It has to be stressed that it varies across different age groups.

Table 110 of EUROSTAT (1996a) provides more insight into the characteristics of the non-participants. Seven categories are distinguished: (1) awaiting recall to work, (2) own illness or disability, (3) personal or family responsibilities, (4) education or training, (5) retirement, (6) belief that no work is available, and (7) other reasons. We could consider the sixth category as comprising of discouraged workers who are structurally unemployed in our definition. Comparison of these figures with the figures of the OECD (see OECD 1995) indicates that this is indeed a good measure. In a sensitivity analysis, we include the discouraged workers in the group of structurally unemployed (see section 5).

Variable	
Unemployment	
Unemployment rate	0.097
Fraction with duration > 1 year	0.45
Fraction with duration > 2 years	0.27
Wages (earnings) [a]	
Minimum wage [b]	456
Mean wage	1378
Kaitz index [c]	0.32
D5/D1-ratio	1.78
D9/D5-ratio	1.86
D9/D1-ratio	3.31
Average replacement[b]	0.63
Marginal wedge	0.40
Non-participation	
Non-participation rate, age 20-65	0.30

[a] Gross levels, in Pound Sterling per month. Di is the i^{th} decile of the earnings distribution.
[b] Source: Central Planning Bureau (1995).
[c] The Kaitz index is defined as the ratio of minimum wage and average earnings, see Dolado et al. (1996).

Table 1: Some descriptive statistics for 1994

3.3 Construction of the unemployment benefits distribution

The benefits data provided by OECD (1997) are our starting point for the construction of the distribution of b in the population. These data concern calculated after-tax unemployment benefits for different types of households conditional on the event that the head of the household receives either unemployment insurance or social assistance. It is important to stress that these calculations are basically made for every worker in the labor force, so that the averages correspond to the average worker and not to the average currently unemployed worker. If calculations would be based on currently unemployed workers corrections for selectivity would have to be made to obtain the population distribution. The benefits include supplementary housing and family benefits. The calculations are for 1995. OECD (1997) distinguishes three prototypes of households: (1) single persons, (2) single parents with two children, and (3) married couples with two children. Table 3 summarizes these data.

We use the EUROSTAT LFS to translate the benefit distribution for households into the distribution for individuals. Table 114 of EUROSTAT (1996b) presents numbers of private households by household type. Members of a household who are under 15 years of age are counted as children, while members aged 15 or above are counted as adults. Therefore it is not unusual to find households with 3 or more adults. The LFS distinguishes 5 main types of households: (1) one person households, (2) several adults and no children (3) one adult with children, (4) two adults and children and (5) three or more adults and children. Note that the fourth category contains households with two parents and children below 15 as well as one-parent families with one of the children being 15 years or older. In Table 115 of EUROSTAT (1996b), the activity rates by household type are summarized. These give the number of household members in the labor force divided by the total number of adults within the household type, for each household type.

We obtain the benefits distribution over individuals by using the information of the two tables mentioned above. First, we multiply the number of households in each household type by the number of adults in each type. This gives the number of adults in a given household type. Note that we have to split up the second category mentioned above, since this category represents both two-adult households and three-or-more-adult households. We use a number of 3.37 adults in the case of a household with three or more adults. It turns out that the sensitivity of the estimation results with respect to this assumption is small. The

	Fraction of households	Fraction of adults in labor force	Fraction of adults
Single	0.7139	0.6865	0.6312
Single parent	0.0473	0.0249	0.0186
Couple	0.2388	0.2866	0.3503

Table 2: Distribution of households, adults, and adults in labor force over household types derived from the labor force survey

constructed benefits distribution does not change very much even if we use a value of 5 or 6. Next, we multiply the numbers of adults in the different household types by the corresponding activity rates. This results in a distribution for the five main household types described above. Now, recall that OECD (1997) only considers three household types. We classify individuals in households with several adults and no children, i.e. category 2 of the LFS classification as single. Moreover, we merge the fourth and fifth category to obtain the category of households with children.

Table 2 gives the distribution of households and adults over household types for the year 1994.

As noted in the introduction, we assume that for a given household type, unemployment income is constant during the spell of unemployment. Here, we operationalize this by taking the relevant benefit level to be a weighted average of the two successive benefit levels given in OECD (1997). The weights are the percentage of unemployed with a duration less than two years and the percentage with a duration of more than two years. We examine the sensitivity of the results with respect to this assumption. Figure 3 illustrates the resulting distributions of b. The second category (single parents) constitutes a small fraction of the labor force. This could be sensitive to the EUROSTAT (1996b) classification of household types, which does not distinguish between parents and other adults. It is possible that a fraction of the household categories (2), (4), and (5) are actually also one-parent families. Comparisons with official statistics of single parenthood in the United Kingdom suggests that this is indeed a serious problem in the labor force survey. For example, Haskey (1993) reports that there were around 1.3 million single parent households in the year 1991. In comparison, the labor force survey reports 766 thousand households with one adult and children in 1992. Again a sensitivity analysis is all we can do about this.

By invoking the relation $(1 - \tau_h(\xi_h))\xi_h + d_h = b_h$, we obtain the distribution

	Net unemployment insurance	Net social assistance	Average net benefits	Taxes[a]	FC[b]	Gross reservation wage[c]
Single	455	455	455	121	–	576
Single parent	660	564	590	-409	370	-188
Couple	752	661	686	-218	370	98

Table 3: After-tax benefits levels, taxes, family credits and reservation wages of different household types, in Pound Sterling per month.

[a]Taxes at the reservation wage

[b]Family credit at the reservation wage

[c]Reservation wages are the sum of columns 3, 4 and 5

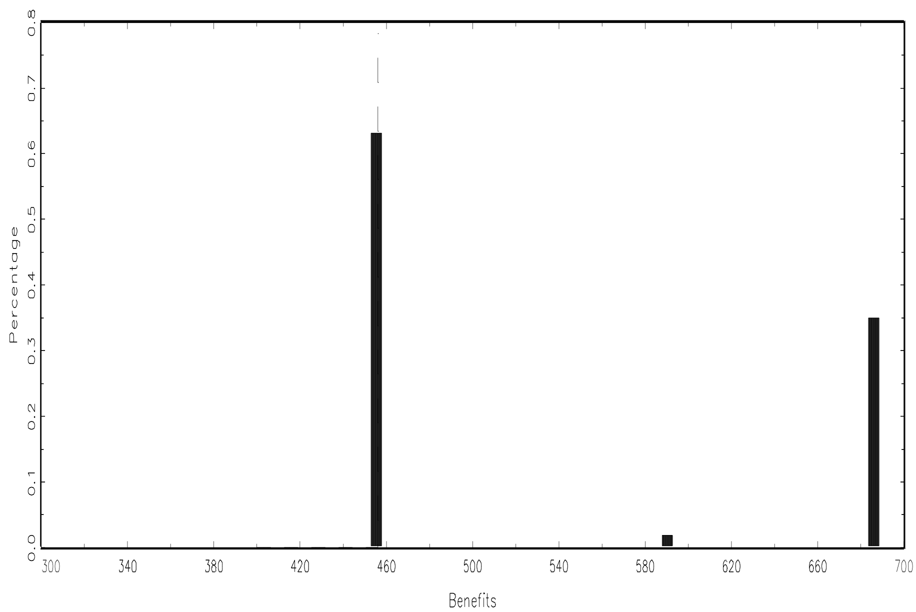

Figure 3: Distribution of benefits levels among different household types for the year 1994

of (gross) reservation wages from the benefits distribution. Table 3 presents this for the year 1994. The reservation wage for single parents is negative. This is a direct result of the FC. By comparing the reservation wages to the minimum wage (see Table 1), it follows that there may be unemployment because of high unemployment benefits for single individuals and because of the minimum wage for individuals in other household types.

The high reservation wage of single individuals means that these individuals should have longer unemployment spells. Evidence from recent research in duration models for the United Kingdom confirms this. For example Dolton and O'Neill (1996) find that the transition from unemployment to a job for adults with children is almost 4 times as large as that of adults without children.

4 The empirical implementation

4.1 The likelihood function

Since we allow for three different benefits levels, we estimate the model of section 2 with $M = 3$. Recall that we have three sets of endogenous variables. First, for individuals in the LFS sample who are in the labor force we observe whether they are unemployed or employed. Secondly, for unemployed individuals in the LFS sample we observe the elapsed unemployment duration. Thirdly, for individuals in the earnings sample we observe the wage. When deriving the likelihood function, we interpret the samples as random samples of individuals from the corresponding populations.

Let us examine the distributions of each of the three sets of endogenous variables. The marginal probability of unemployment is equal to u, which is obtained by using equation (14). Hence, whether a randomly chosen individual is unemployed or not is determined by a Bernoulli distribution with this parameter u.

We define $\Psi(t)$ as the distribution function of elapsed unemployment durations in the stock of unemployed, and $\overline{\Psi}(t)$ as the corresponding survivor function. Note that $\alpha = \overline{\Psi}(\infty)$. Individuals who are frictionally unemployed have an outflow rate given p of $\lambda\overline{F}(\bar{\xi}_h|p); h \in \{1, \ldots, H\}$. As a result,

$$\overline{\Psi}(t) = \alpha + \frac{1}{u}\sum_{h=1}^{H}\int_{\underline{p}(\overline{\xi}_h)}^{\overline{p}(\overline{\xi}_h)} \frac{m_h}{1+\kappa\overline{F}(\overline{\xi}_h|p)} e^{-\lambda\overline{F}(\overline{\xi}_h|p)t} d\Gamma(p) + \\ \frac{1}{u}\frac{1}{1+\kappa}e^{-\lambda t}\sum_{h=1}^{H} m_h\overline{\Gamma}(\overline{p}(\overline{\xi}_h)) \tag{17}$$

The value of α is determined by equation (15). Note that if the benefits distribution is degenerate, $\overline{\Psi}(t)$ reduces to $\alpha + (1-\alpha)e^{-\lambda t}$. In that case, α and λ can be estimated directly from the unemployment duration data. In any case, the probability that an unemployed individual is in the duration class $[t_{i-1}, t_i)$ is equal to $\Psi(t_i) - \Psi(t_{i-1}) = \overline{\Psi}(t_{i-1}) - \overline{\Psi}(t_i)$. These probabilities define the grouped unemployment duration distribution, which is a multinomial distribution.

By analogy to equation (12), the distribution of earnings (i.e., cross-sectional wages) equals

$$G(w) = \int_{p\in\mathcal{W}^{-1}(p)} G(w|p)d\Gamma\left(p|p\geq\overline{\xi}_1\right) + \Gamma\left(\underline{p}(w)|p\geq\overline{\xi}_1\right) \tag{18}$$

The probability that an employed individual has a wage which falls in the earnings class $[w_{i-1}, w_i)$ is equal to $G(w_i) - G(w_{i-1})$. These probabilities define the grouped earnings distribution, which is a multinomial distribution. Note that the use of grouped data makes our estimation method, to some extent, robust against outliers in the wage data.

We maximize the following log likelihood function, in notation to be explained below,

$$\log L = N_1\log u + N_2\log(1-u) + \sum_{i=1}^{C_t} N_{1,i}\log\left(\overline{\Psi}\left(t_{i-1}\right) - \overline{\Psi}\left(t_i\right)\right) \\ + \sum_{i=1}^{C_w} N_{3,i}\log\left(G\left(w_i\right) - G(w_{i-1})\right) \tag{19}$$

where C_t and C_w represent the number of duration and earnings classes, N_1+N_2 is the total number of individuals in the sample for the unemployment rate, with N_1 the number of unemployed, and $N_{1,i}$ is the number of unemployed with a duration in the i^{th} class, so that, obviously, $N_1 \equiv \sum N_{1,i}$. Furthermore, $N_{3,i}$ is the number of individuals in the sample for the earnings distribution with earnings in the i^{th} class. Moreover, the t_i's and w_i's are the threshold values of the duration classes and earnings classes, respectively, where we use the conventions $t_0 = w_0 = 0$ and $t_{C_t} = w_{C_w} = \infty$. The values of N_1, N_2, and $N_{1,i}$ can be calculated from the number of households in the Labor Force Survey, using the average number of adults per household by household type and the activity rates by household type[8]. The value of N_3 can be deduced from the number of respondents in the New Earnings Survey. For example, the values of N_1, N_2 and N_3 are equal to 62359, 6013 and 110964 for the year 1994. Note that in Ψ (equation (17)) we integrate with respect to $d\Gamma(p|u = 1)$. Additionally, although the distribution of $F(w|p)$ and $G(w|p)$ are non-differentiable for some particular values of w, the log-likelihood function is continuous and differentiable. This is caused by the integration over intervals in our procedure. Hence, we can use any maximization algorithm that uses the first order derivative. In the sections that follow, we use the method of Broyden-Fletcher-Goldfarb-Shanno (BFGS).

Of course, we have to substitute the structural expressions for $F(w|p)$ and $G(w|p)$ into the above expressions. The parameterization of the productivity distribution is discussed in the next subsection.

4.2 Choice of the productivity distribution

In our empirical work the distribution of p is chosen to give a good fit to the observed wage distribution. First, it should be noted that with a discrete distribution of unemployment income b, both the wage offer and the earnings distributions will have zero density in an interval below each reservation wage. This is true irrespective of the choice of the distribution of p. The empirical wage distribution does not have such gaps. There are two reasons why we think that this feature of the equilibrium distribution does not invalidate our estimates. The first reason is that the discrete distribution of b is a discretization of a continuous distribution that we do not observe. In principle, it is possible to generate

[8]As discussed in section 3.2, the LFS-UK is not a simple random sample, because of the oversampling in Northern Ireland. Moreover, the reported statistics have been computed using weights that undo over/underrepresentation of gender and age categories. The MLE remains consistent, as long as the weighting is to the relevant population. Our variance estimates are biased, although the bias will be small if the weights do not vary too much. For the computation of the correct variances, we need the weights and the relevant average, e.g. the fraction in a particular unemployment duration interval, for the strata. Unfortunately, neither the weights, nor the relevant averages are reported.

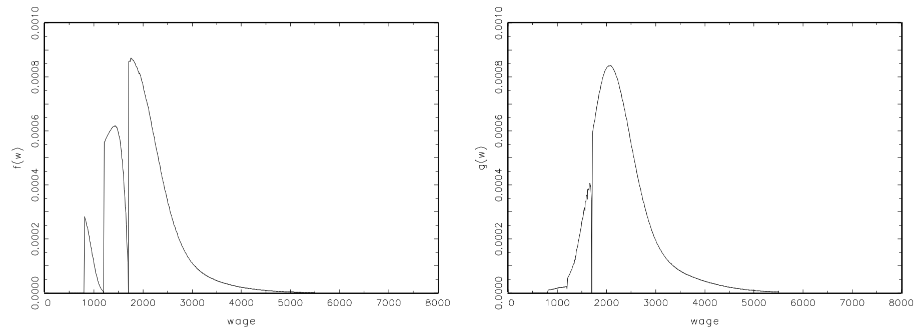

Figure 4: Wage offer and earnings density, using a mixture of log normal distributions, $f(x) = \pi \log N(\mu_1, \sigma^2) + (1 - \pi) \log N(\mu_2, \sigma^2)$, $\lambda = 0.07$, $\delta = 0.006$, $\mu_1 = 7.7$, $\mu_2 = 8.2$, $\sigma = 0.2$ and $\pi = 0.9$

such a continuous distribution using a microsimulation model that computes for every, and not just the unemployed, participant in the labor market his or her unemployment income. Unfortunately, we do have access to such a model. The second reason is that we use grouped wage data. In such data the gaps, which turn out to be small for well-fitting distributions of p, are not visible. As long as the empirical fractions are fitted, we do not worry too much about the shape of the wage density within the intervals.

For the value of κ that is consistent with the duration data, the wage offer distribution is concentrated near the maximum wage in a submarket. This implies that the right tail of the wage offer and earnings distributions will resemble the productivity distribution. In figure 4 we give the earnings density for a productivity distribution that is a mixture of two lognormal distributions. This class of productivity distributions is able to fit the observed wage data.

In Figure 5 we illustrate the effect of benefits dispersion on the shape of the earnings density. We choose again a mixture of two lognormals for the distribution of p. We consider two cases (i) a three point distribution for b with points of support 800, 1200 and 1600, and corresponding probabilities 0.25, 0.5 and 0.25, and (ii) a degenerate distribution of b concentrated in 1200, i.e. the mean of the three point distribution. The effect of the benefits dispersion is restricted to the lower tail of the earnings density. This is confirmed by the quantiles of the two distributions reported in table 4.

4.3 A sampling experiment

In our empirical work, the estimates are based on large data sets. However, the data are grouped, and the model is a highly nonlinear mixture. To see what

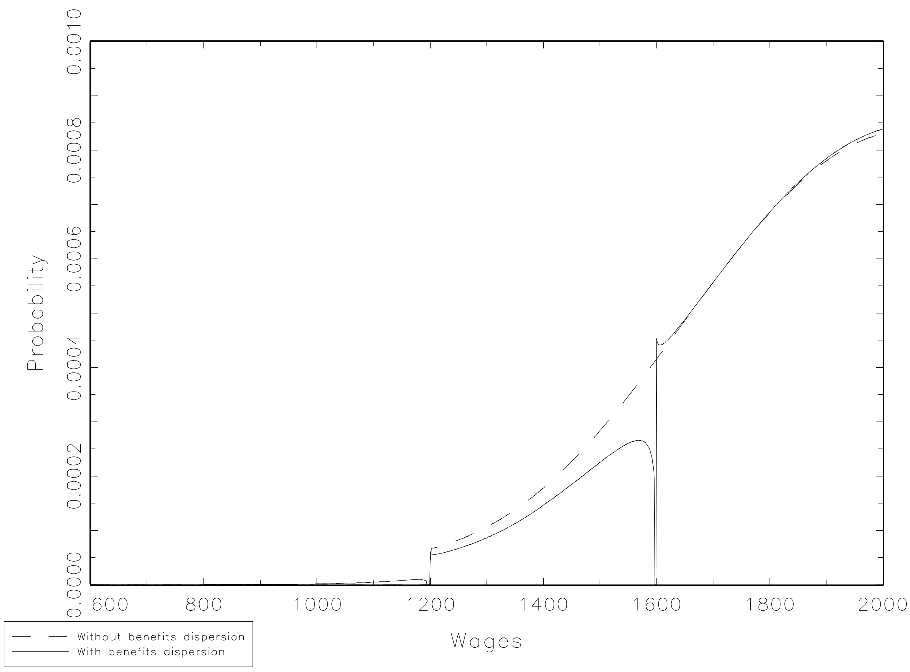

Figure 5: Illustration of the effects of benefits dispersion

Quantile	With dispersion	Without dispersion
1%	1309	1315
5%	1522	1517
10%	1665	1645
20%	1828	1813
30%	1958	1945
40%	2079	2065
50%	2200	2187
60%	2332	2319
70%	2490	2476
80%	2706	2692
90%	3111	3095

Table 4: Quantiles of the earnings density with and without benefits dispersion

Parameter	True value	Mean value	Theoretical standard deviation	Standard deviation
Parameters of the model				
λ	0.0700	0.0697	0.0032	0.0034
δ	0.0060	0.0059	0.0003	0.0003
μ_1	7.7000	7.6950	0.0031	0.0040
μ_2	8.2000	8.1961	0.0145	0.0160
σ	0.2000	0.2057	0.0024	0.0033
π	0.9000	0.9026	0.0072	0.0081
κ	11.6667	11.7584	0.4020	0.4546
Distribution of unemployment				
α	0.1659	0.1830	0.0080	0.0098
u_f	0.0874	0.0869	0.0024	0.0030

Table 5: Results of the monte carlo simulation

precision we may expect, we perform a sampling experiment. We only report the results for a single choice of the parameters. The number of observations is 10000, and the unemployment durations and wages are grouped in 5 and 18 intervals as in the observed data. The distribution of the reservation wage has three points of support 600, 1200 and 1700 with probabilities 0.6, 0.2, and 0.2.

The parameters λ and δ are set to 0.07 and 0.006. Furthermore, the productivity distribution is a mixture of lognormals with means 7.7 and 8.2, and common standard deviation 0.2. The minimum wage is not binding, i.e. lower than the smallest reservation wage.

In table 5, we report the results of 1000 replications. The theoretical standard deviations have quite similar values as the empirical standard deviations. As can be seen from figure 6, the fitted wage and duration distributions are close to the population distribution.

5 The results

We estimate the model for 1992-1996. We consider five years to check whether the parameters are relatively stable over time. The results are summarized in table 6. It is found that the parameter estimates do not vary too much over the years.

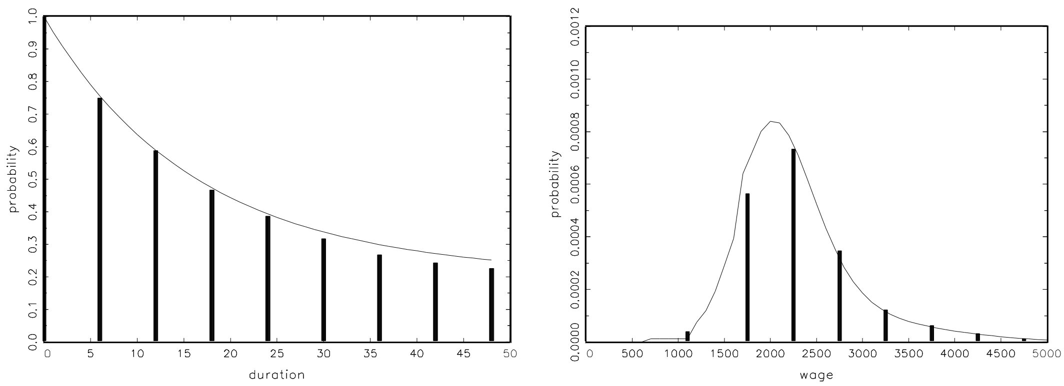

Figure 6: Estimated earnings density and survivor function of the Monte Carlo simulations

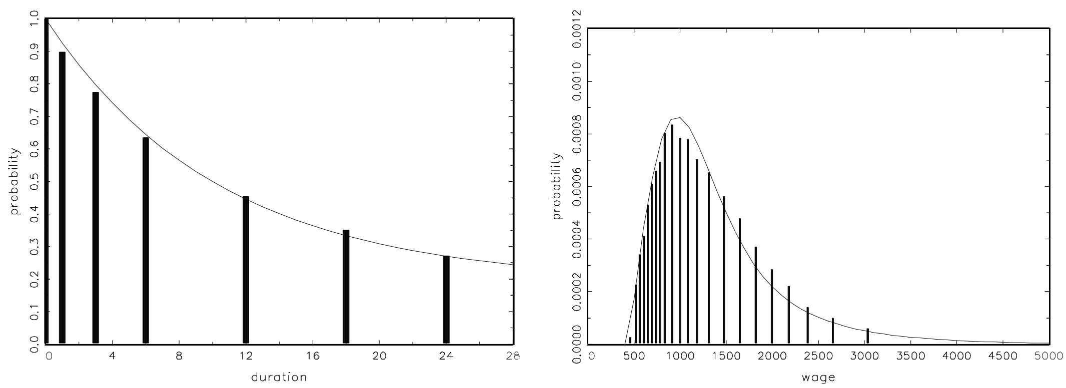

Figure 7: Estimated and observed earnings density and survivor function of the year 1994

The parameter estimates can be used to decompose the unemployment rate. It is found that only about 7% of total unemployment is structural, and that most of the structural unemployment is due to high reservation wages. The remainder of total unemployment is due to search frictions.

The fit of the earnings and unemployment duration distributions is reported in figures 7. Although we do not observe the unemployment duration distribution by household type, the model predicts that there is a relation between type and duration. In table 8 we report the fraction unemployed after 12 and 24 months. Single workers are predicted to have longer unemployment durations than workers in other household types. This effect is only due to the higher reservation wage of single workers.

We looked at two alternative model specifications to contrast our results with. First, as we stated earlier in this paper, there are problems with the count of the long term unemployed. Our measure did not take the number of discouraged

Parameter	1992	1993	1994	1995	1996
Parameters of the model					
λ	0.1073	0.0881	0.0967	0.1117	0.1242
	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.0006)
δ	0.0118	0.0100	0.0090	0.0088	0.0093
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
μ_1	6.9835	7.0457	7.0704	7.1028	7.0865
	(0.0126)	(0.0152)	(0.0224)	(0.0319)	(0.0284)
μ_2	7.6474	7.7443	7.7629	7.7822	7.7490
	(0.0209)	(0.0338)	(0.0617)	(0.0992)	(0.0683)
σ	0.3073	0.3468	0.3861	0.4044	0.3896
	(0.0048)	(0.0057)	(0.0081)	(0.0110)	(0.0098)
π	0.7381	0.8036	0.8407	0.8550	0.8225
	(0.0199)	(0.0246)	(0.0383)	(0.0575)	(0.0500)
κ	9.0924	8.7725	10.7599	12.7417	13.2964
	(0.1373)	(0.1118)	(0.1412)	(0.1779)	(0.1894)
Distribution of unemployment					
Total unemployment	0.1022	0.1080	0.0994	0.0890	0.0843
	(0.0012)	(0.0013)	(0.0012)	(0.0012)	(0.0011)
Structural unemployment					
by minimum wages	0.0007	0.0012	0.0022	0.0025	0.0020
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
by unemployment benefits	0.0090	0.0112	0.0166	0.0170	0.0157
	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Frictional unemployment	0.0919	0.0950	0.0801	0.0691	0.0662
	(0.0011)	(0.0011)	(0.0010)	(0.0009)	(0.0009)

* *Standard errors are between parentheses*

Table 6: Estimation results

Variable	Estimate
Earnings distribution	
Mean earnings	1398
Standard deviation	729
Productivity distribution	
Mean productivity	1475
Standard deviation	761

Table 7: Mean and standard deviation of wage and productivity distribution

	Fraction
After 12 months	
$\overline{\psi}(12\|\text{"single"})$	0.51
$\overline{\psi}(12\|\text{"lone"})$	0.36
$\overline{\psi}(12\|\text{"couple"})$	0.36
After 24 months	
$\overline{\psi}(24\|\text{"single"})$	0.33
$\overline{\psi}(24\|\text{"lone"})$	0.16
$\overline{\psi}(24\|\text{"couple"})$	0.16

Table 8: Fraction unemployed of the different household types after 12 and 24 months

workers into account. We re-estimated our model by including the jobless who do not seek employment because they think no jobs are available. Second, previous discussion in this paper suggested that the numbers of lone parents we used in our empirical analysis might be seriously underestimated. Official publications that count the number of lone parents find figures that are up to 100% higher. We re-estimated our model for the case in which we increased the share of single parents in the distribution of households by 2% (to a total of almost 4%). We reduced the percentages of the other two household types by one percent to compensate for this increase.

Both re-estimations for the year 1994 are summarized in table 9. When we include the number of discouraged workers, then the number of long term unemployed is increased. Therefore, structural unemployment increases. From our estimates, it is seen that this resulted in an increase of σ and π. The other parameters do not change much. The change of the share of single parents in the households distribution does not lead to very important changes in the parameter estimates.

6 Policy evaluation

For a sophisticated evaluation of possible changes in policy, it is important to realize that it is not sufficient to look at measures like total and structural unemployment only. It is also important to look at the effect of total welfare in the economy. Eckstein and Wolpin (1990) use a social welfare function to analyze this

Parameter	Discouraged workers	Single parents
λ	0.0965	0.0967
δ	0.0083	0.0090
μ_1	7.0880	7.0708
μ_2	7.8210	7.7637
σ	0.4102	0.3870
π	0.8882	0.8420
κ	11.6203	10.7744

Table 9: Sensitivity analysis of the results

effect. Following these authors, we define the social welfare function as follows:

$$\mathcal{S} = E_\Gamma(p) - \sum_h m_h \int_0^\infty u_h(p) p d\Gamma(p)$$

Eckstein and Wolpin (1990) include the non-monetary value of leisure into their analysis. In our analysis the unemployment income is set equal to unemployment benefits, and these benefits are not included in the social welfare function. This is valid if benefits are pure income transfers between different groups of the population. If there is a balanced budget and if the taxes needed to finance the increase in benefits are not taken out of wages or are completely borne by individuals with high wages, then this is indeed the case. According to our model, the increase in taxes does not influence the labor market participation decision for these individuals. We note that our welfare function measures total production within the economy, which is an objective measure of welfare. This means that the social welfare decreases with unemployment and therefore with the levels of unemployment benefits. However, this relationship is not one to one, since the unemployment of some individuals decreases total production more than the unemployment of others.

Our first exercises in policy evaluation concern an increase and a decrease of 10% of all benefits. Note that the effects of an increase and a decrease are not completely opposite, since these depend on the productivity distribution and the initial situation. Additionally, we note that there are some problems concerning policy evaluations based on a decrease of benefits, since they depend on the left tail of the productivity distribution for which we do not have any data. This means that it is not possible to observe what individuals would have earned if they would have been working. Additionally, we are interested in what happens if all reservation wages are equal to the highest reservation wage. We also consider the case that all reservations wages are equal to the average level of the reservation wage. This means that reservation wage for all individuals is equal to 398 pounds. Finally, we look at the effects of a 10 percent increase of the mandatory minimum wage.

Table 10 shows that the increase of 10% of benefits has a quite large effect on both structural and total unemployment. Moreover, social welfare decreases. A decrease of all benefits gives the opposite effects. An increase of all reservation wages to the highest reservation wage is found to have less effects than an overall increase. A policy change that makes all reservation wages equal to the average level of the reservation wages has a similar effect as a 10% reduction of all benefits. Finally, an increase in the mandatory minimum wage leads to a moderate decrease of social welfare, while total and structural unemployment are increased almost as much as for the first and third policy evaluations. The costs of such a system are moderate and only consist of the extra payments for unemployment benefits. We note that the optimal benefits scheme is given by all combinations for which the unemployment benefits are lower or equal to the mandatory minimum wage.

As stated in the introduction, we also look at the effects of the present system of the Family Credit (FC) in the United Kingdom. We do this by looking at predicted outcomes of our model if the existing FC is abolished. Table 11 summarizes the results. It is found that the structural unemployment rate is increased substantially compared to the case where the FC is present, while total unemployment does not increase that much. Additionally, it is found that the costs of the present system are about 38 pounds per month per inhabitant. Although these costs are quite high, it is found that they are outweighed by the change in unemployment benefit payments.

7 Conclusions

This paper studies the effect of unemployment benefits and the minimum wage on labor market outcomes. In particular, we are interested in the effects of benefits and the mandatory minimum wage on unemployment. Our model is based on an equilibrium search model which allows for differences in unemployment benefits as well as productivity levels and job-to-job transitions. We use readily available aggregate data, published by the OECD (1997) and EUROSTAT (1996a). Our estimation method is structural and we use a maximum likelihood approach. The estimated structural parameters are the friction parameters and

Variable	Estimate
Level of social welfare	
Original level	1335
10% increase of all unemployment benefits	1328
10% decrease of all unemployment benefits	1339
All benefits equal to highest benefits	1332
All benefits equal to mean benefits	1342
10% increase of the mandatory minimum wage	1333
Unemployment level	
Original level	0.1035
10% increase of all unemployment benefits	0.1151
10% decrease of all unemployment benefits	0.0955
All benefits equal to highest benefits	0.1098
All benefits equal to mean benefits	0.0905
10% increase of the mandatory minimum wage	0.1042
Structural unemployment level	
Original level	0.0193
10% increase of all unemployment benefits	0.0312
10% decrease of all unemployment benefits	0.0112
All benefits equal to highest benefits	0.0271
All benefits equal to mean benefits	0.0059
10% increase of the mandatory minimum wage	0.0265
Change in benefits budget	
10% increase of all unemployment benefits	8.759
10% decrease of all unemployment benefits	-6.237
All benefits equal to highest benefits	4.388
All benefits equal to mean benefits	-10.444
10% increase of the mandatory minimum wage	1.140

Table 10: Results of the policy simulations for the year 1994

Variable	Estimate
Level of social welfare	1309
Total unemployment level	0.1422
Structural unemployment level	0.0581
Costs of the present FC	38.26
Increase in outlays for beneftis	81.31

Table 11: Results of the FC policy evaluation

the parameters of the aggregate productivity distribution. Different components of the unemployment rate are directly obtained from the parameters.

Data of benefit levels are not available at the aggregate level. Therefore, we construct this distribution by the calculating the benefit level by household type and the distribution of individual workers among these different household types. We calculate the reservation wages by using these benefit levels and taking the tax system into account. We find that reservation wages for parents are much lower than for other individuals.

We obtain good results from our highly stylized model. There are many unrealistic aspects, but it is hard to think of any model that is not unrealistic in many respects. We find that 80 percent of total unemployment is due to search frictions. The remaining part results from the mandatory minimum wages and unemployment benefits, where the latter is most important. We find that the unemployment rate of households with children is only determined by the mandatory minimum wage. Hence, marginal increases of the unemployment benefits of these households as well as their in-work benefits do not change unemployment rates. From our policy simulations, we also find that changes in the unemployment benefits to their average level have quite important positive effects on social welfare. This is mainly due to the fact that such a policy decreases the reservation wage of households without children. Other policy simulations involving benefits, like changing all unemployment benefits with a fixed percentage or an increase of the benefits to the highest benefits have a smaller effect on social welfare, even if they change the system considerably. Increasing the mandatory minimum wage affects the level of social welfare by increasing structural unemployment among parents. The unemployment rates among households without children are not affected.

We evaluate the present system of the Family Credit (FC) by comparing it with our predictions in the situation that it does not exist. We find that such a policy increases both structural and total unemployment and that social welfare is reduced. Although the costs of the present FC are high, these are outweighed by the decrease in unemployment benefits. Since we find that households with children already have sufficient incentives to accept jobs at the minimum wage, extending the present system to these households does not improve social welfare. Social welfare is increased by a lower minimum wage for households with children, if such a selective minimum wage were possible.

References

Bartholomew, R., A. Hibbett and J. Sidaway (1992), Lone parents and the labour market: evidence form the labour force survey, *Employment Gazette*, 559–577.

Bontemps, C., J.M. Robin and G.J. van den Berg (1999), An empirical equilibrium job search model with search on the job and heterogeneous workers and firms, *International Economic Review* **40**, 1039–1075.

Bontemps, C., J.M. Robin and G.J. van den Berg (2000), Equilibrium search with continuous productivity dispersion: theory and non-parametric estimation, *International Economic Review* **41**, 305–358.

Burdett, K. and D.T. Mortensen (1998), Wage differentials, employer size and unemployment, *International Economic Review* **39**, 257–273.

Card, D. and A.B. Krueger (1995), *Myth and measurement*, Princeton University Press, Princeton.

Central Planning Bureau (1995), *Replacement rates, a transatlantic overview*, CPB working papers **80**, Central Planing Bureau, The Hague.

Devine, T.J. and N.M. Kiefer (1991), *Empirical Labor Economics: The Search Approach*, Oxford University Press, Oxford.

Diamond, P.A. (1971), A model of price adjustment, *Journal of Economic Theory*, **3**, 156–168.

Dolado, J., F. Kramarz, S. Machin, A. Manning, D. Margolis and C. Teulings (1996), The economic impact of minimum wages in Europe, *Economic Policy* **23**, 319–372.

Dolton, P. and D. O'Neill (1996), Unemployment duration and the Restart effect: some experimental evidence, *Economic Journal* **106**, 387–400.

Eckstein, Z. and K.I. Wolpin (1990), Estimating a market equilibrium search model from panel data on individuals, *Econometrica* **58**, 783–808.

EUROSTAT (1996a), *Labour Force Survey, Results 1996*, Office for Official Publications of the European Communities, Brussels.

EUROSTAT (1996b), *The European Union labour force survey. Methods and definitions*, Office for Official Publications of the European Communities, Brussels.

Flinn, C.J. and J.J. Heckman (1983), Are unemployment and out of the labor force distinct labor force states, *Journal of Labor Economics* **1**, 28–42.

Gönül, F. (1992), New evidence on whether unemployment and out of the labor force are distinct states, *Journal of Human Resources* **27**, 329–361.

Haskey, J. (1993), Estimated number and demographic characteristics of one-parent families in Great Britain, *Population Trends* **71**, 26–33.

Hopenhayn, H.A. and J.P. Nicolini (1997), Optimal unemployment insurance, *Journal of Political Economy* **105**, 412–438.

Jones, S.R.G., and W.C. Riddell (1999), The measurement of unemployment: an empirical approach, *Econometrica* **67**, 147–162.

Kiefer, N.M., and G.R. Neumann (1993), Wage dispersion with homogeneity: The empirical equilibrium search model, *in* N.C. Westergaard-Nielsen and P. Jensen, *Proceedings of the third symposium on panel data and labor market dynamics*, North-Holland, Amsterdam.

Koning, P.W.C., G. Ridder and G.J. van den Berg (1995), Structural and frictional unemployment in an equilibrium search model with heterogeneous agents, *Journal of Applied Econometrics* **10**, S133–S151.

Layard, R., S. Nickell and R. Jackman (1991), Unemployment: macroeconomic performance and the labour market, Oxford University Press, Oxford.

Mortensen, D.T. (1986), Job search and labor market analysis, *in* O. Ashenfelter and R. Layard, *Handbook of Labor Economics* **2**, North-Holland, Amsterdam.

Mortensen, D.T. (1990), Equilibrium Wage Distributions: A Synthesis,*in* J. Hartog, G. Ridder and J. Theeuwes, *Panel Data and Labor Market Studies*, North-Holland, Amsterdam.

Mortensen, D.T. and C.A. Pissarides (1999), New developments in models of search in the labor market, *in:* O. Ashenfelter and D. Card, *Handbook of Labor Economics* **3**, North-Holland, Amsterdam.

OECD (1995), Supplementary measures of labour market slack: an analysis of discouraged and involuntary part-time workers, *in* OECD, *Employment Outlook*, OECD, Paris.

OECD (1997), *Making Work Pay*, OECD, Paris.

Pissarides, C.A. (1990), *Equilibrium unemployment theory*, Blackwell, Oxford.

Ridder, G., and G.J. van den Berg (1997), Empirical equilibrium search models, *in* D.M. Kreps and K.F. Wallis, *Advances in economics and econometrics: Theory and applications: Seventh World Congress*, Econometric Society Monographs **28**, Cambridge University Press, Cambridge.

Ridder, G., and G.J. van den Berg (1999), Estimating measures of labor market imperfection in five OECD countries, using aggregate data in an equilibrium search framework, Department of Economics, Vrije Universiteit, Amsterdam.

Scholz, J.K. (1996), In-work benefits in the United States: the earned income tax credit, *Economic Journal* **106**, 156–169.

Van den Berg, G.J. (1990), Nonstationarity in job search theory, *Review of Economic Studies* **57**, 255–277.

Van den Berg, G.J. (1992), A structural dynamic analysis of job turnover and the costs associated with moving to another job, *Economic Journal* **102**, 1116–1133.

Van den Berg, G.J., and G. Ridder (1998), An empirical equilibrium search model of the labor market, *Econometrica* **66**, 1183–1221.

Wolpin, K.I. (1995), *Empirical methods for the study of labor force dynamics*, Harwood Academic Publishers, Luxembourg.

Appendix. Analytical solution for $F(w|p)$

It is possible to derive analytical expressions for the wage offer and earnings distributions for any given productivity level p. For convenience, ignore the minimum wage. It is useful to distinguish between seven cases (with corresponding shapes): four in the case $\underline{w}(p) = \xi_1$, two in the case $\underline{w}(p) = \xi_2$ and one in the case $\underline{w}(p) = \xi_3$. It is not very informative to present the solutions for all these cases, so we consider just one case. If $(\xi_3 - \frac{m_1 \xi_1}{(1+\kappa)^2})/(1 - \frac{m_1}{(1+\kappa)^2}) < p < \min\{\frac{\xi_3 - m_1 \xi_1}{1 - m_1}, \frac{(m_1+m_2)\xi_2 - m_1 \xi_1}{m_2}, (\xi_3 - \xi_2 \frac{m_1}{m_1+m_2})/(1 - \frac{m_1}{m_1+m_2})\}$, then the wage offer distribution is equal to

$$F(w|p) = \begin{cases} 0 & \text{if } w < \xi_1 \\ \frac{1+\kappa}{\kappa}\left(1 - \sqrt{\frac{p-w}{p-\xi_1}}\right) & \text{if } \xi_1 \le w < p - (p-\xi_2)\frac{m_1+m_2}{m_1} \\ \frac{1+\kappa}{\kappa}\left(1 - \sqrt{\frac{p-\xi_2}{p-\xi_1}\frac{m_1}{m_1+m_2}}\right) & \text{if } p - (p-\xi_2)\frac{m_1+m_2}{m_1} \le w < \xi_2 \\ \frac{1+\kappa}{\kappa}\left(1 - \sqrt{\frac{p-w}{p-\xi_1}\frac{m_1}{m_1+m_2}}\right) & \text{if } \xi_2 \le w < p - \frac{p-\xi_3}{m_1+m_2} \\ \frac{1+\kappa}{\kappa}\left(1 - \sqrt{\frac{p-\xi_3}{(p-\xi_1)m_1}}\right) & \text{if } p - \frac{p-\xi_3}{m_1+m_2} \le w < \xi_3 \\ \frac{1+\kappa}{\kappa}\left(1 - \sqrt{\frac{p-w}{(p-\xi_1)m_1}}\right) & \text{if } \xi_3 \le w < p - \frac{m_1(p-\xi_1)}{(1+\kappa)^2} \\ 1 & \text{otherwise} \end{cases}$$

Its density function equals

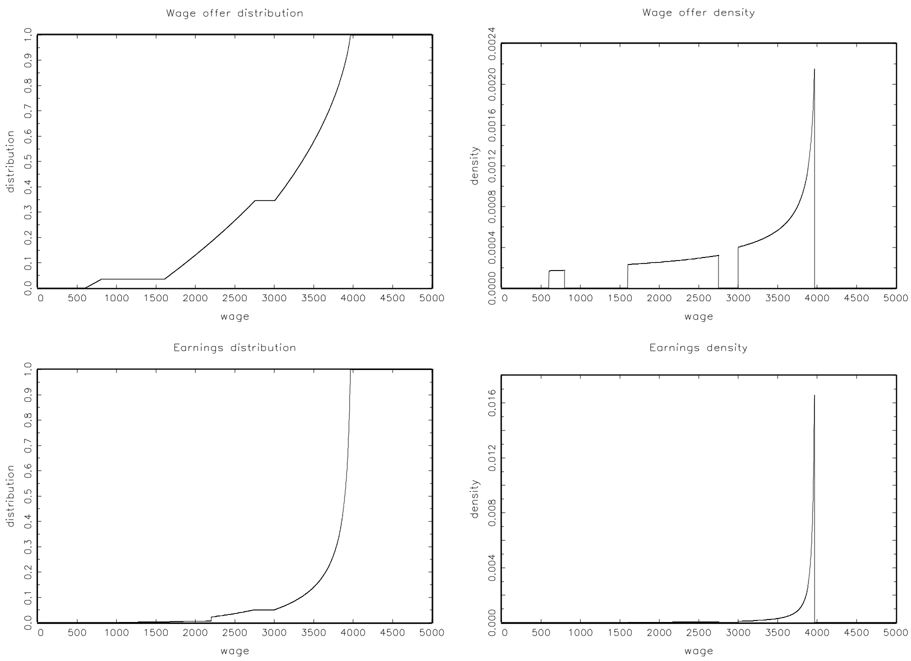

Figure 8: Wage offer distribution and density function, given $p = 4000$, $m_1 = 0.6$, $m_2 = 0.2$, $b_1 = 600$, $b_2 = 1600$, $b_3 = 3000$, $\tau(w) = 0$, $\lambda = 0.04$ and $\delta = 0.006$

$$f(w|p) = \begin{cases} \frac{1}{2\kappa}\frac{1}{\sqrt{(p-w)(p-\xi_1)}} & \text{if } \xi_1 \leq w \leq p - (p-\xi_2)\frac{m_1+m_2}{m_1} \\ \frac{1}{2\kappa}\frac{1}{\sqrt{(p-w)(p-\xi_1)\frac{m_1}{m_1+m_2}}} & \text{if } \xi_2 \leq w \leq p - \frac{p-\xi_3}{m_1+m_2} \\ \frac{1}{2\kappa}\frac{1}{\sqrt{(p-w)(p-\xi_1)m_1}} & \text{if } \xi_3 \leq w \leq p - \frac{m_1(p-\xi_1)}{(1+\kappa)^2} \\ 0 & \text{otherwise} \end{cases}$$

Figure 8 provides a numerical example, displaying $F(w|p)$ as well as the corresponding $G(w|p)$ and their densities.