The design of unemployment transfers: Evidence from a dynamic structural life-cycle model *

Peter Haan† and Victoria Prowse‡

February 10, 2012

Abstract

In this paper we use a dynamic structural life-cycle model to analyze the employment, fiscal and welfare effects induced by unemployment insurance. The model features a detailed specification of the tax and transfer system, including unemployment insurance benefits which depend on an individual's employment and earnings history. The model also captures the endogenous accumulation of experience which impacts on future wages, job arrivals and job separations. For better identification of the structural parameters we exploit a quasi-natural experiment, namely reductions over time in the entitlement period for unemployment insurance benefits which varied by age and experience. The results show that a policy cut in the generosity of unemployment insurance operationalized as a reduction in the entitlement period generates a larger increase in employment and yields a bigger fiscal saving than a cut operationalized as a reduction in the replacement ratio. Welfare analysis of revenue neutral tax and transfer reforms also favors a reduction in the entitlement period.

Keywords: Unemployment insurance, Replacement ratio, Entitlement period, Life-cycle labor supply, Tax reform, Method of Simulated Moments.

JEL Classification: C23, C25, J22, J64.

*The authors would like to thank Jerome Adda, Jesper Bagger, Richard Blundell, Michael Lechner, Arne Uhlendorff, Bas van der Klaauw and seminar participants at Statistics Norway, University of Kent, WPEG Conference, IZA, University of Frankfurt, University of Dresden, EALE 2009, and the Max Planck Institute for Demographic Research. We would like to thank Netspar for financial support for this project. Bill Goffe kindly supplied MatLab code for simulated annealing. Computations were performed using facilities at the Oxford Supercomputing Centre.

†DIW Berlin, phaan@diw.de

‡Department of Economics, University of Oxford, victoria.prowse@economics.ox.ac.uk

1 Introduction

In many countries unemployment insurance is considered to be an important component of the transfer system, providing income to unemployed individuals who have recently moved out of employment. However, several governments have recently reduced the generosity of their unemployment insurance schemes, with the dual objectives of increasing employment and reducing social expenditure. We use a dynamic structural life-cycle model of labor supply to evaluate the employment, fiscal and welfare effects induced by unemployment insurance. Specifically, we consider the effects of reductions in the generosity of unemployment insurance brought about by changes to the two central dimensions of unemployment insurance, namely the entitlement period and the replacement ratio. Our model includes a comprehensive specification of the tax and transfer system, including unemployment insurance benefits that are linked to an individual's working history. The model captures transitions into and out of employment occurring over the life-cycle and stochastic job arrivals and job separations. Finally we include endogenous accumulation of experience which impacts on future wages, and job arrival and separation rates.

By evaluating the design of unemployment insurance in a dynamic structural life-cycle model, this study extends the previous empirical literature on unemployment insurance. Indeed, an important literature has been concerned with estimating the employment effects of unemployment insurance using reduced form, typically quasi-experimental, methods. Following Meyer (1990) numerous studies use regional or age specific variation in the institutional design of unemployment insurance to identify the causal effects of the entitlement period and the replacement ratio on the duration of unemployment. Examples include Katz and Meyer (1990) and Card and Levine (2000) for the US and Hunt (1995), Lalive *et al.* (2006), Van Ours and Vodopivec (2006), Kyyrä and Wilke (2007) and Caliendo *et al.* (2009) for Europe. These studies tend to find significant effects of the generosity of unemployment insurance on employment and, where applicable, retirement. In this paper we gain additional insight into the effects of unemployment insurance by leveraging our structural model.

The embedding of our analysis in a dynamic structural life-cycle model has three prominent advantages relative to a reduced form approach. First, the economic model captures the complex and varied incentives effects induced by unemployment insurance, as discussed in Mortensen (1977). It follows that, using our parameter estimates, we are able to quantify the employment effects caused by changes in unemployment insurance experienced by individuals with different employment histories and with different distributions of offered wages. In particular, we are able to separate out Mortensen's *entitlement effect* whereby a reduction in the generosity of unemployment insurance makes unemployed individuals who have exhausted their entitlement to unemployment insurance less likely to enter employment. Second, by exploiting the institutional details concerning the tax and transfer system contained in the structural model, we are able to derive the fiscal costs of policy changes, taking into account both changes in the transfer payments made to non-working individuals, and changes in the tax revenues received from those in employment. Moreover, we are able to analyze revenue neutral changes in the entitlement

period and the replacement ratio. Third, drawing on the specification of preferences in our model, we can evaluate the welfare effects of policy changes. This allows us to move beyond an assessment of employment effects, and to look also at changes in well-being induced by reforms to the system of unemployment insurance.

Policy evaluations based on structural models are sometimes treated with skepticism as identification of the parameters is often not transparent (Keane and Wolpin, 2009). Recent contributions by Todd and Wolpin (2006) and Attanasio *et al.* (2005) propose using a randomized experiment to provide validation or clearer identification of the central structural parameters in dynamic life-cycle models. We follow this idea and propose an identification strategy which supplements cross correlations between endogenous variables and correlations between endogenous variables and exogenous variables with variation obtained from a quasi-natural experiment. Specifically, we exploit changes in the institutional design of unemployment insurance over time which varied by age and working history. Therefore, we make use of the variation on which several of the aforementioned reduced form studies rely.[1] In this respect our paper also contributes to the growing literature which tries to combine the advantages of the reduced form analysis with structural modeling.[2]

In order to analyze the employment, fiscal and welfare effects of the design of unemployment insurance in a dynamic structural model we must generalize existing dynamic structural life-cycle models of labor supply with endogenous accumulation of experience, e.g., Eckstein and Wolpin (1989), by incorporating a detailed specification of the tax and transfer system. On the tax side, we model the taxation of labor and non-labor income and we account for employee and employer social security contributions. In terms of transfers, an unemployed individual receives either social assistance, i.e., a means-tested transfer to raise income to the universal minimum income, or non means-tested unemployment insurance benefits, which are tied to the individual's recent employment history and previous earnings. The entitlement period for unemployment insurance depends on experience and age. Thus, in addition to capturing the dependence of wages on endogenously accumulated experience, as in Eckstein and Wolpin (1989), our life-cycle model accounts for the effect of previous employment and previous earnings on the transfers received by unemployed individuals.

A small number of papers have included transfers paid to unemployed individuals within a dynamic structural life-cycle model of labor supply. Among others, Wolpin (1992) and Adda *et al.* (2009) include a specification of unemployment insurance benefits, and Adda *et al.* (2007) include both unemployment insurance benefits and means-tested social assistance.[3] The analysis undertaken in this study extends the previous literature in several respects. Notably, we

[1] See Hunt (1995) and Fitzenberger and Wilke (2009) for Germany and Van Ours and Vodopivec (2006) for Slovenia.

[2] A recent example is Novo and Silva (2010) who provide validation for a calibrated structural search model by using changes in the entitlement period for unemployment insurance in Portugal. While the quasi-natural experiment is similar in our application, the models differ in many aspects. Most importantly, we estimate the structural parameters driving life-cycle behavior instead of using calibration.

[3] Additionally, several studies follow Rust and Phelan (1997) and analyze retirement behavior in a dynamic structural life-cycle setting. These papers account for the relevant aspects of the pension system.

utilize a more realistic specification of the household budget constraint. With respect to the modeling of out-of-work transfers, we include both unemployment insurance and means-tested social assistance. Moreover, in contrast to Adda *et al.* (2007), we allow the entitlement period for unemployment insurance to depend on the individual's age and working history.[4] We argue that this detailed modeling of the fiscal incentives is necessary to capture correctly labor supply incentives which vary according to wage, age and experience.

Our model further includes a number of empirically relevant features. First, dependent on age and health status, an individual has a probability of being able to access early retirement and, subject to having access, he or she can decide to retire before the compulsory retirement age of 65 years. Second, we allow for several sources of non-stationarity over the life-cycle due to the effects of age, health and endogenously accumulated experience. Specifically, all three variables feature in the job arrival rate, the job separation rate and the wage offer distribution. Furthermore, pensions and unemployment insurance rules vary according to age and experience, and access to early retirement varies by age and health status. Finally, we allow for heterogeneity in job arrival and job separation rates, preferences and wages due to unobserved individual characteristics.

This paper is related to several studies which estimate structural search models in order to quantify the employment effects of unemployment insurance e.g., van den Berg (1990), Ferrall (1997) and Frijters and van der Klaauw (2006). Common to all these studies is that they focus exclusively on the transition out of unemployment for an inflow sample of unemployed individuals or school drop-outs. The samples used in these studies therefore consist of individuals who are homogenous in terms of their entitlement to unemployment insurance. In contrast, we model multiple transitions between employment states occurring over the life-cycle and can distinguish between individuals with different accumulated entitlement periods for unemployment insurance.

Similar to e.g., Gourinchas and Parker (2002) and French (2005), we use the Method of Simulated Moments (MSM) to estimate our dynamic structural life-cycle model. The empirical analysis is based on a thirteen year panel of single men and women without dependent children taken from the German Socio Economic Panel (SOEP). This data set contains detailed income and demographic information and follows employment behavior on a monthly basis. In the empirical analysis we account for all major aspects of the German tax and transfer legislation. During the sample period 1995 - 2007 several large scale tax reforms changed working incentives either by decreasing marginal tax rates or social security contributions or by changing the design of out-of-work transfers. As mentioned above, we use this variation, in particular changes in the entitlement period for unemployment insurance, to improve identification of the structural parameters.

Using our structural model we are able to fit the salient features of the sample including the patterns of labor supply and retirement behavior over the life-cycle, the distribution of offered wages and the exit rates from employment and unemployment. The structural parameter estimates are used to compare the employment, fiscal and welfare effects of cuts in the entitlement

[4]The entitlement period for unemployment insurance depends on age in numerous countries including Austria, Denmark, France, Germany, Italy, Japan, Korea and Portugal.

period and cuts in the replacement ratio. In summary, when the policy maker wants to reduce the generosity of unemployment insurance, our results favor cutting the entitlement period rather than the replacement ratio; cutting the entitlement period provides a larger fiscal saving, induces more employment and leads to a smaller increase in early retirement than cutting the replacement ratio. Welfare analysis also favors cuts in the entitlement period over cuts in the replacement ratio.

The paper proceeds as follows. Section 2 outlines our model of labor supply over the life-cycle. Section 3 details the adopted empirical specification. In Section 4 we list the selection criteria which determine our sample of single adult households taken from the SOEP, and provide a descriptive analysis of observed labor supply and retirement behavior. In Section 5 we detail the estimation method and discuss identification. In Section 6 we presents our structural parameter estimates and assess the model's goodness of fit, and in Section 7 we use the estimated structural parameters to evaluate the employment, welfare and fiscal effects of policy changes to the design of unemployment insurance. Section 8 concludes the paper with a discussion of the broader implications of our results for policy makers.

2 Model

2.1 Overview of the model

In order to analyze the employment, fiscal and welfare effects induced by the design of unemployment insurance we derive and estimate a dynamic structural life-cycle model with three labor market states, namely full-time employment, f, unemployment, u, and retirement, r.[5] We propose a discrete time, finite horizon model in which job arrivals, job separations and labor supply choices occur at quarterly intervals. We assume that the maximum life-time is 78 years and compulsory retirement occurs at age 65 years. Individuals are indexed by $i = 1, ..., N$ and quarters of calender time are indexed by t.

We model only the life-cycle labor supply of single adult households without dependent children. We focus on individuals aged 40 years and above and reasonably assume that family composition is constant over the individual's future life. It is assumed that men and women aged over 40 years have finished their education, and all analysis is conditioned on educational qualifications obtained prior to age 40 years. Finally, as is common in this literature, e.g., Rust and Phelan (1997), we assume that individuals do not save and are credit constrained.[6] In a more general model, in addition to the tax and transfer system, precautionary savings would provide insurance by allowing intertemporal consumption smoothing, e.g., Low *et al.* (2009). In such a setting households are less dependent on the transfer system and therefore any behavioral effects induced by changes in unemployment insurance are likely to be lower. Therefore, our

[5]While retirement is not the focus of this paper, we include retirement in the model as early retirement is common in practice and treating individuals who enter retirement before the age of compulsory retirement as unemployed is likely to bias downwards estimates of the employment effects of unemployment insurance.

[6]French (2005) is one of the few examples that allows for saving in a structural life-cycle model of retirement.

estimates of the behavioral effects induced by changes in unemployment insurance should be interpreted as upper bounds.

Our selection criteria have been chosen partly to limit the complexity of the empirical analysis. However, this population is of central interest when studying the effects of different systems of unemployment insurance. In general, single adult households are relatively dependent on the transfer system as they cannot rely on the income of other household members. Further, by following individuals up to the age of compulsory retirement we are able to determine the extent to which the design of unemployment insurance contributes to the high rates of unemployment among older individuals.

2.2 Labor market transitions

Transitions between labor market states depend on the one hand on the structure of the labor market, and on the other hand on individuals' preferences for income and leisure and on their expectations of future income and future labor supply behavior. The structure of the labor market is defined by the job arrival and job separation rates, retirement possibilities, the distribution of offered wages and the tax and transfers system, which determines the net income associated with each labor market state. We simplify the search process and assume that all unemployed individuals have a constant job search intensity. Implicitly, this implies that an individual has a single choice variable, his or her current labor market state, and each period this is optimized so as to maximizes the value of expected discounted future utility. In the following we describe the processes whereby individuals can make transitions between labor market states.

2.2.1 Retirement possibilities

When an individual enters the labor market following the completion of full-time education he or she is not eligible for early retirement. However, an employed or unemployed individual has a probability $\Lambda_{i,t} = \Phi(\lambda_x X^R_{i,t})$ of becoming eligible for early retirement at time t, where λ_x is a parameter vector and $X^R_{i,t}$ is a vector of individual characteristics including age terms and health status.[7] Here and henceforth $\Phi()$ denotes the cumulative distribution function for a standard normal random variable. Once eligible for early retirement the individual keeps this status for the rest of his or her life. Retirement is modeled as an absorbing state; once retired, an individual cannot make a transition into employment or unemployment.[8]

We argue that this specification of the eligibility for early retirement provides a good approximation to the complex reality of the German retirement system. In Germany transitions into retirement are possible before the age of compulsory retirement. Eligibility for early retirement depends primarily on health status, gender, age and working history, however firm specific circumstance and agreements can also affect an individual's eligibility for early retirement. As the firm specific factors that influence retirement possibilities do not feature in our data set it is not possible to derive precisely an individual's eligibility for early retirement.

[7] As discussed in Appendix II, health status is not a choice variable but evolves stochastically over the life-cycle.

[8] This assumption is in line with the German legislation and is supported strongly by the data.

2.2.2 Transitions out of unemployment

In each period t, every unemployed individual receives with probability $\Theta_{i,t} = \Phi(\theta_x X_{i,t} + \mu_i^\theta)$ an offer of a full-time job. The job arrival probability depends on age, experience and region of residence[9], collectively denoted by $X_{i,t}$, and on an individual specific unobservable μ_i^θ which will be specified below. The gross wage associated with this job arrival is denoted $w_{i,t}$. An unemployed individual in receipt of a job arrival must choose between rejecting the job arrival and remaining unemployed, and accepting the job arrival, in which case he or she makes a transition into employment. Those currently eligible for early retirement additionally have the option of making a permanent move into retirement. Unemployed individuals face one-off costs c_{uf} each time they make a transition into employment. These costs may be pecuniary, e.g., having to purchase clothes or equipment when starting a job, or non-pecuniary, e.g., habit formation. In either case, these transition costs can be described as state dependence effects, see Hyslop (1999).[10] With probability $(1 - \Theta_{i,t})$ an unemployed individual does not receive a job arrival and thus a transition into employment is not possible. However, if eligible the individual can move into retirement.[11]

2.2.3 Transitions out of employment

Each period an employed individual experiences a job separation with probability $\Gamma_{i,t} = \Phi(\gamma_x X_{i,t} + \mu_i^\gamma)$ which again depends on observed characteristics, $X_{i,t}$, and individual specific unobservables, μ_i^γ. If the individual experiences a separation and is not currently eligible for early retirement then he or she must make a transition into unemployment. However, if eligible for early retirement he or she must choose between unemployment and early retirement. With probability $(1 - \Gamma_{i,t})$ the employed individual does not experience a separation at time t and, assuming no eligibility for early retirement, he or she can choose between staying in employment with a gross wage of $w_{i,t}$ and making a transition into unemployment. Retirement is an additional option for those individuals who are currently eligible. Again, we allow state dependence or transition costs c_{fu} that are incurred when an individual moves from employment to unemployment.

The individual specific unobservables μ_i^θ and μ_i^γ are assumed to be random effects that are jointly normally distributed with zero means, variances $\sigma^2_{\mu^\theta}$ and $\sigma^2_{\mu^\gamma}$ respectively and a covariance $Cov_{\mu^\theta \mu^\gamma}$.

[9] In the empirical analysis region of residence consists of either east or west Germany. The labor market conditions are worse in east Germany than in the west.

[10] In a different application of dynamic structural life-cycle modeling, Keane and Wolpin (1997) report that transition costs, which they term mobility costs, were necessary to fit accurately the degree of persistence in occupational choices.

[11] Given the limited information in the data set we cannot observe job-to-job transitions. Therefore, we cannot model on-the-job search or distinguish between general and firm specific human capital.

2.3 Financial rewards and labor market status

In contrast to most previous studies of employment behavior over the life-cycle, we assume that individuals make employment and retirement decisions based on net rather than gross income. Our model therefore includes a detailed specification of the tax and transfer system which maps from gross labor income and non-labor income[12], demographic characteristics, employment and earnings histories to net incomes in full-time employment, unemployment and retirement. We argue that net incomes are the most accurate way to describe work incentives (see also Laroque and Salanie, 2002). Working with net incomes further allows us to derive the effects on the government's net revenue position of a policy change and to compare revenue neutral policy changes. This study uses the German tax and transfer system as a benchmark. The main features of this system are noted here while Appendix I provides a more detailed description together with information concerning recent relevant changes to the system.[13]

2.3.1 Net income in full-time employment

Individual i's net income if he or she works full-time at time t takes the following form

$$m_{i,f,t} = F_f(w_{i,t}, I_{i,t}; TS_t). \tag{1}$$

Net income in full-time employment depends on the offered gross wage $w_{i,t}$, non-labor income $I_{i,t}$, and the tax and transfer system of the given period TS_t. The tax and transfer system determines social security contributions and income tax deductions.

2.3.2 Net income in unemployment

The net income of an unemployed individual whose last period of employment was at time s is determined as follows

$$m_{i,u,t} = F_u\left(EP_{i,t}, EL_{i,t}, I_{i,t}, m_{i,f,s}; TS_t\right). \tag{2}$$

In the above $EP_{i,t}$ denotes the months of unemployment insurance benefits the individual is entitled to at time t and $EL_{i,t}$ is an indicator for the individual being eligible for unemployment insurance at time t. Eligible individuals receive non means-tested unemployment insurance benefits. Specifically, eligible individuals who have positive months of entitlement receive unemployment insurance benefits known as ALG I[14] and equal to 60% of the net income in their most recent job, $m_{i,f,s}$. Until 2005, those who exhausted their entitlement to ALG I received a second

[12] We assume that each individual has an initial endowment of assets which remains constant and they receive capital income depending on the year specific rate of return.

[13] Restricting attention to single adult households without dependent children simplifies greatly the modeling of the tax and transfer system as the family related components of the legislation, such as the joint income taxation of married couples and child related transfers, do not need to be considered.

[14] The names of the transfer programs changed in course of the transfer reform in 2005. For simplicity, we use ALG I and ALH to refer to transfers which are dependent on previous earnings or employment, and use ALG II to refer to the minimum income component.

type of unemployment insurance benefits known as ALH which were paid at a lower rate of 53% and continued indefinitely. An individual who is not entitled to unemployment insurance, or whose net income after receiving unemployment insurance is sufficiently low, receives social assistance (ALG II). Social assistance payments are a non time-limited transfer which raises the individual's net income up to the universal minimum income.

The tax and transfer system influences the entitlement period for unemployment insurance benefits in two ways. First, the rules dictate a maximum entitlement period, which varies discontinuously according to age. Second, individuals accumulate entitlement to unemployment insurance at a rate of one month for every two months of employment. Individuals who leave unemployment before they have exhausted their entitlement to unemployment insurance carry forward their remaining entitlement. Hence, only individuals with sufficiently long working histories have the maximum entitlement period; actual entitlement periods for unemployed individuals who are part way through a spell of unemployment and for employed individuals who have recently been unemployed are lower than the maximum entitlement, and potentially zero. Appendix I provides further details concerning the age specific maximum entitlement periods for unemployment insurance. Eligibility for unemployment insurance is determined when the individual starts a spell of unemployment and does not change over the course of the unemployment spell. To be eligible for unemployment insurance an individual must have worked at least one year during the previous three years, or from 2005 two years, prior to entering unemployment.

In theory, those who voluntarily choose to move into unemployment are not eligible for unemployment insurance for the first three months of their unemployment spell. However, in reality it is very difficult to distinguish between voluntary and involuntary separations. Therefore we assume that all unemployed individuals are eligible to receive unemployment insurance from the start of their unemployment spell. In our model individuals can change their employment behavior only at a quarterly intervals and therefore this assumptions affects only the first quarter of the unemployment spell.

2.3.3 Net income in retirement

We approximate the net income in retirement in the following way

$$m_{i,r,t} = F_r\left(PI_{i,t}, I_{i,t}; TS_{i,t}\right). \tag{3}$$

where $PI_{i,t}$ denotes the total pensionable income accumulated by individual i over his or her working life up to time t. In any given month, the pensionable income of a working individual consists of the individual's gross earnings, while the pensionable income of an unemployed individual is the value of any unemployment insurance benefits received. We approximate pension income as 60% of the individual's pensionable income averaged over the maximum working life, and impose a cap of 2000 Euros per month. Finally we assume that individuals with pension income less than the minimum income receive social assistance to raise their income in retirement

up to this level.[15]

2.4 Optimal labor supply over the life-cycle

By drawing on dynamic programming techniques, we use our model to describe optimal employment and retirement behavior over the life-cycle in a forward looking setting where the individual considers the dependence of payoffs occurring in the future on his or her current labor supply decision. There are several mechanisms linking today's employment and retirement decision with future payoffs. Employment in the current quarter increases an individual's experience which impacts on future job arrival and job separation rates and leads to higher expected future wage offers, assuming positive returns to experience. Two additional intertemporal linkages occur through unemployment insurance benefits. First, employment in the current period increases the duration of entitlement to unemployment insurance payments, thus increasing the value of unemployment in the future. Second, wage based rewards to human capital accumulation mean that current employment leads to higher future unemployment insurance benefits. A forward looking model is required to capture how individuals respond to the dynamic incentives presented by the accumulation of experience and the tax and transfer system. For example, our forward looking model recognizes that an individual may choose to have a spell of unemployment, during which he or she claims generous unemployment insurance benefits, prior to entering retirement. A myopic model, in contrast, would not recognize that unemployment insurance benefits may provide a stepping stone from employment into retirement.

An individual's life-cycle utility can be expressed in terms of the state specific value functions $V_t^j(s_{i,t})$ for $j = f, u, r$. The state variables $s_{i,t}$ consist of all variables affecting the contemporaneous utilities, the job arrival rate, $\Theta_{i,t}$, the job separation rate, $\Gamma_{i,t}$, the probability of having access to early retirement, $\Lambda_{i,t}$, and the offered wage, $w_{i,t}$. At time t, the individual is assumed to know the current value of $s_{i,t}$ but may not know the values of all or some elements of $s_{i,t+k}$ for $k > 0$. However, the distribution of $s_{i,t+1}$ is known to the individual at time t and is assumed to depend only on $s_{i,t}$. The value function associated with full-time employment is defined as discounted value of the individual's expected life-time utility if he or she works full-time in the current quarter and makes optimal labor supply and retirement decisions in all subsequent quarters. The value function for unemployment is similarly defined. The value function associated with retirement is defined as the discounted value of the individual's expected life-time utility if he or she enters retirement in the current quarter and stays in retirement for the remainder of his or her life.

[15] In practice, individuals have various sources of pension income including state pensions, private pensions and income from firm-specific pension plans. The state pension is by far the most important source of pension income. State pension payments are determined by pension points accumulated over the working life together with yearly point values. Our chosen approximation of the pension system is less complex. However, we allow pension income to depend on employment behavior over the whole working life and therefore capture the most relevant feature of the pension system for our analysis.

The state specific value functions are defined recursively as follows

$$V^f_{i,t}(s_{i,t}) = U_{i,f,t}(s_{i,t}) + \Gamma_{i,t}\left\{\Lambda_{i,t}\delta\mathbf{E}_t\left[\max\{V^u_{i,t+1}, V^r_{i,t+1}\}\right] + (1-\Lambda_{i,t})\delta\mathbf{E}_t V^u_{i,t+1}\right\} + (1-\Gamma_{i,t})\left\{\Lambda_{i,t}\delta\mathbf{E}_t\left[\max\{V^f_{i,t+1}, V^u_{i,t+1}, V^r_{i,t+1}\}\right] + (1-\Lambda_{i,t})\delta\mathbf{E}_t\left[\max\{V^f_{i,t+1}, V^u_{i,t+1}\}\right]\right\}, \quad (4)$$

$$V^u_{i,t}(s_{i,t}) = U_{i,n,t}(s_{i,t}) + (1-\Theta_{i,t})\left\{\Lambda_{i,t}\delta\mathbf{E}_t\left[\max\{V^u_{i,t+1}, V^r_{i,t+1}\}\right] + (1-\Lambda_{i,t})\delta\mathbf{E}_t V^u_{i,t+1}\right\} + \Theta_{i,t}\left\{\Lambda_{i,t}\delta\mathbf{E}_t\left[\max\{V^f_{i,t+1}, V^u_{i,t+1}, V^r_{i,t+1}\}\right] + (1-\Lambda_{i,t})\delta\mathbf{E}_t\left[\max\{V^f_{i,t+1}, V^u_{i,t+1}\}\right]\right\}, \quad (5)$$

$$V^r_t(s_{i,t}) = U_{i,r,t} + \delta\mathbf{E}_t V^r_{i,t+1}. \quad (6)$$

In the above $U_{i,j,t}$ denotes the individual's flow utility associated with state j at time t and δ denotes the discount factor. The discount factor is a crucial parameter in the life-cycle optimization problem as it describes how strongly expected future utility affects the individual's current choice. In the empirical analysis we follow the literature and assume an annualized discount factor of 0.96.[16]

The individual maximizes his or her life-cycle utility subject to a budget constraint. Since in our framework individuals neither save nor borrow, the budget for consumption equals state specific net income. We assume that the individual has full information about the tax and transfer system in the current period but does not anticipate future changes in the tax and transfer system. Therefore, we solve for optimal labor supply behavior assuming that individuals expect that the current tax and transfer system will prevail indefinitely. Optimizing behavior on the part of an unemployed individual in receipt of a job offer or an employed individual who is not subject to a job separation implies that the individual will choose employment if and only if $V^f_{i,t}(s_{i,t}) \geq V^u_{i,t}(s_{i,t})$, assuming no access to early retirement. Conversely, if $V^u_{i,t}(s_{i,t}) > V^f_{i,t}(s_{i,t})$ then the individual will choose unemployment. If the individual has the option of early retirement then he or she will work full-time if and only if $V^f_{i,t}(s_{i,t}) \geq V^u_{i,t}(s_{i,t})$ and $V^f_{i,t}(s_{i,t}) \geq V^r_{i,t}(s_{i,t})$, will be unemployed if and only if $V^u_{i,t}(s_{i,t}) > V^f_{i,t}(s_{i,t})$ and $V^u_{i,t}(s_{i,t}) \geq V^r_{i,t}(s_{i,t})$, and otherwise the individual will move into retirement. A previously employed individual who experiences a separation at time t or an unemployed individual who does not receive a job offer will choose retirement if $V^r_{i,t}(s_{i,t}) \geq V^u_{i,t}(s_{i,t})$, providing that he or she has access to early retirement, and otherwise will be unemployed. At age 65 all remaining non-retired individuals must enter compulsory retirement.

3 Empirical specification and implementation

In the following we discuss the specifications of the flow utilities and the distribution of offered wages, and the treatment of the initial conditions. This supplements the specifications of the job arrival and job separation rates which where presented in Section 2.2, and the specification of the health equation detailed in Appendix II.

[16] Magnac and Thesmar (2002) discuss identification of the discount factor in dynamic discrete choice models.

3.1 Flow utilities

Flow utilities from full-time work, unemployment and retirement are given by

$$U_{i,f,t} = \beta_y \frac{[m_{i,f,t}(1 - c_{uf} y_{i,u,t-1})\eta_i]^{(1-\rho)} - 1}{1-\rho} + \varepsilon_{i,f,t}, \quad (7)$$

$$U_{i,u,t} = \beta_y \frac{[m_{i,u,t}(1 - c_{fu} y_{i,f,t-1})]^{(1-\rho)} - 1}{1-\rho} + \varepsilon_{i,u,t}, \quad (8)$$

$$U_{i,r,t} = \beta_y \frac{m_{i,r,t}^{(1-\rho)} - 1}{1-\rho} + \varepsilon_{i,r,t}. \quad (9)$$

In the above $m_{i,f,t}$, $m_{i,u,t}$ and $m_{i,r,t}$ denote the individual's net income in full-time employment, unemployment and retirement respectively. η_i describes the degree of complementarity between consumption and leisure and thus provides information about the reservation wage or the share of net income necessary to compensate the individual for the disutility of work. We allow for heterogeneity in the complementarity and assume that $\eta_i \sim N(\mu_\eta, \sigma_\eta^2)$. To guarantee that all individuals enjoy positive utility from leisure time η_i is truncated from above 1. η_i is also truncated from below at zero to ensure that flow utility is represented by a real valued function. The variables $y_{i,u,t-1}$ and $y_{i,f,t-1}$ are indicators of unemployment and full-time employment in the previous quarter and therefore c_{uf} and c_{fu} represent state dependence effects or transition costs associated with moving between unemployment and employment and vice versa. The state dependence parameters multiply the net incomes in the flow utilities and therefore these parameters may be interpreted as shares of net income. ρ describes the concavity of the utility function; we follow the previous literature and assume that individuals are risk averse, and set $\rho = 1.5$.[17] β_y determines the importance of consumption in the utility function, relative to the unobservables $\varepsilon_{i,f,t}$, $\varepsilon_{i,u,t}$ and $\varepsilon_{i,r,t}$. The unobservables $\varepsilon_{i,f,t}$, $\varepsilon_{i,u,t}$ and $\varepsilon_{i,r,t}$ are assumed to be mutually independent and independent over time. Additionally, $\varepsilon_{i,j,t}$ for all i, j and t is assumed to have a type I extreme value distribution. At time t individual i knows the current values of $\varepsilon_{i,j,t}$ for $j = f, u, r$ but has no information about the future values of these unobservables.

3.2 Gross wages

Individual i's log offered gross wage is assumed to evolve according to

$$\log(w_{i,t}) = \lambda_z z_{i,t} + \alpha_i^w + \upsilon_{i,t}. \quad (10)$$

In the above $z_{i,t}$ are observed individual characteristics that affect wages including education, region of residence, experience and experience squared. The coefficients on the experience terms capture the effect of human capital accumulated via previous employment on an individual's wage. $\upsilon_{i,t}$ is a shock to individual i's wage occurring at time t and is assumed to be independent of observed individual characteristics, to occur independently over time and to be normally distributed with zero mean and variance σ_υ^2. Individual i is assumed to know the current

[17] See Laibson *et al.* (2007) for a detailed discussion of the difficulties of identifying the coefficient of relative risk aversion.

value of $\upsilon_{i,t}$ but does not know the future values of the time varying shocks to wages. α_i^w is a time invariant individual specific random effect assumed to be known to the individual and unconditional normally distributed with zero mean and variance $\sigma^2_{\alpha^w}$. Wages are observed only for working individuals and therefore wage observations are subject to selectivity. In the econometric analysis we account for this selection process by modeling employment and wages jointly. Non-labor income and intertemporal and cross sectional variation in net income induced by the tax and transfer system affect the employment process but not the distribution of offered wages and therefore provide exclusion restrictions for identification of the parameters in the wage equation.

3.3 Initial conditions

The dynamic nature of our model implies that we cannot treat the initial sample observations of experience and labor market status as exogenous with respect to the individual's labor supply choices during the sample period. To account for the endogeneity of the initial conditions we follow Heckman (1981) and use a reduced form model to approximate labor supply behavior prior to entering the sample, and allow the unobservables affecting the initial observations to be correlated with the random effects appearing in the flow utilities, the job arrival and separation rates and the wage equation. While Heckman (1981) proposed a probit model for the initial state, we generalize this to account for the endogeneity of both the initial state and initial experience, and to allow retirement to be the initial state. Specifically, we use a reduced form dynamic multinomial probit model to approximate labor supply and retirement behavior between entering the labor market, assumed to occur when the individual finished full-time education, and entering the sample. The data generation process for behavior prior to entering the sample is based on three indices $IE_{i,\tau}$, $IU_{i,\tau}$ and $IR_{i,\tau}$, which collectively determine if an individual is employed, unemployed or retired at time τ, where τ indexes all periods between the individual leaving full-time education and entering the sample. More precisely, an individual is employed at time τ if $IE_{i,\tau} \geq IU_{i,\tau}$ and $IE_{i,\tau} \geq IR_{i,\tau}$, is unemployed if $IU_{i,\tau} > IE_{i,\tau}$ and $IU_{i,\tau} \geq IR_{i,\tau}$ and is retired otherwise. We model retirement as an absorbing state, hence any individual who retires prior to entering the sample cannot subsequently move into employment or unemployment.

In the empirical implementation, the index $IE_{i,\tau}$ is a linear function of observed characteristics, including experience and household composition prior to entering the sample, the random effects μ_i^θ, μ_i^γ, α_i^w and η_i, and an error term $\epsilon^I_{i,f,\tau}$. The second index $IR_{i,\tau}$ is a linear function of age terms and an error term $\epsilon^I_{i,r,\tau}$ while, for identification purposes, the third index $IU_{i,\tau}$ depends only on an error term $\epsilon^I_{i,u,\tau}$. The three error terms are mutually independent, independent over time and individuals and are drawn from a standard normal distribution.

3.4 Value function approximation

We approximate the value function using recursive simulation and interpolation. We start with a grid of state space points for age 64.75 years. The state space variables are then updated to the age 65 years values in accordance with the stochastic evolution of the variables as specified

by the structural model. We evaluate the age 65 years value function at our grid of age 65 years state space points. Ordinary least Squares (OLS) regression is used to express the expected age 65 years value function in terms of state space variables known at age 64.75 years. Next, we move back one quarter to age 64.5 years, update the state space variables, and compute the three age 64.75 years labor market state specific value functions. We replace the expected age 65 years value function appearing in the state specific value functions with the approximation obtained in the previous step. The maximum of the three state specific age 64.75 years value functions is regressed on state space variables known at age 64.5 years. The regression results relates the age 64.5 years state space points to the expected maximum of the three age 64.75 years state specific value functions. We continue in this way until we reach age 40 years. This procedure is repeated for each of the 13 different tax and transfer systems operational during the sample period to capture the year specific aspects of the fiscal legislation.

One of the main challenges when approximating the value function is to capture accurately the labor supply incentives created by the accumulation of experience and complex dependence of unemployment insurance benefits on an individual's working history. Depending on age, an individual's entitlement to unemployment insurance depends on working behavior over the past 3-8 years, while experience can range between zero and 47 years. Thus, with employment measured at quarterly intervals, the state space is extremely large. In order to approximate accurately the dependence of the value function on an individual's working history we include as explanatory variables in the OLS regressions experience and squared experience and a large number of finer measures of working behavior over the last 8 years. Regarding the latter, we translate the working history in the last 8 years into a set of 5 variables which collectively summarize the aspects of recent working behavior that are relevant to unemployment insurance benefits. Specially, the summary variables take the form of the entitlement period corresponding to the working history in counterfactual regimes in which the maximum entitlement periods are 6, 12, 18, 26 and 32 months. We discretize these five summary variables and include in the OLS regression a dummy variable for each value of each of the summary variables. The OLS regressions also include net income in employment and this variable interacted with the all of the included measures of employment history, observed and unobserved characteristics and currently accumulated pension rights. Furthermore the coefficients on all variables are allowed to vary according to the current employment status. In total the OLS regression includes 178 regressors and we use a grid with 7000 state space points.

4 Data and descriptive evidence

This study draws on data from the SOEP which is an annual representative panel survey of over 11,000 households living in Germany and contains information about working behavior, socio-economic variables and income from all sources at the individual and household levels.[18] We construct an unbalanced panel of individuals with consecutive observations in at least two quarters between 1996 - 2008 inclusive which yields retrospective information for the fiscal years

[18]For a detailed description of the SOEP data set, see Haisken De-New and Frick (2005).

1995 - 2007.[19] In our analysis we focus on a sample of single adult households in which the household head is aged between 40 and 65 years and reports living without dependent children at the time of the interview.[20] We exclude individuals whose primary earnings are from self-employment as well as those in full-time education as, in both cases, labor supply behavior differs substantially from that of the rest of the population of interest. These exclusions yield a sample with 33883 person-quarter observations corresponding to 2126 different single individuals of whom 1150 are women and 976 men. The median number of observations per individual is 12 quarters and around 25% of the individuals are observed for 6 or more years.

4.1 Employment and retirement behavior

The SOEP data set includes detailed information about employment and retirement behavior in each month of the year prior to the interview date. For tractability, we group the monthly information for each individual to form quarterly observations with the individual's labor market state in the first month of the quarter determining the quarterly outcome. In this analysis we distinguish between employment, assumed to be full-time work, unemployment and retirement.[21] Individuals who report sufficient income from pensions are classified as retired. A measure of experience at the time that the individual entered the sample is constructed from retrospective information concerning the individual's working history. This variable is then updated at quarterly intervals over the sample period in accordance with the individual's observed employment behavior. At age 65 years all remaining non-retired workers are reclassified as retired.

Figure 1 shows the shares of employment, unemployment and retirement by age separately for men and women and by region of residence, i.e., east or west Germany. In general, the behavior of the various subgroups is similar. Until the age of 55 years employment rates are fairly high and decline to zero over the last 10 years of the working life. Before age 55 years the majority of the non-work corresponds to unemployment whereas retirement increases markedly after age 60 years. Employment rates for men and women are quite similar. This is not surprising since our sample consists only of single individuals without dependent children. A difference by gender only becomes visible at the end of the working life. In particular, women tend to retire earlier than men. As expected, by region of residence we find strong differences: averaged over the whole age distribution, the employment rate is 10 percentage points higher in west Germany, and older east Germans have a higher propensity to retire than west Germans of the same age. These differences are likely to be related to the worse economic conditions in east Germany.

For men and women in both parts of Germany unemployment rates peak at around age 60 years and decline thereafter. This pattern may reflect older individuals optimally using unemployment as a stepping stone into retirement. Indeed, older individuals are likely to be eligible for early retirement, and for eligible individuals there is no risk of a large reduction in

[19] The German fiscal year commences on 1st January.

[20] We allow for different marital status and dependent children before the first sample observation when estimating the initial conditions. See Section 3.3.

[21] Given our sample selection criteria, only around 5% of the population under study works fewer than 30 hours per week and therefore it is reasonable to treat all employment as full-time work.

Figure 1: Observed employment and retirement behavior by gender and region of residence

the future income when unemployment insurance runs out as they can make a transition into retirement and receive income from a pension.[22] Unemployment is less attractive for those who are not eligible for early retirement, likely to be younger individuals, as they will be subject to a large drop income if they have not accepted a job before their entitlement to unemployment insurance runs out.

4.2 Gross wages

The SOEP data set includes the gross earnings in the month prior to the interview date. Using the corresponding working hours, including hours of payed over-time work, we construct an hourly wage measure. For time-consistency we cannot use the retrospective employment information and the current wage information from the same survey wave. Instead, we make use of the panel dimension of the data: as we observe the exact interview date we can match the wage information collected in one year to the corresponding quarter of the retrospective employment information collected in the next year. We do not observe the wage for individuals who were not working in the month prior to the interview, in quarters in which the individual was not surveyed or for those who failed to respond to all of the relevant survey questions. In the econometric analysis we account for all three sources of missing wage observations as described in Haan and Prowse (2010).

[22]In principle, in order to continue receiving unemployment insurance an older unemployed individual needs to be searching for a job and ready to take up a job. However in reality it is very unlikely the workers older than 60 years get job offers which they are forced to take up by the employment office.

5 Estimation strategy and identification

5.1 The Method of Simulated Moments

The parameters appearing in the job arrival and job separation rates, preferences, gross wages and the initial conditions are estimated jointly using the Method of Simulated Moments (MSM): parameters are chosen to minimize the distance between a set of moments pertaining to the values of the endogenous variables, namely wages and labor supply behavior, as observed in the sample and the average values of the same moments in a number of simulated data sets.

Estimation proceeds as follows. R data sets with the same empirical distribution of exogenous individual characteristics as in the sample are constructed. Using a particular vector of parameters, denoted θ, labor supply outcomes and wages are simulated for each individual in each of the R data sets.[23] In more detail, values of the time invariant unobservables are drawn for each individual. Next, conditioning on the exogenous variables, each individual's labor supply behavior for the period between leaving full-time education and entering the sample is simulated using the above specification of the initial conditions. This provides a simulated initial labor market state for each individual as well as simulated values of each individual's initial experience, initial entitlement to unemployment insurance, total pensionable income up to the time of entering the sample and net income in his or her most recent job. Finally, starting from the simulated initial values of the endogenous variables and using the structural model we simulate a labor market state for each individual in each quarter during the sample period.

Let M^s denote the vector of moments computed from the sample observations and $M^r(\theta)$ for $r = 1, ..., R$ denote the same moments computed using the R^{th} simulated data set. The metric $J(\theta)$ is constructed as follows

$$J(\theta) = \left(M^s - \frac{1}{R} \sum_{r=1}^{R} M^r(\theta) \right) \widehat{\Omega} \left(M^s - \frac{1}{R} \sum_{r=1}^{R} M^r(\theta) \right)', \tag{11}$$

where $\widehat{\Omega}$ is a weighting matrix. We follow Pischke (1995) and use a weighting matrix equal to $1/N$ times the inverse of the variances of the sample moments.[24] $\widehat{\Omega}$ is estimated using bootstrap resampling of individuals from the original data set. The MSM estimator minimizes the distance between the simulated and the observed moments: $\widehat{\theta} = \text{argmin}_\theta J(\theta)$. The term $\frac{1}{R} \sum_{r=1}^{R} M^r(\theta)$ appearing in $J(\theta)$ is not a continuous function of the parameter vector θ as small changes in θ cause discrete changes in labor supply behavior for some individuals. Consequently gradient and Hessian based optimization methods are unsuitable methods for minimizing $J(\theta)$. Instead we use Simulated Annealing in the form suggested by Goffe *et al.* (1994) to solve for the MSM estimates.

[23] The results presented below were obtained using $R = 10$.

[24] We choose not to weight by the inverse covariance matrix in order to minimize possible finite sample biases of the form discussed by Altonji and Segal (1996).

5.2 Chosen moments and identification

In Appendix III we provide a detailed presentation of the chosen moments including the number of moments and information about which parameter is primarily identified by each moment. In this section we make some more general comments pertaining to identification and discuss how we use moments based on a quasi-natural experiment to strengthen identification.

Among others, Aguirregabiria and Mira (2009) discuss the identification of structural models and outline the necessary assumptions to identify the structural parameters. In general, given assumptions about agents' rationality and beliefs, cross correlations between endogenous variables and correlations between endogenous variables and exogenous variables are sufficient for identification. However, policy evaluations based on structural models are sometimes treated with skepticism as identification of the parameters is often not transparent. The recent contributions by Todd and Wolpin (2006) and Attanasio *et al.* (2005) propose using a randomized experiment for validation or improved identification of the central structural parameters in dynamic life-cycle models. We follow the idea of Attanasio *et al.* (2005) and suggest an identification strategy which exploits additionally moments based on variation generated by changes in the institutional design of unemployment insurance, namely a reduction in the maximum entitlement period which was introduced in April 1997.[25]

Section 2.3.2 above described the process whereby individuals accumulate entitlement to unemployment insurance. In April 1997 the maximum entitlement period for unemployment insurance was reduced for unemployment spells starting after 1st April 1997. This reform had a large effect on the work incentives for employed and newly unemployed individuals aged between 42-46, 49-51 and 54-56 years with sufficiently long pre-reform entitlement periods for unemployment insurance.[26] Figure 2 shows the average change in the entitlement period by age caused by a move from the pre April 1997 regime to the post April 1997 regime. We also plot the corresponding change in the maximum entitlement period. As explained above, the two differ because, regardless of age, individuals with short entitlement periods were not affected by the reform. Moreover, we see a strong pattern in the mean change in the entitlement period by age, with individuals aged under 42 years or over 61 years being unaffected and individuals aged between 42-46, 49-51 and 54-56 years experiencing on average large reductions in entitlement.[27]

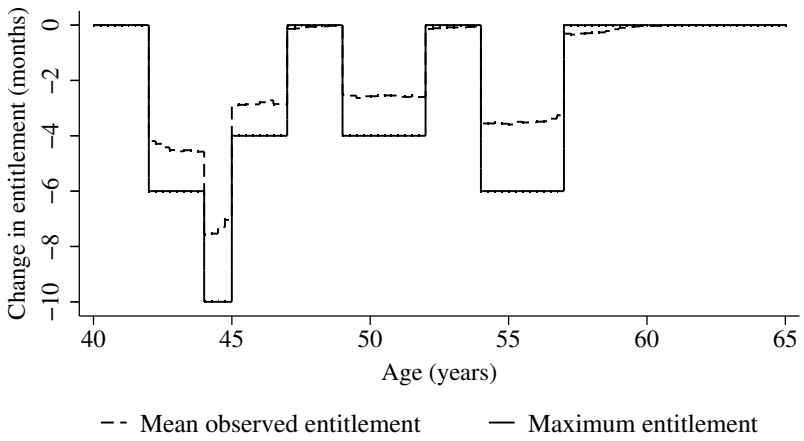
We exploit the quasi-experimental nature of this reform and use a difference-in-differences procedure to show that the entitlement period for unemployment insurance has a significant causal effect on labor market status. Parameter estimates from the difference-in-differences es-

[25] As shown in Table 2 in Appendix I, in February 2006 the design of unemployment insurance was again subject to a major reform which reduced the maximum entitlement period to 18 months. Unfortunately we cannot exploit this legislative change for identification since we observe individuals for only 7 quarters after the 2006 reform.

[26] Fitzenberger and Wilke (2007) evaluate the same April 1997 reform using quantile regression and find small effects on the duration of unemployment, particularly for older unemployed individuals. Hunt (1995) exploits earlier reforms of the German unemployment insurance system and using hazard rate models finds that increases in the entitlement period reduced exit rates from unemployment.

[27] Some individuals aged 47-48, 52-53 and 57-61 years were affected as the reform reduced their entitlement period at younger ages and they carry forward this lower entitlement.

Figure 2: Change in the mean observed and maximum entitlement period caused by a move from the pre April 1997 regime to the post April 1997 regime



timation provide additional moments for the structural estimation. We argue that identification given these additional moments is cleaner and more transparent than just exploiting simple correlations between labor market status and the entitlement period since the quasi-natural experiment generates moments which are not driven by unobserved heterogeneity or other persistent individual characteristics and therefore can be linked clearly to a causal effect. The additional moments obtained from the quasi-experiment are particularly informative about the importance of net income to individuals' labor supply behavior and therefore provide identifying information about the parameters that determine the preference for consumption in the flow utilities.

In more detail, additional moments based on the quasi-experiment are obtained using a difference-in-differences estimation procedure which captures variation in the intensity of the treatment across individuals. Prior to estimation, we construct each individual's entitlement period in each quarter according to the legislation before and after the April 1997 reform. These variables are denoted $EP_{i,t}^{pre}$ and $EP_{i,t}^{post}$ respectively. The difference $(EP_{i,t}^{post} - EP_{i,t}^{pre})$ measures the effect on individual i's entitlement period at time t of a move from the pre April 1997 regime to the post 1997 regime. This difference is zero for individuals belonging to the control group at time t, namely individuals whose entitlement period was unaffected either due to their age or low pre reform entitlement period. Those whose entitlement period was affected at time t are termed treated and for these individuals the change in the entitlement period varies by age and employment history. In order to identify the causal effect of the duration of unemployment insurance on labor market status we analyze separately the labor market transitions of employed and unemployed individuals and posit the following linear probability model

$$y_{i,j,t} = \gamma(EP_{i,t}^{post} - EP_{i,t}^{pre}) + \lambda(EP_{i,t}^{post} - EP_{i,t}^{pre})Post_t + \varepsilon_{i,j,t}, \tag{12}$$

where $y_{i,j,t}$ is an indicator of individual i being in labor market state j at time t, $\varepsilon_{i,j,t}$ is an error term and $Post_t$ is an indicator variable which equals one if the observation was made during the

post 1997 regime and is zero otherwise. Additionally we include age dummies, quarterly time dummies and measures of education and region of residence. γ reflects the correlation between labor market status as the change in the entitlement period caused by the 1997 reform that exists due to the combined effects of experience, unobserved heterogeneity, and the entitlement period itself, while λ measures the causal effect of the entitlement period on labor market status; an estimate of λ that is significantly different from zero implies that labor market status responds to the entitlement period for those whose entitlement was affected by the April 1997 reform. As we impose linearity, λ can be interpreted as the average effect of a one month increase in the entitlement period for those individuals who actually experienced a change in their entitlement period.

We make two further comments regarding this model. First, for the identification of the causal effect, λ, in (12) the error term, $\varepsilon_{i,j,t}$, must be uncorrelated with the interaction effect $(EP_{i,t}^{post} - EP_{i,t}^{pre})Post_t$ after partialling out the effects of the other variables in the model. This assumption would fail to hold if at the time of the reform the persistence of the error term changed differently for treated and control individuals, however this seems implausible. Second, as we impose linearity in the effect of the treatment intensity on labor market status the model is less flexible than a non-parametric specification using a full set of treatment dummies. However this specification provides an efficient way to use all of the variation in entitlement periods generated by the reform, which is important given our relatively small sample size. Moreover, the restrictive linearity assumption in the difference-in-differences estimation does not affect the interpretation policy effects derived from the structural model, our preferred tool for policy analysis.

We estimate eight different specifications of (12). Using a sample of individuals who were employed in the last quarter, we run regressions for being employed and being retired in the current quarter. This exercise is repeated instead using a sample of individuals who were unemployed in the last quarter.[28] These two regressions are implemented first constraining the parameters λ and γ to be common to all individuals and then allowing these parameters to vary by subgroups defined according to education and region of residence. Table 1 shows the estimated values of λ, the coefficient on the change in the entitlement period.

[28] As full-time employment, unemployment and retirement are mutually exclusive and collectively exhaustive there is no loss from omitting transitions into unemployment.

Table 1: Percentage point effect of the entitlement period on transitions out of employment and out of unemployment

	Employment to Retirement	Employment to Employment	Unemployment to Retirement	Unemployment to Employment
	Estimation with common coefficients			
Common effect	-0.126*	-0.062	-0.013	-0.842*
	(0.067)	(0.176)	(0.376)	(0.491)
	Estimation with subgroup specific coefficients			
High education in west	-0.133*	0.035	1.794	0.510
	(0.066)	(0.179)	(1.623)	(1.732)
High education in east	-0.143*	-0.014	-1.081*	-1.502
	(0.072)	(0.404)	(0.597)	(1.215)
Low education in west	-0.107*	-0.111	-0.365	-0.847
	(0.068)	(0.234)	(0.485)	(0.639)
Low education in east	-0.285**	0.321	0.008	-1.630**
	(0.128)	(0.792)	(0.216)	(0.701)
Number of observations	13485	13485	4551	4551

Notes: Robust standard errors clustered at the individual level are shown in parenthesis. ** and * indicate significance at the 5% and 10% levels respectively. All regressions also include yearly age and quarterly time dummies, controls for region of residence and education and the change in the entitlement period caused by the April 1997 reform. High education is greater than 11 years and low education is 11 or fewer years.

We find several cases in which the entitlement period has a significant effect on transitions between labor market states. The results show that averaged over subgroups a reduction in the entitlement period of one month increases the probability of a transition from employment to retirement by 0.12 of a percentage point, and this effect is significant at the 7 percent level. This effect is strongest for individuals residing in east Germany and is significant at the 5% level for low educated east Germans. This result is in line with the above mentioned stepping stone effect: a reduction in the generosity of unemployment insurance makes using unemployment as a stepping stone into retirement less attractive and therefore employed individuals are more likely to move directly into retirement. In contrast, the results show no significant effect of a change in the entitlement period on the persistence in employment. For transitions out of unemployment, we find roughly opposite results. An increase in the entitlement period significantly reduces the probability of a highly educated east German moving into retirement, but has no effect on movements into retirement for individuals in the other subgroups. On average a reduction in the entitlement period of one month increases the probability of a transition into employment by 0.89 of a percentage point and this effect is significant at the 8 percent level. This effect is higher for the low educated and for individuals residing in east Germany. We use all twenty parameter estimates shown in Table 1 as additional moments when estimating the structural model.

6 Results

6.1 Structural parameter estimates

Table 2 shows the estimated values of the parameters appearing in the wage equation, the job arrival and separation rates, preferences and the equation describing access to early retirement. Estimates of the parameters characterizing the initial conditions are presented in Appendix IV.

Looking first at the wage equation, we see that log wages are concave in experience. This finding underlines the importance of human capital accumulation for the wage process, and for labor supply behavior over the life-cycle more generally. Offered wages are found to be 40% higher in west Germany than in the east, and native Germans and men receive significantly higher wage offers than immigrants and women respectively. We estimate the rate of return to one year of education to be 8%. The estimation results show no significant effect of persistent unobserved characteristics on wages.

We find that older individuals, east Germans and those with health problems are relatively unlikely to receive a job arrival and have relatively high job separation rates. We find significant experience effects in the job arrival and separation rates which stresses the importance of analyzing life-cycle employment in a dynamic framework. The estimation results show significant effects of unobserved characteristics on the job arrival and job separation rates and the unobservables affecting these two processes are found to be positively correlated. This implies that individuals who are relatively likely to receive job arrivals also have relatively high separation rates. In other words, such individuals have a fast rate of turnover on the labor market. As expected, we find that the probability of having access to early retirement is increasing in age and is positively related to having health problems.

The estimated value of β_y reveals that individuals have a significantly positive preference for consumption. We find that η_i, the individual specific complementarity parameter, displays significant variation over individuals. After allowing for the truncation of η_i from above at 1 and below at 0, the mean value of η_i is 0.83. Ignoring transition costs, this implies that on average the net reservation wage for full-time work is 20% higher than net income in unemployment. We find significant costs of moving into employment. Specifically, the cost of a move into employment is estimated to be 65% of net income in unemployment which, based on an average monthly net income in unemployment of 686 Euros, implies a one-off transition cost of 445 Euros associated with moving into employment. In contrast, we find no significant costs of moving from employment into unemployment.

Table 2: Estimates of Structural Parameters

	Coefficient	Standard Error
Wage equation		
Intercept	0.994	0.098
$(\text{Age}-54)\text{I}(54 \leq \text{Age} < 59)$	-0.120	0.015
$(\text{Age}-59)\text{I}(\text{Age} \geq 59)$	0.055	0.019
Health Problems	-0.133	0.048
West	0.410	0.034
Experience (years)/10	0.350	0.027
Experience^2 (years)/1000	-0.791	0.072
Education (years)/10	0.800	0.074
Male	0.112	0.030
German	0.070	0.047
Standard deviation of random effect in wages σ_{α^w}	0.023	0.054
Standard deviation of transitory shocks to wages σ_υ	0.131	0.012
Arrival rate		
Intercept	-4.508	0.319
$(\text{Age}-40)\text{I}(40 \leq \text{Age} < 54)$	-0.220	0.211
$(\text{Age}-54)\text{I}(54 \leq \text{Age} < 59)$	-0.150	0.096
$(\text{Age}-59)\text{I}(\text{Age} \geq 59)$	-0.496	0.172
Health Problems	-0.166	0.314
West	1.095	0.306
Experience (years)/10	0.941	0.115
Standard deviation of random effect in arrivals σ_{μ^θ}	1.600	0.096
Separation rate		
Intercept	-6.119	0.996
$(\text{Age}-40)\text{I}(40 \leq \text{Age} < 54)$	-0.372	0.512
$(\text{Age}-54)\text{I}(54 \leq \text{Age} < 59)$	0.411	0.252
$(\text{Age}-59)\text{I}(\text{Age} \geq 59)$	1.260	0.304
Health Problems	4.280	0.807
West	-1.164	0.586
Experience (years)/10	-0.540	0.279
Standard deviation of random effect in separations σ_{μ^γ}	1.494	0.589
Covariance between random effects in arrivals and separations $Cov_{\mu^\theta\mu^\gamma}$	2.087	0.883
Preferences		
Cost of transition into employment c_{uf}	0.656	0.081
Cost of transition into unemployment c_{fu}	0.201	0.183
Mean of complementary parameter (before truncation) μ_η	0.971	0.142
Standard deviation of complementarity parameter (before truncation) σ_η	0.140	0.079
Coefficient on consumption β_y	4.043	1.287
Access to retirement		
Intercept	-1.500	0.165
$(\text{Age}-54)\text{I}(54 \leq \text{Age} < 59)$	0.050	0.046
$(\text{Age}-59)\text{I}(59 \leq \text{Age} < 62)$	0.161	0.103
$(\text{Age}-62)\text{I}(\text{Age} \geq 62)$	-0.037	0.126
Health Problems	0.530	0.297

Notes: The health process is defined and estimated in Appendix II.

6.2 Goodness of fit

Figure 3 presents a graphical analysis of the model's goodness of fit. Employment, unemployment and retirement over the life-cycle are predicted satisfactorily. The distribution of the simulated log wages for individuals in employment in the quarter in which they were interviewed and adjusted for survey non-response, matches accurately the distribution of sampled wages. Finally, the general trends over the life-cycle in the exit rates from employment and unemployment are captured by the model. As we observe only a relatively small number of transitions between labor market states at a given age, the observed exit rates from employment and unemployment are somewhat noisy. Therefore it is not surprising that we do not fit the exit rates as well as other aspects of behavior.

Figure 3: Goodness of fit

Table **??** provides information about the fit of moments derived from the difference-in-differences estimation described in Section 5.2. In addition to the observed moments (repeated from Table 1) we present the fitted counterparts and t-tests for the significance of the difference between the fitted and observed moments. The table shows that the structural model fits the difference-in-differences moments fairly accurately. The t-statistics indicate that only in one case, namely transitions from employment to retirement for low educated east Germans, is the difference between the observed and the fitted moment significant at the 5% level. Since we observe very few low educated east Germans making a transition from employment to retirement, this significant difference is not very surprising. The structural model is able to fit the causal effect of unemployment insurance on transitions from unemployment to employment very accurately. However, in general it seems that the structural model under predicts the effect of unemployment insurance on transitions from employment into retirement. We postulate this may be due to our approximation to net income in retirement, described in Section 2.3.3, or to the structure imposed on the flow utilities, specifically the restriction that the coefficient on consumption, β_y, does not vary across labor market states.

	Employment to to Retirement	Employment to Employment	Unemployment to Retirement	Unemployment to Employment
		Common effect		
Fitted	-0.035	-0.148	-0.047	-0.730
Observed	-0.126	-0.062	-0.013	-0.842
t-test for difference	1.352	-0.481	-0.088	0.214
		High education in west		
Fitted	-0.010	-0.170	0.129	-1.144
Observed	-0.133	0.035	1.794	0.510
t-test for difference	1.821	-1.102	-0.941	-0.809
		High education in east		
Fitted	-0.028	-0.047	-0.258	-0.447
Observed	-0.143	-0.014	-1.081	-1.502
t-test for difference	1.472	-0.069	1.038	0.814
		Low education west		
Fitted	-0.020	-0.191	0.152	-0.592
Observed	-0.107	-0.111	-0.365	-0.847
t-test for difference	1.268	-0.337	0.992	0.371
		Low education east		
Fitted	0.013	-0.104	-0.517	-1.053
Observed	-0.285	0.321	0.008	-1.630
t-test for difference	2.089	-0.437	-1.753	0.636

7 Policy analysis

7.1 Employment and fiscal effects of the unemployment insurance

We use our estimates of the structural parameters to simulate the employment and fiscal effects of the unemployment insurance system. Specifically, we explore the effects of: (i) a reduction in the replacement ratio for ALG I from 60% to 55%; and (ii) a reduction in the maximum entitlement period from 32 months to 12 months for all ages. We use the German 2001 tax and transfer system as the benchmark. Table 3 summarizes the employment and fiscal effects of a reduction in the replacement ratio and in the entitlement period for particular groups of individuals, defined by employment status at age 40 years or by education and region of residence. We report the effects at different points in the life-cycle, namely at ages 41, 55 and 63 years.[29]

We focus first of the effects of a change in the replacement ratio. Averaged over the life-cycle and over the sampled individuals, reducing the replacement ratio to 55% leads to a fall in the net transfers made by the government, including additional tax revenues received by the government due to higher employment rates, of around 5 Euros per person per month. Overall we find that a reduction in the replacement ratio to 55% leads to a fall in unemployment, however the effect varies strongly by age. Whereas the average reductions in unemployment at ages 41 and 55 years are only 0.4 and 0.1 of a percentage point respectively, the reduction in unemployment is 1.55 percentage points at the end of the working life. In line with previous results for Germany, e.g., Hunt (1995), we find that the primary behavioral effect of a reduction in the generosity of employment insurance it to cause older unemployed individuals to move into retirement.

For individuals who were unemployed without entitlement for unemployment insurance at age 40 years a reduction in the generosity of unemployment insurance has no effect on labor market status at age 41 years and there is a positive effect on unemployment at age 55 years. This finding is consistent with Mortensen's *entitlement effect*, whereby unemployed individuals with zero entitlement have a reduced incentive to enter employment when the generosity of

[29]In a similar fashion, we could use our model to evaluate the 2006 reform of unemployment insurance in Germany (described in Table 6). Using a hazard rate model, Schmitz and Steiner (2007) find that the 2001 reform had large effects on the employment behavior of older individuals.

unemployment insurance is reduced.[30] For individuals in this group, at age 63 years we find no effect on employment but retirement increases by 0.37 of a percentage point.

For employed individuals with below full entitlement at age 40 years we again find that cutting the replacement ratio increases the probability of unemployment at age 55 years which is consistent with the *entitlement effect*. In contrast, for employed individuals with full entitlement at age 40 years a reduction in the replacement ratio has the expected negative effect on unemployment at all ages, and in line with the legally determined maximum entitlement period increasing in age, the effect is largest at age 63 years. We find very little variation in the labor supply effects of a cut in the replacement ratio across subgroups defined by education and region of residence, but we note that the average fiscal saving is greatest for the group of high educated west Germans. This result reflects the dependence of unemployment insurance benefits on previous earnings together with the relatively high wages of west Germans with high education.

We now turn to the effect of cutting the legally defined maximum entitlement period to 12 months for all ages. This reform has no direct effect on the entitlement periods of those aged under 42 years, but reduces the maximum entitlement period by between 2 and 20 months for older individuals. Individuals aged 57 years and above are the group most severely affected by this reform. Although a reduction in the maximum entitlement period to 12 months has no direct effect on the transfers paid to those aged under 42 years these individuals may adjust their labor market behavior as they anticipate experiencing a reduction in their maximum entitlement period once they reach 42 years of age.

The results in Table 3 show that on average cutting the maximum entitlement period to 12 months produces a fiscal saving of around 8 Euros per person per month and leads to larger labor supply effects than those obtained by cutting the replacement ratio to 55%. We see some small labor supply effects at age 41 years, arising from individuals adjusting labor supply in anticipation of lower maximum entitlement periods in the future. At age 55 years we find a small positive effect on unemployment for individuals who had zero entitlement at age 41 years, which again may be partly driven by the *entitlement effect*. This is not the case for those who were employed with full entitlement at age 40 years. Interestingly, and in contrast to the effect of a cut in the replacement ratio, at age 63 years we find that a reduction in the maximum entitlement period to 12 months has a large positive effect on employment, while on average retirement increases by only 0.53 of a percentage point. This large employment effect towards the end of the working life contributes to the relative large fiscal saving associated this reduction in the maximum entitlement period.

A comparison of the employment and fiscal effects induced by a cut in the replacement ratio and by a cut in the maximum entitlement period suggests recommending the entitlement period over the replacement ratio as a policy tool. A similar policy conclusion was reached in Lalive *et al.* (2006) in the context of Austria. Based on regional and intertemporal variation

[30] Unlike Mortensen (1977), in our model reductions in the generosity of unemployment insurance may cause non-entitlement unemployed individuals to be more or less likely enter employment due to the effects of experience and the option of early retirement. Therefore the negative labor supply effects evident in Table 3 do not reflect solely an *entitlement effect*.

Table 3: Employment and fiscal effects of reductions the replacement ratio and the entitlement period

Subgroup	Age 41 years			Age 55 years			Age 63 years			D.Net
	f	u	r	f	u	r	f	u	r	Transfer
Reduce Replacement Ratio to 55%										
All	0.394	-0.388	-0.006	0.012	-0.100	0.088	0.459	-1.546	1.088	-4.771
Unemployed with zero entitlement at age 40 years	0.000	0.000	0.000	0.000	0.186	-0.186	0.000	-0.372	0.372	-2.458
Full-time employed with below full entitlement at age 40 years	0.212	-0.212	0.000	-0.212	0.212	0.000	0.425	-1.841	1.416	-3.013
Full-time employed with full entitlement at age 40 years	0.469	-0.469	0.000	0.037	-0.198	0.161	0.505	-1.691	1.186	-5.410
High educated west German	0.431	-0.431	0.000	0.011	-0.126	0.116	0.683	-1.840	1.156	-6.381
Low educated west German	0.333	-0.333	0.000	0.031	-0.146	0.115	0.344	-1.614	1.270	-3.876
High educated east German	0.317	-0.317	0.000	0.000	-0.124	0.124	0.430	-1.730	1.300	-4.350
Low educated east German	0.334	-0.334	0.000	-0.012	-0.104	0.115	0.449	-1.703	1.254	-4.259
Reduce Maximum Entitlement Period to 12 months										
All	0.018	-0.012	-0.006	-0.141	0.012	0.129	2.399	-2.928	0.529	-8.171
Unemployed with zero entitlement at age 40 years	0.000	0.000	0.000	-0.186	0.372	-0.186	0.186	0.186	-0.372	-3.200
Full-time employed with below full entitlement at age 40 years	0.071	-0.071	0.000	-0.283	0.283	0.000	2.266	-2.195	-0.071	-6.197
Full-time employed with full entitlement at age 40 years	0.015	-0.022	0.007	-0.132	-0.051	0.183	2.709	-3.441	0.732	-9.078
High educated west German	0.032	-0.042	0.011	-0.116	-0.053	0.168	2.902	-3.574	0.673	-10.476
Low educated west German	0.010	-0.021	0.010	-0.146	-0.010	0.156	2.259	-2.801	0.541	-7.262
High educated east German	0.011	-0.023	0.011	-0.158	-0.011	0.170	2.397	-3.132	0.735	-7.804
Low educated east German	0.012	-0.023	0.012	-0.173	0.012	0.161	2.393	-2.991	0.598	-7.807

Notes: Figures under f, u and r denote the percentage point changes in full-time employment, unemployment and retirement respectively. D.Net transfer is the change in the mean monthly transfer per person from the government, and including employee and employer Social Security Contributions. High educated individuals have more than 11 years of education and low educated individuals have 11 or fewer years of education. Due to the small sample size we omit the results for unemployed individuals with high entitlement at age 40 years. Behavioral changes are first measured at age 41 years as predicted labor supply at age 40 years is based on the initial conditions and therefore is invariant with respect to the policy parameters.

in the design of unemployment insurance, Lalive *et al.* (2006) identify the causal effects of the replacement ratio and the entitlement period on the duration of unemployment using a reduced form model. They conclude that the entitlement period is a more effective tool for policy makers than the replacement ratio, primarily because labor supply behavior is more sensitive to changes in the entitlement period.

7.2 Revenue neutral employment and welfare effects

When conducting policy evaluations based on structural models it is possible to go beyond an analysis of employment effects and to provide evidence about the welfare implications of policy reforms. Based on the results of structural modeling we can address central questions for policy makers concerning the gainers and losers from tax reforms, the size of welfare effects in monetary terms or the design of the optimal tax and transfer system. However, answering such questions would take us well beyond a positive analysis and require normative assumptions about the social welfare function. In this paper we work with a very simple social welfare measure in order to minimize normative assumptions. Specifically, we interpret the individual specific value functions as measures of individual well-being over the remainder of the life-cycle and look only at the proportions of individuals made better off and worse off by revenue neutral reforms to the tax and transfer system.[31] By looking at revenue neutral reforms we hold fixed the position of the government, and by focusing on whether individuals are made worse or better off in terms of their value function we avoid any interpersonal comparisons.

We analyze seven alternative unemployment insurance schemes which vary in the replacement ratio and the entitlement period. These parameters are listed in the first two columns of Table 4. In order to make the reforms revenue neutral we adjust income taxation proportionately, and the size of the income tax reduction is presented in column three. We hold the rest of the tax and transfer system, including the means-tested out-of-work transfers, constant and use the 2001 tax and transfer system as the benchmark. Table 4 further shows the changes in employment, unemployment and retirement induced by each reform and age specific percentages of gainers and losers as measured at three different points during the life-cycle. In all reforms, individuals gain from lower income tax when they are in employment but may be worse off if they are unemployed. Whether the value function increase or decreases depends on the balance of these countervailing effects in expectation over the remainder of the life-cycle.

[31] Obviously this measure has limitations. For example we cannot derive conclusions about the size of welfare effects or the distribution of gainers and losers.

Table 4: Welfare effects of revenue neural reductions in the replacement rate and entitlement period

Maximum Entitlement Period	Replacement Ratio (%)	% change in income tax to obtain revenue neutrality	Labor supply effects					
			f (%)	u (%)	r (%)			
6	60	-6.41	1.01	-1.26	0.25			
12	60	-4.06	0.72	-0.84	0.12			
18	60	-2.50	0.49	-0.54	0.05			
6	55	-6.56	0.98	-1.34	0.36			
12	55	-4.61	0.76	-1.04	0.28			
18	55	-3.44	0.59	-0.81	0.21			
32	55	-2.19	0.35	-0.44	0.09			
		Age 40 years		Age 55 years		Age 63 years		
		better off (%)	worse off (%)	better off (%)	worse off (%)	better off (%)	worse off (%)	
6	60	65.31	31.49	32.08	62.03	26.03	67.17	
12	60	93.41	3.36	34.42	59.35	28.65	63.62	
18	60	95.18	1.58	42.02	51.64	33.74	57.78	
6	55	60.71	36.09	30.19	63.98	24.49	68.91	
12	55	67.10	29.67	28.19	65.66	23.78	68.89	
18	55	68.08	28.69	26.71	67.08	22.63	69.58	
32	55	60.49	36.28	35.69	58.04	29.09	61.76	

Notes: Figures under f, u and r denote the percentage point changes in full-time employment, unemployment and retirement respectively averaged over sampled individuals and over age. Welfare effects are based on changes in individual value functions for the sampled individuals. Retired individuals are neither worse off or better off, provided that their pensions were not altered by the policy change.

Looking at the first three policies in Table 4, where the entitlement period is cut but the replacement ratio is held fixed at 60%, we see that cutting the entitlement period to 6 months, which affects entitled individuals of all ages, allows income tax payments to be reduced by 6.4%. This reform causes a one percentage point increase in employment, averaged over the sample individuals and over age. According to our welfare measure we find that 63% of individuals aged 40 years are better off due to these changes. Cutting the maximum entitlement period to 12 or 18 months leads to smaller increases in employment and allows smaller reductions in income tax. Following these two reforms, individuals aged 40 years benefit from lower income tax payments in the current period and lower expected payments in the future, while at age 40 years cutting the maximum entitlement period to 12 or 18 months reduces life-cycle utility only to the extent to which future expected net income in unemployment is reduced. Thus, as the negative consequences of these reforms are delayed until later in the life-cycle, at age 40 years over 90% of individuals are better off following these reforms.

Cutting the replacement ratio to 55% but holding the maximum entitlement period fixed at 32 months produces a smaller increase in employment and, as measured at age 40 years, makes fewer individuals better off than reforms in which only the maximum entitlement period is cut. Moreover, cutting simultaneously the entitlement period and the replacement ratio produces similar increases in employment to those obtained by cutting only the entitlement period, but tends to make fewer individuals better off. In line with our previous findings, these results provide further support for cutting the entitlement period rather than the replacement ratio if the government is aiming to reduce the generosity of unemployment insurance.

In all reform scenarios the fraction of individual made better off is declining with age. This can be explained by two factors. First, older individuals are more likely to be subject to a job separation and receive fewer job offers. Older individuals therefore have a higher probability of being unemployed and the expected loss from less generous unemployment insurance benefits is relatively high. Second, the maximum entitlement period is increasing with age and therefore reductions in the generosity affect older individuals more than younger individuals.

8 Conclusion

The design of unemployment insurance is an important question for policy makers and has implications for employment and retirement behavior over the life-cycle. In this study we have developed a dynamic structural life-cycle model with sufficient generality and richness to allow us to evaluate the employment, fiscal and welfare effects induced by unemployment insurance. Critically, our model captures accurately the working incentives presented by the tax and transfer system, and includes unemployment insurance benefits that may depend on an individual's working and earnings history. Structural modeling allows us to conduct policy analysis that goes beyond numerous empirical evaluations analyzing the employment effects of unemployment insurance using reduced form, typically quasi-experimental, methods. The model is estimated using German panel data from the SOEP covering an fairly homogeneous sample of single adult households. The structural parameters are estimated using MSM and we improve identification by exploiting a quasi-natural experiment which reduced the maximum entitlement period for unemployment insurance for individuals with certain age and employment history credentials.

Overall, we find that a reduction in the generosity of unemployment insurance leads to a fall in unemployment which is matched partly by higher employment and partly by increased early retirement. Not surprisingly, we predict the largest labor supply responses for individuals older than 60 years as the unemployment insurance rules are most generous for this age group, and a relative large fraction of such individuals are unemployed. Our results are consistent with Mortensen's *entitlement effect* as we predict an increase in unemployment for individuals without entitlement when generosity of unemployment insurance is reduced. Cutting the replacement ratio leads to slightly lower employment effects and to a smaller reduction in net government transfers than cutting the entitlement period. In this respect our results support previous findings suggesting that changing the entitlement period is a more effective policy tool than adjusting the replacement ratio.

Finally, we draw on the specification on preferences embedded in the structural model and conduct a simple analysis of welfare. The results indicate again that cuts in the entitlement period are preferred to cuts in the replacement ratio and further we find that there is little to be gained, either in terms of welfare or in increased employment, from adjusting both the replacement ratio and the entitlement period. Of course this final part of our analysis is subject to critiques of our chosen welfare measure, as will always be the case when attempting to aggregate measures of individual well-being. Indeed the welfare analysis is presented more to illustrate the added leverage that can be obtained by analyzing unemployment insurance in a

structural model than as a definitive answer as to the welfare implications of different systems of unemployment insurance.

Appendix I: The German tax and transfer system

This appendix describes the key elements of the German tax and transfer system and how we implement the legislation in the setting of a dynamic life-cycle model of labor supply. Although the general structure of income taxation, social security contributions and transfers was unchanged over the years 1995 - 2007, several reforms affected the progressivity and generosity of this system.

Social Security Contributions (SSC)

In each month, an individual's income from employment is subject to social security deductions for health, unemployment and pension benefits.[32] As shown in columns 2-4 of Table 5, except for unemployment insurance, the rates for SSC increased slightly over time. Social security contributions are capped, and the upper level of monthly earnings subject to SSC is higher in west Germany than in the east (5200 Euros compared to 4500 Euros in 2005).

Table 5: Key parameters of the German tax and transfer system

	Social Security Contributions			Income taxation		ALG II	
Year	Health Insurance (%)	Pension Insurance (%)	Unemployment Insurance (%)	Tax Allowance per year	Top Marginal Tax Rate (%)	Average West per month	Average East per month
1995	7	9.3	3.3	4050	53	564	553
1996	7.5	9.65	3.3	6021	53	571	560.5
1997	7.75	10.15	3.3	6021	53	580	569.5
1998	7.75	10.15	3.3	6156	53	586	575
1999	7.75	9.85	3.3	6507	53	594	584
2000	7.75	9.85	3.3	6876	51	606	596
2001	7.75	9.55	3.3	7200	48.5	617	606
2002	7.75	9.75	3.3	7200	48.5	629	617
2003	8	9.75	3.3	7200	48.5	634	622
2004	8	9.75	3.3	7632	45	643	631
2005	8.5	9.75	3.3	7632	42	653	637
2006	8.5	9.75	3.3	7632	42	658	642
2007	8.5	9.75	2.1	7632	42*	662	645

* From 2007, taxable income above 250000 Euros per year has been taxed at a rate of 45%.
Notes: All payments are given in Euros. The rates of the SSC describe only the employee's share. The employer contributes the same amount. ALG II payments include housing benefits.

Income taxation

In contrast to SSC, income tax is computed on an annual basis and at the household level. An individual's annual taxable income is defined as the sum of gross income from employment above an exemption threshold, gross income from assets above a disregard and income from renting.

[32] In addition to the employee's SSC, the employer contributes about the same amount in SSC. Since July 2005 there has been a small divergence from this rule which we neglect in this study.

Moreover SSC up to a maximum amount are deducted. An individual's annual income tax liability is obtained by applying the income tax function to taxable income. The income tax function is a smooth function of taxable income above a further exemption threshold. The exemption threshold increased between 1995 and 2006 while, over the same period, the top marginal tax rate decreased from 53% to 42% (see Table 5). In addition to income tax, individuals pay an extra tax (Solidaritaetszuschlag) to finance the cost of German reunification. This extra tax was decreased in 1998 from 7.5% to 5.5% of income tax payments.

Transfer system

As described in Section 2.3.2, transfers to unemployed individuals consist of unemployment insurance, in the form of either ALG I or ALH, or means-tested social assistance (ALG II). Table 6 shows the maximum entitlement period for unemployment insurance over time by age. The maximum entitlement period is increasing in age, and has been shortened over time.

Table 6: Maximum entitlement period over time by age

Age (years)	until April 1997	from April 1997 until Jan 2006	since Feb 2006
< 42	12	12	12
42-43	18	12	12
44	22	12	12
45-46	22	18	12
47-48	22	22	12
49-51	26	22	12
52-53	26	26	12
54	32	26	12
55-56	32	26	18
≥ 57	32	32	18

Notes: Adapted from Schmitz and Steiner (2007).

In contrast to unemployment insurance, the amount of ALG II, or social assistance, does not depend on previous earnings. Entitlement rules are independent of working history and the transfer is permanent. The transfer consists of a person-related part that varies by region of residence and housing benefits that may vary by individual. However, housing benefits only guarantee a reasonable apartment given the number of household numbers. In the last two columns of Table 5 we provide information about the average monthly benefit payments by year in east and west Germany.

Note the ALG II is means-tested against income from all sources. Thus, if the ALG I benefits for an eligible unemployed individual are lower than the ALG II benefits then he or she receives, in addition to ALG I, the difference between the two transfers. Unemployment insurance transfers are not directly taxed. Instead, ALG I and ALH are added to taxable income to determine the individual's average tax rate, which is then applied to taxable income to determine the individual's tax liability. ALG II payments have no tax implications.

Implementation

Income tax is based on annual income. However we model labor supply decisions at quarterly intervals. In our implementation of the German tax and transfer system we calculate net income

in the current quarter based on an annualized version of the individual's income in the current quarter. The procedure assumes implicitly that individuals base their labor supply decision in the current quarter on their net income relating to their current gross income and ignore any adjustments in taxes and transfer pertaining to income received previously in the fiscal year. Additionally we assume full take-up of benefits.

Appendix II: Estimation of the health equation

Health is an important state variable in the structural model as health affects job arrivals, job separations, wages and the probability of having access to early retirement. It is well known that health status varies considerably over the life-cycle and health problems are often very persistent. Therefore, we model health status over the life-cycle using a dynamic model. At time t we measure health with an indicator variable, Health Problems$_{i,t}$, which takes value one if the individual reports health problems and is zero otherwise. We assume that health status evolves stochastically over the life-cycle according to the following equation

$$\text{Health Problems}_{i,t}(\text{Health Problems}_{i,t-1}, g_{i,t}, \phi_{i,t}) = \pi_1 \text{Health Problems}_{i,t-1} + \pi_2 g_{i,t} + \phi_{i,t}, \quad (13)$$

where $g_{i,t}$ consists of individual characteristics that impact on health, including education and age. Health status in the previous quarter, Health Problems$_{i,t-1}$, captures persistence in health status. The unobservable $\phi_{i,t}$ is assumed to occur independently over both individuals and time and to have a standard normal distribution. Given these distributional assumptions, estimation of the parameters in (13) can be conducted prior to estimation of the structural parameters and the parameters describing the initial conditions.

The sampled individuals were asked to record their health status only in the quarter when the annual survey took place. A standard probit model cannot therefore be used to estimate the parameters in (13) as health status in the previous quarter, Health Problems$_{i,t-1}$, is unobserved. Instead we use the MSM to estimate the unknown parameters. The moments used in this estimation procedure consist of coefficients from an OLS regression of observed health status on the previous observation of health status, Health Problems$_{i,t-4}$, and observed individual characteristics. Additionally the list of moments includes the proportions of individuals whose health remained good, remained poor and changed from good to poor between adjacent surveys.

Table 7 reports the MSM parameter estimates. The coefficient on health status in the previous quarter is positive and highly significant indicating strong persistence in health status on a quarter by quarter basis. Additionally we see that health tends to decline with age but improves with experience and education. Ceteris paribus, men are more likely to have health problems than women.

Table 7: Estimates of parameters in the health equation

	Coefficient	Standard Error
Health Problems$_{t-1}$	4.122	0.129
(Age-40)/10	0.210	0.041
Education (years)/10	-0.206	0.048
West	-0.008	0.052
Male	0.119	0.045
Experience (years)/10	-0.100	0.027
Intercept	-2.091	0.034

Appendix III: Chosen moments

Table 8 describes the moments that we use in the MSM estimation of the parameters appearing in the structural model and the initial conditions. In the first column we describe how we construct each set of moments, the second column shows the number of moments in each set, and in the final column we indicate which parameters are primarily identified by each set of moments. In total we use 301 moments to estimate at total of 59 parameters. The largest fraction of the moments are age and quarter specific means of labor market outcomes, including measures of the initial state. Further, we construct several moments which describe the persistence in wages and in labor supply behavior. These moments provide identifying information about transition costs and the persistent unobservables. In order to identify the effects of age and observed characteristics in the various equations, we run several OLS regressions of outcome variables, including wages and transitions between labor market states, on age and observed individual characteristics.

Table 8: Description of moments

Description of moments	Number of moments	Primarily identifying
Regression of employment on initial employment state and initial experience	2	Variance of complementarity between consumption and leisure (σ_η)
Regression of the individual specific number of transitions from unemployment to employment on initial employment state, initial experience, initial entitlement period, region, initial health and age terms	10	Variance of the individual specific unobservable ($\sigma^2_{\mu^\theta}$) and coefficients on observed characteristics in the job arrival rate
Regression of the individual specific number of transitions from employment to unemployment on initial employment state, initial experience, initial entitlement period, region, initial health and age terms	10	Variance of the individual specific unobservable ($\sigma^2_{\mu^\gamma}$) and coefficients on observed characteristics in the job separation rate
Regression of initial employment on initial experience, initial health, region, education, functions of initial non-labor income, nationality, children, martial status and age terms	15	Parameters determining initial employment
Regression of initial retirement on age terms	5	Parameters determining initial retirement
Regression of transitions from unemployment to employment on experience, health, entitlement period, region, and age terms	11	Parameters determining job arrivals
Regression of transitions from unemployment to retirement on experience, health, entitlement period, region, and age terms	11	Parameters determining access to early retirement
Regression of transitions from employment to unemployment on experience, health, entitlement period, region, and age terms	10	Parameters determining job separations
Regression of transitions from employment to retirement on experience, health, entitlement period, region, and age terms	10	Parameters determining access to early retirement
Treatment effects obtained from regressions of transition between labor market states on the change in entitlement period caused by 1997 unemployment insurance reform (see Equation (12) and Table 1)	20	Coefficient on consumption (β_y)
Regression of log wages on experience, health, initial employment, initial experience, region, education, nationality, gender and age terms	15	Parameters determining wages
Distribution of log wages: percentiles; standard deviation; autocorrelations	7	Unobservables affecting wages
Correlation between individual specific number of transition into and out of employment	1	Covariance between unobservables in arrivals and separations ($Cov_{\mu^\theta\mu^\gamma}$)
Persistence in labor market status: frequencies of various sequences of transitions	18	State dependence effects
Labor supply over the life-cycle: quarterly employment and retirement rates; age specific employment and retirement rates	156	Age effects

Notes: Region is an indicator of the individual residing is west Germany. Health is an indicator of the individual having health problems. Gender is a dummy for male. Education refers to years of eduction. The chosen functions of initial non-labor income are indicators of annual non-labor income being positive but less than 400 Euros per year and being above 400 Euros per year. Nationality is an indicator of being a native German. Children and marital status are indicators of the individual having dependent children or having been married prior to entering the sample.

Appendix IV: Initial conditions

To complete the description of the estimation results, Table 9 presents the coefficients appearing in the initial conditions. These parameters are descriptive of individuals' behavior prior to their entering the sample, and therefore do not have a structural interpretation. The coefficients on the persistent unobservables capture the endogeneity of the initial conditions.

Table 9: Estimates of parameters describing the initial conditions

	Initial employment		Initial retirement	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	1.665	0.481	-3.000	0.071
I($54 \leq$ Age < 59)	0.280	0.305	0.293	0.323
I($59 \leq$ Age)	-0.679	0.303	1.156	0.123
Experience (years)/10	-0.400	0.080		
Health Problems	-2.080	0.214		
Persistent unobserved individual effect in wages	-4.991	0.611		
Persistent unobserved individual effect in preferences	0.885	0.181		
Persistent unobserved individual effect in separation rate	-0.220	0.210		
Persistent unobserved individual effect in arrival rate	0.219	0.242		
West	3.220	0.503		
Education (years)/10	2.504	0.518		
I($0 <$ Non-labor income (Euros/year) ≤ 400)	3.686	0.569		
I(Non-labor income (Euros/year) > 400)	4.443	0.601		
Male	-0.187	0.387		
German	-0.092	0.264		
Previously had children	-0.855	0.397		
Previously been Married	-0.662	0.349		

References

Adda, J., Costa Dias, M., Meghir, C., and Sianesi, B. (2007), Labour Market Programmes and Labour Market Outcomes: A Study of the Swedish Active Labour Market Interventions, *Mimeo*.

Adda, J., Dustmann, C., Meghir, C., and Robin, J.-M. (2009), Career Progression and Formal versus On-the-Job Training, *IFS Working Paper*, volume 09/06(2260).

Aguirregabiria, V. and Mira, P. (2009), Dynamic Discrete Choice Structural Models: A Survey, *forthcoming in Journal of Econometrics*.

Altonji, J. and Segal, L. (1996), Small-Sample Bias in GMM Estimation of Covariance Structures, *Journal of Business and Economic Statistics*, volume 14(3): pages 353–366.

Attanasio, O. P., Meghir, C., and Santiago, A. (2005), Education Choices in Mexico: Using a Structural Model and a Randomised Experiment to Evaluate Progresa, *IFS Working Paper*.

Caliendo, M., Tatsiramos, K., and Uhlendorff, A. (2009), Benefit Duration, Unemployment Duration and Job Match Quality: A Regression-Discontinuity Approach, *IZA Discussion Paper*, volume 4670.

Card, D. and Levine, P. B. (2000), Extended benefits and the duration of UI spells: Evidence from the New Jersey Extended Benefit Program, *Journal of Public Economics*, volume 78(1-2): pages 107–138.

Eckstein, Z. and Wolpin, K. (1989), Dynamic Labour Force Participation of Married Women and Endogenous Wage Growth, *Review of Economic Studies*, volume 56(3): pages 375–390.

Ferrall, C. (1997), Unemployment Insurance Eligibility and the School-to-Work Transition in Canada and the United States, *Journal of Business and Economic Statistics*, volume 15(2): pages 115–129.

Fitzenberger, B. and Wilke, R. (2007), New Insights on Unemployment Duration and Post Unemployment Earnings in Germany: Censored Box-Cox Quantile Regression at Work, *ZEW Discussion Papers*, volume 07-007.

——— (2009), Unemployment Durations in West-Germany Before and After the Reform of the Unemployment Compensation System during the 1980s, *forthcoming in German Economic Review*.

French, E. (2005), The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour, *Review of Economic Studies*, volume 72(2): pages 395–427.

Frijters, P. and van der Klaauw, B. (2006), Job Search with Nonparticipation, *Economic Journal*, volume 116(508): pages 45–83.

Goffe, W. L., Ferrier, G. D., and Rogers, J. (1994), Global Optimization of Statistical Functions with Simulated Annealing, *Journal of Econometrics*, volume 60(1-2): pages 65–99.

Gourinchas, P. and Parker, J. (2002), Consumption Over the Life Cycle, *Econometrica*, volume 70(1): pages 47–89.

Haan, P. and Prowse, V. (2010), A Structural Approach to Estimating the Effect of Taxation on the Labor Market Dynamics of Older Workers, *forthoming in Econometrics Journal*.

Haisken De-New, J. and Frick, J. (2005), *Desktop Compendium to The German Socio-Economic Panel Study (SOEP)*, DIW.

Heckman, J. (1981), The Incedental Parameter Problem and the Problem of Initial Conditions in Estimating a Discrete Time-Discrete Data Stochastic Process, in *Structural Analysis of Discrete Data with Econometric Applications*, edited by Manski, C. F. and McFadden, D., pages 179–195, MIT Press.

Hunt, J. (1995), The Effect of Unemployment Compensation on Unemployment Duration in Germany, *Journal of Labor Economics*, volume 13(1): pages 88–120.

Hyslop, D. (1999), State Dependence, Serial Correlation and Heterogeneity in Intertemporal Labor Force Participation of Married Women, *Econometrica*, volume 67(6): pages 1255–1294.

Katz, L. F. and Meyer, B. D. (1990), The Impact of the Potential Duration of Unemployment Benefits on the Duration of Unemployment, *Journal of Public Economics*, volume 41(1): pages 45–72.

Keane, M. and Wolpin, K. (2009), Empirical Applications of Discrete Choice Dynamic Programming Models, *Review of Economic Dynamics*, volume 12(1): pages 1–22.

Keane, M. P. and Wolpin, K. I. (1997), The Career Decisions of Young Men, *Journal of Political Economy*, volume 105(3): pages 473–522.

Kyyrä, T. and Wilke, R. (2007), Reduction in the Long-term Unemployment of the Elderly: A Success Story from Finland, *Journal of the European Economic Association*, volume 5(1): pages 154–182.

Laibson, D., Repetto, A., and Tobacman, J. (2007), Estimating Discount Functions with Consumption Choices over the Lifecycle, *NBER Working Paper*, volume 13314.

Lalive, R., van Ours, J., and Zweimüller, J. (2006), How Changes in Financial Incentives Affect the Duration of Unemployment, *Review of Economic Studies*, volume 73(4): pages 1009–1038.

Laroque, G. and Salanie, B. (2002), Labour Market Institutions and Employment in France, *Journal of Applied Econometrics*, volume 17(1): pages 25–48.

Low, H., Meghir, C., and Pistaferri, L. (2009), Wage Risk and Employment Risk over the Life Cycle, *forthcoming in American Economic Review*.

Magnac, T. and Thesmar, D. (2002), Identifying Dynamic Discrete Decision Processes, *Econometrica*, volume 70(2): pages 801–816.

Meyer, B. (1990), Unemployment Insurance and Unemployment Spells, *Econometrica*, volume 57(4): pages 757–782.

Mortensen, D. (1977), Unemployment Insuracne and Job Search Decisions, *Industrial and Labor Relations Review*, volume 30(4): pages 506–517.

Novo, A. and Silva, A. (2010), Using an Unemployment Insurance Reform to Test an Equilibrium Search Model, *Mimeo*.

Pischke, J. (1995), Measurement Error and Earnings Dynamics: Some Estimates from the PSID Validation Study, *Journal of Business and Economic Statistics*, volume 13(3): pages 305–314.

Rust, J. and Phelan, C. (1997), How Social Security and Medicare Affect Retirement Behavior in a World of Incomplete Markets, *Econometrica*, volume 65(4): pages 781–832.

Schmitz, H. and Steiner, V. (2007), Benefit-Entitlement Effects and the Duration of Unemployment: An Ex-Ante Evaluation of Recent Labour Market Reforms in Germany, *IZA Discussion Paper Series*, (2681).

Todd, P. and Wolpin, K. (2006), Using Experimental Data to Validate a Dynamic Behavioral Model of Child Schooling: Assessing the Impact of a School Subsidy Program in Mexico, *American Economic Review*, volume 96(5): pages 1384–1417.

van den Berg, G. J. (1990), Nonstationarity in Job Search Theory, *Review of Economic Studies*, volume 57(2): pages 255–277.

Van Ours, J. and Vodopivec, M. (2006), How Shortening the Potential Duration of Unemployment Benefits affects the Duration of Unemployment: Evidence from a Natural Experiment, *Journal of Labor Economics*, volume 24(2): pages 351–378.

Wolpin, K. I. (1992), The Determinants of Black-White Differences in Early Employment Careers: Search, Layoffs, Quits, and Endogenous Wage Growth, *The Journal of Political Economy*, volume 100(3): pages 535–560.