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Evidence from a Dynamic Structural  
Life-Cycle Model**

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## IMPRESSUM

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# Employment effects of welfare reforms - Evidence from a dynamic structural life-cycle model\*

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## Abstract

In this paper we develop a dynamic structural life-cycle model of labor supply behavior which fully accounts for the effects of income tax and transfers on labor supply incentives. Additionally, the model recognizes the demand side driven rationing risk that might prevent individuals from realizing their optimal labor supply state, resulting in involuntary unemployment. We use this framework to study the employment effects of transforming a traditional welfare state, as is currently in place in Germany, towards a more Anglo-American system in which a large proportion of transfers are paid to the working poor.

**Keywords:** Life-cycle labor supply, Involuntary unemployment, In-work credits.

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# 1 Introduction

Traditionally, governments have designed transfer systems and income support programs to provide assistance to the poor and thus to guarantee a degree of equity in society. However, over the last two decades, several governments have started to use the transfer system in addition as a policy instrument to increase work incentives by subsidizing work, so called in-work credits. The most prominent examples of in-work credits are the Earned Income Tax Credit (EITC) in the US and the Working Tax Credit (WTC) in the UK. The idea of these programs, often referred to as “Making Work Pay” policies, is to target low income households with an income supplement that is contingent on work. In today’s political discussion, in-work credits are seen as an important means of increasing work incentives for groups of individuals with high rates of voluntary non-employment.

A large empirical literature has evaluated the effects of in-work credits, frequently the EITC or the WTC, on labor market behavior (for comprehensive surveys, see Blank, 2002, Blundell, 2000 and Hotz and Scholz, 2003). These studies are either based on ex-post evaluation methods exploiting randomized social experiments (see Card and Hyslop, 2005, and Card and Robins, 1996) or quasi-natural experiments (e.g. Eissa and Liebman, 1996) or use semi-structural estimation techniques to evaluate policy reforms from an ex-ante perspective (see Blundell *et al.*, 2000). In contrast to the previous literature, we seek to evaluate the effects of in-work credits using a dynamic structural life-cycle model. The main advantage of this approach is that the structural parameters can be used to simulate the effects of proposed or hypothetical reforms to the system of in-work credits over the life-cycle while recognizing the forward looking and intertemporal nature of individuals’ labor supply behavior.

The model that we propose builds on a large body of literature analyzing labor supply behavior over the life-cycle. Blundell *et al.* (2007) divide the life-cycle labor supply literature into two streams according to the channel through which dynamic effects enter the model. The first class of models account for saving and borrowing and thus introduce dynamic effects through the intertemporal budget constraint. Preferences, however, are assumed to be intertemporally separable. This literature goes back to Heckman and MaCurdy (1980) and MaCurdy (1981). The resulting theoretical model predicts that individuals will reduce labor supply early and late in the life-cycle while using the savings channel to maintain a constant marginal utility of consumption. Several studies have used

this approach to estimate the labor supply effects of tax reforms over the life-cycle. One example is Ziliak and Kniesner (1999) who model the effects of progressive income tax on life-cycle labor supply. Using their dynamic model, the authors analyze income tax reforms occurring in the US during the 1980s and find larger labor supply effects than those found in evaluations based on static labor supply models.

In the second class of life-cycle labor supply models, to which our approach belongs, the dynamics of labor supply enter via the dependence of current preferences, prices or constraints on previous labor supply behavior. Models in this category allow the current employment decision to affect future labor supply behavior due to habit formation or through effects on future budget constraints due to human capital accumulation or the dependence of benefit entitlement on the individual's working history. These models therefore capture intertemporal dependencies directly. Dynamic labor supply models of this form are part of the large literature on dynamic programming which was initiated by the contributions of Wolpin (1984), Pakes (1986) and Rust (1987).

To the best of our knowledge, the first study to use dynamic programming to estimate a life-cycle labor supply model was Eckstein and Wolpin (1989) who focused on the labor force participation of married women. The key feature of their model specification is that accumulated experience is endogenous in the wage process and thus the current labor supply decision affects future wages. This study has strongly influenced the following literature and the methodology has been the reference model for numerous studies of life-cycle labor supply including Adda *et al.* (2006), Berkovec and Stern (1991), Eckstein and Wolpin (1999), Keane and Wolpin (1997) and van der Klaauw (1996).

In this paper we address two central issues which we believe have not previously been included in a life-cycle model of labor supply. First, we model the demand side driven rationing of the labor supply choice. In general, in forward looking labor supply models, individuals choose their current actions so as to maximize the discounted expected value of their lifetime utility. In our framework, we additionally allow for the possibility of rationing which prevents individuals from realizing their optimal labor supply choice, resulting in involuntary unemployment. This feature of our model is similar to the treatment of involuntary unemployment adopted in the context of static models of labor supply pursued by, *inter alia*, Blundell *et al.* (1987), Bingley and Walker (1997) and Ham (1982). However, while in a static model rationing affects contemporaneous utilities, in a model in which individuals are forward looking the risk of involuntary unemployment

affects both the current rewards and expected future benefits associated with current behavior, and individuals optimally account for these effects.

The second central issue addressed in this paper concerns the effects of the tax and transfer system on life-cycle employment behavior. In standard life-cycle models, the rewards to work are taken to be the gross rather than the net wage. Such models capture neither progressive income tax nor the impact governmental transfers on the income of the working population. In some studies, out-of-work benefits are incorporated; Adda *et al.* (2007), for example, model unemployment benefits using a time-varying replacement ratio. However the withdrawal of out-of-work transfers concurrent with employment is generally neglected. Given the importance of the tax and transfer system in all developed countries, we argue that a detailed depiction of the whole tax and transfer system is necessary to describe fully choice specific rewards and thus to capture accurately work incentives. Rust and Phelan (1997), Blau and Gilleskie (2006), Casanova Rivas (2007), Karlstrom *et al.* (2004) and Heyma (2004) argue in the same way when analyzing the effect of the social security system on retirement behavior, while Yamada (2007) includes progressive income tax when analyzing the life-cycle employment behavior of Japanese women. However, all of these papers model only selected parts of the transfer system.<sup>1</sup> In contrast, in this paper we argue that, for the purpose of evaluating the effects of welfare reforms, it is necessary to model accurately the whole tax and transfer system. Indeed, due to means testing and the withdrawal of transfers, all parts of the tax and transfer system are linked and interact. Consequently, evaluating the effect of a change to one aspect of the tax and transfer system requires the entire system to be modeled. In order to obtain the precise work incentives provided by the tax and transfer system we draw on a detailed tax microsimulation model.

The empirical analysis draws on panel data from the German Socio-Economic Panel (SOEP) covering the fiscal years 1999 - 2005. Attention is focused on men aged 25-59 years with low or no educational qualifications, a group exhibiting high levels of both voluntary non-employment and involuntary unemployment. Estimation proceeds via a multi-step procedure the final step of which provides maximum likelihood estimates of the parameters describing preferences and labor market constraints.

The parameter estimates are used to evaluate the life-cycle employment effects on

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<sup>1</sup>Specifically, given their application, Rust and Phelan (1997) and the related papers focus only on policies affecting the elderly while not implementing income tax or transfer programs relevant to the whole population, while Yamada (2007) abstracts from many of the details of the Japanese tax system.

German men of introducing a work-contingent transfer program, namely the “Employment Bonus”, which is effectively a wage subsidy for low wage workers. In line with the previous literature we find moderately sized labor supply responses for men and these are concentrated on the extensive margin. On average, the Employment Bonus has a positive labor supply effect which is largest for men aged over 50 years reflecting a relatively high sensitivity to improved work incentives for men close to the end of their working lives. We find that the largest labor supply effects of the Employment Bonus are for low educated men residing in east Germany, which is due to the focus of the Employment Bonus on men with low wages.

The paper is organized as follows. In the next section, we describe a life-cycle model of labor supply with involuntary unemployment, together with the adopted empirical specification and the multi-step estimation procedure. Section 3 contains an overview of the data and details the main features of the labor supply behavior of our sample of low educated German men. The results of the estimation are detailed in Section 4. Our analysis of the life-cycle labor supply effects of introducing the Employment Bonus is presented in Section 5. The final section concludes.

## **2 Life-cycle labor supply with involuntary unemployment**

### **2.1 An overview of the model**

This section describes a discrete dynamic life-cycle model of male labor supply. The model recognizes the presence of labor market constraints which might prevent an individual from realizing his desired hours of work leading to involuntary unemployment. Utilities are a function of labor market state specific net household incomes, and thus the model explicitly accounts for the effects of the tax and transfer system on work incentives. Individuals are assumed to be rational and forward looking implying that every year each man acts so as to maximize his discounted expected lifetime utility.

In the analysis we focus on the labor supply behavior of men with low educational attainment and therefore modest potential earnings. This group has a relatively weak attachment to the labor market and is therefore a target group for transfer reforms aiming to increase employment. Moreover, involuntary unemployment is particularly prevalent among this group. The focus on men is mainly justified by technical reasons. Specifically,



by analyzing male labor supply behavior we avoid the complications encountered when modeling fertility and part-time work, which is common among women. Extensions to other key labor market groups, in particular married women with children, remain for future work. When studying male labor supply behavior, we simplify the utility maximization problem of the household to the individual decision process of the man and assume that the working and fertility behavior of the female spouse, if present, are unaffected by the man's behavior. Furthermore, we restrict attention to men of prime working age, defined as 25-59 years. By excluding men aged under 25 years we avoid the complexities of modeling educational choices (see Keane and Wolpin, 1997).

The model proceeds as follows. At ages  $t = 25, \dots, 59$  years individual  $i$  may search for a job or may choose to be non-employed ( $n$ ). Individuals who are successful in finding a job choose freely between working full-time ( $f$ ), defined as 38.5 weekly working hours, and working over-time ( $o$ ), defined as 44 weekly working hours. This discrete distribution of hours is motivated by the empirical distribution of working hours which is discussed in Section 3. Following Blundell *et al.* (1987), individuals who searched but were unsuccessful in finding a job are defined as involuntarily unemployed ( $u$ ). This definition of involuntary unemployment is consistent with several sources of involuntary unemployment including frictional unemployment, minimum wage legislation and unionized wage setting. In the following, the individual's preferred labor market state is denoted by  $j^* \in \{o, f, n\}$  while, after recognizing the possibility of demand side rationing, the individual's observed labor market state is denoted by  $j \in \{o, f, n, u\}$ .

Individual  $i$ 's probability of being unrationed and thus obtaining or keeping a job is given by  $\Gamma_{i,t}$ . The probability of rationing depends on individual and household specific characteristics, the local unemployment rate and the individual's previous labor market state. In our framework it is not possible to distinguish between the job arrival rate and the separation rate. However, in the empirical specification, we attempt to capture variation in job arrival and separation rates by allowing the effect of the local unemployment rate to be different for those previously working over-time, those previously holding full-time jobs, those who were previously involuntarily unemployed and those who were previously voluntarily non-employed.

In each labor market state  $j = o, f, n, u$  the individual receives a flow utility  $U_{i,j,t}$  which is a function of net household income in state  $j$ , a state specific effect, demographic characteristics, including household structure variables, and the individual's pre-

vious labor market state. The inclusion of the lagged labor market state, which follows Francesconi (2002) and van der Klaauw (1996), captures both habit formation and adjustment costs, for example job search costs. Net household income for non-working individuals is determined by non-labor income and the transfer system. Net household income in over-time and full-time jobs is derived from the individual's gross wage, the hours of work associated with over-time and full-time jobs and the tax and transfer system. Through the gross wage, the distribution of in-work incomes is conditional on individual characteristics that affect wages. We assume that non-working individuals evaluate their utility from working based on their expected wage. In our specification, consumption is assumed to equal current net household income. As stated by Blundell *et al.* (2007), dynamic programming models of labor supply largely ignore households' saving and borrowing decisions. Rust and Phelan (1997) discuss this assumption in some detail and provide arguments in favor of equating income with consumption, the main justification being the lack of reliable information on consumption, savings and assets in longitudinal data. Moreover, as we employ a sample of low educated men ignoring the saving decision is less severe than in many other applications.<sup>2</sup>

The individual's decision problem can be expressed in terms of the value function  $V(s_{i,t}, Y_{i,t-1})$  which equals the discounted expected value of the individual's utility from time  $t$  onwards assuming that in each year the individual makes his labor supply decision so as to maximize the discounted expected value of his future utility. The value function depends on the individual's previous labor market state,  $Y_{i,t-1} = (Y_{i,o,t-1}, Y_{i,f,t-1}, Y_{i,n,t-1}, Y_{i,u,t-1})$  where  $Y_{i,j,t}$  for  $j = o, f, n, u$  are indicators of individual  $i$  being in labor market state  $j$  at time  $t$ , and the state variables  $s_{i,t}$  which consist of all other variables entering the contemporaneous utilities and the probability of rationing at time  $t$  such as net household incomes and the number of children in the household. The individual is assumed to know the current value of  $s_{i,t}$  but, at time  $t$ , may not know the values of all or some elements of  $s_{i,t+1}$ . However, the distribution of  $s_{i,t+1}$  is known to the individual at time  $t$  and it is assumed to depend only on  $s_{i,t}$  and  $Y_{i,t}$ .

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<sup>2</sup>On average, the low educated men in our sample save about 130 Euros per months which amounts to roughly 5% of average gross earnings. For the sample of all men 25-59 years, including the high skilled, savings are approximately 10% of gross earnings.

The value function for this problem takes the following form

$$V_{i,t}(s_{i,t}, Y_{i,t-1}) = \max \begin{bmatrix} \Gamma_{i,t} V_{i,t}^o(s_{i,t}, Y_{i,t-1}) + (1 - \Gamma_{i,t}) V_{i,t}^u(s_{i,t}, Y_{i,t-1}) \\ \Gamma_{i,t} V_{i,t}^f(s_{i,t}, Y_{i,t-1}) + (1 - \Gamma_{i,t}) V_{i,t}^u(s_{i,t}, Y_{i,t-1}) \\ V_{i,t}^n(s_{i,t}, Y_{i,t-1}) \end{bmatrix}, \quad (1)$$

where  $V_{i,t}^j(s_{i,t}, Y_{i,t-1})$  for  $j = o, f, n, u$  are employment state specific value functions with the following recursive structure

$$V_{i,t}^o(s_{i,t}, Y_{i,t-1}) = U_{i,o,t} + \delta \mathbf{E}_t[V_{i,t+1} | s_{i,t}, Y_{i,t} = (1, 0, 0, 0)], \quad (2a)$$

$$V_{i,t}^f(s_{i,t}, Y_{i,t-1}) = U_{i,f,t} + \delta \mathbf{E}_t[V_{i,t+1} | s_{i,t}, Y_{i,t} = (0, 1, 0, 0)], \quad (2b)$$

$$V_{i,t}^n(s_{i,t}, Y_{i,t-1}) = U_{i,n,t} + \delta \mathbf{E}_t[V_{i,t+1} | s_{i,t}, Y_{i,t} = (0, 0, 1, 0)], \quad (2c)$$

$$V_{i,t}^u(s_{i,t}, Y_{i,t-1}) = U_{i,u,t} + \delta \mathbf{E}_t[V_{i,t+1} | s_{i,t}, Y_{i,t} = (0, 0, 0, 1)]. \quad (2d)$$

In the above  $\delta$  is the discount factor. The discount factor is a crucial parameter for the life-cycle maximization, as it describes how strongly expected future utility affects the individual's current choice. In the empirical analysis we follow the literature and assume the discount factor to be equal to 0.95.<sup>3</sup> In Section 5.3 we discuss the sensitivity of our results with respect to the discount factor and estimate a myopic model.

Given these definitions, the first and second arguments of the right hand side of equation (1) represent the individual's discounted expected lifetime utility if at time  $t$  he chooses to search for a job and if successful chooses to work, respectively, over-time hours or full-time hours and from time  $t + 1$  onwards makes optimal labor supply decisions. Likewise, the last argument of the right hand side of equation (1) is the man's discounted expected lifetime utility if his choice is to be non-employed today and from time  $t + 1$  onwards he makes optimal labor supply decisions.

Equations (1) and (2a)-(2d) implicitly define the individual's optimal labor supply decision at each age  $t = 25, \dots, 59$  years. For the purpose of the subsequent analysis, the individual's decision problem is restated in terms of the two following quantities

$$\Delta_{i,t}^{of} = V_{i,t}^o(s_{i,t}, Y_{i,t-1}) - V_{i,t}^f(s_{i,t}, Y_{i,t-1}), \quad (3a)$$

$$\Delta_{i,t}^{on} = V_{i,t}^o(s_{i,t}, Y_{i,t-1}) - \frac{V_{i,t}^n(s_{i,t}, Y_{i,t-1})}{\Gamma_{i,t}} + \frac{1 - \Gamma_{i,t}}{\Gamma_{i,t}} V_{i,t}^u(s_{i,t}, Y_{i,t-1}). \quad (3b)$$

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<sup>3</sup>Previous studies, e.g. Karlstrom *et al.* (2004), mention problems identifying the discount factor in similar life-cycle models.

The individual will search and if successful will work over-time at time  $t$  if and only if  $\Delta_{i,t}^{of} \geq 0$  and  $\Delta_{i,t}^{on} \geq 0$ . Similarly, the individual will search and if successful will work full-time at time  $t$  if and only if  $\Delta_{i,t}^{of} < 0$  and  $\Delta_{i,t}^{on} - \Delta_{i,t}^{of} \geq 0$ , and it will be his choice to be non-employed at time  $t$  if and only if  $\Delta_{i,t}^{on} - \Delta_{i,t}^{of} < 0$  and  $\Delta_{i,t}^{on} < 0$ . It should be noted that the voluntarily non-employed consist of individuals with a high preference for leisure who would not search for a job irrespective of the probability of rationing and “discouraged workers” who choose not to search because the possibility of rationing makes voluntary non-employment preferable to job search.

## 2.2 Discussion of the model

Although only four labor market states are distinguished, the model is sufficiently general to allow an analysis of labor supply behavior on both the extensive (participation) and intensive (working hours) margins. Moreover, this model extends the previous literature on life-cycle labor supply in two important respects. First, the possibility of involuntary unemployment is recognized and the rationing process is modeled jointly with the discrete choice model of labor supply. Second, we model in detail the effect of the tax and transfer system on work incentives using a tax microsimulation model, which provides sufficient information to allow the labor supply decision to be conditioned on net, rather than gross, household income.

These extensions, however, lead to several caveats of our modeling approach. Most importantly, we cannot estimate earnings and labor supply behavior jointly as in Eckstein and Wolpin (1989). This is because the tax microsimulation model is too involved to be included when estimating the labor supply model. Specifically, incorporating the tax microsimulation model into the dynamic programming problem implies a number of state variables that is computationally prohibitive. Instead we develop a multi-step estimation procedure, discussed below, which is similar to the two-step estimation method used by Rust and Phelan (1997).<sup>4</sup>

A further limitation of our approach concerns the data used for the analysis. The information on household level demographics and sources of non-labor income required by the tax microsimulation model prevents us from drawing on the administrative data

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<sup>4</sup>Yamada (2007) follows a different approach which highlights the trade-off between the level of detail included when modeling that tax and transfer system and the estimation procedure. He models only selected features of the tax system and working within this relatively simple structure it is possible to estimate jointly equations describing earnings and labor supply.

for Germany which has been used by Adda *et al.* (2006). Instead, we use panel data from the Socio-Economic Panel Study (SOEP) which include the required family and income information. However, the structure of the SOEP is such that individuals are observed only in certain years in their working lives. Therefore, as described below, the approach of Heckman (1981) is used to control for selection effects in the initial observations.

### 2.3 Empirical specification

For the purpose of the empirical analysis, individual  $i$ 's probability of not being rationed at time  $t$  is given by

$$\Gamma_{i,t} = \Lambda(\psi z_{i,t} + \eta r_{i,t} Y_{i,t-1} + \lambda Y_{i,t-1} + c_{i,s}), \quad (4)$$

where  $\Lambda$  denotes the logistic distribution function. The probability of being unrationed is conditioned on observed individual and household characteristics,  $z_{i,t}$ , the individual's previous labor market state,  $Y_{i,t-1}$ <sup>5</sup>, and the local unemployment rate,  $r_{i,t}$ . Different effects of the local unemployment rate on the probability of being rationed are allowed depending on  $Y_{i,t-1}$ .  $c_{i,s}$  represents an unobserved time-invariant individual specific random effect which is distributed as described below.<sup>6</sup>

The following specification of the contemporaneous utility functions is adopted

$$U_{i,j,t} = \gamma_j Y_{i,t-1} + \theta_j g(m_{i,j,t}) Y_{i,t-1} + \beta_j x_{i,t} + c_{i,j} + \varepsilon_{i,j,t} \quad \text{for } j = o, f, n, u. \quad (5)$$

The first term in the above represents the effect of the individual's previous labor market state on his current utility which is unrelated to net household income and reflects habit formation of adjustment costs. The second term denotes the effect of the individual's net household income in state  $j$ ,  $m_{i,j,t}$ , on the individual's state specific utility at time  $t$ . The relationship between net household income and contemporaneous utility is determined by three different effects. First, via variation in  $\theta_j$ , the effect of net household income on current utilities depends on the individual's current labor market state, reflecting

<sup>5</sup>Where required, involuntary unemployment provides the base category.

<sup>6</sup>Potentially, mobility between the different localities might cause an endogeneity problem when estimating the rationing risk. However, over the observed period, only 135 of the 2437 households moved between different localities and only 12 of the movers changed their employment status when moving. Thus, mobility should not cause any inconsistency in the results.

complementarity or substitutability between leisure and net household income.<sup>7</sup> Second, the effect of net household income on current utility may vary according to the individual's previous labor market state reflecting, for example, a higher marginal utility of net household income among individuals previously in employment than among individuals previously out of work which could arise from habit formation. Third, the function  $g$  determines the relationship between net household income and utility conditional on the individual's current and previous labor market states. The following specification of  $g$  is employed

$$g(m_{i,j,t}) = \frac{m_{i,j,t}^{1-\rho} - 1}{1-\rho}, \quad \rho \geq 0. \quad (6)$$

The above is a constant relative risk specification which allows utility to be linear in net household income when  $\rho = 0$  and logarithmic in income as  $\rho \rightarrow 1$ .

The third term in equation (5) captures the effects of individual and household characteristics,  $x_{i,t}$ , on state specific utilities at time  $t$ . The employment specific coefficients on individual characteristics allow the effects of these variables to vary according to the chosen labor market state. The time-invariant individual specific random effects  $c_{i,j}$  for  $j = o, f, n, u$  allow individuals to have systematic differences in the unobserved components of their utilities, and are necessary to establish the extent to which persistence in labor market outcomes is due to the effect of previous employment outcomes rather than persistent unobserved individual characteristics, see Heckman (1981) and Hyslop (1999). The last component of the utilities,  $\varepsilon_{i,j,t}$ , captures the time-varying component of the individual's unobserved preferences.

Let  $\varepsilon_{i,t}$  denote  $\varepsilon_{i,j,t}$  stacked over  $j = o, f, n, u$  and let  $c_i$  denote  $c_{i,k}$  stacked over  $k = o, f, n, u, s$ . Further, we define  $\tilde{s}_{i,t}$  as the state space  $s_{i,t}$  excluding  $\varepsilon_{i,t}$  and  $c_i$ . Estimation requires expressions for the individual's probability, conditional on  $\tilde{s}_{i,t}$ ,  $Y_{i,t-1}$  and  $c_i$ , of state  $j^*$  being the individual's desired labor market state at time  $t$ . Expressions for these probabilities, denoted  $\Omega_{i,j^*,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i)$  for  $j^* = o, f, n$  are obtained by using equations (3a) - (3b). We assume that  $\varepsilon_{i,j,t}$  is independent over time, individuals and labor market states and has a type I extreme value distribution and, in the following we

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<sup>7</sup>This feature of the specification, which is repeated elsewhere, is more flexible than the alternative method of interacting an arbitrary function of leisure with the variables and then imposing common coefficients on the interacted variables across labor market states.

normalize  $\varepsilon_{i,u,t} = \varepsilon_{i,n,t}$ .<sup>8</sup> Manipulations yield the following multinomial logit probabilities

$$\Omega_{i,o,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) = \Pr \left( \begin{array}{l} \Delta_{i,t}^{of} \geq 0 \\ \Delta_{i,t}^{on} \geq 0 \end{array} \middle| \tilde{s}_{i,t}, Y_{i,t-1}, c_i \right) = \frac{\exp(q_{i,o,t})}{Q_{i,t}}, \quad (7a)$$

$$\Omega_{i,f,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) = \Pr \left( \begin{array}{l} \Delta_{i,t}^{of} < 0 \\ \Delta_{i,t}^{on} - \Delta_{i,t}^{of} \geq 0 \end{array} \middle| \tilde{s}_{i,t}, Y_{i,t-1}, c_i \right) = \frac{\exp(q_{i,f,t})}{Q_{i,t}}, \quad (7b)$$

$$\begin{aligned} \Omega_{i,n,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) &= \Pr \left( \begin{array}{l} \Delta_{i,t}^{on} - \Delta_{i,t}^{of} < 0 \\ \Delta_{i,t}^{on} < 0 \end{array} \middle| \tilde{s}_{i,t}, Y_{i,t-1}, c_i \right) \\ &= \frac{\exp\left(\frac{q_{i,n,t}}{\Gamma_{i,t}} - \frac{1-\Gamma_{i,t}}{\Gamma_{i,t}} q_{i,u,t}\right)}{Q_{i,t}}, \end{aligned} \quad (7c)$$

where

$$\begin{aligned} q_{i,j,t} &= \gamma_j Y_{i,t-1} + \theta_j g(m_{i,j,t}) Y_{i,t-1} + \\ &\quad \beta_j x_{i,t} + c_{i,j} + \delta \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t}) | \tilde{s}_{i,t}, Y_{i,t}, c_i] \quad \text{for } j = o, f, n, u, \end{aligned} \quad (8)$$

and

$$Q_{i,t} = \exp(q_{i,o,t}) + \exp(q_{i,f,t}) + \exp\left(\frac{q_{i,n,t}}{\Gamma_{i,t}} - \frac{1-\Gamma_{i,t}}{\Gamma_{i,t}} q_{i,u,t}\right). \quad (9)$$

In equation (8) the expectation of  $V_{i,t+1}$  is not conditioned on  $\varepsilon_{i,t}$  because  $\varepsilon_{i,t}$  is independent over time. Given the above specification of the rationing process, the probabilities associated with the four labor market states are as follows

$$P_{i,o,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) = \Omega_{i,o,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) \Gamma_{i,t}(z_{i,t}, r_{i,t}, Y_{i,t-1}, c_{i,s}), \quad (10a)$$

$$P_{i,f,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) = \Omega_{i,f,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) \Gamma_{i,t}(z_{i,t}, r_{i,t}, Y_{i,t-1}, c_{i,s}), \quad (10b)$$

$$P_{i,n,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) = \Omega_{i,n,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i), \quad (10c)$$

$$P_{i,u,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i) = (1 - \Omega_{i,n,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c_i))(1 - \Gamma_{i,t}(z_{i,t}, r_{i,t}, Y_{i,t-1}, c_{i,s})). \quad (10d)$$

### 2.3.1 Identification

Several normalizations are necessary in order to ensure identification of the model. In the equation describing the utility from involuntary unemployment, the intercept is excluded

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<sup>8</sup>The last restriction implies that the unobserved time-varying components of individuals' utilities from voluntary non-employment and involuntary unemployment are identical. This assumption substantially simplifies subsequent derivations and from an economic stand point this restriction can be justified.

and the coefficients on the previous labor market state are normalized to zero ( $\gamma_u = 0$ ). Following these normalizations, it is possible to identify  $\gamma_j$  for  $j = o, f, n$  and the three remaining labor market state specific intercepts due to variation in the probability of involuntary unemployment across individuals (see equation (3b)).

It is further assumed that the effects of net household income and individual and household specific characteristics on the individual's utility are the same for voluntary non-employment and involuntary unemployment. Similarly, the random effects for voluntary non-employment and involuntary unemployment are assumed to be equal ( $c_{i,n} = c_{i,u}$ ). These restrictions improve the identification of the model.<sup>9</sup> Moreover, the model specification still permits individuals to have different contemporaneous utilities in voluntary non-employment and involuntary unemployment due to systematic effects occurring through the labor market state specific intercepts or due to the effects of the man's employment history. Furthermore, differences in individual specific unobservables between the involuntary unemployed and voluntarily non-employed enter through the specification of the labor market constraints in equation (4). Following these normalizations, formal identification requires that the random effect and coefficients on individual and household specific characteristics in the utilities from voluntary non-employment and involuntary unemployment be normalized to zero.

### 2.3.2 Unobserved heterogeneity

The model is estimated using distributional assumptions on  $c_{i,j}$  for  $j = o, f, s$ . In the spirit of Heckman and Singer (1984), the random effects have a nonparametric discrete distribution. Specifically, the random effects are constructed using the following factor loadings:

$$c_{i,o} = c_{i,o}^1 v^1 + c_{i,o}^2 v^2, \quad (11a)$$

$$c_{i,f} = c_{i,f}^1 v^1 + c_{i,f}^2 v^2, \quad (11b)$$

$$c_{i,s} = c_{i,s}^1 v^1 + c_{i,s}^2 v^2, \quad (11c)$$

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<sup>9</sup>Specifically, the different effects of net household income, individual and household specific characteristics and the random effects on an individual's utilities from voluntary non-employment and involuntary unemployment are identified via variation in the probability of involuntary unemployment. However, as the probability of involuntary unemployment is close to zero for many individuals, there is limited identifying variation relevant to the coefficients.



Table 1: Distribution of the Random Effects

Random Parameter			Probability ( $\alpha_k$ )
$c_{i,o}$	$c_{i,f}$	$c_{i,s}$	
$c_{i,o}^1 + c_{i,o}^2$	$c_{i,f}^1 + c_{i,f}^2$	$c_{i,s}^1 + c_{i,s}^2$	$A^1 A^2$
$c_{i,o}^1 - c_{i,o}^2$	$c_{i,f}^1 - c_{i,f}^2$	$c_{i,s}^1 - c_{i,s}^2$	$A^1(1 - A^2)$
$-c_{i,o}^1 + c_{i,o}^2$	$-c_{i,f}^1 + c_{i,f}^2$	$-c_{i,s}^1 + c_{i,s}^2$	$(1 - A^1)A^2$
$-c_{i,o}^1 - c_{i,o}^2$	$-c_{i,f}^1 - c_{i,f}^2$	$-c_{i,s}^1 - c_{i,s}^2$	$(1 - A^1)(1 - A^2)$

where  $(c_{i,o}^1, c_{i,o}^2, c_{i,f}^1, c_{i,f}^2, c_{i,s}^1, c_{i,s}^2)$  are unknown parameters and  $v^1, v^2 \in \{-1, 1\}$ .  $v^1$  and  $v^2$  are assumed to occur independently with  $\text{Prob}(v^1 = 1) = A^1$  and  $\text{Prob}(v^2 = 1) = A^2$ . This specification yields four values of the random effect  $c_i$ , denoted  $(c^1, c^2, c^3, c^4)$ . The associated probabilities are denoted by  $(\alpha_1, \alpha_2, \alpha_3, \alpha_4)$ . Table 1 provides a full description of the distribution of the random effects.

### 2.3.3 Likelihood function

The parameters of the model are estimated using Maximum Likelihood. Given a sample of  $N$  individuals whose labor market outcomes are observed at  $t = \pi_i, \dots, \Pi_i$ , the likelihood function is as follows

$$\mathcal{L} = \prod_{i=1}^N \sum_{k=1}^4 \alpha_k \left( \left[ \prod_{t=\pi_i+1}^{\Pi_i} \prod_{j=o,f,n,u} P_{i,j,t}(\tilde{s}_{i,t}, Y_{i,t-1}, c^k)^{Y_{i,j,t}} \right] \times \prod_{j=o,f,n,u} p_{i,j}(m_{i,o,\pi_i}, m_{i,f,\pi_i}, m_{i,n,\pi_i}, x_{i,\pi_i}, c^k)^{Y_{i,j,\pi_i}} \right). \quad (12)$$

In the above, the term in parenthesis is individual  $i$ 's likelihood contribution conditional on a particular value of  $c_i$  with  $p_{i,j}$  denoting the probability associated with the initial observation for individual  $i$ . The individual's unconditional likelihood contribution is obtained by forming an appropriately weighted average of the conditional likelihood contributions. Following Heckman (1981), the probability attached to the individual's initial state,  $p_{i,j}$ , is assumed to take a flexible form and this is interpreted as a reduced form specification of the labor market outcomes observed at  $t = \pi_i$ .<sup>10</sup>

<sup>10</sup> $p_{i,j}$  is assumed to take the following form

$$p_{i,j} = \frac{\exp(\vartheta_j m_{i,j,\pi_i} + b_j x_{i,\pi_i} + v_j c_{i,j})}{\sum_{k=o,f,n,u} \exp(\vartheta_k m_{i,k,\pi_i} + b_k x_{i,\pi_i} + v_k c_{i,k})}, \quad \text{for } j = o, f, n, u. \quad (13)$$

The identifying normalization  $b_u = \mathbf{0}$  is imposed.

## 2.4 Multi-step estimation procedure

In order to estimate the dynamic programming model of life-cycle labor supply we adopt a multi-step procedure similar to Rust and Phelan (1997). As stressed above, a multi-step procedure is necessary for computational reasons. Maximum Likelihood estimation of the final model requires expressions for the outcome probabilities which depend on labor market state specific net household incomes and expected future value functions. Thus, the multi-step procedure requires first deriving net household incomes, which in turn involves estimating wages for non-working individuals and constructing labor market state gross household incomes. At the next step the parameters describing individuals' expectations about the future values of the state variables, including net household incomes, are estimated. The model of individuals' expectations is used in the final estimation for the purpose of computing the expected future value functions.

In order to capture the true effect of experience it is important that persistent individual specific unobserved heterogeneity is included at each estimation step (see Adda *et al.*, 2007). Thus at each step we incorporate individual specific random effects. However, potential correlations between these unobserved effects can not be modeled because the multi-step procedure prohibits joint estimation of the wage equations, the equations describing individuals' expectations about the evolution of the state variables and the model itself.

### 2.4.1 Gross wages and incomes

When constructing the gross labor earnings of the men, it is necessary to derive the gross wage distribution for the working and non-working populations. This is the distribution of the offered market wages which people expect to receive when working. For individuals in employment in year  $t$  we define their observed wage as their draw from the offered wage distribution. By definition, the offered wage for a working man satisfies either  $\Delta_{i,t}^{of} \geq 0$  and  $\Delta_{i,t}^{on} \geq 0$  or  $\Delta_{i,t}^{of} < 0$  and  $\Delta_{i,t}^{on} - \Delta_{i,t}^{of} \geq 0$  (see equations (3a) and (3b)).

For individuals belonging to the non-working population in year  $t$  we cannot observe their draw from the offered wage distribution. Therefore, it is necessary to estimate person specific expected gross hourly wages for non-working individuals. Using the sample of working individuals, we estimate a standard Mincerian wage equation in which log wages are conditioned measures of experience,  $e_{i,t}$ , and further observed characteristics,

$a_{i,t}$ .

$$\ln(\text{wage}_{i,t}) = \kappa_0 a_{i,t} + \kappa_1 e_{i,t} + \nu_i^{\text{wage}} + \epsilon_{i,t}^{\text{wage}}. \quad (14)$$

The equation includes a individual specific random effect,  $\nu_i^{\text{wage}}$ , and an error term,  $\epsilon_{i,t}^{\text{wage}}$ . Both  $\nu_i^{\text{wage}}$  and  $\epsilon_{i,t}^{\text{wage}}$  are assumed to be *i.i.d.* which allows that parameters in equation (14) are estimated using GLS. Separate wage equations are estimated for east and west Germany. Table 6 in the Appendix contains further details of the specification and the estimation results.

For the non-working population, which amounts to roughly 17% of the population (see Table 1), we impute the mean of the distribution of offered wages, conditional on individual characteristics, and interpret this as the individual's expected gross hourly wage. An individual's draw from the offered wage distribution has a different interpretation for the involuntary unemployed and the voluntarily non-employed. We assume that for the involuntary unemployed the offered market wage implies either  $\Delta_{i,t}^{\text{of}} \geq 0$  and  $\Delta_{i,t}^{\text{on}} \geq 0$  or  $\Delta_{i,t}^{\text{of}} < 0$  and  $\Delta_{i,t}^{\text{on}} - \Delta_{i,t}^{\text{of}} \geq 0$  while for the voluntarily non-employed the offered wage makes non-employment the optimal labor market state, i.e.,  $\Delta_{i,t}^{\text{on}} - \Delta_{i,t}^{\text{of}} < 0$  and  $\Delta_{i,t}^{\text{on}} < 0$ .

The hourly gross wages and the labor market state specific weekly working hours define the man's gross earnings for each labor market state. For couple households, gross earnings consist of the observed labor earnings of the wife and the labor market state specific labor earnings of the husband. The latter define the labor earnings of single men. Gross household income is the sum of gross earnings and income from sources other than labor income, such as income from capital or rental income.<sup>11</sup> Any non-labor income is assumed to be exogenously determined.

### 2.4.2 Net household income

To translate gross household incomes into net household incomes we use the STSM tax microsimulation model which includes all relevant components of the German tax and transfer system.<sup>12</sup> German income tax is based on the principle of comprehensive taxation. That is, the sum of a household's incomes from all sources is taxed as a single sum after several deductions have been applied to arrive at the tax base. Income tax

<sup>11</sup>For the sample of low educated men, labor income is by far the largest component of the gross household income.

<sup>12</sup>See Steiner *et al.* (2005) for a detailed description of the tax microsimulation model.

is computed by applying the income tax function to either the taxable income of each person in the household or of the spouses' joint taxable income, depending on marital status.<sup>13</sup> Income tax and employee's social security contributions are deducted from gross income, and social transfers are added to derive net household income. Social transfers include child benefits, child-rearing benefits, unemployment assistance, housing benefits and social assistance.

### 2.4.3 Computation of value function and individuals' expectations

Evaluating the likelihood requires expressions for the expected value functions  $\mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t}, Y_{i,t}, c_i]$  (see equations (7a) - (9)). Conditioning on  $\tilde{s}_{i,t+1}$ , combining equations (1) and (8) and taking expectations with respect to  $\varepsilon_{i,t+1}$  yields

$$\begin{aligned} \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t+1}, Y_{i,t}, c_i] = & \\ \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s}) \mathbf{E}_t \left[ \max \left[ q_{i,o,t+1} + \varepsilon_{i,o,t+1} + \frac{1 - \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})}{\Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})} q_{i,u,t+1}, \right. \right. & \\ \left. \left. q_{i,f,t+1} + \varepsilon_{i,f,t+1} + \frac{1 - \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})}{\Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})} q_{i,u,t+1}, \right. \right. & \\ \left. \left. \frac{q_{i,n,t+1}}{\Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})} + \varepsilon_{i,n,t+1} \right] \middle| \tilde{s}_{i,t+1}, Y_{i,t}, c_i \right] + & \\ (1 - \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})) \mathbf{E}_t[\varepsilon_{i,n,t+1}]. & \end{aligned} \quad (15)$$

The above distributional assumptions imply<sup>14</sup>

$$\begin{aligned} \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t+1}, Y_{i,t}, c_i] = & \\ \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s}) \left( \Upsilon + \log \left( \exp \left( q_{i,o,t+1} + \frac{1 - \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})}{\Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})} q_{i,u,t+1} \right) \right. \right. & \\ \left. \left. + \exp \left( q_{i,f,t+1} + \frac{1 - \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})}{\Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})} q_{i,u,t+1} \right) \right. \right. & \\ \left. \left. + \exp \left( \frac{q_{i,n,t+1}}{\Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})} \right) \right) \right) + (1 - \Gamma(z_{i,t+1}, r_{i,t+1}, Y_{i,t}, c_{i,s})) \log(\Upsilon), & \end{aligned} \quad (17)$$

<sup>13</sup>In Germany there exists the principle of joint taxation of households, whereby the income tax of a married couple is calculated by applying the tax function to half of the sum of the spouses' incomes; this amount is then doubled to determine the couple's tax liability.

<sup>14</sup>Suppose  $\varepsilon_j$  for  $j = 1, \dots, K$  are identically and independent distributed with a type I extreme value distribution. It follows that

$$\mathbf{E}[\max[a_1 + \varepsilon_1, a_2 + \varepsilon_2, \dots, a_K + \varepsilon_K]] = \Upsilon + \log(\exp(a_1) + \exp(a_2) + \dots + \exp(a_K)). \quad (16)$$

where  $\Upsilon$  is Euler's constant.<sup>15</sup>

The quantity of interest is

$$\mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t}, Y_{i,t}, c_i] = \int \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t+1}, Y_{i,t}, c_i]dG(\tilde{s}_{i,t+1}|\tilde{s}_{i,t}, Y_{i,t}, c_i), \quad (18)$$

where  $G(\tilde{s}_{i,t+1}|\tilde{s}_{i,t}, Y_{i,t}, c_i)$  denotes the conditional distribution of  $\tilde{s}_{i,t+1}$  given  $\tilde{s}_{i,t}, Y_{i,t}$  and  $c_i$ , and represents individuals' expectations concerning the evolution of the state variables,  $\tilde{s}_{i,t}$ . Further progress can be made by partitioning  $\tilde{s}_{i,t}$  into three elements,  $s_{i,t}^p$ ,  $s_{i,t}^{uc}$  and  $s_{i,t}^{ud}$ .  $s_{i,t}^p$  contains all of the elements of  $\tilde{s}_{i,t}$  that are completely predictable over time. Specifically,  $s_{i,t}^p$  contains time-invariant characteristics, consisting of educational attainment (medium or low), country of origin (German or non-German), an indicator of living in east Germany and age terms.<sup>16</sup>  $s_{i,t}^{ud}$  and  $s_{i,t}^{uc}$  contain, respectively, all discrete and continuous elements of  $\tilde{s}_{i,t}$  that vary over time and whose movements are not completely predictable. Taking account of the completely predictable variables, equation (18) can be rewritten as follows

$$\begin{aligned} \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t}, Y_{i,t}, c_i] = \\ \int \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t+1}, Y_{i,t}, c_i]d\Phi(s_{i,t+1}^{uc}, s_{i,t+1}^{ud}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t}^{ud}, Y_{i,t}, c_i), \end{aligned} \quad (19)$$

where  $\Phi(s_{i,t+1}^{uc}, s_{i,t+1}^{ud}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t}^{ud}, Y_{i,t}, c_i)$  is assumed to have the following structure

$$\begin{aligned} \Phi(s_{i,t+1}^{uc}, s_{i,t+1}^{ud}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t}^{ud}, Y_{i,t}, c_i) = & f(s_{i,t+1}^{uc}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t+1}^{ud}, Y_{i,t}) \times \\ & \Theta(s_{i,t+1}^{ud}|s_{i,t+1}^p, s_{i,t}^{ud}). \end{aligned} \quad (20)$$

This factorization limits the number of parameters in the transition matrix of the unpredictable variables while still allowing large subsets of the variables to be jointly determined. The discrete variables are assumed to be unaffected by the man's previous employment state but the evolution of the continuous variables is conditioned on the previous labor market state.<sup>17</sup> Additionally, as is required by the multi-step procedure, the individual specific random effects which affect contemporaneous utilities and the proba-

<sup>15</sup> $\Upsilon=0.577215665\dots$

<sup>16</sup>Throughout the analysis the controls for age consist of  $(age - 24)/10$ ,  $(age - 24)^2/1000$ ,  $\mathbf{1}[age > 51](age - 51)/10$  and  $\mathbf{1}[age > 51](age - 51)^2/100$ . The latter two terms control for changes in behavior as the men approach retirement age.

<sup>17</sup>Conditioning the probabilities of the discrete variables on the man's previous employment behavior did not substantively affect the results.

bility of rationing are excluded from the transition matrices. Substituting equation (20) into equation (19) gives

$$\begin{aligned} & \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|\tilde{s}_{i,t}, Y_{i,t}, c_i] \\ = & \sum_{s_{i,t+1}^{ud'} \in S_{i,t+1}^{ud}} \int \mathbf{E}_t[V_{i,t+1}(s_{i,t+1}, Y_{i,t})|s_{i,t+1}^p, s_{i,t+1}^{uc'}, s_{i,t+1}^{ud'}, Y_{i,t}, c_i] \times \\ & f(s_{i,t+1}^{uc'}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t+1}^{ud'}, Y_{i,t}) ds_{i,t+1}^{uc'} \Theta(s_{i,t+1}^{ud'}|s_{i,t+1}^p, s_{i,t}^{ud}), \end{aligned} \quad (21)$$

where  $S_{i,t+1}^{ud}$  denotes the set of all possible realizations of the discrete state variables at time  $t$  and  $s_{i,t+1}^{ud'}$  denotes an element of  $S_{i,t+1}^{ud}$ .

It remains to evaluate the integral over  $s_{i,t+1}^{uc}$  occurring in equation (21). The integral is approximated by discretizing  $s_{i,t+1}^{uc}$ . Specifically, each element of  $s_{i,t+1}^{uc}$  is divided into five categories such that 20% of the observations fall into each category. Each category is assigned a value equal to the mean of the observations falling into the category. Let  $R$  denote the number of different combinations of the discretized variables observed in the sample, let  $s^{uc,r}$  for  $r = 1, \dots, R$  denote mean value of state variables  $s^{uc}$  in the  $r^{\text{th}}$  category and define  $l_r$  and  $u_r$  as the upper and lower bounds associated with  $s^{uc,r}$ . It follows that the conditional probability of next year's realization of the state variables falling into the  $r^{\text{th}}$  category is given by

$$F(s^{uc,r}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t+1}^{ud}, Y_{i,t}) = \int_{l_r}^{u_r} f(s^{uc}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t+1}^{ud}, Y_{i,t}) ds^{uc}, \quad (22)$$

Following this discretization, the integral occurring in equation (21) is approximated by

$$\sum_{r=1}^R \mathbf{E}_t[V_{i,t+1}(s_{i,t+1})|s_{i,t+1}^p, s^{uc,r}, s_{i,t}^{ud}, Y_{i,t}] \frac{F(s^{uc,r}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t+1}^{ud}, Y_{i,t})}{\sum_{s=1}^R F(s^{uc,s}|s_{i,t+1}^p, s_{i,t}^{uc}, s_{i,t+1}^{ud}, Y_{i,t})}. \quad (23)$$

The denominator in the above is necessary as it is possible that not all possible combinations of the discretized variables are observed in the sample.

## Discrete Variables

The empirical specification is such that the unpredictable discrete variables consist of whether the man has a spouse and, if applicable, spouse's level of education (medium or low) and labor market state (voluntarily non-employed, working part-time or working

full-time) and the number of dependent children under 18 years of age (zero, one, two or three or more). 18 different combinations of these discrete variables occur in the sample. The probability of any one of these combinations is estimated using a multinomial logit model in which the choice probabilities are conditioned on lagged dependent variables indicating which of the 18 discrete combinations of the unpredictable discrete variables applied to the household in the previous year, all possible interaction of the country of origin, the man's educational attainment and living in east Germany, and age terms.

### **Continuous Variables**

The unpredictable continuous variables correspond to net household income if the man is working over-time, working full-time or does not have a job and the local unemployment rate. The correlation between net household income in over-time and full-time work is extremely high and hence the net household income in over-time work is excluded from the state space and modeled as a time-varying deterministic function, which varies according demographic variables, of net household income in full-time work.<sup>18</sup>

Utilities are a function of labor market state specific net household incomes which are derived from the tax microsimulation model as described previously. However, when modeling expectations regarding future state specific net household incomes we do not apply the tax microsimulation model because the large number of state variables involved would make the dynamic programming problem too computationally intensive. Instead we estimate reduced form equations which relate net incomes to demographic variables and previous employment outcomes in a flexible way. This modeling approach is consistent with individuals having a very detailed understanding of the tax and transfer system in the current year but relying on an approximation, specifically the reduced form equations, when forming expectations about future net incomes.

In the reduced form specification, net household incomes in full-time work and voluntary non-employment are assumed to be normally distributed with means that depend on the current values of the predictable and unpredictable discrete variables detailed above and an indicator of the man was in employment in the previous year. Thus, we

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<sup>18</sup>Including net household income at over-time into the state space and modeling in the same way as net household income in full-time work does not effect the results but does lead to an increase in computational complexity.

estimate the following equations

$$m_{i,j,t} = \zeta_t F_{i,t} + \nu_i^{m_j} + \epsilon_{i,t}^{m_j} \quad \text{for } t = 2000, \dots, 2005; j = f, n, \quad (24)$$

where  $F_{i,t}$  contains various interactions between individual characteristics, lagged participation and the indicator of having a medium level of education interacted with lagged participation. The reduced form specification compounds the evolution of labor market state specific gross household incomes with the effect of the tax and transfer on net household income. Hence, although the tax and transfer system is not conditional on educational qualifications or previous working behavior, these variables are included in  $F_{i,t}$  as they affect the evolution of gross household incomes. The coefficients in the equations describing net household incomes in full-time work and voluntary non-employment are allowed to vary over time in an unrestricted fashion reflecting changes in the tax and benefit system over the sample period that affected the relationship between net household incomes and demographic variables. Individuals forming expectations at time  $t$  assume that the current tax and transfer system will be maintained in the future. Since the state specific net household incomes depend on age and the individual's previous labor market state, the specification captures the effect of human capital accumulation over the life-cycle.  $\nu_i^{m_j}$  is an individual specific random effect, assumed to be *i.i.d.*, while  $\epsilon_{i,t}^{m_j}$  is an *i.i.d.* error term. The parameters of the two reduced form equations are estimated using GLS.

The local unemployment rate is assumed to follow a first order autoregressive process

$$r_{i,t} = \alpha_{0,E} East_i + \alpha_{0,W} West_i + \alpha_{1,E} w_{i,t-1} East_i + \alpha_{1,W} r_{i,t-1} West_i + \nu_i^w + \epsilon_{i,t}^r. \quad (25)$$

The above specification allows the intercept and the coefficient on previous labor market conditions to differ for east and west Germany.  $\nu_i^w$  is an individual specific random effect, assumed to be *i.i.d.*, while  $\epsilon_{i,t}^r$  is an *i.i.d.* error term. The parameters describing the evolution of the conditions in the local labor market are estimated using GLS. Errors, including the random effects, in the three reduced form equations are assumed to be mutually independent.



### 3 Data and descriptive statistics

This study draws on data from the SOEP which is a representative sample of over 11,000 households living in Germany containing yearly information about working behavior and socio-economic variables at the individual and household levels.<sup>19</sup> We construct an unbalanced panel of men with consecutive observations in at least two years between 2000 - 2006 inclusive which yields retrospective information for the fiscal years 1999-2005. Data on the local unemployment rate, which is used to identify some parameters related to involuntary unemployment, are collected by the Employment Office for each of 438 counties. This information is matched exactly to each household in the sample.<sup>20,21</sup>

In our analysis we focus on men of prime working age with low potential earnings. More precisely, we restrict the sample to men older than 25 and younger than 59 years with either no, a low or a medium school degree and at most the lowest vocational degree.<sup>22</sup> School drop-outs and those with a low school degree are classified as low educated while those with a medium school degree, which entails one year more study than the low school degree, are classified as medium educated. Further, we exclude self-employed men as well as men in full-time education as their labor supply behavior differs substantially from that of the rest of the population of interest. These exclusions yield a sample with 12,152 person year observations corresponding to 2,522 different men.

#### Working behavior of men

Figure 1 shows the distribution of weekly working hours in our sample of men. Roughly 17% of the men in the sample do not work. This group includes both those who are voluntarily non-employed and those who are involuntary unemployed. Only 3% of men in employment work less than 35 hours per week and hence we define men working up to 40 hours per week as being in full-time employment while men working 40 or more hours per week are classified as working over-time. The pronounced peaks in the distribution

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<sup>19</sup>For a detailed description of the data set, see Haisken De-New and Frick (2005).

<sup>20</sup>Data on the local unemployment rate are collected monthly. However, as the interviews of the SOEP are mainly conducted in the first quarter of the year we use local labor market indicators in April of each year.

<sup>21</sup>The local unemployment rate varies between about 2% to more than 30% with an average rate of 11.68 and a variance of 33.34.

<sup>22</sup>A tighter definition of men with low potential earnings is not possible due to the number of observation.

Table 2: Labor market status

	Share	Median Hours	Mean Age	Mean U. Rate
Vol. Non-employment	.09	-	49.07	13.11
Inv. Unemployment	.08	-	42.07	15.87
Full-time	.55	38.5	42.45	11.10
Over-time	.28	44	41.39	11.92
Average			42.73	11.89

Source: SOEP 2000 - 2006 and Bundes Agentur für Arbeit.

of male working hours justify why we choose to model the labor supply behavior of men on the extensive and intensive margins in a discrete framework rather than assuming a continuous specification of working hours.

[ **Figure 1 about here**]

## Voluntary non-employment and involuntary unemployment

The SOEP yields information to identify the involuntary unemployed as defined above. Each non-working individual is asked (i) whether he has actively searched for a job within the last four weeks; and (ii) whether he is ready to take up a job within the next two weeks. We follow the ILO definition and treat those who answer both questions positively as involuntarily unemployed.

Table 2 shows that around half of the non-working men are involuntarily unemployed according to the above definition. Specifically, 8% of the sampled men are involuntary unemployed and 9% are voluntarily non-employed.<sup>23</sup> The voluntarily non-employed tend to be older than the average which reflects high rates of voluntary non-employment among men in their fifties, while the involuntarily unemployed tend to live in localities with relatively high rates of unemployment. The majority of sampled men work full-time and close to 30% work over-time. The median weekly working hours for men in full-time and over-time work are, respectively, 38.5 and 44 and these values are used in the empirical analysis when deriving labor market state specific gross earnings.

Working behavior varies strongly by education and region. In Table 3 we analyze average labor market status separately for east and west Germans and by educational

<sup>23</sup>These rates differ from official unemployment statistics since their denominators contain some of the inactive population (precisely the voluntary non-employed) and also because of selection criteria.

Table 3: Labor market status and wages by subgroup

	Share	Share Over-time	Share Full-time	Share Vol. Non-emp.	Share Inv. Unemp.	Median Hourly Wage
East German low educ.	.07	.19	.37	.19	.23	8.93
East German medium educ.	.18	.33	.45	.08	.13	10.76
West German low educ.	.54	.24	.59	.10	.05	14.49
West German medium educ	.20	.34	.59	.03	.02	17.23

Source: SOEP 2000 - 2006 and Bundes Agentur für Arbeit.

attainment. The share of non-working men is highest among low educated east Germans. Specifically, 19% of low educated east Germans are voluntarily non-employed while 23% are faced with involuntary unemployment. At the other extreme, 95% of men with medium education living in west Germany are in employment and the rate of involuntary unemployment for this group is only 2%. The relatively high level of voluntary non-employment among low educated east Germans is likely to reflect partly a discouragement effect whereby the low probability of finding a job deters workers from searching. In line with the differences in employment behavior, we find differences in the wage distribution. In the last column we present the median gross hourly wage, derived as described above, for each subgroup. This information is crucial to understanding the labor supply effects induced by the Employment Bonus, discussed below in the application of the model. The median wage of low educated east Germans is about 9 Euros per hour which is only half the median wage of the medium educated west Germans. Interestingly, the median wage for medium educated east Germans is markedly lower for west Germans with low education and this region matters more than education.

## Labor market status over the life-cycle

Figure 2, presented below in the context of the results, illustrates the observed employment behavior of the sampled men according to age. Full-time employment is slightly inverse U-shaped with a small increase in the first years and a sharp drop after age 50 years, while over-time work is monotonically decreasing with age. Involuntary unemployment is slightly higher for men under 30 than for older men, while voluntary non-employment is stable up to age 50 but beyond this age voluntary non-employment increases sharply reaching 40% by age 59 years. This trend is mainly driven by early retirement but may also reflect increasing numbers of discouraged workers. These pat-

Table 4: Persistence in working behavior

		State in year $t$			
		Vol. Non-emp.	Inv. Unemp.	Full-time	Over-time
State in year $t - 1$	Vol. Non-Part.	74.30	14.71	6.78	4.22
	Inv. Unemp.	18.23	53.70	18.09	9.97
	Full-time	2.33	3.35	79.33	15.00
	Over-time	2.39	3.59	29.96	64.06

All numbers are in percentages.

Source: SOEP 2000-2006.

terns are fairly similar for subgroups defined by educational attainment or region (not shown), albeit with relatively high levels of involuntary unemployment and voluntary non-employment among the low educated and the east Germans.

## Persistence in labor market outcomes

Table 4 shows the high level of persistence in labor market status over time which has been well-documented in the previous literature. Over the period of one year, persistence is close to 80% for full-time work and 64% over-time work. Voluntary non-employment is a more absorbing state than involuntary unemployment. As shown by previous studies, this persistence can be explained by a combination of unobserved and observed characteristics and by the effect of state dependence in labor supply behavior (see, for example, Hyslop, 1999). This motivates our empirical specification which conditions current utilities on labor market status in the previous year.

## 4 Estimation results

The proposed labor supply model is characterized by non-linearities and the multiple interactions and therefore a meaningful interpretation of the coefficients is generally difficult. Instead, we present the predictive performance of the model and labor supply elasticities both of which are based on the structural estimates (for the coefficient estimates see Tables 7 and 8 in the Appendix). In addition, the following results are important to mention. We find a significant positive effect of the local unemployment rate on the rationing probability. This effect is greatest in east Germany and is larger for individuals previously in employment than for individuals who were not working in the previous year. There is significant evidence supporting the presence of persistent unobserved heterogeneity. The coefficients on the indicators of the lagged labor market state

are mostly insignificant, however, coefficients on the interactions of lagged full-time and over-time work with current net household income are significantly positive. Thus the contemporaneous utility of individuals who were previously in employment is increasing in current net household income while the contemporaneous utilities of those previously not in employment do not depend on current net household income. Furthermore, the effect of current net household income is significantly higher for individuals working full-time than for individuals working over-time which indicates that, conditional on employment, income and leisure are complementary. Finally the estimated value of  $\rho$ , the parameter governing the extent of any concavity of utility in net household income (see equation (6)) is 0.38(0.26), which is mild evidence of the utility, conditional on the individual's current and previous labor market state, being concave rather than linear in income and significant evidence that the utility function is less concave in income than a logarithmic function.

#### **4.1 Performance of the model: In sample and out of sample predictions**

[Figure 2 about here]

In Figure 2 we report the in sample performance of our model. At each age, we predict the proportion of men in each labor market state and compare these to the proportions observed in the sample. We find a close correspondence between the observed and predicted outcomes over the entire life-cycle which indicates that the model performs well. Formally, according to  $\chi^2$  tests, the differences between the observed and expected frequencies of men in the four labor market states are insignificant at the 5% level at all but four ages.

In general, the in sample fit of a structural life-cycle model is not considered to be a powerful specification test. Therefore, we provide additional information about the out of sample performance of our model. Since we cannot use an external data source to validate our model, we re-estimate the model using a sub-sample containing observations from the years 1999-2004 and use the estimated structural parameters to predict the working behavior of men observed in the year 2005. Table 5 shows the observed and simulated shares of the labor market states in 2005. Unfortunately, we have too few observations for the year 2005 to compare the shares at each age in a meaningful way.

Table 5: Out of sample fit: Employment shares in the year 2005

	Over-time	Full-time	Vol. Non-emp.	Inv. Unemp.
Observed percentages in 2005	29.87	53.19	8.32	8.62
Predicted percentages (Out of sample)	26.15 (1.62)	54.94 (2.03)	8.07 (1.49)	9.36 (0.54)
Squared deviations (Out of sample)	13.86 (0.15)	3.06 (0.14)	0.06 (0.26)	0.55 (0.09)
Predicted percentages (In sample)	26.86 (1.63)	54.25 (1.40)	7.85 (1.59)	9.55 (0.58)
Squared deviations (In sample)	9.05 (0.37)	1.13 (0.58)	0.22 (0.81)	0.87 (0.36)

Out of sample prediction is based on information of a sub-sample containing observations from the fiscal years 1999-2004. In sample prediction is based on the whole sample 1999-2005. Standard errors in parenthesis.

Thus, we present only the overall shares. For comparative reasons we also show the predictive performance obtained using the full sample and this defines another in sample measure of the predictive performance of the model. As a measure of goodness of fit we present the squared deviations between the predicted and the observed shares.

Overall, the out of sample fit is satisfying. The sample average of the employment shares in the years 2005 can be reproduced reasonably well using only information from previous years. The accuracy of the out of sample performance of the model is underlined by comparing the squared deviations of the out of sample and in sample predictions; the two are not substantially different.

## 4.2 Labor supply elasticities

In order to understand labor supply behavior over the life-cycle we derive labor supply elasticities. In this model it is not possible to calculate analytically labor supply elasticities. Instead we derive elasticities numerically by simulating the effect of a 10% increase in the men's gross wages.<sup>24</sup> In more detail, initially we simulate labor supply behavior based on the observed gross wages and the associated net household incomes. Specifically, for a subgroup of interest, labor market outcomes at age 25 year are simulated. Given labor market outcomes at age 25 years, values of the state variables at age 26 years are obtained by drawing from the appropriate distribution. Conditional on the updated state variables and the labor market outcomes at age 25 years labor market outcomes at

<sup>24</sup>To be consistent with the assumptions of the model, we only increase the wages for men; female spouses are assumed not to adjust their labor supply in response to the reform.

age 26 are simulated, and so forth up to age 59 years. Gross wages are then increased by 10% and the tax microsimulation model is used to update the net household incomes. The above described simulation exercise is then repeated using the new values of the net household incomes. When performing these simulations it is assumed that the labor demand restrictions are not affected by the wage increase. In this respect our analysis is partial since we do not model potential labor demand effects of the increase in gross wages. It should further be noted that the resulting elasticities are long-run in the sense that they account for effect of the wage increase occurring through net incomes and as well as indirect effect occurring through individuals' employment histories.

In Figure 3 we present the gross wage elasticities of average working hours for four subgroups distinguished by region of residence and educational attainment. We analyze these subgroups by simulating the life-cycle employment behavior of a large number of men who at age 25 years are single with no children.<sup>25</sup> The men's wages and the rate of unemployment in their local labor market at age 25 years are taken to be the average values of these variables among the relevant group of sampled men at age 25 years.

[Figure 3 about here]

For all subgroups, the gross wage elasticity of working hours is slightly inverse U shaped between ages 25 and 50 years but increases markedly in the last 10 years of the working life. Averaged over the life-cycle, the elasticity is highest for low educated west Germans and lowest for medium educated east Germans. Several factors contribute to variation in the elasticities over time and between the subgroups. First, involuntary unemployment matters. *Ceteris paribus*, the higher the rationing risk, the lower the realized employment effects of increased work incentives. This effect is important for east Germans, particularly for the low educated, and contributes to the relatively high elasticities for west Germans. The pattern of employment over the life-cycle also impacts on the wage elasticities. In particular, the high levels of voluntary non-employment observed at the end of the working life mean that there is a large pool of men over 50 years of age who may be induced into the labor market by increased work incentives. State dependencies in working behavior also affect the pattern of individuals' responses to increased work incentives. As mentioned above, we find significant positive dependencies in working behavior over time. This implies that increased participation and working

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<sup>25</sup>Each simulation is conducted using a sample size of 12000.

hours among the young will *ceteris paribus* lead to higher participation and working hours later in the life-cycle. Thus state dependencies tend to lead to increasing elasticities over time and therefore provide a candidate explanation for the increasing elasticities in the first part of the working life and may be reinforcing the effect of age on the elasticities occurring beyond age 50 years. Of course, in a life-cycle setting, various other factors are in operation, most notably changing demographic characteristics and incentives for human capital accumulation that diminish with age, and hence it is not possible to determine exactly the driving force of the variation in the gross wage elasticities of average working hours.

To understand better the labor supply behavior, we apply the decomposition suggested by McDonald and Moffitt (1980) and split the gross wage elasticity into a component due to changes on the extensive margin (a participation effect) and a component due changes on the intensive margin (a conditional working hours effect). As documented by, *inter alia*, Heckman (1993), Kimmel and Kniesner (1998) and Meyer (2002) the extensive margin is generally the driving force for labor supply responses. Effects along the intensive margin are in general negligible and can be even negative if the marginal utility of income decreases with working hours.

**[Figure 4 about here]**

Figure 4 shows the decomposition of the gross wage elasticity of average working hours for the whole sample (rather than for a particular subgroup).<sup>26</sup> In line with the previous literature, we find a relatively large effect on the extensive margin which behaves in a similar fashion to the total elasticity. The effect on the intensive margin is negative, reflecting a movement from full-time work to over-time work. While the negative effect on the intensive margin is significant, it is small in magnitude.

**[Figure 5 about here]**

Figure 5(a) shows that the 10% increase in gross wages leads to an increase in average weekly hours of work of around 0.1 of an hour for men aged 25 years rising to 0.7 of an hour for men aged 59 years. Figure 5(b) shows the reduction in voluntary non-employment underlying the relatively large elasticity on the extensive margin; a 10%

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<sup>26</sup>Gross wage elasticities for the whole sample are derived by simulating the effect of a 10% increase in gross wages on the life-cycle behavior of a group of men who at age 25 years have the same characteristics as the men aged 25 years in the sample.



increase in gross wages causes a reduction in voluntary non-employment of around 1-1.5 of a percentage point for the under fifties, rising to 2 percentage point for those aged 59 years. In absolute terms, the reduction in overtime work is around 0.8 of a percentage points while the increase in full-time work varies between 1 and 2 percentage points.

The model has three features capable of generating a substitution from over-time work to full-time work following a proportion increase in full-time and over-time wages. First, depending on the curvature of the utility function in net household income, proportional increases in full-time and over-time net household incomes may lead the utility from over-time work to increase by less than the utility from full-time work. Second, the structure of the tax and transfer system means that proportional increases in the man's gross earnings lead to different proportional increases in full-time and over-time net household incomes. Third, complementarities between income and leisure mean that an increase in net household income is valued more by an individual working full-time than by an individual working over-time. In the current setting, the observed reduction in over-time work can be traced to a combination of the structure of the tax and transfer system, which features slightly higher marginal tax rates for over-time workers than for full-time workers, and a complementarity between income and leisure. Indeed, the parameter estimates show that the utility function is less curved than logarithmic function and hence diminishing marginal utility cannot explain the reduction in over-time work.

## **5 The life-cycle employment effects of in-work transfers: The Employment Bonus**

The German welfare system can be characterized as a traditional welfare system with relatively generous out-of-work transfers that are withdrawn at high rates when people start working. In the political discussion this has often been criticized and the low working incentives have been identified as a central reason for high unemployment, particularly among the low educated. Drawing on the international experience, mainly from EITC in the US and the WTC in the UK, there is an ongoing debate about changing the German welfare system by shifting more transfers to the working poor and thus increasing work incentives. Amongst others, Blundell (2000), Blank (2002) and Hotz and Scholz (2003) discuss the effects of in-work credits in the UK and in the US. They find positive labor supply effects for first earners in couples and single households which are counteracted by strong negative effects for the secondary earner. The negative effects are related to

the means-testing based on family rather than individual earnings.

A reform which avoids the negative secondary earner effects is the Employment Bonus, as implemented in Belgium, (see Orsini, 2006). This transfer program is similar to a wage subsidy for low wage workers. Entitlement is conditioned on the individual's full-time equivalent monthly earnings, which is computed by multiplying contractual gross monthly earnings by the ratio of weekly full-time hours, defined as 40 hours, to contractual hours. The calibration of the Belgium Employment Bonus in 2004 was such that individuals with full-time equivalent earnings less than or equal to 1,210 Euros per month (which corresponds to a gross wage of 7.20 Euros per hour) were entitled to the full Employment Bonus, equal to 140 Euros per month for an individual working full-time. This payment was increased or decreased proportionately for higher or lower hours of work. In other words, an individual earning 7.20 Euros per hour received subsidy equal to 11.6% of his gross earnings which translates into a payment of 73.32 Euros per month if he works 20 hours per week or 162.73 Euros per month if he works 45 hours per week. Starting at 1,210 Euros per month, the Employment Bonus is phased out at a taper rate of 17.8% and is fully exhausted at a full-time equivalent income of 2,000 Euros per month (corresponding to a gross wage of 11.84 Euros per hour).

The Employment Bonus therefore differs from the EITC and the WTC in several important respects. First, unlike the WTC, the Employment Bonus does not depend on a minimal number of weekly working hours but increases proportionally with working hours. Second, the entitlement is based on individual rather than household earnings. This means that the Employment Bonus avoids the negative secondary earner effects mentioned above. Lastly, as payments made under the Employment Bonus depend on full-time equivalized earnings rather than actual earnings, this program is targeted people with low wages rather than with low earnings.<sup>27</sup>

## 5.1 Work incentives of the Employment Bonus

In order to understand the effects of the Employment Bonus on the work incentives we present budget lines for stylized households under the 2005 German tax and transfer

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<sup>27</sup>According to Orsini (2006), the budgetary effects of the Employment Bonus for Belgium are negative but of moderate size. The negative effects of the subsidy for the eligible working population are partly compensated by the positive effects of the additional workers who pay income taxes, make social security contributions and are no longer dependent on unemployment benefits. Anecdotal evidence suggests that fraud seems to be a minor problem as employers report wages and working hours. Reporting lower wages would reduce pension entitlement and the number of working hours can be compared with sector averages.

system and after the Employment Bonus has been imposed on top of the 2005 system (see Figure 6). We focus on low wage (7.5 Euros per hour) and medium wage (10 Euros per hour) single men without children.

[Figure 6 about here]

Depending on housing benefits, a single man receives out-of-work benefits totaling nearly 600 Euros per month. The high rate at which benefits are withdrawn means that the Employment Bonus has little effect on work incentives for men working less than 30 hours per week. However, at high hours of work the Employment Bonus vastly increases work incentives for both men. Furthermore, since the Employment Bonus is conditioned on full-time equivalent earnings, strong incentives are present even at high working hours. Also, the dependence of the subsidy on the hourly wage is clear. The man with a low wage receives close the maximum subsidy whereas the medium wage man receives only part of the subsidy.

The work incentives are very similar for couple households (not shown) and this distinguishes the Employment Bonus from the WTC and the EITC. For a first earner - a household where the female spouse is not working - household out-of-work benefits are high, particularly for a household with children, and therefore the Employment Bonus affects the budget lines only at high hours of work. For a secondary earner - for example a household where the female spouse is working full-time - the Employment Bonus has a positive effect even at low working hours as this household is not eligible for out-of-work transfers.

## 5.2 Effects on life-cycle employment

Using the same simulation method as for the gross wage elasticities, we derive the life-cycle labor supply effects induced by the Employment Bonus. In Figures 7(a) and(b) we present the labor supply effect of the Employment Bonus measured by the percentage change in weekly working hours. We disentangle the total hours effect and present the behavioral changes along the extensive and intensive margins. Figure 7(c) shows the increase in average weekly hours of work induced by the employment bonus while Figure 7(d) shows the corresponding reduction in voluntary non-employment. As discussed above, the work incentives created by the Employment Bonus are largest for the low wage men. Therefore, we derive the results for the subgroup of low educated men in east Germany. In addition we also compute the average effect for the whole sample.

[Figure 7 about here]

In general, the labor supply responses induced by the Employment Bonus are similar to those resulting from an increase in gross wages. Again we find a relatively large response on the extensive margin and, although the Employment Bonus makes over-time work particularly attractive as the subsidy is conditioned on the individual's full-time equivalent earnings, we find a minor negative effect on the intensive margin. Essentially, the Employment Bonus affects labor supply behavior by inducing voluntarily non-employed men to enter employment. Indeed, among low educated east Germans the Employment Bonus reduces the rate of voluntary non-employment by around 0.6 of a percentage point for those aged under 50 years, and by somewhat more for older men. This corresponds to an increase in average weekly working hours of around 0.15 for the under fifties rising to 0.4 of an hour per week for those aged 58-59 years. The pattern of responses over the life-cycle follows a similar pattern for the group of low educated east Germans and the sample average although we find much higher employment effects for low educated east Germans than for the sample average. Therefore, the greater incentives created by the Employment Bonus for low wage workers created by the withdrawal of the subsidy with full-time equivalent earnings more than offset the effect of high labor market restrictions in east Germany.

### 5.3 Forward looking versus myopic individuals

The value of the discount factor is a crucial parameter in the life-cycle model. As discussed above it is difficult to obtain a meaningful estimate of the discount factor. Therefore, for the analysis of the life-cycle labor supply model we have imposed the relatively high discount factor of 0.95, which is commonly used in life-cycle models of household behavior. In order to understand the extent to which the estimation results depend on the choice of discount factor we re-estimate the model using the extreme case where the discount factor is zero. This scenario describes a world in which individuals' current actions are driven entirely by their current utilities and thus no weight is given to their expected future utilities. Figure 8 shows the average relative change in working hours induced by the Employment Bonus for the subgroup of east Germans with low education based on the forward looking and myopic models.

[Figure 8 about here]

Overall, we find different employment effects depending on the assumptions about individuals' expectations. Over most of the working life the employment effects are larger in the forward looking model. Holding the estimated parameters constant in the two models, this result is intuitive particularly at the beginning of the working life. A forward looking individual understands that his current behavior affects his future income which has a positive effect on the expected utility. Of course, the parameter estimates differ between the two models. This provides a second reason why the two models imply different labor supply effects of the Employment Bonus. Indeed, differences between the parameter estimates explain why the myopic model suggests larger labor supply effect for men in their early fifties than the forward looking model. As discussed above, it is difficult to justify a high or low discount factor. Therefore, the labor supply results derived in the myopic and forward looking models should be seen as lower and upper bounds of the labor supply effects of introducing the Employment Bonus.

## 6 Conclusion

In this paper we have developed a dynamic structural life-cycle model of labor supply behavior which explicitly accounts for the effects of income tax and the transfer system. In addition, the model recognizes the demand side driven rationing risk that might prevent individuals from realizing the labor supply state that, according to life-cycle utility maximization, is optimal. This framework allow a rigorous analysis of the employment effects of reforms to the tax and transfer system.

The empirical analysis is based on panel data from the German Socio-Economic Panel (SOEP) for the years 1999 - 2005. In the empirical analysis we focus on men with low potential earnings, a group exhibiting high levels of both voluntary non-employment and involuntary unemployment. The simulated employment pattern over the life-cycle implied by the model accurately replicates the observed employment behavior. This is true for the in sample and the out of sample prediction. In line with the previous literature we find moderate labor supply responses of men which are highly concentrated at the extensive margin. On the intensive margin we find small negative effects which are due to the estimated differences in the marginal utility of income at full-time and over-time work which rises from a complementarity between income and leisure. We find higher responses for west German men as they are less likely to be restricted on the labor market.

The model is used to evaluate the life-cycle employment effects of introducing the Employment Bonus, a work-contingent transfer program, in Germany. We find that, on average, the Employment Bonus has a positive labor supply effect which is largest towards the end of the working life. The Employment Bonus affects low educated men living in east Germany more than other groups of men which reflects the focus of the Employment Bonus on men with low wages.

The presented analysis can be seen as a first attempt to capture the effects of the tax and transfer system and potential fiscal reforms on life-cycle employment. Important extensions range from the joint modeling of net household income and life-cycle employment to the joint estimation of labor supply of both spouses in a household context. The latter extension, which requires modeling fertility and part-time work, will allow a study of the effect of the tax and transfer system on the life-cycle working behavior of both spouses in couple households.

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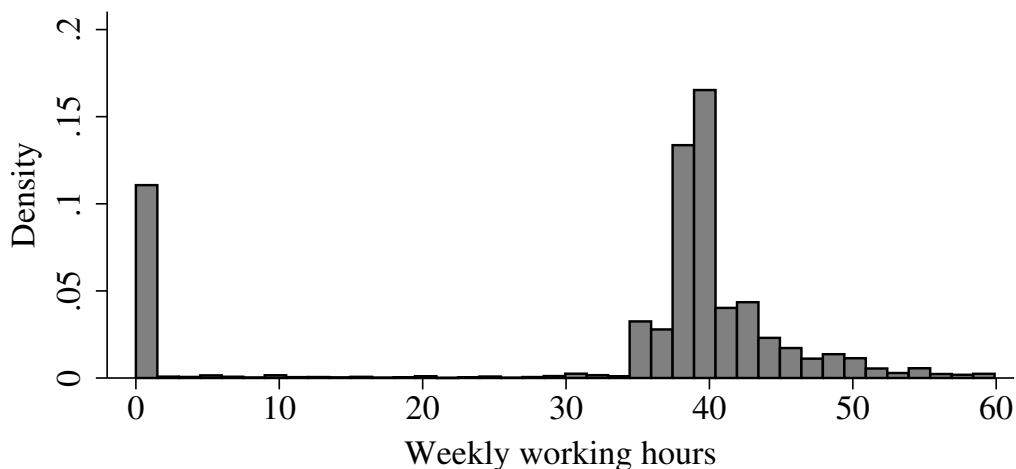
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# Figures

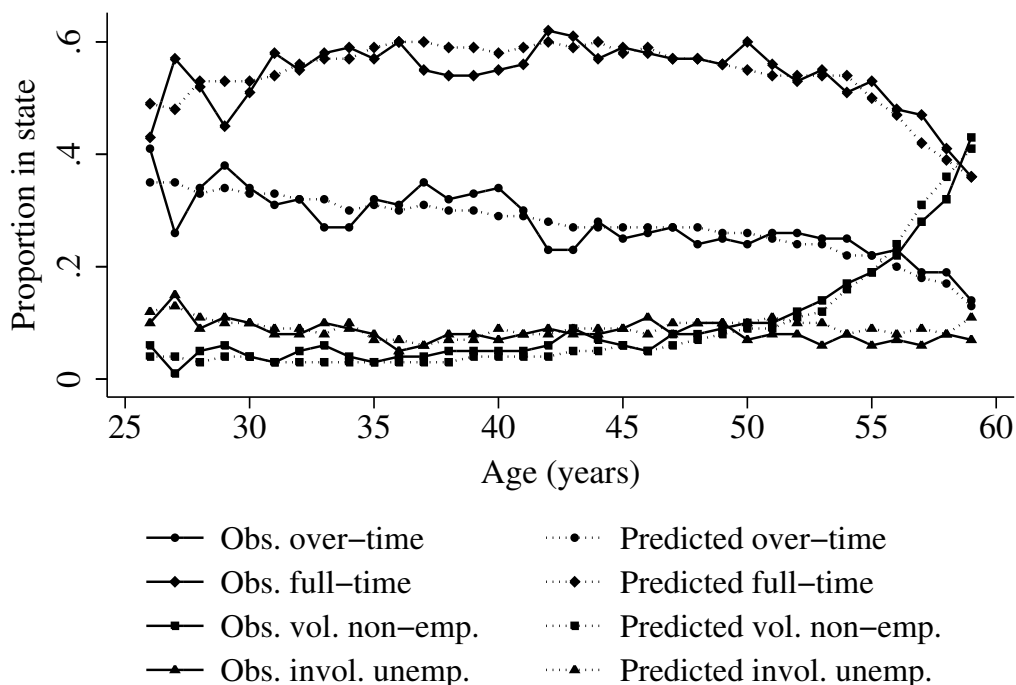
Figure 1: Histogram of observed weekly working hours



Notes: Weekly working hours are reported contractual hours plus reported paid overtime. For the purpose of this graph, the sample has been truncated at 60 hours per week which excludes about 2% of the observations.

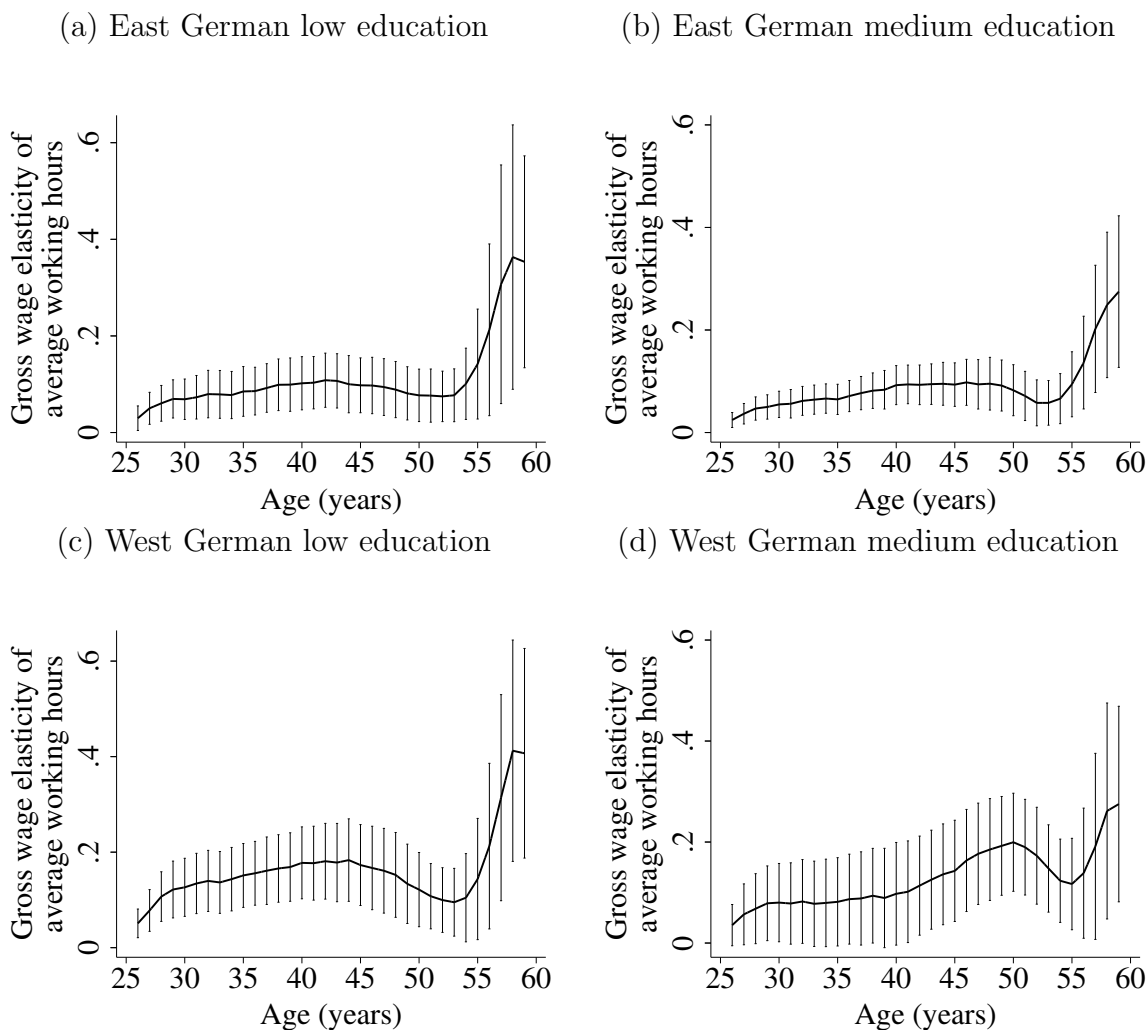
Source: SOEP 2000 - 2006.

Figure 2: Life-cycle employment behavior: In sample prediction



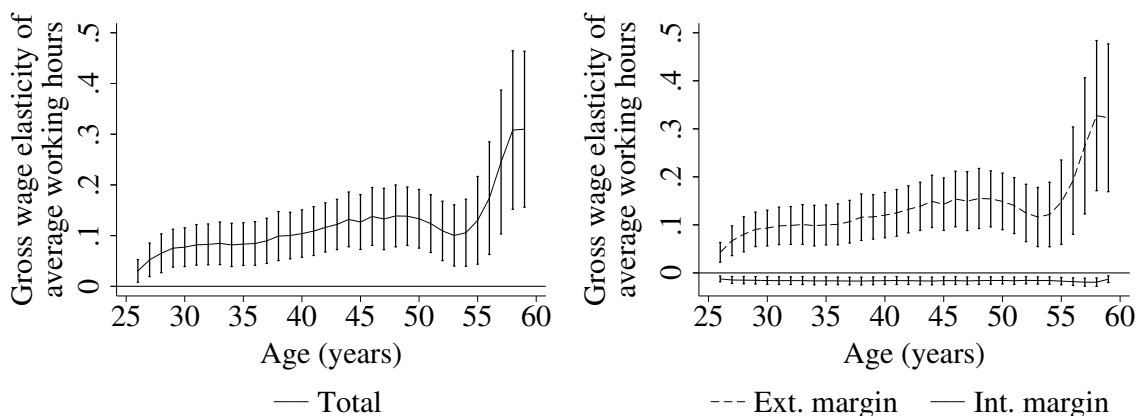
Notes: Based on  $\chi^2$  tests, the predicted and observed frequencies are significantly different at the 5% level only at ages 27, 33, 42 and 43 years. At the 1% level, the observed and expected frequencies are only significantly different at age 43 years.

Figure 3: Life-cycle gross wage elasticities of average working hours by subgroup



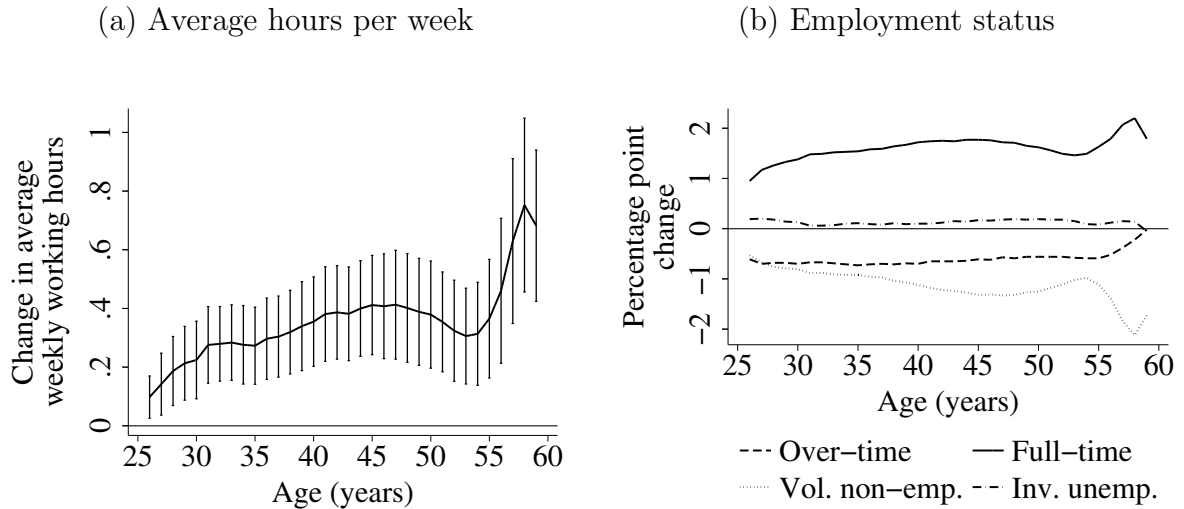
Notes: The vertical bars represent 95% confidence intervals. Gross wage elasticities are derived numerically by simulating the effect of a 10% increase in gross hourly wages.

Figure 4: Life-cycle gross wage elasticities of working hours for whole sample: Total, extensive margin and intensive margin



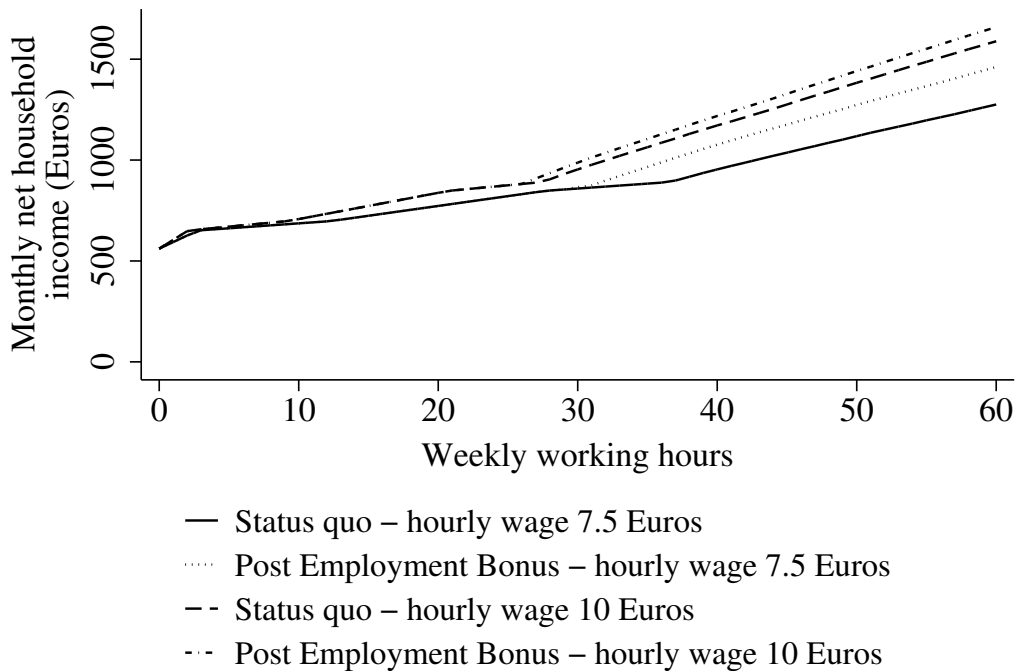
Notes: The decomposition follows the method of McDonald and Moffitt (1980). Also see Notes for Table 3.

Figure 5: Life-cycle effects of a 10% increase in gross wages for whole sample



Notes: The vertical bars in (a) represent 95% confidence intervals. Confidence intervals omitted from (b) the interest of clarity; standard errors show that the reduction in voluntary non-employment is significant at all ages.

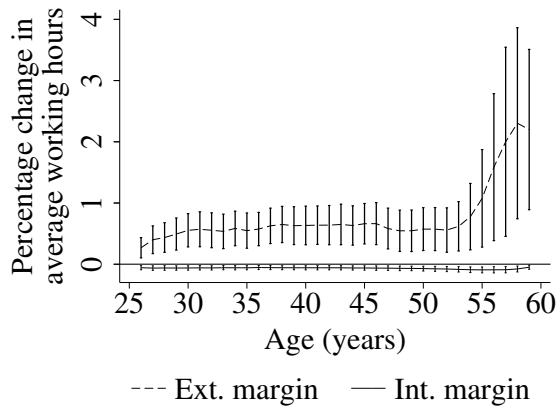
Figure 6: Budget constraints for a single man without children



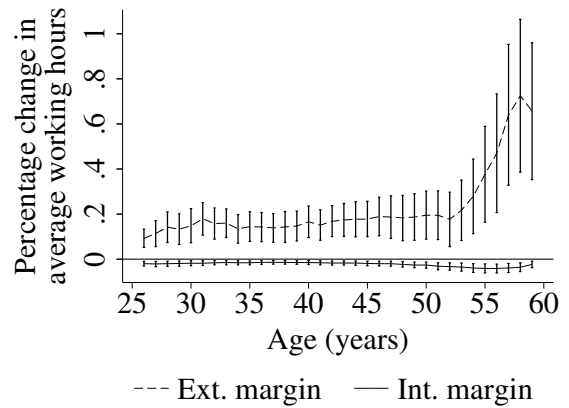
Source: STSM tax microsimulation model.

Figure 7: Life-cycle effects of the Employment Bonus

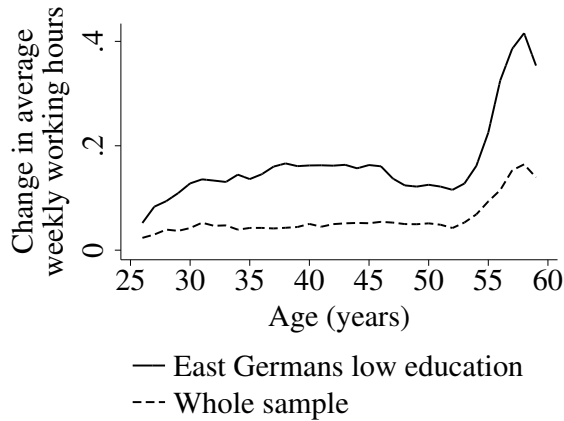
(a) Percentage change in average working hours for east Germans with low education



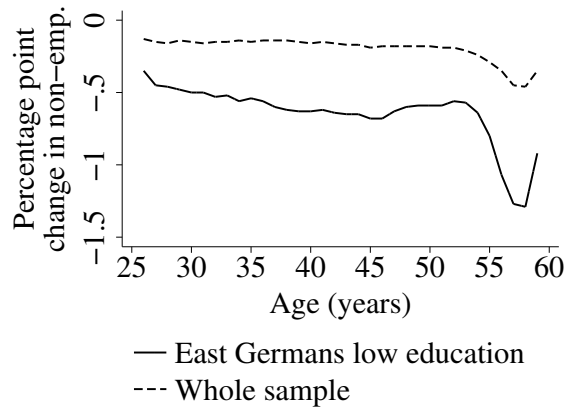
(b) Percentage change in average working hours for whole sample



(c) Change in average weekly working hours

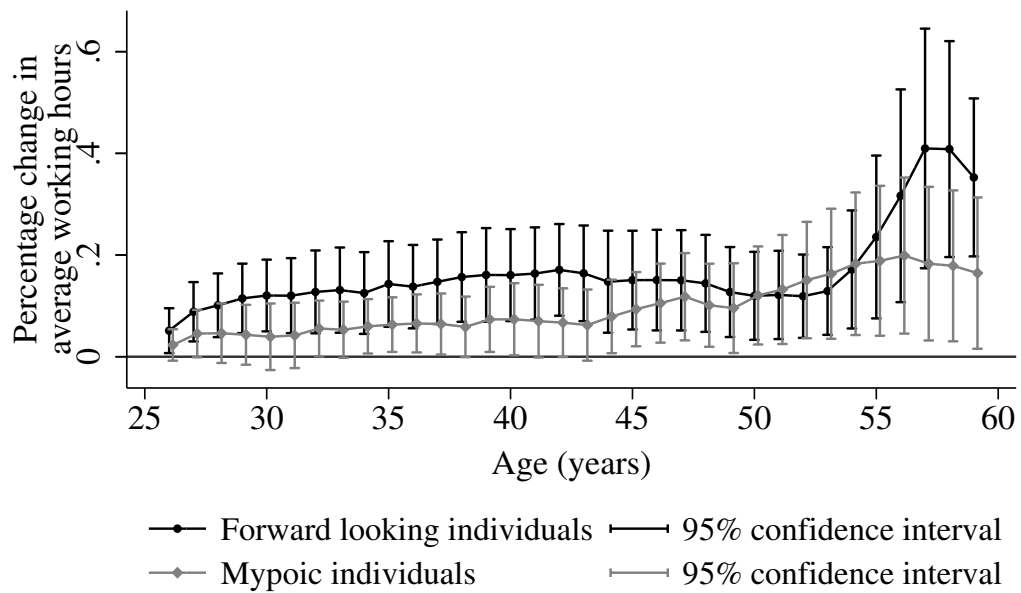


(d) Percentage point change in voluntary non-employment



Notes: The vertical bars in (a) and (b) represent 95% confidence intervals. Confidence intervals omitted from (c) and (d) in the interest of clarity; standard errors show that the reduction in voluntary non-employment and the increase in average weekly working hours are significant at all ages for the whole sample and for the subgroup of east Germans with low education.

Figure 8: Forward looking versus myopic individuals - The effect of the Employment Bonus on working hours for low educated east Germans



# Appendix

Table 6: Random effects wage estimation

	West Germany		East Germany	
	Coefficient	Std. error	Coefficient	Std. error
Age	2.4862	0.5403	4.5048	1.1339
Age <sup>2</sup>	-2.4631	0.6884	-6.2564	1.4592
Low school degree	0.0442	0.0272	0.1125	0.0992
Medium school degree	0.1671	0.0289	0.1931	0.1001
Vocational degree	0.0744	0.0147	0.0487	0.0336
Years of tenure	0.8265	0.1221	1.0072	0.2384
Years of tenure <sup>2</sup>	-0.0029	0.0037	-0.0156	0.0077
Experience	0.3119	0.2107	-0.6653	0.4533
Experience <sup>2</sup>	-0.6787	0.6057	3.1963	1.3239
Previous unemployment	-1.0172	0.0740	-0.6788	0.1219
Bad health	-0.0155	0.0663	-0.1510	0.1819
Bad health <sup>2</sup>	-0.0153	0.1036	0.3040	0.2590
Migrant	-0.0180	0.0180	0.0969	0.1047
Migrant from Turkey	0.0443	0.0294	-	-
Married	0.0361	0.0080	0.0289	0.0168
Child younger 4 years	0.0027	0.0079	0.0142	0.0186
Child between 4 and 6 years	0.0026	0.0068	-0.0116	0.0169
Child between 7 and 16 years	0.0053	0.0066	0.0055	0.0129
Child older 16 years	-0.0304	0.1176	0.1887	0.1255
Other household income	-0.0368	0.0054	-0.0893	0.0148
Other household income <sup>2</sup>	0.0048	0.0012	0.0204	0.0040
Constant	1.8168	0.1011	1.4947	0.2218
$\sigma_\nu$		0.244		0.242
$\sigma_\epsilon$		0.149		0.154

School drop-outs are base category for education.

Experience is measured in months of full-time work.

Previous unemployment is measured in number of months not working in the last 10 years.

Number of observations: West (9604), East (2823).

Source: SOEP 2000-2006.

Table 7: Utility function

	Over-time		Full-time		Vol. Non-employment	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
$Y_{i,o,t-1}$	0.8728	1.5973	1.5253	1.4483	-0.0720	1.5000
$Y_{i,f,t-1}$	0.1586	1.5530	2.6745	1.4257	1.2814	1.2807
$Y_{i,n,t-1}$	-2.5505	1.7459	-1.8634	1.1432	-0.0437	0.1776
$Y_{i,o,t-1} * g(\text{income}_j)$	3.4265	1.5520	5.2651	2.1287	4.4565	2.6520
$Y_{i,f,t-1} * g(\text{income}_j)$	3.6321	1.5657	6.3961	2.3784	6.3579	3.2021
$Y_{i,n,t-1} * g(\text{income}_j)$	0.0059	1.7183	1.4147	1.4747	2.4818	1.7692
$Y_{i,u,t-1} * g(\text{income}_j)$	1.4523	1.7035	1.9816	1.5865	1.7634	1.6346
(Age-24)/10	0.1455	0.4406	4.5048	1.1339	-	-
(Age-24) <sup>2</sup> /1000	-1.7361	1.3893	-6.2564	1.4592	-	-
$1[\text{Age}>51](\text{Age}-51)/10$	-1.4193	1.5709	0.1125	0.0992	-	-
$1[\text{Age}>51](\text{Age}-51)^2/100$	-2.4085	2.3488	0.1931	0.1001	-	-
East German, low educ.	-0.4835	0.3563	0.2401	0.3409	-	-
East German, medium educ.	0.0166	0.2478	0.2599	0.2405	-	-
West German, low educ., migrant	-0.2741	0.2793	0.5566	0.2542	-	-
West German, low educ., native	-0.4040	0.1638	0.0246	0.1508	-	-
West German, medium educ., migrant	0.2630	0.5744	1.1751	0.4913	-	-
1 dependent child	-0.0276	0.1907	-0.1568	0.1795	-	-
2 dependent children	-0.0835	0.2194	-0.2410	0.2044	-	-
3 or more dep. children	-0.2408	0.3025	-0.6159	0.2793	-	-
Wife working part-time	-0.0237	0.2267	-0.3327	0.2206	-	-
Wife working full-time	0.6017	0.2069	0.5595	0.1992	-	-
Single	-0.2787	0.2571	0.3014	0.2321	-	-
Wife medium educ.	-0.1510	0.1580	-0.1377	0.1430	-	-
Constant	1.5667	1.9683	2.2260	1.7659	0.4557	0.2902
Factor loading $c^1$	-1.6758	0.1305	-0.6829	0.1195	-	-
Factor loading $c^2$	-0.0076	0.1198	1.0287	0.1131	-	-
	Ancillary Parameter				Std. error	
Probability factor $\nu^1 = 1$					0.4853	
Probability factor $\nu^2 = 1$					0.6019	
Concavity in net income $\rho$					0.3238	
Log likelihood					-9268.79	

Source: SOEP 2000-2006. The parameters for the initial state are not reported. Parameters are jointly estimated with the rationing equation, see Table 8.



Table 8: Probability of being unrationed

	Coefficient	Std. error
$Y_{i,o,t-1}$	4.1265	0.4589
$Y_{i,f,t-1}$	4.6625	0.3798
$Y_{i,n,t-1}$	1.2361	0.2649
(Age-24)/10	0.7335	0.3497
(Age-24) <sup>2</sup> /1000	-2.2305	1.1432
$1[\text{Age}>51](\text{Age}-51)/10$	0.8200	1.1238
$1[\text{Age}>51](\text{Age}-51)^2/100$	-1.1651	1.5118
East German, low educ.	-0.5492	0.4109
East German, medium educ.	-0.0936	0.3924
West German, low educ., migrant	-1.0453	0.2633
West German, low educ., native	-0.6157	0.2217
West German, medium educ., migrant	-0.5446	0.4381
1 dependent child	0.0087	0.1476
2 dependent children	0.0189	0.1594
3 or more dep. children	-0.2287	0.2077
Wife working part-time	0.3013	0.1395
Wife working full-time	0.4680	0.1502
Single	0.0064	0.1723
Wife medium educ.	0.4009	0.1300
$Y_{i,o,t-1}*\text{LUR}$	-0.8436	0.3732
$Y_{i,o,t-1}*\text{East}*\text{LUR}$	-1.0944	0.2412
$Y_{i,f,t-1}*\text{LUR}$	-1.0680	0.2908
$Y_{i,f,t-1}*\text{East}*\text{LURC}$	-1.3769	0.1855
$Y_{i,n,t-1}*\text{LUR}$	-0.6208	0.3256
$Y_{i,n,t-1}*\text{East}*\text{LUR}$	-0.8015	0.2046
$Y_{i,u,t-1}*\text{LUR}$	-0.4375	0.2758
$Y_{i,u,t-1}*\text{East}*\text{LUR}$	-0.5699	0.1568
Constant	-0.2097	0.4392
Factor loading $c^1$	-0.2743	0.0781
Factor loading $c^2$	0.1653	0.0676

LUR is the local unemployment rate.

Source: SOEP 2000-2006.