Optimal Life Cycle Unemployment Insurance

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Abstract

We argue that US welfare would rise if unemployment insurance were to be increased for young workers and decreased for old. This is because young workers have little means to smooth consumption during unemployment, and want jobs to accumulate high-return human capital. So unemployment insurance is highly valuable to them while the induced moral hazard problem is mild. We consider a life cycle model with unemployment risk and endogenous search effort, that we calibrate to match US labor market institutions. We find that allowing unemployment replacement rates and other government transfers to decline with age yields sizeable welfare gains which amount to more than two thirds of the gains attained under the constrained optimal scheme for unemployment insurance over the life cycle.

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1 Introduction

The principle that government transfers and taxes should be conditioned on observable, immutable indicators of skills goes back at least to Akerlof (1978). More recently Kremer (2001), Erosa and Gervais (2002), Gervais (2004), Farhi and Werning (2010), Gorry and Oberfield (2010), Mirrlees et al. (2010), and Weinzierl (2011) have also stressed the importance of conditioning labor and capital income tax rates on age when designing an efficient tax system. In principle the same logic applies for the optimal design of unemployment insurance and other labor market institutions. Indeed several important economic variables (such as wages, wealth, consumption, and unemployment duration) vary over the life cycle which suggests that workers' incentive to search for a job as well as their ability to cope with unemployment risk also vary over the life-cycle. Here we argue that, given current US labor market institutions, welfare would rise if unemployment insurance were to be increased for relatively young workers (in their mid twenties and early thirties) and decreased for old workers (in their forties and mid-fifties).

The idea is that unemployment insurance is highly valuable to young workers—because they typically have little means to smooth consumption during an unemployment spell—while the costs of the implied moral hazard problem are mild—because young workers want jobs to improve life-time career prospects, and to accumulate human capital whose marginal return is high when young. The intuition for this claim can be seen using a simple intuitive formula. Consider a government who uses one dollar to finance an increase in the level of unemployment benefits b_n for a given age group n. Denote by μ_n the mass of unemployed workers in the age group, by c_{un} their consumption level when unemployed and by $u'(c_{un})$ the associated marginal utility of consumption. If all currently unemployed workers receive a unit of money, welfare would increase by $\mu_n u'(c_{un})$. But standard moral hazard problems imply that more generous government transfers increase unemployment, and each unemployed worker receives benefits b_n. So a marginal increase in government transfers yields only $1/\left[\mu_n + b_n d\mu_n/db_n\right] = 1/\left[\mu_n(1+\eta_n)\right]$ units of income to a currently unemployed worker, where η_n is the elasticity of group n unemployment to the corresponding unemployment benefits. By multiplying the two terms we find the following welfare gains from the marginal change in government transfers:

$$\varrho_n = \frac{u'(c_{un})}{1+\eta_n}. \tag{1}$$

Intuitively the numerator measures the marginal value of the increase in Unemployment Insurance, the denominator the incentive costs of the induced moral hazard problem. Generally a revenue neutral change in unemployment insurance that increases benefits for a given age group n while decreases them for another age group

m is welfare improving whenever $\varrho_n > \varrho_m$, which can be used to identify possible gains from redistributing unemployment insurance over the life cycle.

To document how ϱ_n varies across age groups, we first use data from the Panel Study of Income Dynamics (PSID) and show that consumption of unemployed workers is strictly increasing in age. Roughly speaking an unemployed worker in his thirties consumes 20 per cent less goods than a unemployed worker in his late fifties. We also use data from the Current Population Survey (CPS) and from the Survey of Income and Program Participation (SIPP) to analyze how the unemployment level of different age groups responds to changes in unemployment benefits. As in Chetty (2008) we exploit changes in the level of benefits within US states over time. We find that, while the unemployment elasticity to unemployment benefits is small and statistically insignificant for workers in their mid twenties and early thirties, the elasticity is positive and significant for workers in their mid forties and fifties. Similar results are found by Meyer and Mok (2007). Gritz and MaCurdy (1992) also show that changes in benefits have insignificant effects on the unemployment level of young workers. This evidence indicates that providing additional insurance to young worker is highly valuable, while the incentive costs of the induced moral hazard problem are small, which implies that ϱ_n is unambiguously larger for young than for old workers.

The data also provide more direct evidence that unemployment insurance is highly valuable to young workers and it has small moral hazard costs for them. We show that consumption losses upon unemployment are more pronounced for young than for old workers, and that the search behavior of young workers is strongly responsive to the provision of severance payments at the time of job loss. This indicates that young workers have little ability to smooth consumption during unemployment and require more liquidity and insurance. Chetty (2008) notices that the effects of benefits on the unemployment of wealthy workers—who arguably have great ability to smooth consumption during unemployment—measures the severity of the moral hazard problem. We find that the unemployment duration of old workers with high level of assets is highly affected by benefits, while the unemployment duration of young wealthy workers is little sensitive to benefits. This suggests that the moral hazard problem is severe for old workers while it is minor for young workers. This squares well with the idea that young workers want jobs not only to increase current income net of benefits but to acquire labor market skills and to improve working life career prospects, which is coherent with the evidence in Topel and Ward (1992).

To study the magnitude of the potential welfare gains of age dependent unemployment insurance we consider a conventional life cycle model with decreasing returns to labor market experience and ongoing unemployment risk. Workers are born with no human capital and no assets and can save in a riskless bond. When employed, they accumulate human capital, they receive wages and pay income taxes that are used to finance the unemployment insurance program and retirement pensions. Workers can lose their job and when unemployed they choose how intensively to search for a new job. During unemployment they receive unemployment benefits which are a constant fraction of past wages. The model is calibrated to match US labor market institutions and other key features of the life cycle of workers .

We optimally choose age-dependent replacement rates and/or income tax rates to maximize the worker's initial expected utility.[1] We find that under the optimal age dependent policy, replacement rates are increased from the current value of 50 per cent to around 80 percent for workers in their mid twenties and to 60 per cent for workers in their thirties. Workers in their forties and in their fifties, instead, obtain benefits equal to 20 and 10 percent of their past wage, respectively. When allowing for just age-dependent replacement rates, welfare gains are approximately equivalent to a 1 percent increase in life time consumption. When we combine age-dependent unemployment insurance with age-dependent taxes, gains go up to the equivalent of a 4 percent increase in life time consumption.

To analyze whether age dependent policies exhaust an important part of the existing unexploited gains present in the current US system, we consider the problem of an agency that optimally choose benefits, taxes and pensions as function of the entire worker's history. As in Hopenhayn and Nicolini (1997), the agency can observe workers' assets but not search effort, so unemployment insurance induces moral hazard problems. Following Spear and Srivastava (1987), we solve the problem using worker's promised continuation utility as a sufficient statistic for worker's history. The solution yields some insights about the gains from age dependent policies. As in Hopenhayn and Nicolini (1997), benefits and reemployment wages net of taxes decrease with the duration of the current unemployment spells to give workers better incentives to search for a job. Interestingly benefits and net income decrease faster for old than for young worker. This is because old workers are more productive, so having them idle is more costly from a social point of view. As a result, replacement rates are on average decreasing in age while taxes are increasing. In principle age dependent policies can only imperfectly reproduce the solution of the optimal program. We surprisingly find that the combination of age-dependent unemployment insurance with age-dependent taxes yields gains that amounts to more than two thirds of the welfare gains obtained under the optimal programm.

Further relation to the literature Using different methodologies, several authors have

[1]An alternative would be to have replacement rates and taxes being conditioned on the current level of assets rather than on age. Although this policy would distort saving incentives and it is in principle inferior to an age dependent policy, it could still yield important welfare gains. This is one of the point made by Conesa, Kitao, and Krueger (2009) and Rendahl (2009).

argued that the level of unemployment benefit is close to optimal in the US, see for example Davidson and Woodbury (1997), Shimer and Werning (2007), Pavoni (2007), and Chetty (2008). Our results show that, although benefits are about optimal on average, there are still sizable welfare gains from redistributing unemployment insurance over the life cycle—increasing it for young and decreasing it for old.

This paper relates to the ongoing literature that starting with Hopenhayn and Nicolini (1997) has analyzed the optimal design of labor market institutions, see also Pavoni and Violante (2007), Shimer and Werning (2008), Rendahl (2009), and Pavoni, Setty, and Violante (2010). The literature typically focuses on the problem of an initially unemployed worker who becomes permanently employed after finding his first job. With the exception of Hopenhayn and Nicolini (2009) the issue of recurrent unemployment spells is typically neglected. The literature has also abstracted away from life cycle considerations, which is the main focus of this paper. In particular we emphasize the importance of non linear returns to labor market experience, which we find is important to explain why the moral hazard problem for unemployed young workers is mild.[2]

Baily (1978) and Chetty (2006) have proposed a simple intuitive formula to evaluate whether unemployment benefits are optimal on average. Our formula is similar to theirs but it focuses on possible gains from redistributing unemployment insurance over the life-cycle or more generally across any groups of workers classified by observable, immutable skill characteristics including gender or race. Our formula holds exactly in the simple stylized life cycle model of Section 2. But the quantitative analysis also indicates that the formula works well in more conventional life cycle models typically used for quantitative analysis: after finding the optimal age dependent policy, we find that ϱ_n becomes almost invariant across age groups, which indicates that the formula correctly identifies existing gains from redistributing unemployment insurance over the life-cycle.

Shimer and Werning (2007) and Chetty (2008) have criticized the Baily's formula on the grounds that its use relies on specifying highly controversial preference parameters. Our formula, is less subject to their criticism in that its ability to identify redistributions gains just relies on signing the relative magnitude of ϱ_n across skill groups. This is often possible by just comparing unemployment elasticities and consumption levels when unemployed across skill groups, without having to specify any preference parameter.

Chéron, Hairault, and Langot (2008a, 2008b) have studied the role of age de-

[2]The issue of the endogenous accumulation of human capital is emphasized also by Shimer and Werning (2006) and Pavoni (2009) who study how search incentives are affected by human capital depreciation during unemployment.

pendent labor market policies in a Mortensen and Pissarides (1994) search model with finitely lived workers. Our paper is obviously related to theirs but with some important differences. They emphasize the demand side of the labor market and the role of age-dependent policies in solving the conventional search inefficiencies in vacancy creation typically present in random search models; see Pissarides (2000) for an introduction to this class of models. Search inefficiencies naturally vanish in extended versions of the search model where firms post wage contracts, workers observe them and direct search accordingly, see for example Moen (1997), Acemoglu and Shimer (2001), Shimer (2005) and more recently Menzio and Shi (2011). Here we emphasize labor supply effects and that the trade-off between the gains from unemployment insurance and the incentive costs of the induced moral hazard problem varies over the life cycle.

Section 2 discusses a simple life cycle model where the formula in (1) holds exactly. Section 3 contains preliminary evidence. Section 4 presents the quantitative life-cycle model. Section 5 solves for the optimal unemployment insurance problem. Section 6 considers age dependent policies. Section 7 discusses robustness. Section 8 concludes. An Online Appendix provides details on data and computation.

2 A simple model

We present a simple stylized life-cycle model where our formula holds exactly. We later show that the formula also works well in a more conventional life-cycle model more suitable for quantitative analysis. In this simple model workers live for six periods $n = 1$–6. They are young, $j = y$, during the first three $n = 1$–3, and old, $j = o$, during the last three $n = 4$–6. Unemployment is the only source of risk in the model. Workers are employed with probability one in all periods except in period two and five when they have to search for a job. This characterizes the fact that unemployment risk is recurrent, it affects both young and old, and it has transitory effects. Unemployment is endogenous due to search intensity decisions. Search intensity reduces the probability of unemployment and the amount of leisure enjoyed by the worker. We assume that a worker who is unemployed with probability μ at the end of period two or five enjoys utility from leisure equal to $\psi(\mu)$, with $\psi'(\mu) > 0$ and $\psi''(\mu) < 0$. Workers initially have no wealth. They can not borrow and they can save in a riskless bond that pays a constant interest rate equal to the subjective discount rate of workers, both normalized to zero. Following well established evidence from wage regressions, we assume that wages w_n, $n = 1$–3 increase over time when young, while they are flat and equal to $\bar{w}$ when old, with $w_1 < w_2 < w_3 < \bar{w}$. If unemployed at age $j = y, o$ (end of period two or five) workers obtain unemployment benefits b_j. Consumption utility in a period is $u(c)$.

We assume that consumption is equal to income for young workers: a young worker expects future increases in labor income and would like to borrow to smooth consumption, but he can not due to the borrowing constraint.[3] This simplifying assumption implies that old workers' decisions are unaffected by the employment history when young, which in turn guarantees that changes in benefits when young (old) do not affect unemployment when old (young). This separability property is required for the formula to hold exactly. The quantitative analysis below shows that the property holds well also when young workers do save and borrow.

Separability implies that worker's initial expected utility can be expressed as equal to $V \equiv Y(b_y) + O(b_o)$ where

$$Y(b_y) \equiv u(w_1) + \max_{\mu} \left[\psi(\mu) + \mu u(b_y) + (1-\mu)u(w_2)\right] + u(w_3), \tag{2}$$

is the sum of worker's utilities obtained when young $n = 1$–3, while

$$O(b_o) \equiv \max_{\mu, a \geq 0} u(\bar{w} - a) + \psi(\mu) + \mu \left[u(b_o + a) + u(\bar{w})\right] + (1-\mu)2u\left(\bar{w} + \frac{a}{2}\right) \tag{3}$$

is the analogous sum of utilities when old, $n = 4$–6. In (3), a denotes the precautionary savings that the household accumulates in period four to finance consumption during unemployment in period five, which occurs with endogenously determined probability μ. If the worker instead remains employed, a is used to increase consumption equally in period five and six. This accounts for the last term in (3).[4]

The government chooses b_j, $j = y, o$ so as to maximize worker's initial expected utility V subject to the budget constraint

$$\mu_y b_y + \mu_o b_o = T \tag{4}$$

where μ_y and μ_o represent the equilibrium unemployment level of young and old workers as implied by the problem in (2) and (3), respectively. T is some exogenous government income used to finance the unemployment insurance program. In the quantitative model below this income is obtained by taxing labor. Let λ denote the Lagrange multiplier of the budget constraint in (4). To maximize V we can write the Lagrangian of the problem and then take the first order condition with respect to b_j, $j = y, o$. After using the envelope theorem, we immediately obtain that it is optimal to increase b_j if

$$\mu_j u'\left(c_{uj}\right) > \lambda \mu_j + \lambda \frac{d\mu_j}{db_j} b_j$$

[3]Even if wages are growing and the interest rate is zero, young workers might want to accumulate some precautionary savings to insure the risk of unemployment in period two. Here we assume that the demand for consumption smoothing dominates the precautionary savings motive. The formal condition involves a simple inequality for the traditional Euler equation for consumption that we omit for brevity.

[4]In equilibrium a will always be in the interval $(0, \bar{w} - b_o)$, so the constraint $a \geq 0$ will be slack, while the borrowing constraint will be binding in period five if the worker is unemployed.

where c_{uj} denotes consumption when unemployed at age j. By rearranging we obtain that the above condition is equivalent to

$$\varrho_j \equiv \frac{u'(c_{uj})}{1+\eta_j} > \lambda \tag{5}$$

where $\eta_j \equiv \frac{d \ln \mu_j}{d \ln b_j}$ is the elasticity of age-group j unemployment to benefits. The ratio in the left hand side is the net welfare gain of marginally increasing government transfers to unemployed workers of age j: the numerator measures the value of the marginal increase in UI benefits; the denominator the cost of the induced increase in unemployment. Notice that, if young workers were not hand-to-mouth consumers, the numerator would remain unchanged—again due to the envelope theorem—while the denominator would have to be modified slightly since changes in b_y and b_o would affect μ_o and μ_y, respectively. In the quantitative model we find that these cross-derivatives are small. Optimal life cycle unemployment insurance requires having $\varrho_j = \lambda$ for any age group j. Generally there are welfare gains from increasing transfers to young unemployed workers at the expense of the old whenever

$$\varrho_y > \varrho_o. \tag{6}$$

Interestingly, the comparison does not involve evaluating consumption losses upon displacement. This is simply because the government compares the gains of increasing transfers to unemployed workers of different age, whose marginal value is measured by their state contingent marginal utility of consumption.

The derivation that leads to (6) is little, if at all, affected when considering several extensions of the baseline model. In particular the formula remains valid when:

1. *Differences in workers demand* The utility from leisure is age-specific, $\psi_j(\mu)$, $j = y, o$, with $\psi'_j(\mu) > 0$ and $\psi''_j(\mu) < 0$. This accounts for possible differences in the demand for workers of different age, which can affect job finding probabilities.

2. *Varying job loss probabilities* Workers search for a job in period two and five with age specific probability δ_j, $j = y, o$ (in the baseline model $\delta_y = \delta_o = 1$). This takes into account that the risk of job loss varies over the life cycle.

3. *Other income sources* Workers have access to other sources of income y_j (say due to the spouse income), whose relative importance varies over the life cycle.

4. *Changing household size* The household is represented by a simple unitary model with consumption utility $m_j u(C/m_j)$, where m_j denotes household size when household head has age j, while C denotes household total consumption expenditures. This takes into account that household size changes over the life cycle

due to marriage, children birth or old children leaving the household. Due again to the envelope theorem, the marginal value of a unitary increase in benefits is $u'(C/m_j)$. This just implies that c_{uj} in (5) has to be interpreted as per capita household consumption when age j household head is unemployed.

3 Some empirical evidence

We now show that in the US the unemployment elasticity to Unemployment Insurance (UI) benefits and the consumption while unemployed are both lower when young than when old. This indicates that inequality (6) holds both because young workers' incentives to search for a job are less affected by benefits—the denominator in (5) is smaller for young than for old—and because young workers value unemployment insurance more—the numerator is higher. We then provide more direct evidence i) that the moral hazard problem induced by unemployment insurance is mild for young workers, and ii) that young workers have little means to smooth consumption during unemployment and thereby value highly the insurance and liquidity provided by UI benefits.

3.1 Unemployment elasticity to benefits

We analyze the effects of UI benefits on the unemployment of workers of different age by first using unemployment duration models for individual data and then using aggregate evidence from US states.

3.1.1 Unemployment duration models

We use individual data from the Survey of Income and Program Participation (SIPP) over the period 1985-2000. Each SIPP panel surveys households at four month intervals for 2-4 years and contains information on employment status at the weekly frequency and UI benefit receipt. The sample selection criteria are exactly as in Chetty (2008): we restrict attention to prime-age males who have taken up UI benefits after a job loss, are not on temporary layoff, and have at least three months of work history in the survey (so pre-unemployment wages can be computed). To measure UI benefits we use two statistics provided by Chetty (2008): one is the *average* benefits in each state and year as reported by the Department of Labor; the other is an imputation of *individual* benefits using the simulation program by Cullen and Gruber (2000).[5] The Online Appendix discusses further details of the

[5]Chetty (2008) also provides a measure for the maximum level of benefits in the state. This measure is less relevant for our analysis since the maximum benefit level might be more or less binding depending on the worker's wage which is positively correlated with his age. In any case results are little changed when using this alternative measure.

data.

We start splitting the sample in two age groups depending on whether workers have 20 to 40 or 41 to 60 years of age. The split by age is justified by the fact that, after 40 years of age, the return to labor market experience substantially flattens while assets increase significantly. We show later that this matters for determining the insurance value and the moral hazard costs of unemployment insurance. We later consider a finer disaggregation by age. For each sample, we estimate the following semi-parametric Cox regression model for unemployment duration:

$$\ln h_{it} \quad = \quad \beta \ln b_{it} + \theta X_{it} + \text{err}. \tag{7}$$

where i denotes the worker, t the duration of the current unemployment spell, h_{it} is the job finding probability at unemployment duration t, b_{it} is the level of UI benefits, and X_{it} are set of controls including worker's age, years of education, family status, previous job tenure, a spline in past logged wages, dummies for year, states, and unemployment duration and the interaction of benefits with unemployment duration. The effects of benefits are identified using a difference-in-differences identification strategy that exploits changes in the UI regulation of US states through time.[6] Table 1 reports the results. Panel (a) uses average benefits, panel (b) individual benefits. The first column of each panel deals with the full sample estimates, that are analogous to those in Chetty (2008). Here the elasticity of the job finding probability to

Table 1: Job finding elasticity to benefits, SIPP data

(a) Average UI benefits

	All	*20-40 yrs*	*41-60 yrs*
ln ben.	-.53**	-.37	-1.34***
	(.27)	(.33)	(.49)
N.	4560	2873	1522

(b) Individual UI benefits

	All	*20-40 yrs*	*41-60 yrs*
ln ben.	-.36***	-.22	-.86***
	(.11)	(.16)	(.19)
N.	4529	2858	1522

Notes: Estimates of β in the Cox duration model (7) using SIPP data. In panel (a) benefits are state-year averages, in panel (b) are individually imputed using the simulation program by Cullen and Gruber (2000). First column deals with full sample, second and third with workers of age from 20 to 40 years, and from 41 to 60 years, respectively. Standard errors clustered by state in parenthesis. "***" indicates significance at 1%, "**" at 5%, "*" at 10%.

benefits is very close to one half and strongly statistically significant. The results in the following two columns show that the full sample estimates in Chetty (2008) hide

[6] Of course some changes could be endogenous for example because states are more likely to increase benefits when unemployment is high. To address the relevance of this concern, we conducted a placebo test similar to Chetty (2008) and we estimated the Cox model in (7) using the sample of workers who did not take up UI benefits. We found that in this sample benefits have no statistically significant effects on unemployment duration. We also tried to include aggregate variables as controls and to instrument the benefits level variable in (7) with its two to four years lagged value. Results change little, and if some age differences increase.

some important heterogeneity across workers of different age. When considering the sample of workers from 20 to 40 years of age the effects of benefits on job finding are quantitatively small and not statistically significant for either measure of benefits. In the sample of older workers the estimated elasticity is instead close to one and strongly statistically significant with either benefits measure.[7]

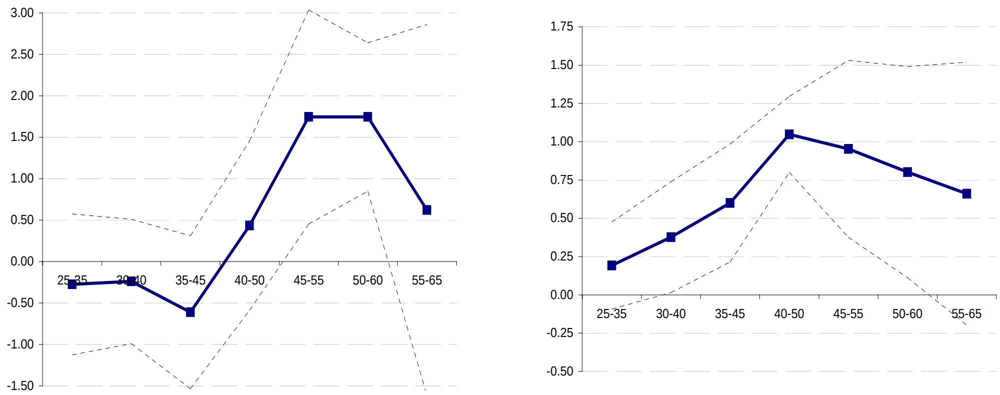
We now split the data into finer age group of workers. To maintain sample size, we estimate the duration model in (7) using eight partly overlapping samples of workers with age differences of ten years. To measure the unemployment elasticity to benefits, we use the relation $d \ln u / d \ln b = -(1-u) d \ln f / d \ln b$, where u and f are the sample average of the unemployment rate and finding rate, respectively. The relation is exact if benefits affects unemployment only though the job finding rate. Figure 1 reports the resulting unemployment elasticity. Panel (a) uses average benefits, panel (b) individual benefits. The dotted lines represent 90 percent confidence intervals. When considering the average measure of benefits, the estimated unemployment elasticity is close to zero for workers below forty while it is around one and a half for workers in their mid forties and early fifties. For workers close to retirement the unemployment elasticity falls close to zero. The results are similar when measuring benefits at the individual level, although now the elasticity is significantly different from zero also for workers in their thirties and results are somewhat less precise for workers in their late fifties.

3.1.2 US states aggregate evidence

So far we have focused on how UI benefits affects the job finding rates of unemployed workers. But benefits can affect unemployment through labor force participation or through the unemployment inflow rate. Benefits could also have some aggregate equilibrium effects not properly measured when using individual unemployment duration regressions. To address some of these concerns, we use US states aggregate unemployment data. The idea is to consider each state as a somewhat separate labor market with different unemployment insurance laws. We then use monthly data from the Current Population Survey (CPS) to calculate UI benefits and unemployment over population ratios by age groups for each state and semester in the years from 1984 to 2000. We restrict the sample to male workers with 16 to 64 years of age. To construct a measure of benefits by state, semester in the year and age, we impute pre-unemployment wages for each unemployed worker and then calculate individual benefits using the UI benefits calculator from Cullen and Gruber (2000).

[7]We checked that results are robust to including as controls the log of individual wealth or of net liquid assets at the time of the job loss, or to using a Weibull model for unemployment duration. We have also split the sample in three educational groups (college graduates, some high school, less than high school) and found similar results in each of the three groups.

Figure 1: Unemployment elasticity to benefits by age group, SIPP data



(a) Average benefits

(b) Individual benefits

Notes: Unemployment elasticity to benefits for different age groups of workers. Estimates based on model (7) using SIPP data. Unemployment elasticities are calculated using the formula $\frac{d\ln u}{d\ln b} = -(1-u)\frac{d\ln f}{d\ln b}$, where u and f are the sample average of the unemployment rate and finding rate, respectively. Panel (a) uses average state benefits, panel (b) individual benefits. Dotted lines are 90 percent confidence intervals.

Pre-unemployment wages are imputed using a conventional wage regression which is estimated in each state and year with the March CPS survey.[8] For each age group in a given state and period we calculate the average UI benefit and pre-unemployment wage, that we use to estimate the following regression model:

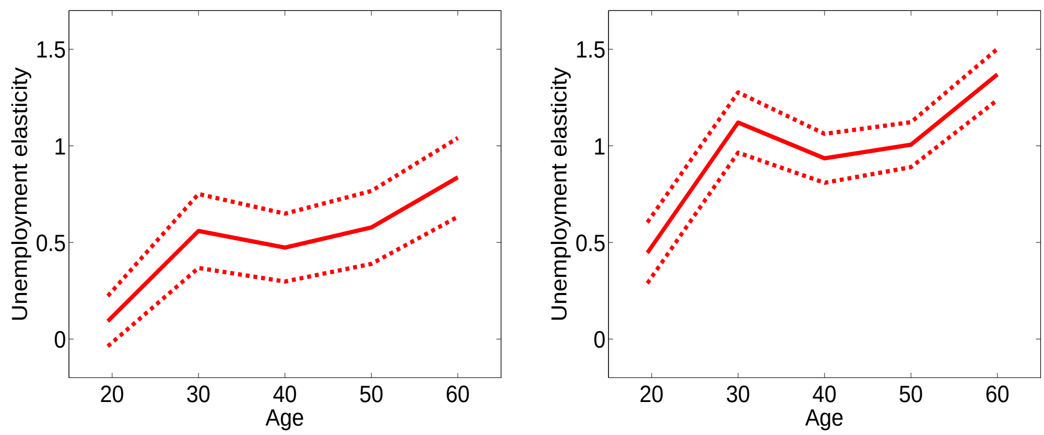
$$\ln u_{itj} \quad = \quad \sum_n \beta_n q_j^n \ln b_{itj} + \theta X_{itj} + \text{err}. \tag{8}$$

where i stands for state, t for period (semester-year) and j for age group, u_{tij} is the unemployment over population ratio of age group j in state i in period t, q_j^n is a dummy variable which is equal to one if the observation corresponds to age group n, b_{itj} is the imputed average benefit level deflated with the CPI index. The variables X_{itj} are a set of controls, including time, state, and age group dummies, the imputed logged average pre-unemployment wages (again deflated with the CPI index), the proportion in the group of white, of married workers, of workers with working spouse, and of unemployed workers with five different educational levels. Standard errors are clustered at the state level, since different US states are considered as (at least) partially segmented labor markets.

[8]The dependent variable of the wage regression is logged weekly wages and the independent variables are a quadratic polynomial in age, four educational dummies, two race dummies, and a marital status dummy.

Figure 2 plots the estimated unemployment elasticity to benefits for different age groups of workers, as measured by the β_n coefficients in (8). Dotted lines are ninety percent confidence intervals. The left panel reports the OLS estimates. The right panel are the analogous estimates where benefits are instrumented using their own three years lagged value, in an attempt to control for possible endogeneity problems—for example because the average replacement rates changes over the business cycle due to changes in the composition of the pool of unemployed. The OLS estimates indicate that unemployment elasticity are increasing by age. They are very close to zero for workers in their twenties and around 0.7 for workers in their fifties. With IV the age profile is similar but elasticities become larger and more in line with the estimates from the individual unemployment duration analysis in Figure 1. This is consistent with the idea that changes in the composition

Figure 2: Unemployment elasticity to benefits by age group, aggregate data



(a) Unemployment elasticity, OLS

(b) Unemployment elasticity, IV

Notes: Estimates of β_n in (8) using US states aggregate unemployment data from CPS. Left panel are OLS estimates, right panel are IV estimates where current benefits are instrumented using its own lagged three years value. Dotted lines are 90 percent confidence intervals.

of the pool of unemployed workers makes replacement rates increase in recessions.[9] A difference relative to the individual unemployment duration analysis, is that the elasticity is no longer close to zero for workers close to retirement, possibly due to aggregation problems.[10]

[9]There is now debate on the cyclical properties of the composition of the pool of unemployed, see Mueller (2010) for recent evidence.

[10]We checked that results are robust to the inclusion of the maximum duration of benefits as additional controls or to using the lagged value of benefits rather than its contemporaneous value as independent variable.

3.2 Consumption while unemployed

To estimate how the consumption of unemployed workers varies with age, we use data from the Panel Study of Income Dynamics (PSID). Consumption is measured using either food consumption, that is reported directly from PSID, or the imputation for total consumption expenditures in non durables goods from Blundell, Pistaferri, and Preston (2008). Food consumption is the average weekly per capita expenditures in the household on food at home. As argued by Blundell, Pistaferri, and Preston (2008) people typically report their food expenditures in an average week around the week of the survey. Nondurable consumption is the analogous average for the sum of expenditures in food, alcohol, tobacco, services, heating fuel, transport, personal care and clothing and footware. Sample selection is as in Blundell, Pistaferri, and Preston (2008), who focus on continuously married couples headed by a male with 21 to 65 years of age with no dramatic changes in family composition over the sample period. These restrictions are intended to control for dramatic exogenous shocks unrelated to changes in employment status. We then run the following regression:

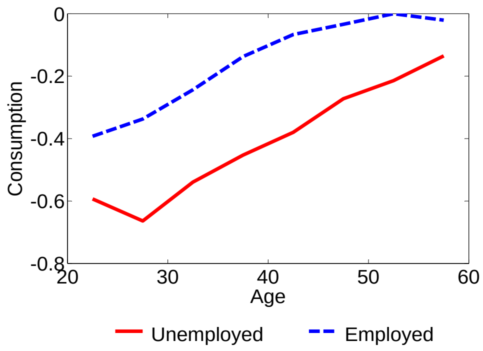
$$\ln c_{it} = \sum_n \beta_n^e e_{it}^n + \sum_n \beta_n^u u_{it}^n + \theta X_{it} + \text{err}. \tag{9}$$

where i denotes the worker, t is the year, c_{it} is consumption per capita in the household, e_{it}^n and u_{it}^n are employment status dummies that are equal to one if, at the interview date, the household head of age n is employed or unemployed, respectively. Finally X_{it} are set of controls, including educational level and race of the head of household, whether the head is self employed, state and time dummies, number of kids in the household, the presence of disabled people, kids out of home, and the number of other household members.

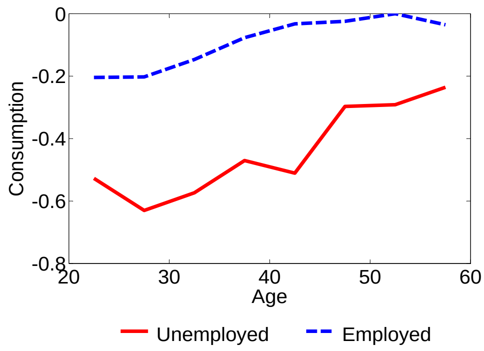
Figure 3 shows the estimated age profile of consumption of employed workers as a dashed line and of unemployed workers as a solid line. Panel (a) deals with food consumption, panel (b) with total consumption in nondurables. Consumption of employed workers increases with age reaching a peak between 51 and 55 years of age. Consumption of unemployed workers also increases with age and it is always lower than consumption of employed workers. Figure 3 plots the cumulative distribution function of consumption when unemployed for several age groups of workers, as implied by (9). Panel (c) deals with food consumption, panel (d) with total consumption in non durables. Either figure indicates that consumption is higher for older workers in the first order stochastic dominance sense, which is even stronger evidence for the claim that consumption of unemployed workers increases with age.[11]

[11] We checked that results are robust to including temporary laid off workers in the pool of

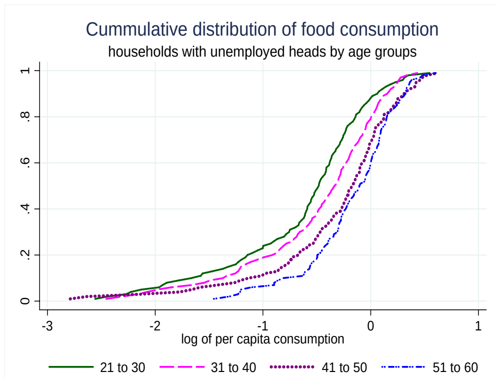
Figure 3: Food and total consumption by age, PSID



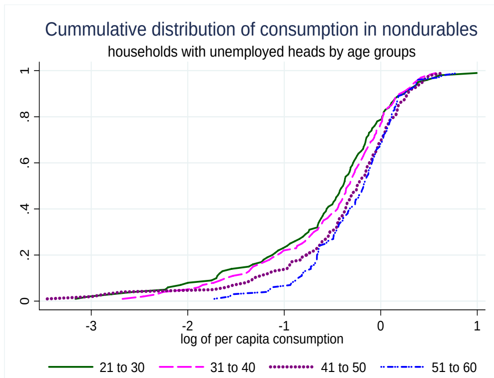
(a) Average food consumption



(b) Average consumption in nondurables



(c) CDF food consumption



(d) CDF consumption in nondurables

Notes: Life cycle profile of household per capita consumption. Left column is for food consumption, right column for total consumption expenditures in nondurables. The second row reports empirical CDF for the consumption level of unemployed workers of different age. All estimates are based on estimating (9) on PSID data.

3.3 Moral hazard and liquidity effects

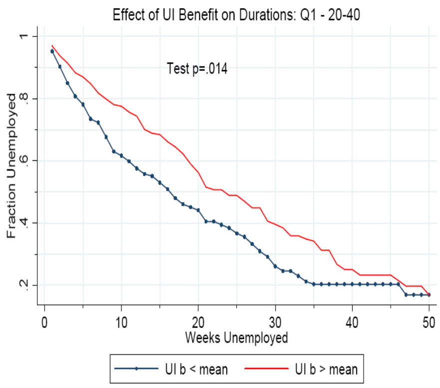
The previous results indicate that unemployment insurance induces mild incentive costs and it is highly valuable to young workers. We now provide more direct evidence that i) the moral hazard problem induced by unemployment insurance is mild for young workers and ii) that young workers value highly unemployment insurance because they have little means to smooth consumption during unemployment.

Moral hazard effects by age As shown by Chetty (2008), UI benefits increase unemployment duration due to a conventional moral hazard effect—benefits reduce

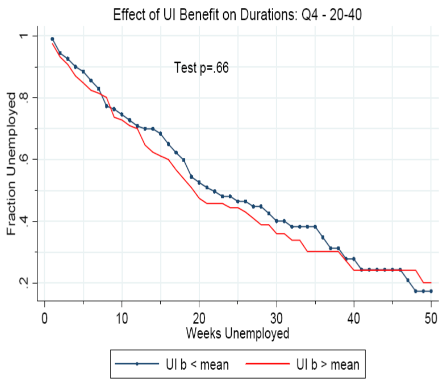
unemployed workers, to weighting observations, to using total expenditures in food either at home or out of home (rather than just food at home), and to dropping observations with consumption levels below the bottom or above the top percentile of the consumption distribution.

the net income gains from finding a job— and due to a liquidity effect—benefits allow to better equalize the marginal utility of consumption when employed and when unemployed. So the evidence that the unemployment elasticity to benefits increases with age does not necessarily indicate that the moral hazard problem is milder for young than for old workers. To identify moral hazard effects Chetty (2008) argues that workers with high asset levels have great ability to smooth consumption during unemployment. For these workers, liquidity effects are absent and benefits increase unemployment just due to moral hazard. To pursue this logic, we use the SIPP data and analyze how benefits affects the unemployment probability of wealthy workers of different age. In Figure 4, we plot Kaplan-Meier survival probability of

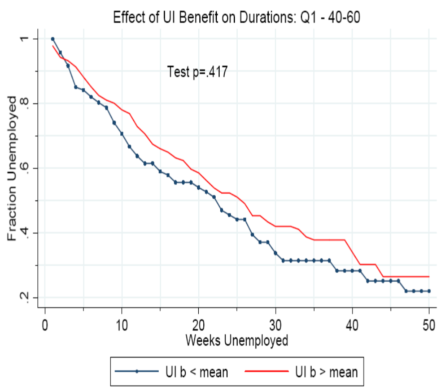
Figure 4: Unemployment survival probability for young and old workers, by assets



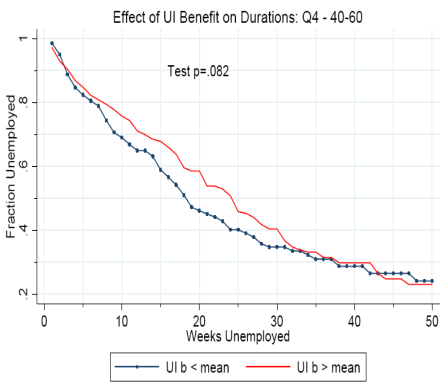
(a) Young poor



(b) Young rich



(c) Old poor



(d) Old rich

Notes: Kaplan-Meier survival probability in unemployment for different benefits levels, age and wealth, using SIPP. All survival curves are adjusted for possible seam effects. Solid lines correspond to benefit levels above the median, dashed lines to benefits below the median. First row is for 'young' workers (20 to 40 years of age), second row for 'old' workers (40 to 60 years of age). Left column is for poor worker (bottom quartile of wealth), right column for wealthy workers (top quartile of wealth). The probability under the null hypothesis that the survival curves are identical is obtained using the nonparametric Wilcoxon test.

remaining unemployed for 'young' workers (20-40 years of age) and 'old' workers (40-60 years of age) with wealth levels in the bottom quartile (left column) and top quartile (right column) of the distribution of wealth. Wealth is measured as liquid assets net of unsecured debt at the time of job loss. Panels (a) and (b) are for 'young' workers, panels (c) and (d) are for 'old' workers. In each panel, the solid and dashed line are the survival curves for workers in states with benefits above and below the corresponding sample median, respectively. Panels (b) and (d) indicate that the effects of benefits on the unemployment probability of wealthy workers vary by workers' age. For young wealthy workers UI benefits have no significant effects on unemployment: the Wilcoxon test fails to reject the null hypothesis of equality in survival curves of workers with benefits above and below the median. For old wealthy workers the two survival curves do differ and the Wilcoxon test marginally rejects the null hypothesis that the two survival curves are equal. This is prime facie evidence that the moral hazard problem induced by unemployment insurance are more severe for old than for young workers.

To better analyze how wealth affects the relation between job finding and benefits for workers of different age, we estimate the following Cox model analogous to (7):

$$\ln h_{it} \;=\; \sum_n \beta_n q_{it}^n \ln b_{it} + \theta X_{itj} + \text{err.} \tag{10}$$

where q_{it}^n is an indicator variable that is one if worker's wealth is in quartile n (with higher n indicating greater wealth). Controls are as in the estimation of equation (7) with the additional inclusion of wealth dummies and their interaction with unemployment duration. Table 2 reports the estimated β_n coefficients in the full sample, and in the samples of 'young' and 'old' workers. The Cox duration analysis confirms that benefits reduces job finding rates of old workers with assets in the top third or fourth quartile of the wealth distribution. The effects are somewhat stronger when measuring benefits with state averages. Overall this evidence is consistent with the claim that the moral hazard problem of unemployment insurance is more important for old than for young workers.

Liquidity effects by age Panel (a) in Figure 4 and Table 2 provide some evidence that UI benefits increase the unemployment probability of young poor workers, especially when focusing on the individual measure of benefits. This is coherent with the idea that UI benefits provide some valuable liquidity to young workers which allow them to better smooth consumption during unemployment. We now provide two additional pieces of evidence consistent with this view. We first borrow from Chetty (2008) the idea that severance payments provide some liquidity to unemployed workers with no moral hazard costs. By comparing the search behavior

Table 2: Job finding elasticity to benefits by assets, SIPP

(a) Average UI benefits

	All	*20-40 yrs*	*41-60 yrs*
$Q_1\times$ ln ben.	-.98**	-.78	-1.28**
	(.40)	(.57)	(.70)
$Q_2\times$ln ben.	-.73*	-.58	-1.52
	(.42)	(.48)	(1.41)
$Q_3\times$ln ben.	-.48	.05	-1.74***
	(.36)	(.52)	(.57)
$Q_4\times$ln ben.	.10	1.16	-2.13***
	(.47)	(.73)	(.69)
N.	4054	2498	1420

(b) Individual UI benefits

	All	*20-40 yrs*	*41-60 yrs*
$Q_1\times$ln ben.	-.64***	-.55*	-1.32***
	(.24)	(.30)	(.43)
$Q_2\times$ln ben.	-.76***	-.92***	-.26
	(.22)	(.23)	(.55)
$Q_3\times$ln ben.	-.56***	-.31	-1.11***
	(.15)	(.24)	(.35)
$Q_4\times$ln ben.	.02	.66*	-.79*
	(.26)	(.35)	(.47)
N.	4054	2498	1420

Notes: Estimates of β_n in the Cox model (10) using SIPP data. Q_j, $j = 1, 2, 3, 4$ are the quartile of the wealth distribution in the corresponding sample. Further details are as in Table 1.

of unemployed workers who have received severance payments with the behavior of similar workers who have not, we can identify the importance of liquidity effects. We use surveys data collected by Mathematica on behalf of the Department of Labor, which contain information on whether displaced workers have received severance payments at the time of the job loss.[12] The sample selection criteria mimic those used with the SIPP data: we focus on the search behavior of permanently displaced male workers with complete data on tenure and severance pay, see Online Appendix for details. The final sample comprises 2441 spells, 18% of them for workers who have received some severance payment. With these data we estimate the following Cox proportional hazard model for unemployment duration analogous to (7):

$$\ln h_{it} \quad = \quad \beta \text{Sev}_i + \theta X_{it} + \text{err.} \tag{11}$$

where Sev_i is an indicator variable which is equal to one if the displaced worker has received some severance payments. The additional controls X_{it} include worker's age, four education dummies, a spline in past tenure, one in past wages, the log of unemployment benefits, fixed effects for state, occupation and industry, unemployment duration dummies and the interaction of severance payment dummy with unemployment duration. Again the model is estimated for the full sample and for the two age groups of workers. The resulting estimate for β is reported in Table 3. The first column reproduces the full sample results in Chetty (2008), which indicate that unemployed workers with severance pay experiences a percentage reduction in job finding rates of around one quarter. When we split the sample by workers' age

[12]Policies about severance payments vary by firms with a common package typically offered to all firm employees, see Lee Hecht Harrison (2001). Severance payments are usually related to tenure. Many companies require a minimum level of job tenure to grant severance payment and, beyond that threshold, pay around one week of wages per year of tenure.

we find that the reduction in finding rates for young workers is around one third, while for old workers it is close to zero and not statistically significant at conventional levels. This is coherent with the idea that young workers have little means to smooth consumption during unemployment.

Table 3: Job finding elasticity to severance pay, Mathematica data

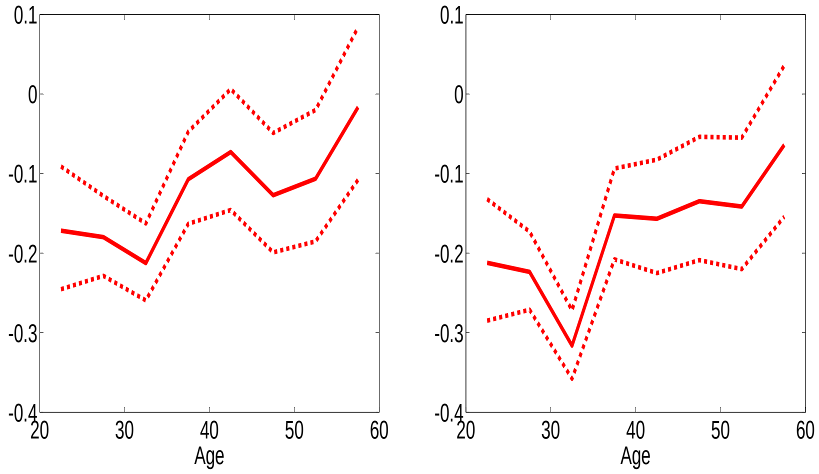
	All	*20-40 yrs*	*41-60 yrs*
Sev. pay	-.23***	-.32***	-.06
	(.07)	(.09)	(.10)
N.	2428	1514	840

Notes: Estimates of β in (11) using Mathematica data. First column deals with full sample, second and third with workers of age from 20 to 40 years, and from 41 to 60 years, respectively. Standard errors clustered by state in parentheses. "***" indicates significance at 1%, "**" at 5%, "*" at 10%.

The age pattern of consumption losses upon unemployment also indicates that young workers find difficult to smooth consumption during unemployment. To estimate consumption losses, we follow Gruber (1997) and estimate equation (9) but now including individual fixed effects and dummy variables characterizing changes in employment status. The coefficient of the change in employment status from employment to unemployment characterizes the size of the average consumption loss upon unemployment. We allow this effect to vary by age. Figure 5 shows the age profile of consumption losses for food consumption (left panel) and total consumption in nondurables (right panel). Consumption losses are around 17% for workers in their twenties and thirties and fall to 5-10% for workers in their fifties and sixties.[13] Consumption losses are slightly larger when considering total consumption expenditures in nondurables, but the age profile is similar. This is again evidence coherent with the idea that young workers have little precautionary savings and limited liquidity to smooth consumption during unemployment, which is related to the evidence in Gourinchas and Parker (2002) and Nahm and Schoeni (2006).

[13] There are several papers that have measured consumption losses upon unemployment. Gruber (1997) uses PSID data and finds average food consumption losses upon unemployment of around 7%; Browning and Crossley (2001) use Canadian data and reports losses of around 14% in total consumption expenditures. Similar results are found by Bloemen and Stancanelli (2005) using UK data and by Sullivan (2008) again with the PSID. All authors point out that these average estimates are the result of aggregating vastly different individual consumption responses. Our results show that part of this heterogeneity is due to the life cycle.

Figure 5: Consumption losses upon unemployment



(a) Food consumption losses (b) Total consumption losses

Notes: Consumption losses upon unemployment by age, PSID data. Dotted lines are 90 percent confidence intervals.

4 Laboratory economy

We now consider a life cycle model with ongoing unemployment risk that we use as a laboratory economy to answer two questions. First we study the magnitude of the potential welfare gains of age dependent unemployment insurance. Second we compare these gains with those attained under the constrained optimal scheme for unemployment insurance over the life cycle. We first characterize the economy and its equilibrium conditions. Then we turn to calibration and discuss key properties of the calibrated economy.

4.1 Assumptions

Workers live for $\bar{n}_w + \bar{n}_r$ periods. They are active in the labor market in the first $\bar{n}_w$ periods, retired in the last $\bar{n}_r$ periods. Workers have discount factor β and receive utility from consumption $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, with $\sigma > 0$. They are born with no job, no human capital, $e = 0$, no assets, $a = 0$, and can save in a riskless bond who pays a constant interest rate r that satisfies $\beta = \frac{1}{1+r}$. Workers have limited ability to borrow and their assets cannot be lower than the borrowing threshold l. In each period of employment, workers accumulate one unit of human capital and they receive wages $w(e)$ that satisfies $w' \geq 0$ and $w'' \leq 0$. This formalizes the notion that there are positive but decreasing returns to labor market experience. Employed workers lose their job with probability δ and when unemployed they choose how intensively to search for a new job. Search intensity reduces the probability of unemployment and the amount of leisure enjoyed by the worker. We assume that a worker who receives job offers with probability $1-\mu$ enjoys utility from leisure $\psi(\mu)$, with $\psi'(\mu)>0$ and $\psi''(\mu)<0$. Here μ denotes the within period unemployment probability of a worker searching for a job. We adopt the same timing convention as in Lentz and Tranaes (2005) and Chetty (2008), whereby successful search in a period leads to a job in the same period. Unemployment is the only source of risk in the model. If unemployed at the end of the period, workers receive unemployment benefits which are a fraction ρ of their wage. During the last $\bar{n}_r$ periods, workers receive pensions which are a fraction π of workers' net wage at the time of retirement. This is a simplified characterization of the US pensions system. During employment, workers pay income taxes that are a fraction τ of their labor income. Taxes are used to finance the unemployment insurance program and retirement pensions. The government faces the same interest rate as the households and its budget is balanced.

4.2 Equilibrium conditions

Let $c^e(e,a,a')=(1-\tau)w(e)+(1+r)a-a'$ denote the consumption of an employed worker of age $n\leq\bar{n}_w$ with human capital e and assets a, who chooses asset level a' for next period. The value of being employed for this worker satisfies:

$$V(n,e,a)=\max_{a'\geq l} u\left(c^e(e,a,a')\right)+\beta\left[(1-\delta)V(n+1,e+1,a')+\delta J(n+1,e+1,a')\right] \tag{12}$$

where the last term incorporates the fact that with probability δ the worker has to search for a new job. The value of searching is given by

$$J(n,e,a)=\max_{\mu\in[0,1]} \psi(\mu)+\mu U(n,e,a)+(1-\mu)V(n,e,a)$$

which uses the timing convention that, with probability $1-\mu$, search leads to a job in the same period, while, with probability μ, the worker remains unemployed whose value is given by

$$U(n,e,a)=\max_{a'\geq l} u(c^u(e,a,a'))+\beta J(n+1,e,a') \tag{13}$$

where $c^u(e,a,a')=\rho w(e)+(1+r)\,a-a'$ denotes current period consumption when unemployed. In writing (12) and (13) we adopted the convention that

$$V(\bar{n}_w+1,e,a)=U(\bar{n}_w+1,e,a)=R(e,a),$$

where R denotes the value of retiring at $n=\bar{n}_w+1$ with human capital e and assets a. This value is equal to

$$R(e,a)=\frac{1-\beta^{\bar{n}_r}}{1-\beta}c^p(e,a)$$

where $c^p(e,a) = \pi w(e)(1-\tau) + \frac{1-\beta}{1-\beta^{\bar{n}_r}} a$ is the constant over time consumption level after retirement. At birth, workers have to search for a job, they have no experience and no assets so their welfare is given by $W_s \equiv J(1,0,0)$.

4.3 Calibration

The model is calibrated to US data at the quarterly frequency. The calibration targets are reported in Table 4, the resulting parameters values are in Table 5.

Table 4: Calibration targets and model fit

Moment cond.	Data	Model	Source
Separation rate	.04	.04	JOLTS
Pensions repl. rate	.44	.44	OECD
Benefits repl. rate	.50	.50	SIPP
Wage profile:			
21-30 years	1.00	1.00	CPS
31-40 years	1.43	1.43	CPS
41-50 years	1.59	1.58	CPS
Unemployment rate	.057	.057	BLS
Relative finding rates by age:			
21-30 years	1.00	1.00	CPS
31-40 years	.76	.78	CPS
41-50 years	.61	.60	CPS
51-60 years	.47	.49	CPS
Assets over mean annual labor income:			
55-64 years	5.01	5.02	SCF
Minimum	-.103	-.103	CEX

Technology We assume that workers are born at 20 years of age, they are active for 45 years in the labor market, $\bar{n}_w = 180$, and live twenty five years after retirement, $\bar{n}_r = 100$. The wage function $w(e)$ is chosen so that log wages are a cubic polynomial in labor market experience: $w(e) = \exp(\theta_1 e + \theta_2 e^2 + \theta_3 e^3)$. The parameters $\theta_i = 1, 2, 3$ are implicitly set to match the relative workers' wages by age in Table 4. Roughly, wages increase by around 60 per cent over the life of an average worker. These estimates are obtained using data for male workers from the March CPS over the period 1990-2000, see the Online Appendix for details. The resulting $w(e)$ function is nondecreasing and concave in e. We set the separation rate δ to .04 which is consistent with data on average job tenure and reproduces the mean separation rate from JOLTS over the period 2005-2007. The borrowing limit l is set to be equal to minus ten percent of the mean annual labor income in the economy. This corresponds to the bottom decile of the distribution of workers' net (liquid) assets in the Consumption Expenditure Survey (CEX) over the period 1990-2003.[14] We

[14]We define net liquid assets as the sum of savings, checking and brokerage accounts, market value of owned stocks and bonds minus the amount owed by the household, excluding mortgages

later perform a robustness exercise relative to the choice of this target.

Search effort The search effort function $\psi(\mu)$ is a spline through the four points reported in Table 5. These points are calibrated in equilibrium to match an aggregate unemployment rate of 5.7 percent (which is the US average over the 2000-2009 period) and relative finding rates by age. Finding rates are estimated using a Cox duration model on CPS data over the period 1998-1999, see Online Appendix for details. Our estimates are in line with those in Low, Meghir, and Pistaferri (2010). Roughly speaking, the duration of an unemployment spell for a worker in his twenties is half the analogous duration for a worker in his fifties, see Table 4. The resulting $\psi(\mu)$ function depicted in panel (a) of Figure 6 is concave.

Remaining preferences To have a reasonable life cycle profile for workers' net worth, we set σ to target the median level of the ratio of net worth of households with heads between 55 to 64 years of age to mean annual income. This value is around 5, according to data from the Federal Reserve Board's Survey of Consumer Finances in 2004. The model needs a value of σ close to 2 to match this target. We set β to .99, to match an annual interest rate of approximately 4%.

Policy parameters The UI benefit replacement rate ρ is set to .5, which follows Chetty (2008). The pensions replacement rate π is set to .44, which is in line with data for US male workers according to OECD (2007). The tax rate τ is set to keep government budget balanced. The implied tax rate is 9.53%, see Table 5.

Table 5: Parameters values

Parameter	Definition	Value
$\bar{n}_w$	Periods in labor market	180
$\bar{n}_r$	Periods retired	100
β	Discount factor	.99
δ	Separation rate	.04
ρ	Benefit replacement rate	.50
π	Pensions replacement rate	.44
θ_1	$w(e)$ function parameter	0.0186
θ_2	$w(e)$ function parameter	$-1.4e^{-4}$
θ_3	$w(e)$ function parameter	$2.9e^{-7}$
l	Borrowing constraint	$-.79$
σ	Risk aversion	2.0
τ	Tax rate	.095
$\psi(\mu)$	Value of ψ at $\mu = [0, .05, .35, .65, .95]$	$-[3.2, 1.47, .63, .03, 0]$

Notes: The search effort function $\psi(\mu)$ is a spline defined by the points in the table.

and vehicle loans, see Online Appendix for further details.

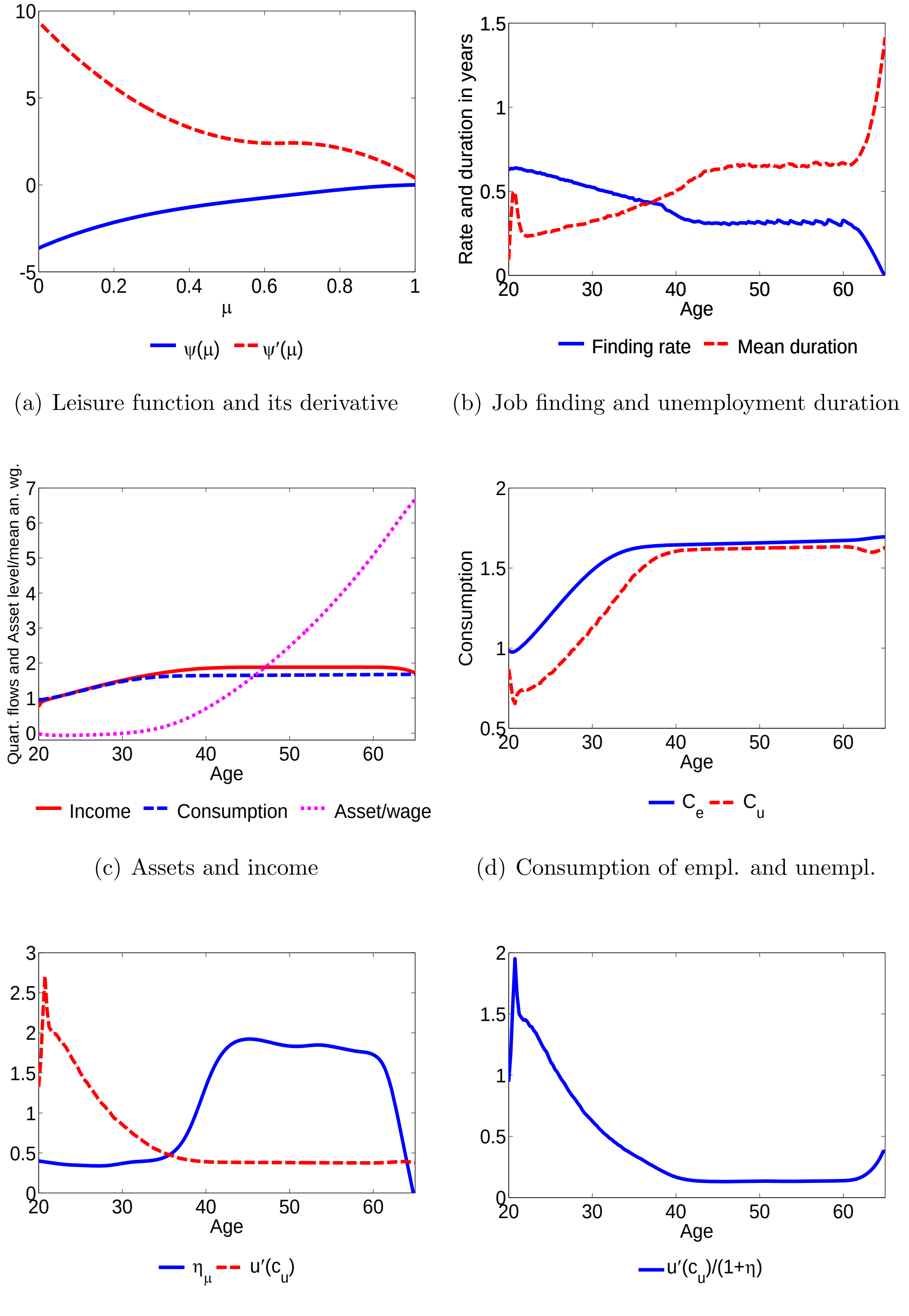
4.4 Further properties of the calibrated economy

Figure 6 characterizes the age profile of key variables in the calibrated economy. Panel (b) deals with finding rates and unemployment duration, panel (c) with income, consumption and assets, panel (d) with consumption when employed and when unemployed. Finding rates decreases from 70% for workers in their twenties to 35% for workers in their mid fifties. Unemployed workers close to retirement have finding rate close to zero. This is because the ψ function in panel (a) has strictly positive first derivative for unemployment probability equal to one, so unemployed workers close to retirement always shirk and optimally choose $\mu = 1$. The unemployment risk faced by workers over their working life is sizeable: around twelve per cent of workers spend more than ten per cent of their working life into unemployment. Evidence from NLSY79 indicates that this is an underestimate of the actual unemployment risk faced by US households over their life cycle. Mean labor income (which includes UI benefits) peaks in the mid forties and more than doubles over the life cycle. Two years before retirement, income falls due to the high unemployment rate. Average consumption peaks three years before income and remains roughly constant until the end of life. Consumption increases on average by fifty percent over the life-cycle, which is roughly in line with the empirical evidence, see for example Fernández-Villaverde and Krueger (2007). Mean assets are zero at the beginning of life and start to increase in the late thirties and keep increasing until retirement. These features are roughly in line with the data. Average consumption losses upon unemployment are close to 20% for workers in their twenties and they fall to about 5% for workers in their mid forties. Consumption losses for workers close to retirement are slightly larger. This is due to the fact that job loss affects their remaining life time labor income almost permanently, given their very low finding rates and limited remaining working life.[15]

Panel (e) plots as a dashed line the age profile of the expected marginal utility of consumption of an unemployed worker and, as a solid line, the age profile of the unemployment elasticity to benefits. The expected marginal utility of consumption when unemployed is decreasing with age, since the average consumption of unemployed workers increases with age. The unemployment elasticity is close to .5 for workers in their twenties and it increases to around one and a half for workers in their forties and fifties. For workers close to retirement the elasticity drops to

[15]Consumption losses upon unemployment of old workers tend to be larger in the data than in the model. Allowing for losses of human capital upon job displacement (say due to job specific human capital) would allow the model to better match the data. But this would also require using severance payments as an additional policy instrument to insure wage losses upon displacement, which is a further (important) issue that we do not emphasize in this paper. In the conclusions we further elaborate on this point.

Figure 6: Properties of laboratory economy



(a) Leisure function and its derivative

(b) Job finding and unemployment duration

(c) Assets and income

(d) Consumption of empl. and unempl.

(e) Marg. utility and unemployment elasticity

(f) Redistribution formula

Notes: Income and consumption are expressed as quarterly flows. Assets levels are expressed as proportion of mean annual labor income in the economy.

zero. This profile is remarkably similar to the estimated counterpart obtained in the unemployment duration analysis in Figure 1, even if it was not a calibration target. Panel (f) plots the ratio of the expected marginal utility of consumption of an unemployed worker to one plus the unemployment elasticity to benefits, which is the model counterpart of ϱ_n in (1). This ratio is unambiguously decreasing with age. Its value is close to 2 for workers in their twenties and close to one fourth for workers in their forties and early fifties. This suggests that one unit of government money yields eight times larger welfare gains when assigned to young unemployed workers than to middle-aged unemployed workers.

Although, the distribution of assets is more dispersed in the data than in the simulated economy, the model matches reasonably well the fraction of unemployed young workers with negative assets. This is important because the value of the additional liquidity provided by unemployment insurance to unemployed workers depends on the number of unemployed workers who are financially constrained. Table 6 shows that the fraction of workers in their twenties and thirties with net wealth less than minus ten percent of annual labor income is close to ten percent, both in the data and in the model. The analogous fraction for workers of 40 to 60 years of age is 4 per cent in the data, while it is close to zero in the model. So this specification might underestimate the value of providing liquidity to middle aged workers. We later analyze the importance of this concern by changing the value of the borrowing limit l.

Table 6: Wealth distribution of unemployed workers

	20-40	40-60
Model	.09	.00
Net wealth	.08	.04

Notes: percentage of unemployed workers with assets lower than minus ten percent of average annual labor income. Data come from CEX over the 1990-2003 period.

5 Optimal life cycle unemployment insurance

Before analyzing age dependent policies, we study the problem of an agency that observes workers' assets and maximizes initial worker's utility by choosing benefits b, taxes t, and pensions p as a function of the entire worker's history. Since assets are observable, we can think that the agency directly controls workers' consumption. In practice we solve the dual problem of minimizing the cost to the agency (given by the sum of benefits and pensions net of income taxes) of providing a given expected utility to the worker. Government budget is balanced, exactly as in Section 4. We first characterize the solution to the first best problem where search effort is observable. We then turn to the more relevant case where, as in Hopenhayn and Nicolini (1997), search effort is unobservable and unemployment insurance induces moral hazard problems. The Appendix provides computational details.

5.1 Observable search effort

When search effort is observable, no moral hazard problem is present and the agency can provide perfect consumption insurance to the worker. The cost of providing consumption c to a worker of age $n \leq \bar{n}_w$ with labor market experience e who is searching for a job is the difference between the present value of consumption expenditures and the expected future income $Y(n, e, c)$ produced by the worker:

$$\Upsilon(n, e, c) = \frac{1 - \beta^{\bar{n}_w + \bar{n}_r + 1 - n}}{1 - \beta} c - Y(n, e, c) \tag{14}$$

Search effort is set to maximize the utility value of Y. The right hand side in (14) is decreasing in c because higher consumption implies greater expenditures as well as less future income Y since search effort is reduced due to an income effect. The optimal value of c, denoted by c^*, solves the equation $\Upsilon(1, 0, c^*) = 0$. The dotted line in panel (a) of Figure 11 characterizes the resulting age profile of job finding rates. Job finding rates are slightly increasing with age until two years before retirement, when they start to fall rapidly to zero. Since the ψ-function is concave, the agency would like to smooth search effort over time, but the opportunity cost of having an old worker unemployed is high due to their high productivity. So job finding rates are generally (mildly) increasing in age. Just before retirement, investing in search is unprofitable since little time is left to capitalize any investment. So job finding rates drop to zero.

5.2 Unobservable search effort

When the agency can not observe search effort, unemployment insurance induces moral hazard problems. Following Spear and Srivastava (1987), we solve the problem using worker's promised continuation utility as a sufficient statistic for worker's history. Let $C^e(n, e, v)$ be the cost to the agency of providing continuation utility v to an employed worker of age $n \leq \bar{n}_w$ and labor market experience e. The function $C^u(n, e, v)$ is the analogous cost function for a worker searching for a job. Finally

$C^r(v)$ denotes the cost at retirement. The function $C^e(n,e,v)$ satisfies:

$$\begin{aligned} C^e(n,e,v) &= \min_{t,v'_u,v'_e} -t+\beta\delta C^u(n+1,e+1,v'_u)+\beta\left(1-\delta\right)C^e(n+1,e+1,v'_e) \\ & \quad s.t. \\ v &= u(w(e)-t)+\beta\delta v'_u+\beta\left(1-\delta\right)v'_e. \end{aligned} \tag{15}$$

The agency choose taxes t (which reduces costs) and future promised utilities, subject to the promise keeping constraint in (15). The analogous cost function for an unemployed worker $C^u(n,e,v)$ solves

$$C^u(n,e,v) = \min_{v_e,v_u,v'_u,b,\mu} (1-\mu)C^e(n,e,v_e)+\mu\left[b+\beta C^u(n+1,e,v'_u)\right] \tag{16}$$

$$s.t.$$

$$v = \psi(\mu)+(1-\mu)v_e+\mu v_u \tag{17}$$

$$\mu = \arg\max_{x\in[0,1]} \psi(x)+(1-x)v_e+xv_u \tag{18}$$

$$v_u = u(b)+\beta v'_u. \tag{19}$$

The agency choose benefits b and state contingent promised utilities, subject to the promise keeping constraint in (17), the incentive compatibility constraint for effort provision in (18), and the definition of the utility promised to an unemployed worker in (19). Since the worker retires at age $\bar{n}_w+1$ we also have that

$$C^u(\bar{n}_w+1,e,v)=C^e(\bar{n}_w+1,e,v)=C^r(v).$$

Finally the cost of promising utility v at retirement is equal to

$$C^r(v)=\frac{1-\beta^{\bar{n}_r}}{1-\beta}p \tag{20}$$

where p is the constant over time consumption level after retirement that solves:

$$v=\frac{1-\beta^{\bar{n}_r}}{1-\beta}u(p).$$

The maximal utility, W^*, attained by the worker at birth is obtained by solving

$$C^u\left(1,0,W^*\right)=0.$$

Figures 7 and 8 characterize properties of the solution. Panels (a) and (b) in Figure 7 plot the time path of benefits b (solid line), taxes t (dashed line), and finding rates $1-\mu$ (dotted line) for a worker who remains permanently unemployed, after becoming first unemployed at 20 and 55 years of age, respectively. The different histories imply that the two workers also differ in terms of skill e and promised utility v. As in Hopenhayn and Nicolini (1997) benefits are decreasing in unemployment duration while labor income taxes and job finding rates are increasing: the agency provides dynamic incentives to ease the moral hazard problem induced by unemployment insurance. Panel (c) plots the evolution of unemployment benefits as a ratio of net labor income for the two types of workers. For workers who become first unemployed at an older age, net replacement rates are lower and they decrease faster. As a result job finding rates are higher, see panel (d). The agency wants to give older workers stronger incentive to search for a job, because the opportunity cost of having a skilled worker unemployed is higher. After controlling for skill, age differences in replacement rates are reverted. This is shown by the dotted lines in panel (c) and (d) that show the evolution of replacement rates and job finding rates of a permanently unemployed worker of 55 years of age and zero labor market experience, $e = 0$.

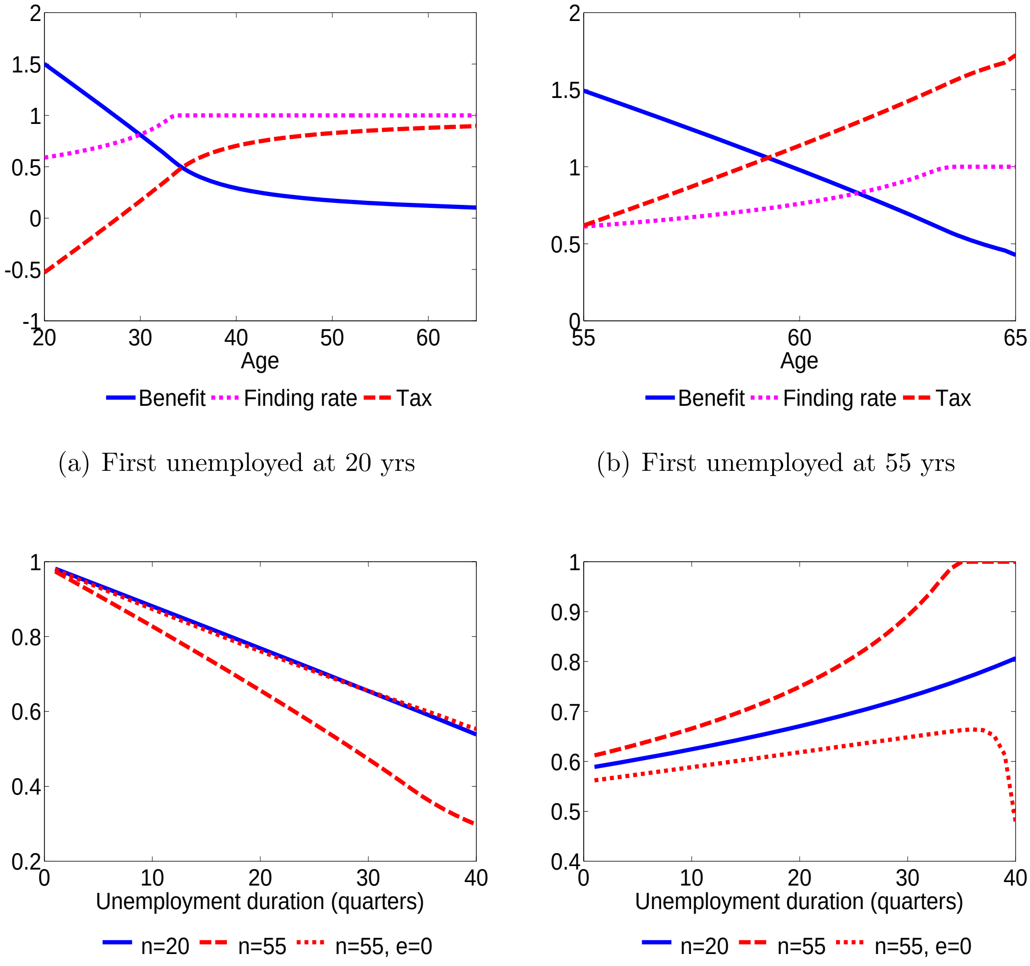
Figure 8 characterizes the age profile of (gross) replacement rates and tax rates (panel a) and of consumption when employed and when unemployed (panel b). Replacement rates are on average decreasing in age, because old workers are more productive on average. So the agency wants to give them stronger incentive to search for a job. Taxes are designed to smooth the age profile of consumption, so taxes rates are increasing in age. With moral hazard, the agency can not perfectly insure workers against the risk of unemployment. So consumption is on average higher when employed than when unemployed. Consumption losses are overall small (close to one percent), and slightly increasing with age. This is again due to the high opportunity cost of having an old skilled worker unemployed. The age profile of job finding rates is generally increasing until two years before retirement and closely mimics the analogous profile of the first best problem.

To sum up, after designing unemployment insurance optimally, replacement rates are on average decreasing with age while tax rates are increasing. Job finding rates and consumption losses are also increasing with age. This is at variance with existing US evidence and suggests that age dependent unemployment insurance could be welfare improving. Table 7 compares the welfare gains under the policy with observable and unobservable search effort. Differences in welfare gains are small, but gains relative to the status quo are sizable, roughly equivalent to a 4.5 per cent increase in per period consumption.

6 Age dependent policies

In the previous Section the government could condition transfers on workers' entire labor market history as well as on their assets, age, experience, and employment status. The government was restricted just by the incentive compatibility constraint

Figure 7: Optimal unemployment insurance: simulated histories



(a) First unemployed at 20 yrs

(b) First unemployed at 55 yrs

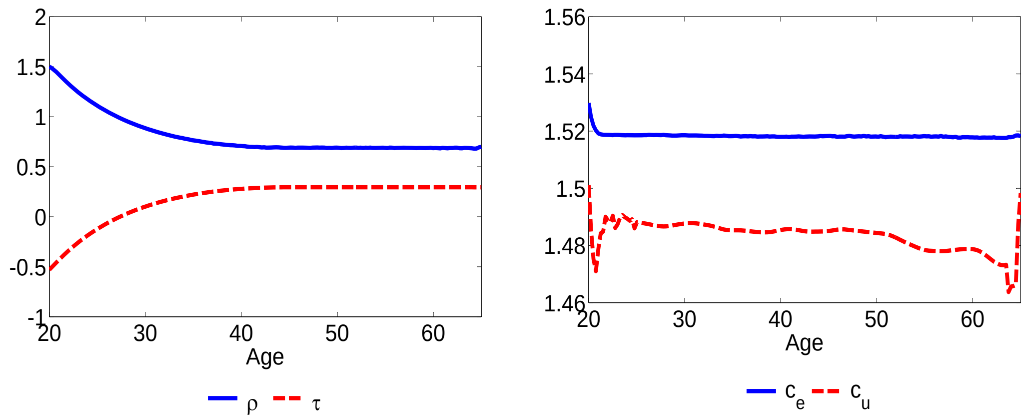
(c) Net replacement rates

(d) Finding rates

Notes: Panels (a) and (b) are simulated histories for a permanently unemployed worker who becomes first unemployed at 20 and 55 years of age, respectively. Panel (c) and (d) plots net replacement rates and job finding rates for the two previous types of workers and for a worker with 55 years of age and no labor market experience, $e = 0$. Unemployment duration is in quarters.

for the provision of search effort. We now study age dependent policies, where the government can condition UI replacement rates, ρ_n, and labor income tax rates, τ_n, on age n. We assume that ρ_n and τ_n are a Chebyshev polynomial in age of the fifth order. We search for the polynomial coefficients that maximize workers utility at birth and we check that results are little affected by allowing for higher order polynomials. Pensions replacement rates are left unchanged, while tax levels are always adjusted to keep government budget balanced. We first focus on the optimal age-dependent replacement rate policy and then allow income tax rates also to vary

Figure 8: Optimal unemployment insurance: age profiles



(a) Replacement rates and taxes

(b) Consumption of empl. and unempl.

Notes: Mean gross replacement rate, tax rate and consumption while employed and unemployed for simulated histories of workers under the optimal policy.

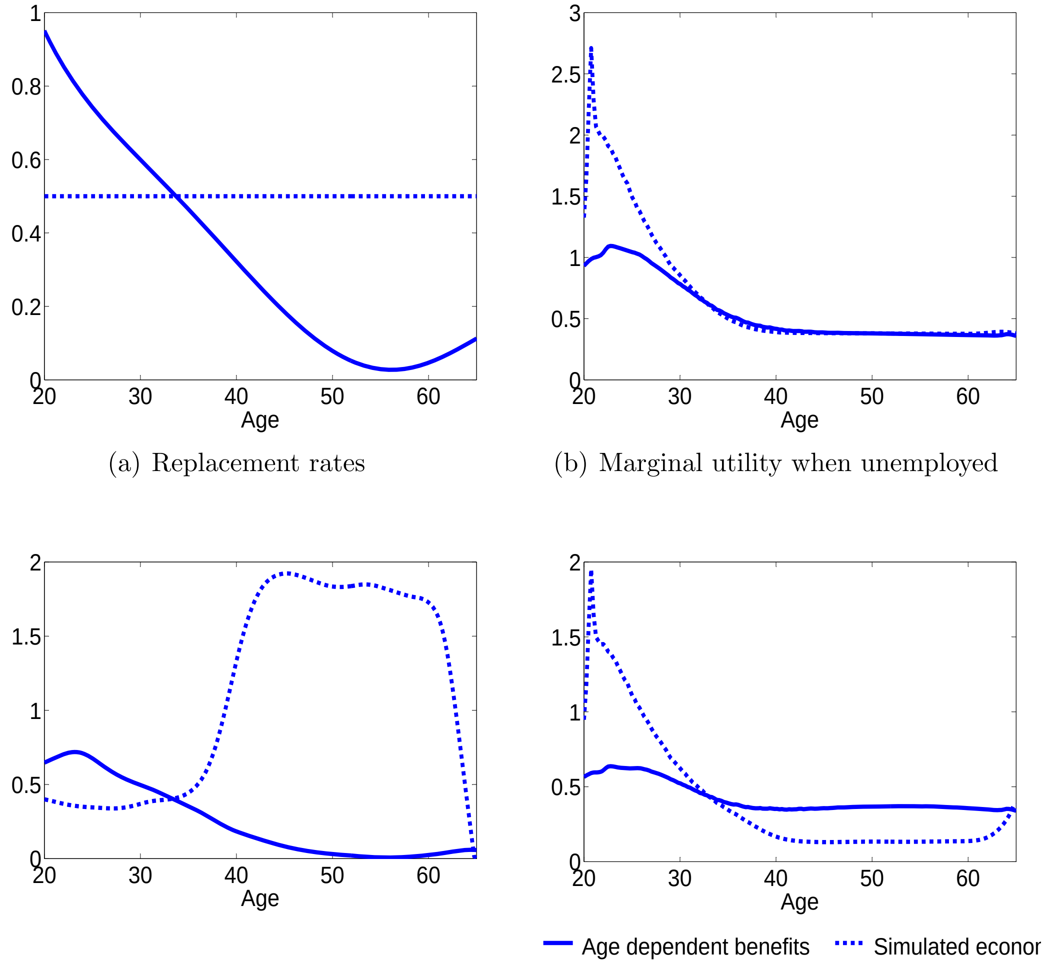
with age. For each policy, we study how replacement rate and tax rates vary by age and we analyze the properties of the ϱ_n ratio in (1). We then quantify the gains of age dependent policies and compare them with those attained under the optimal life cycle unemployment insurance problem.

6.1 Age-dependent policies

The solid lines in the four panels of Figure 9 characterize the economy where unemployment benefits replacement rates are allowed to vary with age. Dotted lines correspond to the baseline economy of Section 4. Panel (a) focuses on the age profile of unemployment replacement rate, panel (b) on the profile of the average marginal utility of consumption when unemployed, panel (c) on the unemployment elasticity to benefits, and panel (d) on the ratio of the average marginal utility of consumption when unemployed to one plus the unemployment elasticity, which is the model counterpart of ϱ_n in (1).

Under the optimal age dependent policy, replacement rates are increased from the current value of 50 per cent to around 80 percent for workers in their mid twenties and to 60 per cent for workers in their thirties. Workers in their forties and in their fifties, instead, obtain benefits equal to 20 and 10 percent of their past wage, respectively. The age profile of the average marginal utility of consumption when unemployed is substantially flatter than in the baseline economy. The unemployment elasticity to benefits, η_n, is generally smaller than in the baseline economy and clearly

Figure 9: Age dependent replacement rates only



(a) Replacement rates

(b) Marginal utility when unemployed

(c) Unemployment elasticity

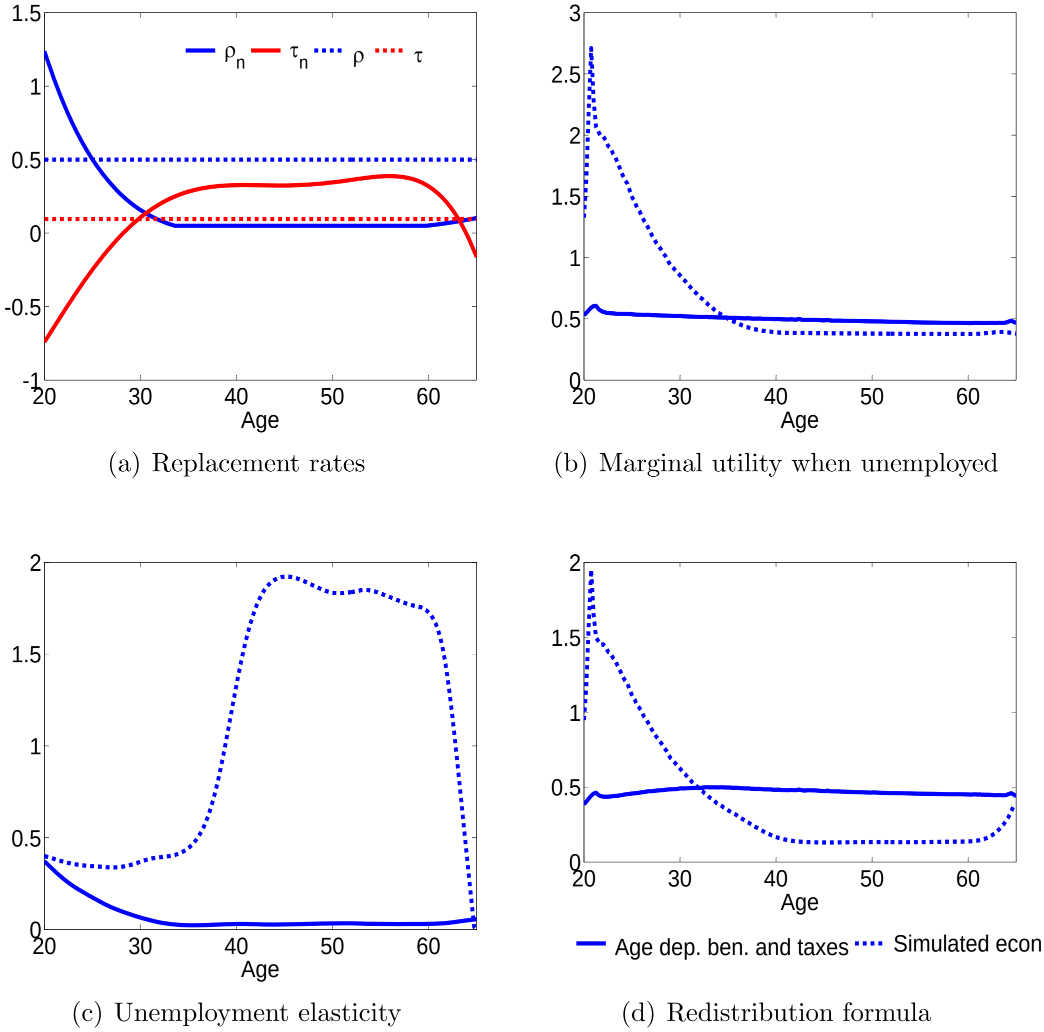
(d) Redistribution formula

Notes: In all panels dotted lines correspond to the baseline economy, solid lines corresponds to the economy with optimally set age dependent UI replacement rates.

decreasing in age. Because of this, the age profile of the ϱ_n ratio is now substantially flatter than in the baseline economy.

Figure 10 is analogous to Figure 9 but where now we also allow labor income tax rates to vary with age. The age profile of replacement rates is decreasing in age as in Figure 9, but now replacement rates are significantly smaller especially for workers older than forty years of age. Tax rates are generally increasing with age until the very late fifties when they start to decrease quickly until retirement. The profile of taxes generally helps in achieving a smoother age profile of consumption. Taxes before retirement are low to provide strong incentives to highly productive old workers, as well as to finance a high consumption level during retirement. Remember

Figure 10: Age dependent replacement rates and tax rates



(a) Replacement rates

(b) Marginal utility when unemployed

(c) Unemployment elasticity

(d) Redistribution formula

Notes: In all panels dotted lines correspond to the baseline economy, solid lines corresponds to the economy with optimally set age dependent UI replacement rates and labor income tax rates.

that we are not maximizing with respect to the pension replacement rate, which, given the profile of taxes, is likely to be inefficiently low.[16] The age profile of the marginal utility of consumption when unemployed and of the unemployment elasticity to benefits become substantially flatter than in the baseline economy. As

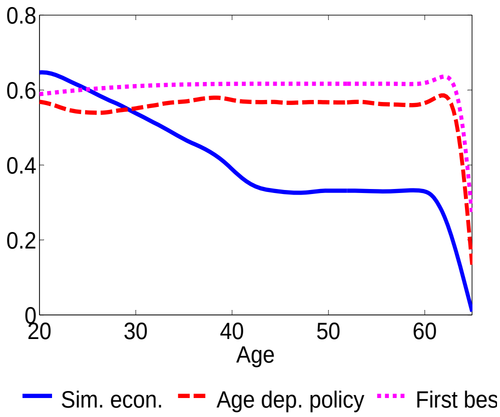
[16]The age profile of taxes is indeed affected by the choice of the pension replacement rate. To analyze this issue, we have also studied age-dependent policies in the economy where the pension net replacement rate is set to one. In this economy the age profile of benefits remains almost unchanged while tax rates reach a peak of 35% at 45 years of age and then start to fall to 10% at 60 years of age. In the last five years before retirement, taxes start to rise again reaching a maximum rate of 50% at retirement.

a result the age profile of the model counterpart of ϱ_n becomes almost invariant to age, which indicates that this ratio correctly identifies the existence of welfare gains from redistributing unemployment insurance over the life-cycle.

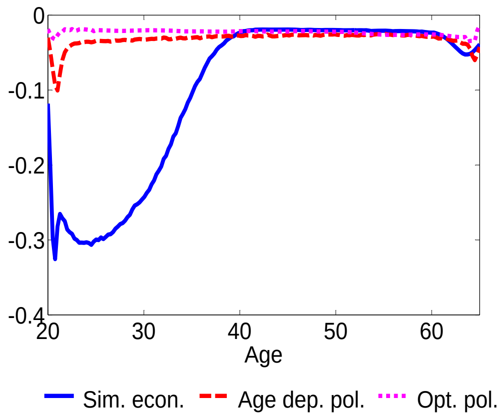
6.2 Welfare comparisons

Figure 11 characterizes the age profile of job finding rates (panel a), and consumption losses due to unemployment (panel b) in the baseline economy (solid line), in the economy with the combined age dependent policy for benefits and taxes (dashed line) and in the optimal problem studied in Section 5 (dotted line). Age profiles do differ in the three economies. In the first best economy and in the age dependent policy economy job finding rates are mildly increasing with age, consumption is relatively flat, consumption losses are small and their magnitude is relatively independent of age. In the baseline economy job finding rates are strongly decreasing in age, consumption is increasing and consumption losses are large for workers in their twenties and thirties.

Figure 11: Comparisons between age-dependent and optimal policy



(a) Finding rate



(b) Consumption loss due to unemployment

Notes: solid lines correspond to the baseline economy; dashed lines to the economy with age dependent replacement rates and tax rates; dotted lines correspond to the first best economy with observable search effort in panel (a) and to the optimal policy with unobservable search effort in panel (b).

Table 7 quantifies the welfare gains under the different allocations.[17] The first best policy with observable search effort yields welfare gains equivalent to a 4.4%

[17]In the baseline economy average unemployment replacement rates might not be optimal. To better isolate the effects of age dependent unemployment insurance, welfare gains are always measured relative to the economy with an optimal unemployment replacement rate. In practice, as many others (see Davidson and Woodbury 1997, Shimer and Werning 2007, Pavoni 2007, and

increase in consumption. The economy with unobservable search effort yields similar welfare gains. We normalize these gains to 100% and compare them with those attained under alternative age dependent policies. When allowing for age-dependent replacement rates, welfare gains are approximately equivalent to a 1 percent increase in life time consumption. When we combine age-dependent unemployment insurance with age-dependent taxes, gains go up to an equivalent of a 4 percent increase in life time consumption. Age-dependent policies reproduces 90% of the welfare gains attained under the optimal unemployment insurance program.[18]

It is also useful to study the economy where unemployment insurance replacement rates are maintained at the current US level and labor income tax rates are allowed to vary with age. In this economy, tax rates are implicitly set to smooth the age profile of income (including pensions). So consumption is relatively smooth over the life cycle but not across employment states. The economy with age dependent income tax rates yields welfare gains equivalent to two thirds of the gains attained under the combined age dependent policy for replacement rates and taxes, with the remaining one third due to age dependent replacement rates.

Table 7: Welfare comparisons

Economy	Welfare gains (%)	Consum. equiv. (%)
Baseline economy with optimal replacement rate	0	0
Age dependent replacement rate	21.9	1.0
Age dependent tax rate	70.8	3.1
Age dependent replacement rate and tax rate	92.7	4.1
Optimal life cycle unemployment insurance	100.0	4.4
First best (observable effort)	105.5	4.6

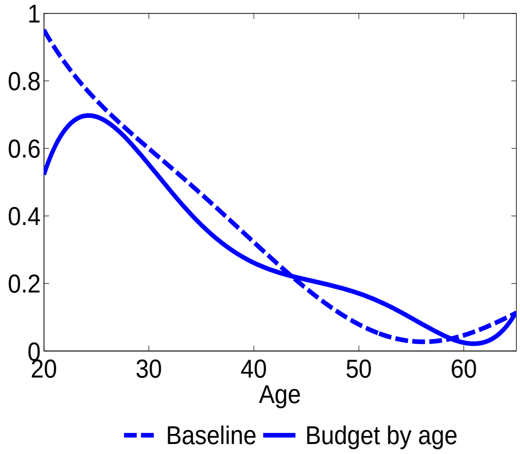
Part of the welfare gains come from redistributing income from old wealthy workers to young poor workers. To study the importance of this channel, we consider an economy where the UI replacement rate for a given age group is financed with tax income levied on workers of the same age group, which prevents redistributing income across age groups. As result, the government problem now involves setting a budget constraint for each age group—which for simplicity we assume to be of five years each. Retirement pensions are financed with a constant over-time income

Chetty 2008), we find that the optimal replacement rate is close to the actual US level—and equal to 0.45. Differences with the baseline economy of Section 4 are therefore minimal.

[18]The analysis in Shimer and Werning (2008) provides a good intuition for why there are small welfare gains from making UI benefits dependant on unemployment duration. Even when benefits do not decrease with unemployment duration, workers assets fall as workers spend longer time into unemployment. This leads to a fall consumption, which gives unemployed workers enough incentives to search for new jobs.

tax-rate, which amounts to imposing an additional constraint to the government problem. The resulting optimal age dependent replacement rate corresponds to the solid line in Figure 12. For comparison, the optimal age dependent replacement rate of Figure 9a also appears as a dotted line. The UI replacement rate is again generally decreasing in age (at least for workers above twenty five), but, since no intergenerational redistribution is possible, the age profile is now flatter. Welfare gains now amount to half of a percent increase in life time consumption which corresponds to approximately half of those obtained when income can be redistributed across age groups, see Table 7.

Figure 12: Age dependent replacement rate with age specific budget constraint



Notes: Dotted line corresponds to the baseline economy, solid line to the economy where the government budget constraint is satisfied for each non overlapping age groups of five years.

Decomposing welfare gains Welfare gains arise because of four different first order effects.[19] There are gains due to better consumption smoothing over the life cycle, to better consumption smoothing across employment states, to a changing allocation of search effort, and finally there are production efficiency gains, since the unemployment rate falls among old highly productive workers, which increases output. Production efficiency gains are equal to the expected increase in the the present value of output produced by a worker. To measure the contribution of the three other effects, we focus on the expected utility at birth of a fictional worker intended to be representative of a given economy, up to first order effects. The representative worker is active in the labor market for $\bar{n}_w$ periods and retired in the remaining $\bar{n}_r$ periods of his life. At each age n the worker has a probability ν_n of being unemployed, equal to the age specific unemployment rate in the economy. If

[19]There are also second order effects due to changes in the level of risk.

employed, the worker has consumption level c_n equal to the analogous average consumption level in the economy. If unemployed, his consumption level is $c_n(1-\varphi_n)$, where φ_n denotes the average consumption loss upon unemployment at age n in the economy. The mass of people searching is $\frac{\delta}{1-(1-\delta)\mu_n}$ and the within period unemployment probability is μ_n, equal to the average probability of remaining unemployed for a worker searching for a job at age n. The utility of the representative worker at birth is set equal to

$$\mathbf{UR}(\widetilde{c},\widetilde{\varphi},\widetilde{\mu}) = \sum_{n=1}^{\bar{n}_w+\bar{n}_r} \beta^{n-1}\left[(1-\nu_n)\,u(c_n) + \nu_n u(c_n(1-\varphi_n)) + \frac{\delta}{1-(1-\delta)\mu_n}\psi(\mu_n)\right]$$

which is function of the sequence of consumption $\widetilde{c}$, of consumption losses upon unemployment $\widetilde{\varphi}$, and of search effort $\widetilde{\mu}$. We checked that UR approximates well the utility at birth of the corresponding economy. This is because cross sectional heterogeneity in consumption and search effort is relatively small. We calculate the value of UR in the baseline economy and then measure how this value varies when replacing (one at a time) $\widetilde{c}$, $\widetilde{\varphi}$ and $\widetilde{\mu}$ of the baseline economy with the analogous sequence for the economy with age dependent policies. This measures the gains from better consumption smoothing over the life cycle, from better consumption smoothing across employment states, and from changing search effort, respectively. The sequence of consumption $\widetilde{c}$ from the economy with age dependent policies is scaled down by the size of the production efficiency gains. Gains measures are converted into consumption equivalent units and correspond to percentage increases. The resulting gains are reported in Table 8 both for the economy with age dependent benefits only (in column two) and for the economy where both taxes and benefits vary with age (in column three). In the economy with age dependent benefits only,

Table 8: Decomposing welfare gains of age dependent policies

Source of gain	Age dependent benefits only	Age dependent benefits and taxes
Production efficiency	1.2	2.2
Consumption smoothing over time	0.2	2.6
Consumption smoothing across states	0.3	0.6
Search effort over time	-0.4	-0.7
Sum	1.3	4.7

Notes: Gains are relative to the baseline economy and are measured in terms of percentage increases of consumption equivalent units.

production efficiency gains account for most of the welfare gains. In the economy with age dependent benefits and taxes, production efficiency gains accounts for approximately half of the total welfare gains. These gains arise because age dependent policies solve more efficiently the moral hazard problem induced by unemployment insurance and increase the employment of old highly productive workers. In the economy with age dependent benefits and taxes, gains from better consumption smoothing over the life cycle are large and comparable to the magnitude of production efficiency gains in the economy. These gains are smaller but still present also in the economy with age dependent benefits only. This is because young workers use their high UI replacement rates to obtain a smoother consumption profile over the life cycle. The gains from better consumption smoothing across employment states are close to half of a percentage point increase in life-time consumption. The contribution of the changing allocation of leisure to welfare is negative, since average search effort in the economy increases.

7 Alternative specifications

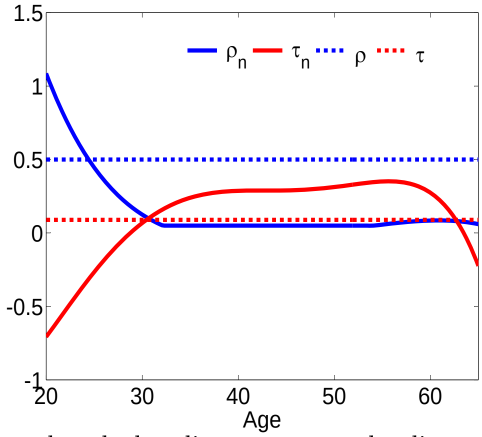
We next discuss the robustness of results to alternative specifications of the baseline model. We first study the effects of relaxing the borrowing constraint l, and then analyze the case in which returns to experience are constant. Finally we allow the search effort function ψ to vary with age.

7.1 Relaxing the borrowing limit

To study the effects of relaxing the borrowing constraint l, we multiply its value by a factor of five—so we now have $l = -3.95$. Figure 13 shows the optimal profile of age dependent unemployment replacement rates and labor income tax rates. Replacement rates share the profile of the age dependent policy of the baseline economy, but they are on average smaller. The welfare gains of the reform are reported in Table 9. The gains from setting optimally age dependent benefits and taxes are equivalent to an increase in consumption by 2.4%, relative to the economy with an optimally set constant over time replacement rate—which is now equal to 37% and therefore substantially lower than in the data. Again age dependent policies achieve 90% of the gains attained under the first best policy.

We have also studied the case where the borrowing limit l is set at its natural level, so that no worker in the economy is financially constrained. In this economy, the age profile of consumption is still increasing due to the accumulation of precautionary savings early in life, but consumption increases by just 5% over life time and consumption losses upon unemployment are small (around 3% on average). Yet we find that, even in this economy, unemployment replacement rates decrease with age under the optimal age dependant policy. This is again both because the moral hazard problem of unemployment insurance is less severe for young workers and because young workers are in the process of accumulating precautionary savings and

Figure 13: Age dependent policy rates with relaxed borrowing constraints



Notes: Dotted lines correspond to the baseline economy, other lines correspond to the economy with relaxed borrowing constraint.

so have less ability to smooth consumption during unemployment.

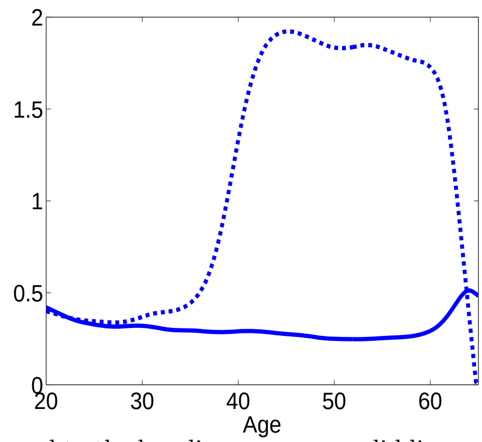
Table 9: Welfare comparisons with relaxed borrowing constraints

Economy	Welfare gains (%)	Consum. equiv. (%)
Optimal replacement rate level (37%)	0	0
Age dependent replacement rate and tax rate	89.0	2.4
Optimal life cycle unemployment insurance	100.0	2.7
First best (observable effort)	108.5	2.9

7.2 Non-decreasing returns to experience

We now study some properties of the economy with constant returns to labor market experience ($\theta_1 > 0, \theta_2 = \theta_3 = 0$). Figure 14 below plots as a solid line the unemployment elasticity to benefits, η_n. Again for comparison we plot the analogous elasticity in the baseline economy as a dotted line. We see that, with constant returns to labor market experience, the unemployment elasticity becomes decreasing in age. This is at variance with the empirical evidence discussed in Section 3. Moreover the unemployment elasticity is generally smaller than in baseline economy. This suggests that allowing for decreasing returns to labor market experience is important to explain why the moral hazard problem induced by unemployment insurance is smaller for young than for old workers. When computing the optimal age dependent policy in this economy, we find that unemployment replacement rates are still decreasing with age, but now decrease at a lower rate. Moreover replacement rates become smaller for young workers. This is because the moral hazard problem is now more severe for young workers.

Figure 14: Unemployment elasticity with and without decreasing returns



Notes: Dotted lines correspond to the baseline economy, solid line corresponds to the economy with constant returns to labor market experience ($\theta_1 > 0, \theta_2 = \theta_3 = 0$).

7.3 Age dependent ψ-function

In the baseline economy, workers of different age are equally able to find a job. In practice firms demand for workers of different age might differ and finding a job after displacement could be very costly for old workers. This might imply that old workers require more unemployment insurance than young workers. To account for possible differences in the demand for workers of different age we follow the same logic as in Section 2 and we allow the search effort function to vary by age so that

$$\ln \psi(n, \mu) = \gamma_0 + \left(\gamma_1 \mu + \gamma_2 \mu^2\right) \exp\left(\alpha_1 n + \alpha_2 n^2\right) \cdot \tag{21}$$

We calibrate this economy to match the detailed age profile of job finding rates reported in Table 10. The other targets are as in Table 4. The calibrated α_1 and α_2 coefficients are positive, which indicates that finding a job is more costly for an old than for a young worker. As shown by the dotted line in panel (a) of Figure 15, in this new calibrated economy the unemployment elasticity to benefits is generally decreasing with age. There are two alternative ways of interpreting this result. One is that the search function in (21) is not an accurate description of the data. Another is that the demand for old unemployed workers can not be too low, because otherwise the unemployment of workers in their forties and fifties would not be as responsive to changes in unemployment benefits as indicated by the empirical analysis in Section

Table 10: Targets and fits for economy with age varying ψ-function

Moment cond.	Data	Model	Source
Unemployment	.057	.057	BLS
Relative finding rates by age:			
20-29 years	1.0	1.0	CPS
30-39 years	.80	.81	CPS
40-44 years	.68	.66	CPS
45-49 years	.51	.54	CPS
50-62 years	.45	.43	CPS
Asset level			
55-64 years	5.01	4.84	SCF

Notes: Other targets are as in Table 4.

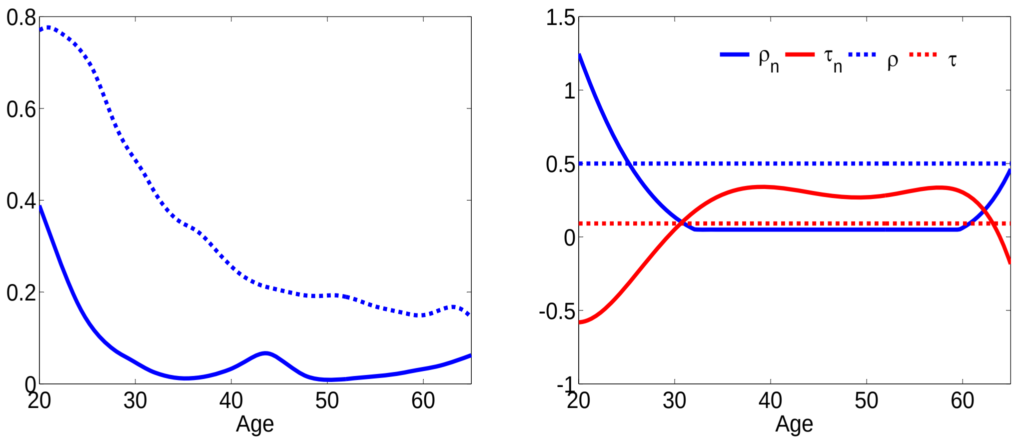
3. Moreover in this economy, consumption losses tend to be increasing after age 45, which is again at odds with the empirical evidence in Figure 5. This is again indirect suggestive evidence that differences in workers demand by age might not be too large.

Panel (b) of Figure 15 plots the age profile of the optimal age dependent replacement and tax rates of this economy. Interestingly unemployment replacement rates are still greater for workers in their twenties and early thirties than for workers in their forties and early fifties. But now replacement are no longer monotonically decreasing in age. They first decrease until the late fifties and then increase until retirement age. This is partly due to the fact that benefits are insuring unemployed workers close to retirement for their long lasting unemployment spells and their higher consumption losses upon displacement. We also find that ϱ become completely flat at the optimal age dependent policy, which confirms the conclusions in Section 2 that the redistribution formula is useful even under the presence of differences in the demand of workers of different age.

8 Conclusions

Unemployed young workers have a high marginal utility from consumption, experience large consumption losses upon unemployment, and they respond little to changes in unemployment insurance benefits. This indicates that unemployment insurance is highly valuable to them while the induced moral hazard problem is mild. Using a life cycle model with unemployment risk and endogenous search effort, we find that under the optimal age dependent policy, replacement rates are increased from the current value of 50 per cent to around 80 percent for workers in their mid twenties and to 60 per cent for workers in their thirties. Workers in their forties and fifties, instead, obtain benefits equal to 20 and 10 percent of their

Figure 15: Economy with age varying ψ-function



(a) Unemployment elasticity (b) Age dependent replacement and tax rates

Notes: In all panels dotted lines correspond to the baseline economy, solid lines corresponds to the economy with age varying search effort function.

past wage, respectively. Allowing unemployment replacement rates and other government transfers to decline with age yields sizeable welfare gains which amount to more than two thirds of the gains attained under the constrained optimal scheme for unemployment insurance over the life cycle. The quantitative analysis also shows that, after searching for the optimal age dependent policy, the ratio of the marginal utility of consumption when unemployed to one plus the unemployment elasticity to benefits becomes almost invariant across age groups, which indicates that this ratio correctly identifies possible gains from redistributing unemployment insurance over the life-cycle. Results are robust to the introduction of possible differences in the demand for workers of different age, and to alternative specifications for the borrowing possibilities of workers. We have also found that allowing for decreasing returns in labor market experience is important to explain why, in the data, young workers unemployment is little sensitive to changes in UI benefits.

Of course, the introduction of age dependent labor market institutions might have to deal with important redistributions concerns. The analysis of this paper suggests however that age dependent policies are Pareto-improving when applied just to new generations of workers entering the labor market. In this paper we have focused on how unemployment insurance benefits should vary over the life cycle. But the analysis could be well extended to discuss additional features of UI systems (such as benefits duration and eligibility) as well as several other labor market institutions, including policies for employment protection, severance payments, and poverty assistance. Along some of these dimensions it could well turn out that old workers require more protection than young workers do. For example old workers might have accumulated large levels of job specific human capital, which makes their wage losses upon displacement larger than those of young workers. This would help explaining why consumption losses upon job displacement of old workers are larger in the data than in the model. In this context, the optimal package for unemployment insurance would require giving old workers a combination of high severance payments, to insure the risk of wage losses upon displacement, and low UI benefits, to give the right incentives to search for a new job. This again emphasizes the importance of taking a life cycle perspective in designing labor market institutions.

Future research should also evaluate the welfare gains of age dependent policies relative to unemployment insurance arrangements different from those currently in place in the US. In particular Feldstein and Altman (1998) and Feldstein (2005) have sponsored the introduction of individual saving accounts to reduce the moral hazard costs of unemployment insurance. The idea is that when employed the worker saves a fraction of his labor income in an individual saving account which the worker uses when unemployed to finance the UI benefits payments dictated by the current US system. At retirement, any residual positive balance is transferred back to the worker. The quantitative welfare gains of savings accounts systems have been studied by Ferrada (2010), Setty (2010), and Pallage and Zimmermann (2010). Our robustness exercise shows that replacement rates should decline with age also when workers can freely borrow to smooth consumption during unemployment. Since savings accounts are essentially a means of providing greater liquidity to unemployed workers, this suggests that there should be welfare gains from having unemployment replacement rates decrease with age also in plausible implementations of the saving accounts proposal.

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