Online Appendices for the paper
“Optimal Life Cycle
Unemployment Insurance”

Claudio Michelacci and Hernán Ruffo
APPENDIX

Section A describes the data, Section B extends the analysis of the model in Section 2 and derives the extended redistribution formula discussed in Section 2.3, Section C discusses computational details.

A Data appendix

We describe the data from SIPP, CPS, PSID, Mathematica, and SCF used in the paper.

A.1 The SIPP

The data from the Survey of Income and Program Participation (SIPP) is obtained from Chetty (2008) and Johnson and Mommaerts (2011) and they are constructed starting from the 1985, 1986, 1987, 1990, 1991, 1992, 1993, 1996, 2001, and 2004 panels of SIPP. Interviews were conducted every four months for a period of two to four years. As in Chetty (2008), the analysis on unemployment duration uses data that span the beginning of 1985 to the middle of 2000. The original sample is restricted to those male workers between 18 and 65 years of age with an unemployment spell, with at least three months of work history, that reported non-zero unemployment duration, that actively search for a job, that were not temporary layoffs and that received UI benefits in the first month of the unemployment spell, from all states but Maine, Vermont, Iowa, North Dakota, South Dakota, Alaska, Idaho, Montana and Wyoming since SIPP does not provide a unique identifiers for these small states. The final sample covers 4560 unemployment spells, see the Appendix in Chetty (2008) for further details. The analysis on wage losses span the years 1996 to 2007, covering the 2001 recession but not the 2007-2009 recession. As in Johnson and Mommaerts (2011), we do not use earlier panels because they lack detailed information on why respondents separate from their jobs, which we use to separately identify quits from layoffs. The original sample is restricted to those male white workers between 18 and 65 years of age who work full time (at least thirty hours per week in their main job), who are displaced and who have collected UI benefits at some point during their unemployment spell. We exclude self-employed workers. Respondents enter the sample when first displaced from a job at which they had been working for at least two months and they remain in the sample until they first find a new full time job that lasts for at least one month. To focus on displacement for exogenous reasons, we classify respondents as displaced if they report separating from their employer because of layoff, slack work, employer bankruptcy, or because the employer sold the business. We include in the sample only the first unemployment spell for each worker. Below we describe in more details the variables used in the paper.

Age This is equal to the age of workers measured in years, which corresponds to variable TAGE in the survey.

Age specific average benefits level These are calculated exactly as in the CPS analysis below, see Section A.2.
**Average benefits** This is the average benefits in each state and year provided by the Department of Labor.

**Marital status** This is a dummy variable which is equal to one if the individual is currently married. This is constructed using variable EMS which can take the following values: 1. Married, spouse present; 2. Married, spouse absent; 3. Widowed; 4. Divorced; 5. Separated; 6. Never married. An individual is classified as married if he reports EMS=1 or EMS=2.

**Individual UI benefits** We use the imputation by Chetty (2008) who is based on estimating a first-stage equation for earnings using OLS on the full sample of individuals who report a job loss at some point during the sample period. He regresses nominal log wages in the year before job loss on years of education, age at job loss, years of tenure on the last job, a dummy for left-censoring of this job tenure variable, industry, occupation, month, and year dummies, and the unemployment rate in the relevant state/year. Using the coefficient estimates, he predicts log wages for each job loser, and recover the predicted wage in levels. He then uses the predicted wage to simulate the claimant unemployment benefit using the UI benefit calculator by Cullen and Gruber (2000).

**Earnings losses** Earnings losses upon displacement are calculated as the percentage differences between the value of monthly labor earnings in the job before displacement and the value of monthly earnings in the new job after reemployment.

**Monthly labor earnings** This is constructed using variable TPMSUM in the survey that reports total earnings from job before deductions received in the month of the survey.

**Previous job tenure** This variable is constructed using variable TSJDATE in the survey, which reports the year/month when the current job has started.

**Unemployment duration** SIPP reports the employment status of individuals for every week that they are in the sample. Weekly employment status (ES) can take the following values: 1. With a job this week; 2. With a job, absent without pay, no time on layoff this week; 3. With a job, absent without pay, spent time on layoff this week; 4. Looking for a job this week; 5. Without a job, not looking for a job, not on layoff. A job separation is defined as a change in ES from 1 or 2 to 3, 4, or 5. As in Cullen and Gruber (2000), unemployment duration is obtained by summing the number of consecutive weeks with ES ≥ 3, starting at the date of job separation and stopping when the individual finds a job that lasts for at least one month (i.e., reports a string of four consecutive ES=1 or ES =2). Individuals are defined as being on temporary layoff if, at any point in the spell, they report ES = 3. They are defined as searching if they report ES = 4.

**Job finding probability at unemployment duration** This is constructed using the weekly employment status variable ES described above and corresponds to a transition from ES=4 to a string of four consecutive ES=1 or ES=2.

**Year** This is a dummy that identifies the year of the interview.

**Years of education** This is simply constructed using variable HIGRADE in the survey, which reports the highest grade or year of school attended.
Worker's wealth Asset data are generally collected only once in each panel, so pre-unemployment asset data is available for approximately half of the observations. Total net wealth is defined as values of stocks, bonds, savings and current accounts plus the value of properties, business and vehicle equities net of secured and unsecured debt. The values of assets and liabilities are constructed using answers to several questions that report the individually reported estimate of the average amount that husband and wife jointly hold in a specific asset or liability over the four months period preceding the date of the interview.

Worker's net liquid wealth is measured at the time of job loss as total wealth minus home, business and vehicle equity net of unsecured debt (which is equal to the amount owed by the household, excluding mortgages and vehicle loans). The variable is again constructed using answers to several questions that report the individually reported estimate of the average amount that husband and wife jointly hold in a specific asset or liability over the four months period preceding the date of the interview.

Displaced workers Wage losses upon re-employment are used as a calibration target, see Table 4. These are calculated by focusing on a sample of displaced workers. Displaced workers are identified using the variable ERSEND which report the “Main reason why the individual stopped working for employer”. The variable ERSEND can take the following values: 1. On Layoff; 2. Retirement or old age; 3. Childcare problems; 4. Other family/personal obligations; 5. Own illness; 6. Own injury; 7. School/Training; 8. Discharged/fired; 9. Employer bankrupt; 10. Employer sold business; 11. Job was temporary and ended; 12. Quit to take another job; 13. Slack work or business conditions; 14. Unsatisfactory work arrangements (hours, pay, etc); 15. Quit for some other reason. Individuals are classified as displaced if they stopped working for the employer and they report ERSEND=1, 8, 9, or 10.

Hours This is constructed using the variable EJBHRS that report “How many hours per week the worker usually works at all activities at his main job”.

Table A1 gives summary statistics for the core sample and for two different age groups: workers of age from 20 to 40 years and from 40 to 60 years. Monetary values are in 1990 dollars converted using the CPI index. The median UI benefits recipient is a high school graduate and has pre-UI gross annual earnings of 20,711. The group of workers with 20 to 40 years of age has 2873 observations, the group of workers with 41 to 60 years of age has 1522 observations. Mean unemployment duration is 20 weeks for the whole sample. Unemployment spells for workers with more than 40 years of age are 4 weeks longer than the analogous spells for workers with less than 40 years of age. The individually imputed UI benefit level (in 1990 dollars) is around 20% higher for the old than for the young. This difference is explained by the fact that mean pre-unemployment wage is 30% higher for the old. The resulting average replacement rate is therefore lower for the old workers than for the young.
Table A1: Summary Statistics, SIPP sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>All</th>
<th>20-40 years</th>
<th>41-60 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Annual wage</td>
<td>20711.27</td>
<td>18699.21</td>
<td>24665.52</td>
</tr>
<tr>
<td>Median Annual Wage</td>
<td>17780.48</td>
<td>16512.12</td>
<td>21745.91</td>
</tr>
<tr>
<td>Years of education</td>
<td>12.1</td>
<td>12.1</td>
<td>12.2</td>
</tr>
<tr>
<td>Weekly indiv UI benefits</td>
<td>165.72</td>
<td>153.30</td>
<td>187.87</td>
</tr>
<tr>
<td>Mean unemp. duration</td>
<td>20.45</td>
<td>18.90</td>
<td>22.68</td>
</tr>
<tr>
<td>Median unemp. duration</td>
<td>15.00</td>
<td>14.00</td>
<td>17.00</td>
</tr>
<tr>
<td>Mean liquid assets</td>
<td>22545.31</td>
<td>14897.08</td>
<td>34086.46</td>
</tr>
<tr>
<td>Mean net liquid assets</td>
<td>18583.77</td>
<td>11044.50</td>
<td>29902.03</td>
</tr>
<tr>
<td>Mean total wealth</td>
<td>62705.52</td>
<td>44955.76</td>
<td>90015.60</td>
</tr>
<tr>
<td>Percent with Mortgage</td>
<td>.45</td>
<td>.40</td>
<td>.54</td>
</tr>
<tr>
<td>Quartile of net liquid assets:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>-2177.89</td>
<td>-2231.28</td>
<td>-2081.14</td>
</tr>
<tr>
<td>Q2</td>
<td>-54.92</td>
<td>-63.28</td>
<td>-42.43</td>
</tr>
<tr>
<td>Q3</td>
<td>919.15</td>
<td>911.81</td>
<td>948.12</td>
</tr>
<tr>
<td>Q4</td>
<td>19897.43</td>
<td>12427.25</td>
<td>31077.48</td>
</tr>
<tr>
<td>Observations</td>
<td>4560</td>
<td>2873</td>
<td>1536</td>
</tr>
</tbody>
</table>

Figure A1: Unemployment elasticity to benefits by age group: age-specific average measure of UI benefits, SIPP

Notes: Unemployment elasticity to benefits for different age groups of workers. Estimates are based on model (14) using SIPP data and the age-specific average measure of benefits. Other details are as for panel (a) in Figure 1.

A.2 Aggregate US states data using CPS

Aggregate US states data are calculated using monthly data from the Current Population Survey databases freely available from Integrated Public Use Microdata Series (IPUMS), see Ruggles et al. (2010) for description of IPUMS. Information on labor force, employment, unemployment, and other demographic and labor force characteristics is available in every month, while earnings data are available in the March survey. We restrict the sample to male workers with 16 to 64 years of age. Similar to SIPP the sample period is 1984-2000. For each state, semester and age group we aggregate individual data using CPS provided weights. Below we describe more in detail the variables used in the analysis.
**Pre-unemployment wage:** It is imputed at the individual level after running a conventional wage regression in each state and year using the March CPS survey. The dependent variable in the wage regression is weekly logged wages and the independent variables are a quadratic polynomial in age, four educational dummies (for high school dropouts, high school degree, some college and complete college), two race dummies and a marital status dummy. Using the estimated coefficients we impute wage to every unemployed worker. Weekly wages are computed using the variable EARNWEEK in IPUMS which reports information on “usual labor earnings per week at the current job, before deductions”.

**Age specific average benefits level** We impute benefits at the individual level using the UI benefit calculator by Cullen and Gruber (2000). As an input we use the individual imputation for pre-unemployment wages calculated above. In three states, the UI benefits calculator requires previous job tenure as an input. For these states, we impute tenure using a quadratic function of age which we estimate using the Mathematica data below. Individual benefits are then aggregated to obtain a measure of average benefits for each age group in a given semester and given state. Average benefits are always adjusted to guarantee equality with the unconditional average benefits measure in each state and year as reported by the US Department of Labor. In all regressions, the age groups considered for constructing the age specific average measure of benefits always coincide with the age groups for which we calculate the age-specific unemployment elasticity to benefits.

**Educational composition** We construct five educational dummies using information obtained from the variable EDUC in IPUMS which corresponds to answers to the following question: “What is the highest level of school (name/you) (have/has) completed or the highest degree (name/you) (have/has) received?” We use this information to construct the following five educational groups: (i) less than 5 grade; (ii) 5th grade to 12th grade without diploma; (iii) High school diploma; (iv) some college or vocational program but no degree; (v) Bachelor’s degree or more.

**Race composition** We construct a dummy variable that is one if worker is white, as inferred from the answer to “I am going to read you a list of five race categories. Please choose one or more races that (NAME/you) (considers yourself/considers himself/considers herself) to be: White; Black or African American; American Indian or Alaska Native; Asian; OR Native Hawaiian or Other Pacific Islander”. Starting from this information we calculate the proportion of white unemployed workers in each state, period and age group.

**Married dummy** We construct a dummy variable that is one if worker is married, as inferred from the answer to “(Are/Is)(name/you) now married, widowed, divorced, separated or never married?” We use this information to calculate the proportion of married unemployed workers in each state, period and age group.

**Unemployment over population ratio** We identify a worker as unemployed if he is non-employed and he is actively searching for a job using the variable EMPSTAT in IPUMS. The relevant question to assess his/her state is the following: “By (the week before last/last week), I mean the week beginning on Sunday, (date), and ending on Saturday, (date), did (name/you) do ANY work for (pay/either pay or profit)?” 1. Yes 2. No 3. Retired 4. Disabled 5. Unable to work. A worker is actively searching
for a job if he answers positively to the following question: “Have you been doing anything to find work during the last 4 weeks?”.

**Unemployment duration** Given the current employment status of the worker (see above), the unemployment duration of the current unemployment spell is calculated using the variable DURUNEMP in IPUMS which reports the number of consecutive weeks for which the unemployed worker has remained jobless. The reported number is capped at 98 weeks. For each age group, the average unemployment duration in Section 4 is calculated over the sample period 1990-2010 using a sample of male workers unemployed at the time of the survey, and with positive unemployment duration. The average is weighted using CPS provided weights.

**Wage profile** The life cycle profile of wages is used as calibration targets, see Table 4 and Figure 4. These profiles are calculated using CPS data over the period 1990 to 2010. We use a sample of male workers with 20 to 64 years of age, who are employed and have received positive labor income in the week of the interview. We regress the log of “usual labor earnings per week at the current job, before deductions” (variable EARNWEEK) deflated using the CPI index and divided by hours worked in the previous week, on a full set of yearly age dummies and on dummies for four educational groups (high school dropouts, completed high school, some college and college degree or more), marital status (equal to one if married), race (equal to one if white), being US native and for state and year. Observations are weighted using the personal weight provided by CPS. We exponentiate the estimated dummy coefficients for age to calculate relative wages by age. To construct the educational dummies we again use the variable EDUC. Hours worked in previous week are calculated using variable HRSWORK.

Figure A2: Unemployment elasticity to benefits by age, CPS results with IV

![Figure A2](image.png)

(a) CPS results with one lag IV  
(b) CPS results with three lags IV

Notes: Estimates of $\beta_n$ in (15) when benefits are instrumented with its own lagged value. Panel (a) uses one lag as IV, Panel (b) three lags. Other details are as in Figure 1.

**A.3 The PSID**

The Panel Study of Income Dynamics (PSID) started in 1968 collecting information on a sample of roughly 5,000 households. Of these, about 3,000 were representative
of the US population as a whole (the core sample), and about 2,000 were low-income families (the Census Bureau’s Survey of Economic Opportunities, or SEO sample). We use the core and SEO samples in our analysis, dropping the Latino and Immigrant samples. Our sample focuses on male individuals with 21 to 65 years of age who at least at some point over the sample period 1978-1992 were heads of household.

Age To minimize measurement error we construct the variable age by using information on year of birth from the individual files and define age as the difference between the survey year and year of birth. For those heads with no information on year of birth, we utilize the first record on self-reported age available in the survey and then construct a consistent age series.

Education Up to 1991 (1990 data) the relevant question was coded according to: 1 if 0-5 grades completed, 2 for 6-8 grades, 3 for 9-11 finished grades, 4 for 12 grades (high school), 5 for 12 grades plus non-academic training, 6 for college dropout, 7 for college degree with no advanced degree, 8 for college and advanced degree and 9 to not available. Starting from 1992, the education variable corresponds to actual grade of school completed with figures in the 0-16 range. The education variable is recoded so as to belong to one of three following categories: high school graduate, college dropout, and bachelor degree or college and advanced/professional degree.

Employment (unemployment) status dummies The employment status is inferred using the question “Are you (head) working now, looking for work, retired, keeping house, a student or what?”. The household head is unemployed if at the interview date he is without a job and is actively looking for work.

Family size and Number of kids They are constructed using answers to: “Is someone other than this year’s head/wife included in the family unit? [Which is his/her] relationship to head?”.

Food consumption Food consumption is reported directly from PSID. Food consumption is the average weekly expenditures on food at home per capita in the household. Since interviews are usually conducted around March, it has been argued that people report their food expenditure for an average week around that period, rather than for the previous calendar year as is the case for family income. For robustness exercises we used both food consumption at home and out of home which is constructed using answers to the questions: “Did you (or anyone in your family) receive government food-stamps last month? In addition to what you bought with foodstamps, did you (or anyone in your family) spend any money on food that you use at home? How much? Do you have any food delivered to your door which is not included in that? About how much do you (or anyone else in your family) spend eating out, not counting meals at work or at school?”. We drop food consumption data that belong to either the bottom or the top percentile of the distribution of food expenditures per capita in the household.

Total consumption expenditures in non durables goods This is the imputation by Hryshko, Luengo-Prado, and Sorensen (2010) for total consumption expenditures in non durable goods using CEX data, which extend the sample selection criteria by
Relative to Blundell, Pistaferri, and Preston (2008), the imputation by Hryshko, Luengo-Prado, and Sorensen (2010) uses data on regional price indexes rather than US city averages, disregards information on prices of transportation and alcohol, it drops the numbers of kids as independent regressor, it adds dummy variables to account for marital status. The table below reproduced from Hryshko, Luengo-Prado, and Sorensen (2010) reports the variables and the coefficients used in their imputation. The definition of nondurable consumption is the same as in Attanasio and Weber (1995): it is the sum of food (defined above), alcohol, tobacco, and expenditure on other nondurable goods, such as services, heating fuel, public and private transport (including gasoline), personal care, and semidurables, defined as clothing and footwear. This definition excludes expenditure on various durables, housing (furniture, appliances, etc.), health, and education. It corresponds to the average weekly expenditures at home per capita in the household. We drop data on total consumption expenditures in non durables when the imputation is based on food consumption data that belong to either the bottom or the top percentile of the distribution of food expenditures per capita in the household.

**Race** It is the recoding of the answer to “And, are you white, black, American Indian, Aleut, Eskimo, Asian, Pacific Islander, or another race?” so as to get three groups: white, black and other.

**Region** This variable can take four values corresponding to the four regions North-east, Midwest, South and West where the household head resides.

**Wages** They are constructed using information on labor income and yearly hours. Labor income corresponds to total annual labor income from all jobs. Self-employed income is split between labor and capital income. In this case only the labor part is added. Yearly hours correspond to total annual hours worked for money, from family files. It refers to all possible jobs of the worker. Hourly wage are then obtained by dividing labor income by yearly hours. Observations where the resulting hourly wage falls below half of the minimum wage in the corresponding year are dropped. Wages are expressed in 1982-84 dollars by using the CPI price index.

**Time dummies** These are dummies for the year of the survey.

---

<table>
<thead>
<tr>
<th>Log nondurable cons.</th>
<th>Log nondurable cons. x HS</th>
<th>Log regional food CPI</th>
<th>Log nondurable cons. x coll.</th>
<th>Log regional fuel-util. CPI</th>
<th>Log nondurable cons. x White</th>
<th>Log nondurable cons. x Family size</th>
<th>Log high school</th>
<th>Log college</th>
<th>Log Male head</th>
<th>Log Married</th>
<th>Log Age</th>
<th>Log Age sq./100</th>
<th>Log Constant</th>
<th>Adj. R sq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.730***</td>
<td>0.023</td>
<td></td>
<td></td>
<td></td>
<td>0.047***</td>
<td>0.055***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.721</td>
</tr>
<tr>
<td>(15.84)</td>
<td>(1.03)</td>
<td></td>
<td></td>
<td></td>
<td>(6.91)</td>
<td>(17.34)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1980</td>
<td>0.122***</td>
<td>Log nondurable cons. x 1981</td>
<td>0.103***</td>
<td></td>
<td>-0.252</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.45)</td>
<td>(1.03)</td>
<td>0.094***</td>
<td>(9.09)</td>
<td></td>
<td>(-2.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1982</td>
<td>0.089***</td>
<td></td>
<td></td>
<td>Log regional fuel-util. CPI</td>
<td>-0.113***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8.87)</td>
<td>(1.03)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1983</td>
<td>0.083***</td>
<td>Log nondurable cons. x 1984</td>
<td>0.081***</td>
<td>Log high school</td>
<td>-0.924***</td>
<td>Log Male head</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8.77)</td>
<td>(17.34)</td>
<td>0.081***</td>
<td>0.097)</td>
<td>Log Male head</td>
<td>(-1.22)</td>
<td>(15.41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1986</td>
<td>0.076***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.95)</td>
<td>(17.34)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1987</td>
<td>0.070***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.301</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.03)</td>
<td>(15.41)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1988</td>
<td>0.067***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.55)</td>
<td>(15.41)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1989</td>
<td>0.061***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.301</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10.07)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1990</td>
<td>0.051***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10.05)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1991</td>
<td>0.043***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.51)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1992</td>
<td>0.041***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.56)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1993</td>
<td>0.038***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.52)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1994</td>
<td>0.034***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.64)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1995</td>
<td>0.030***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.51)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1996</td>
<td>0.023***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8.92)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1997</td>
<td>0.020***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8.47)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1998</td>
<td>0.017***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8.46)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 1999</td>
<td>0.013***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8.57)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 2000</td>
<td>0.011***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9.59)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log nondurable cons. x 2001</td>
<td>0.006***</td>
<td></td>
<td></td>
<td>Log Married</td>
<td>-0.924***</td>
<td>Log Married</td>
<td>0.082***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7.58)</td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td>(8.75)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: t-statistics in parentheses. Instruments for log nondurable consumption (and its interaction with year and education dummies) are the averages of log head’s wages specific to cohort, education, and head’s sex in a given year (and their interactions with year and education dummies). *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
A.4 Mathematica data

Mathematica conducted two surveys on behalf of the Department of Labor: (i) the Pennsylvania Reemployment Bonus Demonstration, a sample of 5,678 job losers in Pennsylvania in 1991; (ii) the Study of Unemployment Insurance Exhaustees, a sample of 3,907 workers covered by UI benefits in 1998 in 25 states of the US. The datasets are publicly available through the Upjohn Institute. The information in the two datasets is similar. They contain information on prior wages, weeks of UI paid, as well as demographic characteristics, household income, job characteristics (tenure, occupation, industry), and receipt of severance pay. Since Pennsylvania is not included in the Exhaustees study, there is only one year of data for each state in the sample. We use the sub-sample of the two data sets provided by Chetty (2008), who focuses on prime-age unemployed male workers and make exclusions analogous to those applied to SIPP. In particular all observations with missing data on severance payments, years of job tenure, reported survey durations, or variables used to predict net liquid wealth are excluded. We also exclude temporary layoffs (individuals who expected a recall). The final sample comprises 2441 spells, 18% of them for workers who have received some severance payment. Below we describe more in details the variables used in the analysis:

Unemployment duration The unemployment duration is computed as the difference in weeks between the date when worker finds the job and the date when the worker lost his job, as inferred from the answers to the following questions: “What was the last date that you worked on that job before you applied for unemployment insurance benefits on (claims date)?”.

Severance pay This is a dichotomic variable that equals one if the worker has received a severance pay from the employer at the time of job displacement, according to the answer to the question “When that job ended, did you receive severance pay, a buyout or some other payment?”.

Tenure spline This is spline in the number of years spent working at the firm where the worker was laid off, as inferred from the answers to “Now, I’d like to ask you about the job you had just before you filed for unemployment benefits: When did you first start working for that employer?”; and “what was the last date that you worked on that job before you applied for unemployment insurance benefits?”.

Wage spline A spline of log wages in the pre-unemployment job. Wages are calculated using the question “How much did you usually make, before taxes and other deductions, per week when that job ended? Please include tips, commissions, and regular overtime”.

Unemployment benefits The log of the weekly UI benefit as reported in the Mathematica data. This information comes directly from the administrative data.

Educational dummies A series of dichotomic variables for dropout and college graduate workers, as inferred from the answer to the question “What is the highest diploma or degree you have received?”.
A.5 SCF

The Survey of Consumer Finances is a triennial statistical survey of the balance sheet, pension, income and other demographic characteristics of families in the United States. Data are collected by the National Opinion Research Center at the University of Chicago under the sponsorship of the Federal Reserve Board. The SCF is intended to provide accurate descriptions of the current financial situations of US households, the data are primarily cross-section in nature, although some panel data have also been collected in recent years. Here we use the 2007 cross-section available at http://www.federalreserve.gov/econresdata/scf/. Since a large share of wealth is held by a relatively small share of the population, the SCF uses a dual sample frame, with a standard representative sample supplemented by a special sample of high-income taxpayers (see below). To calculate statistics we use use sample weights as provided by SCF and we include all implicates. Our sample consists of household heads of 20 to 65 years of age who have been employed at least at some point of their life. The survey collects very detailed information on assets and liabilities, and the composition of household wealth which we use to construct the variable Household’s net worth following the criteria detailed in Figure A3.

*Household’s average quarterly income in previous calendar year.* It includes wages, self-employment and business income, taxable and tax-exempt interest, dividends, realized capital gains, food stamps and other support programs provided by the government, pension income and withdrawals from retirement accounts, Social Security income, alimony and other support payments, and miscellaneous sources of income.” In calculating averages we drop households whose income is greater than 5 millions, which represents less than 1% of the households in the survey. The resulting average is divided by four to obtain a measure of households’ quarterly income.
Figure A3: Calculation of Net Worth in SCF

Total net worth [NETWORTH]

- Total financial assets (FIN)
  - Total assets [ASSET]
    - All types of transaction account (liquid assets) [LIQ]
      - Checking accounts [CHECKING]
      - Savings accounts [SAVING]
      - Call accounts [CALL]
      - Money market deposit accounts [MMDA]
      - Money market accounts [MMA]
      - Stock mutual funds [STMMUT]
      - Tax-free bond mutual funds [TFBMMUT]
      - Govt. bond mutual funds [GOMUT]
      - Other bond mutual funds [OBMMUT]
      - Combination and other mutual funds [COMUT]
      - Other mutual funds [OMUT]
    - Certificates of deposit [CDS]
    - Directly held pooled investment funds (excl. money mkt funds) [NMMF]
      - Tax-exempt bonds [NOTXBND]
      - Mortgage-backed bonds [MBTBND]
      - US govt & govt agency bonds & bills [GOFBND]
      - Corporate and foreign bonds [OBBND]
    - Savings bonds [SAVBND]
    - Directly held stocks [STOCKS]
      - Two-exempt bonds [NOTBND]
      - Trusts [TRUSTS]
      - Other managed assets [OTHMA]
        - Annuities [ANNUIT]
        - Individual retirement accounts/Keoghs [IRAKH]
        - Future pensions on current job [THIRT]
        - Future pensions [PURPEN]
    - Directly held bonds (excl. bond funds or savings bonds) [BOND]
      - Mortgages & home equity loans secured by primary residence [HOMEMORT]
      - Home equity lines of credit secured by primary residence [HELOC]
    - Cash value of whole life insurance [CASHLI]
      - Vehicles (incl. RVs, planes, boats, etc.) [VEHIC]
      - Primary residence [HOUSES]
      - Residential property excl. primary resid. (e.g., vacation homes) [ORESRE]
      - Net equity in nonresidential real estate [NRESE]
      - Businesses (with either an active or inactive interest) [BUS]
      - Other managed assets [OTHMAN]
      - Credit card balances after last payment [CCBAL]
      - Other debt (e.g., loans against pensions or life insurance, margin loans) [ODEBT]
      - Other lines of credit (not secured by resid. real estate) [OTHLOC]
      - Installment loans [INSTALL]
      - Other debt [OTHDEB]
      - Installment loans after last payment [CCBAL]
      - Education loans [EDN_INST]
      - Vehicle loans [VEH_INST]
    - Other misc. financial assets [OTHFIN]
      - Mortgages & home equity loans secured by other residential property [HOMEMORT]
      - Debt secured by other residential property [OHERDEB]
      - Education loans [EDN_INST]
      - Home equity lines of credit secured by primary residence [HELOC]
      - Installment loans [INSTALL]
      - Other debt [OTHDEB]
      - Installment loans after last payment [CCBAL]
  - Other misc. financial assets [OTHFIN]

Total nonfinancial assets [NFIN]

- Vehicles (incl. RVs, planes, boats, etc.) [VEHIC]
- Primary residence [HOUSES]
- Residential property excl. primary resid. (e.g., vacation homes) [ORESRE]
- Net equity in nonresidential real estate [NRESE]
- Businesses (with either an active or inactive interest) [BUS]
- Other misc. nonfinancial assets [OTHFIN]

Total debt [DEBT]

Notes: Names in brackets refer to variables in the SCF Bulletin extract data.
B Derivation of $\tilde{\varrho}_n$ in the model of Section 2

In this Appendix we extend the model of Section 2 in three dimensions:

1. We allow for the possibility that young workers in period one could save.

2. We assume that the benefit levels set by the government can affect the present value of the tax income available for the UI program. This is a natural equilibrium outcome when, as in the quantitative analysis, the UI program is financed through labor income taxes since benefits affect tax income through their effects on employment as well as on workers’ human capital (which is accumulated on the job and/or lost upon unemployment). As a result the government budget constraint is as in (9).

3. We recognize that the optimal choice of benefits might be subject to some feasibility constraints, that impose that benefits can not fall below a minimum level $\bar{b}_n$ so that the constraint in (10) has to be satisfied. In the quantitative analysis of Section 4 this minimum level is set to zero, so that $\bar{b}_n = 0$.

B.1 Notation

Since young workers can save, outcomes when young affect workers decisions when old. Generally worker’s choices are now contingent on the entire worker’s history at the time when choices are made. In particular, this means that workers choose assets in periods $i = 2, 3, 4$ contingent on whether in period 2 the worker was unemployed, $j = u$, or employed, $j = e$. Similarly assets decisions in period $i = 5, 6$ are contingent on workers employment state, $j = u, e$ in period 2 as well on worker’s employment state $z = u, e$ in period 5. Let $a^j_i$ denote asset level in period $i = 3, 4, 5$, which is chosen in period $i - 1$ conditional on period two employment state $j = u, e$. Similarly let $a^{jz}_i$ denote asset level in period $i = 6$, which is chosen in period five, conditional on period two employment state $j = u, e$ and period five employment state $z = u, e$.

Clearly since all workers are initially identical, assets levels in period two, $a^u_2$, are the same for all workers. We can then denote by $a_i$, $i = 3, 4, 5, 6$ the vector of history dependent choice at $i - 1$ for next period asset values, so that

$$a_i = (a^u_i, a^e_i), \forall i = 3, 4, 5, \quad \text{while} \quad a_6 = (a^{uu}_6, a^{ue}_6, a^{eu}_6, a^{ee}_6)$$

With a slight abuse of notation we can also collect into a single vector all choices for next period assets $a = (a_2, a_3, a_4, a_5, a_6)$. By applying the same logic to the choices for the unemployment probabilities in period two and five, we have that all workers choose the same unemployment probability $\mu_y$ in period two, while the choice for the unemployment probability in period five is $\mu^y_5$, which is contingent on employment state in period 2, $j = u, e$. We can then define by

$$\mu = (\mu_y, \mu_u, \mu^e_5)$$

the vector of choices of within period unemployment probabilities. Let $p^j(\mu_y)$ denote the probability of being in state $j = u, e$ in period 2 and by $p^{jz}(\mu)$, the probability
of being in state \( j = u, e \) in period 2 and in state \( z = u, e \) in period 5. Clearly we have \( p^u(\mu_y) = \mu_y \) and \( p^e(\mu_y) = 1 - \mu_y \), which allow to express \( p^{jz}(\mu) \) as equal to

\[
p^{jz}(\mu) = p^j(\mu_y)p^z(\mu_y).
\]

This makes explicit that the choice for the unemployment probability in period 5 is conditioned on the employment state in period two.

Since wage income is deterministic in age, consumption when employed in any period \( i = 1, 2, 3, 4, 5, 6 \) can be expressed as function of current period assets and next period assets so that

\[
c_i^e(a_i, a_{i+1}) = w_i + \frac{a_i}{\beta} - a_{i+1}
\]

where \( w_4 = w_5 = w_6 = \overline{w} \). In period 2 and 5, the worker could be unemployed and his consumption is given by

\[
c_i^u(a_2, a_3) = b_y + \frac{a_2}{\beta} - a_3, \quad \text{and} \quad c_i^u(a_5, a_6) = b_o + \frac{a_5}{\beta} - a_6,
\]

respectively.

### B.2 Worker’s problem

The utility at birth of workers is equal to the sum of the discounted utilities obtained by the worker in the first two periods of his life \( V^f, i = 1, 2 \), in the second two periods \( V^s, i = 3, 4 \), and the last two periods \( V^l, i = 5, 6 \), which are given by

\[
V^f(\mu, a_2, a_3) = u(w_1 - a_2) + \beta \left[ \psi(\mu_y) + \sum_{j=u, e} p^j(\mu_y)u(c_j^e(a_j^2, a_j^3)) \right],
\]

\[
V^s(\mu, a_3, a_4, a_5) = \beta^2 \sum_{j=u, e} p^j(\mu_y) \left[ u(c_j^e(a_j^3, a_j^4)) + \beta u(c_j^e(a_j^4, a_j^5)) \right]
\]

\[
V^l(\mu, a_5, a_6) = \beta^4 \sum_{j=u, e} \sum_{z=u, e} p^{jz}(\mu) \left[ \psi(\mu_y) + u(c_j^u(a_j^5, a_j^6)) + \beta u(c_j^e(a_j^6, a_j^7)) \right]
\]

The utility at birth of workers can then be expressed as equal to

\[
U(b_y, b_o) = \max_{\mu, a \geq 0} \{ V^f(\mu, a_2, a_3) + V^s(\mu, a_3, a_4, a_5) + V^l(\mu, a_5, a_6) \}
\]

which fully characterizes the worker’s problem.

### B.3 Government’s problem

The government chooses \( b_y \) and \( b_o \) to maximize worker’s utility at birth in (31). In solving the problem the government takes into account that worker’s unemployment probabilities are given by

\[
\mu = \arg \max \left\{ \max_{a \geq 0} \left[ V^f(\mu, a_2, a_3) + V^s(\mu, a_3, a_4, a_5) + V^l(\mu, a_5, a_6) \right] \right\}
\]
which defines $\mu$ as a function of $b_y$ and $b_o$, so we have $\mu_y = \mu_y(b_y, b_o)$, $\mu_o = \mu_o^n(b_y, b_o)$, and $\mu_o^u = \mu_o^u(b_y, b_o)$, which allow to define the unemployment level in period five as equal to

$$\mu_o(y, b_0) = \mu_y(b_y, b_0)\mu_o^u(b_y, b_0) + [1 - \mu_y(b_y, b_0)] \mu_o^u(b_y, b_0).$$

The Lagrangian of the government problem can then be written as

$$L(b_y, b_o, \lambda, \xi_y, \xi_o) = U(b_y, b_o) + \lambda [T(b_y, b_o) - \beta_y\mu_y(b_y, b_o)b_y - \beta_o\mu_o(b_y, b_o)b_o]$$

$$+ \beta_y\xi_y(b_y - \bar{b}_y) + \beta_o\xi_o(b_o - \bar{b}_o) \quad (32)$$

which incorporates both the government budget constraint in (9) and the positive benefits constraint in (10). The constraint imposed by workers’ choices for search effort are embodied in the construction of the functions $\mu_y(b_y, b_o)$, $\mu_o^n(b_y, b_o)$, and $\mu_o^u(b_y, b_o)$. After using the general envelope theorem, we obtain that it is optimal to increase $b_n$ if

$$\beta_n\mu_n E[u'(c_{un})] + \beta_n \xi_n > \lambda \beta_n \mu_n + \lambda \sum_{i=y, o} \beta_i \frac{\partial \mu_i}{\partial b_n} b_i - \lambda \frac{\partial T}{\partial b_n} \quad (33)$$

where $E[u'(c_{un})]$ denotes the expected marginal utility of consumption of an unemployed worker of age $n = y, o$ (period 2 or 5) which for $n = y$ is simply equal to

$$E[u'(c_{uy})] = u'(c_y^u(a_2, a_3))$$

since all unemployed young workers share the same history and consume the same. But for $n = o$, the expected marginal utility of consumption of an unemployed worker is equal to

$$E[u'(c_{uo})] = \frac{\mu_o^u u'(c_o^u(a_2^o, a_3^u)) + \mu_o^u u'(c_o^u(a_2^o, a_3^u))}{\mu_o^u + (1 - \mu_y) \mu_o^u}.$$ 

which recognizes that the consumption level of unemployed old workers depends on their employment status in period two, which could affect their asset position in period five. In the expression (33) the second term in the left hand side and the last two terms in the right hand side of the inequality are novel relative to the first order condition (6) obtained in the simplified version of the model. By rearranging, we obtain that (33) is equivalent to

$$\tilde{\eta}_n \equiv \frac{E[u'(c_{un})] + \frac{\mu_o^u}{\mu_n}}{1 + \frac{\beta_o \mu_o^u}{\beta_n \mu_n}} > \lambda \quad (34)$$

where

$$\tilde{\eta}_n \equiv \sum_{i=y, o} \frac{\partial \mu_i}{\partial b_n} \cdot \frac{\beta_i b_i}{\beta_n \mu_n} \quad (35)$$

is the modified elasticity of age-group $j$ unemployment to benefits as in (12). Equation (34) corresponds to the expression for $\tilde{\eta}_n$ in (11). Generally there are welfare gains from increasing transfers to young unemployed workers at the expense of the
This is the logic behind our modified redistribution formula $\tilde{\varrho}$.

**B.4 Back to the simple formula**

Notice that when $a_2 = a_3 = a_4 = 0$, we also have that $a_u^u = a_e^e$ and $a_u^e = a_e^e$ $\forall z = u, e$ which means that assets choices are independent of the employment state of workers in period two. In this case the employment choices of old workers become independent on the past history of workers $\mu_o^u = \mu_o^e$, and the cross elasticity in (35) coincides with the simple elasticity studied in the main text. The simple formula of the main text is obtained when we also have $\kappa_n = 0$, $\forall n = y, o$ and the tax income allocated to the UI program is independent of the UI benefits set by the government, so that $\frac{\partial T}{\partial b_n} = 0 \forall n = y, o$.
C Computational details

Here we discuss first how we solve the quantitative model of Section 4. Then we discuss how we calculate derivatives and redistribution formulas. Finally we turn to computational details about solving the optimal unemployment insurance program when search effort is observable.

C.1 Solving the baseline economy

We discretize the state space of value functions. For points within the grid we interpolate using quadratic methods. The value functions for different $n$ are constructed by backward induction, starting from $n = \bar{n}_w$ and then back until $n = 1$. In solving the model we impose (24) by using a recursive formulation. Let

$$C_r = \frac{1 - \beta^{n_r}}{1 - \beta} \pi,$$

denote the present value of the cost to the government of providing retirement pensions to a worker who has just retired. Let $C_e(n, e, a)$ denote the cost to the government of providing the transfers net of taxes dictated by the government policy to an employed worker of age $n$, human capital $e$ and with assets $a$. Similarly let $C_u(n, e, a)$ and $C^*(n, e, a)$ denote the analogous cost to the government when providing transfers to an unemployed worker with no human capital loss, and to an unemployed worker who, at some time during the unemployment spell, has experienced a loss in human capital, respectively. In calculating these cost functions the choice of workers for next period assets $a'$ and the unemployment probability $\mu$ are taken as given. This is why all the state variables of the worker’s problem enter the definition of the government cost function. Let $a^e(n, e, a)$, $a^u(n, e, a)$ and $a^*(n, e, a)$ denote the level of next period assets chosen, as function of age $n$, human capital $e$ and current assets $a$, by a worker who is currently employed, unemployed with no loss of human capital and unemployed with human capital loss, respectively. Similarly let $\mu^e(n, e, a)$ and $\mu^*(n, e, a)$ denote the within period unemployment probability chosen, as a function of state variables, by a worker who is unemployed with no loss of human capital and unemployed with human capital loss, respectively. Notice that for unemployed workers $e$ refers to worker’s human capital at displacement. These policy functions allow us to define explicitly the form of the government cost functions. The cost to the government of providing the transfers net of taxes dictated by the government policy to an employed worker of age $n$, human capital $e$ and with assets $a$ satisfies

$$C_e(n, e, a) = -\tau_n w(e) + \beta (1 - \delta_n) C_e(n + 1, e + 1, a^e(n, e, a))$$
$$+ \beta \delta_n \mu^u(n + 1, e + 1, a^e(n, e, a)) C_u(n + 1, e + 1, a^e(n, e, a))$$
$$+ \beta \delta_n [1 - \mu^u(n + 1, e + 1, a^e(n, e, a))] C^e(n + 1, e + 1, a^e(n, e, a))$$
The analogous cost when providing transfers to an unemployed worker collecting UI benefits with no human capital loss satisfies

\[ C^u(n, e, a) = \rho_n w(e) + \beta (1 - \gamma) \mu^n(n + 1, e, a^n(n, e, a)) C^n(n + 1, e, a^n(n, e, a)) \\
+ \beta (1 - \gamma) [1 - \mu^u(n + 1, e, a^u(n, e, a))] C^u(n + 1, e, a^u(n, e, a)) \\
+ \beta \gamma \mu^u(n + 1, e, a^u(n, e, a)) C^u(n + 1, e, a^u(n, e, a)) \\
+ \beta \gamma [1 - \mu^u(n + 1, e, a^u(n, e, a))] C^u(n + 1, \kappa(n + 1, e), a^u(n, e, a)) \]

Finally the cost of the transfers to an unemployed worker collecting UI benefits who, at some time during the unemployment spell, has experienced a loss in human capital is equal to

\[ C^* (n, e, a) = \rho_n w(e) + \beta \mu^* (n + 1, e, a^* (n, e, a)) C^* (n + 1, e, a^* (n, e, a)) \\
+ \beta [1 - \mu^* (n + 1, e, a^* (n, e, a))] C^* (n + 1, \kappa(n + 1, e), a^* (n, e, a)) \]

where these expressions are defined for \( n \leq \bar{n}_w \) with the convention that

\[ C^e(\bar{n}_w + 1, e, a) = C^u(\bar{n}_w + 1, e, a) = C^*(\bar{n}_w + 1, e, a) = C^\kappa \]

At birth, \( n = 1 \), workers have to search for a job, they have no experience and no assets so imposing (24) is equivalent to imposing the requirement that

\[ C^u(1, 0, 0) = 0. \]

\( \) 

C.2 Calibration of the functions \( \psi(\mu) \)

The second derivative of the function \( \psi \) has to be negative \( \psi'' \leq 0 \) and it plays a key role in determining the value of the unemployment elasticity with respect to benefits. So we decided to model its profile directly and to impose explicitly the constraint that the second derivative is always negative, \( \psi'' \leq 0 \). To achieve this the function \( \psi(\mu) \) is parameterized in terms of six values. The value of the second derivative of \( \psi \) at \( \mu = 0 \), the analogous value at \( \mu = 1 \) and its maximum value (minimum absolute value) which is reached at an endogenously determined \( \mu^* \). All these values are constrained to be negative. In addition, the function \( \psi(\mu) \) is characterized by its value at \( \mu = 1 \) and the the value of its first derivative at \( \mu = 1 \). To sum-up the function \( \psi \) is fully characterized by the following six values: \( \psi(1), \psi'(1) \geq 0, \psi''(1) \leq 0, \psi''(0) \leq 0, \psi''( \mu^* ) \leq 0 \) and finally by the value for \( \mu^* \) at which \( \psi'' \) reaches its maximum. The profile of the second derivatives of \( \psi'' \) is a linear spline through the knots at \( \psi''(1) \leq 0, \psi''(0) \leq 0, \) and \( \psi''( \mu^* ) \leq 0 \). We impose the constraint that \( \psi'' \) can never be greater than \( \psi''( \mu^* ) \). By integrating the profile of second derivatives and given an initial condition for the first derivative—which is provided by the value of \( \psi'(1) \geq 0 \)—we obtain a characterization of the entire profile of \( \psi' \). Given the profile of \( \psi' \) and an initial condition for \( \psi \) at \( \mu = 1 \), we finally obtain the entire profile of the function \( \psi \), which is plotted in the main text. It is easy to check that the resulting \( \psi \) function is perfectly approximated by a cubic spline evaluated at five different values where the intermediate knot \( \mu^* \) is endogenously determined.
C.3 Variables definition

We discuss the construction of some variables in the model.

**Mass of workers collecting UI benefits** As discussed in the text, the fraction of workers of age $n$ who are collecting UI benefits is equal to

$$\mu_n = \int_{R^+} \chi^u(n,de)$$

(37)

**Mass of workers searching for a job** Let $\chi^s(n,e)$ denote the measure of workers of age $n$ who are searching for a job and who were displaced with human capital $e$. Given $\chi^e(n,e)$ and $\chi^u(n,e)$ we have that

$$\chi^s(n,e) = \chi^u(n-1,e) + \delta_{n-1} \chi^e(n-1,e-1)$$

The right hand side is the sum of two terms that measure the two inflows into the pool of searchers of age $n$. The first term measures the mass of workers of age $n-1$ who have collected benefits in a period and who will search for a job in the next period when they are one year older. The second term takes into account that the pool of workers searching for a job is also augmented by the fraction $\delta_{n-1}$ of the workers of age $n-1$ and human capital $e-1$ who are currently employed and lose their job. These workers will have to search for a new job in the next period when they have age $n$ and human capital $e$. The mass of workers of age $n$ searching for a job can then be defined as equal to

$$\sigma_n = \int_{R^+} \chi^s(n,de)$$

whose interpretation is analogous to that in (37).

**Job finding rate** The job finding rate of workers of age $n$ is denoted by $f_n$ and it is simply equal to the ratio between the mass of workers of age $n$ who find a job in a period and the pool of searchers of age $n$ in that period:

$$f_n = \frac{\sigma_n - \mu_n}{\sigma_n}$$

(38)

**Unemployment rate** In standard surveys workers are classified as unemployed if, at the interview date, workers are without a job and they are actively searching for a job. In terms of our model, this number is different depending on whether the interview were to be performed at the beginning of, during or at the end of the model period, which corresponds to one quarter in our calibration. To account for this problem we assume that the unemployment rate of workers of age $n$ is equal to

$$u_n = 0.5\sigma_n + 0.5\mu_n.$$ 

This expression can be justified by assuming that workers interviews occur randomly over the period and that workers find jobs at a constant uniform linear probability in the period. Let $f_n$ denote the model probability of finding a job in a period for a given age group $n$. Assume that the probability of
finding a job in the first $i$th fraction of the period is $i f_n$ where $i \in [0, 1]$. Then the probability that a worker of age $n$ is classified as unemployed in the period is equal to

$$1 - \int_0^1 i f_n di = 1 - 0.5 f_n$$

Given these considerations we can then define the unemployment of workers of age $n$ as equal to

$$u_n = (1 - 0.5 f_n) \sigma_n = 0.5 \sigma_n + 0.5 \mu_n$$

where the last equality uses the definition of the age specific job finding rate in (38).

**Unemployment duration** One period in the model corresponds to one quarter. Unemployment duration in the CPS data is measured in weeks. To convert the unemployment duration of the model into weeks we proceed as follows. Let $f_n$ denote the probability of finding a job in a period for a given age group $n$. Remember that one period in the model correspond to one quarter. Now assume that the quarter is divided into 13 weeks and that workers are randomly interviewed in any of these 13 weeks to infer the duration of their current unemployment spell. Also assume that the probability that a worker finds a job in any week of the quarter is

$$\bar{f}_n = 1 - (1 - f_n) \frac{1}{13}$$

This guarantees that the probability of remaining unemployed in all the 13 consecutive weeks of the quarter is $(1 - \bar{f}_n)^{13} = 1 - f_n$. Then, if workers have an unemployment duration in the model equal to $j = 0, 1, 2, 3..$, their unemployment duration in weeks is calculated as equal to $I + 13j$ where

$$I = \sum_{i=1}^{12} i (1 - \bar{f}_n)^i \sum_{i=0}^{12} (1 - \bar{f}_n)^i,$$

which measures the average duration in weeks of workers who have been just displaced from their previous job and start searching for a new one in the current model period. After remembering that

$$\sum_{i=0}^{T} (1 - \bar{f}_n)^i = \frac{1 - (1 - \bar{f}_n)^{T+1}}{\bar{f}_n}$$

and that

$$\sum_{i=1}^{T} i (1 - \bar{f}_n)^{i-1} = \frac{1 - (1 + \bar{f}_n T) (1 - \bar{f}_n)^T}{(\bar{f}_n)^2}$$

Notice that the probability $i f_n$ can also be justified by taking a Taylor expansion, around $f_n = 0$, of the expression for the geometric probability of finding a job before $i$, which is equal to $1 - (1 - f_n)^i$. 

---

30 Notice that the probability $i f_n$ can also be justified by taking a Taylor expansion, around $f_n = 0$, of the expression for the geometric probability of finding a job before $i$, which is equal to $1 - (1 - f_n)^i$. 

---

A-20
we can express $I$ as equal to

$$I = \frac{(1 - \bar{f}_n) - (1 + 12 \times \bar{f}_n) (1 - \bar{f}_n)^{13}}{\bar{f}_n - \bar{f}_n (1 - \bar{f}_n)^{13}}$$

This is the expression for $I$ used in the computer code.

**C.4 Age profiles of separation rates and wage losses upon re-employment in baseline calibration**

Figure A4 plots the age profiles in the baseline calibration of separation rates, $\delta_n$, panel (a) and wage losses upon re-employment $\pi_n - 1$, panel (b).

**Figure A4: Some functions in the baseline calibration of laboratory economy**

C.5 Calculating elasticities and redistribution formulas in the quantitative analysis

Let $\rho = \{\rho_1, ..., \rho_{n_w}\}$ denote the vector containing the entire age profile of UI replacement rates in a baseline economy. To calculate elasticities and redistribution formulas at age $n$ of the corresponding baseline economy, we consider changes in replacement rates at $p$ consecutive quarters starting from age $n$. For every $n$ we then consider two economies one with lower and one with higher replacement rates at age $n$, $\rho^i_n = \{\rho_1, ..., \rho_{n-1}, \vartheta^i_n, \vartheta^i_{n+1}, ..., \vartheta^i_{n+p-1}, \rho_{n+p}, ..., \rho_{n_w}\}$, $i = l, h$ where $\vartheta^l_{n+j} = \rho_{n+j} - \frac{\epsilon}{2}$ and $\vartheta^h_{n+j} = \rho_{n+j} + \frac{\epsilon}{2}$, $\forall j = 0, 1, ..., p - 1$. In the paper we work with $\epsilon = 0.02$ and $p = 4$, which corresponds to a change in benefits for an age group of one year. We consider one year changes in benefits both to increase sample size and to reduce the likelihood that the change in policy affects workers’ search effort decisions though effects on unemployment duration dependence in benefits, which is an issue somewhat unrelated to age dependent policies. To avoid this problem we could have indexed the level of replacement rates, rather than to current age, to the age at which the worker is displaced. But this specification would require having an additional state variable in the worker problem, which would involve additional...
computational costs. We checked that results are little affected when choosing $p = 3$ or $p = 5$ rather than $p = 4$.

C.5.1 Calculating $\eta_n$

Given the policy change for age group $n$ the unemployment elasticity is calculated as equal to

$$
\eta_n = \frac{\sum_{i=0}^{p-1} d\mu_{n+i} \rho_{n+i}}{\epsilon \sum_{i=0}^{p-1} \mu_{n+i}^0},
$$

(39)

In the expression $\mu_{n+i}^0$ denotes the measure of workers of age $n+i$ who are collecting UI benefits before the policy change while $d\mu_{n+i}$ denotes the difference between the level of workers of age $n+i$ who are collecting UI benefits in the economy with high benefits $\rho_h^0$ and the analogous level in the economy with low benefits $\rho_l^0$. Notice that for completeness $d\mu_{n+i}$ should be indexed to the policy change considered. Yet to simplify notation we did not make this dependence explicit. Conceptually in the expression (39), the exogenous change in benefits is equal to $db_n = w_n^0 d\rho_n = w_n^0 \epsilon$, where $w_n^0$ denotes the average wage at displacement of the workers of age $n$ who are collecting UI benefits before the policy change. When $p = 1$, (39) reads as $\eta_n = \frac{d\mu_{n+1}}{\epsilon \mu_n^0}$ which is simply the elasticity of unemployment with respect to replacement rates.

So in calculating the unemployment elasticity, the denominator includes just the really exogenous component of the change in government expenditures for the UI program, omitting any induced effect due to either changes in unemployment or in workers’ human capital. Notice that (39) takes into account that benefits are changed for $p$ consecutive quarters. The expression in (39) can be interpreted as a simple weighted average of the relevant unemployment elasticities with respect to UI replacement rates evaluated at $n$ up to $n + p - 1$, with weights equal to the relative unemployment of the age group, $\frac{\mu_{n+i}^0}{\sum_{i=0}^{p-1} \mu_{n+i}^0}$. Finally notice that for the purpose of calculating unemployment elasticities unemployment is defined as the mass of workers who are collecting UI benefits, which is consistent with the empirical analysis.

C.5.2 Calculating $\tilde{\rho}_n$

Consider the model in Section B and let

$$
D(b_y, b_o) = \sum_{i=y,o} \beta_i \mu_i(b_y, b_o) b_i - T(b_y, b_o)
$$

denote the government budget deficit, where $T$ denotes the expected present value of the tax income collected by the government to finance the UI program. Notice that the denominator of the modified formula in (11) is equal to the ratio of the derivative of the government budget deficit with respect to the age specific level of benefits and the level of the group specific unemployment rate—i.e. it is equal to $\frac{\partial D}{\partial b_n} \cdot \frac{1}{\mu_n}$. When $b_n$ marginal increases, the budget deficit increases because of i) the increase in the
transfers received by the already unemployed workers targeted by the policy change (equal to \( \mu_n \)), ii) the increase in transfers due to the increase in unemployment of all different age groups (which is measured by the term \( \sum_{i=y} \frac{\partial \mu_i}{\partial b_n} (\beta_n b_i) \)), and iii) the reduction in tax income (which is measured by the term \(- \frac{dT}{db_n}\)). This leads to an alternative expression for \( \tilde{\varrho}_n \) (11) as equal to

\[
\tilde{\varrho}_n = \frac{1}{\beta_n \mu_n} \cdot \frac{dD}{db_n}.
\]

This is the expression we use to calculate \( \tilde{\varrho}_n \) in the quantitative analysis of Section 4 where the government deficit is defined as equal to

\[
D(\rho) = \sum_{n=1}^{\tau_n w} \beta^n \int_{R^+} \rho_n w(e) \chi^u(n, de) + \sum_{n=\tau_n w+1}^{\tau_n w} \beta^n \pi \chi^e(n) - \sum_{n=1}^{\tau_n w} \beta^n \int_{R^+} \tau_n w(e) \chi^e(n, de)
\]

(41)

The feasibility constraint in the quantitative analysis is \( \rho_n \geq 0 \). To calculate \( \kappa_n \) we notice that, if the constraint in (10) is not binding for age group \( n \), we have that \( \kappa_n = 0 \), while, if the constraint is binding, \( \kappa_n \) can be calculated by measuring how much welfare would fall if we were to increase the value of the constraint \( b_n \). If we denote by \( W \) the expected welfare of workers at birth under a given choice of \( \rho \), we should have that

\[
\frac{dW}{db_n} = -\beta^n \kappa_n
\]

which is zero when the constraint is not binding. Notice that the present value Lagrange multiplier of the feasibility constraint is \( \beta^n \kappa_n \), exactly as in (32). The expected marginal utility of consumption of unemployed workers of age \( n \) is calculated as equal to the average expected marginal utility of all age groups affected by the policy change, \( \frac{1}{p} \sum_{i=0}^{p-1} E[u'(c_{un+i})] \). Overall the modified formula in the quantitative analysis is calculated as equal to

\[
\tilde{\varrho}_n = \frac{1}{p} \sum_{i=0}^{p-1} \left\{ E[u'(c_{un+i})] + \frac{\kappa_{n+i}}{\mu_{n+i}} \right\},
\]

(42)

which, exactly as in (39), takes into account that benefits are changed for \( p \) consecutive quarters. In the expression above \( w^0_{n} \) denotes again the average wage at displacement of the workers of age \( n \) who are collecting UI benefits before the policy change, while \( \mu^0_{n} \) is the mass of workers of age \( n \) who are collecting UI benefits before the policy change. As in (39), the exogenous change in benefits is equal to \( db_n = w^0_{n} d\rho_n = w^0_{n} \epsilon \). The denominator of (42) corresponds to the denominator in (40) which is the derivative of government deficit with respect to changes in benefits. The term \( dD \) denotes the difference between the government deficit in the economy with high benefits levels \( \rho^h_{n} \) and the analogous value in the economy with low benefit levels \( \rho^l_{n} \). In principle \( dD \) should have been indexed to the policy change considered. Yet to simplify notation we did not make this dependence explicit. Finally notice
that in the denominator of the derivative of government deficit with respect to benefits, we focus just on the really exogenous change in government expenditures for the UI program, omitting any induced effects due to either changes in unemployment or in workers’ human capital.

C.5.3 Calculating the cross elasticity \( \tilde{\eta}_n \)

Let

\[
B(b_y, b_o) = \sum_{i=y,o} \beta_i \mu_i (b_y, b_o) b_i
\]

denote the total amount of government money spent for unemployment insurance. It is easy to check that in the model in Section B

\[
\frac{\partial B(b_y, b_o)}{\partial b_n} = \beta_n \mu_n (1 + \tilde{\eta}_n)
\]

To calculate \( \tilde{\eta}_n \) in (35) we first calculate the changes in the money spent for unemployment insurance \( B \) and then obtain the elasticity \( \tilde{\eta}_n \) by using the fact that (43) implies that

\[
\tilde{\eta}_n = \frac{1}{\beta_n \mu_n} \cdot \frac{\partial B(b_y, b_o)}{\partial b_n} - 1
\]

This is the expression we use to calculate \( \tilde{\eta}_n \) in the quantitative analysis of Section 4 where the total amount of government money spent for unemployment insurance is defined as equal to

\[
B(\rho) = \sum_{n=1}^{\tilde{n}_w} \beta^n \int_{R^+} \rho_n w(e) \chi^u (n, de).
\]

Given (43) and the policy changes discussed in Section C.5, we then calculate \( \tilde{\eta}_n \) as equal to

\[
\tilde{\eta}_n = \frac{dB}{\epsilon \sum_{i=0}^{n-1} \beta^{n+i} \mu_{n+i} w_{n+i}^0} - 1
\]

where \( dB \) is the difference in UI expenditures between the economy with high benefit levels \( \rho_h^n \) and the economy with low benefits \( \rho_l^n \). Notice that for completeness \( dB \) should have been indexed to the policy change considered. Yet to simplify notation we did not make this dependence explicit. The logic of calculating the derivative as in (46) is analogous to the logic used to obtain (39) or (42).

C.6 Solving the optimal UI problem with observable search effort

Here we discuss how we solve the optimal life cycle unemployment insurance problem of Section 5 where search effort is observable, which corresponds to the first best problem. To solve for this problem we search for the value of consumption \( c^* \) that
makes $Y(1, 0, c^*)$ in (26) equal to zero:

$$
\frac{1 - \beta \bar{n}_w + \bar{n}_r}{1 - \beta} c^* - Y(1, 0, c^*) = 0
$$

(47)

where the function $Y(n, e, c)$ denotes the expected present value of income generated by a worker of age $n$ searching for a new job who had human capital $e$ at the start of the current job search spell and who has not experienced any loss in his human capital. Here $c$ denotes the constant consumption flow granted to the worker in each remaining period of his life. Let $\bar{\mu}(n, e, c)$ denote the the within-period unemployment probability function under the optimal policy of an unemployed worker of age $n$, who had human capital $e$ at the start of the current job search spell, who is granted consumption flow $c$ for each remaining period of his life and who has not experienced any loss in human capital. The functions $\bar{\mu}(n, e, c)$ and $\bar{\mu}^*(n, e, c)$ denote the the within-period unemployment probability function analogous to $\bar{\mu}(n, e, c)$ but for an unemployed worker who has already experienced a loss in human capital. Given these functions we can express $Y$ recursively as equal to:

$$
Y(n, e, c) = \bar{\mu}(n, e, c) \beta [(1 - \gamma) Y(n + 1, e, c) + \gamma Y^*(n + 1, e, c)] + [1 - \bar{\mu}(n, e, c)] Y^e(n, e, c)
$$

(48)

where

$$
Y^e(n, e, c) = w(e) + \beta [(1 - \delta_n) Y^e(n + 1, e + 1, c) + \delta_n Y(n + 1, e + 1, c)]
$$

(49)

is the expected present value of income generated by an employed worker of age $n$ with human capital $e$ who is granted consumption level $c$ for all the remaining periods of his life, while

$$
Y^*(n, e, c) = \bar{\mu}^*(c, e, n) \beta Y^*(n + 1, e, c) + [1 - \bar{\mu}^*(n, e, c)] Y^e(n, \kappa(n, e), c)
$$

(50)

is the expected present value of income analogous to $Y(n, e, c)$ but for an unemployed worker who has already experienced a loss in human capital. The expression in (50) incorporates the assumption that, after experiencing a loss in human capital, the worker is reemployed with human capital $\kappa(n, e)$ where $e$ refers to worker’s human capital at the start of the current job search spell.

Consider a worker of age $n$ searching for a job who had human capital $e$ at the start of the current job search spell, who is granted consumption flow $c$ for each remaining period of his life and who has not experienced any loss in human capital during the current job search spell. Under the optimal policy, this worker generates a value measured in utils equal to

$$
S(n, e, c) = \max_{\mu \in [0, 1]} \{ \psi(\mu) + \mu \beta [(1 - \gamma) S(n + 1, e, c) + \gamma S^*(n + 1, e, c)] + (1 - \mu) S^e(n, e, c) \}
$$

(51)
where

\[ S^e(n, e, c) = u'(c) w(e) + \beta [(1 - \delta_n)S^e(n + 1, e + 1, c) + \delta_n S(n + 1, e + 1, c)] \]  \hspace{1cm} (52)

is the expected present value, again measured in utils, of the income produced by an employed worker of age \( n \) with human capital \( e \) who is granted consumption level \( c \) for all the remaining periods of his life. The present utility value of searching for a worker who has already experienced a loss in human capital is instead equal to

\[ S^*(n, e, c) = \max_{\mu \in [0,1]} \{ \psi(\mu) + \mu \beta S^*(n + 1, e, c) + (1 - \mu) S^e(n, \kappa(n, e), c) \} \]  \hspace{1cm} (53)

which is analogous to \( S(n, e, c) \) but for the case when the unemployed worker has already experienced a loss in human capital. For any \( n, e, \) and \( c \) the within-period unemployment probability functions under the optimal policy \( \bar{\pi} \) and \( \bar{\pi}^* \) are implicitly defined by (51) and (53), respectively. So we have

\[ \bar{\pi}(n, e, c) = \arg_{\mu \in [0,1]} \max \{ \psi(\mu) + \mu \beta [(1 - \gamma)S(n + 1, e, c) + \gamma S^*(n + 1, e, c)] + (1 - \mu) S^e(n, e, c) \} \]  \hspace{1cm} (54)

and

\[ \bar{\pi}^*(n, e, c) = \arg_{\mu \in [0,1]} \max \{ \psi(\mu) + \mu \beta S^*(n + 1, e, c) + (1 - \mu) S^e(n, \kappa(n, e), c) \} . \]  \hspace{1cm} (55)

For any given value of \( c \), we can use (51), (52) and (53) to solve for \( S, S^e, \) and \( S^* \) backward starting from \( n = \bar{n}_w \) after using the terminal conditions \( S(\bar{n}_w + 1, e, c) = S^e(\bar{n}_w + 1, e, c) = S^*(\bar{n}_w + 1, e, c) = 0 \). The within period unemployment probability functions \( \bar{\pi} \) and \( \bar{\pi}^* \) are then obtained by using (54) and (55), respectively. Given \( \bar{\pi} \) and \( \bar{\pi}^* \) and after using the terminal conditions \( Y(\bar{n}_w + 1, e, c) = Y^e(\bar{n}_w + 1, e, c) = Y^*(\bar{n}_w + 1, e, c) = 0 \) we can use (48), (49) and (50) to calculate \( Y, Y^e, \) and \( Y^* \) which can be used to solve for the value of \( c^* \) that satisfies (47).

### C.7 Consumption equivalent gains relative to baseline calibration

All consumption equivalent gains are calculated relative to the baseline calibration discussed in Section 4. Let’s start defining the relevant policy rules under the baseline calibration for consumption, next period asset levels and within-period unemployment probabilities. Policy rules are always specified as a function of worker’s age \( n \), worker’s human capital \( e \) and worker’s current assets \( a \). For unemployed workers \( e \) refers to human capital at the start of the current job search spell. More specifically, let \( \hat{c}^e(n, e, a) \), \( \hat{c}^a(n, e, a) \) and \( \hat{c}^*(n, e, a) \) denote the consumption level chosen in the baseline calibration by a worker who is currently employed, unemployed with no loss of human capital and unemployed with human capital loss, respectively. Also let \( \hat{a}^e(n, e, a) \), \( \hat{a}^a(n, e, a) \) and \( \hat{a}^*(n, e, a) \) denote the next period asset level chosen by a worker who is currently employed, unemployed with no loss of human capital and unemployed with human capital loss, respectively. Finally let \( \hat{\mu}^e(n, e, a) \) and \( \hat{\mu}^*(n, e, a) \) denote the within period unemployment probability chosen in the baseline calibration by a worker who is unemployed with no loss of
human capital and unemployed with human capital loss, respectively. Now suppose that in every possible state consumption level choices are multiplied by a factor $\theta$. We can then calculate the utility value from consumption obtained by the worker in each possible state after this multiplicative change in consumption levels. When the worker is employed at age $n$, with human capital $e$ and asset level $a$ the utility value he obtains from consumption becomes equal to

$$L^e(n, e, a, \theta) = \theta^{1-\sigma} u(\hat{c}^e(n, e, a)) + \beta (1 - \delta_n) L(n + 1, e + 1, \hat{a}^e(n, e, a), \theta)$$

which uses the fact that the utility function is CARA and for simplicity we assumed that $\sigma \neq 1$. So the scaling factor in consumption $\theta$ can be taken out of the utility function as a multiplicative factor. The last term incorporates the fact that with probability $\delta_n$ a worker of age $n$ has to search for a new job whose utility value from consumption is given by

$$L^j(n, e, a, \theta) = \hat{\mu}^u(n, e, a) L^u(n, e, a, \theta) + [1 - \hat{\mu}^u(n, e, a)] L^e(n, e, a, \theta)$$

where

$$L^u(n, e, a, \theta) = \theta^{1-\sigma} u(\hat{c}^u(n, e, a)) + \beta (1 - \gamma) \hat{L}^j(n + 1, e, \hat{a}^u(n, e, a), \theta)$$

$$+ \beta \gamma \hat{L}^j(n + 1, e, \hat{a}^u(n, e, a), \theta)$$

(58)

denotes the utility value from consumption when being unemployed without having experienced a loss in human capital. The function $L^*_{j}$ in (58) denotes the utility value from consumption when searching for a job after having experienced a loss in human capital, which satisfies the following relation

$$L^*_{j}(n, e, a, \theta) = \hat{\mu}^* (n, e, a) L^*(n, e, a, \theta) + [1 - \hat{\mu}^* (n, e, a)] L^e(n, e, a, \theta).$$

(59)

In the expression above $L^*$ denotes the utility value from consumption when being unemployed after a loss in human capital, which satisfies

$$L^*(n, e, a, \theta) = \theta^{1-\sigma} u(\hat{c}^*(n, e, a)) + \beta L^*_{j}(n + 1, e, \hat{a}^*(n, e, a), \theta).$$

(60)

In writing (56), (58) and (60) we adopted the convention that

$$L(\bar{n}_w + 1, e, a, \theta) = L(\bar{n}_w + 1, e, a, \theta) = L^*(\bar{n}_w + 1, e, a, \theta) = \theta^{1-\sigma} \cdot \frac{1 - \beta^{\bar{n}_w}}{1 - \beta} u(\hat{c}^r(a))$$

The utility value from consumption at birth is equal to $L^j(1, 0, 0, \theta)$, which satisfies

$$L^j(1, 0, 0, \theta) = \theta^{1-\sigma} L^j(1, 0, 0, 1).$$

Notice that $L^j(1, 0, 0, 1)$ is the utility value from consumption at birth in the baseline calibration. Now consider a policy reform that yields a welfare gains relative to the welfare in the baseline calibration equal to $\Delta W \equiv \Delta J(1, 0, 0)$. The consumption equivalent gain change is calculated as equal to $\theta (\Delta W) - 1$ where $\theta (\Delta W)$ is given
C.8 Baseline economy under the natural borrowing limit

We analyze our economy under the assumption that workers face a natural borrowing limit, equal to the present value of the income that the worker would obtain if he were to shirk in every working period until retirement. This implies that the assets of a worker of age $n$ with human capital $e$ should be greater than

$$l(n,e) = -\left[\frac{1 - \beta^{\tilde{n}_w-n+1}}{1 - \beta} \rho w(e) + \beta^{\tilde{n}_w-n+1} \frac{1 - \beta^{\tilde{n}_r}}{1 - \beta} \pi \right].$$

To understand the term in square brackets notice that if a worker of age $n$ who has human capital $e$ shirks forever, he obtains UI benefits $\rho w(e)$ in each of the $\tilde{n}_w-n+1$ remaining periods of his working life and then he will obtain retirement pensions $\pi$ that he will start receiving in $\tilde{n}_w-n+1$ periods. Under this assumption the key equations of the model in Section 4 should be modified to incorporate the new borrowing limit. The value of being an employed worker of age $n \leq \tilde{n}_w$ with human capital $e$ and assets $a$ will now be given by:

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

which takes into account that next period assets should be greater than $l(n+1, e+1)$. Remember that $c^e(e,a,a') = (1 - \tau_n) w(e) + (1 + r) a - a'$. The value of searching is again given by

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

The value of remaining unemployed at the end of the period should now satisfy

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

where $c^u(e,a,a') = \rho_n w(e) + (1 + r) a - a'$ denotes again current period consumption when unemployed. The function $J^*$ denotes the value of searching after experiencing a loss in human capital, which remains untouched and again given by

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

The value of being unemployed after a loss in human capital satisfies

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

by

$$\theta(\Delta W) = \left[\frac{\Delta W}{L^1(1,0,0,1)} + 1\right]^{1/\sigma}.$$
where again $c^*(n, e, a, a') = \rho_n w(e) + (1 + r) a - a'$ and the borrowing limit is as in (62). We also still adopt the convention that

$$V(\bar{n}_w + 1, e, a) = U(\bar{n}_w + 1, e, a) = U^*(\bar{n}_w + 1, e, a) = \frac{1 - \beta^{n_w}}{1 - \beta} u(c^*(a))$$

where $c^*(a) = \pi + \frac{r a}{1 - \beta^{n_w}}$. The government budget constraint is also untouched and reads as follows

$$\sum_{n=1}^{\bar{n}_w} \beta^n \int_{R^+} \rho_n w(e) \chi^u(n, de) + \sum_{n=\bar{n}_w+1}^{\bar{n}_r} \beta^n \pi \chi^r(n) = \sum_{n=1}^{\bar{n}_w} \beta^n \int_{R^+} \tau_n w(e) \chi^e(n, de)$$

where integrals are conventionally defined Lebesgue integrals. Here again $\chi^e(n, e)$ denotes the measure of employed workers of age $n$ and experience $e$, $\chi^u(n, e)$ denotes the measure of unemployed workers of age $n$ who were displaced with human capital $e$ and finally $\chi^r(n) = \int \chi^e(\bar{n}_w, de) + \int \chi^u(\bar{n}_w, de) = \chi^r$ denotes the measure of retired workers of age $n$, which is constant and independent of age.