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# Unemployment Insurance when the Wealth Distribution Matters

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**Abstract**

This paper analyzes the welfare effects of unemployment insurance in a life-cycle model, focusing on partial vs. general equilibrium effects. We study an OLG economy with learning-by-doing human capital accumulation. Agents can be employed or unemployed. While unemployed agents costly search for new jobs. We calibrate the model to the U.S. economy, and find that replacement ratio and potential duration are close to the current one. But, in contrast with the previous literature, we find that the optimal policies under general and partial equilibrium are almost the same. Through a series of exercises we conclude that the life-cycle model provides two key components, crucial for welfare evaluation: it emphasizes workers' insurance needs by accurately reproducing the left tail of the wealth distribution, and generates a realistic response of precautionary savings to transfers.



*JEL classification*: E62; H21; E24

*Keywords*: Unemployment insurance. Human capital. Life cycle. Wealth inequality. General equilibrium.



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# 1 Introduction

Unemployment insurance (UI) provides workers with means to smooth consumption after job loss, but reduces their incentives to find a new job. This trade-off between insurance and incentives has been the focus of the optimal UI analysis and a fundamental issue of economic policy for over a century. Although initially controversial, an extensive literature abstracting from general equilibrium effects widely agrees that UI is socially valuable. How generous the system should be is still debatable, but there is consensus that it should exist. In contrast, the literature focusing on general equilibrium points out that public transfers only substitutes private insurance (through savings), reduces physical capital and production, and generates additional price adjustments that render UI undesirable. In this paper we show that both views are reconciled when the sources of wealth inequality are carefully considered and incorporated.

There are two key elements shaping the discrepancy between partial and general equilibrium approaches in the literature. One is the degree of insurance needs. General equilibrium models tend to generate few asset-poor workers and, thus, little value for public transfers. The other is the elasticity of savings to changes in the benefits embodied in the UI system. Infinitely-lived agents models tend to amplify the response of assets and, hence, social costs of UI. Throughout the paper we argue that an overlapping generations model provides a setup that naturally generates the wealth distribution and the capital elasticity of the data, and we find that a UI system funded through labor taxation has mild effects reducing private savings and search effort.

We build a life-cycle model where risk averse workers derive utility from consumption and leisure. They begin their working life without assets or working experience, then accumulate assets and human capital while working. While employed they can choose their work intensity. An exogenous separation shock makes workers fall into unemployment, in which case they are eligible for UI transfers of limited duration. While unemployed, jobless workers actively search for a job at a utility cost. At the end of their working life, agents retire and receive a pension from the government. Workers are employed by competitive firms operating a constant returns of scale technology relying in both, physical and human capital. Finally, there is a government that provides UI and pension benefits, funded through a proportional labor income tax, balancing its budget in every period.

This life-cycle structure generates important economic mechanisms that are relevant for welfare evaluation (Michelacci and Ruffo, 2015). Young workers are typically not able to save enough to face an unemployment spell because of their limited employment history. Moreover, due to the increasing life cycle income profile, young workers do not save much at the beginning of their working life. These effects generate a savings life-cycle profile and an assets distribution that are consistent with the data. In particular, they generate a proportion of liquidity constrained unemployed workers that is close to the observed. This point is crucial for the adequate measurement of UI welfare gains. If workers could completely finance their consumption while unemployed, UI would lack most of its appeal. In addition, the life-cycle concerns reduce the response of assets to transfers. This is because, in our model, agents have incentives to save for reasons beyond unemployment risk. Saving for retirement is the main reason to accumulate assets, explaining most of the assets accumulation.

In this context, we search for the UI replacement ratio and potential duration that maximizes the workers lifetime utility at birth. We find that the optimal policy in partial equilibrium has the same potential duration and a slightly higher replacement ratio than the current U.S. system, but still close to it (63% compared to the current 50%). The welfare effects are sizeable, the estimated losses of eliminating the UI system are equivalent to a fall in 4% of lifetime consumption. Importantly, *the result is almost unchanged when we allow for general equilibrium effects*. The reason is that both labor and capital adjust in a similar proportion, letting capital-labor ratio to remain fairly constant around the optimum. Thus, the change in factor prices in general equilibrium has small welfare effects.

Our result is consistent with the partial equilibrium literature, but at odds with the previous results in general equilibrium. There are several reasons for this, mostly associated with the life-cycle effects. The standard approach is to analyze the problem assuming infinitely lived agents facing unemployment risk. In these frameworks agents have strong incentives to save when employed (especially when the wage is high) and have infinite periods to do so. As a result, they are able to accumulate enough assets to insure against most adverse future histories. Thus, these models typically lack asset-poor workers, generating a distribution of assets less dispersed than the empirically observed. There is a mechanism akin to Clementi and Hopenhayn (2006) allowing agents to "escape" the financial constraints. This also implies that in infinitely lived agents' models the elasticity of assets with respect to UI benefits is large. Hence, physical capital strongly responds to UI, generating a sizeable reduction in aggregate production. As a consequence, this modelling choice reduce the welfare gains and increase the welfare costs of UI.

One may wonder whether matching wealth inequality by other means would be enough to overcome this problem. For instance, since Krusell and Smith (1998) it is customary to generate more dispersion by appealing to stochastic heterogeneous discount factors. This "trick" only reshuffles the savings elasticities of agents, with an average that must remain approximately constant to generate the same aggregate capital. With infinite periods to adapt to alternative UI policies, the welfare effects are not far from the standard setup with homogeneous discount factors, for instance, Mukoyama (2013). It is not enough to generate the right amount of wealth inequality, but to do it by the right reasons.

To show the relevance of life-cycle effects on the distribution of assets and the response of aggregate capital to changes in UI, we start by shutting down many age dependent components. We eliminate the human capital accumulation process, extend the working life and give workers a more generous pension. Importantly, we allow for an initial distribution of assets that reproduces the distribution of assets of those that exit the model. We show that in this model, with moderated life-cycle effects and consistent with the previous literature, the optimal UI plummets to close to zero even in partial equilibrium.

Still, one may wonder that UI could be replacing missing instruments to provide intergenerational transfers to the young. To this end, we also construct alternative economies (where the income life-cycle profile is flatten or where there is a budget constraint by age), keeping the savings life-cycle profile, and show that the conclusions are maintained. As long as liquidity constraints are relevant and savings are sufficiently inelastic, for the young due to scarcity and for the older due to retirement concerns, it is optimal to provide UI.

Finally, one important element in our baseline economy is that even though the UI affects aggregate capital and labor, it does so proportionally, so that the capital-labor ratio, and therefore prices, are barely affected. To show this, we analyze alternative funding strategies, using capital taxation and delay lump sum taxation upon retirement. In these alternatives the capital-labor ratio is more sensitive and therefore the general equilibrium effects are larger. We show that whenever the ratio is reduced due to the increase in UI, the general equilibrium analysis prescribes less generous UI compared to partial equilibrium analysis. Conversely, whenever the capital-labor ratio is increased due to more generous UI, the general equilibrium analysis suggests more generous UI compared to partial equilibrium.

Our contribution is, thus, to build a bridge between two branches of the literature and to emphasize the role of the distribution of assets and the elasticity of savings with respect to UI. We show that if the capital-labor ratio does not change with UI, the general equilibrium effect is nil. In such a case, partial equilibrium approach is accurate. In the case in which the capital-labor ratio changes, the additional price effect should be considered for the identification of the optimal policy.

The paper is structured as follows. In the Section 1.1 we briefly review the extensive related literature. In Section 2 we present the economic environment and in Section 3 its calibration to the U.S. economy. Section 4 presents the main results. In Section 5 we present a series of exercises to understand the underlying economic mechanisms, leaving the robustness exercises to Section 6. Finally, Section 7 concludes.

## 1.1 Literature review

The trade-off between insurance and search effort has been extensively studied through optimal dynamic contracts by Shavell and Weiss (1979), Hopenhayn and Nicolini (1997, 2009) and Shimer and Werning (2008, 2006), among many others. These papers emphasize the role of changing consumption, benefits and labor taxes through the unemployment spell to provide incentives to job-search. They also show that the optimal policies provide substantial insurance and increase welfare.

The UI policy has also been studied using sufficient statistics approach since Baily (1978). That paper proposes that the optimal UI should be set so that the utility loss due to consumption drop upon unemployment equates the elasticity of the duration of unemployment spell with respect to a balanced budget increase in UI benefits and taxes. A series of papers, Shimer and Werning (2007), Chetty (2008) and Landais (2015), extend this approach using search models of the labor market to identify marginal welfare gains and losses of changing UI. After measuring costs and benefits with the U.S. data, they typically find that the UI system is close to the optimal or even that there are welfare gains of making it more generous.

The UI system has been also evaluated through quantitative models of the labor market with moral hazard, as in Hansen and Imrohoroglu (1992). Some of these papers find that the US system is close to the optimal and they evaluate the welfare gains of introducing reforms, such as introducing UI savings accounts (Setty, 2017), conditioning UI to assets of the unemployed (Koehne and Kuhn, 2015), to age (Michelacci and Ruffo, 2015), or to business cycle variables (Schwartz, 2013). All of them suggest that UI provides relevant welfare gains.

There are several papers analyzing general equilibrium effects. They do so by introducing capital as a production factor. They argue that UI imposes strong welfare costs and provides little welfare gains, making it mostly useless or even harmful (Alvarez and Veracierto, 1998, 2001; Young, 2004; Mukoyama, 2010, 2013; Popp, 2017). A main argument is that both assets and labor are reduced by UI, causing aggregate activity to fall (Young, 2004). Thus, once general equilibrium effects are taken into account, induced social costs of UI are strong.

This literature has mostly used infinitely lived agents models. This modelling choice has been used in Young (2004), that adds capital to Wang and Williamson (2002), and finds that the reduction in aggregate activity outweighs the insurance of UI. Also, Mukoyama (2010, 2013) concludes that UI is not welfare enhancing in GE. However, these two papers are still away from generating wealth dispersion that maps to insurance needs.[1] Additionally, Young

[1] In Young (2004) wealth dispersion arises only from uninsurable employment risk but wealth dispersion is far below the observed. Mukoyama (2010) generates dispersion by introducing (random) heterogeneous discount factors. Hence, wealth dispersion is the agents' optimal choice, and uncorrelated with income shocks.

(2004) clearly shows that assets are very elastic, both to UI and to factor prices. These settings suffer from the same issues pointed out by Engen and Gruber (2001), generating excessive crowding out of private savings.[2] Birinci and See (2022), in a general equilibrium setting, focuses on the heterogeneous responses to UI, dealing with many of the issues aforementioned, but their model omits capital as a production factor, it does not include the life cycle behavior, and does not aim to identify an optimal system.

# 2 The model

The economy is populated by a continuum of agents, a competitive firm, and the government. At any point in time agents can differ in their age $j \in \{1, 2, 3, ...\}$, wealth level $a$, position in the job ladder $\kappa \in \mathbf{K}$, and their activity status $i \in \{e, u, R\}$ where $e$ denotes currently employed, $u$ currently unemployed and $R$ retired agents. For those unemployed, the duration of the current unemployment spell is denoted by $\psi \in \mathbf{\Psi}$.

## 2.1 Competitive Firm

The firm has access to a constant return to scale technology $F(K, H)$, where $K$ denotes physical capital and $H$ denotes units of effective labor. The firm pays wage, $w$, per unit of effective labor, rents capital at the rate $r$, and incurs a depreciation cost at the rate $d$. The firm's objective is to maximize its profits:

$$\max_{K,H} K^{\alpha} H^{1-\alpha} - (r + d)K - wH \ .$$

The first order conditions of the firm's problem provide

$$w = (1 - \alpha) \left( \frac{K}{H} \right)^{\alpha},$$

$$r = \alpha \left( \frac{K}{H} \right)^{\alpha - 1} - d.$$

## 2.2 Agents

Each period, a measure one of agents enter the labor market, with age $j = 1$. Agents can work up to age $j = T$. At $T$ an agent must retire, and collects pension proceeds $Pw$ each period while alive. Agents die stochastically with age dependent probability $\delta(j)$. We assume

[2] In Young (2004), when UI is eliminated, assets increase by 63% in the absence of factor price adjustments and by 3% after they adjust.

that $\delta(j) = \delta_j$ for $j \leq T$ and $\delta(j) = \delta_R$ for $j > T$, which state that the death probability is only age dependent for agents in working age. This assumption helps us to simplify the value after retirement. Note that we are assuming retirement is exogenous at age $T$. As Costa (1998) and Bloom et al. (2007) show, the retirement age in the U.S., as in many other countries, has been continuously decreasing over the last century. Hence, our assumption is conservative on capturing the effect of aging on savings.[3]

Let $u(c, n, s)$ denote the per period utility flow of an agent that consumes $c$, works a proportion $n \in [0, 1]$ of its working time endowment, and exerts $s \in [0, 1]$ search effort to find a job. We assume that $u(c, n, s)$ takes the following form:

$$u(c,n,s) = \begin{cases} \frac{\left((1-n)^{\omega} c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} & \text{if } i = e, \\ \frac{\left(c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} - \gamma_0 \frac{(1-s)^{1-\gamma_1}}{|1-\gamma_1|} & \text{if } i = u, \\ \frac{\left(c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} & \text{if } i = R. \end{cases}$$

with $\gamma_1 > 1$. The employed agent's formulation is similar to the specification in Abdulkadiroglu et al. (2002).

The movements through the job ladder are stochastic and follow the following law of motion:

$$\kappa_{t+1} = \begin{cases} \kappa_t & & \text{if } i_t = R, \\ \kappa_t & & \text{if } i_t = u, \\ \kappa_t + 1 & \text{with prob. } \chi(n) & \text{if } i_t = e, \\ \kappa_t & \text{with prob. } 1 - \chi(n) & \text{if } i_t = e. \end{cases} \tag{1}$$

Note that an agent can move up in the job ladder with positive probability only when she is employed, and that this probability, $\chi(n)$, depends on her labor intensity choice. Moreover, the law of motion in equation (1) makes clear that agents cannot fall in the ladder. Every movement has a permanent effect.

Each step in the job ladder is associated to a particular level of human capital $h(\kappa)$, mapping steps $\kappa$ into units of effective labor. As a result, employed agents receive a net labor compensation, $nh(\kappa)w(1 - \tau)$. This is proportional to the effective units of labor supplied

[3]As Bloom et al. (2014) argue, as life expectancy increases there are two effects affecting the retirement decision. On the one hand, workers can extend their working life to compensate the longer retirement, but on the other hand, the increase in labor productivity that usually accompanies a longer life increases the demand for leisure (income-wealth effect), which induces an earlier retirement. The net effect of living longer on the retirement age is then ambiguous. Recent work, such as Shourideh and Troshkin (2017), however, point to the dominance of the income-wealth effect, except for individuals in top income decile. Alternative explanations of why agents do not retire older range from an increased female labor force participation, as proposed by Borella et al. (2017). For a cross-section of countries, Bonfatti et al. (2019) discuss the binding statutory nature of retirement in many countries.

to the firm, $nh(\kappa)$, and net of the tax liabilities $\tau$, that are used to fund the UI and pension systems.

Let $1-\pi_j$ denote the (exogenous) job separation probability by age. After separation workers become unemployed and receive insurance in the form of a replacement ratio $B(\psi)$, where the dependence on $\psi$ shows that the compensation scheme can depend on the duration of the current unemployment spell. Unemployed agents collect $B(\psi)\bar{n}h(\kappa)w(1-\tau)$ as income, which depends on the average labor intensity in the economy, $\bar{n}$.[4]

We now describe the problem of retired, employed, and unemployed agents. Let $V^R(a)$ denote the value for a retired agent with current wealth $a$, let $V_j^e(a,\kappa)$ denote the value for an employed worker of age $j$ with current wealth $a$ and accumulated labor capital $\kappa$, and let $V_j^u(a,\kappa,\psi)$ denote the value for an unemployed worker of age $j$ with current wealth $a$, accumulated labor capital $\kappa$ and current unemployment duration $\psi$.

### 2.2.1 The problem of a retired agent

When retired, an agent can finance her consumption with her own past savings and transfers from the pension system. The pension benefits are represented by replacement ratio $P$. Thus, a retired agent's value function $V^R(a)$ solves the following Bellman equation:

$$\begin{aligned} V^R(a) &= \max_{c,a'} \frac{\left(c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} + \beta(1-\delta_R)V^R(a') \\ s.t. & \\ & c + a' = (1+r)a + Pw, \\ & a' \geq 0\ ,\ c \geq 0. \end{aligned}$$

A natural implication of the problem of a retired agent is that consumption and assets accumulation are a function of the current agent's asset level. That is, $c = c^R(a)$ and $a' = a^R(a)$.

[4]Linking the benefits to the average rather than the individual's specific hours of the last job allows us to simplify the computation, so that we no not need to keep track of one additional state variable. Given that the number of hours worked are fairly constant, we still refer to $B$ as the replacement ratio.

### 2.2.2 The problem of an unemployed agent

An unemployed agent's value function $V_j^u(a, \kappa, \psi)$ solves:

$$\begin{aligned} V_j^u(a,\kappa,\psi) &= \max_{c,a',s} \frac{\left(c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} - \gamma_0 \frac{(1-s)^{1-\gamma_1}}{|1-\gamma_1|} \\ &+ \beta(1-\delta_j)\left[sV_{j+1}^e(a',\kappa) + (1-s)V_{j+1}^u(a',\kappa,\psi+1)\right] \\ s.t. \quad & \\ & c + a' = (1+r)a + B(\psi)\bar{n}h(\kappa)w(1-\tau), \\ & a' \geq 0\ ,\ c \geq 0, s \in [0,1]. \end{aligned}$$

when $j < T$. In the last period the problem is slightly different because the agent knows that at $j = T$ she must retire. Thus, at $j = T$ the objective function must be replaced with the following,

$$V_T^u(a,\kappa,\psi) = \max_{c,a',s} \frac{\left(c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} - \gamma_0 \frac{(1-s)^{1-\gamma_1}}{|1-\gamma_1|} + \beta(1-\delta_j)V^R(a').$$

Notice that the optimal choice of search effort is 0 at $j = T$, because retirement is mandatory after that period. The solution to the unemployed agent's problem is a set of policy functions: $c = c_j^u(a, \kappa, \psi)$, $a' = a_j^u(a, \kappa, \psi)$, and $s = s_j(a, \kappa, \psi)$.

### 2.2.3 The problem of an employed agent

For all $j < T$ the employed agent's value function $V_j^e(a, \kappa)$ solves:

$$\begin{aligned} V_j^e(a,\kappa) &= \max_{c,a',n} \frac{\left((1-n)^{\omega}c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} + \beta(1-\delta_j)\left[\chi(n)\left(\pi_j V_{j+1}^e(a',\kappa+1) + (1-\pi_j)V_{j+1}^u(a',\kappa+1,1)\right)\right. \\ & \left. +(1-\chi(n))\left(\pi_j V_{j+1}^e(a',\kappa) + (1-\pi_j)V_{j+1}^u(a',\kappa,1)\right)\right] \\ s.t. \quad & \\ & c + a' = (1+r)a + nh(\kappa)w(1-\tau), \\ & a' \geq 0\ ,\ c \geq 0\ ,\ n \in [0,1]. \end{aligned}$$

As with the unemployed worker, the employed worker knows at $j = T$ that next period she must retire. As a result, even though the constraint set remains the same, at age $T$ the employed worker's objective function is given by

$$V_T^e(a,\kappa) = \max_{c,a',n} \frac{\left((1-n)^{\omega}c^{1-\omega}\right)^{1-\sigma}}{1-\sigma} + \beta(1-\delta_j)V^R(a').$$

The solution to the employed agent's problem is a set of policy functions: $c = c^e_j(a,\kappa)$, $a' = a^e_j(a,\kappa)$, and $n = n_j(a,\kappa)$.

## 2.3 The government

The government collects taxes and makes the necessary transfers to sustain the UI and pension systems. It does so by maintaining a balanced budget. This implies that in each period the following government budget constraint is satisfied:

$$\int \tau n_j(a,\kappa)h(\kappa)wX^e_j(a,\kappa)d(\kappa\times a\times j) + \int \tau h(\kappa)B(\psi)\bar{n}wX^u_j(a,\kappa,\psi)d(\kappa\times a\times j\times\psi)$$
$$= \int h(\kappa)B(\psi)\bar{n}wX^u_j(a,\kappa,\psi)d(\kappa\times a\times j\times\psi) + Pw\int X^R(a)da.$$

where $X^R(a)$ denotes the measure of retired agents with wealth $a$; $X^e_j(a,\kappa)$ denotes the measure of employed agents of age $j$, with wealth $a$ in the job ladder step $\kappa$; $X^u_j(a,\kappa,\psi)$ denotes the measure of unemployed agents of age $j$, with wealth $a$, who where in the job ladder step $\kappa$, but have been unemployed for $\psi$ periods.[5]

## 2.4 Stationary equilibrium

In what follows we focus on stationary equilibria to compare alternative policies.

**Definition**. Given a policy rule $\{\tau, B(\psi), P\}$, a stationary equilibrium is prices $\{w, r\}$ and measures $X^R(a)$, $X^e_j(a,\kappa)$, $X^u_j(a,\kappa,\psi)$ $\forall j,a,\kappa,\psi$, such that:

1. Agents maximize utility,

2. Markets clear,

$$H = \int h(\kappa)n_j(a,\kappa)X^e_j(a,\kappa)d(j\times a\times\kappa), \tag{2}$$
$$K = \int a\left[X^r(a) + X^e_j(a,\kappa) + X^u_j(a,\kappa,\psi)\right]d(j\times a\times\kappa\times\psi). \tag{3}$$

3. The feasibility constraint is satisfied,

$$\begin{aligned} F(K,H) - dK &= \int c^R(a)X^R(a)da + \int c^e_j(a,\kappa)X^e_j(a,\kappa)d(j\times a\times\kappa) \\ &+ \int c^u_j(a,\kappa,\psi)X^u_j(a,\kappa,\psi)d(j\times a\times\kappa\times\psi). \end{aligned}$$

[5]See the definition and computation of these measures in Appendix C.

At this stage it is worth making some observations. First, $H$ in equation (2) is akin to the aggregate human capital in the economy. However, it only includes the employed human capital, as there is always idle human capital, with aggregate value $\int h(\kappa)X_j^u(a,\kappa,\psi)d(j\times a\times \kappa\times\psi)$. Second, notice that the measure of retirees' assets and consumption do not depend on the agent's age. This is due to the assumption that after retirement the survival probability is constant. Finally, because of Walras' Law, the feasibility constraint is unnecessary: as long as the asset's market clearing condition embedded in equation (3) is satisfied, the feasibility constraint should also be satisfied.

# 3 Calibration

We set the model-period equal to a calendar quarter (12 weeks) to have sufficient flexibility on the unemployment duration spell. We assume that the starting age of an individual ($j = 1$) is analogous to 23 years old in calendar time and we set the compulsory retirement age to be 65 years old, setting $T = 172$. In our baseline calibration we assume that all workers begin their life with no assets and a proportion $1 - \pi_1$ are initially unemployed. In Table 1 we present the calibrated parameters and functions. We discuss the calibration exercise according to the quantification method: some are imputed from exogenous sources to the model, while others require calibration through indirect inference.

## 3.1 Imputation of parameters

*UI system parameters.* To calibrate the economy we need to specify the UI system. Following the literature we set the UI system to provide a replacement ratio of 0.5 for up to 6 months (two model periods):

$$B(\psi) = \begin{cases} 0.5 & \text{if } \psi \leq 2, \\ 0 & \text{if } \psi > 2. \end{cases} \tag{4}$$

This replacement ratio is around the values typically used in the literature (for example, Wang and Williamson (2002)).

*Capital share of output $\alpha$, depreciation rate $d$, death probability $\delta_j$ and job-keeping probability $\pi_j$.* As it is standard in the literature we set the capital share of output $\alpha$ to be 0.3 and the depreciation rate to $d = 0.01$.[6] We quantify the death probability $\delta_j$ using the 2007 United States survival probability actuarial data collected by the Social Security Adminis-

[6]Along with the assets lost by the assumption that agents do not leave legacies, we add up to 5% of assets lost within the year.

**Table 1:** Calibration of parameters and functions

| Parameter/function | Value | How to calibrate | Moment | |
|---|---|---|---|---|
| | | | Model | Data |
| | | *Imputed parameters* | | |
| Capital share of output $\alpha$ | 0.3 | standard | - | - |
| Depreciation rate $d$ | 0.01 | standard | 0.05 annual† | - |
| Death probability $\delta(j)$ | see Figure 19 | Social Security data | - | - |
| Job keeping probability $\pi_j$ | see left panel of Figure 3 | estimates from CPS data | - | - |
| | | *Calibrated parameters* | | |
| Discount factor $\beta$ | $(0.96)^{1/4}$ | capital to output ratio (2.7) | 2.7 | - |
| Labor disutility $\omega$ | 0.65 | 40-42 hours worked per week | 0.34 | 0.34 |
| Risk aversion $\sigma$ | 3.86 | risk aversion of retirees= 2 | - | - |
| Search cost: level p. $\gamma_0$ | 0.27 | avg. unemployment rate (2004-12) | 0.068 | 0.068 |
| Search cost: elast. p. $\gamma_1$ | 1.8 | elast. of job-finding to benefits | -0.32 | -0.32 |
| Human capital $h(\kappa)$ and $\chi(n)$ | see Figure 1 | returns to experience | - | - |
| | | *Policy parameters in the calibrated economy* | | |
| UI system $B$ | 0.5 | replacement ratio of UI to 50% | - | - |
| UI system $\psi$ | 2 | unemployment duration of 26 weeks | - | - |
| Pension system $P$ | 0.045 | pension expenditures over GDP | 0.068 | 0.068 |
| Tax rate $\tau$ | 0.124 | Balance budget | - | - |

**Notes:** The model period is set to 12 weeks. Total periods in the labor market $T = 172$. All workers are born with no assets and no experience. Initially unemployed workers: $1 - \pi_1 = 0.1233$. † In the depreciation rate we compute also the lost capital due to agents' death in the model.

tration (see Figure 19).[7] Notice that in our model we impose the same death probability $\delta_R$ for retired agents (with age above 65). We compute $\delta_R$ so that the expected lifetime at age 65 matches the empirical life expectancy which is 17 years; this implies that $\delta_R \approx 0.016$. We set the separation rate by age, $1 - \pi_j$, from CPS data, and we depict these rates in the left panel of Figure 3.[8]

## 3.2 Calibration of remaining parameters by indirect inference

We quantify the remaining parameters by calibrating the model to the United States economy.

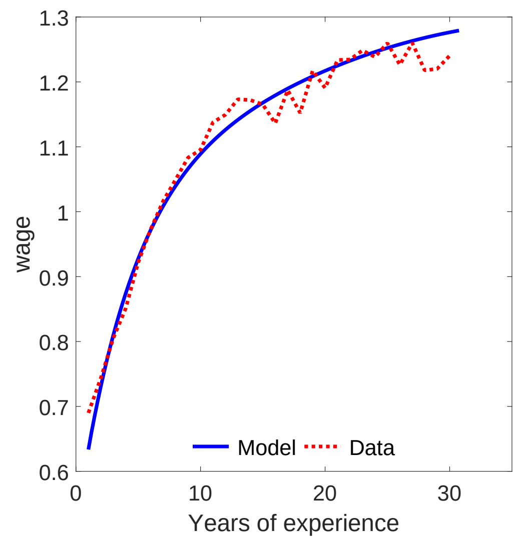
*Discount factor $\beta$.* As it is standard we target the capital to GDP ratio to calibrate $\beta$. Higher values of it induce higher savings, which in turn increases the capital output ratio.

*Labor disutility $\omega$ and risk aversion parameter $\sigma$.* A higher value for $\omega$ decreases labor

[7] The data is available at www.ssa.gov/oact/STATS/table4c6.html

[8] This data was constructed by Robert Shimer. For additional details, please see Shimer (2012) and his website http://sites.google.com/site/robertshimer/research/flows. The same disclaimer applies for the job finding rate which we use later on to compute unemployment rates by age.

**Figure 1:** Human capital: data and calibrated model




**Notes:** The red (dashed) line is the non-parametric estimate of the returns to experience as explained in Appendix B.1. The blue (solid) line is the profile of wages in the calibrated model.

intensity $n$. Thus, we use the average number of hours worked by the employed as a moment to identify $\omega$. From McGrattan and Rogerson (2004) we know that individuals between 23 and 65 years old work between 40 and 42 hours per week (depending on sex and marital status) so our target for the proportion of time spent at work is 0.34. For $\sigma$ we match the risk aversion of retirees to the standard value of 2.[9]

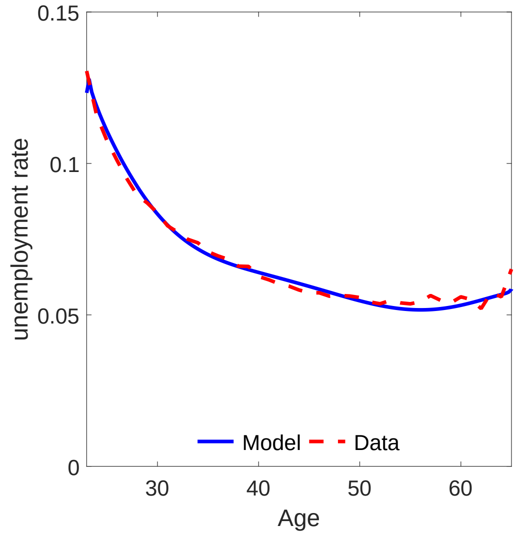
*Human capital $h(\kappa)$, the job ladder $\mathbf{K}$, and $\chi(n)$.* To maintain tractability we assume that the job ladder is composed of 10 steps so that $\mathbf{K} = \{1, 2, 3, ..., 10\}$, and that:

$$\chi(n) = \begin{cases} \hat{\chi} & \text{if } n \geq \frac{1}{6}, \\ 0 & \text{if } n < \frac{1}{6}. \end{cases} \tag{5}$$

so that an employed worker needs to work the equivalent to at least 4 hours per day to have a positive probability of climbing the ladder. Once above this threshold, the probability of moving up in the ladder is constant and independent of both $n$ and $\kappa$. Each step in the ladder is associated with effective human capital $h(\kappa)$. We calibrate $h(\kappa)$ and $\hat{\chi}$ jointly by matching the empirical wage - experience profile that arises from a standard regression using NLSY 1979 (see Appendix B.1). We use the first 8 steps of the ladder to match the empirical human capital function (with experience levels that range from 1 to 35 years) and we use the

[9]Notice that under our utility function specification the relative risk aversion (RRA) is $1-(1-\sigma)(1-\omega)$, from where, given RRA and $\omega$, can be used to back out $\sigma$.

**Figure 2:** Unemployment rate by age




**Notes:** The red (dashed) line is the unemployment rate by age from the data, as implied by the CPS job finding and job keeping rates. The blue (solid) line is the unemployment rate from the calibrated model.

last 2 steps to extrapolate the ladder up 42 years of experience (so that the experience levels span the entire working life of agents in the model). Furthermore, the calibration exercise implies that $\hat{\chi} = 0.088$. In Figure 1 we plot the estimate of average human capital level and the calibrated ladder.

*Search cost parameters $\gamma_0$ and $\gamma_1$.* We target the average unemployment rate to 6.8%, the average from 2004 to 2012 in the US. At the same time, we target the elasticity of job-finding rate with respect to UI. We consider the elasticity of -0.32 (Landais, 2015). The elasticity of job-finding rate with respect to UI is a crucial component for the analysis of the UI system according to the sufficient statistic literature (Chetty, 2008). In the model, we measure the elasticity as the partial effects of benefits. To be precise, we change benefit level ($B$) only, while we keep taxes and other general equilibrium variables constant. We do this to isolate the effect of benefits in job-finding rate, and more closely connect with the empirical literature that compares the unemployment duration of workers with different UI levels, but with otherwise similar environments (for example Landais (2015); for additional details about the procedure for calibrating this function see in Appendix B.2). We obtain $\gamma_0 = 0.27$ and $\gamma_1 = 1.8$. Figure 2 presents the unemployment rate by age constructed using the job keeping probability and job finding probability implied by the CPS (red dashed line) and the rate implied by the calibration exercise (blue solid line).

# 4 Results

In this section we present the main results of the paper. We first show how the model performs in non-targeted moments and then we present the welfare evaluations of alternative unemployment insurance policies.

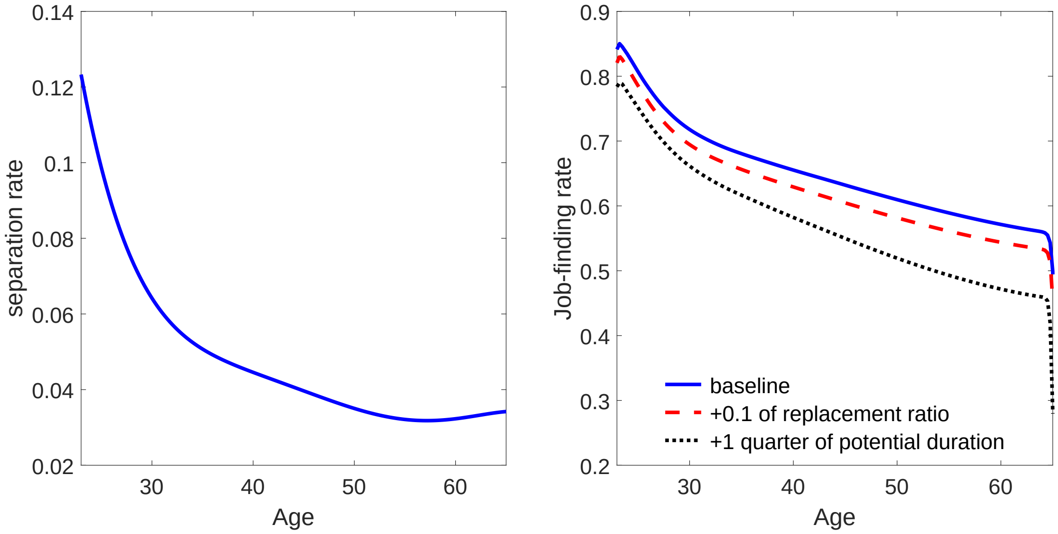
## 4.1 Some features of the parameterized economy

A key moment of our analysis is the unemployment rate by age (see Figure 2). The unemployment rate is almost 13% for the young workers (those that in our model begin their working lives) and then decreases to about 5% for workers close to retirement. The model does a remarkable good job at matching not only the level but also the slope. This together with the fact that we also target the elasticity of the job finding rate gives confidence that the model is well suited for our goal.

The unemployment rate by age profile is generated by (exogenous) separation and (endogenous) finding rates that vary by age. Panel (a) of Figure 3 presents the separation rate by age. Initial separation is close to 12% for those at the beginning of their working life, and rapidly decreases to below 4%. Thus, unemployment risk mostly affects young workers. The blue solid line in Panel (b) presents the job-finding rate by age. At the beginning of their working life, unemployed workers exert high effort in finding a job. There are two main reasons for this high effort. First, young workers begin their working life without assets, so that they need to escape unemployment before UI is exhausted. Second, they invest in job-search to increase their human capital. This component is relevant during the first half of the life. After that, human capital does not increase much for the median worker. The job-finding rate then decreases, when workers are able to better self-smooth consumption during unemployment. At the end of working life this rate drops because workers are about to retire, decreasing the value of finding a job.

To understand the reaction of the job-finding rate to changes on unemployment benefits, in Panel (b) of Figure 3 we also plot counterfactual rates with an alternative replacement ratio and duration. The red dashed line depicts the job-finding rate when the replacement ratio is set 10 percentage points higher. This higher transfer reduces the incentives to search for workers of all ages. The effect of the change in the policy is more appreciable for older workers. In fact, the elasticity of the job-finding rate with respect to benefits in our model is smaller for younger workers than for older ones. This feature has been documented elsewhere (Michelacci and Ruffo, 2015), and arise naturally in a life-cycle setting. The dark dotted line shows the job-finding rate by age when UI potential duration is extended one model period (12 weeks). Again, the job-finding rate falls sharply and, again, the fall is larger for older

**Figure 3:** Job-finding and separation rates



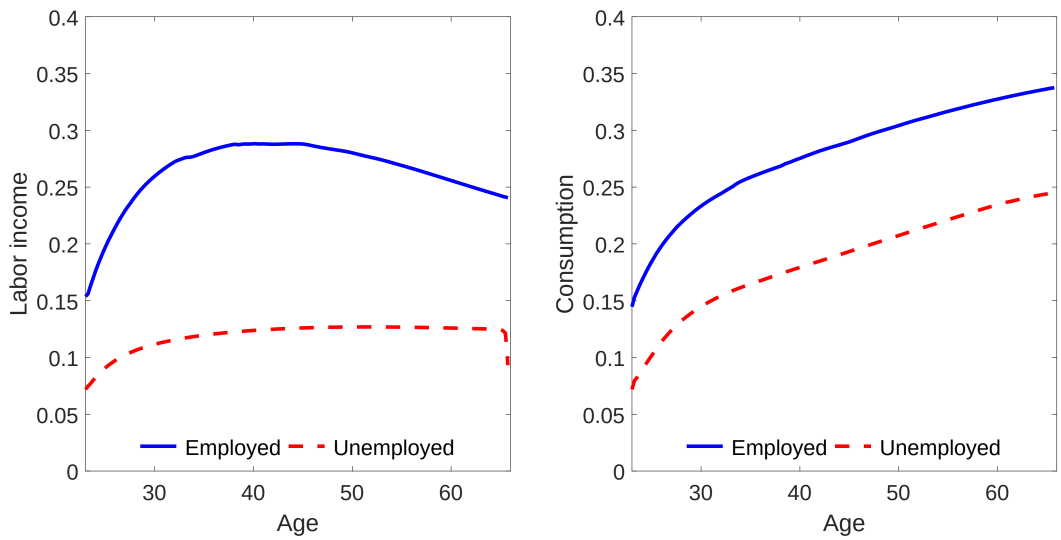

(a) Separation (b) Job-finding

**Notes:** Panel (a) reports separation rates as exogenously calibrated in the model (Shimer, 2012). The blue solid line in panel (b) reports the average job-finding rate by age in the calibrated model; the red dashed line is the average job-finding rate by age if benefits were to increase by 10 percentage points; the black dotted line is the same profile in the calibrated model, but if potential duration were to be extended one additional quarter.

workers. Even though the response to the change in duration seems to be larger, one must bear in mind that the increase in the replacement ratio is 20% (10%/50%), while the increase in the duration is much larger, of 50% (1/2). For this reason, the elasticities do not greatly differ.

Figure 4 plots labor income—in panel (a)—and consumption—in panel (b)—of employed and unemployed workers by age. The blue solid line depicts the average labor income of employed workers, which it is increasing by age up to a peak at age 45 and then starts to decrease. The pattern is affected by the human capital profile (as shown in Figure 1) and total hours worked. In the calibrated economy hours worked increase with human capital and decrease with assets. For that reason, the model generates a reduction in total labor income for employed workers after age 50. The dashed red line of Panel (a) also plots the average unemployed worker's income. This amount depends on human capital and on the average duration of unemployment spells. We find that this income is mildly increasing, at a slower rate than the labor income for the employed. This is partly because the UI exhaustion is increasing by age. The rapid increase in average unemployment duration at the end of the working life explains the drop in the average UI transfers for those periods. Panel (b) in the figure depicts the evolution of average consumption of the employed and the unemployed. Consumption levels are increasing in age, which is consistent with the accumulation of human

**Figure 4:** Income and consumption through the life-cycle



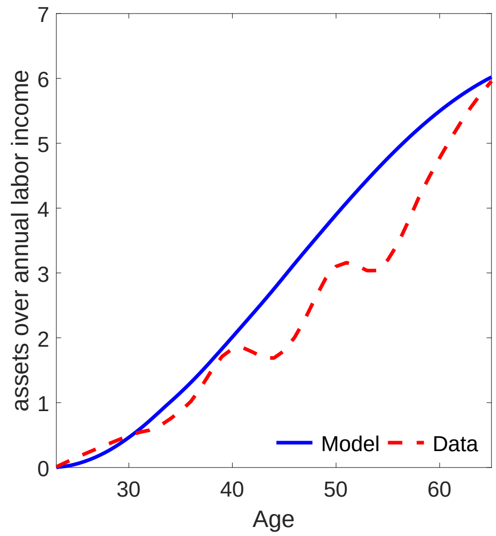

(a) Labor income (b) Consumption

**Notes:** Panel (a) reports the average labor income of employed workers and average UI compensation of unemployed workers, by age, in the calibrated model. Panel (b) reports the average consumption level of employed and unemployed workers by age.

capital and assets. There is a strong consumption drop upon separation. A proportion of the income drop is compensated by dissaving, particularly after age 30.

The agent's key instrument to insure unemployment risk is assets holdings. Understanding its availability and sensibility to the model's fundamentals is of a first order issue to determine the need for additional insurance. Figure 5 presents wealth accumulation through life. Comparing the calibrated economy with net worth data from the Survey of Consumer Finances, 2007, we find that the average wealth by age closely follows the data, even when wealth-age profile is not a targeted moment. The figure shows that workers tend to save little at the beginning of their working lives, and accumulate wealth at a higher pace after the first ten years of their working life. At the beginning of the working life, savings are determined by at least two forces. First, workers expect an increase in their labor income because of human capital accumulation, so they would prefer to borrow. Second, workers face a high probability of losing their jobs, and for that reason they want to build precautionary savings. These two forces partially compensate each other, generating a mild increase in assets. Wealth is accumulated until the end of the working life. During these last years, workers continue to save to finance their retirement, given that pensions would not fully replace their income. Thus, life-cycle effects introduce several determinants for savings. Savings are not

**Figure 5:** Wealth by age




**Notes:** The blue solid line reproduces the level of assets by age reported as a ratio over the annual labor income in the model. The red dashed line reports the per capita net worth by the age of the head of household over the overall annual labor income from the Survey of Consume Finance, 2007.

only driven by unemployment risk in our model.

The model reproduces most of the observed wealth inequality. The Gini coefficient for the assets distribution is around 0.68 and for earnings is 0.37 (see Figure 20). The first figure is smaller than its empirical counterpart (0.75-0.8) while the second is closer to the observed, 0.4-0.45. See for instance Castaneda et al. (2003). The main area where we fail is in the upper tail of the distributions, top 1%. However, it is well known that the upper tail of both, income and wealth distributions are mainly shaped by entrepreneurs, and thus highly dependent on heterogeneous returns to investments (Cagetti and De Nardi, 2006). Since our focus is on the labor income earners this discrepancy is mostly irrelevant.[10]

Given our purposes, the left tail of the asset distribution is more important than the Gini coefficient. Table 2 reports the distribution of assets relative to income for the employed and unemployed workers, comparing the calibrated economy with the data.[11] The model performs fairly well when compared to total assets. In the literature (Gruber, 2001; Chetty, 2008) it is generally argued that the relevant savings to hedge unemployment risk are liquid assets. However, we believe this is a lower bound for the achievable insurance. Other, less

[10]There could be additional general equilibrium effects. But since entrepreneurs would be unaffected by UI, the response of aggregate capital to alternative policies would be even smaller, reinforcing our results.

[11]We consider the wealth of the unemployed at the beginning of their unemployment spell. We do so to abstract from unemployment duration components. We compare to results by Gruber (2001) that restricts the sample to those that are displaced during the SIPP panel (after the first interview and before the second), what results in an undersampling of long spells.

**Table 2:** Assets distribution: asset holdings relative to annual labor earnings

| | Unemployed | | | Employed | | |
|---|---|---|---|---|---|---|
| | Model | Data | | Model | Data | |
| | | financial | total | | financial | total |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 10th pctile | 0.02 | 0.00 | 0.00 | 0.10 | 0.01 | 0.06 |
| 25th pctile | 0.22 | 0.01 | 0.20 | 0.72 | 0.05 | 0.63 |
| 50th pctile | 1.31 | 0.10 | 1.85 | 2.39 | 0.20 | 2.36 |

**Notes:** The table reports the distribution of assets relative to pre-unemployment net labor earnings for the unemployed (columns (1) to (3)) and relative to current net labor earnings for the employed. (columns (4) to (6)). In the model, the wealth of the unemployed is measured at displacement. Data is from SIPP 1984-1992 panels as reported by Gruber (2001). Financial assets include interest earning assets in institutions, equity, mutual funds, bonds and checking accounts. Total assets adds retirement savings accounts, homes, vehicles, and personal businesses, and subtracts unsecured debt.

liquid, assets can serve the same purpose. They can either signal good credit worthiness or being directly used as collateral. Moreover, if the unemployment spell is sufficiently long the agent can always reduced its holdings of less liquid assets. If these options were not available, our model would be somewhat overstating the workers' consumption smoothing possibilities.

In any case, our model generates a substantial measure of liquidity constrained unemployed workers. In particular, about 67% of workers can self-finance (completely replace wage income) during a typical unemployment spell with their assets. This figure is half way between the observed figures, which are 75% if total assets are considered and about 50% if only liquid assets are taken into account (see Gruber (2001)).

## 4.2 Welfare analysis and decomposition

We now turn to evaluate the welfare effects of changes in the UI system. We follow the literature and evaluate welfare at birth,

$$W_1 = (1-u_1)V_1^e(a=0,\kappa=1) + u_1 V_1^u(a=0,\kappa=1,\psi=1)\ ,$$

where $V_1^e$ and $V_1^u$ are the value functions of employed and unemployed workers at age 1, and $u_1$ ($\approx 0.12$) is the proportion of unemployed workers at the beginning of their working life.

We report welfare changes in terms of consumption-equivalent variation. In other words, we compute the percentage change in consumption at all future dates and states required to make the agent in the benchmark economy indifferent to the reformed economy in steady state. This measure can be computed as:

$$1 + CEV_1 = \left( \frac{W_1^P}{W_1^B} \right)^{\frac{1}{(1-\omega)(1-\sigma)}} \tag{6}$$

where $W_1^B$ is welfare in the benchmark economy and $W_1^P$ is welfare under an alternative policy. We choose the policy that maximizes welfare as the benchmark for comparison, and thus $CEV$ should be read as welfare losses due to not implementing the optimal policy.

We also perform a decomposition of welfare losses. For that purpose, we first consider (i) an increase in benefits, (ii) the corresponding increase in taxes that balance the budget in partial equilibrium (PE), and (iii) the effect of changing prices. In this last step, we change taxes accordingly to balance the budget in general equilibrium (GE). The increase in benefits would be welfare improving, the change in taxes is welfare decreasing, while the induced change in prices is the GE effect with an ambiguous welfare effect. In each of these steps, we consider all the behavioral responses associated to all the shocks.

Let $W^{GE}(B_0)$ be the welfare evaluation of the $B_0(\psi)$ UI policy in GE.[12] As a result of the solution to this economy, a set of endogenous variables $(\tau_0^{GE}, \bar{n}_0^{GE}, w_0^{GE}, r^{GE})$ are generated. Let $P_0 = \{w_0, r_0\}$ be the price vector and $W^{PE}(B_0; P_0)$ be the solution and welfare evaluation of the same policy in partial equilibrium, using factor prices $P_0$. From this solution, fiscal variables $F_0^{PE} = \{\tau_0^{PE}, \bar{n}_0^{PE}\}$ are endogenously determined to balance the budget. Finally, let $\widetilde{W}^{PE}(B_0; P_0, F_0)$ be the solution of the problem under the same UI policy in PE, but without imposing a balanced budget. In this case, taxes and average hours worked are inputs to the problem.

Our decomposition rests on the following identity,

$$W^{GE}(B_0) = W^{PE}(B_0; P_0^{GE}) = \widetilde{W}^{PE}(B_0; P_0^{GE}, F_0^{GE}) \ .$$

In words, if we evaluate the unbalanced partial equilibrium economy in the endogenous variables that arise in general equilibrium (such as tax rate, average hours worked and factor prices), we obtain the same results and, thus, the same welfare evaluation as in GE. The

[12]Note that in the notation $W^{GE}(B_0)$ we have skipped the dependency of $B$ on $\psi$. We do this to avoid cluttered notation. Nevertheless, the reader should keep in mind that a different $B$ could be either a change in replacement ratio, in potential duration or in both.

decomposition of the welfare gain due to a change from $B_0(\psi)$ to $B_1(\psi)$ can be written as:

$$\begin{aligned} W^{GE}(B_1) - W^{GE}(B_0) = & \overbrace{\widetilde{W}^{PE}(B_1; P_0^{GE}, F_0^{GE}) - \widetilde{W}^{PE}(B_0; P_0^{GE}, F_0^{GE})}^{\text{benefits effect}} \\ & + \overbrace{\widetilde{W}^{PE}(B_1; P_0^{GE}, F_1^{PE}) - \widetilde{W}^{PE}(B_1; P_0^{GE}, F_0^{GE})}^{\text{tax effect}} \\ & + \overbrace{\widetilde{W}^{PE}(B_1; P_1^{GE}, F_1^{GE}) - \widetilde{W}^{PE}(B_1; P_0^{GE}, F_1^{PE})}^{\text{price effect}} \ . \end{aligned} \tag{7}$$

The total effect of the policy change in general equilibrium can be decomposed as the sum of three different partial equilibrium effects: the benefits, tax, and price effects. The benefits effect accounts for the impact of changing the UI system but keeping everything else constant, including taxes. The tax effect corrects the calculations by the tax change needed to finance the change in the UI system. The price effect further adjusts the calculations for the price changes experienced as a result of the change in the UI system. Notice that the sum of the benefits and tax effects also account for the total effect in partial equilibrium.[13] This implies that the price effect is equivalent to the GE contribution, and encompasses what general equilibrium adds to the analysis.

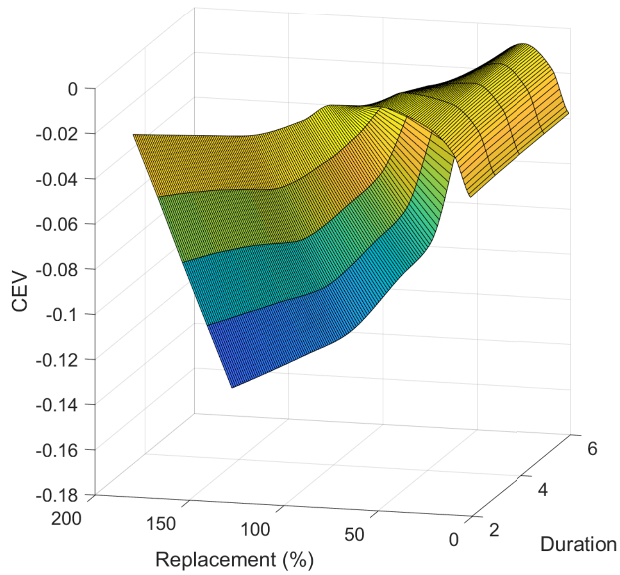
## 4.3 Welfare effects of UI

We now turn to the main results of our welfare evaluations. We evaluate welfare in steady state for different UI policies. To make sure that we are not identifying a critical point that is not a global maximum, we compute welfare for a grid of many combinations of replacement ratios and potential duration. We present the general results and identify the welfare maximizing policy. We then compare several alternatives to this optimal benchmark, *so that each result should be interpreted as the welfare loss due to being far from the welfare maximizing UI system*. Moreover, in what follows we concentrate mostly on duration values of at least two model periods. The reason is that in our model the first period is a transfer to all separated workers, independently of the extension of the unemployment spell. From the point of view of the worker's behavior, that type of transfer corresponds more to a severance pay than to unemployment insurance.

In Figure 6 we present the CEV measure after evaluating the grid in GE. At the origin (no benefits) there are welfare losses of about 4%. Welfare increases steeply with the replacement ratio until about 50%, which is the calibrated economy value. After this point, welfare

[13] The taxation policy $F_1^{PE}$ is consistent with $B_1(\psi)$, in the sense that it balances the budget in partial equilibrium.

**Figure 6:** Consumption equivalent welfare effects of UI in GE



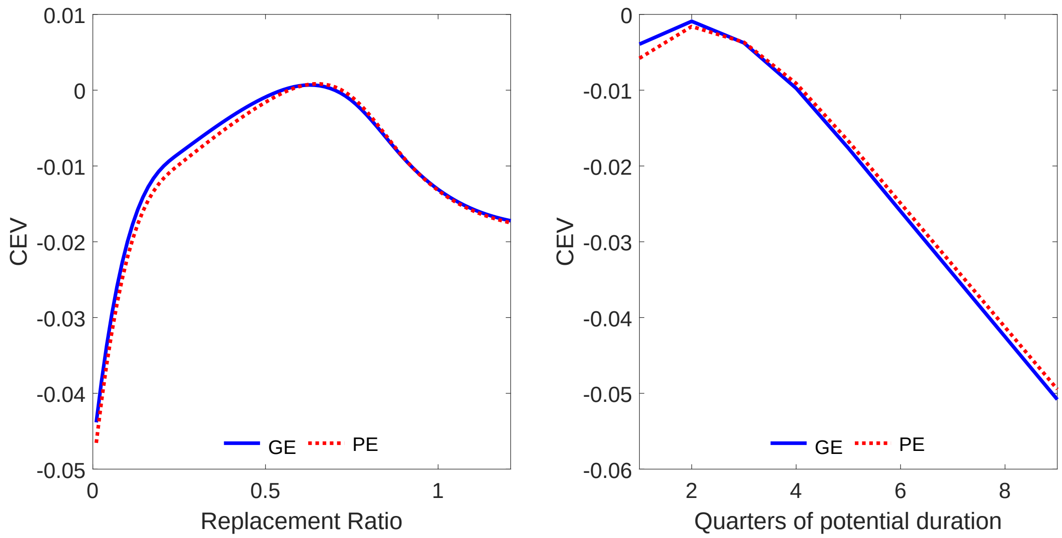

**Notes:** The figure plots the consumption equivalent measure (CEV) of welfare comparing each point in the grid of replacement and potential duration to the welfare maximizing UI (63% replacement ratio and 2 model periods). The plot is the result of a spline interpolation of the evaluations of a grid of replacement ratios and potential duration.

tends to stabilize and then falls. The fall is moderated when the potential duration is short (especially at 2 quarters, which is the calibrated duration) and steep when the potential duration is long (6 quarters or longer UI policies). In our model, long periods of high replacement ratios (150% for one year and a half, for example) generates a welfare loss of about 16%. But the same potential duration for a replacement ratio of 50% implies 2% welfare loss. The maximum welfare is reached at a replacement ratio of 63% and a potential duration of 2 model periods (six months), that is relatively close to the calibrated economy.

The blue solid line of Figure 7 plots two cuts of the previous function. Panel (a) plots CEV of changing the replacement ratio with a potential duration constant at 2 model periods. The welfare maximizing point is at replacement ratio of 63%. The welfare gain from the calibrated economy is only about 0.2% of permanent consumption, but again, the welfare gain compared to no-UI is substantial. Panel (b) shows the welfare effects of extending potential duration while keeping replacement ratio fixed to 50%. It shows that a duration of two model periods provides the highest level of welfare.

In Table 3 we present the effect of further increasing the generosity of UI from the welfare maximizing system on several variables. Column (2) shows the effect of increasing the replacement ratio 10 percentage points. Taxes increase from 13% to 14% and both capital and labor (employed human capital) decrease about 1%. The fall in labor is the result of a reduc-

**Figure 7:** Welfare effects of UI in general and partial equilibrium




(a) The effect of the replacement ratio (b) The effect of potential duration

**Notes:** The figure plots the CEV of welfare comparing UI systems to the welfare maximizing UI policy (63% replacement ratio and 2 model periods). Panel (a) sets potential duration to two model periods and shows different replacement ratios (a grid of replacement ratios is evaluated and the remaining levels are interpolated using a spline). Panel (b) sets replacement ratio to 50% and shows different potential durations. Blue lines plot cuts of the function presented in Figure 6 and are general equilibrioum (GE) evaluations. Dotted red lines are evaluations in partial equilibrium (PE).

tion in search effort (from 65% to 62% on average), the consequent increase in unemployment and lower average human capital of the employed, as well a change in total hours worked. Also, there is a small reduction in wages and a very small increase in interest rate. Column (4) also shows the same variables when UI potential duration increases to 3 model periods. Qualitatively, the effects are similar but they are quantitative stronger. Furthermore, the aggregate capital seems more affected in this case than human capital, leading to a stronger change in factor prices. Nevertheless, changes in prices are still very small (about 0.1%).

It is worth emphasizing that *factor prices are relatively unaffected around the welfare maximizing policy.* (See Figure 21 that provides a more general description of the effect of UI on the equilibrium variables.) This is a first indication that our environment generates a drastically different outcome from the previous literature that suggests large general equilibrium effects. For this reason, we now look deeper into the partial and general equilibrium effects.

**Partial and general equilibrium effects.** Figure 7 plots the CEV measure for a PE solution in red dashed lines. In both, panel (a) and panel (b), the welfare effects in PE are very similar to the ones in GE. In particular, the welfare maximizing policy is practically

**Table 3:** General and partial equilibrium effects of changes in the UI system

| Variable | Initial | Change in level GE | PE | Change in duration GE | PE |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Replacement | 0.63 | 0.73 | | 0.63 | |
| Pot.duration | 2 | 2 | | 3 | |
| | | *Change in % from the benchmark* | | | |
| Tax rate $\tau$ | 0.133 | 6.1 | 6.1 | 11.9 | 11.9 |
| Capital $K$ | 171.59 | -1.0 | -1.5 | -2.9 | -4.3 |
| Human cap. $H$ | 5.87 | -0.8 | -0.8 | -2.4 | -2.3 |
| Search $s$ | 0.65 | -5.0 | -5.0 | -18.6 | -18.7 |
| Unemployment | 0.07 | 5.3 | 5.3 | 28.1 | 28.1 |
| Ratio $K/H$ | 29.22 | -0.2 | -0.8 | -0.5 | -2.1 |
| Wage $w$ | 1.927 | -0.1 | 0.0 | -0.1 | 0.0 |
| Int. rate $r$ | 0.018 | 0.1 | 0.0 | 0.0 | 0.0 |

**Notes:** The table reproduces the effects of changing UI system in 10 percentage points of replacement ratio, columns (2) and (3), and one model period of potential duration, columns (4) and (5), from the welfare maximizing UI system. GE: general equilibrium. PE: partial equilibrium.

indistinguishable between the two. To emphasize this point, we appeal to Table 3 that presents information related to other variables involved in the previous exercise. Column (3) reports the main variables of the solution in PE when increasing 10 percentage points the replacement ratio from the welfare maximizing policy. In this case, capital decreases by approximately 2%, while human capital is reduced in 1%, leading to a reduction in the capital-labor ratio of less than 1%. This change in the PE capital-labor ratio is what generates a very small adjustment of factor prices when we allow for general equilibrium effects. In turn, the fact that wages tend to fall and interest rate tends to rise is what makes the capital-labor ratio even less responsive in GE. Overall, both solutions are strikingly similar. An analogous result can be obtained from the increase in potential duration in one additional quarter, shown in columns (4) and (5).[14]

**Decomposition.** Table 4 complements the previous results by performing the welfare loss decomposition described in equation (7). The next to last column corresponds to an increase in replacement ratio of 10 percentage points, while the last one corresponds to the increase in potential duration of one model period.

The increase in the replacement ratio decreases CEV by 0.09% in general equilibrium and by 0.06% in partial equilibrium. The decomposition provides that welfare changes are mostly explained by differences in the direct effect of the transfers–the benefits effect– and

[14]See Figure 21 for further description of the response of endogenous variables. The PE and GE solutions are indistinguishable for many of the endogenous variables.

**Table 4:** Welfare gains decomposition

| Variable | Benchmark/ | Change in UI | |
|---|---|---|---|
| | Tag | Level | Pot. duration |
| Replacement ratio | 0.63 | 0.73 | 0.63 |
| Potential duration | 2 | 2 | 3 |
| *Total welfare gains w.r.t. benchmark, CEV in %* | | | |
| General Equilibrium (GE) | | -0.09 | -1.25 |
| Partial Equilibrium (PE) | | -0.06 | -1.13 |
| Total Welfare Difference, GE-PE (price effect) | | -0.03 | -0.12 |
| Benefits effect | | 0.87 | 0.61 |
| Tax effect | | -0.93 | -1.73 |

**Notes:** The table reproduces the welfare decomposition of changing UI system in 10 percentage points and one model period from the welfare maximizing UI system. Welfare gains are decomposed according to equation (7) and transformed to CEV.

its implications in the government's tax policy. Interestingly, the general equilibrium effects that follow from the price change are small, and aids little to explain the differences between general equilibrium and partial equilibrium effects. The increase in potential duration provides similar results, but multiplied by more than an order of magnitude. The welfare effects are stronger, leading to an overall welfare loss of 1.25% in GE and 1.13% in PE, with a price effect of -0.12%. The stronger effects that we find when increasing the potential duration of the UI system are due to a significantly larger elasticity of the unemployment rate to changes in duration than to changes in the replacement ratio. As shown in Table 3 an increase of 16% (10/63) in the replacement ratio rises unemployment by 5.3%, so that the elasticity is around 1/3. Instead, the 50% (1/2) increase in potential duration rises unemployment by 28.3%, which implies an elasticity of almost 0.6. Since the gains due to insurance are similar, 0.9% vs. 0.6%, the larger required increase in taxes to finance the unemployed generates a substantially larger welfare loss.

Given these results, a natural question arises: what features of the environment generate the stark difference with the previous literature in general equilibrium? One may be worried that the UI system is also satisfying other needs. For instance, it could be helping agents to overcome their impossibility to intertemporally smooth consumption. In Section 6 we show that this is not the case. Instead, in Section 5 we argue that the mild GE effects are due to the low substitutability of private savings and public insurance.

# 5 Savings and the optimal UI system

In the previous section we showed that the price effect of changing the UI system is small, implying that the welfare maximizing UI system in general equilibrium is similar to that one in partial equilibrium. This is driven by the low sensitivity of the capital-labor ratio. In this section we single out the model ingredients affecting the way agents react to savings incentives, and how these feed in to the aggregate wealth distribution, playing a crucial role in determining the sensitivity of the capital-labor ratio. First, we emphasize the role of life-cycle effects by eliminating age-dependent features. We use this simplified model to discuss the relevance of the initial wealth distribution and of the elasticity of aggregate capital with respect to the unemployment insurance benefits. Second, we show how the model can generate a substantially different sensitivity of the capital-labor ratio to changes in the UI system as a result of how these changes affect the agents' incentives to save and work. In order to do so, we consider different taxation schemes, as savings rates strongly depend on the way the UI system is funded. We also show that the sign of the general equilibrium effect–the price effect–can be positive or negative. That is, whether the general equilibrium model suggests a more generous UI system than the partial equilibrium model crucially depends on the sign of the response of capital-labor ratio.

## 5.1 The relevance of life-cycle

We start by showing that a fundamental feature of our environment is the way workers save over their life span. To showcase this, we eliminate multiple features of the model that create heterogeneity across age groups, so that the savings behavior by agents and the equilibrium wealth distribution resemble those resulting from a model with infinitely lived agents. By contrasting the results in both models, we argue that the life-cycle profile of savings reduces the sensitivity of the capital-labor ratio.

Specifically, in this alternative setting we impose finite, but substantially longer lives, minimizing the resulting age-dependent profiles.[15] In particular, we double the number of periods in the labor market by setting $T = 344$. We set the death probability to a constant

[15] Alternatively, we could solve a standard Aiyagari (1994) economy with infinite lives, and agents subject to only unemployment risk. We have done so. However, our numerical explorations show areas of stability issues for some parameters values. The problem arises when the equilibrium interest rate is close to the discount rate. This happens when there is low (endogenous) risk or high insurance. This problem reduces the confidence on the results, especially on areas which are of interest. In contrast, maintaining the finite lives assumption, no matter how large the finite number, preserves the stability for all parameter values. Some alternative ways to overcome this concern would be: making the unemployment insurance system less generous, increasing the discount rate, or adding some extra idiosyncratic labor income risk. This last one seems particularly promising, but would further depart the model from our benchmark, complicating the analysis and comparison.

$\delta_j = 0.0047$ to get the same expected lifetime than in the calibrated economy[16], and the survival probability at retirement to $\delta_R = 0.008$ to double the expected lifetime at retirement. By setting these numbers, we extend the number of periods in the labor market and, at the same time, we reduce the importance of retirement: only 20% of each cohort becomes retired. This is important as we want to mimic a more stationary environment where incentives to save are kept approximately constant. Retirement is at odds with that purpose, in particular because retirees rapidly consume their assets. We also eliminate human capital accumulation, so that the job ladder has only one step, $\kappa = 1$, and we set human capital to the average in our baseline. We eliminate the dependency of the separation rates on age, by setting the separation rate to a constant $1 - \pi = 0.044$.[17]

Further, to approximate infinite lives, we allow workers to receive an inheritance at the beginning of their working lives. To this end, we assume that the wealth distribution at birth is equal to the wealth distribution of agents that die. Thus, the initial wealth distribution is endogenous, and will be affected by changes to the UI system. We additionally recalibrate the discount factor, the pensions level, the utility of leisure, and the search cost parameters. For that purpose we use indirect inference, where the targets are the capital output ratio of 2.7, the proportion of time spent at work of 0.34, the pension expenditures over GDP of 6.8%, the unemployment rate of 6.8%, and the elasticity of job-finding rate to UI level of -.32, the same targets as the baseline economy (see Table 1). We get $P = 0.0983$, $\beta = (0.9524)^{1/4}$, $\omega = 0.605$, $\gamma_0 = 0.299$, and $\gamma_1 = 1.7483$.

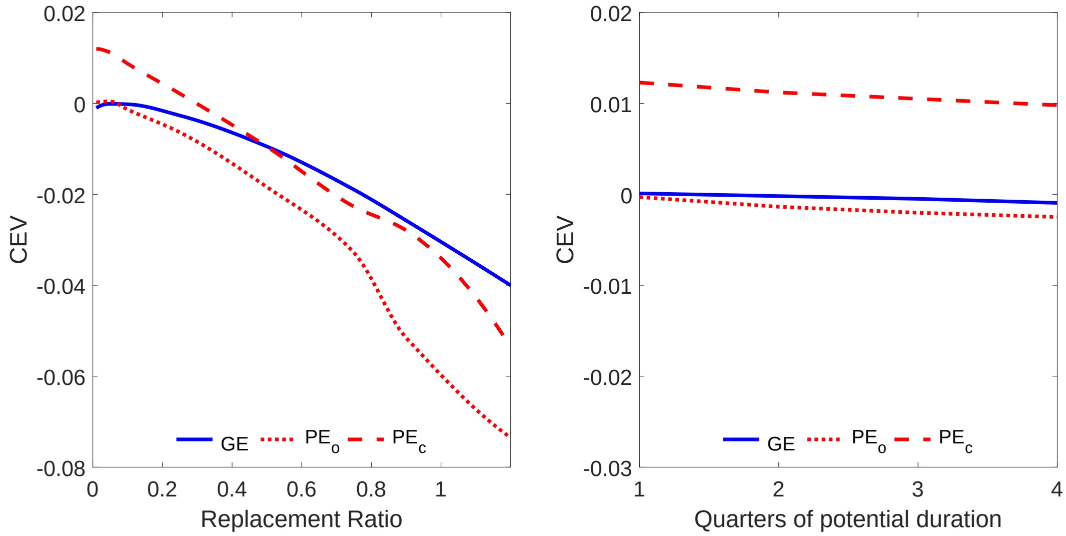
Figure 8 shows the welfare effects of changing the UI system in the simplified model. The policy that maximizes welfare in general equilibrium prescribes a replacement ratio of 5% with two model periods of potential duration. Here, the UI system does not provide much insurance. The potential welfare gains of moving from the current to the welfare maximizing policy are approximately 1% CEV. When we analyze the partial equilibrium solution we find that the welfare maximizing policy is similar to the one in general equilibrium.

Table 5 summarizes the changes in some relevant statistics when the replacement ratio increases by 10 percentage points above its welfare maximizing level. In general equilibrium aggregate capital $K$ falls 0.5%, human capital $H$ falls 0.5% and the capital-labor ratio $K/L$ falls 0.1%. In partial equilibrium $K$ falls 4.2%, $H$ increases 0.2%, and $K/L$ falls 4.4%. As the table shows, these differences also translate into differences in factor prices in GE: interest rate increases 0.1% while wages fall 0.03%. Notice how these results differ from those in the baseline calibration in Table 3, and included in Table 5 as Baseline to ease the discussion.

[16]The expected lifetime in our baseline economy is 53 years, which is composed by very high survival rate during the first 43 years and about 17 additional years of expected lifetime at retirement.

[17]This number is consistent to the average monthly layoff and dischargers in JOLTS from 2004 to 2012 (the same period for which we compute the calibrated unemployment rate of 6.8%).

**Figure 8:** Welfare effects of UI in general and partial equilibrium, diminished life-cycle effects




(a) The effect of the replacement ratio (b) The effect of potential duration

**Notes:** The figure plots the CEV measure comparing UI systems to the welfare maximizing UI policy in general equilibrium (5% replacement ratio and 2 model periods) for the extension without human capital or other life-cycle effects. Panel (a) fixes potential duration to two periods and studies the effect of changing the replacement ratio on welfare. Panel (b) fixes the replacement ratio to 5% and studies the effect of changing the potential duration of UI benefits on welfare. In both panels, the blue line represents the CEV differences in general equilibrium, the dashed red line represents the CEV differences in partial equilibrium where prices are consistent with a UI system with 0.5 replacement ratio and two periods of potential duration, and the dotted red line presents the CEV in partial equilibrium where prices are consistent with the welfare maximizing UI system.

In the baseline economy, changing the UI system away from the welfare maximizing policy generates very similar effects in allocations in both general and partial equilibrium. As the table shows, the same is not true in the economy with no age profiles.

There are two reasons for the larger response of aggregate capital. First, in this extension there are less incentives to save for retirement. Thus, the contribution of the employment risk motive to total savings is significantly larger, and therefore, aggregate savings are more responsive to UI. Second, the initial distribution is intergenerationally linked. Thus, any initial change in assets is then amplified. To be explicit, the fall in savings would reduce assets of the currently living. When they die, the drop in assets translates into the initial assets distribution of newborns. Given that this process continues *ad infinitum*; the fall in savings is amplified compared to the baseline life-cycle model.

Table 6 extends the decomposition of welfare changes, introducing the update in the initial distribution of assets. Again, we increase 10 percentage points the replacement ratio from the welfare maximizing policy, which is 5%, and compute welfare effects. For the ease of comparison, the column labeled Baseline reproduces the results of the baseline described

**Table 5:** General and partial equilibrium effects of an increase in replacement ratio of 10 pp from the optimal level, diminished life-cycle effects

| Variable | Baseline | | No life-cycle | |
|---|---|---|---|---|
| | GE | PE | GE | PE |
| Replacement ratio | 0.63 to 0.73 | | 0.05 to 0.15 | |
| Potential duration | 2 | | 2 | |
| *Change in %* | | | | |
| Capital $K$ | -1.0 | -1.5 | -0.5 | -4.2 |
| Human capital $H$ | -0.8 | -0.8 | -0.5 | 0.2 |
| Search effort $s$ | -5.0 | -5.0 | -1.7 | -1.5 |
| Unemployment | 5.3 | 5.3 | 1.6 | 1.5 |
| Ratio $K/H$ | -0.2 | -0.8 | -0.1 | -4.4 |
| Wage $w$ | -0.1 | 0.0 | -0.03 | 0.0 |
| Int. rate $r$ | 0.1 | 0.0 | 0.1 | 0.0 |

**Notes:** The table reproduces the effects on endogenous variables of changing UI system by 10 percentage points from the welfare maximizing UI system. GE: general equilibrium. PE: partial equilibrium.

in Table 4. Welfare effects in GE have small negative effects, of 0.03% CEV, while welfare losses in PE are larger, of -0.6%. Thus, moderating life-cycle effects from the model does not reduce welfare gains due to GE effects; the most important negative welfare effects are in PE. To understand them, we follow the decomposition. The uncompensated UI transfer (UI effect) increases welfare in 0.5%, while the corresponding increase in taxes leads to a welfare loss smaller in absolute value. From these two effects only, it seems that rising UI would provide small welfare gains. Nevertheless, when we let the initial distribution of assets to update, there is a very strong welfare loss of 0.6%: savings and assets are reduced due to the increase in UI, and this feeds into the initial distribution of assets, inducing a negative welfare effect. Notice, then, that all the negative welfare effects in PE are driven by this last effect. The comparison with the baseline, where this effect is not present, is clear.

The GE adds to the previous PE two additional steps: first, we change the factor prices taking initial distribution of assets fixed as in PE; second, we let the initial distribution of assets to update. When factor prices change ($r$ increase and $w$ drops) the welfare effect is negative but small (-0.05% CEV). But this price factor change induces an increase in savings and initial assets that more than compensates for the price factor change, inducing a welfare gain of about 0.6% CEV, as reported in the last line of Table 6.

All in all, this alternative environment shows that life-cycle effects are crucial for our result. While there are many differences with the baseline economy, we want to emphasize two main effects that are quantitatively important: the distribution of assets among the unemployed and the elasticity of aggregate capital.

In this extension the initial distribution of assets provides the unemployed a means to

**Table 6:** Welfare gains decomposition of an increase in replacement ratio of 10 pp from the optimal level, diminished life-cycle effects

| Variable | Baseline | No life-cycle |
|---|---|---|
| *Total welfare gains ($CEV \times 1000$) w.r.t. benchmark* | | |
| General Equilibrium | -0.90 | -0.33 |
| Partial Equilibrium | -0.63 | -5.79 |
| Difference GE-PE | -0.26 | 5.46 |
| UI effect | 8.74 | 5.06 |
| Tax effect | -9.29 | -4.61 |
| Initial distr. of assets | 0.00 | -6.21 |
| Price effect | -0.23 | - 0.45 |
| Initial distr. of assets in GE | 0.00 | 6.36 |

**Notes:** the table reproduces the decomposition of welfare effects of changing the UI system in 10 percentage points from the welfare maximizing UI system.

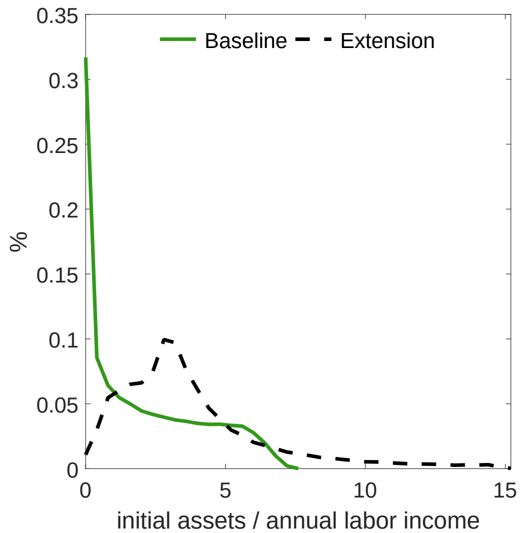
smooth consumption. Additionally, given that the income profile is flat, the incentives to save while young are stronger, and these initial assets are saved. As a result, the assets for the young are higher, and the overall distribution of assets is less concentrated in lower values. Panel (a) of Figure 9 shows the histogram of the assets of the unemployed workers at separation, comparing this extension with the baseline economy. In the life-cycle economy more than 25% of unemployed workers has little or no assets at the beginning of the unemployment spell. The corresponding proportion for this alternative environment is approximately 2%. Additionally, in this extension the mode corresponds to more than two years of average labor income, well above the required savings to finance a typical unemployment spell.

The second difference arising from the elimination of the life-cycle effects is that the elasticity of capital-labor ratio is higher. Panel (b) of Figure 9 shows capital-labor ratio and relative prices, $r/w$. Both axes are in logs. The green line represents the baseline economy with the calibrated level of benefits, under different relative prices.[18] The black line represents the analogous curve when the life cycle features are muted. The fact that the elasticity of the relative supply of factors is much lower in our baseline economy compared to the extension can be readily seen from the slope of these lines.

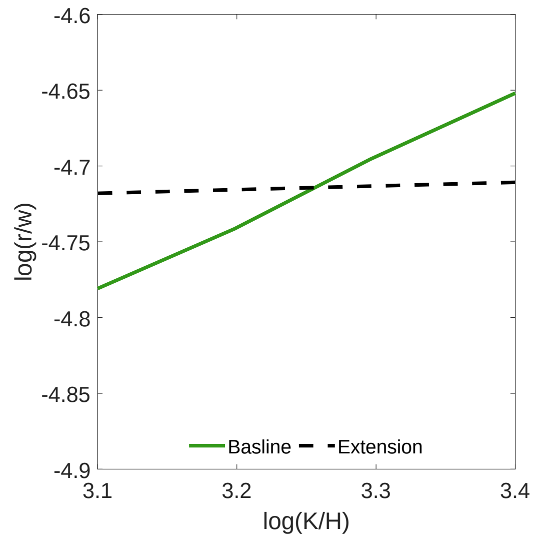
Figure 10 shows the same axis as in the previous figure. Again, solid lines represent the capital-labor ratio of the economy with the UI system as in the calibrated economy (50% replacement ratio for two model periods). In this figure, two additional lines are plotted

[18]The curve reports the adjustment of capital-labor ratio to relative factor prices. We consider different relative factor prices and compute the workers' problem in PE to get the labor and assets supplied. Taxes are kept constant at the calibrated level and the government budget is not necessarily satisfied.

**Figure 9:** Assets distribution among the unemployed and elasticity of relative factor supply




(a) Unemployed wealth distribution




(b) $K/H$ relative supply

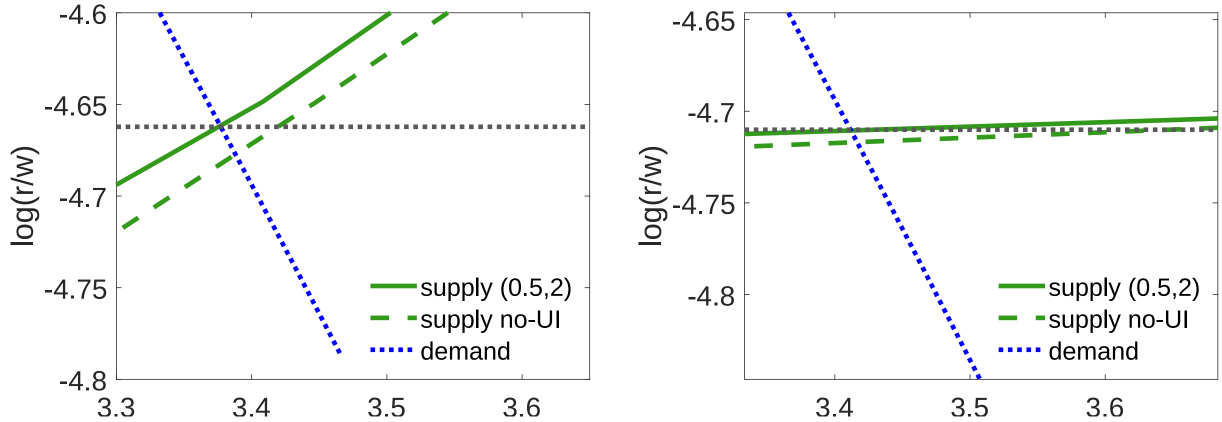
**Notes:** Panel (a) represents the distribution of assets relative to average annual labor income of the unemployed at the beginning of their spell, comparing our baseline economy and the extension without human capital accumulation or other life-cycle effects. Panel (b) reports the relative factor supply (in logs) as a function of relative factor prices at the calibrated system (50% of replacement ratio for two model periods or six months), comparing our baseline (green line) with the extension without human capital (black dashed line)

for each case. The negative slope (dotted) lines represent the relative demand of factors, that arise from the first order condition of the firms. In absence of depreciation, this would represent an elasticity of -1. The point in which the green dotted curve and the green solid curve intersect represent the relative prices and the relative factors in GE for our baseline economy, panel (a), and the extension, panel (b). Dashed lines represent the relative supply of factors in the no-UI case (a replacement ratio of zero). The elimination of UI shifts the supply curve to the right, implying that the capital-labor ratio increases if relative prices are kept constant. This can be observed with the help of the dotted black line. The comparison between both panels shows that the elasticity of capital-labor ratio with respect to UI is larger when there are no life-cycle effects.

The GE in the no-UI case is found where the dashed line intersect the negative sloped dotted line. To reach this point, relative prices adjust (interest rate down and wages up), reducing the capital-labor ratio in equilibrium. The comparison between the two panels again highlights the large elasticity of supply of relative factors with respect to relative prices in the extension: only a small change in prices is required to restore the capital-labor ratio in equilibrium in the extension.

All in all, Figure 10 emphasizes two important points: dropping life-cycle effects induces

**Figure 10:** Relative factor supply and demand




(a) Baseline (b) Extension

**Notes:** The figure reports the relative factor supply for different relative factor prices at the calibrated system (50% of replacement ratio for two model periods or six months) in the solid line, and of no-UI in dashed line, comparing our baseline (left panel) with the extension with diminished life-cycle effects (right panel). The negative slope dotted lines represent the relative factor demand in each case.

a higher elasticity of capital-labor ratio with respect to both prices and UI changes.

Along with the previous results, we can emphasize two characteristics of this extension: there are more assets to the unemployed and there is a stronger response of aggregate capital to UI. These are also features of the infinitely lived agents models, typically used in the literature to assess the welfare effects of UI in GE. In a way, this exercise shows the reason why infinitely lived agents models reject the relevance of UI is not the presence of general equilibrium effects, but that they generate assets distributions and elasticities that reduce welfare gains and increase welfare costs of UI, even in partial equilibrium.

One may wonder, what environment is more empirically accurate? First, we argue in Section 4, the baseline version clearly outperforms in terms of assets distribution the extension without human capital (see Table 2). This extension clearly generates little insurance needs among workers. Second, while the information on the elasticity of assets with respect to benefits is scarce, Engen and Gruber (2001), using 1984-1990 data from SIPP, report that increasing the replacement ratio 10% would lower broad asset holdings of employed workers by only 0.4%, implying an elasticity of -0.04.[19] *We find this same elasticity in our baseline model when we consider aggregate capital; the corresponding elasticity in the extension without human capital is much higher.* In a proper infinitely lived agent this elasticity would be even higher.[20]

[19]The paper reports several effects of UI on assets, but this is the more closely related to our exercise.

[20]This can be observed in Young (2004) where the elasticity seems very high: without price changes eliminating UI would increase aggregate assets by 63%. Also, in Koehne and Kuhn (2015) the elasticity is

## 5.2 Heterogeneous discount factors

Our results so far show that the distribution and the elasticity of assets are crucial to understand the welfare effects of UI. In particular, when life-cycle effects are mitigated, the model fails to reproduce the relevance of liquidity constraints of the data and increases elasticity of assets to levels empirically implausible, rendering UI worthless.

The literature has used heterogenous discount factors to generate larger dispersion in asset accumulation. As an example, Mukoyama (2010) extends one of the versions of the infinitely-lived agents models by introducing stochastic discount factors.[21] With this heterogeneity, that model generates more wealth dispersion and is able to reproduce a Gini of 0.8 (instead of 0.32 of the model with homogeneous discounting). In spite of this change in wealth dispersion, the results are qualitatively unchanged compared to the homogeneous case.

We now turn to evaluate up to what extent the introduction of heterogeneous discount factors in our extension could lead to a wealth distribution more in line with the data and fix the issues that arise when we abstract from the life-cycle effects. Additionally, we compute the welfare maximizing policy and compare it with previous results.

For that purpose, we extend the environment described in subsection 5.1 by introducing two types of workers, with low or high discount factor, $\beta_l$ and $\beta_h$, respectively. These types are randomly assigned at the beginning of the life. The other characteristics do not differ: both types begin their working life with the same chances of being unemployed and the same initial distribution of wealth. We calibrate these discount factors to maintain the aggregate capital-labor ratio and to generate an initial distribution of assets among the unemployed similar to the one in our baseline calibration. We consider this target more adequate for our purposes and more comparable to our baseline economy than the Gini of the overall wealth dispersion. On the whole, we set $\beta_l = (0.945)^{1/4}$ and $\beta_h = (0.967)^{1/4}$.

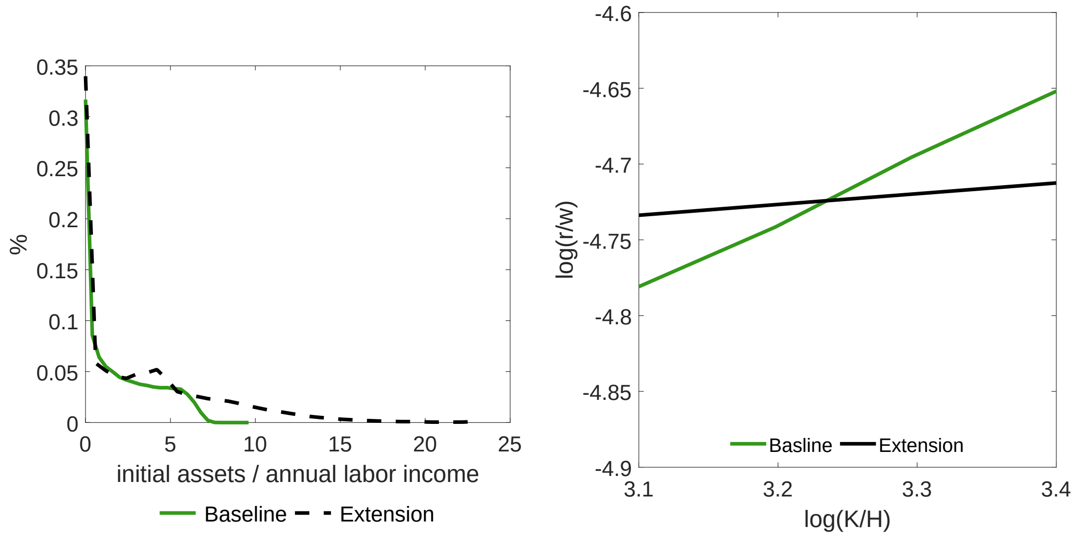
The left panel of Figure 11 plots the initial distribution of assets with this calibration. The black dashed line shows that, when we consider heterogeneous discount factors, more than 25% of the unemployed workers are liquidity constrained (close to the borrowing limit) at the beginning of their unemployment spell. This high proportion of unemployed workers with little wealth to self-smooth consumption can increase the social value of UI. For comparison, we also plot the same distribution in our baseline economy.

The left panel of Figure 12 shows the CEV of different replacement ratios in this extension, setting potential duration to two model periods. Both the partial equilibrium and the general

-1. While the exercises are not completely comparable, these responses illustrate the high elasticity in the infinitely lived agent model.

[21] Discount factors are governed by a three-state, first-order Markov process. The calibration in that paper is set so that 10% of the population are affected by the high level discount factor and 10% by the low level. The expected duration within these extreme values is 50 years in that model.

**Figure 11:** Assets distribution among the unemployed and elasticity of relative factor supply with heterogeneous discount factors




(a) Unemployed wealth distribution (b) $K/H$ relative supply

**Notes:** Panel (a) represents the distribution of assets relative to average annual labor income among the unemployed at the beginning of their spell, comparing our baseline economy and the extension without human capital accumulation and heterogeneous discount factors. Panel (b) reports the relative factor supply (in logs) as a function of relative factor prices at the calibrated system (50% of replacement ratio for two model periods or six months), comparing our baseline (green line) with the extension without human capital and heterogeneous discount factors (black line)

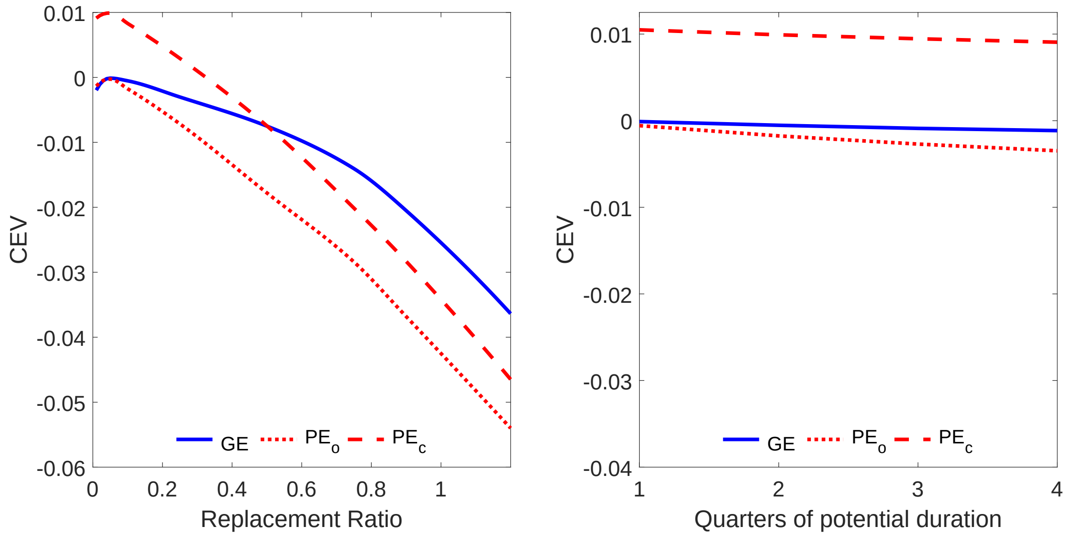
equilibrium evaluations indicate that the welfare maximizing replacement ratio is low. The plot is very close to the one presented in Figure 8 and the optimal level is not substantially different. Also, the CEV welfare gains from the calibrated economy to the optimal level of benefits are similar.

The right panel of Figure 12 shows the CEV of changing potential duration setting the replacement ratio fixed to a level close to the welfare maximizing policy. Again, this plot is similar to the one with homogeneous discounting.

Table 7 shows the effects of increasing the replacement ratio 10 pp. from the welfare maximizing level of 5%. For the ease of comparison, we reproduce the results of the homogeneous discounting case. The increase in UI reduces both capital and labor by 2.4% and 0.1%, respectively. The change in capital labor ratio in PE leads to a small change in factor prices in GE.

Table 8 provides the decomposition of welfare gains when the replacement ratio increases 10 pp from the welfare maximizing replacement ratio, comparing the economy with homogeneous discounting to the stochastic discount factor case. We find similar results for both cases. The main difference between the two cases is that with stochastic discounting the

**Figure 12:** Welfare effects of UI in general and partial equilibrium, diminished life-cycle effects and heterogeneous discount factors




(a) The effect of the replacement ratio (b) The effect of potential duration

**Notes:** The figure plots the CEV comparing UI systems to the welfare maximizing UI policy in general equilibrium (5% replacement ratio and 2 model periods) for the extension with diminished life-cycle effects and heterogeneous discount factors. Panel (a) fixes potential duration to two periods and studies the effect of changing the replacement ratio on welfare. Panel (b) fixes the replacement ratio to 5% and studies the effect of changing the potential duration of UI benefits on welfare. In both panels, the blue line represents the CEV differences in general equilibrium, the dashed red line represents the CEV differences in partial equilibrium where prices are consistent with a UI system with 0.5 replacement ratio and two periods of potential duration, and the dotted red line presents the CEV in partial equilibrium where prices are consistent with the welfare maximizing UI system.

**Table 7:** General and partial equilibrium effects of an increase in replacement ratio of 10 pp from the optimal level, extensions with diminished life-cycle effects and heterogeneous discount factors

| Variable | Homog. discount GE | Homog. discount PE | Het. discount GE | Het. discount PE |
|---|---|---|---|---|
| Replacement ratio | 0.05 to 0.15 | | 0.05 to 0.15 | |
| Potential duration | 2 | | 2 | |
| *Change in %* | | | | |
| Capital $K$ | -0.5 | -4.2 | -0.5 | -2.4 |
| Human cap $H$ | -0.5 | 0.2 | -0.5 | -0.1 |
| Unemployment | 1.6 | 1.5 | 1.7 | 1.5 |
| Ratio $K/H$ | -0.1 | -4.4 | -0.1 | -2.1 |
| Wage $w$ | -0.03 | 0 | -0.02 | 0 |
| Int. rate $r$ | 0.10 | 0 | 0.08 | 0 |

**Notes:** The table reproduces the effects on endogenous variables of changing UI system by 10 percentage points from the welfare maximizing UI system. GE: general equilibrium. PE: partial equilibrium.

effects of the initial distribution of assets are smaller in absolute value.

**Table 8:** Welfare gains decomposition of an increase in replacement ratio of 10 pp from the optimal level, extensions with diminished life-cycle effects and heterogeneous discount factors

| Variable | Homog. discount | Het. discount |
|---|---|---|
| *Total welfare gains* ($CEV \times 1000$) *w.r.t. benchmark* | | |
| General Equilibrium | -0.33 | -0.99 |
| Partial Equilibrium | -5.79 | -3.3 |
| Difference GE-PE | 5.46 | 2.3 |
| UI effect | 5.06 | 5.58 |
| Tax effect | -4.61 | -4.91 |
| Distribution of assets PE | -6.21 | -3.94 |
| Price effect | -0.45 | -0.33 |
| Distribution of assets GE | 6.36 | 2.9 |

**Notes:** the table reproduces the decomposition of welfare effects of changing the UI system in 10 percentage points from the welfare maximizing UI system.

The results discussed above show the paradoxical finding that, even when the distribution of assets among the unemployed change dramatically, the UI does not seem to gain social value. There are several mechanisms that can explain these facts. First, it is important to bear in mind that lowering the discount factor reduces the incentives to accumulate assets, and changes many other decisions at the same time. For example, for given state variables, a lower discounting induce higher consumption and, through the standard income effect, lower hours worked. Also, the incentives to search are reduced for given state variables. Furthermore, the job-finding elasticity with respect to UI increases substantially. These changes are apparent in the agent's policy functions. They contribute, directly or indirectly, to reduce the welfare gains of UI. These observations suggest that heterogeneous discount factors are effective to increase the importance of liquidity constraints at the calibrated economy but also change important aspects of the economy.

A second important point is that the elasticity of assets, both to UI and to prices, is still very high. The right panel of Figure 11 shows that the capital-labor ratio elasticity is much higher than the one of the baseline. The elasticity in this extension is slightly lower than the one with homogeneous discounting, but the change in capital is still very strong.

This issue turns out to be very important. A high elasticity of capital implies that any reduction in benefits induces a strong response on savings, and shifts the distribution of assets to the right. Of course, the changes in assets have in these extensions a direct effect on welfare: workers begin their life with more assets whenever there is balanced-budget reduction in UI. This affects the welfare value of UI (see the welfare effects of the initial distribution of assets in PE in Table 8.)

In other words, given that the assets' elasticity is still very high, liquidity constrained unemployed still exist in the economy at the calibrated level of UI. However, with lower levels of UI, savings increase so much that liquidity constrained workers are reduced. In this sense, public insurance gets compensated with private savings. This result emphasizes the importance of the assets' elasticity. If this elasticity is (too) high it is not enough to get the initial distribution of assets right.

A third point to emphasize is that the heterogeneity in discount factors also implies an heterogeneity in the valuation of future transfers. A low discount factor reduces the welfare effects of future conditional transfers such as UI; thus, from the point of view of an impatient employed worker, UI has little value. To illustrate this point we analyze the savings decisions of workers.

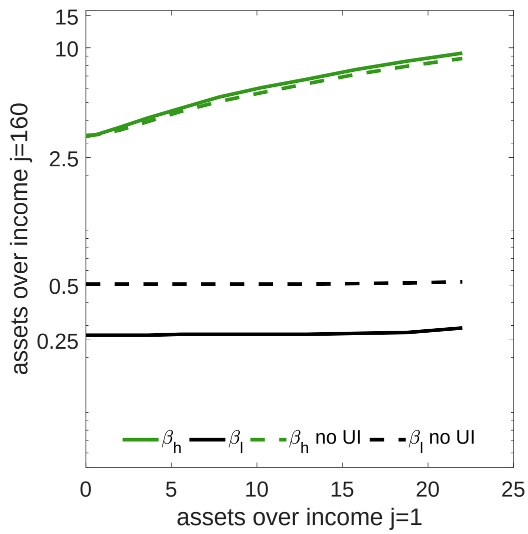
Figure 13 plots the median asset level of employed workers at $j = 160$ as a function of initial assets. The green solid line represents agents with high discount factors in the calibrated economy. Those workers increase assets as of that age compared to initial asset level. The black solid line represents the low discount workers. These assets are in all cases very low. When impatient workers begin their working life with substantial amount of assets (equivalent to 10 years of annual average income, for example) they deplete their wealth progressively so that at $j = 160$ they only have about one quarter of average income. If born without assets, workers with high discount factor save up to three years of average income while workers with low discount factor save up to a quarter of income; this means that they continue to be asset poor the whole working life.

In Figure 13 dashed lines represent the no UI case (when UI replacement ratio is set close to zero). Impatient workers born without assets save more when they do not have UI, but just above half a year of average income. The assets holdings at $j = 160$ are lower for the patient workers. This is because with no UI $r$ is lower (the capital-labor ratio is larger than in the calibrated economy).

All in all, Figure 13 suggests that workers with low discount factors decide to be asset poor. Their priority is current consumption (of both goods and time); the future outcomes, such as the possibility of becoming unemployed, are less relevant for their current welfare. Thus, UI transfers will be also less relevant for the welfare of the employed impatient worker.

In a nutshell, the introduction of heterogeneous discount factors allows a more accurate calibration of wealth dispersion, but at the cost of introducing many other changes directly related to the valuation of UI transfers or indirectly to its social costs. Additionally, this setup does not address the issue of the elasticity of assets. If this elasticity is (too) high it is not enough to get the initial distribution of assets right.

**Figure 13:** Median assets at $j = 160$ as a function of assets at $j = 1$ by worker type




**Notes:** The figure plots the median assets normalized by aggregate annual income at $j = 160$ as a function of normalized initial assets, comparing workers with high and low discount factors. Solid lines represent the calibrated economy; dashed lines represent the economy without UI.

## 5.3 The role of savings responses

In our baseline economy, an increase in the capital-labor ratio generates welfare gains through the price effect. The most obvious reason is that an increase in wages will benefit agents. At the beginning of their lives, workers have no assets and can only earn labor income. Hence, an increase in wages would clearly improve their welfare. Because the production function exhibits complementarity between capital and labor, an increase in the capital-labor ratio increases wages.

Since the only effect of GE is through prices (with the behavioral responses associated to them), the positive link between wages and the capital-labor ratio is a convenient feature that helps us clarify the GE effect. Moreover, because workers are born with no assets, the sign of the price effect is transparent in our model. We use this feature to show that GE effect could be positive or negative, according to the response of capital-labor ratio to UI.

The response of savings strongly depends on taxes. We now change how taxes are collected to allow for different results. To this end, we consider two different extensions. In the first extension, government expenditures are financed 80% by proportional taxes to labor income and 20% by an additional tax on capital income, $\tau_k$. This extension would generate a stronger response of savings to UI. In our second extension, government expenditures are financed 50% by proportional taxes to labor income and 50% by a lump-sum tax at the end of working life, $\mathcal{T}$, up to a maximum (equivalent to half of the assets at the end of working life). In this case, a more generous UI would affect savings less than in the baseline model.

We focus on the difference between PE and GE in the welfare analysis. To be clear, we do not intend to show the convenience of introducing these changes in taxes, but rather to use them to induce different responses of aggregate capital-labor ratio to UI in PE.

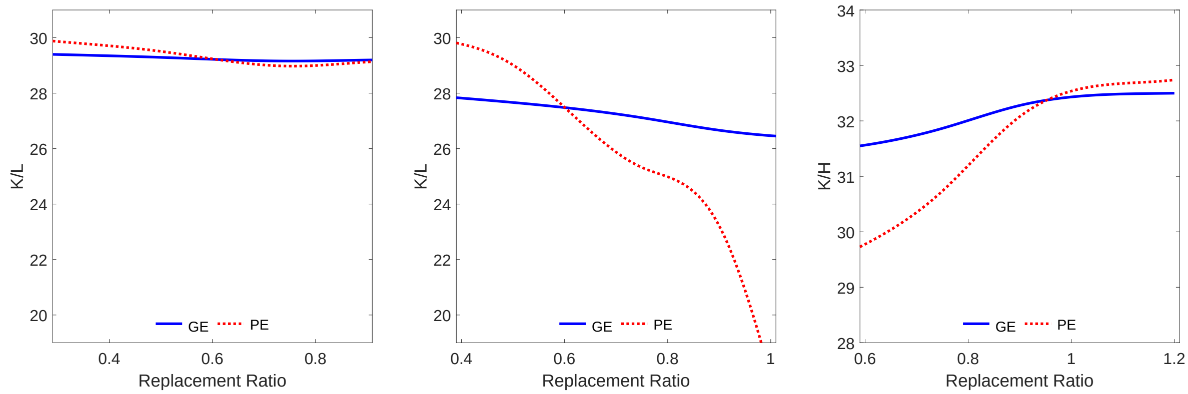
**Results** Figure 14 shows the capital-labor ratio under different replacement ratios setting the potential duration to two model periods. For convenience, we reproduce the baseline economy, panel (a), and we plot the alternative sources of taxation in panel (b) and (c). The dotted red lines are the solutions in PE. There is a clear contrast between the three cases. The capital-labor ratio is almost constant in the baseline economy, decreasing in the economy with capital tax and mostly increasing in the economy with lump sum taxation.

The intuition for the reduction in the ratio due to capital taxation, Panel (b), is that a more generous UI requires a rise in both labor and capital income taxes, reducing not only the means to accumulate assets, but also the incentives. In contrast, in the economy with lump-sum taxes, Panel (c), the capital-labor ratio is increasing. When UI increases labor taxes rise less compared to the baseline economy, but now the workers must pay a large lump-sum tax upon retirement. This implies that the worker must save to cover this future expected tax. These three different responses of capital-labor ratio in PE generate different GE effects.

In Figure 15 we plot the CEV for different UI replacement ratios under three scenarios: the baseline in Panel (a) (same as Panel (b) of Figure 7), the economy with capital taxes, Panel (b), and the economy with a lump-sum taxation, Panel (c). The potential duration is maintained in two model periods, which is the optimal potential duration in all cases. The figure plots CEV evaluated in PE in the dotted red line and in GE in the solid blue line.

In the baseline, PE and GE evaluations are almost indistinguishable, delivering almost the same optimal replacement ratio. In the economy with capital income taxes, Panel (b), the GE effect evaluated at the optimal policy is negative. This implies that any increase in the replacement ratio would yield a higher welfare gain in PE than in GE. This can be seen in the difference between the slopes in the figure: the PE slope is higher than the GE slope. Consequently, in the welfare maximizing GE evaluation, when the slope in the figure is flat, the PE evaluation still yields welfare gains. The optimal replacement ratio is thus higher in PE (71%) than in GE (63%). The reason for this result is that an increase in UI generosity

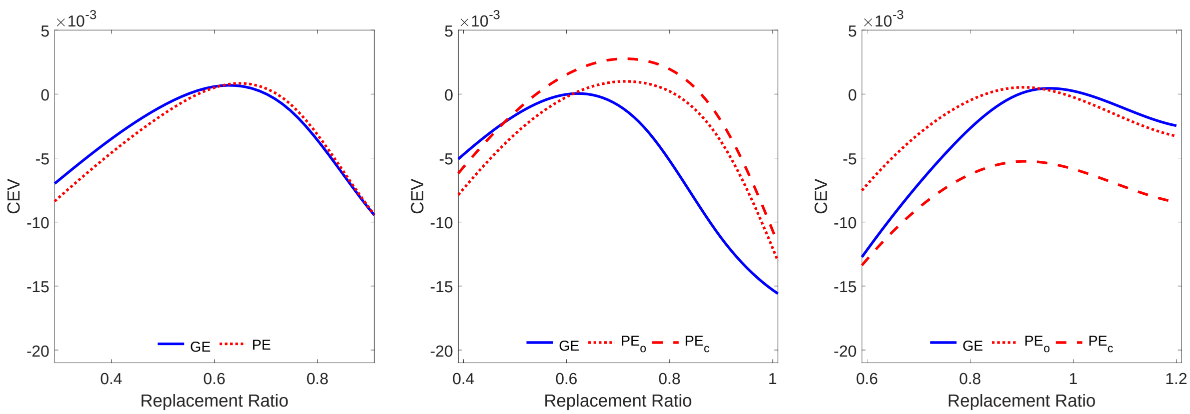
**Figure 14:** Capital-labor ratio under different tax arrangements




(a) Baseline (b) Capital tax (c) Lump-sum tax

**Notes:** Equilibrium capital-labor ratio from changing replacement ratio, fixing potential duration to two periods. Panel (a) is baseline economy, panel (b) is the extension with capital tax, and panel (c) the extension with a lump-sum tax.

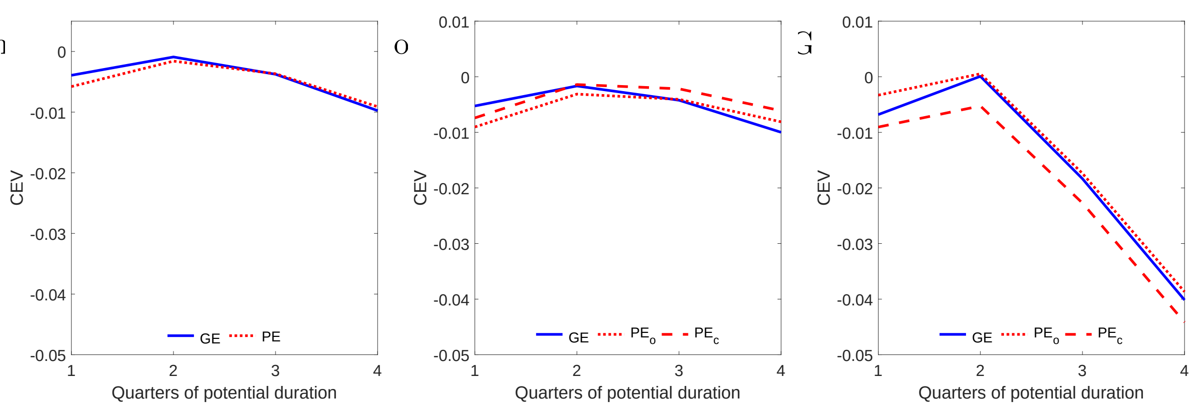
**Figure 15:** Welfare effects of UI replacement ratio under different tax arrangements




(a) Baseline (b) Capital tax (c) Lump-sum tax

**Notes:** The figure plots CEV of changing replacement ratios fixing potential duration to two model periods. Panel (a) reproduces Figure 7. Panels (b) and (c) show extensions with capital and lump-sum tax, respectively. The dashed line labeled $PE_c$ is CEV in PE with prices fixed to the calibrated economy (replacement ratio =50% and potential duration=2). The $PE_o$ line is CEV in PE with prices fixed to the optimal policy, 63% replacement ratio in Panel (b) and 88% in Panel (c).

**Figure 16:** Welfare effects of UI potential duration under different tax arrangements




(a) Baseline (b) Capital tax (c) Lump-sum tax

**Notes:** The figure plots the CEV of changing UI potential duration while setting replacement ratios constant and close to the welfare maximizing replacement ratio in each case. See additional notes to Figure 15.

**Table 9:** General and partial equilibrium effects of an increase in replacement ratio of 10 pp from the optimal level, extensions with different tax arrangements

| Variable | Baseline | | Capital tax | | Lump-sum tax | |
|---|---|---|---|---|---|---|
| | GE | PE | GE | PE | GE | PE |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Replacement ratio | 0.63 to 0.73 | | 0.63 to 0.73 | | 0.88 to 0.98 | |
| Pot.duration | 2 | | 2 | | 2 | |
| *Change in %* | | | | | | |
| Capital $K$ | -1.0 | -1.5 | -1.6 | -7.0 | -0.8 | 0.8 |
| Human cap. $H$ | -0.8 | -0.8 | -0.8 | -0.2 | -1.4 | -1.5 |
| Search $s$ | -5.0 | -5.0 | -4.8 | -4.7 | -14.7 | -14.7 |
| Unemployment | 5.3 | 5.3 | 5.2 | 5.1 | 10.8 | 10.9 |
| Ratio $K/H$ | -0.2 | -0.8 | -0.8 | -6.8 | 0.6 | 2.4 |
| Wage $w$ | -0.1 | 0.0 | -0.2 | 0.0 | 0.2 | 0.0 |
| Int. rate $r$ | 0.1 | 0.0 | 1.0 | 0.0 | -0.7 | 0.0 |

**Notes:** The table reproduces the effects of changing UI system in 10 percentage points from the welfare maximizing system for the baseline economy (columns (1) and (2)), for the extension with capital tax (columns (3) and (4)) and for the extension with a lump-sum tax (columns (5) and (6)).

Instead, when the UI is partially funded with lump-sum taxes at the end of the working life the GE effect is positive. This means that the welfare gains in PE are lower than in GE. This can be observed from the slopes of the figure. At the optimal GE replacement ratio, the slope of the PE welfare function is negative. This means that the replacement ratio that maximizes welfare in PE (89%) is lower than in GE (95%). The reason for this is that capital-labor ratio increases with a more generous UI.

Figure 15, panels (b) and (c), reproduce two PE welfare evaluations. The first one, labeled $PE_c$, uses factor prices of the calibrated economy. The second one, labeled $PE_o$, uses factor prices in the welfare maximizing GE replacement ratio. This last, crosses the $GE$ line in its maximum. An important feature of these two PE welfare evaluations is that they are approximately parallel. This implies that the initial price at which we evaluate PE economies does not change the welfare maximizing policy.

For completeness, in Figure 16 we present the analogous to Figure 15 but keeping fix the replacement ratio and moving potential duration. In the baseline economy, welfare gains in PE and GE are similar and almost indistinguishable. With taxes to capital income the welfare gains in PE are clearly higher than the gains in GE. Finally, with lump-sum taxes upon retirement, welfare gains in GE are higher than those in PE. This could be appreciated when changing potential duration from 1 to 2; for longer potential durations the difference is minor.

In Table 9 we provide information about some endogenous variables due to an increase

**Table 10:** Welfare gains decomposition of an increase in replacement ratio of 10 pp from the optimal level, extensions with different tax arrangements

| Variable | Baseline (1) | Capital tax (2) | Lump-sum tax (3) |
|---|---|---|---|
| *Total welfare gains* ($CEV \times 1000$) *w.r.t. benchmark* | | | |
| General Equilibrium | -0.90 | -0.98 | -2.45 |
| Partial Equilibrium | -0.63 | 0.79 | -3.54 |
| Difference GE-PE (price effect) | -0.26 | -1.78 | 1.09 |
| UI effect | 8.74 | 8.49 | 9.07 |
| Tax effect | -9.29 | -7.57 | -12.38 |

**Notes:** The table reproduces the welfare decomposition of increasing UI replacement ratios in 10 percentage points from the welfare maximizing system, comparing the baseline economy, column (1), the extension with capital income tax, column (2), and the extension with a lump-sum tax, column (3).

in the replacement ratio, to complement Figure 14. For the ease of comparison, columns (1) and (2) reproduce the results for the baseline economy. Columns (3) and (4) show the results for the economy with capital taxes. Comparing these two, the large difference between GE and PE is evident. The reduction in aggregate capital is 7% in PE, while the decrease in human capital is 0.2%. There is, thus, a substantial reduction in the capital-labor ratio of 6.8% in PE. This large substitutability between private and public insurance leads to a large change in prices, increasing the net return to capital in 1% and decreasing wages in 0.2%, in general equilibrium. Columns (5) and (6) show the results for the economy with a lump-sum tax. In this case, on the contrary, an increase in UI replacement ratio induces a rise in the capital-labor ratio of about 2.4% in PE, generated by a decrease in human capital of about 1.5% and an increase in aggregate capital of 0.8%. In GE, thus, price changes have the opposite sign: wages increase (0.2%) while net returns to capital go down in 0.7%.

The discrepancy in the elasticity of the capital-labor ratio reflects in important differences between the welfare evaluations of the partial vs. general equilibria. Table 10 presents the welfare decomposition exercise when replacement ratio increases 10 percentage points. Column (1) reproduces the decomposition in our baseline economy, while column (2) and (3) presents the results for the extensions. As described above, the difference between GE and PE welfare gains are negative (-0.18% of CEV) when there are taxes to capital income, and are positive (0.1% of CEV) when there is a lump-sum tax at the end of the working life. These difference are the price effect, that depends on the capital-labor ratio.

# 6 Robustness

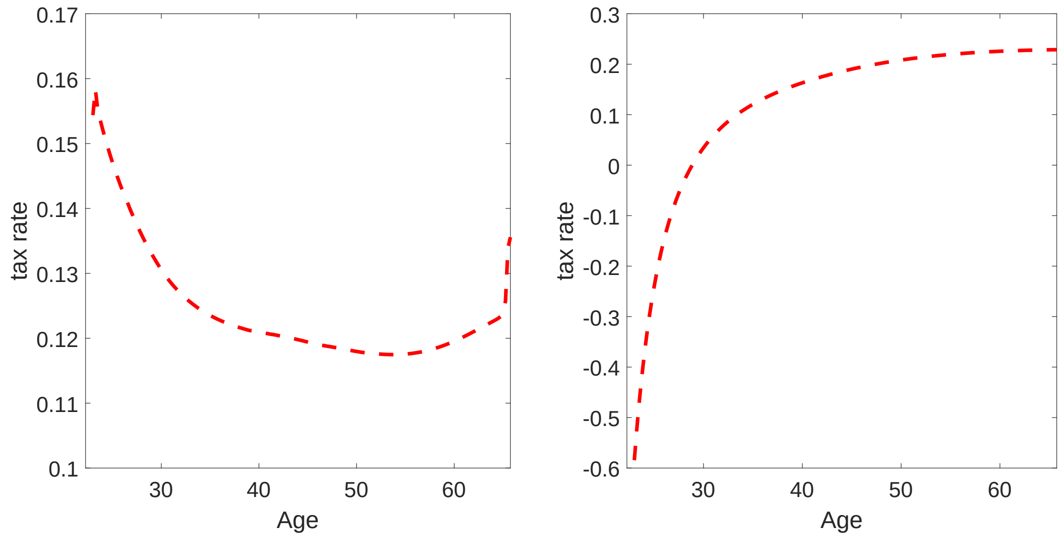
We have shown our main conclusions through our life-cycle model. In our baseline economy, GE and PE evaluations do not differ much around the calibrated UI policy and the welfare maximizing UI is close to the current policy in both GE and PE. So far we have restricted the planner to use only a replacement ratio and potential duration. Thus, the planner has not enough instruments. For example, we do not let the planner to choose age-dependent UI (Michelacci and Ruffo, 2015), or condition UI to assets (Koehne and Kuhn, 2015).

A concern could be that the planner might be using UI to make transfers to the young and, in this way, smooth consumption through life, ameliorating the effects of liquidity constraints. Given that young workers have higher unemployment risk, a higher UI would be an intergenerational transfer. To address this concern, we consider two extensions. In the first extension we eliminate the possibility of intergenerational transfers by balancing the UI budget by age: UI transfers for age $j$ are financed by a labor income tax for workers of the same age. In the second extension we eliminate the life-cycle income profile by setting age-dependent taxes, while keeping the benchmark UI system, flattening the income profile. Note that in both cases we use age-dependent taxes, but in the first case tax rates are higher for the young and in the second tax rates are negative for the young, see Figure 17. We focus on whether the welfare maximizing UI policy changes compared to the baseline model.

The welfare maximizing policy does not change much: the potential duration is again two model periods and the replacement ratio is slightly above the calibrated one. Figure 18 shows the CEV of different replacement ratios for two quarters of potential duration. Panel (a) shows the CEV for the economy in which UI budget is balanced by age; panel (b) shows the CEV for the economy in which net labor income profile is flat. In both cases, the welfare maximizing policy is close to 50% (56% in panel (a) and 53% in panel (b)). As in the baseline, the GE and PE evaluations do not differ much.

Both cases appear to be similar in shape and at their maxima. Nevertheless, the welfare gains are lower in panel (b). For example, the no-UI welfare loss is close to 4% in panel (a) and 2.5% in panel (b). The main difference between the two cases is that when the labor income is constant in age, workers save earlier in life. Thus, they can more effectively self-smooth consumption during the unemployment spell. At the same time, this behavior generates a distribution of assets that is less connected with the data, with fewer liquidity constrained workers. All in all, these exercises show that our results are not driven by a planner using UI to attain intergenerational transfers: when we eliminate this possibility, through a budget by age, or we erase differences in average labor income by age, the main results are maintained.

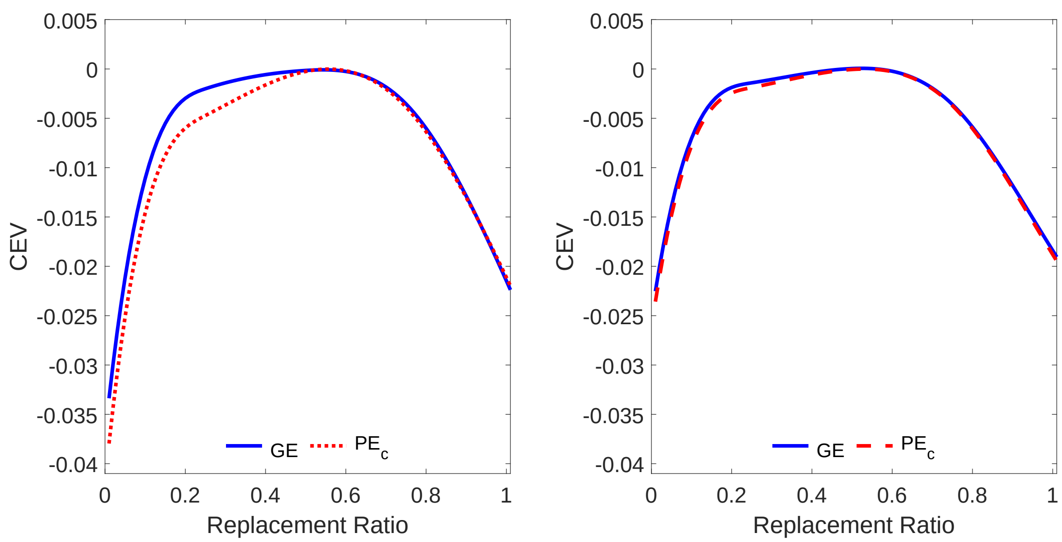
**Figure 17:** Age-dependent tax rates




(a) Balanced budget by age (b) Constant profile of net labor income

**Notes:** The figure plots the age dependent tax rates for the robustness cases in which UI for a given age is financed by taxes to employed workers of the same age, panel (a), and in which age dependent taxes are set to provide a constant profile of net labor income, panel (b).

**Figure 18:** Welfare effects of UI under age-dependent taxes




(a) Balanced budget by age (b) Constant age profile of net labor income

**Notes:** The figure plots the CEV of changing UI replacement ratios setting potential duration to two model periods in the two robustness exercises (see additional notes to Figure 7.)

# 7 Conclusion

This paper evaluates the welfare effects of unemployment insurance in general equilibrium using a life-cycle model. With our quantitative model, calibrated to the US economy, we have shown that unemployment benefits provide important welfare gains. The welfare maximizing policy is moderately more generous than the current one. We obtained similar results for the evaluation in general equilibrium and in partial equilibrium, when factor prices do not adjust. Additionally, we provided a decomposition of welfare gains that shows that the price effect is relatively small in our baseline model. It follows that the general equilibrium effects do not necessarily impose strong welfare costs – as the literature seems to suggest. Life-cycle effects provide two relevant features: the distribution of assets among the unemployed reproduces the importance of liquidity constraints of the data and the response of aggregate capital to benefits is weakened. We discussed some extensions of the model to show these features. The elimination of human capital accumulation and the endogenous provision of initial asset as coming from legacies – among other changes – reduce the relevance of life-cycle effects and at the same time eliminate most of the welfare impact of unemployment insurance. Two crucial features of this extension are that the distribution of savings are such that there are few asset-poor unemployed workers, reducing insurance needs, and that aggregate capital responds strongly to unemployment insurance, increasing costs of providing insurance.

The focus of this paper was the economic mechanisms that savings and capital introduce in general equilibrium. But in the broader literature, there is another important general equilibrium effect. The search externalities and congestion effects in matching models can alter the welfare effects of unemployment insurance and other policies related to job-search decisions. The possible interaction between the two effects is an avenue of future work.

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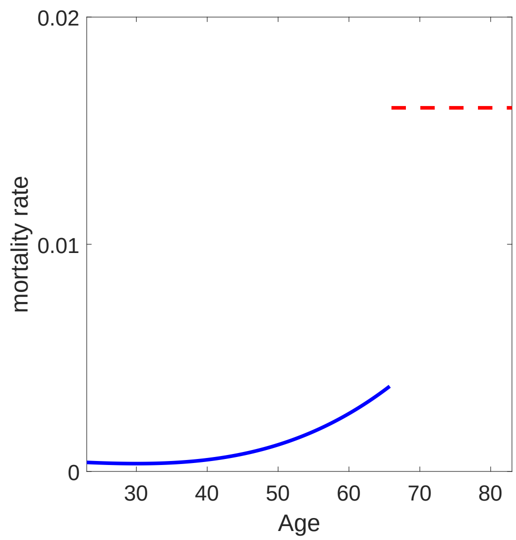
# Appendix

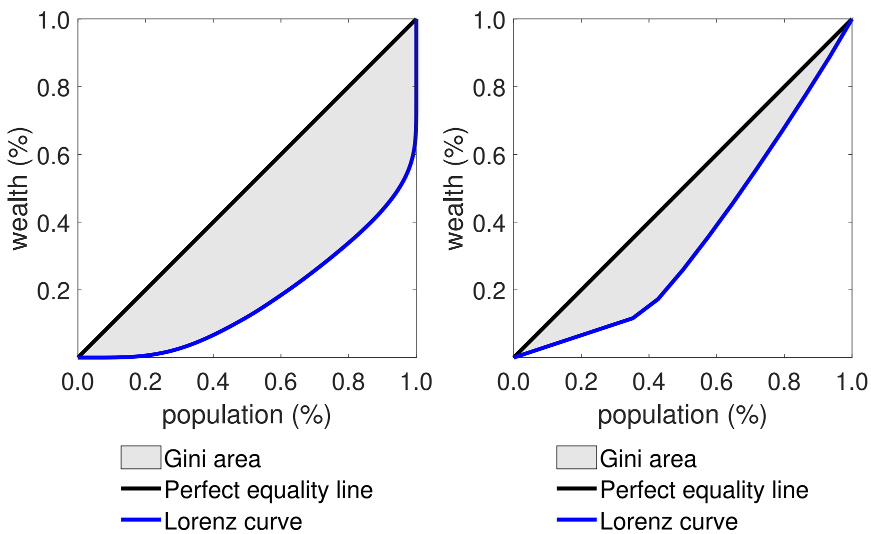
# A Appendix of figures

**Figure 19:** Mortality rates by age




**Notes:** Mortality rates of the model. Up to age 65 these rates are computed from Social Security Administration data; from then on a constant rate is set to reproduce 17 years of life expectancy.

**Figure 20:** Assets and wages distribution

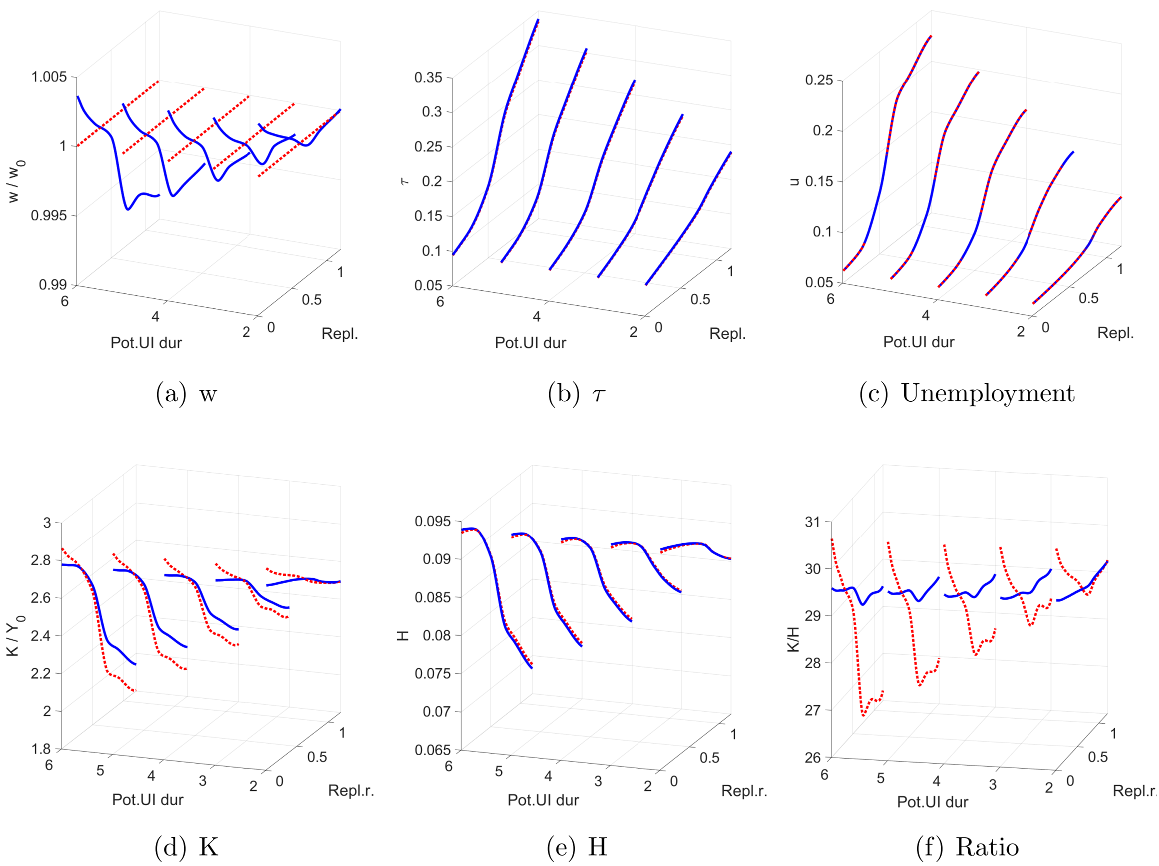



(a) Assets

(b) Wages

**Notes:** The figure reports the Lorenz curve of the assets, panel (a), and wages, panel (b), in the calibrated model.

**Figure 21:** Endogenous variables in GE and PE




**Notes:** The figure plots endogenous variables in GE (blue solid lines) and PE (red dotted lines) for different UI systems, characterized by replacement ratios and potential durations. Panel (a) reports wages as a ratio to the wage in the calibrated economy.

# B Calibration

## B.1 Human capital

We calibrate the human capital function $h(\kappa)$ and the probability of moving up the labor capital ladder $\hat{\chi}$ by matching the empirical return to experience function. As it is standard in the labor literature we postulate a regression that relates wages with experience, educational attainment, and some controls correlated with ability,

$$\ln w_{i,j} = \sum_j \alpha_j \mathbf{I}_j + \alpha_x' X_i + \beta t_i^c + \sum_{\kappa \in \mathbf{K}} \alpha_\kappa' \mathbf{I}_\kappa + \varepsilon_{i,j} \ , \ \varepsilon_{i,j} \sim N(0, \sigma) \tag{8}$$

where $w_{i,j}$ denotes the wage of individual $i$ at time $j$, $t_i^c$ denotes individual $i$ time spent in college, $\mathbf{I}_\kappa$ is a dummy variable for each experience level $\kappa$, and $\mathbf{I}_j$ is a dummy for each year. Notice that we are not imposing a functional form for the return to experience. Instead, our non parametric specification allows each experience level to affect wages in a different way. We run this regression using data from *National Longitudinal Survey of the Youth 1979* and we present the results of the estimation in Table 11. To use the regression results to back out $h(\kappa)$ notice that in the model the hourly wage is $wh(\kappa)$ so that equation (8) can be rewritten as

$$\ln h_{i,j}(\kappa) = \sum_j \alpha_j \mathbf{I}_j + \alpha_x' X_i + \beta t_i^c + \sum_{l \leq \kappa} \alpha_l' \mathbf{I}_l - \ln w + \varepsilon_{i,j} \ , \ \varepsilon_{i,j} \sim N(0, \sigma) \ ,$$

so that the human capital function implied by the data is

$$h(\kappa) = e^{\sum_{l \leq \kappa} \alpha_l \mathbf{I}_l} \tag{9}$$

## B.2 Search cost function

We calibrate the search cost function to the unemployment rate and to the elasticity of job-finding rate with respect to UI benefits. For that purpose we compute the elasticity in the model as follows. First, we consider an increase of 10% of benefit level in a partial equilibrium economy maintaining the tax rate constant. We measure the change in the search effort (job-finding rate) in partial equilibrium for each state variable and we aggregate this change using the distribution of unemployed workers of the baseline economy. We think that this exercise is more in line with elasticities estimations that arise from comparing changes in benefits for some eligible UI recipients only, such as those analyzed by Landais (2015). The elasticities presented in that paper are the result of exploiting regression kink methods for different states of the US. This method compares the unemployment duration of eligible UI unemployed workers within the state in a given period. Thus, this elasticity can be interpreted as a purely labor supply decision, with no role for general equilibrium or macroeconomic effects.[22] Second, we focus only on the effect on the first period job-finding rate. We do this because the response of job-finding rate is key in the periods in which the worker is eligible, and less relevant afterwards.

[22]We use the result in Table A4, third column, which we consider an intermediate level of those reported within Landais (2015).

**Table 11:** Returns to experience

| $\ln w_{i,j}$ | coefficient | standard error |
|---|---|---|
| Yearly experience | | |
| 2nd year | 0.142 | 0.016 |
| 3rd year | 0.202 | 0.016 |
| 4th year | 0.269 | 0.016 |
| 5th year | 0.332 | 0.016 |
| 6th year | 0.350 | 0.016 |
| 7th year | 0.388 | 0.016 |
| 8th year | 0.425 | 0.017 |
| 9th year | 0.440 | 0.017 |
| 10th year | 0.468 | 0.017 |
| 11th year | 0.474 | 0.018 |
| 12th year | 0.498 | 0.018 |
| 13th year | 0.527 | 0.019 |
| 14th year | 0.527 | 0.019 |
| 15th year | 0.558 | 0.02 |
| 16th year | 0.578 | 0.021 |
| 17th year | 0.576 | 0.022 |
| 18th year | 0.600 | 0.022 |
| 19th year | 0.586 | 0.023 |
| 20th year | 0.600 | 0.023 |
| 21st year | 0.615 | 0.024 |
| 22nd year | 0.637 | 0.025 |
| 23rd year | 0.647 | 0.025 |
| 24th year | 0.677 | 0.026 |
| 25th year | 0.682 | 0.026 |
| 26th year | 0.690 | 0.027 |
| 27th year | 0.721 | 0.027 |
| 28th year | 0.737 | 0.028 |
| 29th year | 0.745 | 0.029 |
| 30th year | 0.781 | 0.030 |
| 31st year | 0.761 | 0.032 |
| 32nd year | 0.781 | 0.035 |
| 33rd year | 0.786 | 0.037 |
| 34th year | 0.803 | 0.044 |
| Controls | | |
| male | 0.216 | 0.004 |
| minority | -0.071 | 0.004 |
| time in college $t_i^c$ | 0.072 | 0.001 |
| constant | 0.112 | 0.018 |
| Year dummies | YES | |
| R-squared | 0.166 | |
| # of observations | 48491 | |

**Notes:** The coefficients are the result of estimating equation (8) with data from the NLSY79. We trimmed the data in the following way: we dropped all the observations for agents which did not have at least 10 observed wages and whose average wage is in the lowest or highest 5 percent of the average wage distribution. We look at wages of individuals that graduated from high-school between 1977 and 1992 and for which we have at least 10 observations of wages. We further trimmed the data to discard individuals which average wages where either in the lowest or highest 5 percentile of the average wage distribution. Our wage data starts in 1979 on an yearly basis until 1991 and then bi-yearly until 2010.

# C Measures

Let $\mathbf{1}(a' = \mathbf{a})$ be an indicator function which takes the value of one if $a' = \mathbf{a}$.

The measures $X_j^e(a,\kappa)$, $X_j^u(a,\kappa,\psi)$, $X^R(a)$ solve the following system of equations,

$$
\begin{aligned}
\frac{X^R(a')}{1-\delta_R} &= \frac{1-\delta_T}{1-\delta_R}\left[\int\int X_T^e(a,\kappa)\mathbf{1}\left(a' = a_j^e(a,\kappa)\right) da d\kappa\right. \\
&\quad \left. + \int\int\int X_T^u(a,\kappa,\psi)\mathbf{1}\left(a' = a_j^u(a,\kappa,\psi)\right) da d\kappa d\psi\right] \\
&\quad + \int X^R(a)\mathbf{1}\left(a' = a^R(a)\right) da \\
\frac{X_{j+1}^u(a',\kappa+1,1)}{1-\delta_j} &= (1-\pi_j)\int X_j^e(a,\kappa+1)\mathbf{1}\left(a' = a_j^e(a,\kappa+1)\right) da \\
\frac{X_{j+1}^u(a',\kappa+1,\psi+1)}{1-\delta_j} &= \int\left[1 - s_j(a,\kappa+1,\psi)\right] X_j^u(a,\kappa+1,\psi)\mathbf{1}\left(a' = a_j^u(a,\kappa+1,\psi)\right) da \\
X_1^u(0,1) &= 1-\pi_0 \\
X_1^u(a,1) &= 0 \text{ for } a > 0 \\
\frac{X_{j+1}^e(a',\kappa+1)}{1-\delta_j} &= \pi_j\int \chi\left(n_j(a,\kappa)\right) X_j^e(a,\kappa)\mathbf{1}\left(a' = a_j^e(a,\kappa)\right) da \\
&\quad + \pi_j\int\left[1-\chi\left(n_j(a,\kappa+1)\right)\right] X_j^e(a,\kappa+1)\mathbf{1}\left(a' = a_j^e(a,\kappa+1)\right) da \\
&\quad + \int\int s_j(a,\kappa+1,\psi)X_j^u(a,\kappa+1,\psi)\mathbf{1}\left(a' = a_j^u(a,\kappa+1,\psi)\right) d\psi da \\
X_1^e(0,1) &= \pi_0 \\
X_1^e(a,1) &= 0 \text{ for } a > 0
\end{aligned}
$$

For the previous equations, we have assumed that agents are born with no assets and that a proportion $1-\pi_0$ begin their working life without a job.

# D Numerical Algorithm

Given any policy rule $B(\psi)$, fix a equally spaced grid $A = [a_1, a_2, ..., a_{Na}]$ of points for assets. Here we set $a_1 = 0$, $a_{Na} = 50$ and $Na = 1500$. Fix a grid for human capital $H = [h_1, h_2, ..., h_{Nh}]$. With $h_1 = 0.25$, $Nh = 10$. Each $h_i$ for $i = 2, ..., Nh$ is generated using the Mincerian equation. Finally fix a tolerance level $\epsilon > 0$ sufficiently small. These are the parameters of the algorithm and are kept fixed throughout. Then, choose a capital-labor ratio $R_0$ and total government expenses $\Psi_0$. Then.

Step 1 Given $R_0$ compute the implied wage, $w$, and interest rate, $r$, using the firm's first order conditions. Then, given prices we can solve the problem of the retired agent. This is done using the standard value function iteration method. The solution to this problem generates a value function $V^r(a)$ and a policy function $a'^r(a)$.

Step 2 Given factor prices and $\Psi_0$ compute the tax, $\tau$, that makes the government budget constraint hold with equality.

Step 3 Given $\tau$, $r$, $w$ and $V^r(a)$ we solve the employed and unemployed problem by backward induction. In this step is important to notice that the optimal search effort depends only on the continuation utilities. That is, taking first order conditions we obtain

$$\hat{s}(j,h,a',\psi) = 1 - \left[\frac{\gamma_0}{\beta(1-\delta_j)[V^e_{j+1}(a',h) - V^u_{j+1}(a',h,\psi+1)]}\right]^{1/\gamma_1}$$

Since the solution to this equation does not guaranty that $s \in [0,1]$ we choose

$$s(j,h,a',\psi) = \min\{\max\{\hat{s}(j,h,a',\psi),0\},1\}$$

Note that this is not the optimal search effort yet, since it depends on $a'$ and not on $a$. It only says how much effort the agent would exert contingent on saving $a'$. However, we can replace the above equation in the value function of the unemployed agent reducing the dimensionality of the maximization problem. Once we performed the maximization we obtain $a'^u(j,h,a,\psi)$ and therefore the optimal search effort is given by,

$$s^*(j,h,a,\psi) = s(j,h,a'^u(j,h,a,\psi),\psi)$$

Finally, the employed agent problem generates $a'^e(j,h,a,\psi)$

Step 4 Given $a'^e(j,h,a)$, $a'^u(j,h,a,\psi)$, $a'^r(a)$ and $s^*(j,h,a,\psi)$ we compute the measures using the laws of motions of Section 2.4. Once the measures has been computed we calculate aggregate workers capital, $K'$, aggregate labor, $L$ and total government expenses $\Psi_1$.

Step 5 Given $K'$ and $L$ compute $R_1 = \frac{K'+K^{ent}}{L}$ and check distances. If $|R_0 - R_1| < \epsilon$ stop: solution found. Otherwise set $R_0 = \phi R_1 + (1-\phi)R_0$, for some $\phi \in (0,1)$ and $\Psi_0 = \Psi_1$, and go to Step 1.