Unemployment Insurance when the Wealth Distribution Matters*

Facundo Piguillem
EIEF and CEPR

Hernán Ruffo
UTDT

Nicholas Trachter
Federal Reserve Bank of Richmond

December, 2024

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.

*We thank Fernando Alvarez, Oscar Avila, Emilio Espino, Mark Huggett, Francesco Lippi, Guido Lorenzoni, Guido Menzio, Claudio Michelacci, Juan Pablo Nicolini, Luigi Pistaferri, Rob Shimer, and seminar participants at UTDT, UNLP, CAF, and the Launch @ lunch seminars at EIEF, and SED, Rome Junior Macro, LAMES, RIDGE, LAVG, CEF, EEA-ESEM, and PET conferences for useful comments. The views expressed herein are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of Richmond or the Federal Reserve System.

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 the 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 frameworks 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 modeling choice reduces the welfare gains and increases 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 shortcut 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.[1]

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

[1]In this paper we concentrate on the role of factor prices through capital-labor ratio, and we abstract from the role of search externalities and possible congestion effects present in matching models, effects that are important but independent to the main message of this paper (Krusell et al., 2010; Landais et al., 2018).

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 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 that analyze general equilibrium effects. They do so by introducing capital as a production factor. These articles 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). The main argument is that both assets and labor are reduced by UI, causing aggregate activity to decrease (Young, 2004). Thus, once general equilibrium effects are taken into account, the induced social costs of UI are strong. It is worth noting that the sizable impact of general equilibrium responses is not specific to UI but it is also present any problem of public provision of insurance, as in Krueger and Kubler (2006).

Unlike Krueger and Kubler (2006), the UI literature has mostly appealed to infinitely lived agent's models. This choice has been used in Young (2004), which 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 far from generating wealth dispersion that maps to insurance needs.[2] Additionally, Young (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.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 on 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 firm's first order conditions provide the competitive prices:

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

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

[2]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 heterogeneous (random) discount factors. Hence, wealth dispersion is the agents' optimal choice, and uncorrelated with income shocks.

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 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 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,

[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.

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 κ 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 to the firm, $nh(\kappa)$, and net of the tax liabilities τ, 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 ψ 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 κ, 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 κ and current unemployment duration ψ.

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:

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

A natural implication of the retired agent's problem is that consumption and assets accumulation depend on 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:

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

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, since retirement is mandatory after at T, the optimal search effort choice is 0 at $j = T$. 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:

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

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: $c = c_j^e(a,\kappa)$, $a' = a_j^e(a,\kappa)$, 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:

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

where $X^R(a)$ denotes the measure of retired agents with wealth a; $X_j^e(a,\kappa)$ denotes the measure of employed agents of age j, with wealth a in the job ladder step κ; $X_j^u(a,\kappa,\psi)$ denotes the measure of unemployed agents of age j, with wealth a, who where in the job ladder step κ, but have been unemployed for ψ 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 $X^R(a)$, $X_j^e(a,\kappa)$, $X_j^u(a,\kappa,\psi)$ $\forall j, a, \kappa, \psi$, such that:

1. Agents maximize utility,

2. Markets clear,

$$H \;=\; \int h(\kappa)n_j(a,\kappa)X_j^e(a,\kappa)d(j\times a\times\kappa), \tag{2}$$

$$K \;=\; \int a\left[X^r(a) + X_j^e(a,\kappa) + X_j^u(a,\kappa,\psi)\right]d(j\times a\times\kappa\times\psi). \tag{3}$$

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

3. The feasibility constraint is satisfied,

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

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)).

Table 1: Calibration of parameters and functions

Parameter/function	Value	How to calibrate	Moment	
			Model	Data
		Imputed parameters		
Capital share of output α	0.3	standard	-	-
Depreciation rate d	0.01	standard	0.05 annual†	-
Death probability $\delta(j)$	see Figure 18	Social Security data	-	-
Job keeping probability π_j	see left panel of Figure 3	estimates from CPS data	-	-
		Calibrated parameters		
Discount factor β	$(0.96)^{1/4}$	capital to output ratio (2.7)	2.7	-
Labor disutility ω	0.65	40-42 hours worked per week	0.34	0.34
Risk aversion σ	3.86	risk aversion of retirees= 2	-	-
Search cost: level p. γ_0	0.27	avg. unemployment rate (2004-12)	0.068	0.068
Search cost: elast. p. γ_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 ψ	2	unemployment duration of 26 weeks	-	-
Pension system P	0.045	pension expenditures over GDP	0.068	0.068
Tax rate τ	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.

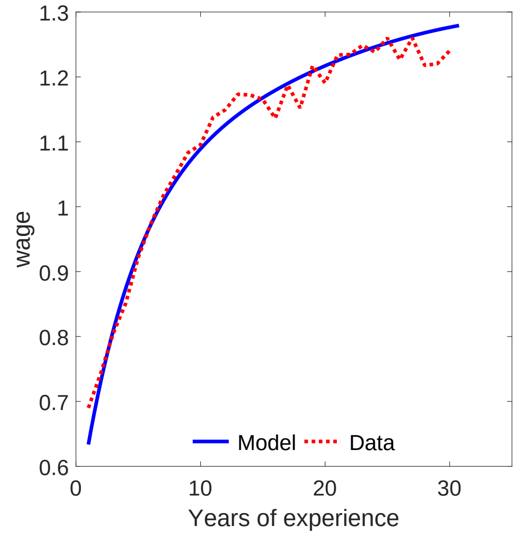
Capital share of output α, depreciation rate d, death probability δ_j and job-keeping probability π_j. As it is standard in the literature we set the capital share of output α to be 0.3 and the depreciation rate to $d = 0.01$.[6] We quantify the death probability δ_j using the 2007 United States survival probability actuarial data collected by the Social Security Administration (see Figure 18).[7] Notice that in our model we impose the same death probability δ_R for retired agents (with age above 65). We compute δ_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]

[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.

[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.

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 β. As it is standard we target the capital to GDP ratio to calibrate β. Higher values of it induce higher savings, which in turn increases the capital output ratio.

Labor disutility ω *and risk aversion parameter* σ. A higher value for ω decreases labor intensity n. Thus, we use the average number of hours worked by the employed as a moment to identify ω. 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 σ 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

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

moving up in the ladder is constant and independent of both n and κ. 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 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 γ_0 and γ_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 a UI system according to the sufficient statistic literature (Chetty, 2008). In the model, we measure the elasticity as the partial effects of a change on benefits. To be precise, we change only the benefit level (B), while keeping taxes and other general equilibrium variables constant. We do this to isolate the effect of benefits in the job-finding rate, and closely connect with the empirical literature that compares workers unemployment duration with different UI levels, but with otherwise similar environments.[10] 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

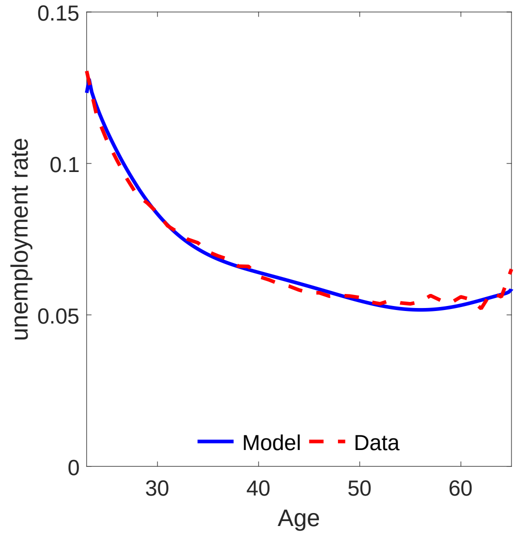
In this section we present the main results of the paper. We first show how the model performs in non-targeted moments and then we present the welfare evaluations of alternative unemployment insurance policies.

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

[10] For example Landais (2015). For additional details regarding the procedure for calibrating this function see in Appendix B.2.

Figure 2: Unemployment rate by age



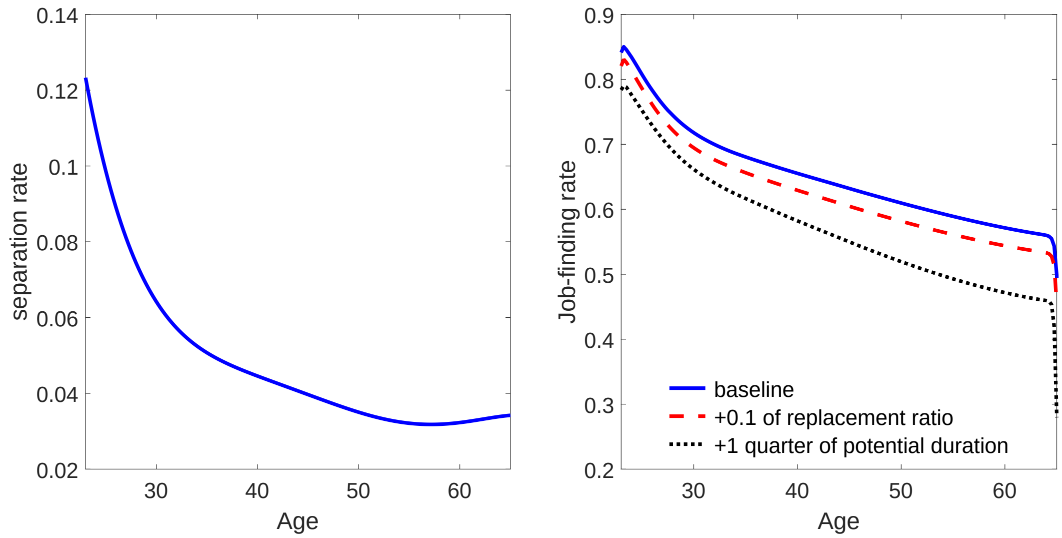
Notes: The red (dashed) line is the unemployment rate by age from the data, as implied by the CPS job finding and job keeping rates. The blue (solid) line is the unemployment rate from the calibrated model.

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) separations 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 the job-finding rate drops because workers are about to retire, decreasing the value of finding a job.

To understand the response 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 incentive to search for workers of all ages. The effect of the change in the policy is more pronounced for older

Figure 3: Job-finding and separation rates



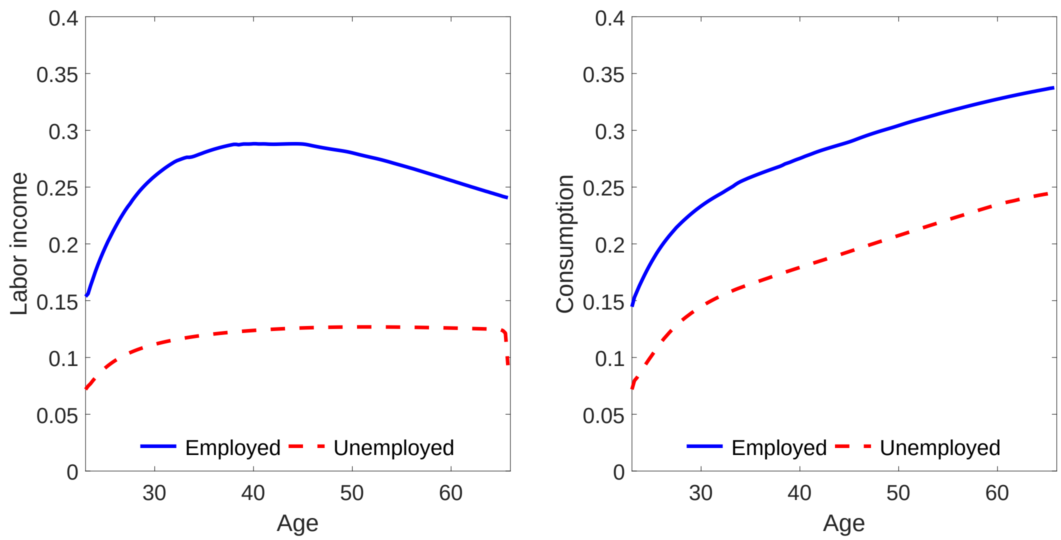
(a) Separation (b) Job-finding

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. 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 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 is it 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 depicts 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

Figure 4: Income and consumption through the life-cycle



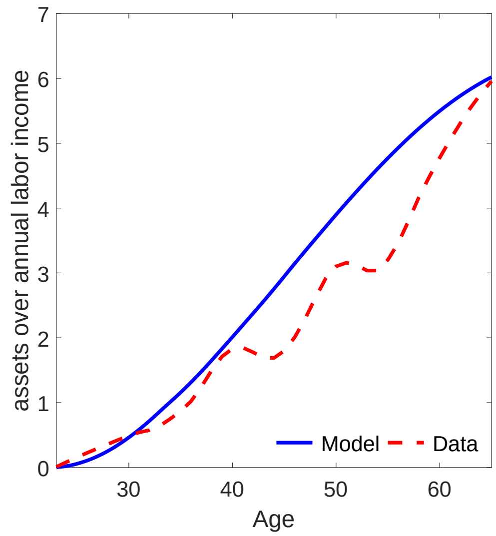
(a) Labor income (b) Consumption

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.

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 fall in the average UI transfers for those periods. Panel (b) in the figure depicts the evolution of average consumption of the employed and unemployed. Consumption levels are increasing in age, which is consistent with the accumulation of human capital and assets. The difference in consumption between employed and unemployed are the result of their lower income. In particular, older unemployed workers are more affected by longer unemployment spells and UI exhaustion.

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

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.

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 only driven by unemployment risk.

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 19). 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.[11]

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.[12] The model

[11] 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.

[12] We consider the wealth of the unemployed at the beginning of their unemployment spell. We do so to

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.

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 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,

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

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.

where V_1^e and V_1^u are the value functions of employed and unemployed workers at age 1, and u_1 (≈ 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.[13] 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

[13]Note that in the notation $W^{GE}(B_0)$ we have skipped the dependency of B on ψ. 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.[14] This implies that the price effect is equivalent to the GE contribution, and encompasses what general equilibrium adds to the analysis.

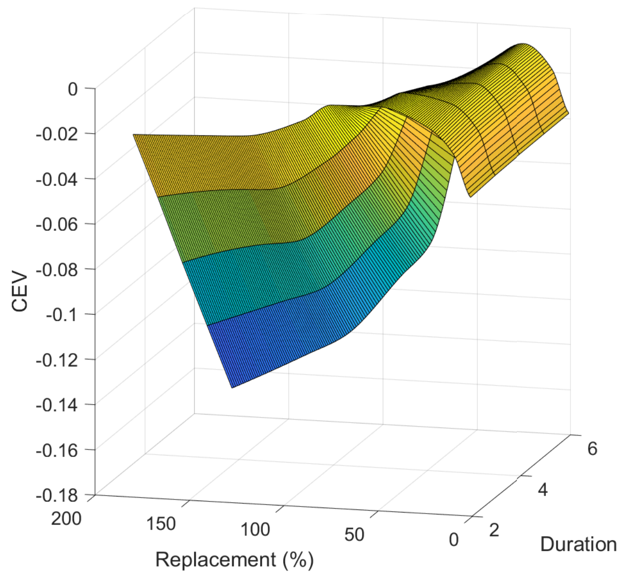
4.3 Welfare effects of UI

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, the first period transfer is similar to a severance pay beyond its unemployment insurance component.

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

[14]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



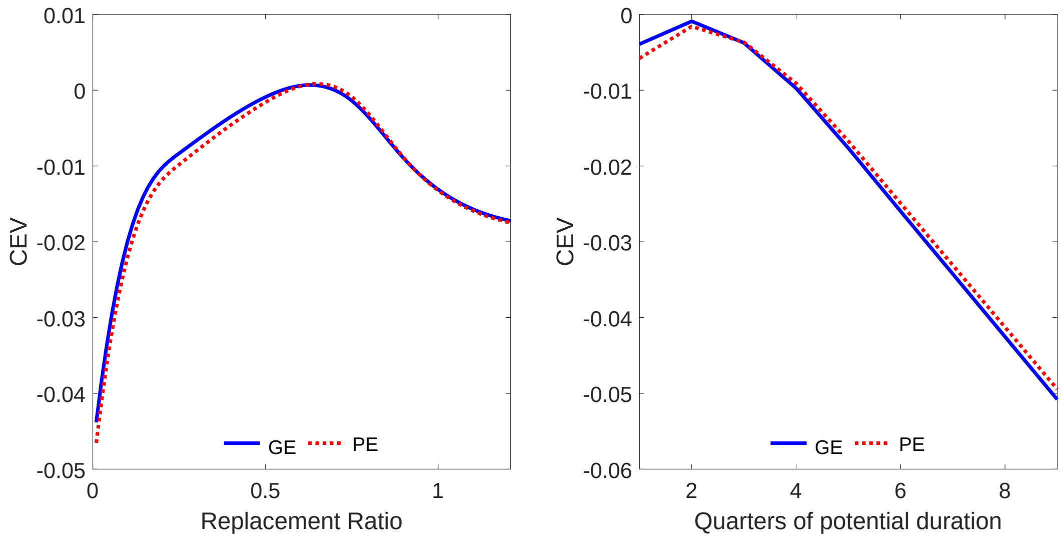
Notes: The figure plots the consumption equivalent measure (CEV) of welfare comparing each point in the grid of replacement and potential duration to the welfare maximizing UI (63% replacement ratio and 2 model periods). The plot is the result of a spline interpolation of the evaluations of a grid of 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 slices of Figure 6. 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 20, providing a more general description of the UI effect on the equilibrium objects.) 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 indistinguishable between the two. To emphasize this point, we appeal to Table 3 that

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

Variable	Initial	Change in level GE	Change in level PE	Change in duration GE	Change in duration 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 τ	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.

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 in general equilibrium. 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).[15]

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 its implications in the government's tax policy. Interestingly, the general equilibrium effects

[15]See Figure 20 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/ Tag	Change in UI Level	Change in UI 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.

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

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, which is, in turn, the result of some relevant components of the model and it is pinned down by the calibration.

In this section we illustrate how the different elements affecting the way agents react to savings incentives, feed into the aggregate wealth distribution and play a crucial role in determining the sensitivity of the capital-labor ratio. We do so by studying variations of our quantitative model. First, we emphasize the role of life-cycle motive by solving an Aiyagari economy with infinite lives, where agents are subject to unemployment risk. We use this model to discuss the relevance of 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 study different taxation schemes as savings rates strongly depend on the way the UI system is funded. Here 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 workers incentives.

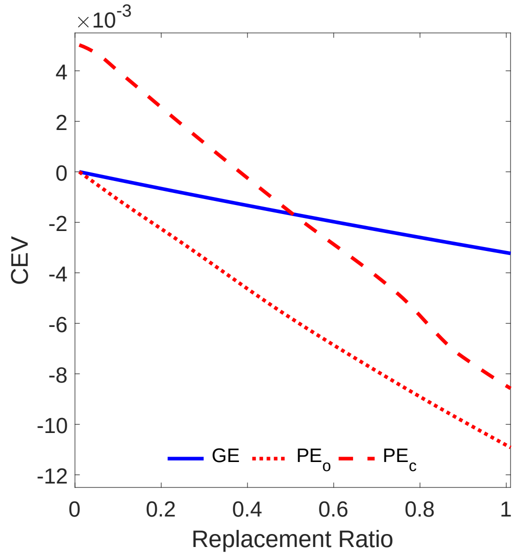
5.1 The relevance of life-cycle

In this section we show that a fundamental feature of our environment is the way workers save over their life span. To showcase this, we use an Aiyagari economy with infinitely-lived agents and no human capital accumulation. By contrasting the results in both models, we argue that the life-cycle profile of savings provides a natural setup to replicate the liquidity constraints of the unemployed.[16]

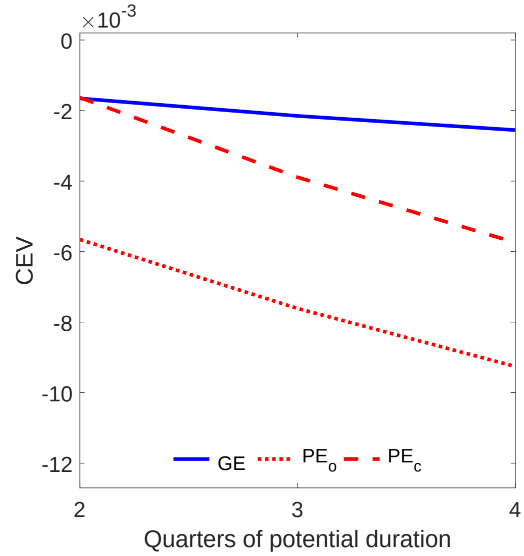
Specifically, consider an infinitely-lived agent under a similar environment that in our baseline model, but without human capital accumulation or any time-dependent variable. In this setup there are no pensions, so that the government set taxes to finance UI only.

[16] In a previous version of this paper we explore these issues by considering an alternative version of our life-cycle model where we eliminate multiple features of the model that create heterogeneity across age groups, and mimic infinitely-lived agents behavior. In that version, we doubled T and set to constant all age-dependent variables, including death probability, separation rate, and human capital. Additionally, initial wealth distribution is generated by the wealth distribution of those that exit the model. With these changes, the savings behavior by agents and the equilibrium wealth distribution resemble those resulting from a model with infinitely-lived agents. In that extension we find similar results to the ones presented in this section.

Figure 8: Welfare effects of UI in general and partial equilibrium, infinitely-lived agents



(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 for the Aiyagari model. 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 50% and studies the effect of changing the potential duration of UI benefits on welfare. In both panels, The blue solid 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 50% 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.

When working, the agent face a constant rate of separation, $1-\pi = 0.044$.[17] We additionally recalibrate the discount factor, 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 unemployment rate of 6.8%, and the elasticity of job-finding rate to UI level of -.32, the same targets of our baseline economy (see Table 1). We get $\beta = (0.92)^{1/4}$, $\omega = 0.636$, $\gamma_0 = 1.46$, and $\gamma_1 = 1.64$.[18]

Figure 8, left panel, shows the welfare effects of changing the UI system in this Aiyagari model after fixing potential duration to two model periods. The policy that maximizes welfare in general equilibrium prescribes zero replacement ratio. 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 0.17% CEV. When we analyze the partial equilibrium solution we find that the welfare maximizing policy is the same as the one in general equilibrium.

[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%).

[18] We acknowledge that the elasticity of job-finding rate is -.12, out of target. See Appendix E for a complete presentation of this model and its calibration.

Table 5: General and partial equilibrium effects of an increase in replacement ratio of 10 pp from the optimal level, infinitely-lived agents

Variable	Baseline		Infinitely-lived	
	GE	PE	GE	PE
Replacement ratio	0.63 to 0.73		0.01 to 0.11	
Potential duration	2		2	
Change in %				
Capital K	-1.0	-1.5	-1.36	-3.33
Labor H	-0.8	-0.8	-0.39	0.07
Search effort s	-5.0	-5.0	-0.04	-0.01
Unemployment	5.3	5.3	0.04	0.00
Ratio K/H	-0.2	-0.8	-0.97	-3.40
Wage w	-0.1	0.0	-0.29	0.0
Int. rate r	0.1	0.0	1.08	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.

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 1.4%, labor falls 0.4%, so that the capital-labor ratio, K/H, is reduced by 1.0%. In partial equilibrium this ratio falls more, 3.4%, given that K changes by -3.3%, while labor is practically unchanged. As the table shows, these differences also translate into differences in factor prices in GE: interest rate increases 1.1% while wages fall 0.3%. Notice how these results differ from those in the baseline calibration in Table 3, and included in Table 5 as Baseline for convenience.

Table 6 extends the decomposition of welfare changes for this case. Again, we increase 10 percentage points the replacement ratio from the welfare maximizing policy, which we set to 0.01%, and compute welfare effects using the initial distribution of workers across states, column (2), and the new stationary distribution, column (3). For the ease of comparison, column (1) reproduces the results of the baseline economy described in Table 4. Welfare effects in GE are small and negative, of 0.035% CEV, while welfare losses in PE are larger, of 0.12%. When we consider the initial distribution of state variables the effects would be negative in GE (-0.124%), but positive in PE (0.033%). To understand these effects, we follow the decomposition. When we fix the distribution of state variables, column (2), the uncompensated UI transfer (UI effect) increases welfare in 0.124%, while the corresponding increase in taxes leads to a welfare loss of -0.09%. The GE adds to the previous PE the change in factor prices: when r increase and w drops the welfare effect is negative (-0.15% CEV). When considering column (3), these effects are different: the UI effect is negligible, tax effect is more negative, and price effect is positive in 0.09% due the increase in capital

Table 6: Welfare gains decomposition of an increase in replacement ratio of 10 pp from the optimal level, infinitely-lived agents (CEV ×1000)

Variable	Baseline	Infinitely-lived	
	(1)	(2)	(3)
		Initial distr.	Stationary distr.
General Equilibrium	-0.90	-1.24	-0.35
Partial Equilibrium	-0.63	0.33	-1.20
Difference GE-PE	-0.26	-1.56	0.85
UI effect	8.74	1.24	-0.02
Tax effect	-9.29	-0.91	-1.18
Price effect	-0.23	-1.56	0.85

Notes: the table reproduces the decomposition of welfare effects of changing the UI system in 10 percentage points from the welfare maximizing UI system. Welfare gains are reported as CEVx1000 from benchmark. Welfare is computed using the initial distribution of workers in column (2) or the stationary distribution in column (3).

income following a higher r.

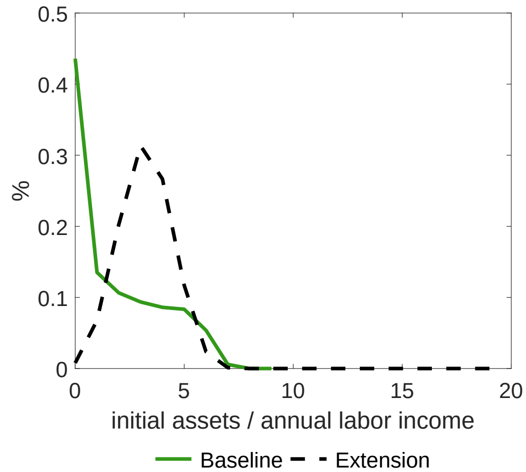
All in all, this alternative environment shows that life-cycle effects are crucial for our result. With infinitely-lived agents, UI provision lacks social value. While there are many differences with the baseline economy, we want to emphasize one main aspect that is quantitatively important: the distribution of assets among the unemployed.

In this extension the initial distribution of assets provides the unemployed a means to smooth consumption. 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 44% of the unemployed workers have little or no assets at the beginning of the unemployment spell. The corresponding proportion in this environment is approximately 1%. Additionally, with infinite lives the mode corresponds to about three years of average labor income, well above the required savings to finance a typical unemployment spell.

A second key difference arising from the elimination of the life-cycle effects is that the response of capital-labor ratio with respect to UI is higher. Figure 10 shows the capital-labor ratio and relative prices in logs. Panel (a) corresponds to our baseline economy, panel (b) to the infinitely-lived agent model. 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, the slope would be -1. Green lines represent the supply component: they plot the capital-labor ratio for different levels of relative prices. The solid green line depicts the calibrated economy (50% replacement ratio for two model periods).[19] The point in which

[19]The curve reports the capital-labor ratio as a function of relative factor prices. For constructing this curve we consider different relative factor prices and compute the workers' problem in PE to get the labor

Figure 9: Assets distribution among the unemployed



Notes: The figure 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 with infinitely-lived agents.

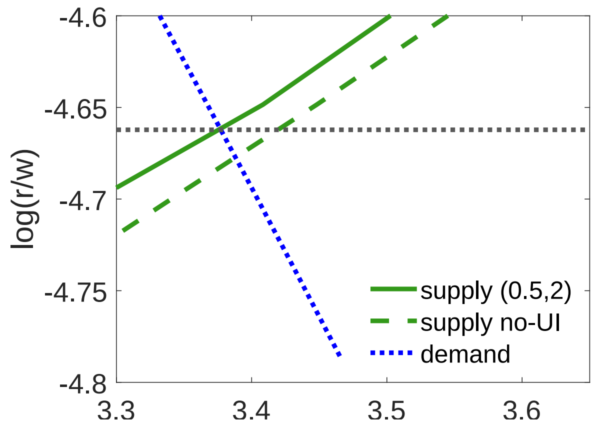
the green solid line and the blue dotted line intersect is the GE in each calibrated economy.

Consider now eliminating UI. Dashed green lines in Figure 10 represent the relative supply of factors in the no-UI case (a replacement ratio of zero). This implies a shift of the curve to the right. The adjustment of the capital-labor ratio in partial equilibrium (keeping relative prices constant) is this horizontal shift. To depict this, the dotted black lines show the relative factor prices of the calibrated economy in GE, so that the no-UI PE at those prices is the point at the intersection between the dashed green line and 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. There are several reasons for this. Briefly, in this extension assets accumulation narrows down to the precautionary savings motive due to unemployment risk, so that private savings compensate any lack of public transfers for the unemployed. Additionally, lower UI implies a higher net wage that incentivizes to work longer hours and save more. Finally, agents have infinite periods to build assets. In all, the stationary distribution of assets is strongly affected by changes in UI.

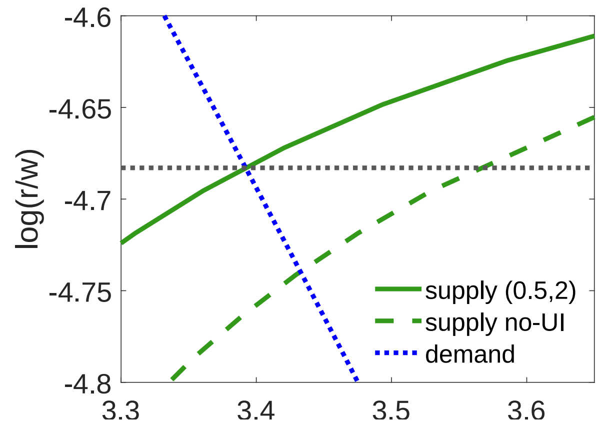
The GE in the no-UI case is found where the dashed line intersect the negative sloped dotted line. To reach this point, relative prices adjust (interest rate down and wages up), reducing the capital-labor ratio in equilibrium. The comparison between the two panels again highlights some differences. For example, when UI is eliminated, the relative supply of factors shifts more in the infinitely-lived agent case, and factor prices have to adjust more to

and assets supplied. Taxes are kept constant at the calibrated level, so that the government budget is not necessarily satisfied.

Figure 10: Relative factor supply and demand



(a) Baseline



(b) Extension: infinitely-lived

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 infinite lived agents (right panel). The negative slope dotted lines represent the relative factor demand in each case.

reach the new GE.

Thus, we emphasize two characteristics of the infinitely-lived agent case: the unemployed begin their spell with more assets and there is a stronger response of aggregate capital to UI. In a way, this exercise shows the reason why UI has been found irrelevant in this type of context: it is not because of the presence of general equilibrium effects, but because infinitely-lived agent models generate assets distributions and responses of aggregate capital 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 infinitely-lived agent case (see Table 2). When life-cycle effects are not present, insurance needs are negligible. 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.[20] We find this same elasticity in our baseline model when we consider aggregate capital. In an infinitely-lived agent model this elasticity would be higher.[21]

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

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

5.2 Heterogeneous discount factors

Our results so far show that the distribution and the response of assets to UI are crucial to understand the welfare effects. In particular, with infinitely-lived agents, the model fails to reproduce the relevance of liquidity constraints of the data.

A standard approach in the literature is to appeal to heterogeneous discount factors to generate larger dispersion in asset accumulation. As an example, Mukoyama (2010) extends one of the versions of the infinitely-lived agents model by introducing stochastic discount factors.[22] 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 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 introduce two types of workers, with low or high discount factor, β_l and β_h, respectively. The measure of workers in each type is the same, and there is an exogenous probability of changing the type. We calibrate these discount factors to maintain the aggregate capital-output 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 $\beta_l = (0.5729)^{1/4}$ and $\beta_h = (0.9567)^{1/4}$. [23]

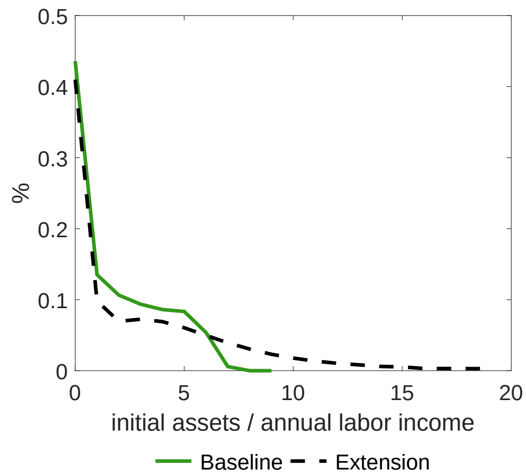
Figure 11 plots the initial distribution of assets for the unemployed workers, and compares this calibration with the baseline economy. In this case, the proportion of laid-off workers with little wealth is comparable to our baseline.

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 equilibrium evaluations indicate that the welfare maximizing replacement ratio is low, about 5%. 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

[22] 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, as discount factors are governed by a three-state, first-order Markov process. The expected duration within these extreme values is 50 years in that model.

[23] Compared to the homogeneous discount factor model, including this heterogeneity does change the response of each type, but does not substantially alter other aggregate targets, such as capital-output ratio, unemployment rate, hours worked, or the elasticity of job-finding with respect to UI level.

Figure 11: Assets distribution among the unemployed with heterogeneous discount factors



Notes: The figure 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 with infinitely-lived agents and heterogeneous discount factors.

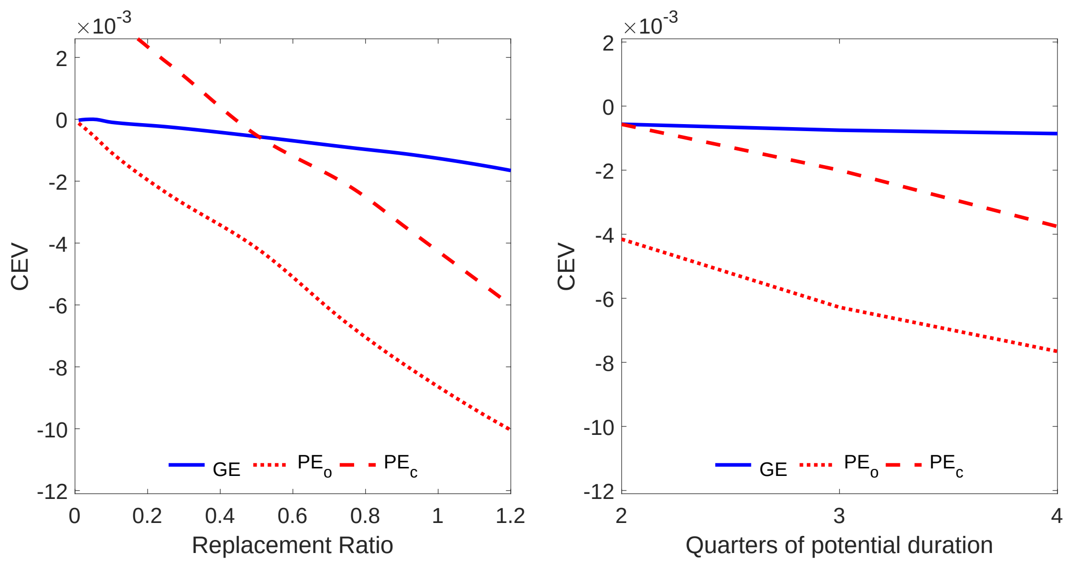
potential duration while fixing the replacement ratio. Again, this plot is similar to the one with homogeneous discounting.

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 capital by 3.2%, while labor is somewhat unaffected. When considering GE, we find an increase in interest rate of about 0.9% and a reduction in wages of 0.2%, which generates a capital-labor ratio reduction of 0.8% 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, with no notable differences.

The results discussed above show the paradoxical result 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 remind that lowering the discount factor reduces the incentives to accumulate assets, but change 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, incentives to invest in job-search is reduced for given state variables. Moreover, the job-finding elasticity with respect to UI increases. These changes are apparent from the agents' policy function. They contribute, directly or indirectly, to reduce the welfare gains of UI. These observations suggest that heterogeneous discount factors are effective to

Figure 12: Welfare effects of UI in general and partial equilibrium, infinitely-lived agents 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 infinitely-lived agents 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 50% and studies the effect of changing the potential duration of UI benefits on welfare. In both panels, the blue solid 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 50% 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 infinitely-lived agents and heterogeneous discount factors

Variable	Homog. discount		Het. discount	
	GE	PE	GE	PE
Replacement ratio	0.01 to 0.11		0.05 to 0.15	
Potential duration	2		2	
Change in %				
Capital K	-1.36	-3.33	-1.19	-3.16
Labor H	-0.39	0.07	-0.41	0.00
Search effort s	-0.04	-0.01	-0.00	0.01
Unemployment	0.04	0.00	0.01	-0.00
Ratio K/H	-0.97	-3.40	-0.79	-3.17
Wage w	-0.29	0.00	-0.24	0.00
Int. rate r	1.08	0.00	0.87	0.00

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.

increase the proportion of liquidity constrained agents at the calibrated economy but also change important aspects of the economy.

A second key point is that the elasticity of assets to UI is still very high. 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. 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.

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.

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

Table 8: Welfare gains decomposition of an increase in replacement ratio of 10 pp from the optimal level, infinitely-lived agents and heterogeneous discount factors (CEV ×1000)

Variable	Homog. discount		Het. discount	
	Initial assets	Stationary distr.	Initial assets	Stationary distr.
General Equilibrium	-1.24	-0.35	-1.00	-0.16
Partial Equilibrium	0.33	-1.20	0.71	-1.15
Difference GE-PE	-1.56	0.85	-1.71	0.98
UI effect	1.24	-0.02	1.54	-0.06
Tax effect	-0.91	-1.18	-0.83	-1.08
Price effect	-1.56	0.85	-1.71	0.99

Notes: the table reproduces the decomposition of welfare effects of changing the UI system in 10 percentage points from the welfare maximizing UI system. Welfare gains are reported as CEVx1000 from benchmark. Welfare is computed using the initial distribution of workers in columns (1) and (3) or using the stationary distribution in columns (2) and (4).

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, τ_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.

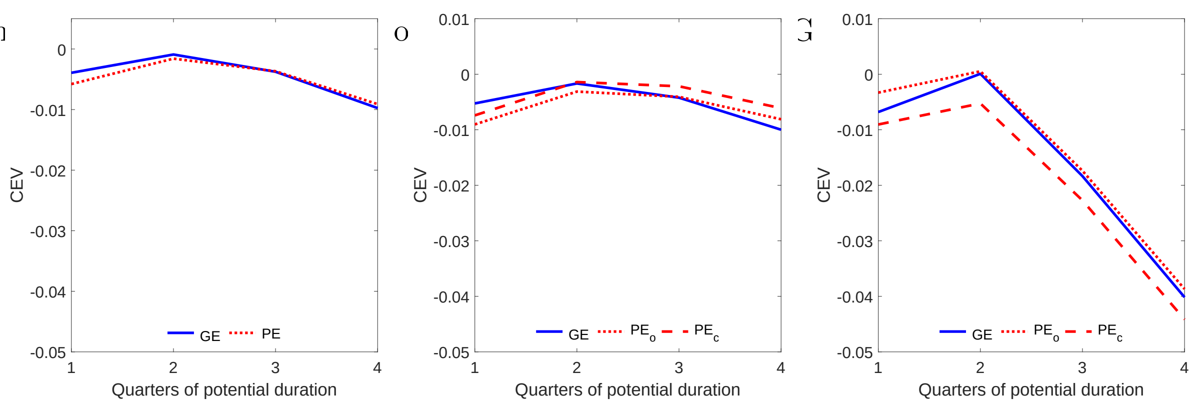
Results Figure 13 shows the capital-labor ratio under different replacement ratios setting the potential duration to two model periods. For convenience, we reproduce the baseline economy, panel (a), and we plot the alternative sources of taxation in panel (b) and (c). The dotted red lines are the solutions 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 14 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 im

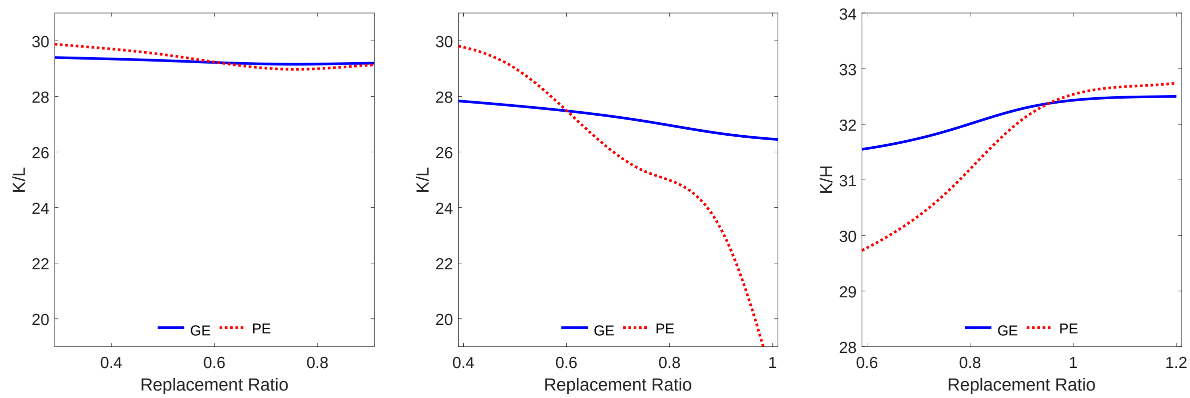
Figure 15: Welfare effects of UI potential duration under different tax arrangements.



(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 14.

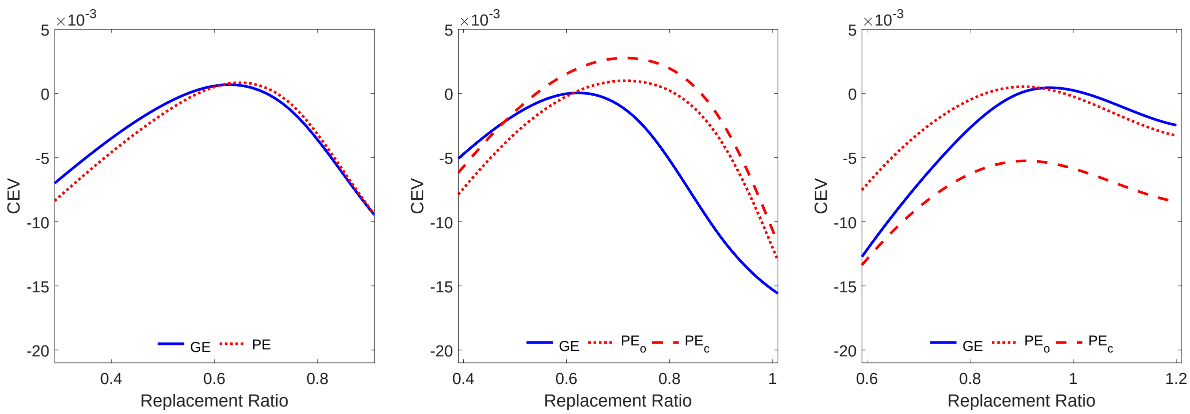
Figure 13: Capital-labor ratio under different tax arrangements



(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 14: 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).

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 14, 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

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)).

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 15 we present the analogous to Figure 14 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 in the replacement ratio, to complement Figure 13. 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

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 × 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).

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%.

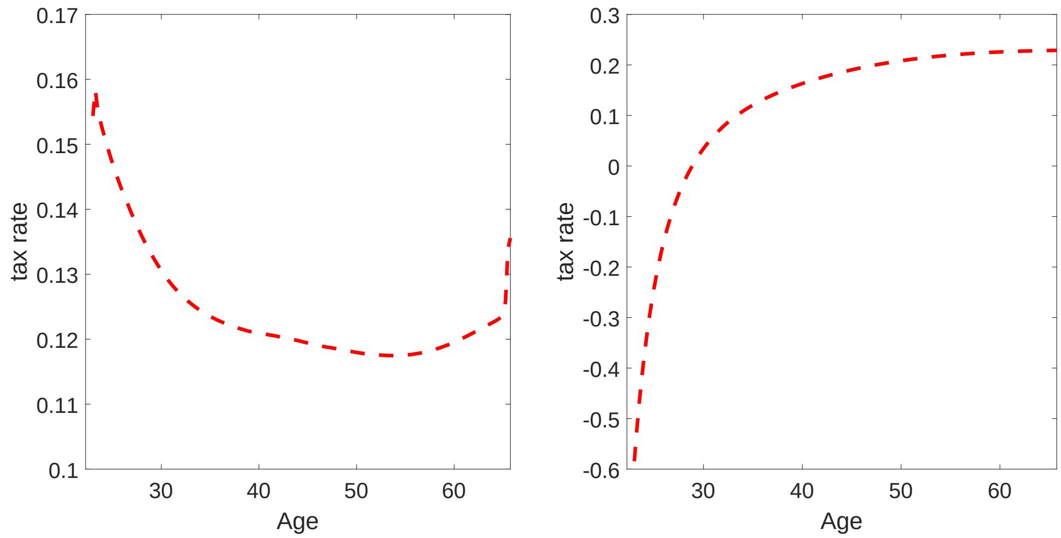
The discrepancy in the elasticity of the capital-labor ratio reflects in important differences between the welfare evaluations of the partial vs. general equilibria. Table 10 presents the welfare decomposition exercise when replacement ratio increases 10 percentage points. Column (1) reproduces the decomposition 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

Figure 16: Age-dependent tax rates



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

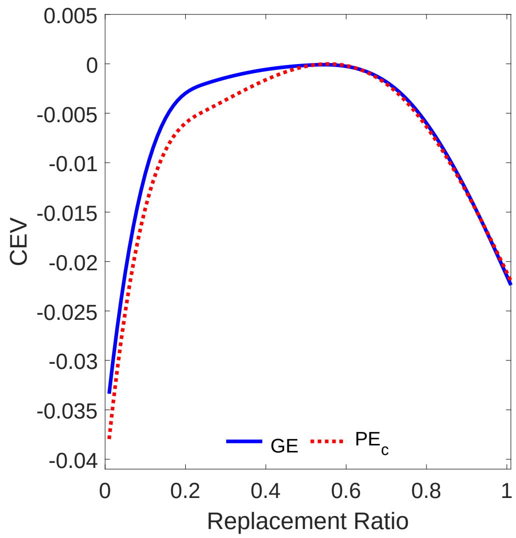
Notes: The figure plots the age dependent tax rates for the robustness cases in which UI for a given age is financed by taxes to employed workers of the same age, panel (a), and in which age dependent taxes are set to provide a constant profile of net labor income, panel (b).

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 16. We focus on whether the welfare maximizing UI policy changes compared to the baseline model.

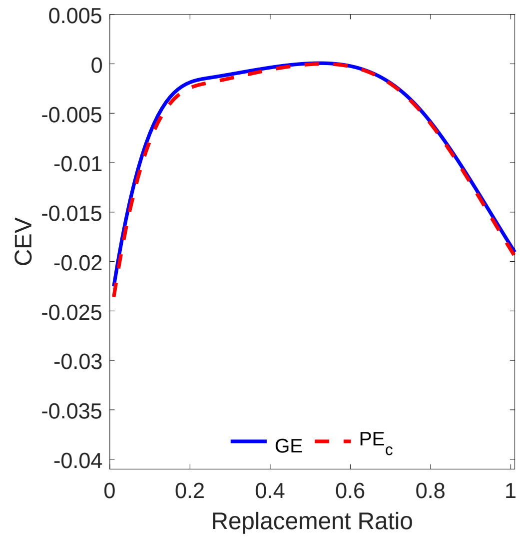
The welfare maximizing policy does not change much: the potential duration is again two model periods and the replacement ratio is slightly above the calibrated one. Figure 17 shows the CEV of different replacement ratios for two quarters of potential duration. Panel (a) shows the CEV for the economy 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

Figure 17: 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.)

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.

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.

References

Abdulkadiroglu, Atila, Burhanettin Kuruscu, and Aysegul Sahin, "Unemployment Insurance and the Role of Self-Insurance," *Review of Economic Dynamics*, July 2002, *5* (3), 681–703.

Aiyagari, S. R., "Uninsured Idiosyncratic Risk and Aggregate Saving," *The Quarterly Journal of Economics*, 1994, *109*(3), 659–684.

Alvarez, Fernando and Marcelo Veracierto, "Search, self-insurance and job-security provisions," Working Paper Series WP-98-2, Federal Reserve Bank of Chicago 1998.

_ **and** _ , "Severance payments in an economy with frictions," *Journal of Monetary Economics*, June 2001, *47* (3), 477–498.

Baily, Martin Neil, "Some aspects of optimal unemployment insurance," *Journal of Public Economics*, 1978, *10* (3), 379–402.

Birinci, Serdar and Kurt See, "Labor Market Responses to Unemployment Insurance: The Role of Heterogeneity," *American Economic Journal: Macroeconomics* forthcoming.

David E. Bloom and David Canning and Richard K. Mansfield and Michael Moore, "Demographic change, social security systems, and savings," *Journal of Monetary Economics*, 2007, *Vol. 54*, 92-114.

David E. Bloom and David Canning and Michael Moore, "Optimal Retirement with Increasing Longevity," *Scandinavian Journal of Economics*, 2014, *116* (3), 838-858.

Andrea Bonfatti and Selahattin Imrohoroglu and Sagiri Kitao, "Aging, Factor Prices and Capital Flows," USC Working Paper. 2019.

Borella, Margherita and Mariacristina De Nardi and Fang Yang, "The Effects of Marriage-Related Taxes and Social Security Benefits," Working Paper 23972, National Bureau of Economic Research, Inc, October 2017.

Cagetti, Marco and Mariacristina De Nardi, "Entrepreneurship, Frictions, and Wealth," *Journal of Political Economy*, University of Chicago Press, vol. 114(5), pages 835-870, October 2006.

Castaneda, Ana and Javier Diaz-Gimenez, and Jose-Victor Rios-Rull, "Accounting for the U.S. Earnings and Wealth Inequality," *Journal of Political Economy*, August 2003, *111* (4), 818–857.

Chetty, Raj, "Moral Hazard versus Liquidity and Optimal Unemployment Insurance," *Journal of Political Economy*, 2008, *116* (2), 173–234.

Clementi, Gian Luca, and Hugo A. Hopenhayn, "A Theory of Financing Constraints and Firm Dynamics.," *Quarterly Journal of Economics*, 2006, vol. 121, no. 1, 2006, pp. 229–265.

Dora L. Costa, "The Evolution of Retirement: Summary of a Research Project," *American Economic Review*, August 1998, *Vol 88* n. 2, 232-236.

Engen, Eric M. and Jonathan Gruber, "Unemployment insurance and precautionary saving," *Journal of Monetary Economics*, 2001, *47* (3), 545–579.

Gruber, Jonathan, "The Wealth of the Unemployed," *Industrial and Labor Relations Review*, 2001, *55* (1), pp. 79–94.

Hansen, Gary D and Ayse Imrohoroglu, "The Role of Unemployment Insurance in an Economy with Liquidity Constraints and Moral Hazard," *Journal of Political Economy*, February 1992, *100* (1), 118–142.

Hopenhayn, Hugo A and Juan Pablo Nicolini, "Optimal Unemployment Insurance," *Journal of Political Economy*, 1997, *105* (2), 412–38.

Hopenhayn, Hugo A. and Juan Pablo Nicolini, "Optimal Unemployment Insurance and Employment History," *Review of Economic Studies*, 2009, *76* (3), 1049–1070.

Koehne, Sebastian and Moritz Kuhn, "Should unemployment insurance be asset-tested?," *Review of Economic Dynamics*, July 2015, *18* (3), 575–592.

Krueger, Dirk and Felix Kubler, "Pareto-Improving Social Security Reform when Financial Markets are Incomplete!?," *American Economic Review*, June 2006, vol. 96, no. 3, pp. 737–755.

Krusell, Per, Toshihiko Mukoyama, and Aysegül Sahin, "Labour-Market Matching with Precautionary Savings and Aggregate Fluctuations," *The Review of Economic Studies*, 2010, *77* (4), 1477–1507.

Krusell, Per, and Anthony A. Smith, Jr, "Income and Wealth Heterogeneity in the Macroeconomy," *Journal of Political Economy*, vol. 106, no. 5, 1998, pp. 867–896.

Landais, Camille, "Assessing the Welfare Effects of Unemployment Benefits Using the Regression Kink Design," *American Economic Journal: Economic Policy*, November 2015, *7* (4), 243–278.

_ **, Pascal Michaillat, and Emmanuel Saez**, "A Macroeconomic Approach to Optimal Unemployment Insurance: Theory," *American Economic Journal: Economic Policy*, May 2018, *10* (2), 152–181.

McGrattan, Ellen R. and Richard Rogerson, "Changes in hours worked, 1950-2000," *Quarterly Review*, 2004, *28* (Jul), 14–33.

Michelacci, Claudio and Hernán Ruffo, "Optimal Life Cycle Unemployment Insurance," *American Economic Review*, 2015, *105* (2), 816–59.

Mukoyama, Toshihiko, "Understanding the welfare effects of unemployment insurance policy in general equilibrium," 2010, (286).

_ , "Understanding the welfare effects of unemployment insurance policy in general equilibrium," *Journal of Macroeconomics*, 2013, *38* (PB), 347–368.

Popp, Aaron, "Unemployment insurance in a three-state model of the labor market," *Journal of Monetary Economics*, 2017, *90* (C), 142–157.

Schwartz, Jeremy, "Unemployment Insurance and the Business Cycle: What Adjustments are Needed?," *Southern Economic Journal*, January 2013, *79* (3), 680–702.

Setty, Ofer, "Unemployment Insurance and Unemployment Accounts: The Best of Both Worlds," *Journal of the European Economic Association*, 03 2017, *15* (6), 1302–1340.

Shavell, Steven and Laurence Weiss, "The Optimal Payment of Unemployment Insurance Benefits over Time," *Journal of Political Economy*, December 1979, *87* (6), 1347–62.

Shimer, Robert, "Reassessing the Ins and Outs of Unemployment," *Review of Economic Dynamics*, April 2012, *15* (2), 127–148.

_ **and Ivan Werning**, "Liquidity and Insurance for the Unemployed," *American Economic Review*, 2008, *98* (5), 1922–1942.

_ **and** _ , "On the Optimal Timing of Benefits with Heterogeneous Workers and Human Capital Depreciation," Working Papers 12230, National Bureau of Economic Research 2006.

_ **and** _ , "Reservation Wages and Unemployment Insurance," *Quarterly Journal of Economics*, 2007, *122* (3), 1145–1185.

Shourideh, Ali and Maxim Troshkin, "Incentives and Efficiency of Pension Systems," Working Paper, Carnegie Mellon University, 2017.

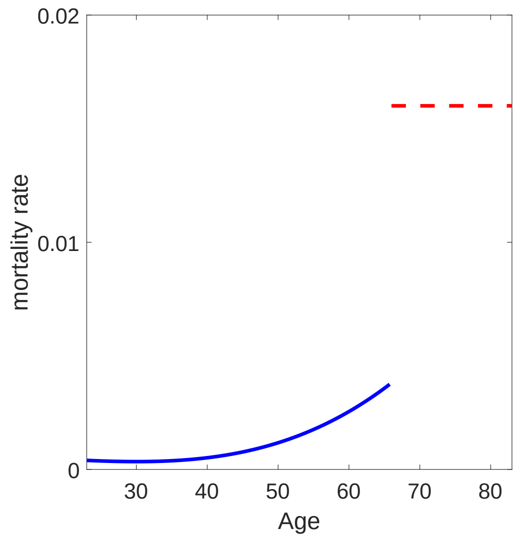
Wang, Cheng and Stephen Williamson, "Moral hazard, optimal unemployment insurance, and experience rating," *Journal of Monetary Economics*, 2002, *49* (7), 1337–1371.

Young, Eric R., "Unemployment insurance and capital accumulation," *Journal of Monetary Economics*, November 2004, *51* (8), 1683–1710.

Appendix

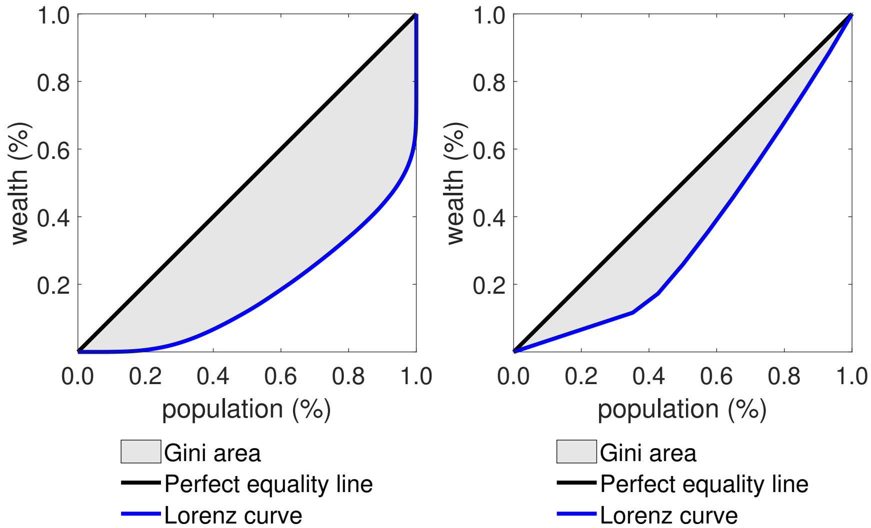
A Appendix of figures

Figure 18: 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.

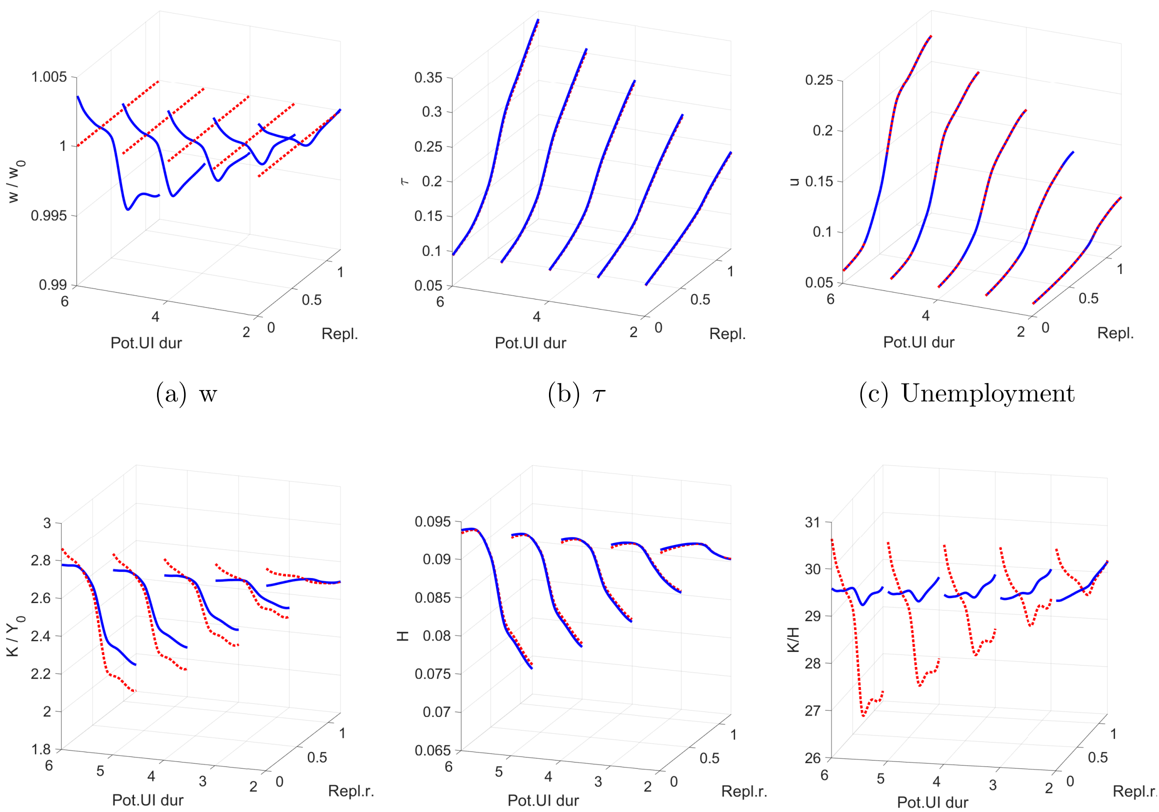
Figure 19: Assets and wages distribution



(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 20: Endogenous variables in GE and PE



(a) w (b) τ (c) Unemployment

(d) K (e) H (f) Ratio

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 κ, 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.[24] 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.

[24] 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,

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

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 Ψ_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 Ψ_0 compute the tax, τ, that makes the government budget constraint hold with equality.

Step 3 Given τ, 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 Ψ_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.

E Infinitely-lived agents

The economy consists of a representative firm, a measure one of risk averse agents, and a government that collects labor income taxes to provide unemployment insurance. The representative firm is identical to our baseline economy: it operates a constant returns to scale technology using physical capital and labor. Agents are ex-ante identical, live for infinite periods, and their preferences are the same as in our baseline, so that utility depends on consumption, c_t, hours worked, n_t, and job-search effort, s_t. Agents accumulate assets, a, and are liquidity constrained, $a \geq 0$. While employed, agents receive labor income net of proportional taxes, $wn(1-\tau)$, and face a layoff with probability $1-\pi$, after which they begin their unemployment spell. For an unemployment duration ψ, the agent receives $B(\psi)\bar{n}w(1-\tau)$ as unemployment insurance transfer, where $\bar{n}$ is the average labor intensity in the economy. Let $v^e(a)$ and $v^u(a,\psi)$ be the value functions of the infinitely-lived agent while employed and unemployed, respectively. Then, the employed agent solves:

$$\begin{aligned} v^e(a) &= \max_{\{c,n,a'\}} \{u(c,n) + \beta[\pi v^e(a') + (1-\pi)v^u(a',1)]\} \\ s.t. &\quad c + a' \leq (1+r)a + (1-\tau)wn \\ &\quad c \geq 0, \quad a' \geq 0 \end{aligned}$$

While unemployed, the agent solves:

$$\begin{aligned} v^u(a,\psi) &= \max_{\{c,s,a'\}} \{u(c,s) + \beta[sv^e(a') + (1-s)v^u(a',\psi+1)]\} \\ s.t. &\quad c + a' \leq (1+r)a + B(\psi)\bar{n}w(1-\tau) \\ &\quad c \geq 0, \quad a' \geq 0 \end{aligned}$$

The government, at the same time, chooses the tax rate in order to satisfy its budget constraint, given by

$$\int \tau wn(a)X^e(a)da = \int B(\psi)\bar{n}w(1-\tau)X^u(a,\psi)d(a\times\psi)$$

where $X^e(a)$ and $X^u(a,\psi)$ are the stationary measures of employed and unemployed agents, respectively.

Once a policy rule $\{\tau, B(\psi)\}$ is set, a stationary equilibrium is prices $\{w,r\}$ and measures, $X^e(a)$ and $X^u(a,\psi)$, such that agents maximize utility, markets clear and the feasibility constraint is satisfied. In particular, market clearing requires:

$$K = \int a[X^e(a) + X^u(a,\psi)]d(a\times\psi)$$

$$H = \int X^e(a)n(a)da.$$

Heterogeneous discount factors

Lets now consider stochastic discount factors. Agents are of two types: those with low discount factor, β_l, and those with a high discount factor, β_h. The type evolves according to a symmetric Markov process. In particular, there is a constant probability that the agent changes the type in the following period. With this extension, the employed agent of type j solves:

$$\begin{aligned} v_j^e(a) = \max_{\{c,n,a'\}} &\Big\{u(c,n) + \beta_j\Big(\varrho\big[\pi\, v_j^e(a') + (1-\pi)v_j^u(a',1)\big] \\ &+ (1-\varrho)\big[\pi\, v_{-j}^e(a') + (1-\pi)v_{-j}^u(a',1)\big]\Big)\Big\} \\ \text{s.t.} \quad & c + a' \leq (1+r)a + (1-\tau)wn, \\ & c \geq 0, \quad a' \geq 0. \end{aligned}$$

where ϱ is the probability of remaining in the same type (with the same β). The unemployed agent of type j solves:

$$\begin{aligned}
v_j^u(a,\psi) = \max_{\{c,s,a'\}} \Big\{ & u(c,s) + \beta_j \Big(\varrho \big[s\, v_j^e(a') + (1-s) v_j^u(a', \psi+1) \big] \\
& + (1-\varrho) \big[s\, v_{-j}^e(a') + (1-s) v_{-j}^u(a', \psi+1) \big] \Big) \Big\} \\
\text{s.t.} \quad & c + a' \leq (1+r)a + B(\psi)\bar{n}w(1-\tau), \\
& c \geq 0, \quad a' \geq 0.
\end{aligned}$$