Unemployment Insurance when the Wealth Distribution Matters*

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Abstract

We study the welfare effects of unemployment insurance in a life-cycle model, with focus on comparing partial and general equilibrium analysis. In the model, agents accumulate human capital and assets during their working life. They suffer an exogenous separation shock and they have to engage in a costly search to find a new job. We calibrate the model to the US economy and find that welfare maximizing replacement rate and potential duration are close to the current one. When we include general equilibrium effects the optimal policy does not change much, in clear contrast with previous literature. This result arises because both labor and assets adjust in a similar proportion in our model, leading to very small factor price changes. We discuss extensions to show that in our model general equilibrium effects go along with the change in capital-labor ratio. In particular, when capital-labor ratio increases due to more generous transfers, the welfare maximizing replacement ratio in general equilibrium is higher than the one in partial equilibrium. We also emphasize two features, crucial for our results: the life-cycle model (i) reproduces the proportion of liquidity constrained unemployed of the data and (ii) moderates the response of assets to unemployment insurance. When we eliminate some life-cycle effects we find that the unemployment insurance has little value and should be very low, both in general and in partial equilibrium. The introduction of heterogeneous discount factors in an economy without life-cycle effects can initially reproduce the proportion of liquidity constrained unemployed workers, but does not solve the problem of the high elasticity of the capital-labor ratio. We conclude that an accurate distribution of assets and a realistic response of precautionary savings with respect to transfers are key to analyze the welfare effects of insurance policies.

JEL classification: E62; H21; E24

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

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1 Introduction

Unemployment insurance (UI) provides workers a mean to smooth consumption after job loss. At the same time, reduces the incentives of jobless workers to find a job. This trade-off between insurance and incentives has been the focus of the literature of optimal UI.

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

This 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; Landais, 2015) extend this approach using search models of the labor market to identify marginal welfare gains and losses of changing UI. After measuring these costs and benefits with the US data, they typically find that the UI system is close to the optimal or even that there are welfare gains of making it more generous.

The UI system has been also evaluated through quantitative models of the labor market with moral hazard, as in Hansen and Imrohoroglu (1992). Some of these papers find that the US system is close to the optimal and they evaluate the welfare gains of introducing reforms, such as introducing UI savings accounts (Setty, 2017), conditioning UI to assets of the unemployed (Koehne and Kuhn, 2015), to age (Michelacci and Ruffo, 2015), or to business cycle variables (Schwartz, 2013; Birinci and See, 2020). In all, these papers suggest that UI provides relevant welfare gains.

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

In this paper we study UI comparing both partial equilibrium and general equilibrium solutions in an attempt to fill the gap between the general equilibrium and the partial equilibrium literature. We build a life-cycle model where risk averse workers derive utility from consumption and leisure. They begin their working life without assets and without labor experience. They can accumulate assets through their labor income and gain human capital through work experience. While employed they can choose their work intensity. An exogenous separation shock makes them to fall into unemployment. In such a case, they are eligible for an UI transfer of limited duration. Jobless workers actively search for a job at a utility cost. At the end of their working life, they retire and get a pension from the government. Competitive firms operate a constant returns of scale technology that use both physical capital and labor. The government funds pensions and UI system through a proportional tax on labor income, balancing its budget.

This life-cycle structure generates important economic mechanisms that are relevant for UI welfare evaluation (Michelacci and Ruffo, 2015). In this paper, we emphasize the role of assets. Young workers are typically not able to save enough to face an unemployment spell because of their limited time within employment. Furthermore, due to the future increase in income, young workers do not save much at the beginning of their working life. These effects generate a life-cycle profile of assets and a distribution of savings that are consistent with the data. More important, they generate a proportion of liquidity constrained unemployed workers that is close to the one observed. This point is crucial for the adequate measurement of the welfare gains of UI. If workers could completely finance their consumption while unemployed, UI would lack most of its appeal.

In this paper, we also emphasize that life-cycle effects reduce the response of assets to transfers. This is because, in our model, agents have incentives to save for reasons beyond unemployment risk. The financing of the retirement period is a main reason to save at the end of the working life and explains much of the total asset level.

We search for the replacement rate and the potential duration of UI that maximizes the lifetime utility of workers from the beginning of their working life. We find that the welfare maximizing policy in partial equilibrium has the same potential duration and a replacement rate higher than the one in the US but close to it (63% compared to the current 50%). Welfare effects of UI are sizeable in our model. The welfare losses of eliminating the UI system are equivalent to a fall in 4% of lifetime consumption. Importantly, our result is almost unchanged when we allow for general equilibrium effects. The reason is that both labor and capital adjust in a similar proportion, letting capital-labor ratio to remain fairly constant around the optimum. Thus, the change in factor prices in general equilibrium has small welfare effects.

In our model UI could be used as a way to provide intergenerational transfers to the young. To acknowledge the fact we construct two robustness exercises. We show that when this motive is not present the conclusions are maintained.

Our result is consistent with the partial equilibrium literature, but at odds with the literature that analyses UI in general equilibrium. There are several reasons, mostly associated with the life-cycle effects. The literature mostly used infinitely lived agents models. In those models, agents have incentives to save during employment, at least to face unemployment risk. Thus, the model typically lack asset-poor workers, generating a distribution of assets less dispersed than the data. Additionally, in these models the elasticity of assets with respect to UI policy is very high. This implies that physical capital would strongly respond to UI, imposing a big reduction in aggregate activity. As a consequence, this modelling choice reduce the welfare gains and increase the welfare costs of UI.

This modelling choice has been used in Young (2004), that adds capital to Wang and Williamson (2002), and finds that the reduction in aggregate activity outweighs the insurance of UI. Also, Mukoyama (2010, 2013) concludes that UI is not welfare enhancing in GE. However, these two papers are still away from generating wealth dispersion that maps to insurance needs.[1] Additionally, Young (2004) clearly shows that assets are very elastic, both to UI and to factor prices.[2]

To explore the GE effects, we extend our model through changes in taxes to produce different response of savings to UI. In the baseline model, general equilibrium effects depend monotonically with capital-labor ratio. We show that whenever capital-labor ratio is reduced due to the increase in UI, general equilibrium analysis prescribes less generous UI compared to partial equilibrium analysis. Conversely, whenever capital-labor ratio is increased due to more generous UI, general equilibrium analysis suggests more generous UI compared to partial equilibrium.

We also use our model to show the importance of life-cycle effects on the distribution of assets and the response of aggregate capital to changes in UI. For that purpose, we eliminate human capital accumulation process, and we eliminate any age-dependent variables. Additionally, we extend the working life and we 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, the optimal UI plummets to close to zero even in 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 capital-labor ratio does not change with UI, general equilibrium effect is nil. In such a case, partial equilibrium approach is accurate. In the case in which capital-

[1] In Young (2004) wealth dispersion stems only from uninsurable employment shocks but wealth dispersion is far below its data counterpart. Mukoyama (2010) generates wealth dispersion by assuming that agents switch randomly in their discount factor. As a result, dispersion in wealth is an optimal choice of agents which is uncorrelated with income shocks.

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

labor ratio change, the additional price effect should be considered for the identification of the optimal policy, and Baily-Chetty sufficient statistics formulas are incomplete.

In this paper we concentrate on the role of capital and we abstract from the role of search externalities and possible congestion effects present in matching models. Other papers have analyzed this effect. For example, Landais et al. (2018) consider efficiency of labor market tightness in matching models. They show that a correction term should be added to the Baily-Chetty formula. This important effect, absent from our model, is independent to the main message of this paper.

In the remainder of this paper we first present our life-cycle model (Section 2) and its calibration to the US economy (Section 3). Section 4 presents the main results, leaving two robustness exercises to Section 5 and extensions to Section 6. Section 7 concludes.

2 The model

The economy is populated by a continuum of agents, a competitive firm, and the government. At any point in time agents differ in (i) their age j, $j \in \{1, 2, 3, ...\}$, (ii) their wealth level a, (iii) their accumulated labor capital κ, $\kappa \in \mathbf{K}$, (iv) their activity status i, $i \in \{e, u, R\}$, where e denotes currently employed, u denotes currently unemployed and R denotes retired, and (v) for those unemployed, the duration of the current unemployment spell ψ, $\psi \in \mathbf{\Psi}$.

2.1 Competitive Firm

The firm runs a constant return to scale technology $F(K, H)$, where K denotes 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 pays the depreciation rate d. The firm's objective is to maximize its profits,

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

which provides

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

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

2.2 Agents

Each period, a measure one of agents enter the labor market, with age $j = 1$. Agents can work up to age $j = T$ where there is compulsory retirement and they collect pension Pw each period. Agents die stochastically with 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.

Let $u(c, n, s)$ denote the utility function of agents where c denotes consumption, $n \in [0, 1]$ denotes labor intensity, and $s \in [0, 1]$ denotes the search effort incurred in finding a job. We assume that $u(c, n, s)$ takes the following form,

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

whith $\gamma_1 > 1$ and where the formulation when the agent is employed is similar to the specification in Abdulkadiroglu et al. (2002).

The accumulation of labor capital is stochastic and follows the following rule,

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

that is, labor capital can only increase when the individual is employed and the probability of an increase depends on her labor intensity choice.

Let $h(\kappa)$ denote the human capital of the agent, where the function transforms accumulated labor capital to effective units of labor. Thus, employed agents receive a compensation for their work, $nh(\kappa)w(1 - \tau)$, which is proportional to the effective units of labor they provide to the firm, $nh(\kappa)$, and where τ is a labor tax used to finance government transfers in UI and pensions.

Let $1 - \pi_j$ denote the (exogenous) job destruction 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 collect $B(\psi)\bar{n}h(\kappa)w(1 - \tau)$ as income, that depends on the average labor intensity in the economy, $\bar{n}$.[3]

[3]Referring to the average number of hours instead to the number of hours of the last job allows us to

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

A retired agent's value function $V^R(a)$ solves the following Bellman equation,

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

The solution to the retired agent's problem is a set of policy functions,

$$\begin{aligned} c &\equiv c^R(a)\ , \\ a' &\equiv a^R(a). \end{aligned}$$

2.2.2 The problem of an unemployed agent

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

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

simplify the computation, so that we do not need to keep track of one additional state variable. Given that the number of hours worked do not change much, we still refer to B as the replacement rate.

when $j < T$, and

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

when $j = T$. Notice that for $j = T$, because the continuation value is the value of retirement, the optimal choice of search effort is 0.

The solution to the unemployed agent's problem is a set of policy functions,

$$\begin{aligned} c &\equiv c_j^u(a,\kappa,\psi) \ , \\ a' &\equiv a_j^u(a,\kappa,\psi) \ , \\ s &\equiv s_j(a,\kappa,\psi) \ . \end{aligned}$$

2.2.3 The problem of an employed agent

An employed agent's value function $V_j^e(a,\kappa)$ solves,

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

when $j < T$ and

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

when $j = T$.

The solution to the employed agent's problem is a set of policy functions,

$$c \equiv c_j^e(a,\kappa) \ ,$$
$$a' \equiv a_j^e(a,\kappa) \ ,$$
$$n \equiv n_j(a,\kappa) \ .$$

2.3 The government

The government runs a UI system and a pension system. The government runs a balanced budget,

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

where $X^R(a)$ denote the measure of retired agents with current wealth a; $X_j^e(a,\kappa)$ denote the measure of employed agents of age j, with current wealth a and labor capital κ; $X_j^u(a,\kappa,\psi)$ denote the measure of unemployed agents of age j, with current wealth a, labor capital κ and unemployment duration spell ψ. (See the definition and computation of these measures in Appendix C.)

2.4 Stationary equilibrium

Given a policy rule $\{\tau, B(\psi), P\}$, a stationary equilibrium is a wage w, an interest rate 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 expected utility,
2. markets clear,

$$H = \int\int\int h(\kappa)n_j(a,\kappa)X_j^e(a,\kappa)djdad\kappa$$
$$K = \int\int\int\int a\left[X^r(a) + X_j^e(a,\kappa) + X_j^u(a,\kappa,\psi)\right]djdad\kappa d\psi \ ,$$

3. the government keeps a balanced budget and,
4. the feasibility constraint is satisfied,

$$F(K,H) - dK = \int\int\int\int c^R(a)X^R(a) + c_j^e(a,\kappa)X_j^e(a,\kappa)c_j^u(a,\kappa,\psi)X_j^u(a,\kappa,\psi)djdad\kappa d\psi \ .$$

3 Calibration

We let a period denote a quarter (12 weeks). We assume that the starting age of an individual is 23 years old and we set the compulsory retirement age to be at 65 years, 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 by first dividing the parameters and functions by the quantification method: some are imputed from exogenous sources to the model, while others require calibration through indirect inference.

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 rate of UI to 50%	-	-
UI system ψ	2	unemployment duration of 26 weeks	-	-
Pension system P	0.178	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.

3.1 Imputation of parameters

UI system parameters. We specify the UI system to provide a replacement ratio of 0.5 for up to 6 months (two model periods),

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

We choose to use this replacement ratio because it is around the one typically used in the literature (for example, Wang and Williamson (2002)).

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. We set the depreciation parameter to $d = 0.01$.[4] 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).[5] 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 plot the job keeping probability π_j in the right panel of Figure 3.[6]

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 this parameter. Higher values for β induce agents to save, which increases the ratio by increasing capital.

Labor disutility ω and risk aversion parameter σ. A higher value for ω decreases labor intensity, n, so that the average number of hours worked is a reasonable 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.[7]

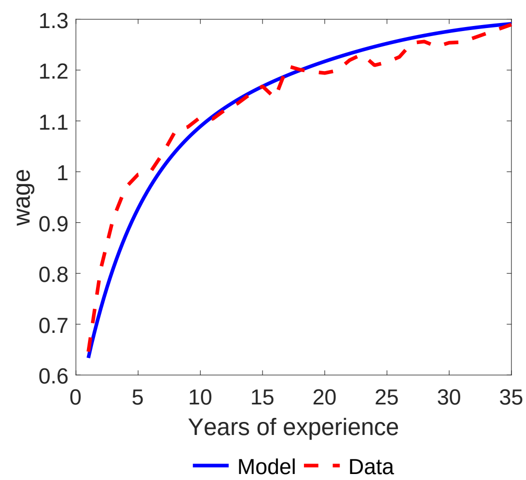
[4] Along with the assets lost by the assumption that agents do not leave legacies, we add up to 5% of assets lost within the year.

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

[6] This data was constructed by Robert Shimer. For additional details, please see Shimer (2012) and his webpage 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.

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

Figure 1: Human capital: data and calibrated function $h(\kappa)$



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.

Human capital, $h(\kappa)$, labor capital set, $\mathbf{K}$, and $\chi(n)$. To keep things tractable we assume that labor capital is a ladder with 10 steps so that $\mathbf{K} = \{1, 2, 3, ..., 10\}$ and

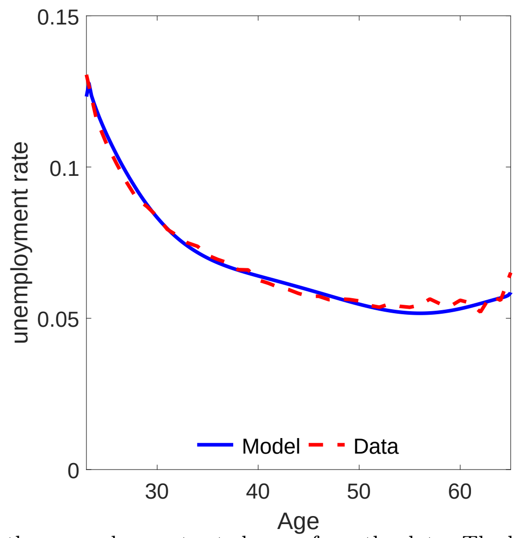
$$\chi(n) = \begin{cases} \hat{\chi} & \text{if } n \geq \frac{1}{6} \\ 0 & \text{if } n < \frac{1}{6} \end{cases}$$

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. We calibrate $h(\kappa)$ and $\hat{\chi}$ by matching the empirical wage - experience profile that arises from a standard regression using NLSY 1979 (see 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 the UI system according to the sufficient statistic literature (Chetty, 2008). In the model, we measure the elasticities as the partial effects of benefits. To be clear, we change benefit level (B) or potential duration (ψ) only, while we keep taxes and other general equilibrium variables constant. We do this to isolate the effect of benefits in job-finding rate, and more closely connect with the empirical literature that compare the unemployment duration of workers with different levels of UI but with otherwise similar environments (for example Landais (2015); see B.2 for details about our calibration of the search cost function).

We reach to $\gamma_0 = 0.27$ and $\gamma_1 = 1.8$. More details about the calibration of this function is presented in Appendix B.2. 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).

Figure 2: Unemployment rate by age



Notes: The red (dashed) line is the unemployment rate by age from the data. The blue (solid) line is the unemployment rate from the calibrated model.

4 Results

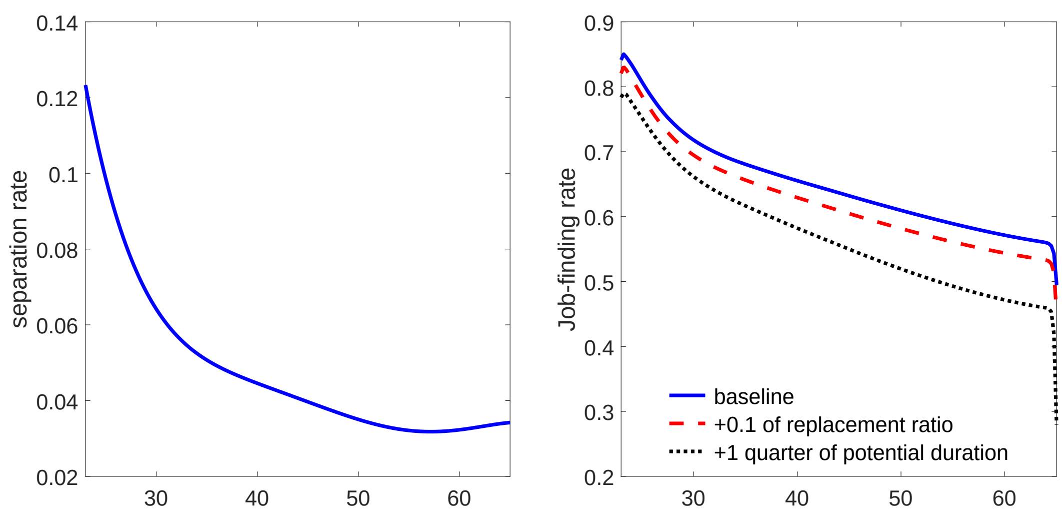
In this section we present the main results of the paper. We first show how the model performs in non-targeted moments and then we present the welfare evaluations of alternative unemployment insurance policies.

4.1 Further characteristics of the laboratory economy

Figure 2 shows the unemployment rate by age. Unemployment rate is almost 13% for the young workers (those that in our model begin their working lives) and then decrease to about 5% for workers close to retirement. This profile is generated by separation and finding rates that vary by age.

Figure 3 presents the exogenous separation rate by age. Initial separation is close to 12% for those in the beginning of their working life while it decreases rapidly to below 4%. This means that unemployment risk affects mostly young workers.

Figure 3: Job-finding and separation rates



(a) Separation (b) Job-finding

Notes: Panel (a) reports separation rates Shimer (2012) as exogenously calibrated in the model. The blue solid line of panel (b) reports 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 10 percentage points; the dark dotted line is the same profile if potential duration were to be extended one additional quarter.

Figure 3 also shows the job-finding rate by age (see the solid blue line). At the beginning of working life, unemployed workers exert a lot of effort in finding a job. There are two main reasons for this. 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. Job-finding rate decreases then, when workers are able to partially self-smooth consumption during unemployment, and then drops at the end of working life, because workers are about to retire and jobs will last only few periods.

The red dashed line of the same Figure 3 plots the job-finding rate when replacement rate is set 10 percentage points higher. This higher transfer reduces the incentives to search for workers in all ages. This behavioral response is even more appreciable for older workers. In fact, the elasticity of job-finding rate with respect to benefits in our model is smaller for younger workers than for older ones. This is a fact that has been documented elsewhere (Michelacci and Ruffo, 2015), and arise naturally in our life-cycle model. The dark dotted line shows the job-finding rate by age when UI potential duration is extended one model period (12 weeks). The response of job-finding is stronger and, again, the response is even larger for older workers.

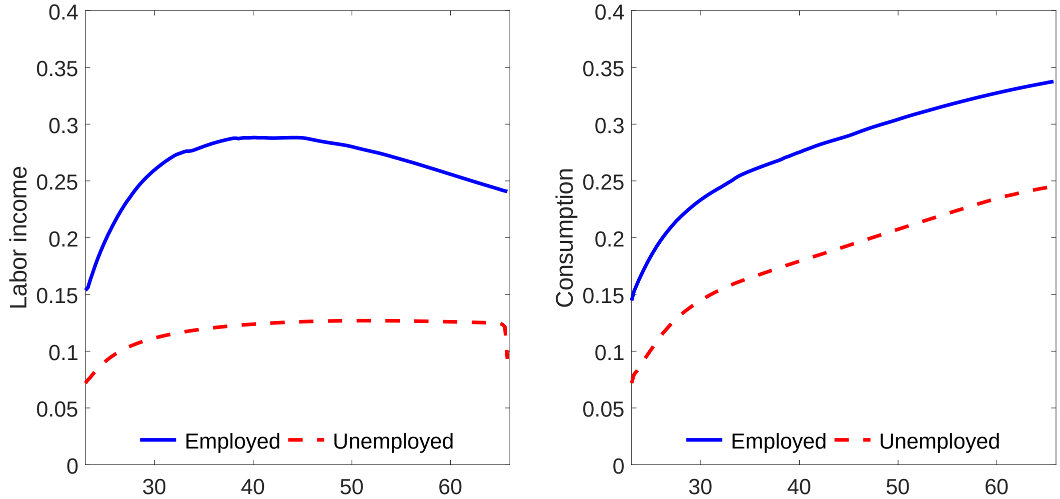
Figure 4 plots income, panel (a), and consumption, panel (b), of employed and unemployed workers by age. Labor income of the employed workers is increasing by age up to a peak at age 45. This profile is affected by the human capital profile (as shown in Figure 1) and total hours worked. In the model, 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.

Panel (a) of Figure 4 also plots the average compensation for the unemployed. This amount depends on human capital and on the average duration of unemployment spells. We find that this income is mildly increasing, at a slower rate than the labor income for the workers. This is partly because the UI exhaustion is increasing by age. The rapid increase in average unemployment duration at the end of the working life explains the drop in the average UI transfers for those periods.

The panel (b) of Figure 4 shows the evolution of average consumption of the employed and the unemployed. Consumption levels are increasing in age, which is consistent with the accumulation of human capital and assets. There is a strong consumption drop upon separation. A proportion of the drop in income is compensated by dissaving, particularly after age 30.

Figure 5 presents wealth accumulation through life, comparing the model with data on net worth from the Survey of Consumer Finances, 2007. We find that the average wealth by age is similar to the one in the data, even when we do not target this evolution. The figure shows that workers tend to save little at the beginning of their working lives, and they tend to accumulate at a higher pace after the first ten years of working life. At the beginning of the working life, savings are determined by at least two forces. First, workers expect an increase in their labor income because of human capital accumulation, and would like 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

Figure 4: Income and consumption through the life-cycle

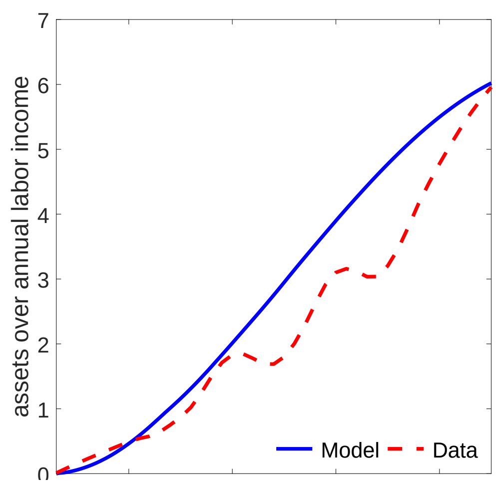


(a) Labor income (b) Consumption

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.

would not fully replace their income. Thus, life-cycle effects introduce several determinants for savings. Savings are not only driven by unemployment risk in our model, and so the aggregate response of assets to changes in UI is somewhat reduced.

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.

The model reproduces much of the inequality of assets of the data. 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 observed counterpart in the economy (0.75-0.8) while the second is close to the one observed, 0.4-0.45. See for instance Castaneda et al. (2003).

Given our main purpose, a more important figure than the Gini, is the left part of the distribution of assets. Table 2 reports the distribution of assets relative to income for the employed and unemployed workers, comparing the calibrated model with the data.[8] The model performs quite well when compared to total assets. As discussed in the literature (Gruber, 2001; Chetty, 2008) the relevant assets for smoothing consumption for unemployment risk are liquid assets. If that is the case, our model is somewhat overstating the smoothing consumption possibilities of the workers.

Importantly, our model generates 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)).

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.

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

4.2 Welfare analysis

We now turn to evaluate the welfare effects of changes in the UI system. As is usual in the literature, we consider the welfare of newborn agents. In particular, the measure of welfare is

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

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

We present the welfare changes in terms of consumption-equivalent terms. 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 the steady state. In our model, this measure can be computed as

$$1 + CE_1 = \left(\frac{W_1^P}{W_1^B}\right)^{\frac{1}{(1-\omega)(1-\sigma)}}$$

where W_1^B is the welfare in the benchmark economy and W_1^P is the welfare under a different policy. We choose the policy that maximizes welfare as the benchmark for comparison, and thus CE should be read as the welfare losses to be far from this policy.

We also construct a decomposition of welfare gains. For that purpose, we first consider (i) an increase in benefits, (ii) the corresponding increase in taxes that balance the budget in PE, and (iii) the effect of changing prices. In this last step, we change taxes accordingly to balance the budget in GE. The first would be welfare improving, the second is welfare decreasing, while the third is the GE effect and its impact on welfare is not obvious. In each of these three steps, we consider all the behavioral responses associated to each of these shocks.

Let $W^{GE}(B_0(\psi))$ be the welfare evaluation of the $B_0(\psi)$ UI policy in GE. As a result of the solution of this economy in GE, a set of variables $(\tau_0^{GE}, \bar{n}_0^{GE}, w_0^{GE}, r^{GE})$, are determined. Let $W^{PE}(B_0(\psi), w_0, r_0)$ be the solution and welfare evaluation of the same policy in partial equilibrium, using factor prices (w_0, r_0). From this solution, $(\tau_0^{PE}, \bar{n}_0^{PE})$ are endogenously determined to balance the budget. Finally, let $\widetilde{W}^{PE}(B_0(\psi), \tau_0, \bar{n}_0, w_0, r_0)$ be the solution of the problem under the same UI policy, in PE without imposing balanced budget constraints. In this case, taxes and average hours worked are inputs in this problem. Our decomposition rests on the following identity:

$$W^{GE}(B_0(\psi)) = W^{PE}(B_0(\psi), w_0^{GE}, r_0^{GE}) = \widetilde{W}^{PE}(B_0(\psi), \tau_0^{GE}, \bar{n}_0^{GE}, w_0^{GE}, r_0^{GE})$$

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 get the same results and, thus, the same welfare evaluation than in GE. The decomposition of the welfare gain of a UI change from $B_0(\psi)$ to $B_1(\psi)$ can be written:

$$\begin{aligned} W^{GE}(B_1(\psi)) \quad &- \quad W^{GE}(B_0(\psi)) = \\ \widetilde{W}^{PE}(B_1(\psi), \tau_0^{GE}, \bar{n}_0^{GE}, w_0^{GE}, r_0^{GE}) \quad &- \quad \widetilde{W}^{PE}(B_0(\psi), \tau_0^{GE}, \bar{n}_0^{GE}, w_0^{GE}, r_0^{GE}) \\ +\widetilde{W}^{PE}(B_1(\psi), \tau_1^{PE}, \bar{n}_1^{PE}, w_0^{GE}, r_0^{GE}) \quad &- \quad \widetilde{W}^{PE}(B_1(\psi), \tau_0^{GE}, \bar{n}_0^{GE}, w_0^{GE}, r_0^{GE}) \\ +\widetilde{W}^{PE}(B_1(\psi), \tau_1^{GE}, \bar{n}_1^{GE}, w_1^{GE}, r_1^{GE}) \quad &- \quad \widetilde{W}^{PE}(B_1(\psi), \tau_1^{PE}, \bar{n}_1^{PE}, w_0^{GE}, r_0^{GE}) \end{aligned}$$

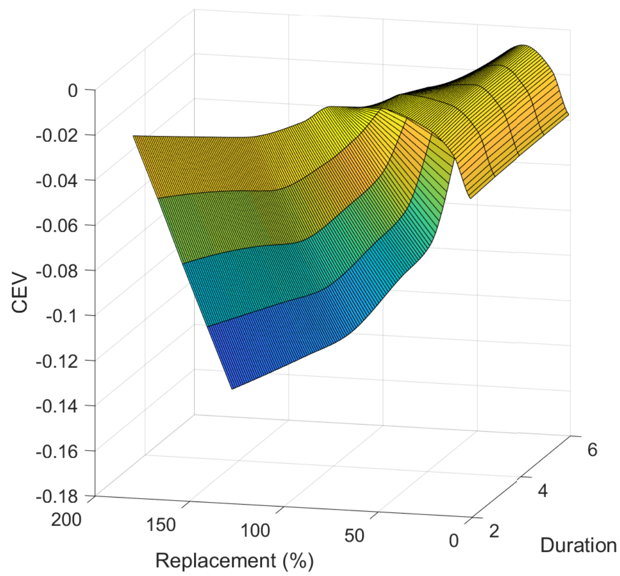
where the first line is the welfare gain in GE, the total effect, the second line is the benefits effect, the third line is the tax effect and the last line is the price effect. Notice that τ_1^{PE} and $\bar{n}_1^{PE}$ are consistent with $B_1(\psi)$, that is, they balance the budget in PE. Thus, the first two effects are the response that would arise in a PE evaluation of a policy change. This means that the third line, the price effect, is equivalent to the GE effect; is what GE adds to the analysis.

4.3 Welfare effects of UI

We now turn to the main results of our welfare evaluations. We evaluate the welfare in steady state for different UI policies, implemented as a grid of replacement rates and potential durations. We present the general results and identify the welfare maximizing policy. We compare all the other cases to this benchmark, so that each result should be interpreted as the welfare loss of being far from the welfare maximizing system. In what follows we concentrate mostly on durations of at least two model periods. The reason is that, in our model, the first period is a transfer to all separated, independently of the extension of the unemployment spell. From the point of view of the worker's behavior, that type of transfer corresponds more to a severance pay than to UI.

Figure 6 shows the CE welfare measure after evaluating the grid in GE. At the origin (no benefits) there are welfare losses of about 4% of consumption. Welfare increases steeply with replacement rate until about 50%, the calibrated economy. After this point, welfare tends to stabilize and drop. This drop is smooth for short potential durations (2 quarters, the calibrated potential duration) and steep for long durations (6 quarters or longer UI policies). In our model, long periods of high replacement rates (150% for one year and a half, for example) generates a welfare loss of about 16%. But the same potential duration for a replacement rate of 50% implies 2% welfare loss. The maximum welfare is reached at a replacement rate of 63% and a potential duration of 2 model periods (six months), that is relatively close to the calibrated economy.

Figure 6: Consumption equivalent welfare effects of UI in GE

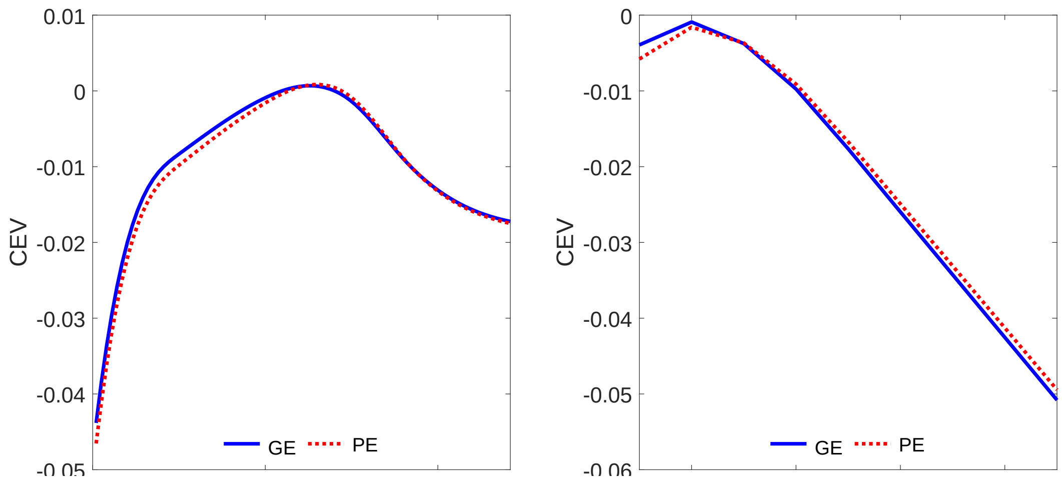


Notes: The figure plots the consumption equivalent measure of welfare loss comparing each point in the grid of replacement and potential duration to the welfare maximizing UI (63% replacement rate and 2 model periods). The plot is the result of a spline interpolation of the evaluations of a grid of replacement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

The blue solid line of Figure 7 plots two cuts of the previous function. Panel (a) plots CE of changing replacement rate with a potential duration constant in 2 model periods. The welfare maximizing point is at replacement rate 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 rate fixed to 50%. It shows that two model periods provides the highest level of welfare.

Table 3 reproduces the effect of increasing the generosity of UI, from the welfare maximizing UI, on several variables. Column (2) shows the effect of increasing replacement rate 10 percentage points. Taxes increase from 13% to 14% and both capital and labor (effective human capital in jobs) decrease in about 1%. The reduction labor is the result of a decrease in the 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, capital

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



(a) Level (PD=2)

(b) Duration ($B = 0.5$)

Notes: The figure plots the consumption equivalent measure of welfare loss comparing UI systems to the welfare maximizing UI policy (63% replacement rate and 2 model periods). Panel (a) sets potential duration to two model periods and shows different replacement rates (a grid of replacement rates is evaluated and the remaining levels are interpolated using a spline). Panel (b) sets replacement rate to 50% and shows different potential durations. Blue lines plot cuts of the function presented in Figure 6 and are GE evaluations. Dashed red lines are evaluations in PE.

seems more affected in this case than human capital, leading to a stronger change in factor prices. Nevertheless, changes in prices are still very low (about 0.1%).

An important issue, noted above, is that wages (and, thus, factor prices) do not change much, particularly close to the welfare maximizing policy. (See Figure 20 that provide a more general description of the effect of UI on the equilibrium variables.)

4.4 Partial and general equilibrium effects

We now turn to the effects of UI in PE. We compare the results in PE with the ones in GE and we present our decomposition.

Figure 7 plots the CE measure for a PE solution in red dashed lines. Both in panel (a) and panel (b) welfare effects in PE are very similar to the ones in GE. In particular, the welfare maximizing policy is practically indistinguishable between the two.

Table 3 better shows the difference between the two solutions, when increasing the generosity of UI. Column (3) reports the main variables of the solution in PE when increasing 10 percentage points the replacement rate from the welfare maximizing policy. In this case, capital decrease in approximately 2%, while human capital is reduced in 1%, leading to a reduction in capital-labor ratio of less than 1%. This change in capital-labor ratio in PE is what generates a very small adjustment of factor prices when we solve the economy in GE.

At the same time, the fact that wages tend to fall and interest rate tend to rise is what makes the capital-labor ratio less responsive in GE. Overall, both solutions are very similar. An analogous result can be obtained from the increase in potential duration in one additional quarter, shown in columns (4) and (5). (Again, 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 3: Partial and general equilibrium effects of changes in UI

Variable	initial	change in level		change in duration	
		GE	PE	GE	PE
	(1)	(2)	(3)	(4)	(5)
Replacement	0.63	0.73		0.63	
Pot.duration	2	2		3	
		Change in % from the benchmark			
Tax rate 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	0.0183	0.1	0.0	0.0	0.0

Notes: The table reproduces the effects of changing UI system in 10 percentage points (columns (2) and (3)) and one model period (columns (4) and (5)) from the welfare maximizing UI system.

4.5 Decomposition

Table 4 shows the results of the welfare gains decomposition exercise. In the second column it compares the welfare gains of an increase in replacement rate of 10 percentage points. Overall, welfare decrease in about 0.09% when we consider GE solution and even less (0.06%) in PE. We decompose these effects into the UI benefits, taxes, and price effects. The UI effect, the (unbalanced) increase in benefits, generates almost a 1% increase in welfare; this is simply the effect of transfers to the unemployed. Additionally, the effect of an increase of taxes to finance that transfer in partial equilibrium represents also almost 1%. We can add these to effects to conclude that PE welfare effect is negative, given that the second effect is slightly higher in absolute value. The GE effect, the effect of factor price changes, is small and negative (0.02%). This adds to the overall welfare loss in GE of 0.09%.

The third column of Table 4 reproduce the same decomposition when potential duration increases in one model period (one quarter). We find now that welfare effects are stronger, leading to an overall welfare loss of 1.1% in PE and 1.2% in GE, while the price effect is -0.1%.

Table 4: Welfare gains decomposition

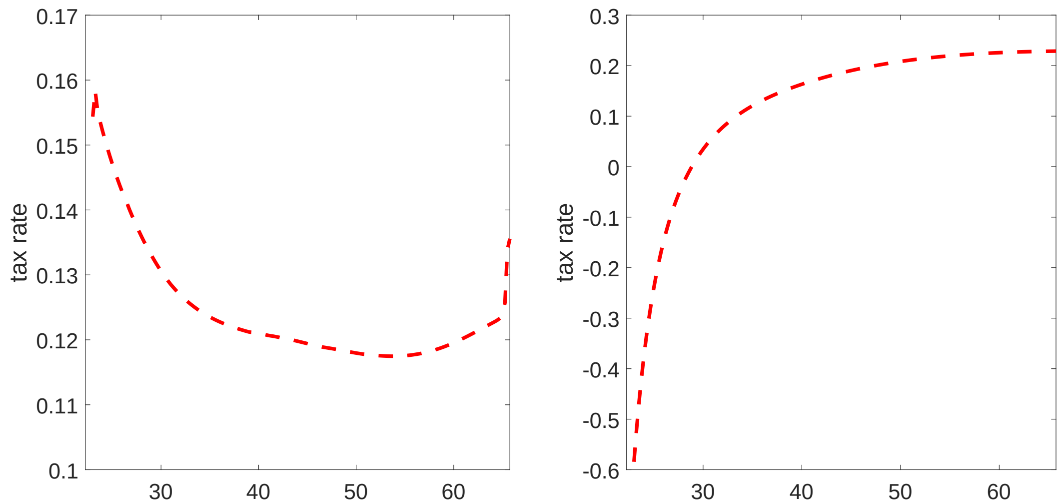
Variable	Benchmark	Change in UI	
		level	pot.duration
Replacement	0.63	0.73	0.63
Pot.duration	2	2	3
Total welfare gains (CEx1000) w.r.t. benchmark			
General Equilibrium	-	-0.90	-12.48
Partial Equilibrium	-	-0.63	-11.32
Difference GE-PE	-	-0.26	-1.16
UI effect	-	8.74	6.13
Tax effect	-	-9.29	-17.34
Price effect	-	-0.23	-1.07

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.

5 Robustness

We have shown our main conclusions through our life-cycle model. In our model, 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. To find this policy, we restrict our planner

Figure 8: Age-dependent tax rates



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

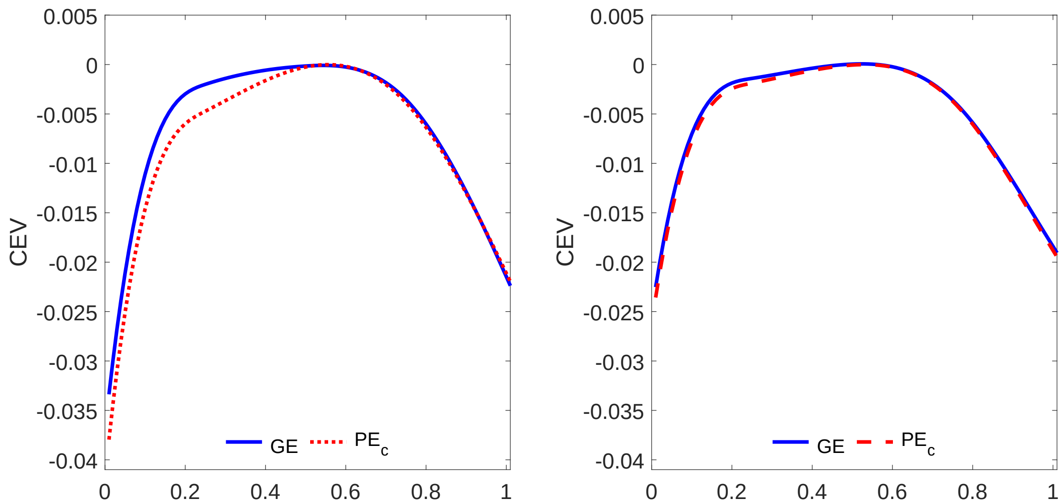
Notes: The figure plots the age dependent tax rates for the robustness cases in which UI for a given age is financed by taxes to employed workers of the same age, panel (a), and in which age dependent taxes are set to provide a constant profile of net labor income, panel (b).

to use only a replacement rate and potential duration of UI. Thus, the planner has few and restricted 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).

An concern could be that the planner might be using UI to provide transfers to young individuals and, in this way, smooth consumption through life, partially offsetting 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 employed workers of that same age. In the second extension we eliminate the life-cycle income profile by setting age-dependent taxes. In this way, young employed workers have higher income levels in this extension. In both cases, we use age-dependent taxes, but in the first case tax rates are higher for the young and in the second case tax rates are negative for the young, see Figure 8. We focus on whether the welfare maximizing UI policy changes in these cases compared to our baseline model.

We find that in these exercises, the welfare maximizing policy does not change much: the potential duration is again of two model periods and the replacement rate is slightly above the calibrated one. Figure 9 shows the CE of different replacement rates for two quarters of

Figure 9: 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 welfare effects of changing UI replacement rates setting potential duration to two model periods in the two robustness exercises (see additional notes to Figure 7.)

potential duration. Panel (a) shows the CE for the economy in which UI budget is balanced by age; panel (b) shows the CE for the economy in which net labor income is flat by age. 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 seem similar in shape and in its maximum. Nevertheless, the welfare gains are lower in panel (b). For example, the no-UI welfare loss is close to 4% in panel (a) and 2.5% in panel (b). The main difference between the two cases is that when the labor income is constant in age, workers save earlier in life. Thus, they can more effectively self-smooth consumption during the unemployment spell when they get displaced. At the same time, this behavior generates a distribution of assets that is less connected with the data, with fewer liquidity constrained workers.

6 Extensions and analysis

In this section we explore the role of assets distribution and savings response to UI in our welfare analysis. To illustrate these issues, we provide some extensions to the quantitative model. We first take advantage of the fact that asset accumulation depends greatly on taxes to generate different capital-labor ratio responses to UI changes. Next, we emphasize the role of the life-cycle effects by eliminating most of the age-dependent features of our quantitative model. We will discuss the relevance of the initial distribution of assets and the elasticity of aggregate capital with respect to UI in such a context.

6.1 The role of savings response

In our baseline economy the price effects generated by GE are small, at least around the calibrated UI policy. This implies that PE and GE do no not differ much. Welfare gains in both types of evaluations are almost identical. The reason is that capital-labor ratio does not change much with marginal variations in UI.

We have emphasized that the GE effect is determined by the capital-labor ratio response in PE. If capital-labor ratio does not change in PE, the GE economy would not differ from the PE. While this observation is relevant in general, the fact that capital-labor ratio does not change depends on the model and its calibration. For that reason, it is important to show cases in which capital-labor ratio changes due to UI.

In our model, an increase in capital-labor ratio yields 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. Thus, the increase in wages would obviously improve their welfare.

The positive link between capital-labor ratio and welfare is a convenient feature that helps us clarify the GE effect in our model. The only effect of GE is through price effects (and the behavioral responses associated to them), and the sign of this effect is very clear in our model, since workers are born with no assets. For now, we concentrate on using this feature to show that GE effect could be positive or negative, according to the response of capital-labor ratio to UI.

In our model, the response of savings strongly depends on taxes. We now change how assets are collected to allow for different results. 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_r. 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, 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. These extensions are only a way to generate different responses of aggregate capital-labor ratio to UI in PE.

6.1.1 Results

Figure 10 shows the capital-labor ratio under different replacement rates setting the potential duration to two model periods. For convenience, we reproduce the baseline economy, panel (a), and we plot the extensions in panel (b) and (c). The dashed 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. This ratio is decreasing in the economy with capital tax. The economic mechanism for this reduction in the factor ratio is that a more generous UI induces a rise in taxes to both labor income and capital income, reducing both incentives and means to accumulate assets. In the economy with lump-sum taxes, shown in panel (c), the capital-labor ratio is increasing. The economic mechanism is that, when UI increases, taxes to labor income rise less in this extension compared to the baseline, and the lump-sum tax, at the end of the life, increases. This implies that the worker has incentives to save to cover that tax at the end of the life. These three different responses of capital-labor ratio in PE provides different GE effect in these three cases.

Figure 11 plots the CE for different UI replacement ratios in three versions of our model: the baseline in panel (a) (we plot again the panel (a) of Figure 7 for convenience), the economy with taxes to capital income, panel (b), and the economy with a lump-sum tax, panel (c). The potential duration is maintained in two model periods, which is the welfare maximizing potential duration in the three of them. The figure plots CE evaluated in PE in the dashed red line and in GE in the solid blue line.

In the baseline, PE and GE evaluations are almost indistinguishable and the welfare maximizing replacement ratio is not different in these two evaluations. In the economy with capital income taxes, panel (b) in the Figure, the GE effect on welfare is negative at the welfare maximizing policy. This implies that any increase in 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 welfare maximizing replacement rate is thus higher in PE evaluation (71%) than in GE evaluation (63%). The reason for this result is that an increase in UI generosity implies a fall in capital-labor ratio, inducing a negative GE effect.

In the extension with lump-sum taxes, the GE effect is positive. This means that the welfare gain in PE are lower than the welfare gains in GE. This can be observed from the slopes of the figure. In particular, in the welfare maximizing replacement rate evaluated in GE, the slope of PE evaluation is negative. This means that the replacement rate that maximizes welfare in PE is lower than the one in GE. Particular numbers for this calibration are 89% and 95% respectively. The reason for this is that capital-labor ratio increases with a more generous UI in this extension.

Figure 11, panels (b) and (c), reproduce two PE welfare evaluations. The first one, labeled PE_c, uses factor prices of the calibrated economy. The second one, labeled PE_o, uses factor prices in the welfare maximizing GE replacement rate. This last, crosses the GE line in its maximum. An important feature of these two PE welfare evaluations is that they are approximately parallel.

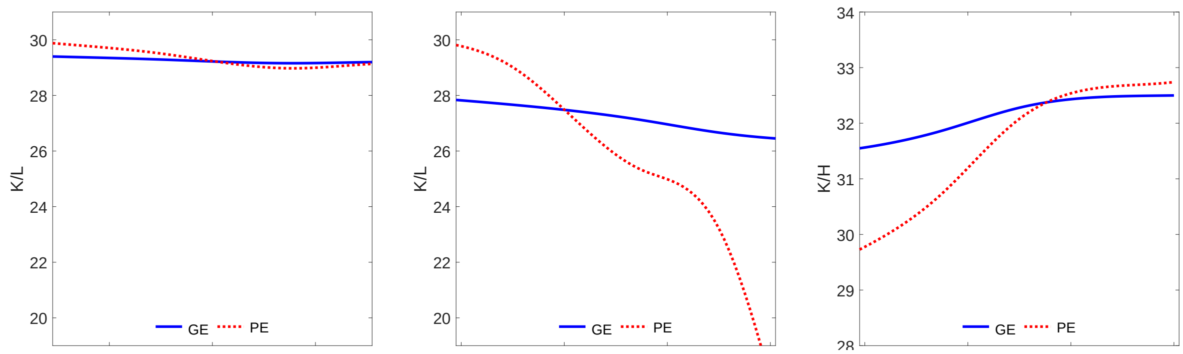
Figure 12 plots the PE and GE welfare evaluations of changes in potential duration of UI. In the baseline economy, welfare gains in PE and GE are similar and almost indistinguishable. With taxes to capital income the welfare gains in PE are clearly higher than the gains in GE. Finally, in the extension with lump-sum taxes at the end of the working life, 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.

Table 5 shows the effect of a higher replacement rate in some endogenous variables of these economies. Columns (1) and (2) report the results for our baseline economy. Columns (3) and (4) show the results for the economy with taxes to capital income. Column (4) shows a stronger effect on capital, as expected; 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 capital-labor ratio of 6.8% in PE. In GE prices change increasing the net returns to capital in 1% and decreasing wages in 0.2%.

Columns (5) and (6) show the results for the economy with a lump-sum tax. In this case, on the contrary, an increase in UI replacement rate induces a rise in 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%.

Table 6 presents the welfare decomposition exercise when replacement rate 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 (-0.12% of CE) when there are taxes to capital income, and are positive (0.1% of CE) 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.

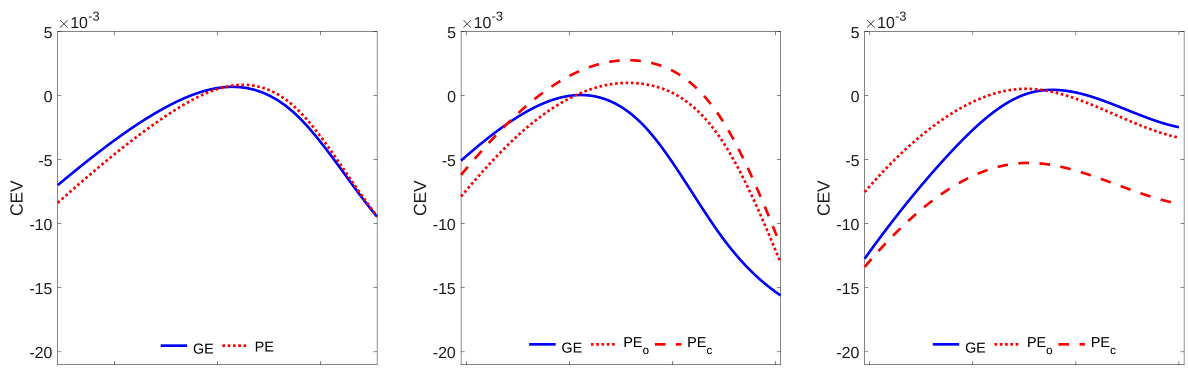
Figure 10: Capital-labor ratio under different tax arrangements



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

Notes: The figure plots the capital-labor ratio that result in equilibrium from changing replacement ratios and with potential duration of two model periods. Panel (a) shows the baseline economy, panel (b) the extension with capital income tax, and panel (c) the extension with a lump-sum tax.

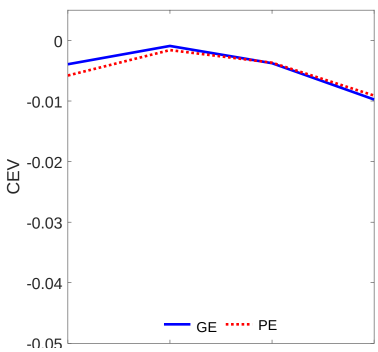
Figure 11: Welfare effects of UI replacement rate under different tax arrangements



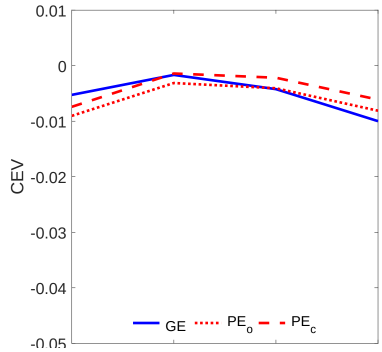
(a) Baseline (b) Capital tax (c) Lump-sum tax

Notes: The figure plots the welfare effects of changing UI replacement rates setting potential duration to two model periods in the baseline and in two extensions. Panel (a) reproduces the corresponding plot in Figure 7, panel (b) shows the extension with capital income tax, and panel (c) shows the extension with a lump-sum tax. In panels (b) and (c), the dashed red line labeled PE_c shows the CE in PE with factor prices fixed to the ones that arise with UI with 50% of replacement rate and two model periods of potential duration. The line labeled PE_o shows the CE in PE with factor prices fixed to the welfare maximizing policy (a replacement rate of 63% in panel (a) and 95% in panel (b)).

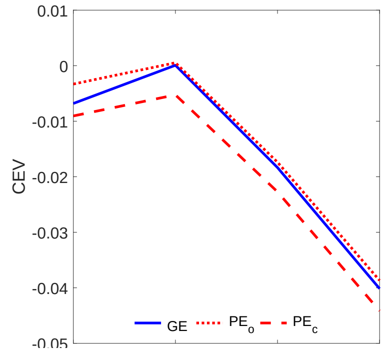
Figure 12: Welfare effects of UI potential duration under different tax arrangements



(a) Baseline



(b) Capital tax



(c) Lump-sum tax

Notes: The figure plots the welfare effects of changing UI potential duration while setting replacement rates constant and close to the welfare maximizing replacement rate in each case. See additional notes to Figure 11.

Table 5: Partial and general equilibrium effects of an increase in replacement rate 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	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)).

Table 6: Welfare gains decomposition of an increase in replacement rate 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 (CEx1000) w.r.t. benchmark			
General Equilibrium	-0.90	-0.98	-2.45
Partial Equilibrium	-0.63	0.79	-3.54
Difference GE-PE	-0.26	-1.78	1.09
UI effect	8.74	8.49	9.07
Tax effect	-9.29	-7.57	-12.38
Price effect	-0.23	-1.77	0.97

Notes: The table reproduces the welfare decomposition of increasing UI replacement rates 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).

6.2 Life-cycle effects

We now turn to analyze the importance of life-cycle effects on our results. Our baseline model has age-dependent variables that generate relevant economic mechanisms. To address their importance, we eliminate many differences by age. First, we eliminate human capital accumulation process ($\kappa = 1$ for all cases). We also eliminate the dependence on age of survival rate ($\delta_j = 0.005$ while $\delta_r \approx 0.016$ is kept unchanged), and of separation rates ($\pi = 0.04$). Additionally, in this extension workers can receive assets at the beginning of their working lives. The distribution of assets of workers that enter the model arise from the distribution of assets of workers that exit the model due to limited survival. Thus, we compute the initial distribution of assets as a legacy from each of those that die to one newborn worker. This distribution is now endogenous and is affected by UI policy. Additionally, given that we introduce legacies, we increase depreciation rate to $d = 0.014$. Finally, we extend the working lives or our agents to 60 years and we increase pensions slightly to $P = 0.2$.

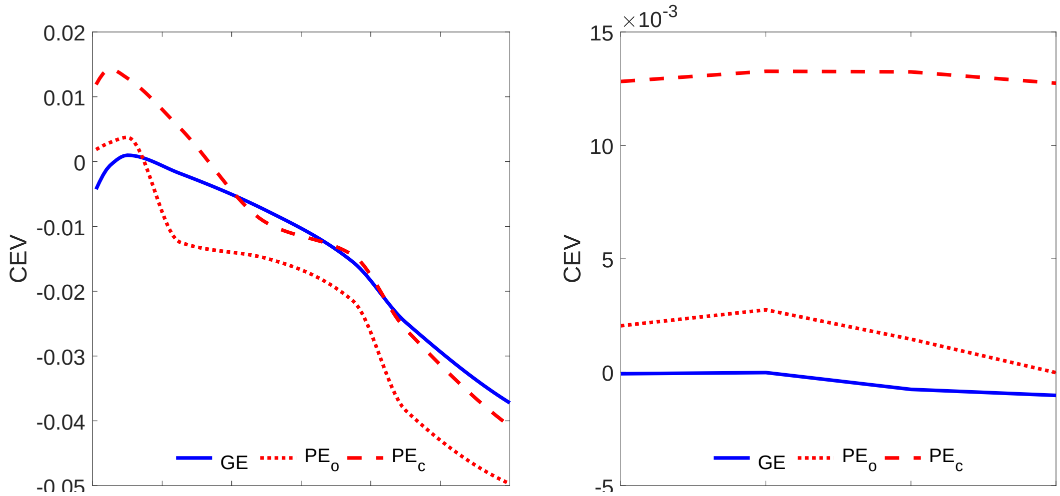
With these changes there are important life-cycle features that are missing. First, there is no increase in income with labor experience. This reduces the value of a job for the young and makes them to search less. Also, the constant profile of hourly wages makes young workers more willing to save. Second, given that pensions are more generous, savings are not related to retirement. Thus, aggregate assets are potentially more responsive to unemployment risk and to the returns to assets. Third, initial distribution of assets generate a means to smooth consumption even when young.

6.2.1 Results

Figure 13 shows the welfare effects of changing UI policy in this extension. The policy that maximizes welfare in GE is the replacement rate of 12% with two model periods of potential duration. In this case, UI does not provide much wellbeing. In particular, the potential welfare gains of moving from the current policy to the maximum welfare are approximately 0.5% in CE. Additionally, the no-UI case provides the same welfare than the current policy. When we analyze the welfare effects of changing UI in PE the welfare maximizing policy is lower compared to the one in GE. Thus, the effects that so strongly reduce the value of UI arise also in PE.

Table 7 shows the changes in variables when the replacement rate increases in 10 percentage points above its welfare maximizing level. The table reports that in PE capital is reduced by 8.6% while labor increases 0.8%, even when average job-finding rate is reduced by 5% and unemployment increases in 5%. This change in factors is very different from our baseline economy (reported in the table for convenience), where capital falls in 1.5% and

Figure 13: Welfare effects of UI without Human Capital or other life-cycle effects



(a) Level (PD=2) (b) Duration ($B = 0.1$)

Notes: The figure plots the consumption equivalent measure of welfare loss comparing UI systems to the welfare maximizing UI policy (12% replacement rate and 2 model periods) for the extension without human capital and other age-dependent variables. Panel (a) shows different replacement rates setting potential duration to two model periods; panel (b) shows different potential durations setting replacement rates to 10%. The dashed red line labeled PE_c shows the CE in PE with factor prices fixed to the ones that arise with UI with 50% of replacement rate and two model periods of potential duration. The dotted red line labeled PE_o shows the CE in PE with factor prices fixed to the welfare maximizing policy.

labor in 0.8%. While in the baseline capital-labor ratio falls 0.8% in PE, in this extension capital-labor ratio drops 9.3%. When factor prices adjust, in GE, we find that wages fall by -0.1% while interest rate increase by 0.6%.

Table 7: Partial and general equilibrium effects of an increase in replacement rate of 10 pp from the optimal level, extension without human capital or other life-cycle effects

Variable	Baseline		no life-cyle	
	GE	PE	GE	PE
Replacement	0.63 to 0.73		0.12 to 0.22	
Pot.duration	2		2	
Change in %				
Capital K	-1.0	-1.5	-0.7	-8.6
Human cap. H	-0.8	-0.8	-0.5	0.8
Search s	-5.0	-5.0	-2.0	-1.5
Unemployment	5.3	5.3	1.9	1.4
Ratio K/H	-0.2	-0.8	-0.3	-9.3
Wage w	-0.1	0.0	-0.1	0.0
Int. rate r	0.1	0.0	0.6	0.0

Notes: The table reproduces the effects on endogenous variables of changing UI system in 10 percentage points from the welfare maximizing UI system.

A main difference in this extension is that aggregate capital falls much more than in our baseline model. There are two reasons for this. First, savings are more responsive to the a change in UI. In this extension there are no incentives to save for retirement. Thus, in absence of this motive to save, balanced-budget changes in UI leads to a higher elasticity of capital. Second, the initial distribution of assets is endogenous and, thus, any initial fall in assets is then amplified by this fact. To be explicit, the fall in savings would reduce assets of the currently living. When they die and exit the model, this fall in assets is reflected in the initial distribution of assets of the newborn. Given that this process iterates until it converges, the fall in savings is amplified in this version of the model compared to the life-cycle model.

Table 8 extends the decomposition of welfare changes for this case, introducing the update in the initial distribution of assets. Again, we change 10 percentage points the replacement rate from the welfare maximizing policy, which is 12%. We also report again the analogous exercise for the baseline model. First, the welfare gains in GE are comparable with those in the baseline model, but the evaluation for PE is very different: there is a welfare drop of about 1% of CE. The decomposition shows that the welfare effects of increasing benefits and taxes to balance the budget in PE generates, in fact, welfare gains. These first two effects take as given the initial distribution of assets. When initial assets are updated, welfare gains in PE turn to the negative 1% welfare loss in PE.

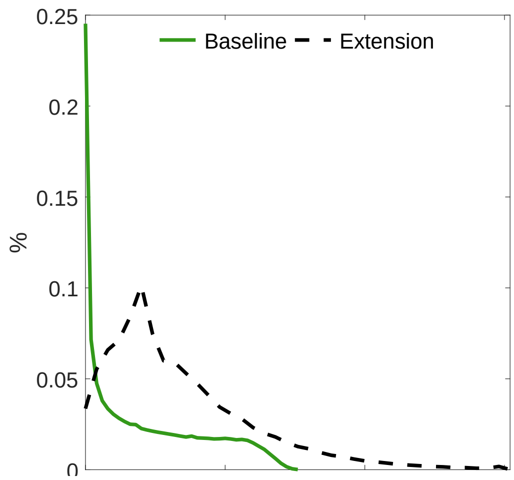
Table 8: Welfare gains decomposition of an increase in replacement rate of 10 pp from the optimal level, extension without human capital or other life-cycle effects

Variable	Baseline	No life-cycle
Total welfare gains (CEx1000) w.r.t. benchmark		
General Equilibrium	-0.90	-0.97
Partial Equilibrium	-0.63	-10.28
Difference GE-PE	-0.26	9.31
UI effect	8.74	4.90
Tax effect	-9.29	-3.90
Initial distr. of assets	0.00	-11.25
Price effect	-0.23	- 1.39
Initial distr. of assets in GE	0.00	10.57

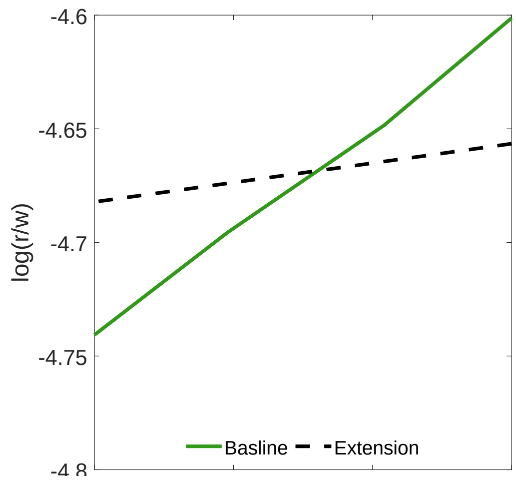
Notes: the table reproduces the decomposition of welfare effects of chaning UI system in 10 percentage points from the welfare maximizing UI system.

The GE effect adds to the previous PE effects the effect of factor prices taking initial as in PE, and the effects of initial assets due to prices changes. When factor prices change (r

Figure 14: Assets distribution among the unemployed and elasticity of relative factor supply



(a) Unemp. distribution of assets



(b) Relative supply of factors

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

increase and w drops) the welfare effect is negative but much less relevant (-0.1% of CE). But this price factor change induces an adjustment in the distribution of assets that more than compensates for the price factor change. This is because assets increase due to the factor price changes and this induce a substantial increase in welfare (of about 1% of CE).

In all, this extension shows that life-cycle effects are crucial for our result. While there are many differences between this extension and our baseline economy, we want to emphasize two main effects that are quantitative important: the distribution of assets among the unemployed and the elasticity of aggregate capital. In this extension the initial distribution of assets provides the unemployed a means to smooth consumption. Additionally, given that income is not increasing, the incentives to save while young are stronger, and these initial assets are saved. For these reasons, the assets for the young are higher, and the overall distribution of assets is less concentrated in lower values. Panel (a) of Figure 14 shows the histogram of the assets of the unemployed workers at displacement, comparing this extension with our baseline economy. In the life-cycle economy about 25% of unemployed workers has no assets at the beginning of the unemployment spell. The corresponding proportion for the extension is approximately 5%. Additionally, the mode in this extension corresponds to two years of average labor income, well above the required savings to finance a typical unemployment spell.

With no life-cycle effects the elasticity of capital-labor ratio is higher. Panel (b) of Figure 14 shows capital-labor ratio as a function of relative prices, r/w. Both axes are in logs. The green line represent the baseline economy with the calibrated level of benefits, under different relative prices.[9] The analogous black line represent the extension, that is, without human capital or other age dependent variables. The fact that the elasticity of the relative supply of factors is much lower in our baseline economy compared to the extension can be readily seen from the slope of these lines, which are considerably larger in the baseline compared to the extension.

Another important observation is that the elasticity of capital-labor ratio with respect to UI is larger when there are no life-cycle effects. Figure 15 shows the same axis as in the previous figure. Again, solid lines represent the capital-labor ratio of the economy with the UI system as in the calibrated economy (50% replacement rate for two model periods). In this figure, two additional lines are plotted for each case. The negative slope (dotted) lines represent the relative demand of factors, that arise from the first order condition of the firms. In absence of depreciation, this would represent an elasticity of -1. The point in which the green dotted curve and the green solid curve intersect represent the relative prices and the relative factors in GE for our baseline economy. Additionally, dashed lines represent the relative supply of factors in the no-UI case (a replacement rate of zero). The elimination of UI shifts the supply curve to the right, implying that the capital-labor ratio increases if relative prices are kept constant. The green square in the figure represent the effect of eliminating UI in PE, that is, in the absence of price adjustments. At the same time, where the green dashed line and the green dotted line intersect is the GE in the no-UI case. To reach this point, relative prices adjust (interest rate down and wages up), reducing the capital-labor ratio in equilibrium.

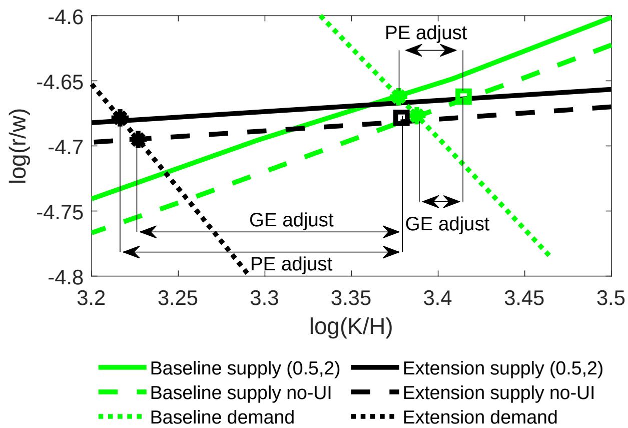
The corresponding black lines represent the economy with no life-cycle effects. Importantly, the PE change in capital-labor ratio is much stronger in this case, implying that the elasticity of capital-labor ratio with respect to UI is higher. At the same time, the price change required to reach GE point is not much bigger than the price change required in our baseline economy, given that the supply elasticity of relative factors with respect to prices is also very high.

In all, Figure 15 emphasizes two important points: the elasticity of the relative supply of factors is much lower in our baseline economy compared to the extension, and the PE response of capital-labor ratio is much stronger in the extension.

These two characteristics of this extension, more assets to the unemployed and a stronger

[9] The curve reports the adjustment of capital-labor ratio to relative factor prices. For that reason, taxes are kept constant and the government budget is not necessarily satisfied in this graph.

Figure 15: Relative factor supply and demand



Notes: The figure reports the relative factor supply for different relative factor prices at the calibrated system (50% of replacement rate for two model periods or six months) in the solid line, and of no-UI in dashed line, comparing our baseline (green lines) with the extension with no human capital (black lines). The negative slope dotted lines represent the relative factor demand in each case.

response of aggregate capital, are also features of the infinitely lived agents models, typically used in the literature to assess the welfare effects of UI in GE. In particular, Young (2004) acknowledges these two issues within the paper. In a way, this extension shows that what makes those models to reject the relevance of UI is not that they include GE effects, but that they result in a role of assets that reduces welfare gains and increases welfare costs of UI, even in PE.

Importantly, our baseline version clearly outperforms the extension without human capital when we consider the data on distribution and elasticity of assets. First, the accuracy of our baseline model in the distribution of assets has been discussed before (see Table 2). Second, 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 rate 10% would lower broad asset holdings of employed workers by only 0.4%, implying an elasticity of -0.04.[10] We find this same elasticity in our baseline model when we consider aggregate capital, while the corresponding elasticity in the extension without human capital is -0.15. In a proper infinitely lived agent this elasticity would be even higher.[11]

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

[11] This can be observed in Young (2004) where the elasticity seems much higher than in our extension, and in Koehne and Kuhn (2015) where the elasticity is -1 in a comparable exercise.

6.3 Heterogeneous discount factors

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

The literature has used heterogenous discount factors to generate larger dispersion in asset accumulation. As an example, Mukoyama (2010) extends one of the versions of the infinitely-lived agents models by introducing stochastic discount factors. Discount factors are governed by a three-state, first-order Markov process. The calibration in that paper is set so that 10% of the population are affected by the high level discount factor and 10% by the low level. The expected duration within these extreme values is 50 years in that model. 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, according to that paper, suggesting that the distribution of assets is unimportant for UI evaluation.

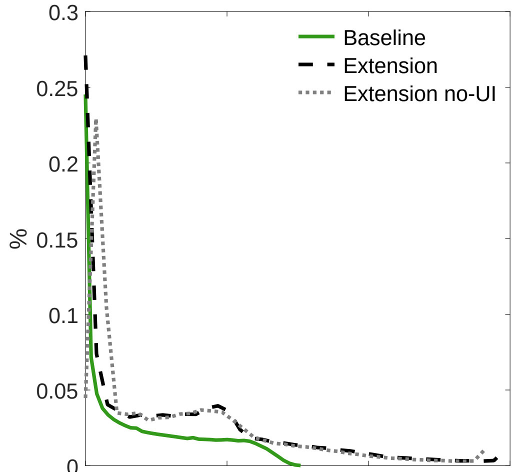
We now turn to evaluate up to what extent the introduction of heterogeneous discount factors in our extension could lead to a wealth distribution more in line with the data and fix the issues that arise when we abstract from the life-cycle effects. Additionally, we compute the welfare maximizing policy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

For that purpose, we introduce two type of workers, with low or high discount factor, β_l and β_h, respectively. The types are randomly assigned at the beginning of the life. The other characteristics do not differ: both types begin their working life with the same chances of being unemployed and the same initial distribution of wealth.

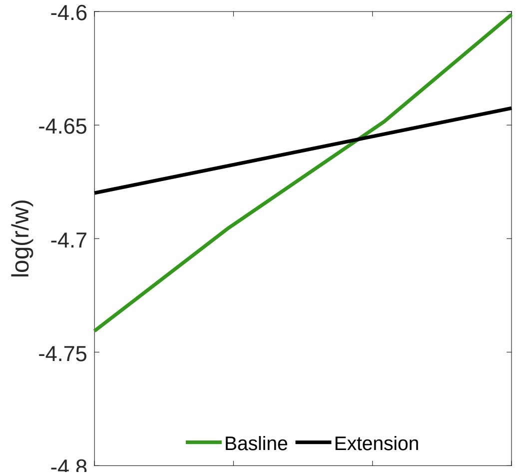
We calibrate these values to maintain the aggregate capital-labor ratio and to generate an initial distribution of assets among the unemployed similar to the one in our baseline calibration. We consider this target more adequate for our purposes and more comparable to our baseline economy than the Gini of the overall wealth dispersion. On the whole, we set $\beta_l = (0.945)^{1/4}$ and $\beta_h = (0.967)^{1/4}$.

The left panel of Figure 16 plots the initial distribution of assets with this calibration. The black dashed line shows that, when we consider heterogeneous discount factors, about 25% of the unemployed workers are liquidity constrained (close to the borrowing limit) at the beginning of their unemployment spell. This high proportion of unemployed workers with little wealth to self-smooth consumption can increase the social value of UI. For comparison, we also plot the same distribution in our baseline economy (see the green solid line). Overall, the distribution of assets among the unemployed is similar in these two economies.

Figure 16: Assets distribution and elasticity of relative factor supply with heterogeneous discount factors



(a) Unemployed wealth distribution



(b) K/H relative supply

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

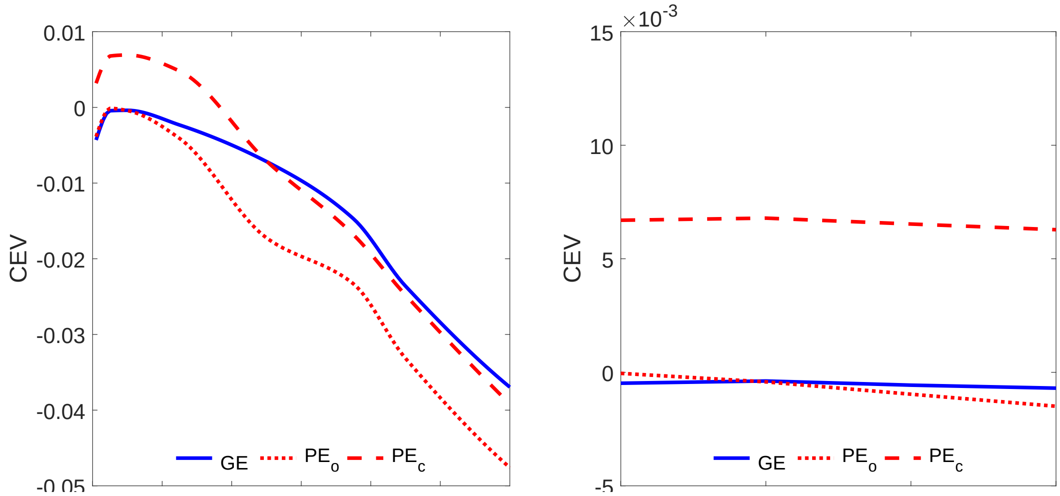
The left panel of Figure 17 shows the CEV of different replacement ratios in this extension, setting potential duration to two model periods. Both the partial equilibrium and the general equilibrium evaluations indicate that the welfare maximizing replacement ratio is low. The plot is very close to the one presented in Figure 13 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 17 shows the CEV of changing potential duration setting the replacement ratio fixed to a level close to the welfare maximizing policy. Again, this plot is similar to the one with homogeneous discounting.

Table 9 shows the effects of increasing the replacement rate 10 pp. from the welfare maximizing level of 7%. For the ease of comparison, we reproduce the results of the homogeneous discounting case. The increase in UI reduces both capital and labor by 1.2% and 0.3%, respectively. Importantly, compared to the homogeneous discounting, capital adjusts less, but labor is reduced in the heterogeneous discounting compared to the increase in the homogeneous discounting case. In any case, capital labor ratio is not substantially affected by the increase in replacement ratio leading to no appreciable changes in prices in GE.

Table 10 provides the decomposition of welfare gains when the replacement ratio increases 10 pp comparing the economy with homogeneous discounting to the stochastic discount factor

Figure 17: UI system and welfare with no age profiles



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

Notes: The figure plots the CEV losses comparing UI systems to the welfare maximizing UI policy in general equilibrium (7% replacement rate and 2 model periods) for the extension without human capital and heterogeneous discount factors. Panel (a) fixes potential duration to two periods and studies the effect of changing the replacement ratio on welfare. Panel (b) fixes the replacement ratio to 5% and studies the effect of changing the potential duration of UI benefits on welfare. In both panels, the blue line represents the CEV differences in general equilibrium, the dashed red line represents the CEV differences in partial equilibrium where prices are consistent with a UI system with 0.5 replacement ratio and two periods of potential duration, and the dotted red line presents the CEV in partial equilibrium where prices are consistent with the welfare maximizing UI system.

case. We find that, in both cases, the PE effect is negative and larger in absolute value than the GE evaluation. Importantly, the welfare gains of increasing UI in PE is only slightly higher in the heterogeneous discounting case. At the same time, the negative effect of increasing taxes is larger. Price effects are inconsequential close to the optimal in this heterogeneous discounting case. A substantial difference between the two economies in this table is related to the effects of the initial distribution of assets: the effect in partial equilibrium is -.2% in the heterogeneous discounting case, compared with -1.1% in the homogeneous discounting case. This is related to the relatively flat PE line at the right of the welfare maximizing replacement ratio in the heterogeneous discounting case; for higher replacement ratios, this effect is much stronger. To be clear, the low effect of the initial distribution of assets is not a property of the heterogeneous discount factor economy, but it is only locally valid.

Table 11 and Table 12 show the effect of a wider change in UI replacement ratio. We report the effects of increasing 40 pp the UI replacement ratio from the welfare maximizing level on some endogenous variables and on welfare. In this case both economies do not seem different.

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

Table 9: Partial and general equilibrium effects of an increase in replacement rate of 10 pp from the optimal level, extension without human capital or other life-cycle effects

Variable	Homog. discount GE	Homog. discount PE	Het. discount GE	Het. discount PE
Replacement ratio	0.12 to 0.22		0.07 to 0.17	
Potential duration	2		2	
Change in %				
Capital K	-0.7	-8.6	-0.6	-1.2
Human capital H	-0.5	0.8	-0.4	-0.3
Unemployment	1.9	1.4	1.8	1.6
Ratio K/H	-0.3	-9.3	-0.1	-0.9
Wage w	-0.1	0.0	0.0	0.0
Int. rate r	0.6	0.0	0.0	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 10: Welfare gains decomposition of an increase in replacement rate of 10 pp from the optimal level, without human capital or other life-cycle effects

Variable	Homog. discount	Het. discount
Total welfare gains (CEVx1000) w.r.t. benchmark		
General Equilibrium	-0.97	-0.64
Partial Equilibrium	-10.28	-1.62
Difference GE-PE	9.31	0.98
UI effect	4.90	5.34
Tax effect	-3.90	-4.88
Initial distr. of assets	-11.25	-2.05
Price effect	- 1.39	-0.13
Initial distr. of assets in GE	10.57	1.06

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

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. Furthermore, job-finding elasticity with respect to UI increases substantially. These changes are apparent in the policy function of agents. They contribute, directly or indirectly, to reducing the welfare gains of UI.

Table 11: Partial and general equilibrium effects of an increase in replacement rate of 40 pp from the optimal level, extension without human capital or other life-cycle effects

Variable	Homog. discount GE	Homog. discount PE	Het. discount GE	Het. discount PE
Replacement ratio	0.12 to 0.52		0.07 to 0.47	
Potential duration	2		2	
Change in %				
Capital K	-2.7	-7.1	-2.4	-11.6
Human capital H	-2.0	-1.2	-2.0	-0.3
Unemployment	10.6	10.4	9.4	8.7
Ratio K/H	-0.7	-5.9	-0.5	-11.3
Wage w	-0.2	0.0	-0.2	0.0
Int. rate r	1.0	0.0	0.6	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 12: Welfare gains decomposition of an increase in replacement rate of 40 pp from the optimal level, without human capital or other life-cycle effects

Variable	Homog. discount	Het. discount
Total welfare gains (CEVx1000) w.r.t. benchmark		
General Equilibrium	-7.89	-6.25
Partial Equilibrium	-12.85	-16.33
Difference GE-PE	4.96	10.08
UI effect	19.06	19.76
Tax effect	-20.93	-19.45
Initial distr. of assets	-10.61	-16.25
Price effect	-1.29	-2.18
Initial distr. of assets in GE	6.39	12.39

Notes: the table reproduces the decomposition of welfare effects of changing the UI system in 40 percentage points from the welfare maximizing UI system.

These observations suggest that heterogeneous discount factors are effective to increase the importance of liquidity constraints at the calibrated economy but change important aspects of the economy at the same time.

A second important point is that the elasticity of assets, both to UI and to prices, is still very high. The right panel of Figure 16 shows that the capital-labor ratio elasticity is much higher than the one of the baseline. The elasticity in this extension is slightly lower than the one with homogeneous discounting, but the change in capital is still very strong.

This issue turns out to be very important. A high elasticity of capital implies that any reduction in benefits induces a strong response on savings, and shifts the distribution of assets to the right. Thus, while in the calibrated economy there is a strong proportion of liquidity constrained unemployed workers, in the economy with no UI there are few (less than 5%) workers with little assets at displacement (see the dotted black line in Figure 16). Of course, the changes in assets have in these extensions a direct effect on welfare: workers begin their life with more assets whenever there is balanced-budget reduction in UI. This affects the welfare value of UI (see the welfare effects of the initial distribution of assets in PE in Table 10.)

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

7 Conclusion

The main aim of this paper was to evaluate 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. We found that the welfare maximizing policy is moderately more generous than the current one. We obtain 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 seem 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 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. A crucial feature of this extension is that savings and aggregate capital respond strongly to unemployment insurance transfers. Up to what extent this response is reasonable is an empirical question.

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

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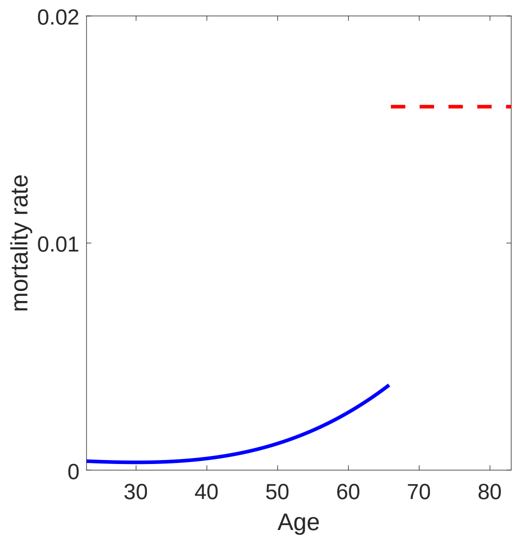
Appendix

A Appendix of figures

Figure 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.

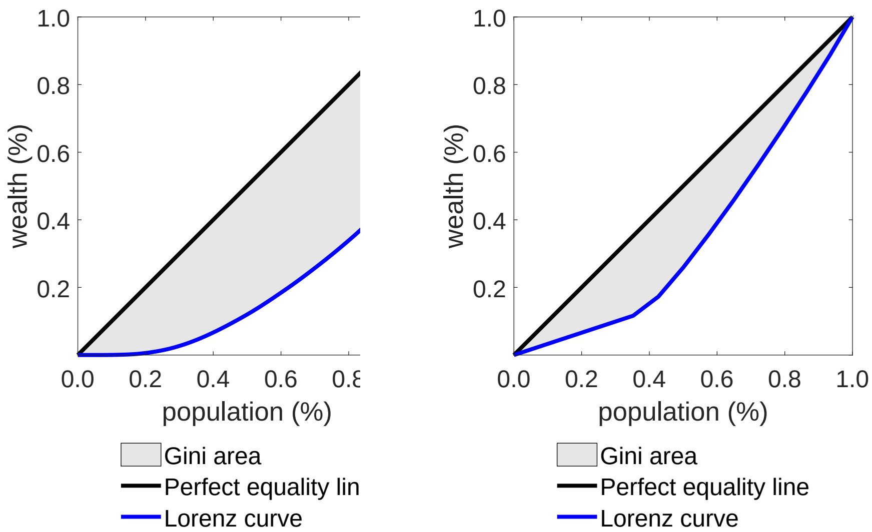
B Calibration

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,

$$\ln w_{i,j} = \sum_j \alpha_j \mathbf{I}_j + \alpha_x' X_i + \beta t_i^c + \sum_{\kappa \in \mathbf{K}} \alpha_\kappa' \mathbf{I}_\kappa + \varepsilon_{i,j} \ , \ \varepsilon_{i,j} \sim N(0, \sigma) \tag{1}$$

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 13. To use the regression results to back out



(a) Assets (b) Wages

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

$h(\kappa)$ notice that in the model the hourly wage is $wh(\kappa)$ so that equation (1) 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

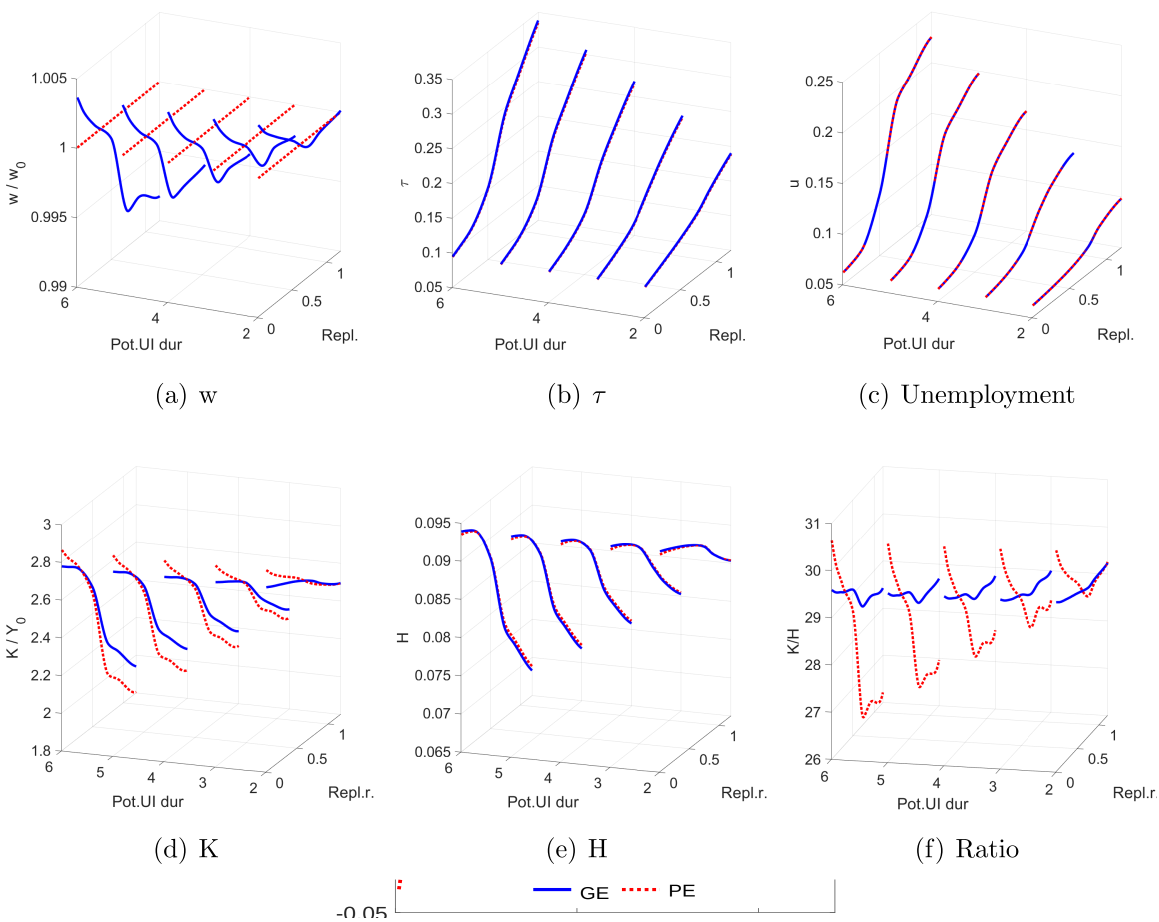
$$h(\kappa) = e^{\sum_{l \leq \kappa} \alpha_l \mathbf{I}_l} \tag{2}$$

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.[12] Second, we focus only on the effect on the first period job-finding

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

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 and PE for different UI systems, characterized by replacement rates and potential durations. Panel (a) reports wages as a ratio to the wage in the calibrated economy.

Table 13: 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 (1) 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.

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.

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,

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

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

D Numerical Algorithm

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