Unemployment Accounts

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February 19, 2012

Abstract

Unemployment Accounts (UA) are mandatory individual saving accounts that can be used by governments as an alternative to the Unemployment Insurance (UI) system. The goal of this paper is to study the welfare implications of a shift from the current UI system to a new UA system in the United States. The UA system works as follows. During employment, the worker is mandated to make deposits into an individual saving account. The worker is entitled to withdraw payments from this account only during unemployment or upon retirement. In contrast, UI is funded by a payroll tax and provides benefits for a limited duration. I build an heterogeneous agents, incomplete-markets life-cycle model, in which workers face income fluctuations and unemployment shocks. I study a two tier UA-UI system where the unemployed first withdraw from their unemployment account until it is exhausted and then receive unemployment benefits. This hybrid policy provides insurance to workers more efficiently than either a traditional UI or a pure UA systems. Relative to a two tier UI system the hybrid policy leads to a welfare gain of 0.9%, and all initial deciles of wealth are better off.

JEL Classification: E24; E61; J64; J65

Keywords: Unemployment Accounts; Unemployment Insurance; Job-search; Moral hazard; Mechanism Design; Optimal Policy;

*This paper is based on the third chapter of my PhD dissertation. I am grateful to my advisor Gianluca Violante and to the two other dissertation committee members Gian Luca Clementi and Lars Ljungqvist. The paper has benefited from discussions with faculty and students at New York University and seminar participants at numerous locations. All remaining errors are mine. *Correspondence:* Ofer Setty, Department of Economics, Tel Aviv University. *E-mail:* ofer.setty@gmail.com.

1 Introduction

Unemployment Accounts (UA) are mandatory individual saving accounts that can be used by governments as an alternative to the Unemployment Insurance (UI) system.

In this paper I study the welfare implications of implementing a UA system in the United States. The importance of such a study is reflected even in the pre-crisis 2007 statistics: state UI programs paid $32 billion in unemployment benefits to 7.6 million unemployed workers[1]. As noted by Feldstein (2005), these policies are particularly important because of their impact on macroeconomic performance. Using a calibrated structural model, I provide a quantitative analysis of both the average and the distributional welfare effects of a shift from UI to UA.

UA work as follows. During employment, the worker is mandated to save a fraction of her labor income in an individual saving account. The worker is entitled to withdraw payments as a fraction of her last earnings (a "replacement rate") from this account only during unemployment. At retirement the residual balance is transferred to the worker. A system of UA was implemented in Chile in 2002 and it is debated whether such a system should be implemented in the United States and in other countries, e.g., Feldstein (2005), Orszag and Snower (2002), and Sehnbruch (2004). In contrast to this system, the UI system is based on government benefits that are financed by a payroll tax and provided for a limited duration.

I study a hybrid UI-UA policy (henceforth UA) that combines elements of each of the two policies. According to this policy upon unemployment the worker is allowed to withdraw payments from her account at a certain rate. Once the account is exhausted the worker receives unemployment benefits according to a replacement rate as in a traditional UI system. This hybrid system is conceptually different from a pure UA system in which no government benefits are provided to workers[2].

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[1] U.S. Department of Labor (2008). "Unemployment Insurance Data Summary," available at: http://www.ows.doleta.gov/unemploy/content/data.asp. Accessed on October 27, 2009.

[2] A pure UA can be considered for reasons such as myopic agents and a government who wishes

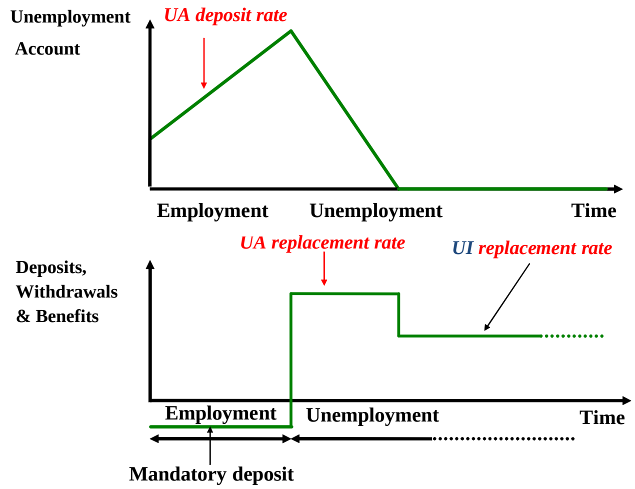


Fig. 1. The UA system. In this example the worker starts off employed. During employment, the worker is mandated to save in the mandatory account and withdraws from the account upon unemployment (top panel). When the account is exhausted the worker becomes eligible to unemployment benefits according to the second replacement rate (top panel).

Figure 1 shows a graphic representation of the UA system for a worker who starts off employed, becomes unemployed and remains unemployed indefinitely. The top panel of the figure shows the balance of the unemployment account. The balance increases gradually during employment and then declines gradually during unemployment. Once the balance is exhausted the account remains at its lower bound of 0.

The bottom panel of Figure 1 shows the deposits, withdrawals and transfers for that worker. During employment the worker pays her mandated contribution to the unemployment account. Upon unemployment, the worker withdraws payments from the account at a pre-specified rate until the account is exhausted at some replacement rate. From that point on, conditional on unemployment, the worker receives unemployment benefits according to some replacement rate, which is assumed in the figure to be lower than the first replacement rate.

to refrain from bailing out retired workers with low levels of savings. In this paper I exclude these considerations by assuming rational workers and government commitment. In such an environment a pure UA policy is dominated by a Laissez-faire unemployment policy.

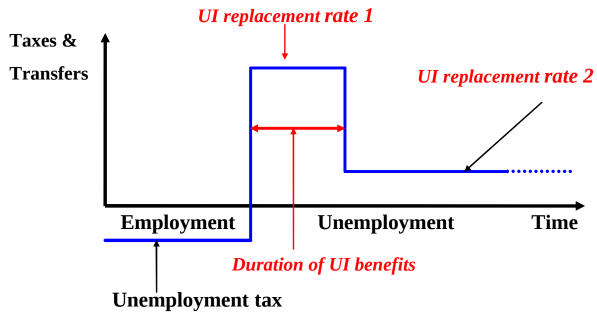


Fig. 2. The UI system. In this example the worker faces the same employment and unemployment spells as in the UA system (Fig. 1). During employment the worker pays an unemployment tax. Upon unemployment, the worker receives a replacement rate for the duration of UI benefits. When the worker reaches the time limit of UI benefits, she receives second tier benefits according to the second replacement rate.

Notice that in the UA system while withdrawals from the account are based on the worker's own resources, unemployment benefits are paid from the pooled resources.

As in the UA system, I allow two tiers of benefits in the UI system. Figure 2 shows a graphic representation of the two-tier UI policy (henceforth UI) for the same worker examined above. During employment, the worker pays an unemployment tax. Upon unemployment, the worker receives benefits proportional to her last earnings, for the duration of UI benefits. From the time limit of the first replacement rate, the worker receives unemployment benefits according to the second replacement rate.

Two differences between the systems should be emphasized. First, while the maximum duration of benefits in UI is fixed, the duration of withdrawals in UA depends on the balance of the unemployment account at the beginning of the unemployment spell. Second, in contrast to the UA system that uses a combination of private and public resources, UI uses only public resources.

In order to study the welfare effects of a shift from UI to UA, I build an heterogeneous agents, incomplete-markets life-cycle model, in which workers face income fluctuations and unemployment shocks. Workers in the model differ along several key dimensions including age, unemployment risk, income and wealth. Unemployment in the model is driven both by exogenous factors (layoffs for employed workers and search frictions for unemployed workers) and endogenous decisions (job quits for employed workers and job-offer rejections for unemployed workers). There are no aggregate shocks in this economy.

In the model the government can implement either a UI or a UA system, each composed of two-tiers. The UI policy is modeled as a choice of two replacement rates, and a time limit of the first replacement rate. The UA policy is modeled as a choice of a deposit rate into the account during employment, a replacement rate funded by the mandatory account, and a replacement rate used from the exhaustion of the mandatory account.

Given the unemployment policy, workers allocate their resources optimally between consumption and savings. In addition, workers with employment opportunities choose between employment and unemployment. The government takes into account these endogenous decisions when designing the parameters of the unemployment system in order to maximize the welfare of the workers. I refer to the combination of instruments that deliver the highest welfare level in each type of system (UI or UA) as optimal UI and optimal UA, respectively[3].

Using this estimate I show that the shift from the optimal UI policy to the optimal UA policy leads to an average welfare gain of 0.9% of lifetime consumption according to the consumption equivalent variation metric.

The main difference between the two systems and the driving force of the welfare gain is the efficiency of allocating government benefits across unemployed workers. Under the UI policy benefits are equally provided to all newly unemployed workers. In contrast, the provision of benefits under the UA depends on the employment history of the worker via the unemployment accounts. The better is the employment history, the longer it will take to the worker to receive government benefits. The account therefore mimics the information that would have been received by keeping track of the complete labor history

[3]Strictly speaking, these policies are sub-optimal because they are based on a limited number of instruments and they do not take into account the complete labor market history of the worker. The choice of using these types of policies is inspired by the actual implementation of unemployment policies throughout the world.

of the worker by using a simple mechanism.

The levels of the mandatory accounts are especially low for two types of workers. The first is young workers who start off with no mandatory savings. Upon unemployment, these workers would exhaust their remaining mandatory account balance quickly and will receive unemployment benefits. The second type of workers who have low balances in the UA system is workers with consecutive unemployment spells. Such workers might not be able to replenish the mandatory account during the employment interval between the unemployment spell. Thus, conditional on unemployment, these two groups of workers will receive relatively more benefits than old workers and workers with good labor market histories[4].

To put the welfare gain of a shift from UI to UA in context, it is useful to use the model as a laboratory for two additional questions. First, the welfare gain from fine tuning the instruments of the actual UI system by implementing the optimal UI policy is 0.1% of lifetime consumption.

Second, the value of insuring workers against unemployment can be assessed by comparing the welfare of workers in the optimal UI system with the welfare of workers in a system without an unemployment policy. I show that the welfare gain from insuring workers against unemployment shocks, compared with no unemployment system, is about 0.3%.

These two findings on the value of fine-tuning the UI policy (0.1% of lifetime consumption) and on the value of insurance (0.3%) emphasize the importance of the welfare gain associated with a shift from UI to UA shown above (0.9%).

Related literature

This paper relates to several branches of literature. An extensive body of literature studies the design of Optimal Unemployment Insurance policies. These papers use re-

[4]The UA system thus introduces a new moral hazard source - employment replenishes the mandatory account and therefore defers the government benefits. This effect is, however, small as the unemployment benefits replacement rate is much lower than 100%.

cursive contracts to formulate a parsimonious relationship between the principal (the government) and the agent (the worker) that is based on the whole labor history of the worker. The seminal paper by Hopenhayn and Nicolini (1997) shows that in the optimal contract, benefits should decline during unemployment, and the labor tax upon re-employment should increase. These two mechanisms guarantee that it is worthwhile for the worker to exert a high job-search effort level during unemployment, because the outcome of employment is at least as good for her as the outcome of unemployment[5].

The recursive contracts setting is the appropriate framework for characterizing optimal contracts. One technical limitation of this framework, however, is that in this model workers are not allowed to save. For the analysis of UA, allowing workers to save is important because savings determine the self-insurance level of workers in the economy. The literature has established that the addition of savings has important implications for the UI policy (e.g., Shimer and Werning (2008), Kocherlakota (2004)). In addition, the importance of long term contracts reduces significantly when savings are allowed (e.g., Hansen and Imrohoroglu (1992) and Abdulkadiroglu, Kuruscu, and Sahin (2002)). Another important advantage of short-term contracts is that they are relatively easy to implement. Indeed, the design of policies in my paper is closely linked to the actual unemployment systems in the real world. Nevertheless, I am still able to adopt the main insights of the Optimal Unemployment Insurance literature[6].

The literature on the UA policy includes several papers that compare variants of UA to UI. Pallage and Zimmermann (2010) use a full blown dynamic general equilibrium model with heterogeneity in employment and wealth to compare the two policies. Their model is based on one saving account that includes both voluntary and mandatory savings. In this

[5]Other selected contributors to this literature are Wang and Williamson (2002) and Pavoni (2007). A sub-branch of optimal contracts literature consists of papers that examine simultaneously more than one policy towards unemployment. Pavoni and Violante (2007) and Pavoni, Setty, and Violante (2010) study Welfare-to-Work programs. These are a mix of government expenditures on various labor market policies targeted to the unemployed.

[6]Pavoni (2007) shows that when there is a lower bound on the level of utility provided to the worker the optimal UI policy resembles a two-tier UI system as the one I incorporate in this paper.

economy very few workers let their unemployment accounts deplete. As a consequence the tax level associated with UA is much lower than that of UI and newborns prefer the UA to the UI system.

Orszag and Snower (2002) compare the two systems and capture qualitatively the difference in employment incentives between the two. Using a two period model that compares a UI system with no savings to a UA system, they show that UA decreases unemployment because the tax level is lower and because workers use their own resources to finance payments during unemployment.

Feldstein and Altman (2007) perform an accounting exercise based on the PSID data. They show that a saving rate of 4% of labor income is sufficient for financing the unemployment benefits of the vast majority of workers, leading to negative balances of only 5% of workers at retirement, death or upon exiting the panel. In addition, they show that the cost of forgiving the negative balances (which is the only usage of the unemployment tax) is roughly half of the cost of the unemployment insurance system.

2 The model

This section has five parts. First, I describe the economic environment of the model. This environment is invariant to the government's activities including the unemployment system. Second, I introduce the government and explain in detail the unemployment policies (UI and UA), the Social Security policy and other government expenditures. Third, I present the worker's optimization problems under each unemployment policy. In these problems, workers take the unemployment system and its parameters as given and maximize their utility. Fourth, I define the stationary recursive competitive equilibrium for the economy. In the fifth and last subsection, I describe the optimal unemployment policy for each system as the choice of the system's instruments over the relevant policy space that maximizes workers' welfare.

The model is rich in especially two aspects. First, workers are heterogeneous in several dimensions including age, unemployment risk, wealth and income. This richness is important for analyzing the welfare gain or loss of various demographic groups. Second, the model includes a detailed productivity process, government expenditures and Social Security transfers. These details are important for matching the net resources that workers have over the life-cycle and across labor market states.

2.1 The economy

2.1.1 Demographics

The model is in discrete time. The economy is stationary, i.e., there are no aggregate shocks. Workers are born at date 1, and live up to T periods. Throughout the life-cycle workers face an age-dependent unconditional survival rate Φ_t.

The life-cycle $[1, T]$ is split into two periods. During age $[1, T_R - 1]$ workers are in the labor force and can be either employed or unemployed. I abstract from labor-force entry and exit considerations since unemployment payments are conditional on being attached to the labor force. During age $[T_R, T]$ workers are retired. I refer to the time span $[1, T_R - 1]$ as the *working age,* and to the time span of $[T_R, T]$ as the *retirement age.*

2.1.2 Preferences

Workers' period utility is $u(c) - Bq$ where c is consumption, B is disutility from work and q is an employment indicator that equals 1 if the worker is employed and 0 if the worker is unemployed or retired. Workers discount the future at rate β. Therefore, workers maximize:.

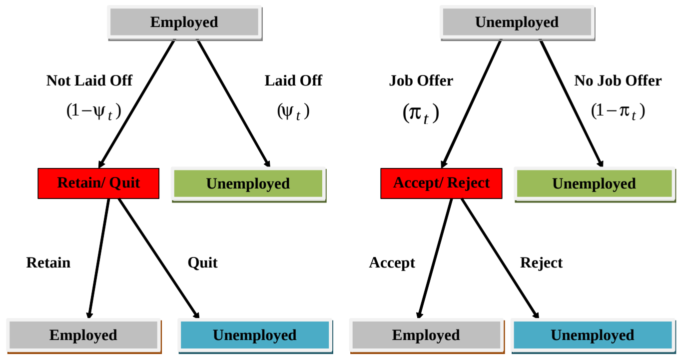


Fig. 3. The labor market and the timig of the model. An employed worker is laid off with an age-dependent probability. A lay off leads to unemployemdnt. An employed worker who is not laid off decides whether to retain the job and remain employed or to quit her job and become unemployed. An unemployed worker receives a job offer with an age-dependent probability. An unemployed worker who does not receive a job offer remains unemployed. An unemployed worker who receives a job offer chooses whether to accept the job-offer and become employed or to reject the job-offer and remain unemployed.

$$U = E_0 \left\{ \sum_{t=1}^{T} \Phi_t \beta^{t-1} \left[u\left(c_t\right) - B q_t \right] \right\}$$

where:

$$q_t = \begin{cases} 1 & if\ employed\ at\ time\ t \\ 0 & otherwise \end{cases}$$

2.1.3 Labor market and timing

Figure 3 shows the labor market structure and the timing of the model for employed and unemployed workers[7]. An employed worker is laid off and becomes unemployed with probability ψ_t that depends on her age t. A worker that is not laid off decides whether to retain or to quit the job. If the worker retains her job, then she remains employed.

[7]The model does not include a choice of intensive margin mainly because UI in most states in the US does not cover part-time workers. See National Employment Law Project (2009): The Unemployment Insurance Modernization Act: Filling the Gaps in the Unemployment Safety Net While Stimulating the Economy. Available at http://www.nelp.org/page/-/UI /uima.fact.sheet.jan.09.pdf?nocdn=1. Accessed September 1, 2009.

The process for an unemployed worker is similar. An unemployed worker with an unemployment duration of d receives at the beginning of the period a job offer with age dependent probability π_t. If the worker does not receive a job offer then she remains unemployed. A worker that receives a job offer decides whether to accept the job offer and become employed or reject it and remain unemployed. I discuss the observability of quits and job-offer rejections later on, when I introduce the government.

The design of the transitions between employment and unemployment therefore allows both exogenous factors and endogenous decisions. The presence of endogenous decisions is a key component in the model as it implies that unemployment is determined within the model and depends on the unemployment policy[8].

2.1.4 Labor productivity process

Workers face a standard individual labor productivity process that accounts for a life-cycle trend and persistent income shocks. The log labor income of an employed individual i at age t is:

$$\begin{aligned} y_{i,t} &= k_t + z_{i,t} \\ z_{i,t} &= \rho z_{i,t-1} + \eta_{i,t} \end{aligned}$$

The first component, k_t, is a life-cycle trend that accounts for the return to experience over the life-cycle and supports the hump shape of labor income towards retirement. The second component, $z_{i,t}$, is an AR(1) process with persistence ρ, and innovations $\eta_{i,t} \sim N\left(\frac{-\sigma_\eta^2}{2}, \sigma_\eta^2\right)$. The initial persistent shock is distributed $z_{i,1} \sim N\left(\frac{-\sigma_1^2}{2}, \sigma_1^2\right)$, thus allowing for initial heterogeneity in earnings already at date 1.

During unemployment, the persistent component of labor income is constant. This

[8] An alternative model of the labor market would include a search effort that affects the job finding probability (and possibly the separation rate as well). As long as the model allows for endogenous employment decisions the results are expected to remain at least qualitatively the same.

formulation is useful for recovering the last labor income, which is the basis for unemployment payments in both systems.

2.1.5 Initial wealth and savings

Workers are born at date 1 with an initial wealth of $a_{i,1}$. The log of initial wealth is distributed $N\left(\frac{-\sigma_a^2}{2}, \sigma_a^2\right)$. Workers can save and borrow up to $\underline{a}$, and the periodic interest rate on assets is r.

2.2 The government

The government implements an unemployment policy (either UI or UA) for insuring workers against unemployment, a Social Security system for retired workers, and a government expenditure.

2.2.1 The UI system

The UI policy includes three instruments (see Figure 2). The first instrument is the duration of the first tier benefits, denoted by D_{UI}. The second instrument is the replacement rate, Q_{UI}^1, used up to the time limit D_{UI}. This instrument determines for each worker the level of benefits during unemployment. The third instrument is the replacement rate once the duration of the first tier benefits is completed, denoted by Q_{UI}^2. The second tier benefits do not have a time limit.

Following the UI policy in the US, UI benefits are only provided to workers who were laid off. Workers who quit are ineligible to benefits. The implied assumption of this restriction is that quits are observed by the government. This assumption is supported by a component of the UI system called "experience ratings", that indexes the unemployment tax rate to the layoffs experience of the firm. Thus, a firm that reports a quit as a layoff would, in general, face a higher unemployment tax rate. This guarantees that the firm has the incentive to report the truth. For more on experience ratings see Wang and

Williamson (2002).

Rejections of job offers, on the other hand, are assumed to be unobservable by the government. Compared with quits, rejections of job-offers are hard to detect as they involve a third party that has no interest in reporting the job-offer rejection. Although some monitoring of such rejections takes place in the US, Setty (2012) shows that the average monthly monitoring probability in the US is 0.22. This is an upper bound for the probability of observing a rejection because some rejections are undetected. I therefore assume that job-offer rejections are perfectly unobservable.

2.2.2 The UA system

The UA policy includes three instruments. The first instrument is the mandatory saving rate during employment, denoted by M_{UA}. This instrument, which is a fraction of labor earnings, determines the **inflow** into the account. The second instrument is the replacement rate, denoted by Q^1_{UA}, provided by withdrawals from the account. This instrument determines the **outflow** from the account. The third instrument is the replacement rate once the mandatory account is exhausted, denoted by Q^2_{UA}. As in the UI system, these second tier benefits do not have a time limit. Upon retirement, the balance of the mandatory account becomes available for the worker.

I assume that the mandatory account bears the same periodic interest, r, as private saving[9]. Note that given that the return on the two assets is the same and that the liquidity of the mandatory account is lower, the worker would always prefer to deposit the minimum amount in the account, and withdraw the maximum amount from the account.

The mandatory account has an upper bound $\overline{a_m}$ and a lower bound of 0. The upper bound is used for technical convenience only and will be calibrated to a level that has no

[9] The return on the mandatory savings could be different than that of the regular savings for at least three reasons: higher regulation on the investment (among other reasons to avoid moral hazard); a higher interest rate given the central management of the funds; and an overhead. I abstract from these considerations and leave them to further research.

effect on welfare compared with a choice of no bound[10]. Relaxing the assumption that the lower bound of the mandatory account is 0 and allowing workers to have negative balances would generate another instrument - allowing workers to borrow against their future income. This idea was suggested by Stiglitz and Yun (2005) and can be implemented in the current framework as well.

I assume for consistency with the UI system that only laid off workers are eligible either for withdrawing from the unemployment account or for second tier benefits[11].

The UA system described here is inspired by the UA system implemented in Chile with the key difference of the additional UI tier as opposed to a minimal transfer in the Chilean system. Appendix 1 presents the Chilean system in detail and describes these differences.

2.2.3 Other government activities

In addition to the unemployment policy, the government administers two other activities. The inclusion of these activities is important for setting the conditions that workers face during employment and retirement.

The first activity is retirement payments to retired workers. This activity follows the two main principles of the Social Security retirement plan in the US: payments are based on lifetime earnings and payments are progressive. The retirement policy in the model differs from the actual retirement policy in the US in the way lifetime savings are calculated. Since lifetime earnings in the model are not part of the worker's state, they are approximated by the worker's last observed labor income. This approximation is explained in the calibration section.

[10] Retirement is an important reason for saving in the model. Since the mandatory account becomes available to workers at retirement, workers substitute regular savings with mandatory savings, without a significant effect on the total saving level. As a consequence, the effect of the upper bound on total assets and employment choices is negligible as long as it is significantly lower than desired savings at retirement.

[11] Since the worker is using her own resources to finance the unemployment benefits, it would be interesting to examine the welfare effect of relaxing the eligibility criterion of UI in UA. In fact, under the Chilean UA policy workers who quit their job are still eligible to withdrawals under some conditions (see Conerly (2002)).

The second activity is government expenditure. The government spends a fixed amount on exogenous expenditures that do not benefit workers. These expenditures are important for setting the correct average labor tax distortion that workers face.

The government finances its three activities (the unemployment system, Social Security, and government expenditure) by collecting a labor income tax for either UI or UA, denoted by τ^{UI} and τ^{UA}, respectively. Note that these two alternative taxes are not decision variables, but rather used to balance the government budget.

2.2.4 Information structure

Mandatory savings are regulated by the government and hence are observable by both the government and the workers. Private individual savings are unobservable to the government.

2.3 The worker's problems

2.3.1 UI

The worker's state under the UI system is composed of five components: age (t), private savings (a), persistent component of labor income (z), unemployment duration (d), and eligibility for unemployment benefits (e).

Workers in the model have two types of decisions. The first type of decision is an *intertemporal* decision of consumption and savings. This decision is based on a specific employment state (employed or unemployed). The second type of decision is the *intratemporal* decision of employment. This decision is relevant only for workers with an employment opportunity (employed workers who are not laid off and unemployed workers with a job offer).

The values for the employed and unemployed workers are $W^{UI}(t,a,z)$ and $V^{UI}(t,a,z,d,e)$ respectively. These values are the outcome of an *intertemporal* maximization over consumption and savings. Note that the value for the employed worker does not include unemployment duration and eligibility, which are only relevant for the unemployed.

The values for workers with job opportunities are given as follows. The value of a worker who was **employed** in the previous period and **was not laid off is** $J_w^{UI}(t,a,z)$. The value of a worker who was **unemployed** in the previous period and **has a job offer** is $J_u^{UI}(t,a,z,d,e)$. These values are the outcome of an *intratemporal* maximization over a choice between employment and unemployment:

$$J_u^{UI}(t,a,z,d,e) = \max_{\{accept,reject\}} \left\{ W^{UI}(t,a,z), V^{UI}(t,a,z,d,e) \right\} \tag{1}$$

$$J_w^{UI}(t,a,z) = \max_{\{retain,quit\}} \left\{ W^{UI}(t,a,z), V^{UI}(t,a,z,1,0) \right\} \tag{2}$$

The value for an unemployed worker who holds a job offer, $J_u^{UI}(\cdot)$, is determined as a choice between becoming employed (accept) and remaining unemployed (reject). Note that since rejections are unobservable by the government the eligibility of remaining unemployed (e) is carried unchanged to unemployment.

Similarly, the value for an employed worker who does not face a layoff shock, $J_w^{UI}(\cdot)$, is determined as a choice between remaining employed (retain) and becoming unemployed (quit). Note that since quits are observable by the government the eligibility upon becoming unemployed (e) is 0.

Using these values, we can now define the value for the employed and the unemployed workers based on the intertemporal decisions. The value of an unemployed worker under

UI is:

$$V^{UI}\left(t,a,z,d,e\right) = \tag{3}$$

$$\max_{c,a'}\left\{u\left(c\right)+\beta\phi_t\mathbf{E}_t\left\{\pi_t J_u^{UI}\left(t+1,a',z,d+1,e\right)+\left(1-\pi_t\right)V^{UI}\left(t+1,a',z,d+1,e\right)\right\}\right\}$$

$$s.t.$$

$$a' = a\left(1+r\right)-c+x$$

$$a' \geqslant \underline{a}$$

$$x = \left\{\begin{array}{ll} Q_{UI}^{1}\exp\left(k_t+z\right)\left(1-\tau^{UI}\right) & if\ e=1\ and\ d\leq D_{UI} \\ Q_{UI}^{2}\exp\left(k_t+z\right)\left(1-\tau^{UI}\right) & if\ e=1\ and\ d>D_{UI} \\ 0 & if\ e=0 \end{array}\right\}$$

The worker in this problem decides on current consumption (c) and future assets (a') in order to maximize current utility from consumption and the future value. The discounted future value is multiplied by the age-dependent conditional survival rate ϕ_t. The future value itself is a composition of the values of receiving and not receiving a job offer with the respective probabilities of π_t and $(1-\pi_t)$.

The first constraint is a standard budget constraint where x is the government transfer. A worker who is eligible for unemployment benefits and whose unemployment duration is within the time limit of UI benefits, receives the first replacement rate of the previous labor earnings. An eligible worker with $d > D_{UI}$ receives the second replacement rate. Finally, the ineligible worker's transfer is 0.

The value of an employed worker under UI is:

$$W^{UI}(t,a,z) = \tag{4}$$
$$\max_{c,a'} \left\{ u(c) - B + \beta\phi_t \mathbf{E}_t \left\{ (1-\psi_t) J_w^{UI}(t+1,a',z') + \psi_t V^{UI}(t+1,a',z',1,1) \right\} \right\}$$
$$s.t.$$
$$\begin{aligned} a' &= a(1+r) - c + \exp(k_t + z)\left(1-\tau^{UI}\right) \\ a' &\geqslant \underline{a} \end{aligned}$$

Note that the eligibility state upon being laid off is equal to 1. Also note that the value of the worker includes the disutility from work $(-B)$.

2.3.2 UA

The value functions for the worker under the UA policy are similar to the ones in UI. The worker's state under the UA system is composed of five components as well: age (t), private savings (a), mandatory savings (a_m), persistent component of labor income (z), and eligibility for withdrawals (e). It differs from the worker's state under UI, because of the additional mandatory savings (a_m), and the absence of the unemployment duration (d). These two changes in the state space of the worker reflect the criterion for unemployment payments: in UI it is the unemployment duration and in UA it is the endogenous balance of the mandatory account. The intratemporal value functions under UA are:

$$\begin{aligned} J_u^{UA}(t,a,a_m,z,e) &= \max_{\{accept,reject\}} \left\{ W^{UA}(t,a,a_m,z), V^{UA}(t,a,a_m,z,e) \right\} \\ J_w^{UA}(t,a,a_m,z) &= \max_{\{retain,quit\}} \left\{ W^{UA}(t,a,a_m,z), V^{UA}(t,a,a_m,z,0) \right\} \end{aligned}$$

The value of an unemployed worker under UA can be written as follows, where m is the withdrawal from the mandatory account, and b is the government transfer.

$$V^{UA}(t,a,a_m,z,e) = \tag{5}$$

$$\max_{c,a}\left\{u(c)+\beta\phi_t \mathbf{E}_t\left\{\pi_t J_u^{UA}(t+1,a',a'_m,z,e)+(1-\pi_t)V^{UA}(t+1,a',a'_m,z,e)\right\}\right\}$$

$$s.t.$$

$$\begin{aligned}
a' &= a(1+r)+m+b-c \\
a'_m &= a_m(1+r)-m \\
b &= \left\{\begin{array}{ll} Q^2_{UA}\exp(k_t+z)\left(1-\tau^{UA}\right)-m & if\ a_m<Q^2_{UA}\exp(k_t+z)\left(1-\tau^{UA}\right) \\ & and\ e=1 \\ 0 & otherwise \end{array}\right\} \\
m &= \left\{\begin{array}{ll} \min\left\{Q^1_{UA}\exp(k_t+z)\left(1-\tau^{UA}\right),a_m(1+r)\right\} & if\ e=1 \\ 0 & otherwise \end{array}\right\} \\
a' &\geqslant \underline{a}
\end{aligned}$$

The objective function that determines $V^{UA}(\cdot)$ is similar to the one in the value of an unemployed worker under UI with the necessary adjustments. Future private savings in the first constraint are determined by the sum of current private savings including the interest rate, the withdrawal from the account, and the second tier benefits minus consumption.

The withdrawal for an eligible worker (m) is equal to the replacement rate of previous earnings if the account has a sufficient balance. Otherwise, it is the balance of the account. The second tier benefits (b) are based on the second replacement rate and are provided to workers who exhausted their mandatory account. Workers with account balances that are lower than the second tier benefits receive the difference in benefits. The mandatory account's balance in the second constraint is updated according to the withdrawal.

The value of an employed worker under UA is:

$$\begin{aligned}
& W^{UA}(t,a,a_m,z) = \\
& \max_{c,a'} \left\{ u(c) - B + \beta\phi_t \mathbf{E}_t \left\{ (1-\psi_t) J_w^{UA}(t+1,a',a_m',z') + \psi_t V^{UA}(t+1,a',a_m',z',1) \right\} \right\}
\end{aligned}$$

$$\begin{aligned}
s.t. &\quad : \\
a' &= a(1+r) + \exp(k_t+z)\left(1-\tau^{UA}\right) - c - \left(a_m' - a_m(1+r)\right) \\
a_m' &= \min\left\{\overline{a_m}, a_m(1+r) + \exp(k_t+z) M_{UA}\right\} \\
a' &\geqslant \underline{a}
\end{aligned}$$

The budget constraint of the worker in the first constraint of $W^{UA}(\cdot)$ includes the deposit to the mandatory account $(a_m' - a_m(1+r))$. This deposit is equal to the deposit rate, times the labor earnings as long as the account's balance is lower than $\overline{a_m}$. Otherwise, it is the deposit that sets the mandatory account's balance at its upper bound.

2.4 Optimal unemployment policies

The objective of each of the optimal unemployment policies is to maximize the welfare of the workers in the economy. The welfare metric that I use is consumption equivalent variation, defined as the scalar ω that solves

$$\sum \mathbf{E}_0 \left\{ \sum_{t=1}^{T} \Phi_t \beta^{t-1} \left[u\left((1+\omega) c_t\right) - Bq_t \right] \right\} = \sum \mathbf{E}_0 \left\{ \sum_{t=1}^{T} \Phi_t \beta^{t-1} \left[u(\widetilde{c}_t) - B\widetilde{q}_t \right] \right\}$$

where $\{\widetilde{c}_t, \widetilde{q}_t\}$ are the optimal consumption and employment levels under the alternative policy. When comparing two policies, this is the percentage increase in consumption that needs to be given to the average worker at each date in her lifetime in the baseline policy (e.g. actual UI) to make her exactly as well off as under the suggested policy (e.g. optimal UI).

The average welfare at time 0 is weighted over the distribution of initial assets and persistent shocks at time 0 with measures $\{\xi_0, 1-\xi_0\}$ for time 0 employed and unemployed workers.

An optimal *Unemployment Insurance* policy is a triplet $\{D_{UI}{}^*, Q_{UI}^1{}^*, Q_{UI}^2{}^*\}$ such that:

- $\mathbf{E}_0 \left\{\xi_0 W^{UI}(t=0,a,z) + (1-\xi_0) V^{UI}(t=0,a,z,d=1,e=1)\right\}$ is maximized,

where the expectation operator is taken with respect to initial wealth and the initial persistent component of income.

- the government budget is balanced:

  $\int_{t<T_R\times A\times Z\times d=0\times E} w\exp(k_t+z)\,\tau^{UI} = \int_{t<T_R\times A\times Z\times 1\leq d\leq D_{UI}\times e=1} Q_{UI}^1 w\exp(k_t+z)\left(1-\tau^{UI}\right)$
  $+\int_{t<T_R\times A\times Z\times d>D_{UI}\times e=1} Q_{UI}^2 w\exp(k_t+z)\left(1-\tau^{UI}\right)+\int_{t\geq T_R\times A\times Z\times D\times E}\exp(k_t+z)\,g(z)+$
  G,

  where $g(z)$ is the determination of Social Security benefits based on the persistent component of labor income.

An optimal *Unemployment Accounts* policy is a triplet $\{M_{UA}{}^*, Q_{UA}^1{}^*, Q_{UA}^2{}^*\}$ such that:

- $\mathbf{E}_0 \left\{\xi_0 W^{UA}(t=0,a,a_m=0,z) + (1-\xi_0) V^{UA}(t=0,a,a_m=0,z,e=1)\right\}$ is maximized,

- the government budget is balanced:

  $\int_{t<T_R\times A\times A_M\times Z\times E} w\exp(k_t+z)\,\tau^{UA} =$

$\int_{(t<T_R\times A\times A_M\times Z\times E)} b\left(1-\tau^{UA}\right)+\int_{t\geq T_R\times A\times A_M\times Z\times E}\exp(k_t+z)\,g(z)+G$,

where b is defined in (5).

TABLE 1

Externally calibrated parameters

Parameter	**Value**	**Source/Moment to match**
Preferences		
$u(c)$	logarithmic	
Disutility from work (B)	0.4	See text
Savings		
Median initial wealth	\$5,600	SIPP (1995)
$\frac{Mean}{Median}$ initial wealth	4.2	SIPP (1995)
Interest rate (r)	4% (annual)	Cooley (1995)
Labor income process		
Persistence (ρ)	0.946 (annual)	Kaplan (2011)
Innovation variance (σ_η)	0.019 (annual)	PSID
Initial wage variance (σ_1)	0.056 (annual)	(1968-1997)
Median earnings	\$2,730 (monthly)	CPS (2001-2005)

3 Calibration

The model is calibrated to match key moments in the US economy given the actual UI policy in the US off recessions.

The calibration strategy is as follows. I first cover the parameters that are calibrated externally to the model. These parameters are expected to affect both policies in a similar way and are used here to fine tune the economic environment that workers face. The second part covers the parameters that affect the consumption-saving and employment decisions of the workers in the economy. These include the discount rate, the social security payments, the tax rate, and the age dependent job offers and separations probabilities. Because of the importance of each of those four parameters I calibrate each of them to match a specific data target.

3.1 Externally calibrated parameters

Table 1 summarizes the values for the externally calibrated parameters in the model.

3.1.1 Life-cycle

The unit of time is one month. This frequency, which is relatively high for a life-cycle model, supports a careful distribution of unemployment shocks. The survival rates are taken from the US Census (2005).

Workers join the labor force at age 25 and are part of the labor force until they are 65. The retirement age of 65 is set to an age that is between the full retirement age range in the US of 65 to 67 (depending on the year of birth) and the early retirement option at age 62[12]. The maximum age, T, is calibrated to 100 years of age.

The life-cycle therefore consists of a working age span of 40 years (or 480 months) and a retirement age span of 35 years (or 420 months).

3.1.2 Preferences

Utility from consumption is logarithmic. The level of disutility from work, B, determines the optimal generosity of the unemployment policy. The values for this parameter in the literature vary between 0.25 in Ljungqvist and Sargent (2008) and 0.67 in Pavoni and Violante (2007). For the model presented here a level of $B = 0.25$ would imply essentially no moral hazard, while a level of $B = 0.5$ would imply a very high sensitivity of the unemployment rate to the the unemployment policy, resulting in the Laissez-faire unemployment policy as the optimal policy. In order to allow for the economic forces of both policies to be active I choose an intermediate level of $B = 0.4$.

3.1.3 Labor productivity

The age profile (k_t) is estimated using mean earnings with cohort effects from the PSID. See Huggett, Ventura, and Yaron (2006) for more details. The income process is based on Kaplan (2011), where $\rho = 0.946$, $\sigma_\eta^2 = 0.019$ (both annual), and the initial variance of the persistent shock is $\sigma_{z_1}^2 = 0.056$. Median monthly earnings are equal to $\$2,730$, based

[12] For more on the Social Security timing see http://www.socialsecurity.gov/retire2/agereduction.htm

on the 2009 CPS data.

3.1.4 Savings

The initial wealth of workers is set in order to match the median wealth of $\$5,600$ and the Gini coefficient of assets of 0.78 at age 25 in the 1995 SIPP data (Anderson (1999)). The borrowing limit is set to 0. The annual interest rate is set to 4% following Cooley (1995).

3.1.5 Actual UI policy in the US

The actual UI policy in the US varies across states but the principles and the levels of instruments are fairly consistent. On average, UI benefits in the US are based on a replacement rate of 50% for a duration of 26 weeks (DOL, 2011).

3.2 Parameters that are matched to specific moments

Table 2 summarizes the values for the Parameters that are matched to specific moments in the model.

3.2.1 The discount rate

The interest rate r, and the discount rate β, are the key parameters that determine the wealth-income ratio through the determination of the average savings in the economy. The wealth-income ratio target of 2.5 is, approximately, the average wealth to average income ratio computed from the 1989 and 1992 Survey of Consumers Finances (SCF), when wealth is defined as total net worth, income is pre-tax labor earnings plus capital income, and when the top 5% of households in the wealth distribution are excluded[13]. See Kaplan and Violante (2010) for more details. To match this target I set the annual interest

[13]Note that given that the top 5% hold 54% of the net worth of wealth (Cagetti and Nardi (2006)), the wealth-income for the whole economy is considerably higher. In general, these 5% are of little interest for the unemployment policy.

rate to 4% (Cooley (1995)) and adjust the discount rate accordingly. The resulting value for the monthly discount rate is 0.9973.

TABLE 2
Parameters that are matched to specific moments

Parameter	Value	Moment to match	Source
Discount rate	0.9973	Wealth income ratio (2.5)	SCF (1989-1992)
Gov. expenditure/Income	9.8%	Effective labor tax (0.29)	Mendoza, Razin, and Tesar (1994)
Average retirement income	$1350	SS formula (monthly)	US policy (2002)
Job offers and separations	By age	UE and EU transitions	Shimer (2011)

3.2.2 Social Security payments

As in the US, Social Security payments for retired workers are based on the worker's lifetime labor earnings, which are not a part of the worker's state. To approximate the retirement payment for each worker, I simulate earnings paths based on the productivity process, and regress the lifetime earnings on the last observed level of earnings. The resulting formula is used to approximate lifetime earnings on the last observed earnings in the model. The approximation is fairly good. The variation of the last earnings level explains 85% of the variation in lifetime earnings. This is due to the high persistence in the productivity process.

3.2.3 Government expenditure

The Government expenditure is set to match the effective tax rate of 0.29 of Mendoza, Razin, and Tesar (1994) for 1995-1998. This tax is split between the transfers of UI (1.7 percentage point), Social Security (17.5 percentage point), and government expenditure (9.8 percentage point). The equivalent **amount** of government expenditures remains fixed throughout the experiments of both UI and UA. Therefore the government expenditure is the same in all experiments.

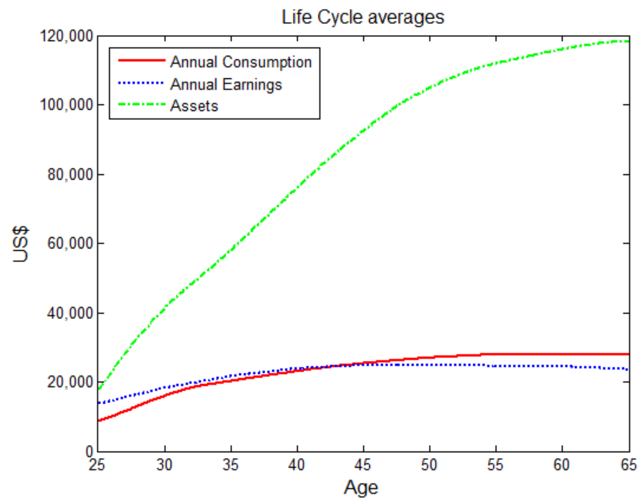


Fig. 4. Model first moments. The figure shows the model's prediction for lifecycle consumption, earnings and assets. Assets increase gradually over the lifecycle as workers save for precautionary reasons and for retirement. In the first part of life, workers' average consumption is lower than their average earnings because they save for precautionary reasons. In the second part of life this trend is reversed.

3.2.4 Unemployment inflows and outflows

The initial employment level is set according to the unemployment rate at age 25. The target age-dependent transitions between employment and unemployment are taken from Shimer (2011). These values are based on the period of 1990-2005 from the CPS data. Since these are affected by both exogenous factors (separations and the absence of job offers) and endogenous decisions (quits and rejections of job offers) I factor the data transitions and use these as the exogenous driving forces for unemployment (ψ_t and π_t). I choose this factor such that the average unemployment in the model equals the average unemployment in the data.

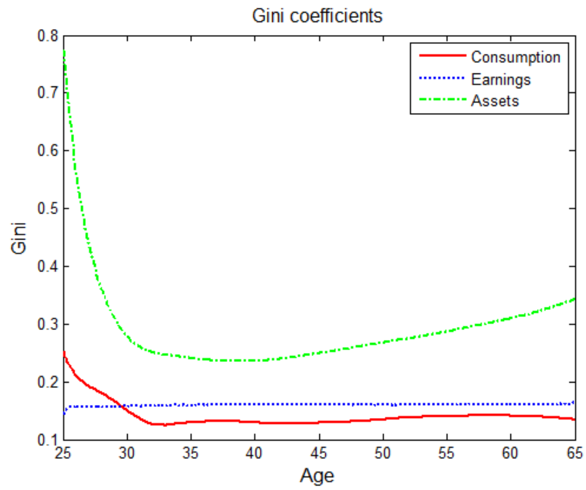


Fig. 5. Model second moments. The figure shows the Gini coefficient for consumption, earnings and assets over the lifecycle. The assets Gini declines gradually as workers with low levels of wealth increase their savings. The consumption Gini is high for young workers because of poor workers who face unemployment.

3.3 Model moments

Figure 4 shows the life cycle means of annual consumption, annual net earnings and assets in the simulation for the actual UI policy. The figure shows that the model has reasonable implications for these variables over the working age. Assets increase over the lifecycle, and flattens at age 55. The savings at age 65 is used by workers as a buffer for retirement, given the low replacement rate of Social Security. Consumption in the first part of life is lower than earnings. This is because workers save for precautionary reasons to insure themselves against unemployment shocks and negative income shocks. In the second part of life, consumption is higher than earnings as precautionary savings are less needed.

Figure 5 shows the Gini coefficients of consumption, earnings and assets. The Gini coefficient of assets starts at a high level that is matched to the data and decreases dramatically as workers with low assets save for precautionary reasons. Then it increases following the labor market experience.

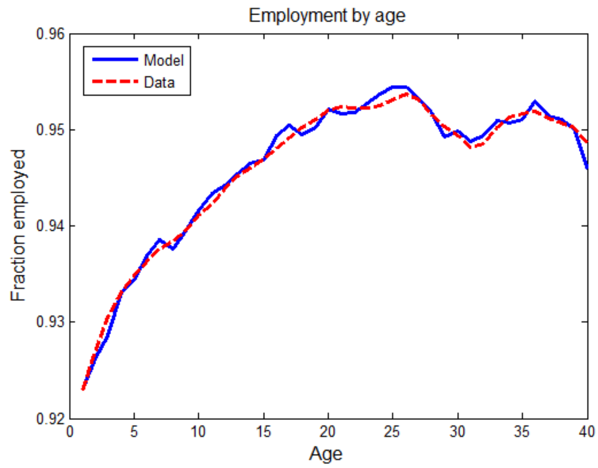


Fig. 6. The employment level in the data and in the model. The figure shows the employment level over the lifecycle. The match is good due to the age-dependent unemployment inflows and outflows in the model.

The Gini coefficient of consumption is relatively high at the beginning of life because poor workers who face either unemployment shocks or negative income shocks have too little assets for smoothing their consumption. The Gini coefficient of earnings increases slightly over the working age. This is due to the already existing variance of the persistent shock at age 25.

Figure 6 compares the data and model employment rate over the working age. The fit is a result of allowing both inflows and outflows of unemployment to be age-dependent. The fact that the two employment profiles are similar across all ages implies that the endogenous employment decisions are somewhat uniform across all age groups.

4 Results

I start this section by comparing the results of the economies with the optimal UI and the optimal UA policies and the resulting welfare gain. I then move to comparing the optimal UI to the actual UI and to a Laissez-faire policy in order to put the welfare gain in context.

TABLE 3

Optimal UI versus Optimal UA

Instruments and statistics	**UI**	**Instruments and statistics**	**UA**
Time limit of benefits D_{UI}	5 months	Deposit rate M_{UA}	5%
First tier replacement rate Q^1_{UI}	50%	Withdrawal rate Q^1_{UA}	50%
Second tier replacement rate Q^2_{UI}	20%	Second tier replacement rate Q^2_{UA}	40%
Tax level	29.1%	Tax level	28.0%
Unemployment level	5.52%	Unemployment level	5.83%
Welfare improvement from			
a shift from UI to UA			0.9%

To find the optimal policy within each type of policy (UI and UA) I use a grid over the three instruments of each policy with 567 combinations for each. The computational method is described in details in Appendix 2.

4.1 Optimal UI versus optimal UA

Table 3 presents the instruments and the cross-section statistics for the optimal UI and optimal UA policies along with the welfare gain for a shift from the optimal UI to the optimal UA policy.

The instruments of the optimal UI policy are similar to those of the actual UI policy in the US and as a consequence the changes in the statistics such as the tax rate and the unemployment rate are small. The moderate first replacement rate of 0.5 is follower by a much lower replacement rate of 0.2. The economy is sensitive to both replacement rates as all unemployed workers are entitled to those types of benefits.

The first replacement rate of the optimal UI are consistent with the one that Chetty (2008) reports. These replacement rates demonstrate the importance of consumption smoothing as discussed by Gruber (1997). Specifically, the observation of Browning and Crossley (2001) that the consumption smoothing benefit of UI is concentrated among a measure of one third of workers in the data (Canadian administrative UI data), highlights the importance of heterogeneity in wealth in my model.

The instruments of the optimal UA policy include a deposit-withdrawal ratio of 1:10

that lead to high balances for prime age workers. The second replacement rate of 0.4 is quite generous given that it is provided without a time limit. This replacement rate is possible since it is only entitled to a minority of the unemployed workers. As a consequence of this generous policy that is targeted at a subset of the unemployed population the unemployment rate increases and the tax rate decreases.

These two seemingly contradicting effect happens because the UA policy deliver benefits to workers selectively and thus it is possible to provides more generosity with lower resources. Compared with an unemployment tax of 1.7 percentage points (out of 29.1%) in the optimal UI, the unemployment tax in the optimal UA policy, which is the tax required to finance the second tier UA benefits is only 0.3 percentage points (out of 28.0%). These 0.3 percentage points are provided exactly to those unemployed workers who need it the most.

The welfare gain is therefore driven by the efficiency of providing insurance in the UA economy, allowing workers to simultaneously reject more job-offers and lower distorting taxes. Quantitatively, the welfare gain associated with a shift between the two steady states is 0.9%. The rejected job-offers are more or less uniform across the age profile and are associated with low productivity - the average productivity in the UA economy is higher by 1.6% compared with that of the UI economy.

Total savings under the UA (the sum of voluntary and mandatory savings) are lower than total savings under UI. This is mostly the result of the higher second tier replacement rate in UA, which decreases the precautionary savings motive for workers. Note that although the UA policy includes mandatory savings, there is a strong substitution between mandatory and voluntary assets in the model as either one can be equally used for retirement. Since labor supply is lower as well, the general equilibrium effects, had they been present in the model, would most likely further increase the welfare gain associated with the shift from UI to UA.

TABLE 4

Optimal UA and a UA policy with lower unemployment

Instruments and statistics	**Optimal UA**	**UA with lower unemployment**
Deposit rate M_{UA}	5%	7%
First tier replacement rate Q^1_{UA}	50%	40%
Second tier replacement rate Q^2_{UA}	40%	30%
Tax level	28.0%	27.3%
Unemployment level	5.83%	5.51%
Welfare improvement from		
a shift from Opt UI to Opt UA	**0.9%**	**0.7%**

Since the welfare gain is based on the inherent distribution mechanism in UA, it can be achieved by a variety of combinations of the UA instruments. For example, we can look into a UA policy that does not increase the unemployment rate in the economy. Such a policy would be less generous relative to the optimal UA policy. The best UA policy subject to a maximum unemployment of the optimal UI policy is presented in Table 4.

The change of each of the three instruments makes the alternative UA policy less generous. The increased deposit rate and the decreased withdrawal rate further delay the second tier benefits, and those benefits are lower as well. The tax rate decreases for two reasons: a decrease of the cost of the second tier benefits and an increase in employment. The welfare gain associated with the alternative UA policy (relative to optimal UI) is lower than before but is still substantial at 0.7%. This alternative UA policy demonstrates the robustness of the policy and the fundamental advantage of providing benefits selectively to workers.

4.1.1 Distributional welfare change

The existence of heterogeneity in the model across age, employment risk, wealth and income, implies that the average welfare change already accounts for different types of workers in the economy. Nevertheless, it is of interest to look at the welfare change of the shift from UI to UA across initial wealth, which is a key source of heterogeneity in the model.

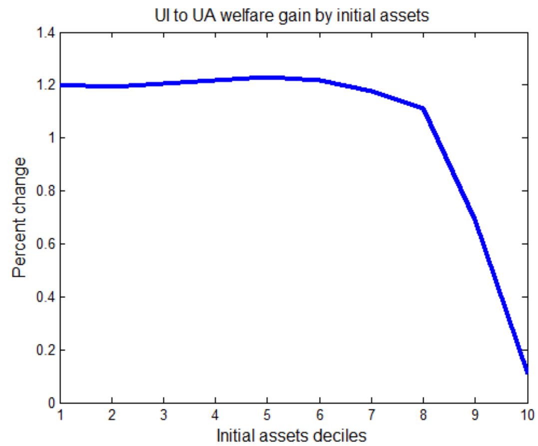


Fig. 7. UA welfare gain by initial assets. The average welfare gain is fairly consistent across the bottom eigth deciles at around 1.2 percent. The top two deciles who have high levels of assets are less sensitive to the unemployment policy.

Figure 7 shows the welfare gain over the ten deciles of initial assets. The welfare change is positive for all deciles of initial assets. Across deciles 1-8 the welfare gain is also quite uniform at around 1.2%. The top two deciles gain less simply because most of their consumption is based on their assets and not on their labor income.

4.2 Optimal UI in context

To put the welfare gain of the shift from UI to UA in context, it is useful to compare the optimal UI to two other policies. The first is the actual UI policy in the US and the other is a Laissez-faire UI policy. Table 5 shows the instruments' values and the cross-sectional statistics for those three policies.

The optimal UI policy is very close to the actual UI policy in the US both in its instruments and in the welfare it provides. This can be seen as fine tuning the actual system given that a two tier policy is possible. The optimal policy is slightly more generous due to the second tier benefits, resulting in a higher tax rate and a higher unemployment rate.

TABLE 5

Actual UI versus Optimal UI and Laissez-faire policies

Instruments and statistics	**Actual UI**	**Optimal UI**	**Laissez-faire**
Time limit of benefits (months)	6	5	0
First tier replacement rate Q^1_{UI}	50%	50%	0%
Second tier replacement rate Q^2_{UI}	0%	20%	0%
Tax level	29.0%	29.1%	27.2%
Unemployment level	5.41%	5.52%	5.37%
Welfare improvement			
relative to Actual UI		**0.1%**	**-0.2%**

The average welfare improvement of fine tuning the instruments of the UI policy is small, at 0.1% of average consumption. This change is small compared with the welfare change of the shift from UI to UA. This is an important finding because it shows that the welfare change following a shift from UI to UA does not come from sensitivity to the policy. For more on this see Ljungqvist and Sargent (2008)

The Laissez-faire UI policy provides no unemployment benefits ($Q^1_{UI} = Q^2_{UI} = 0$). Note that the two other government interventions in this analysis are exactly the same as before, allowing us to analyze the specific effect of the UI benefits. As expected, this policy increases employment and decreases the tax rate in the economy. The average welfare loss of 0.2% is the result of a wide spectrum of welfare changes across deciles of initial wealth: lowest decile suffers a significant welfare **loss** of 1.4%, while the eighth decile enjoys a welfare **gain** of 0.7%. Here, too, the top two deciles are less affected by the unemployment policy.

5 Concluding remarks

In this paper I study a hybrid UA-UI policy that combines elements from both policies. According to this policy an unemployed worker first uses her own mandatory account for payments. Then, when the account is exhausted she receives unemployment benefits from the government. The advantage of this novel policy is that it provides benefits to workers based on their labor market history and provides simultaneously more insurance and lower taxes.

For a wide range of instruments, the hybrid policy leads to a substantial welfare gain relative to a two tier UI system. When comparing the two optimal policies, a shift from UI to UA leads to an average welfare gain of 0.9% of lifetime consumption. This shift makes workers in all deciles of initial wealth better off.

Since the policy uses the accounts to learn about the employment history of workers it seems that a more appropriate title for the hybrid policy would be Employment Accounts. In fact governments could even consider creating fictitious accounts that carry the same information as actual accounts with the advantage that the saving decisions are not enforced.

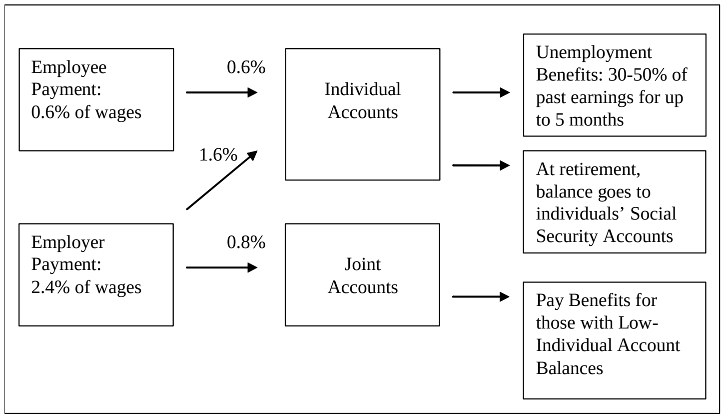
A complementary policy to the one presented here is allowing workers to borrow against their future labor income as proposed by Stiglitz and Yun (2005). Since their paper is mostly qualitative, the framework in this paper can be used to assess the optimal level and the welfare gain resulting from such an instrument.

APPENDIX A: COMPARISON OF UA IN THE MODEL WITH THE CHILEAN SYSTEM

Figure 8 describes the Chilean UA system for workers with open-ended contracts[14]. Both the employee and the employer provide monthly contributions to the UA system. The employer pays the majority of the contribution (2.4% of earnings) and the worker pays an additional 0.6% of her earnings. About 75% of the contribution (2.2% out of the 3%) is deposited in the worker's mandatory account. The remaining of the contribution (0.8% out of 3%) is deposited in the common fund. Upon unemployment, workers are entitled to a schedule of payments that starts at a replacement rate of 50% and decreases linearly to 30% over 5 months. These payments are first financed from the mandatory account. If the account of an unemployed worker is exhausted before the schedule is over, then payments are provided from the common fund.

In the Chilean system the UA withdrawals are followed by a minimum benefit, while in the hybrid policy the withdrawals are followed by UI payments indexed to previous earnings. In addition, the withdrawals from the account during unemployment are constant in the model (they decline in the Chilean policy). This assumption, which simplifies the policy space, is motivated by several recent papers that find that when savings are allowed the importance of declining benefits decreases significantly, e.g. Shimer and Werning (2008), Kocherlakota (2004), and Abdulkadiroglu, Kuruscu, and Sahin (2002).

[14] The rules of savings and withdrawals for fixed-term contracts are slightly different. For an overview of the Chilean UA system see Sehnbruch (2004) and "Unemployment insurance in Chile: Reform and innovation", 2009, International Social Security Association.



Source: NCPA. Brief Analysis. No. 424. 2002

Fig. 8. The Chilean UA system.

APPENDIX B: COMPUTATIONAL METHOD

This appendix describes the computational method of the model. It includes three parts. First, I describe the solution method for the workers' problems for a given UI. Second, I explain how I measure the cross-sectional moments that result from the workers' decisions. Third, I describe the solution method for the optimal UI policy given the cross-sectional moments calculated in the second part.

The computational method for the UA problems and the optimal UA policy follow the same principles with the necessary adjustments

1. **Solving the workers' problems**

   I describe here the solution of the worker's problems under UI for the *working age*. The solution for the retirement age is a simple special case of the one for *retirement age* with a smaller state space.

   (a) **The state space**

   The worker's state under UI is: age (t), private savings (a), persistent component of labor income (z), unemployment duration (d), and eligibility for unemployment benefits (e).

   The state space of age is $\{1, 2, ..., 480\}$ because the unit of time in the model is one month. The state space of unemployment duration is $\{1, 2..., D_{UI} + 1\}$, because unemployment duration becomes irrelevant past the time limit of UI benefits. The state space of eligibility for unemployment benefits is $\{0, 1\}$.

   The other two variables, private savings (a), and persistent component of labor income (z) are continuous. These two variables are discretized linearly over the intervals $[\underline{a}, \overline{a}]$ and $[\underline{z}, \overline{z}]$, respectively.

   $\underline{a}$ is the borrowing limit (currently zero), $\overline{a}$ is equal to \$900,000 so that workers never exceed that level of assets (to avoid unnecessary extrapolations).

   The highest and lowest grid points of z are: $\pm 3 * \sigma_{z_{i,1}} + \sqrt{t-1} * \sigma_{\eta}$, where $\sigma^2_{z_{i,1}}$

is the variance of the initial wage and σ_η^2 is the variance of labor productivity innovations (see the calibration part for the values). The rest of the grid values are spread linearly across $[\underline{z}, \overline{z}]$.

Using 65 values for the grid of assets and 5 values for the grid of the persistent component of labor income, the size of the state space for the worker's problem under the actual UI policy is 2,184,000. This is only the ball park of the number of problems that needs to be solved for two reasons. First, the state space increases with the time limit of the UI policy. Second, the unique number of problems is smaller than the size of the state space since some of the worker's problems over the state space are identical (e.g., the unemployment duration is meaningless for an ineligible worker).

(b) **Solving the worker's problems**

For each possible state over the state space described above, I first solve the intertemporal decisions of consumption - savings for (1) the employed and (2) the unemployed workers with a job opportunity and for (3) the worker with no job opportunity. These are three standard problems in which the labor income or benefits are well defined[15]. Note that since I am using dynamic programming, the future value is already known for each point on the state space.

(c) **Solution method**

For the solution of the three standard problems I use the Endogenous Grid Method (EGM), developed by Carroll (2006). According to the EGM the grid of assets is taken over future assets rather than current assets. This reformulation of the problem reduces the computational burden significantly. For a more detailed description of this method as well as a comparison of computa-

[15] Note that the state of the persistent component of labor income is the net one. This means that the tax level in the economy is not required for solving the worker's problems.

tion time between EGM and Value Function Iteration (VFI) see Barillas and Fernandez-Villaverde (2007). My own experience with using the VFI method for previous versions of the model supports these findings, and I believe that the EGM played a key role in solving the big state-space model in a reasonable time.

The computation of the employment decision for employed and unemployed workers with job opportunities are trivial and are described in the model part of the paper.

2. **Cross section moments**

   (a) **Initial state**

   In order to calculate the relevant cross section moments of the economy (for a given UI policy) I start with an initial guess for the tax τ_1^{UI} and simulate one cohort of $N = 8000$ workers over dates $\{1, 2, ..., T\}$. Note that these workers face survival shocks so the size of the population decreases with age.

   The initial state of workers (employment status, income, and assets) and the income and unemployment shocks, are drawn from the relevant distributions, as explained in the calibration section above.

   For each worker and for each date (as long as the worker is alive), I collect data on taxes and transfers (including UI benefits, Social Assistance, and Social Security).

   (b) **Updating the tax rate**

   The statistics on transfers together with the per capita government expenditure determine the government's expenditure, denoted by E_G. The government's income I_G is simply the sum of tax income over all workers at all ages. As long as $|E_G - I_G| > \varepsilon$, I adjust the tax rate as follows. Given a tax guess τ_m^{UI}, if $E_G - I_G > \varepsilon$, then $\tau_{m+1}^{UI} = \tau_m^{UI} * \sqrt{\frac{E_G}{I_G}}$. Otherwise, if $E_G - I_G < \varepsilon$, then

$\tau^{UI}_{m+1} = \tau^{UI}_{m} * \sqrt{\frac{I_G}{E_G}}$. I use a square root of the expenditure-income ratio to avoid big jumps in the tax level. I also use bounds on the ratio at $\{0.5, 2.0\}$ to avoid overshoots.

(c) **Calculating moments**

When the government budget is balanced according to the conversion criterion above, I calculate the rest of the moments of the model, including average monthly consumption, earnings, assets, and employment, and the Gini coefficient for consumption, earnings, and assets. In addition, I calculate the average utility per worker in the economy (over the working age and the retirement age).

3. **The optimal policy**

The process described so far gives the moments of a stationary economy given a UI policy. In order to choose the optimal UI policy I follow these steps:

(a) **The UI policy grid**

Define the UI policy grid as $D_{UI} \in \mathcal{D}_{UI} \equiv \{0, 1, ..., 8\}$, $Q^1_{UI} \in \mathcal{Q}^1_{UI} \equiv \{0.1, 0, 2..., 0.9\}$, $Q^2_{UI} \in \mathcal{Q}^2_{UI} \equiv \{0.0, 0, 1..., 0.6\}$. Therefore there 567 possible policies.

(b) **Solve for all policy grid points**

$\forall D_{UI} \in \mathcal{D}_{UI}, Q_{UI} \in \mathcal{Q}_{UI}$ repeat steps (1) and (2) above.

(c) **The optimal policy**

The optimal policy is the policy that maximizes the average ex-ante utility of workers. It is always verified that it is not a corner solution in terms of the instruments.

A note on computational time

The number of unique policy grid points is 101 (the replacement rate is meaningless for $D_{UI} = 0$). Running one UI policy node on a two Intel Xeon Quad-Core 64-bit processor, running at 2.33GHz takes about 30 minutes. The solution of one UA policy node takes about 60 minutes (the size of the state space is bigger because of the continuous a_m component).

In order to solve each calibration in a reasonable time I have used "Union Square" (formerly known as the General Cluster), which is a multi-purpose high performance computing resource for the NYU research community. This allows me to solve for several policy nodes simultaneously.

See http://hpc.es.its.nyu.edu/wiki/index.php/DellCluster.

References

ABDULKADIROGLU, A., B. KURUSCU, AND A. SAHIN (2002): "Unemployment Insurance and the Role of Self-Insurance," *Review of Economic Dynamics*, 5(3), 681–703.

ANDERSON, J. M. (1999): "The Wealth of U.S. Families: Analysis of Recent Census Data," *U.S. Department of Commerce, Bureau of the Census*.

BARILLAS, F., AND J. FERNANDEZ-VILLAVERDE (2007): "A Generalization of the Endogenous Grid Method," *Journal of Economic Dynamics and Control*, 31(8), 2698–2712.

BROWNING, M., AND T. F. CROSSLEY (2001): "Unemployment Insurance Benefit Levels and Consumption Changes," *Journal of Public Economics*, 1, 1–23.

CAGETTI, M., AND M. D. NARDI (2006): "Entrepreneurship, Frictions, and Wealth," *Journal of Political Economy*, 114(5), 835–870.

CARROLL, C. D. (2006): "The method of endogenous gridpoints for solving dynamic stochastic optimization problems," *Economics Letters*, 91(3), 312–320.

CHETTY, R. (2008): "Moral Hazard vs. Liquidity and Optimal Unemployment Insurance," *Journal of Political Economy*, 116, 173–234.

CONERLY, W. B. (2002): "Chile Leads the Way with Individual Unemployment Accounts," *National Center for Policy Analysis*, Brief Analysis No. 424.

COOLEY, T. F. (1995): *Frontiers of Business Cycle Research*. Princeton University Press.

DOL (2011): "Comparison of State Unemployment Laws," *Department of Labor, U.S. Employment and Training Administration*, p. available at: http://workforcesecurity.doleta.gov/unemploy/pdf/uilawcompar/2011/preface.pdf.

FELDSTEIN, M. (2005): "Rethinking Social Insurance," *American Economic Review*, 95(1), 1–24.

FELDSTEIN, M., AND D. ALTMAN (2007): "Unemployment Insurance Savings Accounts," in *Tax Policy and the Economy, Volume 21*, NBER Chapters, pp. 35–64. National Bureau of Economic Research, Inc.

GRUBER, J. (1997): "The Consumption Smoothing Benefits of Unemployment Insurance," *American Economic Review*, 87, 192–205.

HANSEN, G. D., AND A. IMROHOROGLU (1992): "The Role of Unemployment Insurance in an Economy with Liquidity Constraints and Moral Hazard," *Journal of Political Economy*, 100, 118–42.

HOPENHAYN, H. A., AND J. P. NICOLINI (1997): "Optimal Unemployment Insurance," *Journal of Political Economy*, 105(2), 412–438.

HUGGETT, M., G. VENTURA, AND A. YARON (2006): "Human capital and earnings distribution dynamics," *Journal of Monetary Economics*, 53(2), 265–290.

KAPLAN, G. (2011): "Inequality and the Lifecycle," *Working paper.*

KAPLAN, G., AND G. L. VIOLANTE (2010): "How Much Consumption Insurance beyond Self-Insurance?," *American Economic Journal: Macroeconomics*, 2(4), 53–87.

KOCHERLAKOTA, N. (2004): "Figuring out the Impact of Hidden Savings on Optimal Unemployment Insurance," *Review of Economic Dynamics*, 7(3), 541–554.

LJUNGQVIST, L., AND T. J. SARGENT (2008): "Two Questions about European Unemployment," *Econometrica*, 76(1), 1–29.

MENDOZA, E. G., A. RAZIN, AND L. L. TESAR (1994): "Effective Tax Rates in Macroeconomics: Cross-country Estimates of Tax Rates on Factor Income and Consumption," *Journal of Monetary Economics*, 34, 297–323.

Orszag, M. J., and D. J. Snower (2002): "From Unemployment Benefits to Unemployment Accounts," *IZA Discussion Paper*, 532.

Pallage, S., and C. Zimmermann (2010): "Unemployment Benefits vs. Unemployment Accounts: A Quantitative Exploration," *Working Paper*.

Pavoni, N. (2007): "On Optimal Unemployment Compensation," *Journal of Monetary Economics*, 54(6), 1612–1630.

Pavoni, N., O. Setty, and G. L. Violante (2010): "Optimal Welfare Programs with Search, Work and Training," *Working Paper*.

Pavoni, N., and G. Violante (2007): "Optimal Welfare-to-Work Programs," *Review of Economic Studies*, 74 (1), 283–318.

Sehnbruch, K. (2004): "Privatized Unemployment Insurance: Can Chile's New Unemployment Insurance Scheme Serve as a Model for Other Developing Countries?," *Center for Latin American Studies, UC Berkeley*, p. 12.

Setty, O. (2012): "Optimal Unemployment Insurance with Monitoring," *Working Paper*.

Shimer, R. (2011): "Reassessing the Ins and Outs of Unemployment," *Working Paper*.

Shimer, R., and I. Werning (2008): "Liquidity and Insurance for the Unemployed," *American Economic Review*, 98(5), 1922–1942.

Stiglitz, J. E., and J. Yun (2005): "Integration of Unemployment Insurance with Retirement Insurance," *Journal of Public Economics*, 89, 2037–2067.

Wang, C., and S. D. Williamson (2002): "Moral hazard, Optimal Unemployment Insurance, and Experience Rating," *Journal of Monetary Economics*, 49(7), 1337–1371.