Should unemployment insurance be asset-tested?

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Abstract

A series of empirical studies has documented that job search behavior depends on the financial situation of the unemployed. Starting from this observation, we ask how unemployment insurance policy should take the individual financial situation into account. We use a quantitative model with a realistically calibrated unemployment insurance system, individual consumption-saving decision and moral hazard during job search to answer this question. We find that the optimal policy provides unemployment benefits that increase with individual assets. By implicitly raising interest rates, asset-increasing benefits encourage self-insurance, which facilitates consumption smoothing during unemployment but does not exacerbate moral hazard for job search. Asset-increasing benefits also have desirable properties from a dynamic perspective, because they emulate key features of the dynamics of constrained efficient allocations. We find welfare gains from introducing asset-increasing benefits that are substantial and amount to 1.5% of consumption when comparing steady states and 0.8% of consumption when taking transition costs into account. More generous replacement rates or benefits targeted to asset-poor households, by contrast, have a negative effect on welfare.

JEL: E21, H21, J65

Keywords: unemployment insurance, asset testing, incomplete markets, consumption and saving

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1 Introduction

This paper starts from the empirical observation that job search behavior depends on the financial situation of the unemployed. For instance, Silvio (2006), Card, Chetty, and Weber (2007), and Lentz (2009) document that higher asset holdings prolong job search, and Chetty (2008) finds that job seekers in financially worse situations react more strongly to changes in the unemployment insurance (UI) system. Motivated by these findings, we ask how the UI system should optimally take the individual financial situation into account. We answer this question using a quantitative model with a realistically calibrated UI program, individual consumption-saving decision, and moral hazard during job search.

We find that the optimal UI system provides benefits that increase with individual assets. The welfare gain of this system over the optimal asset-independent one is sizable and amounts to 1.5 percent of consumption when comparing steady states, and 0.8 percent of consumption when taking transition costs into account. Intuitively, an asset-increasing benefit scheme is preferable to an asset-independent one, because it enhances precautionary savings during employment and thereby allows additional consumption smoothing during unemployment without worsening moral hazard. By contrast, additional insurance coming from higher replacement rates or benefits targeted to asset-poor households has a negative effect on welfare, because such systems crowd out self-insurance and exacerbate moral hazard by distorting the returns to job search. Furthermore, from a dynamic perspective, asset-increasing benefits improve the insurance-incentive trade-off by exploiting the information about past search effort inherent in the accumulated asset stock. A high asset stock signals short unemployment durations in the past, and the optimal policy rewards such histories by paying higher benefits in case the agent becomes unemployed in the present.

Due to the complexity of the government's problem in this setup, we refrain from a characterization of the second best allocation and follow the large strand of the literature that uses calibrated models to study the optimal policy for a restricted class of policy instruments (Ramsey optimal policy).[1] We build an incomplete markets model in which workers are randomly laid off and exert unobservable effort to influence their chances of finding a job. Workers accumulate or decumulate a risk-free asset during employment and unemployment subject to a

[1] See Hansen and Imrohoroglu (1992), Wang and Williamson (2002), and Abdulkadiroglu, Kuruscu, and Sahin (2002), for example.

borrowing constraint. The asset distribution is thus endogenous and depends, in particular, on the structure of the UI system. To keep the analysis tractable, we restrict attention to UI systems that condition only on asset holdings, but not directly on the employment history.[2] Although potentially restrictive, such systems already achieve sizable welfare gains.

In the quantitative analysis we put strong discipline on the model's parameters. We calibrate the model to match the empirical evidence for U.S. job finding and job loss rates, as well as the asset holdings of displaced workers (Gruber, 2001), the estimated change in marginal utility during unemployment (Chetty, 2008), and the elasticity of the job finding rate with respect to the replacement rate (Krueger and Meyer, 2002). Starting from the calibrated benchmark economy we proceed in two steps. In the first step, we show that optimizing the replacement rate of the UI system leads to negligible welfare gains relative to the benchmark system. This finding is in line with results by Chetty (2008), who using a different model and approach also finds that the current U.S. system is close to optimal in terms of the replacement rate. In the second step, we go beyond asset-independent UI systems and explore simple parametric functional forms of asset tests. We maximize social welfare over a large parameter space and show that substantial welfare improvements are possible if asset-increasing UI benefits replace the current asset-independent system.[3] The gains remain large even when we take the transition towards the higher steady state asset stock into account. We also show that additional asset heterogeneity generated by heterogeneous time discount factors does not alter the result that asset-increasing benefits are optimal.

The reason for the optimality of asset-increasing benefits becomes apparent once we distinguish between the two purposes of UI, namely providing liquidity in situations without income and encouraging job search (Chetty, 2008; Shimer and Werning, 2008). The first step of our analysis shows that additional liquidity from more generous UI benefits does not improve welfare, because this crowds out self-insurance and worsens the moral hazard problem, so that agents substitute from search effort towards leisure. Hence, a welfare gain requires to generate additional liquidity without imposing further distortions on the returns to job search. Asset-

[2] For simplification, we assume that assets are observable for the UI agency without costs. How costly it is to monitor asset holdings in practice remains an open question. Yet, the fact that asset-tested social transfer programs are widespread throughout the world suggests that the costs of verifying asset holdings are somewhat limited. Furthermore, under the optimal UI system in our model agents have no incentive to underreport assets, but only to overreport, and the latter is probably a lot easier to detect.

[3] The functional forms also allow for transfers targeted to the asset-poor, i.e. benefits that decrease with assets. We show that asset-decreasing benefits lead to welfare losses.

increasing UI benefits are a simple tool to achieve this goal, since they implicitly raise the rate of return on assets and thereby encourage self-insurance while keeping the average generosity of transfers unchanged. This generates extra liquidity via private asset accumulation without changing the average level of benefits, which means that, loosely speaking, there is no loss of publicly provided liquidity and no increase in moral hazard on average.

In addition to the welfare gain from improved liquidity provision, asset-increasing benefit schemes create a number of desirable effects highlighted in the literature on optimal dynamic contracts. As the agent's asset stock tends to fall during unemployment and grow during employment, the asset stock can be interpreted as a summary statistic of the agent's employment history. Hence, when benefits increase with assets, the duration of present and past unemployment spells has a negative impact on the generosity of public transfers. This property is commonly found to be optimal in the dynamic contracting literature, see Shavell and Weiss (1979) and Hopenhayn and Nicolini (2009). Similarly, since asset-increasing benefit systems enhance precautionary savings, the magnitude of asset accumulation and decumulation tends to be larger than for asset-independent UI systems. This has again favorable dynamic consequences, since consumption after re-employment then decreases more strongly with the duration of previous unemployment spells, which generates larger 're-employment taxes' in the sense of Hopenhayn and Nicolini (1997).

To the best of our knowledge, this paper is the first that delivers an analysis of asset-tested UI in a model with endogenous asset accumulation. Hansen and Imrohoroglu (1992) and Wang and Williamson (2002) use quantitative models similar to ours to study optimal UI systems without asset-tests. While Hansen and Imrohoroglu (1992) explore to what extent optimal replacement rates vary with the degree of moral hazard, Wang and Williamson (2002) investigate the effect of dynamic benefits and experience rating for employers.

In line with the work by Rendahl (2011), our results point out the importance of individual asset holdings as a state for UI policy. Yet, due to key differences in modeling assumptions, we reach very different conclusions on how this state should be used. Rendahl (2011) studies asset-dependent UI in a model with a single unemployed agent who experiences a single unemployment spell. In this setup, the distribution of assets at job loss is exogenous and homogeneous by assumption, and therefore the UI system has no effect on precautionary savings behavior. Moreover, assets include no information on the agent's history prior to the current unemployment spell. These peculiarities of the single spell model seem to matter a lot for the results: Rendahl (2011) finds that optimal unemployment benefits decrease with assets, while we conclude the opposite.

Finally, our results are related to the work by Shimer and Werning (2008), who study the optimal timing of UI benefits in a single-spell model of unemployment where agents have access to a savings technology. They find that UI systems with a simple, time-independent replacement rate are very close to optimal in this environment. Our results show that when asset accumulation prior to job loss and multiple unemployment spells are taken into account, this result no longer applies and large welfare gains are possible by moving to less restrictive UI systems.

The paper proceeds as follows: In Section 2 we describe the model. We describe our calibration, solve for the optimal policy and present the results in Section 3. Section 4 provides some discussion and a sensitivity analysis of the results. We provide conclusions in Section 5.

2 Model

There is a continuum of mass 1 of ex ante identical agents. At each date $t \in \{0, 1, \dots, \infty\}$, the agent's employment state θ_t is an element of the set $\Theta = \{E, U, S\}$, where E stands for employment, U for unemployment, and S for social assistance. Employment states are stochastic and transition probabilities between states depend on the (unobservable) effort exerted by the agent. If the agent exerts effort e_t and is in state θ at time t, then her probability of being in state θ' in period $t+1$ is denoted by

$$\text{Prob}\left(\theta_{t+1} = \theta' \mid \theta_t = \theta,\, e_t\right) = \pi_{\theta\theta'}(e_t).$$

In each period, the agent derives utility $u(c_t)$ from consumption c_t and disutility $\phi(e_t)$ from effort e_t, where $u : \mathbb{R}_+ \to \mathbb{R}$ is strictly increasing and strictly concave and $\phi : \mathbb{R}_+ \to \mathbb{R}$ is strictly increasing and (weakly) convex. Given prices (r, w), discount factor $\beta \in (0, 1)$, utility functions u and ϕ, and the above specification of uncertainty, the agent chooses a consumption sequence $\{c_t\}_{t=0}^{\infty}$, a sequence of asset holdings $\{a_{t+1}\}_{t=0}^{\infty}$, and a sequence of effort levels $\{e_t\}_{t=0}^{\infty}$

to maximize expected discounted life-time utility:

$$\begin{aligned} \max_{\{c_t, a_{t+1}, e_t\}} \quad & \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \left(u(c_t) - \phi(e_t)\right)\right] \\ \text{s.t.} \quad & c_t + a_{t+1} = (1+r)a_t + y(a_t, \theta_t) \\ & a_{t+1} \geq \underline{a},\ c_t \geq 0,\ e_t \geq 0 \\ & a_0, \theta_0 \text{ given} \end{aligned} \tag{1}$$

where $y(a_t, \theta_t)$ denotes the agent's income in period t, r is the return on assets between periods t and $t+1$, and $\underline{a} \leq 0$ represents a borrowing constraint.

If the agent is employed ($\theta_t = E$), she receives a wage w and pays proportional income taxes at rate τ. In state $\theta_t = U$, she receives unemployment benefits $b(a_t)$. Finally, in state $\theta_t = S$ the agent is unemployed and receives social assistance transfers z. The agent's income (excluding interest income) in period t is hence given by

$$y(a_t, \theta_t) = \begin{cases} (1-\tau)w & \text{if } \theta_t = E, \\ b(a_t) & \text{if } \theta_t = U, \\ z & \text{if } \theta_t = S. \end{cases}$$

The government provides unemployment benefits and social assistance benefits and levies a proportional tax τ on labor income. Unemployment benefits $b(a)$ may depend on the agent's current asset position a, while social assistance benefits z are asset-independent for simplicity. The government runs a balanced budget in each period, i.e., the government policy must satisfy

$$\tau w \int_{a_t} d\mu_t(a_t, E) = \int_{a_t} b(a_t) d\mu_t(a_t, U) + z \int_{a_t} d\mu_t(a_t, S) \quad \forall t \tag{2}$$

where μ_t denotes the distribution of agents over asset holdings $A = [\underline{a}, \infty)$ and employment states $\Theta = \{E, U, S\}$ at time t.

The general setup of the model is not accessible for a quantitative analysis. We will therefore make some standard assumptions on functional forms.

Assumption 1. *The agent's period utility function is given by*

$$u(c) - \phi(e) = \begin{cases} (1-\beta)\left(\frac{c^{1-\gamma}}{1-\gamma} - e^{\chi}\right), & \gamma \neq 1, \chi \geq 1, \\ (1-\beta)\left(\log(c) - e^{\chi}\right), & \gamma = 1, \chi \geq 1. \end{cases}$$

Since empirical knowledge on the extent to which workers can influence their layoff risk is very limited, we will model layoffs as exogenous.[4] In addition, we assume that the job search technology of the agent is the same during social assistance and unemployment benefit receipt.

Assumption 2. *Transition probabilities from employment to employment (EE) are independent of the agent's effort:*

$$\pi_{EE}(e) = \pi_{EE},$$

with $\pi_{EE} > 0$*. Transition probabilities from unemployment to employment (UE) and from social assistance to employment (SE) depend on effort in the following way:*

$$\pi_{UE}(e) = 1 - \exp(-\psi e), \qquad \pi_{SE}(e) = 1 - \exp(-\psi e).$$

To economize on the number of state variables, we assume that the duration of unemployment benefits is stochastic.[5] An agent who received unemployment benefits at time $t-1$ and continues to be unemployed at time t will receive unemployment benefits with probability p and social assistance transfers with probability $1-p$. By contrast, an unemployed agent who received social assistance transfers at time $t-1$ and continues to be unemployed at time t will receive social assistance transfers (and no unemployment benefits) with certainty. We will later choose $p = 5/6$, which means that unemployed agents, in expectation, have access to unemployment benefits during the first 6 months of their spell.

Combining these functional forms with the above rules for UI eligibility gives rise to the

[4] From a technical point of view, introducing layoff probabilities that depend on effort would not be difficult. However, in such a setup wealthy workers would ceteris paribus lose their job more often than poor ones. As a consequence, the asset distribution of job losers would dominate that of employed workers, which is contradicted by the findings from Gruber (2001). The fact that wealth matters for transitions from unemployment to employment, on the other hand, is well-established empirically. Silvio (2006) and Lentz (2009), among others, document that wealthier individuals ceteris paribus take longer to find a job. Our model will endogenously generate this feature.

[5] By making the duration of unemployment benefits stochastic, we substantially reduce the computational complexity of the problem, but nonetheless capture the fact that benefits are paid for a limited time only. If the duration of unemployment benefits were deterministic, we would have to introduce the current duration of an unemployed's spell as an additional state variable.

following matrix of transition probabilities over states (E, U, S):

$$\begin{pmatrix} \pi_{EE} & 1-\pi_{EE} & 0 \\ 1-\exp(-\psi e) & \exp(-\psi e)p & \exp(-\psi e)(1-p) \\ 1-\exp(-\psi e) & 0 & \exp(-\psi e) \end{pmatrix} \tag{3}$$

where the first, second, and third row contain the transition probabilities for an agent in state E, U, and S, respectively.

The following assumption allows us to solve the agent's decision problem using first-order conditions.[6]

Assumption 3. *Unemployment benefits $b(a)$ are differentiable on $[\underline{a}, \infty)$.*

2.1 Equilibrium

Recall $\Theta = \{E, U, S\}$ and denote the asset space by $A = [\underline{a}, \infty)$. The agent's problem has a recursive structure and we restrict attention to recursive policies from now on. We adopt standard notation and denote current period's variables without time subscript and next period's variables by a prime, e.g. θ and θ' for the employment state in the current and the next period. The agent's Bellman equation reads

$$\begin{aligned} v(a,\theta) \quad = \quad & \max_{\{a',e\}} u((1+r)a + y(a,\theta) - a') - \phi(e) + \beta \sum_{\theta' \in \Theta} v(a',\theta')\pi_{\theta\theta'}(e) \\ & \text{s.t. } e \geq 0, a' \geq \underline{a}, (1+r)a + y(a,\theta) - a' \geq 0. \end{aligned} \tag{4}$$

A *(recursive) steady state equilibrium* consists of a value function $v : A \times \Theta \to \mathbb{R}$, an asset policy function $a' : A \times \Theta \to \mathbb{R}_+$, an effort policy function $e : A \times \Theta \to \mathbb{R}$, a government policy $(b(\cdot), z, \tau)$ and an invariant distribution μ on the state space $A \times \Theta$ such that:

1. v, a', and e solve the agent's problem (1) given prices (w, r) and the government policy.

2. The government's budget constraint (2) is satisfied.

3. μ is an invariant distribution given decision functions e, a' and transition matrix (3).

[6] We numerically verify that the solution to the agent's first-order conditions is indeed a solution to the agent's decision problem by re-optimizing the agent's decision using grid search and value function iteration.

3 Results

We take a model period to be one month. We normalize the wage rate to 1 and set the interest rate to match an annual return on assets of 4%. The parameters ψ and π_{EE} are chosen to replicate the average job finding and job loss rate in the United States in the period from 1980 to 2005.[7] The target for β is median assets (gross financial wealth) of newly displaced workers reported by Gruber (2001). For reasons specified below, we set the parameters of the agent's utility function to $\gamma = 2$, $\chi = 1$. The benchmark UI policy consists of an asset-independent replacement rate of 0.5, $b(a) = 0.5(1 - \tau)w$, which represents the average replacement rate currently effective in the United States.[8] Social assistance benefits z are chosen according to the average transfer received by a single adult with no children in the 60th month of unemployment in the U.S., which gives $z = 0.08(1 - \tau)w$.[9] The tax rate is $\tau = 0.0211$ and is set to balance the government's budget.

The calibration generates the following parameters: $\pi_{EE} = 0.9855$, $\psi = 0.0472$, $\beta = 0.974$. With these parameters, the steady state equilibrium matches the calibration targets as shown in Table 1. The corresponding consumption and effort decisions can be found in Figure 1.

Table 1: Calibration

	model	target
job finding rate	27.0%	27.0%
job loss rate	1.5%	1.5%
median assets of job losers	1.2	1.2

Notes: Calibration result. The first column gives the data target, the second column the model predicted value of the data target, and the third column the empirical value of the calibration target. The sources for the empirical values of the data targets are given in the main text.

Our choice of the coefficient of relative risk aversion, $\gamma = 2$, turns out to be well in line with the relative change in marginal utility during unemployment estimated by Chetty (2008).

[7] The rates are derived using monthly worker flows from the Current Population Survey (CPS) for all workers aged 16 years and older from 1980 to 2005. Details are available upon request.

[8] According to the OECD, the net replacement rate during the first six months of unemployment in the U.S. in 2009 amounts to 0.49. This number is calculated for single persons with no children and averaged over three stylized pre-unemployment income levels. See `www.oecd.org/dataoecd/17/21/49021188.xlsx` for further details.

[9] The social assistance level of 0.08 is the net replacement rate in the 60th month of unemployment in the U.S. in 2009, calculated for single persons with no children and averaged over three stylized pre-unemployment income levels. See `www.oecd.org/dataoecd/17/19/49021050.xlsx` for further details. Benefits include social assistance (SNAP) and housing benefits.

Consider the expression

$$\frac{u'\left(c^{U}\right)-u'\left(c^{E}\right)}{u'\left(c^{U}\right)} \tag{5}$$

where c^E denotes consumption during employment and c^U represents consumption when receiving UI benefits. We compute this expression by comparing the consumption levels of employed and unemployed agents with identical asset positions. We then average over asset holdings, putting weights according to the asset distribution of the unemployed. While Chetty estimates (a dynamic version of) expression (5) to be roughly 0.6, our model generates a number of 0.64.

To check the plausibility of the effort cost parameter, $\chi = 1$, we examine the elasticity of the job finding rate with respect to UI benefits. Intuitively, the higher the convexity of effort costs, the smaller is the reaction of effort to changes in benefit generosity. With $\chi = 1$, at the benchmark UI system the elasticity of the job finding rate with respect to the replacement rate is approximately 0.48.[10] This number is closely in line with the results by Chetty (2008), who estimates an elasticity of 0.53. Most estimates surveyed by Krueger and Meyer (2002) fall into a similar range.

3.1 Asset-independent UI

We now hold the parameters of the model fixed and vary the replacement rate of the UI system, while adapting the tax rate to keep the government budget balanced. Table 2 displays mean asset holdings, unemployment, taxes and welfare for the steady state equilibria associated with various replacement rates. We also report the utilitarian welfare gain relative to the benchmark policy, expressed in terms of equivalent variation of consumption of the benchmark economy.

Using utilitarian steady state welfare as our criterion, the optimal replacement rate is 40 percent. The welfare gain relative to the benchmark policy is negligible, however, as steady state welfare raises by only 0.02 percent in consumption equivalent terms. The benchmark replacement rate of 50 percent is hence very close to optimal.

The benchmark government policy yields a substantial welfare increase relative to autarky. Table 3 shows the welfare effects of eliminating unemployment insurance and/or social assistance. Relative to the benchmark policy, autarky (no UI, no social assistance) entails steady state welfare losses of 0.64 percent in consumption equivalent terms.

[10]More precisely, a ten percent increase in the replacement rate (from 0.5 to 0.55) reduces the job finding rate of agents receiving UI benefits by roughly 4.8 percent in our model (from 0.2233 to 0.2125).

Table 2: Steady states for various asset-independent replacement rates

replacement	assets	unemployment	tax	welfare change
80%	0.73	6.2%	3.9%	-0.38%
70%	0.84	5.8%	3.2%	-0.18%
60%	0.98	5.4%	2.6%	-0.06%
50%	1.13	5.1%	2.1%	0.00%
40%	1.31	4.8%	1.6%	0.02%
30%	1.53	4.6%	1.2%	0.00%
20%	1.78	4.4%	0.8%	-0.03%

Notes: Results of varying the replacement rate starting from the benchmark economy. Column 1 gives the different replacement rates, column 2 the average asset holdings in the economy, column 3 the unemployment rate, column 4 the tax rate, and column 5 the welfare change expressed as equivalent variation in steady state consumption generated by moving from the benchmark economy to the economy with the new replacement rate.

Table 3: Steady states for the benchmark policy, no UI, no social assistance, and autarky

policy	assets	unemployment	tax	welfare change
benchmark	1.13	5.1%	2.1%	0.00%
no social assistance	1.35	4.6%	1.9%	-0.35%
no UI	2.50	4.1%	0.1%	-0.25%
autarky	2.56	3.8%	0.0%	-0.64%

Notes: Results of eliminating unemployment insurance benefits, social assistance benefits, or both. The first column describes the policy experiment, column 2 gives the average asset holdings in the economy, column 3 the unemployment rate, column 4 the tax rate, and column 5 the welfare change expressed as equivalent variation in steady state consumption.

3.2 Linear asset-dependent UI

We now allow UI benefits $b(a)$ to depend on assets, holding the tax rate $\tau = 0.0211$ fixed at the benchmark level.[11] For now, we restrict ourselves to systems where the replacement rate depends on assets in a linear way,

$$\frac{b(a)}{(1-\tau)w} = \alpha_1 a + \alpha_2. \tag{6}$$

We explore various slopes α_1 and choose the intercept α_2 to preserve budget balance. Recall that the social assistance replacement rate is set to 0.08. We therefore allow for intercept values $\alpha_2 \in [0.08, 1]$.

Table 4 shows that steady state welfare increases in α_1, the slope of the benefit scheme. We

[11] We also explored asset-dependent benefits for alternative tax rates. The results are very similar to the ones reported for $\tau = 0.0211$. Moreover, this tax rate is approximately optimal. See Appendix C for further details.

Table 4: Steady states for linear asset-dependent replacement rates

α_1	α_2	assets	unemployment	welfare change
-0.150	0.615	0.57	4.7%	-0.88%
-0.100	0.590	0.72	4.8%	-0.62%
-0.050	0.553	0.89	4.9%	-0.33%
0.000	0.500	1.13	5.1%	0.00%
0.050	0.419	1.47	5.3%	0.38%
0.100	0.283	2.02	5.7%	0.86%
0.138	0.084	2.83	6.1%	1.34%

Notes: Results for replacement rates that are linear in assets. The first column gives the slope of the replacement rate with respect to assets, column 2 the intercept, column 3 the average asset holdings in the economy, column 4 the unemployment rate, and column 5 the welfare change expressed as equivalent variation in steady state consumption generated by moving from the benchmark economy to the economy with asset-dependent replacement rates. The tax rate $\tau = 0.0211$ is fixed at the benchmark level.

note that the potential welfare gain of linking benefits linearly to assets corresponds to roughly 1.3 percent of steady state consumption. This gain is more than twice as large as the gain of moving the economy from autarky to the benchmark policy. In addition, we find that systems where benefits *decrease* with assets (the conventional definition of an asset test) bring welfare losses compared to the benchmark system with asset-independent benefits. The optimal linear asset-dependent UI system is given by parameters $\alpha_1 = 0.138$, $\alpha_2 = 0.084$. These parameters are at the corner. If we increase the slope α_1 even further, it becomes impossible to find an intercept $\alpha_2 \in [0.08, 1]$ such that the government budget is balanced.

Under the optimal linear asset-dependent system, agents with zero assets face a replacement rate equal to that under social assistance. For the median job loser, having assets of around 3.1, the replacement rate equals 50 percent during the first month of unemployment. Figure 2 shows the shape of UI benefits under this system. Figure 3 displays the corresponding consumption decisions and job finding probabilities.

For mechanical reasons, benefit schemes that increase with assets generate higher unemployment rates than schemes with asset-independent or asset-decreasing benefits. This is simply a peculiarity of our policy experiment. Recall that we fix the tax rate, which implies that the amount of government transfers is approximately the same for all policies. Since asset-increasing UI systems implicitly subsidize pre-cautionary saving and thereby raise steady state asset holdings, the total amount of resources available during unemployment is higher for those systems. Quite straightforwardly, job finding rates are thus lower. It would not be difficult to reduce the tax rate and the average level of benefits such that the job finding rate of the asset-increasing UI system matches the rate of the benchmark policy. Appendix C shows that this does not yield higher welfare.

3.3 Nonlinear asset-dependent UI

We now consider a more flexible functional form for UI benefits. This allows us to locally increase the slope of benefits even further than in the experiments conducted above. Given that the optimal linear benefit function was the one that had the highest possible slope subject to obtaining budget balance, there might be room for a further welfare improvement.

Since asset-decreasing benefit schemes lead to welfare losses in the linear case, we restrict ourselves to a class of increasing functions,

$$\frac{b(a)}{(1-\tau)w} = 1 - 0.92 \exp\left(-\left(a/\lambda_2\right)^{\lambda_1}\right), \tag{7}$$

where λ_1, λ_2 are positive parameters. The class of functions in (7) includes S-shaped and concave benefit schemes, as well as schemes that are approximately linear over some range. Intuitively, the slope parameter λ_1 determines the sensitivity of benefits as we move from the center of the asset distribution to the tails. Notice that benefits exceed the social assistance level of 0.08 and are bounded above by 1 for all parameter values.

We examine different values for λ_1 and choose λ_2 to ensure that the government budget is balanced. Table 5 shows the results of various parameter values for this functional form. Figure 4 displays the shape of UI benefits under the optimal parameters, while Figure 5 shows the corresponding consumption function and optimal job finding probabilities. The steady state welfare gain relative to the benchmark policy is substantial and amounts to an equivalent variation of 1.56 percent of period consumption. Yet, this gain is only slightly larger than the one obtained by the optimal linear benefit system. Besides, we find that steeper slopes of the benefit function are not necessarily better. For functions with parameter values λ_1 higher than the optimal level, $\lambda_1 = 2$, the slope of benefits at the mean of the asset distribution is steeper (and mean asset holdings are higher), but steady state welfare is lower.

Table 5: Steady states for various nonlinear asset-dependent replacement rates

λ_1	λ_2	assets	unemployment	welfare change
1.0	4.378	2.50	5.9%	1.16%
1.5	4.500	3.04	6.2%	1.43%
2.0	4.815	3.48	6.5%	1.56%
2.5	5.200	3.56	6.7%	1.06%

Notes: Results for various asset-dependent replacement rates using the functional form described in equation (7). The first two columns display the parameter values, column states 3 the average asset holdings in the economy, column 4 the unemployment rate, and column 5 the welfare change expressed as equivalent variation in steady state consumption generated by moving from the benchmark economy to the economy with asset-dependent replacement rates. The tax rate $\tau = 0.0211$ is fixed at the benchmark level.

4 Discussion

The quantitative results from the previous section have shown that linking the UI replacement rate to individual assets generates a substantial welfare gain relative to asset-independent systems. Most importantly, we have found that the replacement rate should be an increasing function of assets.

The economic forces behind this result become straightforward once we differentiate between the moral hazard effect and the liquidity effect of UI. As emphasized by Chetty (2008), UI programs play two very distinct roles.[12] On the one hand, they narrow the income gap between employment and unemployment. This distorts the relative price between work and leisure, and results in moral hazard so that unemployed workers substitute from search effort towards leisure. On the other hand, UI programs alleviate borrowing constraints by raising the worker's wealth during unemployment. This second channel, referred to as the liquidity effect, also leads to a reduction in search effort. Although both the liquidity and the moral hazard effect influence the agent's search behavior in a similar direction, the welfare consequences are very different. Liquidity provision is a socially beneficial response to credit market imperfection, while the moral hazard effect resulting from the price distortion is detrimental to social welfare.

Ideally, a UI program should generate liquidity without generating moral hazard. In a model with endogenous asset accumulation, the UI system affects the liquidity situation of unemployed workers not only directly through transfers during unemployment, but also indirectly by changing the worker's precautionary saving behavior prior to job loss. In standard, asset-

[12] Shimer and Werning (2008) also discuss a dual role of UI with a slightly different focus.

independent UI systems, public transfers have an ambiguous effect on the liquidity situation, because any increase in the generosity of UI will crowd out precautionary savings. Systems with asset-increasing UI benefits, however, implicitly raise the rate of return on assets and thereby enhance precautionary savings while keeping the average generosity of transfers unchanged. This generates extra liquidity via private asset accumulation without changing the average level of benefits, which means that the effects on publicly provided liquidity and moral hazard both average out to zero, loosely speaking.

Moreover, if we look at the *dynamic* distribution of moral hazard effects, we find that asset-increasing UI benefits have some additional desirable properties. As long as agents accumulate assets during employment and decrease assets during unemployment, assets are a summary statistic of the agent's employment history, where an high asset stock signals short (and/or infrequent) periods of unemployment. Asset-increasing UI benefits therefore have the feature that benefits decrease with the duration of present and past unemployment spells, which is commonly found to be optimal in the dynamic contracting literature; see Shavell and Weiss (1979), and Hopenhayn and Nicolini (2009). Furthermore, the magnitude of asset accumulation and decumulation tends to be larger in systems with asset-increasing benefits, so that consumption during employment decreases more strongly with the duration of previous unemployment spells. Hence, UI systems with asset-increasing benefits create more significant 're-employment taxes' in the sense of Hopenhayn and Nicolini (1997). In these two ways asset-increasing UI benefits emulate the dynamics of constrained efficient allocations, which complements the efficiency gain resulting from improved liquidity provision.

Finally, by raising the steady state asset stock, asset-increasing UI systems generate extra interest income, compare Table 4, so that a part of the welfare change results simply from higher mean income. For instance, when comparing the benchmark economy to the economy with optimal linear asset-dependent benefits, we observe that the change in the asset stock generates additional interest income equivalent to approximately 0.6 percent of period consumption, while the total welfare gain amounts to 1.34 percent of period consumption.

For a conclusive welfare analysis, the steady state effects discussed above have to be compared to the costs of reaching the new steady state. The following two sections show that the welfare gains of asset-increasing UI systems need to be corrected downwards when the transition phase is taken into account. Yet, transition effects will not invalidate the basic insight that optimal UI benefits are increasing in individual asset holdings.

4.1 A simple transition experiment

To approximate the consequences of an optimal transition, we suppose throughout this section that the government can arbitrarily change the asset distribution at the time of a policy reform using individual specific lump-sum transfers. There are many possible ways to design those transfers. However, in terms of the costs they are all identical: if mean assets in the pre-reform steady state are given by $\bar{a}_{\text{old}}$ and mean assets in the post-reform steady state are $\bar{a}_{\text{new}}$, then the lump-sum transfers can be financed by the government by repaying $r(\bar{a}_{\text{new}} - \bar{a}_{\text{old}})$ in every period. We add this cost or revenue to the government's budget constraint and keep the budget balanced by adjusting UI benefits accordingly.

In this experiment, the economy immediately jumps from the pre-reform steady state to the post-reform steady state. Yet, the costs of changing the asset stock are taken into account, because they enter the government's budget and are repaid over the future. Using this approach, the welfare effects of policies that raise the steady state asset distribution will be corrected downwards. Table 6 displays mean asset holdings, unemployment, taxes and welfare changes for various asset-independent UI systems taking into account the transition costs outlined above. For asset-independent systems, we find that the optimal replacement rate coincides with the benchmark rate of 50 percent.

Table 7 considers UI benefits that are linear in assets. Confirming the results from Section 3.2, we find that welfare is increasing in the slope of UI benefits even when the transition costs described above are included. Since part of the tax revenue is used to finance the change in the steady state asset stock, the benefit functions from Section 3.2 are no longer feasible. The highest possible slope of benefits is now given by $\alpha_1 = 0.12$, and leads to a welfare gain of 0.79 percent of period consumption.[13]

[13] By contrast, when the costs of the lump-sum transfers to change the capital stock are ignored (as in Section 3.2), the intercept of the benefit function with slope $\alpha_1 = 0.12$ can be increased from $\alpha_2 = 0.08$ to a level of $\alpha_2 = 0.20$. At the same time, the welfare gain rises to 1.09 percent of consumption.

Table 6: Steady states for various asset-independent replacement rates. Transition costs as outlined in Section 4.1 are included.

replacement	assets	unemployment	tax	welfare change
80%	0.73	6.2%	3.8%	-0.27%
70%	0.84	5.8%	3.1%	-0.10%
60%	0.98	5.4%	2.6%	-0.02%
50%	1.13	5.1%	2.1%	0.00%
40%	1.31	4.8%	1.7%	-0.03%
30%	1.52	4.6%	1.3%	-0.10%
20%	1.77	4.4%	1.0%	-0.20%

Notes: In this transition experiment, the government immediately moves the economy to the post-reform steady state using individual specific lump sum transfers. The costs or revenues of these transfers enter the government's budget and are repaid over the future.

Table 7: Steady states for linear asset-dependent replacement rates. Transition costs as outlined in Section 4.1 are included.

α_1	α_2	assets	unemployment	welfare change
-0.150	0.658	0.51	4.8%	-0.71%
-0.100	0.621	0.67	4.9%	-0.49%
-0.050	0.571	0.87	5.0%	-0.26%
0.000	0.500	1.13	5.1%	0.00%
0.050	0.394	1.51	5.2%	0.30%
0.100	0.210	2.16	5.4%	0.64%
0.120	0.081	2.62	5.5%	0.79%

Notes: In this transition experiment, the government immediately moves the economy to the post-reform steady state using individual specific lump sum transfers. The costs or revenues of these transfers enter the government's budget and are repaid over the future. The tax rate $\tau = 0.0211$ is fixed at the benchmark level.

4.2 An explicit transition phase

If we rule out individual specific lump-sum transfers, the steady state asset distribution induced by a policy reform cannot be implemented instantaneously. It will thus take some time before individual saving decisions have moved the asset distribution to its new steady state.

The simplest way of modeling an explicit transition would be to posit that the UI reform is not anticipated and takes effect immediately at the time it is announced. For the introduction of asset-increasing benefits, however, this would be the worst possible approach. During the transition phase, agents would not only have to give up consumption to build a higher asset stock, they would also face very little insurance against unemployment. For instance, at the linear UI policy that maximizes steady state welfare in Section 3.2, the replacement rate at average pre-reform asset holdings amounts to little more than 20 percent and so it would take a significant amount of time before the agent is reasonably well insured against unemployment. Indeed, if we perform this exercise, we find that the steady state welfare gain transforms into a welfare loss when taking the transition phase into account.[14]

Underinsurance during the transition phase can be avoided by introducing asset-increasing benefits *on top of* the benchmark system. Specifically, we carry out the following exercise. We set the intercept of the benefit function to $\alpha_2 = 0.5$ and then explore different values for the slope α_1. At the same time, we adjust the tax rate to keep the government budget balanced (in present value terms, including budget effects of the transition). As usual, we assume that agents do not anticipate the policy reform until it takes effect. The results of this experiment are shown in Table 8. We see that asset-increasing UI systems improve welfare by a consumption equivalent variation of up to 0.12 percent. Different from the experiments in Section 3.2, welfare is no longer monotonic in the slope parameter α_1, because higher slopes now require higher taxes and higher average benefits. The tax and benefit levels therefore become inefficiently high when slopes are too steep.

Table 8: Linear asset-dependent replacement rates. Welfare includes the transition phase.

α_1	α_2	assets	unemployment	tax	welfare change
0.000	0.50	1.13	5.1%	2.1%	0.00%
0.025	0.50	1.22	5.3%	2.3%	0.08%
0.050	0.50	1.33	5.6%	2.5%	0.12%
0.075	0.50	1.48	6.0%	2.9%	0.11%
0.100	0.50	1.71	6.7%	3.5%	-0.07%

Notes: The replacement rate is bounded below by fifty percent for all asset levels. In other words, asset-increasing benefits are introduced on top of the benchmark UI system.

Finally, we would like to remark that there are several alternative ways of limiting the harm of the transition phase when an asset-increasing UI policy is introduced. For instance, one could announce the introduction of such policy a number of years in advance. This would give agents the opportunity to accumulate assets while the benchmark UI system is still in place, which is certainly much more sensible than the introduction of an asset-dependent policy without advance notice.[15] Another option would be to pay extra transfers to agents who become

[14]Details are available upon request.

[15]The agent's decision function loses its stationarity during such a transition, which creates challenging computational problems.

unemployed shortly after the policy reform.

4.3 Heterogeneous discount factors

In its basic version, the model generates less asset heterogeneity among job losers than we find in the data documented by Gruber (2001). In fact, a larger degree of heterogeneity might change the case in favor of asset-decreasing benefits, because then transfers targeted to agents with very low liquidity might possibly become more important. To see how our results change with more asset heterogeneity, we follow the approach by Krusell and Smith (1998) and generate a larger variation in the asset distribution using heterogeneous time discount factors.

Throughout this section, we explore a version of the model in which agents have discount factors $\beta \in \{\beta_1, \beta_2, \beta_3\}$. The share of agents with discount factor β_i equals one third for $i = 1, 2, 3$. Discount factors are permanent. We recalibrate the parameters of the model to match the targets from Section 3 as well as the 25th and 75th percentile of gross financial assets of job losers reported by Gruber (2001).[16] This gives parameters of $\pi_{EE} = 0.9855$, $\psi = 0.062$, $\gamma = 2$, $\chi = 1$, $\beta_1 = 0.922$, $\beta_2 = 0.978$, $\beta_3 = 0.996$. As usual, we choose the tax rate τ to obtain budget balance. This results in $\tau = 0.0209$.

With heterogeneous preferences, the definition of a welfare measure becomes less straightforward. For simplicity, we aggregate welfare using equal weights for all types. Since period utilities include the factor $(1 - \beta_i)$ by construction, the first best allocation is the same across groups. Hence, preference heterogeneity per se does not create a motive for redistribution.

Qualitatively, the findings from Section 3 generalize to the model with heterogeneous discount factors and the resulting higher heterogeneity in assets. In particular, UI benefits that increase with assets continue to be optimal. However, the welfare gain of asset-dependent UI systems becomes somewhat smaller. We also find that concave benefit functions are far more beneficial than linear ones. Intuitively, by making the benefits concave in assets, we can reduce the degree of redistribution from asset-poor agents to asset-rich agents, but maintain the feature that asset accumulation is implicitly subsidized (in particular at low asset levels).

The optimal nonlinear asset-dependent policy of the form (7) is given by parameters $(\lambda_1, \lambda_2) = (0.8, 7.737)$ and creates a steady state welfare gain of 1.14 percent in consumption equivalent

[16] According to Gruber (2001), the 25th, 50th, and 75th percentile of the asset distribution (gross financial wealth) of job losers are given by asset holdings of 0.1, 1.2 and 7.8, respectively.

terms. If we take into account the costs of building up the higher asset stock, the optimal parameters are $(\lambda_1, \lambda_2) = (0.3, 40.414)$, and the welfare gain is 0.30 percent. This policy is highly concave in assets. The replacement rate is 0.08 for agents with no assets, 0.34 for agents with assets of 1, and 0.39 for agents with assets of 2, for instance.

4.4 Comparison of results to other quantitative papers

To the best of our knowledge, there is no other quantitative assessment of asset testing in the unemployment insurance literature. In terms of the setup, however, our basic model is related to the works by Hansen and Imrohoroglu (1992) and Wang and Williamson (2002).

Hansen and Imrohoroglu (1992) explore optimal asset-independent UI in a framework where job offers are not observable and, as in the present paper, agents have access to a savings technology subject to liquidity constraints. They find that, depending on the degree of moral hazard, the optimal replacement rate varies between 15 and 65 percent. The present paper finds an optimal asset-independent replacement rate of 40 percent, see Section 3.1, which falls into the range calculated by Hansen and Imrohoroglu (1992). Instead of varying the degree of moral hazard exogenously, we calibrate our model to match empirical findings on the elasticity of the job finding rate with respect to UI benefits.

Our basic model also has similarities with the setup from Wang and Williamson (2002). Yet, we follow a very different calibration strategy. In particular, we use empirical results on asset holdings of job losers as the target for the discount factor, whereas Wang and Williamson (2002) choose a discount factor in line with the real business cycle literature, which results in asset holdings that are about five times larger. It comes as no surprise that the welfare effects of UI are much bigger in the present paper. For instance, relative to autarky the benchmark UI system raises welfare by a consumption equivalent variation of 0.64 percent in our model, whereas Wang and Williamson (2002) find welfare gains of only 0.09 percent. Moreover, the behavioral responses to changes in the replacement rate are stronger in the present paper. In our model, the unemployment rate in autarky is 34 percent lower than under the benchmark UI system, whereas it falls by only 9 percent in the setup from Wang and Williamson (2002).

5 Conclusions

This paper studies the question whether UI benefits should depend on individual asset holdings. We explore this question in a quantitative model where agents face moral hazard during job search and accumulate a risk-free asset for self-insurance. We find that the optimal UI program is one where benefits are an increasing function of assets. Intuitively, since liquidity concerns are crucial for unemployed workers, and since public transfers generally exacerbate moral hazard, it is expedient to encourage precautionary saving rather than to punish it. In addition, asset-increasing benefits emulate key features of the dynamics of constrained efficient allocations. Since the asset stock is a summary statistic of the employment history where high assets signal short unemployment spells, a system where benefits increase with assets rewards histories that are linked to high job search effort in the past.

Two final remarks seem appropriate. First, it is important to keep in mind that all jobs are identical in our model. Our results should thus be interpreted in the sense that the optimal UI replacement rate is an increasing function of assets, not that the absolute level of benefits is increasing with assets.

Second, in practice assets are observable for the UI agency at a cost only. Even though a precise estimate of this cost seems difficult to obtain, we are confident that the benefit quite plausibly outweighs the cost for two reasons. First of all, the welfare gain of conditioning UI on assets is substantial and exceeds even the gain of moving the economy from autarky to the benchmark UI system. Second, under the optimal asset-dependent UI policy agents have no incentive to underreport assets, but only to overreport, which is probably easier to detect.

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A Robustness checks

A.1 Higher asset holdings

In the benchmark economy, the calibration target for asset holdings is median liquid asset holdings (gross financial wealth) of job losers reported by Gruber (2001). As a sensitivity check to our results, we recalibrate the parameters of the model so that job losers have median assets of 2.6, which is approximately twice as much as in the benchmark economy. This generates parameters $\pi_{EE} = 0.9855$, $\psi = 0.0425$, $\beta = 0.98$, $\gamma = 2.8$, $\chi = 1$. The tax rate is fixed at $\tau = 0.0211$ and balances the government's budget.

Using the functional form from Section 3.3, we first compute the nonlinear asset-dependent benefit function that maximizes steady state welfare. We then compute the optimal nonlinear benefit function when the costs of changing the steady state asset stock are taken into account as in Section 4.1. The results can be found in Table 9 and show that the welfare gains of asset-increasing UI systems are of a similar magnitude as in the benchmark calibration.

Table 9: Welfare effects of nonlinear asset-dependent unemployment benefits when asset holdings are higher than in the benchmark calibration

transition costs	λ_1	λ_2	assets	unemployment	welfare change
no	2.5	7.022	5.30	6.5%	1.23%
yes	2.5	7.521	4.67	5.6%	0.55%

A.2 Alternative social assistance systems

In the benchmark calibration, we set social assistance benefits to 8 percent of after-tax labor income, in line with OECD findings on replacement rates for long-term unemployment in the United States. In this section, we explore the sensitivity of our results with respect to alternative specifications of the social assistance system.

We first analyze a case where the social assistance level is more generous. We set $z = 0.15(1-\tau)w$ and re-calibrate the time discount factor β and the efficiency parameter for job search ψ in order to match median asset holdings of job losers and the average job finding rate as in the benchmark model. Since the preference parameters γ and ξ are chosen to match targets related to the UI system, and since these statistics remain almost unchanged, we refrain from recalibrating these parameters.[17] We then explore the introduction of nonlinear asset-dependent UI benefits. We start from the benchmark economy with a replacement rate of 50 percent and, as before, we fix the budget balancing tax rate from this economy, which in this case is $\tau = 0.0218$. Two welfare measures are considered. First, we compare steady state welfare. Second, we take into account the costs of changing the steady state asset stock as in Section 4.1.

Our second experiment abolishes the social assistance system and considers a situation where unemployment benefits are paid indefinitely.[18] Again, we recalibrate the parameters β and ψ to match median asset holdings of job losers and the average job finding rate, and we fix the budget balancing tax rate given by $\tau = 0.0262$.[19] We then compute the welfare effects of introducing nonlinear asset-dependent UI benefits using the two welfare measures discussed in the previous paragraph. Table 10 presents the optimal policies of the different experiments.

Table 10: Welfare effects of nonlinear asset-dependent unemployment benefits given higher social assistance benefits or unlimited duration of unemployment benefits

experiment	transition costs	λ_1	λ_2	assets	unemployment	welfare change
higher level	no	2.1	4.974	3.40	6.2%	1.38%
higher level	yes	2.2	5.290	2.97	5.5%	0.67%
unlimited duration	no	0.8	7.215	4.32	5.3%	1.22%
unlimited duration	yes	1.2	9.878	4.44	4.4%	0.34%

The results in Table 10 are derived using re-calibrated parameters, so they are not directly comparable to the benchmark model. Nonetheless, the results show that the welfare gains of asset-increasing UI benefits in the benchmark calibration are robust to alternative specifications of the social assistance system. It is worth noting that job finding rates in the social assistance state are particularly high, so that only a very small fraction of the population is in this highly transitory state.[20] Hence, the robustness of our results along this dimension does not come as a surprise.

[17] In the calibration, ψ changes from 0.0472 in the benchmark case to 0.0528 and β changes from 0.974 in the benchmark case to 0.9794.

[18] In terms of our model parameters, we set $1 - p$ to 10^{-7}.

[19] The calibration results in $\psi = 0.102$ and $\beta = 0.9905$.

[20] In the benchmark economy 1.2 percent of agents are in the social assistance state.

A.3 Relaxed borrowing constraints

In this section, we explore an alternative value for the agent's borrowing constraint. We set $\underline{a} = -1$ and recalibrate the model to match the same targets as in the benchmark setup. This generates parameters $\pi_{EE} = 0.9855$, $\psi = 0.0405$, $\beta = 0.9755$, $\gamma = 2.75$, $\chi = 1$. The tax rate is $\tau = 0.0212$ and balances the government's budget. Analogous to the analysis from Section 3.3, we compute the nonlinear asset-dependent benefit function that maximizes steady state welfare. We also compute the optimal benefit function when the costs of changing the steady state asset stock are taken into account. The results are given in Table 11. Since the parameters of the model are re-calibrated, the results are not directly comparable to the benchmark setup. However, the results allow us to conclude that the sizable welfare gains of asset-dependent UI systems in the benchmark setup are not an artifact of the particular choice of the borrowing constraint.

Table 11: Welfare effects of nonlinear asset-dependent unemployment benefits when borrowing constraints are less tight

transition costs	λ_1	λ_2	assets	unemployment	welfare change
no	2.2	6.164	3.55	6.5%	1.24%
yes	2.2	6.680	3.09	5.6%	0.64%

B The role of benefit dynamics

This section explores the importance of linking unemployment benefits to the duration of the unemployment spell. More specifically, we compare the welfare effects of an optimal one-stage unemployment benefit system to an optimal two-stage system. In the one-stage system, unemployment benefits are paid indefinitely, which implies that social assistance transfers become irrelevant. The two-stage system consists of one benefit level for the first few months of unemployment and a second benefit level for the remainder, with an indefinite duration as in the one-stage system. The second stage hence resembles the social assistance system from the benchmark economy. The transition from the first to the second stage is stochastic, and the government chooses the expected duration (or transition probability) of the first stage of benefits as well as the two respective benefit levels.

We fix the tax rate at the benchmark level of $\tau = 0.0211$ and explore a wide range of policy parameters. We ensure that the government budget is balanced, which takes away one degree of freedom from the choice of policy parameters and automatically pins down the benefit level of the one-stage system. The optimal policies can be found in Table 12. We see that the optimal two-stage system consists of a replacement rate of 47 percent in the first 2 months of unemployment, followed by a replacement rate of 28 percent for the remainder of the unemployment spell. Hence, compared to the benchmark economy, the optimal two-stage system has a shorter duration of the first stage and more generous benefits during the second stage. Relative to the one-stage system, which features a replacement rate of 32 percent, the two-stage system yields a welfare gain of less than 0.06 percent in consumption equivalent terms. Hence, in our experiment the dynamics of unemployment benefits do not yield large welfare gains. Similar results have been derived for more flexible dynamic benefit systems in related environments by Wang and Williamson (2002) and Shimer and Werning (2008).

Table 12: Steady states for optimal one-stage and two-stage insurance systems

system	first stage	second stage	duration	assets	unemployment	welfare change
benchmark	0.50	0.08	6	1.13	5.1%	0.00%
one-stage	0.32	0.32	∞	0.92	6.2%	0.16%
two-stage	0.47	0.28	2	0.83	5.7%	0.21%

Notes: The first column describes the policy type, the second and third column denote the replacement rate in the first and second stage of benefits, respectively, and the fourth column denotes the expected potential duration of the first stage (in months).

C Asset-dependent benefits for various tax rates

This section explores nonlinear asset-dependent UI benefits when taxes are set to various levels. Table 13 displays the steady states that result when the parameters for the nonlinear benefit function are chosen optimally given the tax rate. We see that welfare is the highest when the tax rate is at the benchmark level, $\tau = 0.0211$.

D Computation

This section sketches how we solve the agent's problem and find the stationary distribution and the optimal policy parameters of the UI system. Since we use standard numerical techniques, we will outline only the general steps of the computation.

Table 13: Steady states for nonlinear asset-dependent replacement rates. The parameters of the benefit function are chosen optimally given the tax rate.

taxes	λ_1	λ_2	assets	unemployment	welfare change
1.00%	2.6	5.396	3.00	5.2%	1.20%
1.50%	2.2	5.161	3.26	5.8%	1.48%
2.00%	2.0	4.859	3.43	6.3%	1.56%
2.11%	2.0	4.815	3.48	6.5%	1.56%
2.50%	1.9	4.577	3.54	6.9%	1.51%
3.00%	1.8	4.258	3.57	7.4%	1.34%

We study benefit schedules that are differentiable in assets (Assumption 3) and assume that first-order conditions are sufficient for the solution of the agent's problem. We verify numerically that this is indeed the case by re-optimizing the agent's decision using grid search and value function iteration. The agent's first-order conditions are straightforward to derive. The agent's effort decision is characterized by the following condition:

$$\phi'(e) = \beta\pi'_{\theta E}(e)v(a', E) + \beta\pi'_{\theta U}(e)v(a', U) + \beta\pi'_{\theta S}(e)v(a', S),$$

where $v(a, \theta)$ denotes the value function in employment state θ when the agent holds assets a. The value function is derived using standard value function iteration on equation (4). The first-order condition for the optimal asset choice is also straightforward to derive. Due to asset-testing, the condition involves a state dependent return,

$$u'(c) = \beta\bigg(\pi_{\theta E}(e)(1+r)u'(c'_E) + \pi_{\theta U}(e)(1+r+b'(a'))u'(c'_U) + \pi_{\theta S}(e)(1+r)u'(c'_S)\bigg)$$

where c'_E, c'_U, c'_S denote the agent's consumption in the next period in states E, U, S, respectively.

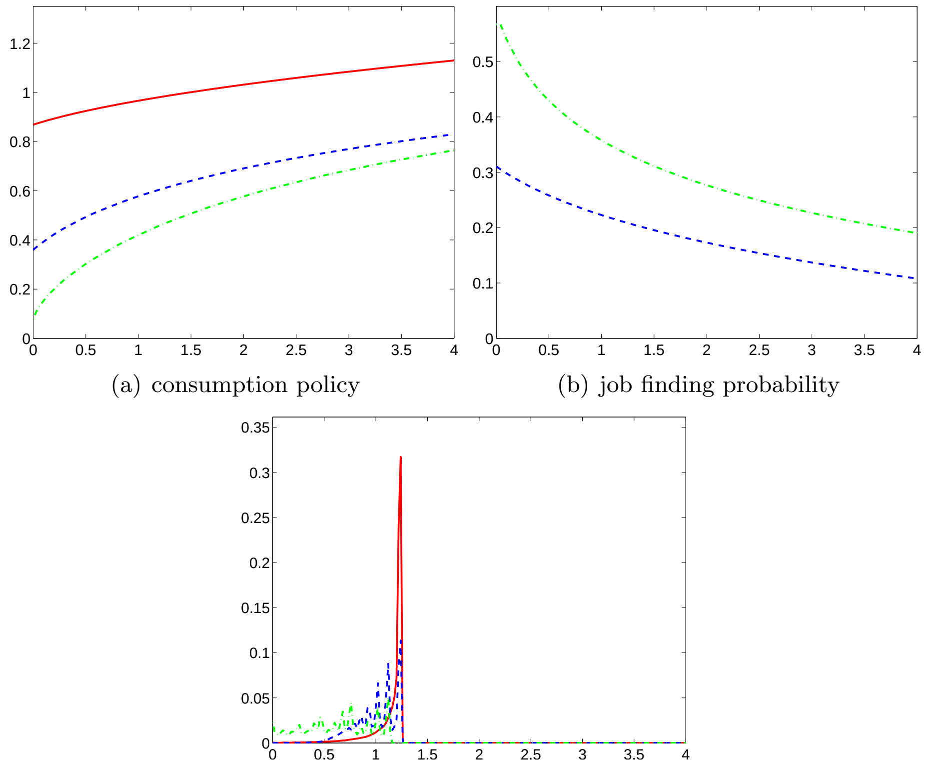
We restrict attention to recursive policy functions, so that finding the optimal policy function is equivalent to finding a fixed point to the first-order conditions. We start with an initial guess for policy functions $c(a, \theta)$ and $e(a, \theta)$ that we specify on an equally spaced grid of asset states and use linear interpolation in between. We use the first-order conditions to update the initial guess and iterate until convergence. We also update the value function in equation (4) during the updating procedure for the policy functions.

To derive the stationary distribution of the economy, we approximate a transition function on the same grid of asset states and use the eigenvector to the largest eigenvalue. Given a stationary distribution over asset and employment states, it is straightforward to compute the government budget. We use bisection on a grid of tax rates or benefit function parameters to achieve budget balance. For the transition in Section 4.1, we compute the steady state asset stocks of the benchmark economy and the economy with asset-dependent benefits, and add the transition costs to the government budget. Note that transition costs in this case are endogenous, but the bisection algorithm can still be applied. For the transition experiment described in Section 4.2, we start with an initial guess for policy parameters (possibly including an initial transfer) and iterate forward using the transition function until the steady state of the economy with asset-dependent benefits is reached. We use linear interpolation for the transition function, too. We check budget balance including the transition and update the government's policy parameters again using bisection until budget balance is reached. Note that policy functions are stationary throughout the transition, because they only depend on the individual states and the UI system, which is constant during the transition.

For the optimal choice of policy parameters, we apply grid search on a pre-specified grid of policy parameters. We compute the steady state for each parameter combination and choose the one that yields the highest welfare. In cases where we also consider the transition, we compare welfare at the onset of the transition.

E Figures

Figure 1: Benchmark economy (replacement rate 0.5)



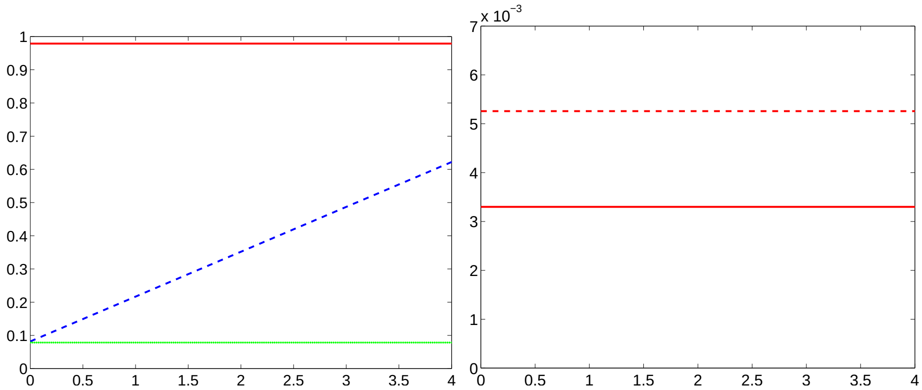
(a) consumption policy

(b) job finding probability

(c) asset distribution

Notes: The upper left panel shows the consumption policy as a function of assets. The upper right panel shows job finding rates as a function of assets. The lower panel displays the asset distribution. In all three plots the red solid line represents employed workers, the blue dashed line represents unemployed workers who receive UI benefits, and the green dashed dotted line represents unemployed workers who receive social assistance benefits.

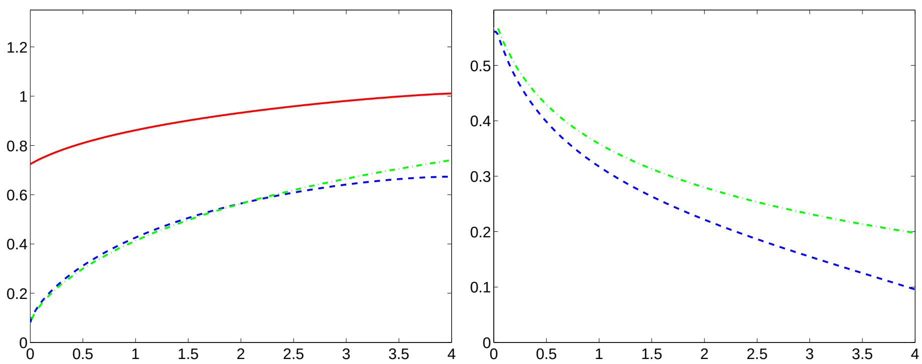
Figure 2: Optimal linear asset-dependent UI system



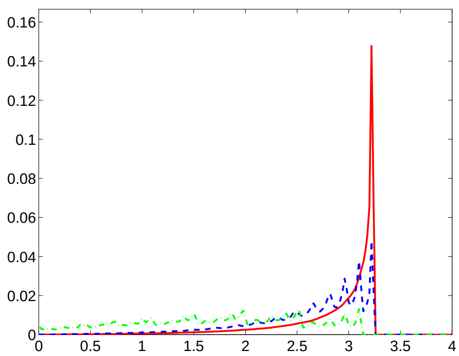
(a) UI benefits (b) rate of return on assets

Notes: The left panel shows the after-tax wage for the employed (red solid line), unemployment insurance benefits (blue dashed line), and social assistance benefits (green dashed dotted line). The right panel shows the technological interest rate (red solid line) and the implied total interest rate (red dashed line) for employed agents when taking the marginal effect of assets on unemployment benefits into account.

Figure 3: Optimal linear asset-dependent UI system



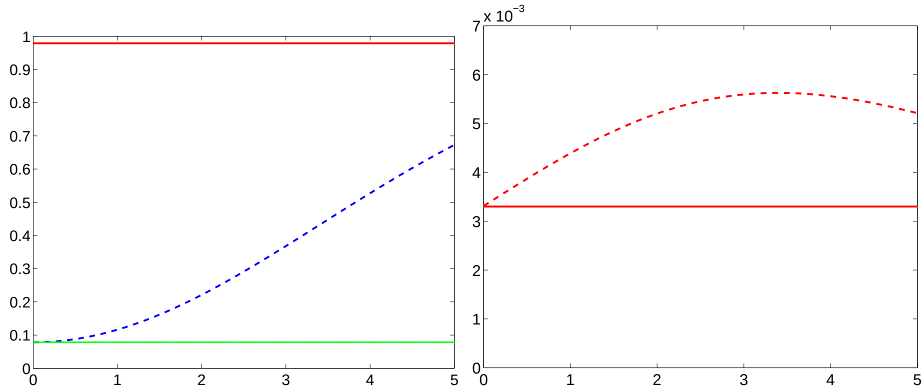
(a) consumption policy (b) job finding probability



(c) asset distribution

Notes: The upper left panel shows the consumption policy as a function of assets. The upper right panel shows job finding rates as a function of assets. The lower panel displays the asset distribution. In all three plots the red solid line represents employed workers, the blue dashed line represents unemployed workers who receive UI benefits, and the green dashed dotted line represents unemployed workers who receive social assistance benefits.

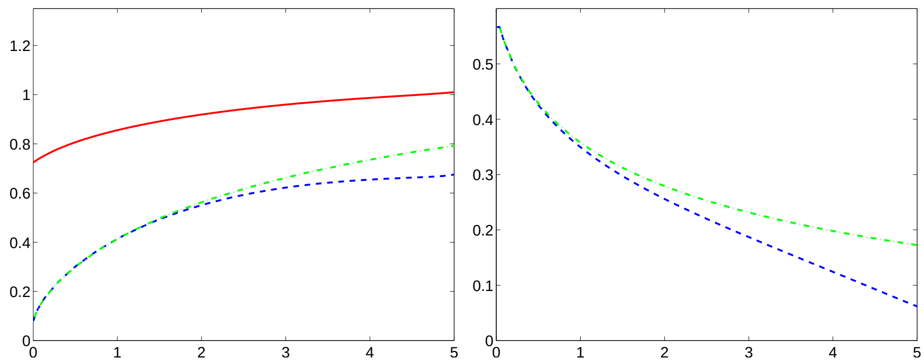
Figure 4: Optimal nonlinear asset-dependent UI system



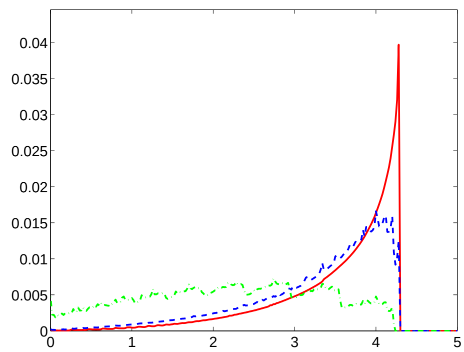
(a) UI benefits (b) effective rate of return on assets

Notes: The left panel shows the after-tax wage for the employed (red solid line), unemployment insurance benefits (blue dashed line), and social assistance benefits (green dashed dotted line). The right panel shows the technological interest rate (red solid line) and the implied total interest rate (red dashed line) for employed agents when taking the marginal effect of assets on unemployment benefits into account.

Figure 5: Optimal nonlinear asset-dependent UI system



(a) consumption policy (b) job finding probability



(c) asset distribution

Notes: The left panel shows the after-tax wage for the employed (red solid line), unemployment insurance benefits (blue dashed line), and social assistance benefits (green dashed dotted line). The right panel shows the technological interest rate (red solid line) and the effective interest rate (red dashed line) for employed agents in this economy.