Unemployment Insurance with Endogenous Search Intensity and Precautionary Saving[1,2]

James S. Costain
Universitat Pompeu Fabra

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Correspondence address:
Department of Economics and Business
Universitat Pompeu Fabra
Ramon Trias Fargas 25-27
08005 Barcelona, Spain
costain@upf.es

Abstract

A welfare analysis of unemployment insurance (UI) is performed in a general equilibrium job matching model. Risk averse workers choose consumption and saving, as well as search effort when unemployed; firms hire workers, purchase capital, and pay taxes to finance worker benefits. The model is calibrated to US data, including microeconomic studies of UI and unemployment spells.

The consumption smoothing benefits of UI are small, especially under logarithmic utility. Likewise, moral hazard is not very important. The most significant welfare effects of UI arise from decreased work disutility, and from search and investment externalities implied by the matching framework.

JEL classification: J65, J64, J22, E21

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[2]This paper comprises the core sections of my dissertation, Costain (1997a).

1 Introduction

This paper provides a quantitative welfare analysis of unemployment insurance (UI) for the United States economy. In spite of the obvious policy relevance of this issue, modelling difficulties have forced most previous studies to consider only the costs of UI, or only its benefits, rather than both simultaneously. There are three main strands to the previous literature. General equilibrium matching models, with linear utility, such as Millard and Mortensen (1994), have examined the costs of UI in terms of the hiring disincentives it creates. Moral hazard models, such as Hopenhayn and Nicolini (1997), have looked at the costs of UI in terms of the disincentive to job search that it imposes upon workers. Precautionary saving models, such as Hubbard, Skinner, and Zeldes (1995), have studied the consumption smoothing benefits of various social insurance schemes. The numerical framework used here will combine elements of all three literatures.

Our model is presented in section 2. Workers choose consumption and saving over the course of their finite lives, and also choose search effort when unemployed; hence the worker's problem contains aspects of both precautionary saving and moral hazard. The wage and the unemployment rate are endogenized by embedding workers and firms in a general equilibrium matching environment. The relationship between unemployment, hiring, and search effort is parameterized in section 3 for consistency with microeconomic studies of unemployment spells. In this context, UI may benefit workers by helping them smooth their consumption, but it also raises unemployment through its impact on the incentives of workers and firms. A welfare calculation must furthermore consider the disutility of search and work, and will be affected by the presence of external effects in search and in capital accumulation.

The numerical results, which appear in the fourth section of the paper, often show significant welfare gains from UI provision, but mostly reveal only very small gains from consumption smoothing *per se*. In our more risk averse simulations, nontrivial consumption smoothing benefits are observed, but with logarithmic utility only the average level of consumption, and not its riskiness, appears to be significant for workers' well-being. Other effects of UI usually play a more important role in the net welfare outcome than does consumption smoothing itself. Decreases in the disutility of work are always a quantitatively important part of the welfare impact of UI. Also, the matching framework used in this paper implies strong externalities between the search and savings of workers and the hiring and investment of firms; we find that the effects of UI on these intertwined incentives has much more significant welfare implications than does its insurance role. The minor scope for consumption smoothing in our model is attributable to the high degree of self insurance occurring in equilibrium; this is true even in a variant of the model where relatively impatient consumers hold small buffer stocks of assets.

The main contribution of this paper its incorporation of endogenous search intensity into a UI model with precautionary saving, whereas comparable recent papers have mostly focused on the tradeoff between consumption smoothing and tax distortions on hiring. By thus introducing an element of moral hazard, we can consider what is probably the primary policy concern expressed about UI programs. We undertake a careful calibration exercise, identifying the parameters related to unobservable search intensity from the literature on the effects of policy experiments on labor market outcomes. The model matches both labor market behavior and median asset holdings of US workers quite well, but we also learn some lessons about our modelling strategy. As has often been noted (Aiyagari 1994), standard precautionary saving models lead to a perhaps unrealistically high degree of self insurance in equilibrium. Also, standard matching models imply powerful responses of hiring and job formation to public policy changes which may be difficult to reconcile with the relatively inelastic responses observed in practice.

1.1 Relation to the literature

A large empirical literature shows that public provision of UI tends to increase unemployment. Meyer (1990) nonparametrically estimates job finding rates and shows significant negative effects of the replacement ratio (the ratio of the UI benefit to the wage) on job finding; Atkinson and Micklewright (1991) find similar but smaller effects. Meyer also demonstrates that job finding increases as a worker's period of UI eligibility runs out, with a clear spike at the end of eligibility. Feldstein (1978) and Anderson and Meyer (1994) measure the role of imperfectly experience-rated UI as a subsidy to temporary layoffs. A number of papers analyze policy changes and controlled experiments, such as Meyer (1995), who reviews experimental programs paying a bonus to those finding jobs quickly, and Solon (1985), who studies the effect of imposing income taxes on UI benefits. Papers attempting to quantify the benefits of UI include Dynarski and Sheffrin (1987), Hamermesh and Slesnick (1995), and

Gruber (1997). Gruber finds that unemployment causes a significant drop in consumption, and that higher UI replacement ratios cushion this drop. Ehrenberg and Oaxaca (1976) are one of the few studies to show that UI may also help workers find higher-wage jobs.

The theoretical literature on UI has been concentrated in three main areas—the theories of job matching, moral hazard, and precautionary saving. In job matching models, the rate of formation of new worker-firm pairs is a function of the levels of vacancies and unemployment, or more generally, the levels of recruitment activity by firms and job search activity by workers; basic references are Mortensen (1986) and Pissarides (1990). In this framework, Millard and Mortensen (1994) analyze the impact of UI policy on the US and UK unemployment rates. Sargent and Ljungqvist (1998) and Coles and Masters (1999) show that UI can lead to high, persistent unemployment if human capital depreciates during unemployment, while Acemoglu (1997) and Marimon and Zilibotti (1999) emphasize that UI may help workers find better jobs. A recent empirical study of matching is Yashiv (1997), who uses generalized method of moments estimation to fit both firm and worker matching behavior for the Israeli economy.

Much of the focus of these general equilibrium matching papers is on how government labor market policies affect firms' willingness to hire workers. But UI also affects the unemployment rate through workers' incentives to find jobs. Since search is most likely unobservable, the effects of UI on search activity are often modeled in a moral hazard framework, as in Hansen and Imrohoroglu (1992), where workers decide whether or not to accept randomly arriving job offers. In their economy, unemployed workers have a positive probability of receiving UI payments even if they reject a job offer, so a rise in UI makes workers less willing to accept jobs. An alternative formulation of moral hazard is adopted here, as in Pissarides (1990), Hopenhayn and Nicolini (1997), Davidson and Woodbury (1997), and Fredriksson and Holmlund (1998). Here, a worker always prefers to accept a job once she finds one, but the probability of finding a job is a function of unobservable search effort, and workers will choose to exert less search effort when UI benefits increase.

Paradoxically, most of the literature studying the effects of UI on unemployment is incapable of addressing the intended benefits of UI, because utility has usually been assumed linear, for the sake of analytical tractability.[1,2] With linear utility, consumers care only about the expected present discounted value of consumption, not its time path or variability, so fair insurance is useless. When utility is concave, consumers prefer insurance, but even here the scope for a welfare improvement from publicly provided UI may be limited by the availability of other methods for smoothing consumption. Thus the precautionary saving literature examines the effectiveness of self-insurance through asset accumulation. Kimball (1990) discusses the mathematics underlying the precautionary saving motive, and numerical simulations of precautionary saving behavior are performed by Zeldes (1989), Deaton (1991), Aiyagari (1994),

[1]With linear utility, since the time path of consumption is irrelevant for utility, we can without loss of generality assume that all income is consumed immediately. Thus workers remain effectively identical regardless of their past labor market histories. By contrast, with concave utility, behavior will depend on asset holdings, and we must therefore keep track of the distribution of asset holdings as we calculate equilibrium.

[2]Alternatively, some studies have assumed workers have no access to credit markets, so that no distribution of assets can arise, even under concave utility.

and Carroll (1997). A number of authors have also studied the response of consumption and saving to the provision of various types of social insurance. Engen and Gruber (1995) and Heer (1998) evaluate the effects of UI on asset holdings. Hubbard, Skinner, and Zeldes (1995) show that means-tested social benefit programs can help account for low asset holdings of the poor. Rendón (1996) studies relations between assets, unemployment, and wages.

Recently, some authors have attempted to combine general equilibrium UI with concave utility. An early paper is the two-period model of Baily (1978). Costain (1995) and Hassler and Rodriguez Mora (1997) have solved general equilibrium UI models for the special case of exponential utility and fixed search intensity, while Acemoglu and Shimer (1999a) consider moral hazard in an exponential utility model. Beyond these, all papers have relied on numerically intensive simulation methods. Hansen and Imrohoroglu (1992), mentioned above, allow for precautionary savings in a model with an exogenous probability of receiving a job offer. Valdivia (1995) numerically solves a general equilibrium job search model of UI with precautionary savings and fixed search intensity. Alvarez and Veracierto (1996) analyze the effects of mandated severance payments in a model with both moral hazard and precautionary saving. The most closely related study is Acemoglu and Shimer (1999b), who simulate a partial equilibrium model with ingredients similar to those of this paper. Like Zhang (1996), they also argue that the increase in job quality implied by higher UI may be quantitatively important.

2 The model and algorithm

We begin with summary of the model. Workers live for a fixed, finite number of periods, and have a constant relative risk aversion (CRRA) utility function over consumption. With CRRA utility, workers are risk averse (that is, greater insurance increases their expected utility) and prudent (that is, they will choose to accumulate assets to protect themselves against future risks). The combination of risk aversion and prudence means that although workers prefer a fair increase in UI, *ceteris paribus*, part of the effect of UI is simply to crowd out self insurance. Precautionary asset accumulation also complicates the solution of the model since agents will achieve different wealth levels depending on their labor market luck, and will then behave differently depending on their wealth levels. For the sake of realism in our asset distribution, we will assume that workers are retired over the last periods of their lives, during which time they receive a fixed social security payment.

Effort also affects workers' utility; we assume that workers experience a fixed level of disutility from work effort when employed, and a variable level of disutility from their choice of job search effort when unemployed. Note that our welfare analysis of UI must take account of its impact on the disutility of effort, and not only its effects on utility from consumption. We assume search effort is unobservable, which means that UI causes a moral hazard problem by decreasing workers' willingness to exert effort in search. We will ignore the possibility of quitting a job to collect UI benefits, which amounts to assuming that quits can be distinguished from layoffs; more generally, it should be noted that this paper focuses on the effects of UI on job formation, neglecting those on job separation.

There are also firms in our economy, which hire workers, purchase capital, and must pay taxes to finance worker benefits; their (riskless) equity is the asset accumulated by workers. Increased UI will make firms less willing to hire workers and purchase capital because it requires higher taxes; their labor and capital choices will also be affected by the interest rate. Together, workers' and firms' search and hiring activities will determine the unemployment rate through a matching technology. Likewise, the interest rate will be determined in general equilibrium by workers' demand for assets and the supply of assets in the form of firm equity.

In this context, we will study the welfare impact of a UI program which pays benefits over the first two periods of any unemployment spell, cutting off payments thereafter. It is financed by a tax on firms, levied on the basis of a fixed payment per employee. We will consider how steady state average utility in the economy changes with the level of UI benefits.

2.1 The worker's problem

For computational reasons, the worker's situation will be described as a discrete time, discrete choice problem. However, this is intended as an approximation to a continuous problem featuring the instantaneous utility function

$$\frac{1}{\alpha}c^{\alpha} - D^{S}s - D^{W}\mathbf{1}_{\{\epsilon=1\}}$$

over consumption c and search effort s. Here $\alpha \leq 1$, $D^S \geq 0$, $D^W \geq 0$, and $\mathbf{1}_{\{\epsilon=1\}}$ is an index function which equals one when the individual is employed and zero otherwise. The individual has a finite, deterministic lifetime, with a working life of T periods followed by T^R periods of retirement, and utility discount rate $\rho > 0$. The transition from employment to unemployment arrives with fixed probability δ per unit of time; the transition back to employment occurs with variable probability πs^Z per unit of time. The worker faces wage w, interest rate r, social security benefit b^R, and an unemployment benefit b^U which is paid for the first two periods of any unemployment spell.

For the discrete model used in this paper, assume that lifetime utility is defined over an integer number of time steps $T + T^R$; in the first T steps, the worker is in the labor force, while during the last T^R steps, she is retired. A new generation of $I/(T+T^R)$ workers is born at each integer time, so the total population is always I. The number of individuals of working age is $I^W \equiv IT/(T+T^R)$. The generation which works in periods t to $t+T-1$ and is retired in periods $t+T$ to $t+T+T^R-1$ will be called generation t.

A worker chooses consumption at each time; during periods of unemployment in her working life, she also chooses search intensity. Consumption c, search effort s, and beginning-of-period asset holdings a (prior to current labor income and expenditures) each must lie in an appropriate finite set:

$$c \in \mathcal{C} \equiv \{0,\ \chi,\ 2\chi,\ \ldots,\ c_{max}\}$$

$$s \in \mathcal{S} \equiv \{0,\ \exp(\sigma_{min}), \exp(\sigma_{min}+\sigma),\ \ldots,\ \exp(\sigma_{max})\}$$

$$a \in \mathcal{A} \equiv \{-a_{min},\ -a_{min}+\chi,\ \ldots,\ 0,\ \ldots,\ a_{max}-\chi,\ a_{max}\}$$

where χ, σ, σ_{min}, σ_{max}, c_{max}, a_{min}, and a_{max} are all positive constants.[3,4] Likewise, the worker's employment state ϵ takes one of five discrete values. We write $\epsilon = 1$ if the worker is employed. The first and second periods of an unemployment spell are given by $\epsilon = 2$ and $\epsilon = 3$, respectively; $\epsilon = 4$ refers to the third and later periods of an unemployment spell, when the worker becomes ineligible for UI. Finally, $\epsilon = 5$ denotes retirement.

We will only consider the economy in an aggregate steady state, so it suffices to write policy functions without mention of aggregate variables. Consumption and search can be written as $c_g(a, \epsilon, t)$ and $s_g(a, \epsilon, t)$ for a member of generation g at time $g \leq t < g+T+T^R$ with beginning-of-period assets a and employment status ϵ. Consumption behavior $c_g(.,.,.)$ will determine the worker's transition from one level of assets to another, given income. Sources of income are the wage w and the unemployment and social security benefits b^U and b^R, as well as interest on assets earned at rate r. End-of-period asset holdings are thus

$$\tilde{a}_g(a, \epsilon, t) \;\equiv\; a \;+\; w\mathbf{1}_{\{\epsilon=1\}} \;+\; b^U\mathbf{1}_{\{\epsilon=2\vee\epsilon=3\}} \;+\; b^R\mathbf{1}_{\{\epsilon=5\}} \;-\; c_g(a, \epsilon, t)$$

and expected assets next period are $R\tilde{a}_g(a, \epsilon, t)$, where $R \equiv \exp(r)$. We make small, random adjustments to the asset accumulation process to ensure that assets remain constrained to the grid set $\mathcal{A}$.[5]

[3] In the last period of life the worker consumes all her remaining endowment, which need not be an integral multiple of χ.

[4] We make use of the constant step size of consumption χ in speeding up calculation; by contrast, there is no computational disadvantage in allowing exponential levels of s.

[5] Suppose assets at the end of period t are $\tilde{a}_t$, so that expected asset holdings at the beginning of period $t+1$ are $R\tilde{a}_t$. Define $(R\tilde{a}_t)^-$ and $(R\tilde{a}_t)^+$ to be the elements of set $\mathcal{A}$ which bound $R\tilde{a}_t$ from below and from above, respectively. We require that realized asset

Search behavior $s_g(.,.,.)$ affects the transition between the unemployed and employed states during the first T periods of life. Job loss is assumed exogenous; a currently employed person of age $T-1$ or less becomes unemployed in the next period with probability $1-\exp(-\delta)$, and otherwise remains employed. An unemployed person of age $T-1$ or less becomes employed in the next period with probability $1-\exp(-\pi s^Z)$ if she chooses search intensity s; otherwise she remains unemployed. Here $Z \in [0,1]$ is an exogenous constant; π is an endogenous coefficient which is related in equilibrium to unemployment and to firms' recruitment behavior.[6]

Table 1 gives a complete statement of the problem of a worker of generation 0. The tiny constant $\underline{\chi}$ is added to consumption to ensure that utility is finite even when consumption is zero. Note that welfare comparisons under extremely low levels of UI are somewhat suspect, as they are sensitive to the value of $\underline{\chi}$; therefore in this paper we will instead focus on utility comparisons between different non-trivial levels of UI. The variable p_o is the probability of beginning life employed; we will see below that it is convenient in our framework to allow this to be a positive number.

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holdings a_{t+1} at the start of period $t+1$ take the following values:

$$a_{t+1} = \begin{cases} (R\tilde{a}_t)^- & \text{with probability} \quad \chi^{-1}\left((R\tilde{a}_t)^+ - R\tilde{a}_t\right) \\ (R\tilde{a}_t)^+ & \text{with probability} \quad \chi^{-1}\left(R\tilde{a}_t - (R\tilde{a}_t)^-\right) \end{cases}$$

[6] Instead of the Poisson arrival rate πs^Z per unit time assumed in the continuous time problem, we specify the job finding probability as $1-\exp(-\pi s^Z)$ to ensure that the probability of finding a job within a period is bounded between zero and one. We ignore the possibility of multiple job offers in the discrete time interval.

Table 1: The worker's problem

$$\max_{\substack{c_0(.,.,.) \in \mathcal{C} \\ s_0(.,.,.) \in \mathcal{S}}} \quad E_0 \sum_{0 \le t < T+T^R} e^{-\rho t} \left[\frac{1}{\alpha} (c_0(a_t, \epsilon_t, t) + \underline{\chi})^{\alpha} \; - \; D^S s_0(a_t, \epsilon_t, t) \; - \; D^W \mathbf{1}_{\{\epsilon=1\}} \right]$$

subject to the asset transition equations:

$$c_0(a_t, \epsilon_t, t) \; + \; \tilde{a}_t \;\; = \;\; a_t \; + \; w \mathbf{1}_{\{\epsilon=1\}} \; + \; b^U \mathbf{1}_{\{\epsilon=2 \vee \epsilon=3\}} \; + \; b^R \mathbf{1}_{\{\epsilon=5\}} \qquad \forall a_t, \epsilon_t, t$$

$$\text{and} \quad a_{t+1} = \begin{cases} (R\tilde{a}_t)^- & \text{with prob.} \quad \chi^{-1} \left((R\tilde{a}_t)^+ - R\tilde{a}_t \right) \\ (R\tilde{a}_t)^+ & \text{with prob.} \quad \chi^{-1} \left(R\tilde{a}_t - (R\tilde{a}_t)^- \right) \end{cases}$$

$$\text{where} \quad a_0 = 0 \;\; \text{and} \;\; a_{T+T^R} \ge 0 \;\; \text{for all histories.}$$

Also subject to the employment transition equations:

$$\mathrm{pr}(\epsilon_0 = 1) \; = \; p_0; \qquad \epsilon_t \; = \; 5 \text{ for } t \ge T$$

and for $t \in \{0, 1, 2, ..., T-2\}$:

$$\text{probability of unemployment at } t+1 \text{ if employed at } t \;\; = \;\; 1 \; - \; \exp(-\delta)$$

$$\text{probability of employment at } t+1 \text{ if unemployed at } t \;\; = \;\; 1 \; - \; \exp\left(-\pi s_0(a_t, \epsilon_t, t)^Z \right)$$

2.2 The firm's problem

Firms act in the interest of their shareholders by maximizing the present value of profits. They hire labor and purchase capital, and the net revenue above their costs is paid out as dividends to shareholders. Like workers, firms are active in a discrete set of times, but unlike workers, firms are infinitely lived, and they face no uncertainty, because we assume they are large enough to treat the arrival of workers as a continuous, deterministic process.[7]

Since we only intend to study aggregate steady states, we again write value functions and aggregate variables without time subscripts. A firm's individual state variables are its stocks of capital and employment, k_t and n_t, and its production function for gross output[8] is $A{n_t}^{\gamma}{k_t}^{1-\gamma}$. Firms adjust their stocks of capital and labor by expenditure on investment i_t and hiring h_t. New employees arrive at rate qh_t, where q is an endogenous coefficient which depends on aggregate search effort and hiring. The fraction of capital remaining after one period's depreciation is $\exp(-\delta_k)$, and likewise the fraction of workers still employed at the firm after a period is $\exp(-\delta)$.

In choosing hiring, the firm takes as given the wage w; wage determination is discussed below. It must also pay a tax τ per employee which is used to finance UI and social security benefits. Hence we can state the firm's problem

[7] Given the constant returns to scale production function we will impose, it would be equivalent to assume that each "firm" consists of only one vacancy each, and that capital is purchased only after a worker is hired, which are common assumptions in the general equilibrium matching literature. For a demonstration of the equivalence of one-on-one matching with a world of constant returns to scale firms, see Pissarides (1990), Ch. 2.

[8] By "gross" we mean including hiring expenditure.

in terms of its value function $V(n_t, k_t)$ as:

$$V(n_t, k_t) \quad = \quad \underset{h_t, i_t}{\text{Max}} \left\{ A{n_t}^{\gamma}{k_t}^{1-\gamma} - wn_t - \tau n_t - h_t - i_t + \frac{1}{R} V(n_{t+1}, k_{t+1}) \right\}$$

$$\text{s.t.} \quad n_{t+1} \ = \ qh_t \ + \ \exp(-\delta) n_t$$

$$\text{and} \quad k_{t+1} \ = \ i_t \ + \ \exp(-\delta_k) k_t$$

This problem yields the following pair of Euler equations:

$$R - \exp(-\delta_k) \quad = \quad A(1-\gamma)(n_t/k_t)^{\gamma} \tag{1}$$

$$R - \exp(-\delta) \quad = \quad q\left(A\gamma(k_t/n_t)^{1-\gamma} \ - \ w \ - \ \tau\right) \tag{2}$$

Note that the Euler equations determine only the ratio n/k, rather than the levels of n and k independently; this follows from our assumption of constant returns to scale in production, hiring, and investment (as is standard in the matching literature) and implies that the size and number of firms is indeterminate. From here on, therefore, we will use the notation n, k, h, and i to refer to the aggregate levels of employment, capital, hiring, and investment, which are well-determined in general equilibrium.

2.3 Wage determination.

Since this is a matching model, where the formation of a worker-firm relationship requires a prior expenditure of time and effort, there is a non-trivial gain in welfare, called the match surplus, accruing to a pair when they meet. In simple competitive models of labor markets, a worker or firm can walk away from any given wage offer to immediately find the market wage, which implies that there is no gain associated with being currently matched and that both sides of the relation are forced to act as price takers. By contrast, in a search model, the surplus must be divided on the basis of bilateral bargaining. In this paper, we will impose a model of bargaining which is justified on the basis of an extensive form alternating offers game by Wolinsky (1987), who shows that it is the most appropriate bargaining solution for a search model with endogenous search intensity.[9]

Our wage bargaining solution is most easily explained as follows. The surplus for a given period is defined to be the difference in the sum of the payoffs of the worker and the firm depending on whether or not work occurs that period; that is, the threat points of the worker and the firm are those associated with a strike.[10] The wage is derived by assuming that fixed fractions of this surplus accrue to the worker and the firm, which also arises as a subgame perfect equilibrium of an alternating offers game played at the start of each period to determine that period's wage.

If work occurs, the marginal product $A\gamma(k/n)^{1-\gamma}$ is produced, and the worker experiences disutility $D^W / (c^{\alpha-1})$, where we have deflated by the worker's

[9] A bargaining solution of this type was first used by Shaked and Sutton (1984).

[10] The more common bargaining solution imposed in the search literature defines the surplus intertemporally as the difference in the sum of the value functions of the worker and the firm between the matched and unmatched states; that is, the threat points are those associated with separation. As shown by Wolinsky (1987), such a solution cannot be derived as a subgame perfect equilibrium of an alternating offers game when search intensity is endogenous. This is because it is never a credible threat to separate from a match with positive surplus, unless one has already obtained an offer to enter into an alternative match. Nor is it a credible threat to incur the disutility costs of searching for such an alternative match when, on the equilibrium path, both parties expect an acceptable wage offer to be made immediately. Costain (1996) also discusses this result, and shows that it can arise either from a single alternating offers game played at the beginning of the match, or from playing a new alternating offers game at the start of each period.

marginal utility of consumption to express the disutility in units comparable to the output of the firm. We will assume that the firm's tax bill is unaffected by a strike; hence the tax rate does not enter into the calculation of the surplus associated with work relative to a strike. The worker's gain from working is her pay minus her disutility. Thus, if the worker's bargaining share is β, Nash bargaining implies:

$$w \; - \; D^W c^{1-\alpha} \;\; = \;\; \beta \left(A\gamma(k/n)^{1-\gamma} \; - \; D^W c^{1-\alpha} \right) \tag{3}$$

Equivalently, we obtain the simple wage equation:

$$w \;\; = \;\; \beta A\gamma(k/n)^{1-\gamma} \; + \; (1-\beta) D^W c^{1-\alpha} \tag{4}$$

which shows that the wage is a weighted average of the marginal product of labor and the disutility of work.

This wage is taken as given in the decision problems of the worker and the firm. No strikes occur in equilibrium, even though it is the threat of a strike that underlies this wage. Unfortunately, note that this bargaining solution should in fact be a function of the asset holdings of the worker, since chosen consumption, and hence marginal utility, will vary with assets. Like Valdivia (1995), we simplify by calculating the wage from (4) relative to average consumption in the economy. See Costain (1998) for an exploration of several simple variations of this wage equation; apparently subtle specification changes can have an important impact on the equilibrium.

2.4 Aggregate consistency conditions

The only role of the government in this economy is to choose the levels of expenditure on UI and social security. We require that the government follow a balanced budget, that is,

$$n\tau \;=\; I^W u^{UI} b^U \;+\; (I - I^W) b^R \tag{5}$$

The variable u^{UI} is the fraction of workers who are currently in the first or second period of an unemployment spell, and therefore eligible for UI benefits.

To state market clearing conditions for this economy, let the measure $\phi_g(a, \epsilon, t)$ be the number of workers of generation g with assets a and employment status ϵ at time t. These frequencies must sum to the total population:[11]

$$\sum_{a,\epsilon,g} \phi_g(a, \epsilon, t) \;=\; I \tag{6}$$

The goods market clearing condition can thus be written as follows:

$$y - i \;\equiv\; An^{\gamma} k^{1-\gamma} - h - i \;=\; \sum_{a,\epsilon,g} c_g(a, \epsilon, t)\phi_g(a, \epsilon, t) \;\equiv\; I\bar{c} \tag{7}$$

We will use the notation $\bar{c}$ for average consumption and y for value added.

In the firm's problem, we assumed capital goods are held by firms, rather than individuals. The natural asset to be held by individuals, then, is the equity of the firms. Asset market consistency requires that total interest earnings by workers on end-of-period asset holdings equal total dividend payments d by firms. We can write this as

$$(R-1)\sum_{a,\epsilon,g} \tilde{a}_g(a, \epsilon, t)\phi_g(a, \epsilon, t) \;=\; d \;\equiv\; y - wn - \tau n - i \tag{8}$$

[11] The summation is over $a \in \mathcal{A}$, $\epsilon \in \{1, 2, 3, 4, 5\}$, and over the set of g alive at t, but we suppress this notation.

The rate of UI-eligible unemployment in our economy is

$$u^{UI} \equiv \sum_{a,\epsilon,g} \mathbf{1}_{\epsilon\in\{2,3\}}\phi_g(a,\epsilon,t) \tag{9}$$

and total unemployment is

$$u^{TOT} \equiv \sum_{a,\epsilon,g} \mathbf{1}_{\epsilon\in\{2,3,4\}}\phi_g(a,\epsilon,t) \tag{10}$$

Equality of labor market stocks requires that

$$I^W(1-u^{TOT}) = n \tag{11}$$

Separation flows are almost immediately consistent since both workers and firms become unmatched at rate $(1-\exp(-\delta))$. The only complication is that we must assume that fraction $\exp(-\delta)$ of the jobs held by retiring workers at time t are inherited by newborn workers at $t+1$; this ensures that firms can choose hiring without considering the age distribution of their workforce.[12]

To ensure consistency of matching flows, we define the matching rate coefficients as follows:

$$\pi \equiv \mu h^{\xi}\left(I^W u^{TOT}\right)^{-\xi} \tag{12}$$

$$q \equiv \frac{1}{h}\sum_{a,\epsilon,g}\phi_g(a,\epsilon,t)(1-\exp(-\pi s_g(a,\epsilon,t)^Z)) \tag{13}$$

The exogenous parameters here satisfy $\mu > 0$ and $\xi \in (0,1)$. With these definitions, total matches formed per period are equal to

$$qh = \sum_{a,\epsilon,g}\phi_g(a,\epsilon,t)(1-\exp(-\pi s_g(a,\epsilon,t)^Z)) \tag{14}$$

[12]This is why we allow a positive probability p_0 of being born employed. Note that for simplicity we also assume inheritance of UI benefit eligibility.

Note that if all workers pick the same level of search effort $\bar{s}$, and if $\pi \bar{s}^Z$ is small, then this matching function can be written approximately as an increasing, concave function of firms' hiring, of the number of unemployed, and of their search activity:

$$\sum_{a,\epsilon,g} \phi_g(a,\epsilon,t)(1-\exp(-\pi_t s_g(a,\epsilon,t)^Z)) \approx \mu h^\xi (I^W u^{TOT})^{1-\xi} \bar{s}_t^Z$$

which may look more similar to the matching functions used in the continuous time frameworks of the general equilibrium matching literature. Finally, note that a steady state solution to the worker's problem will automatically impose the following aggregate consistency condition:

$$qh = (1-\exp(-\delta))n \tag{15}$$

2.5 Solution algorithm

Given our choice of a constant relative risk aversion utility function, our model has no analytical solution. In fact, to calculate an equilibrium we must find a fixed point of the dynamics of the distribution of assets and employment across workers. Such a calculation is generally very complicated since a distribution is a high-dimensional object. However, for this economy, calculating a steady state equilibrium can be reduced to a fixed point problem in three numbers: the interest factor R, the matching rate coefficient π, and the wage w. Table 2 outlines the algorithm.

We assume that the government exogenously specifies benefit levels b^U and b^R. We guess preliminary values for R, π, and w. These five numbers suffice for us to solve the individual's problem by backwards induction from the last

Table 2: The algorithm

0. Pick policy parameters b^U, b^R.

1. Make initial guesses of R, π, and w.

2. Given R, π, w, b^U, and b^R, solve the individual's problem by backwards induction.

3. From the worker's policy functions, calculate the steady state distribution of asset holdings and employment status by age.

4. From workers' steady state behavior, calculate n, u^{TOT}, u^{UI}, τ, and average consumption $\bar{c}$.

5. Use the firm's Euler equations and laws of motion (16)-(19), to calculate k, q, h, and i.

6. Calculate new values for R, π, and w from equations (20), (21), and (22).

7. If guessed and predicted values of R, π, and w are sufficiently close, equilibrium has been found. If not, return to step 2.

period of life. The policy function at each age defines probabilities of transition from each state (a, ϵ) at age t to possible states at age $t+1$. We can use these transition probability matrices to calculate the overall distribution $\phi_g(a, \epsilon, t)$ of assets and employment by age.[13]

Given the solution to the worker's problem, we can calculate average consumption, and then using equations (9), (10), and (11), the labor market variables u^{UI}, u^{TOT}, and n. The government's budget constraint (5) determines the tax rate τ required to finance the chosen benefit levels.

[13] Note that the sequence of transition matrices from age 1 to age 2, age 2 to age 3, etc., can be multiplied to define an overall employment transition matrix from age 1 to retirement. It is the eigenvector (with eigenvalue one) of this matrix that is used to calculate the probability p_0 of being born employed.

We now impose the steady state implications of the firm's problem:

$$R - \exp(-\delta) \;=\; A(1-\gamma)(n/k)^{\gamma} \tag{16}$$

$$R - \exp(-\delta_k) \;=\; q\left(A\gamma(k/n)^{1-\gamma} \;-\; w \;-\; \tau\right) \tag{17}$$

$$qh \;=\; n\,(1 - \exp(-\delta)) \tag{18}$$

$$i \;=\; k\,(1 - \exp(-\delta_k)) \tag{19}$$

Since we already know R and n, equation (16) gives us k. (17) then determines q, while the last two equations determine h and i.

Finally we have sufficient information to check whether we have reached an equilibrium by calculating new values for R, π, and w:

$$R \;=\; 1 \;+\; \frac{(An^{\gamma}k^{1-\gamma} - wn - \tau n - i - h)}{\sum_{a,\epsilon,g} \tilde{a}_g(a,\epsilon,t)\phi_g(a,\epsilon,t)} \tag{20}$$

$$\pi \;=\; \mu h^{\xi}(I^W u^{TOT})^{-\xi} \tag{21}$$

$$w \;=\; \beta A\gamma(k/n)^{1-\gamma} \;+\; (1-\beta)D^W\left(\bar{c} + \bar{\chi}\right)^{1-\alpha} \tag{22}$$

These three equations merely repeat the asset market clearing condition (8), the definition of π (12), and the wage equation (4). A fixed point for R, π, and w under this algorithm is a steady state equilibrium of the economy. Twenty to thirty iterations of the loop stated in Table 2 typically suffice, depending on the accuracy of the initial guess; Newton's method is used to speed final convergence. This process takes two or three hours on a Pentium 200 PC. Note that the simulations reported below are typically accurate to four to five significant figures, which suffices for clear welfare calculations.

3 Parameterization

We will discuss the parameterization in detail since some of our key parameters do not appear often in the macroeconomic literature. The parameterization, summarized in Table 5 of the appendix, proceeds in two stages. First, many parameters can be chosen without actually solving the worker's problem, including the technological parameters, the preference parameters α, ρ, and β, and the disutility of work D^W, which can be identified from the wage equation. Second, the crucial search parameters D^S and Z can only be fitted by solving the worker's dynamic programming problem. These are identified by attempting to match microeconomic evidence on the effects of UI on workers' rates of job finding.

3.1 First parameters

The following units must be chosen for our model: those of population, time, goods, and search effort. We state all quantities in per capita terms, defining the population as $I = 1$. We set the time unit equal to a quarter, and thus choose $T = 180$ and $T^R = 60$, a working life of 45 years followed by 15 years of retirement. Our normalization of the goods unit will occur below when we pick the technological parameters; rather than fixing one specific parameter, we will choose technological parameters to target an equilibrium level of per capita value added approximately equal to one. Similarly, our choice of the units of search intensity will be made below to target an equilibrium level of average search intensity approximately equal to one.[14] Next, given that value added is roughly one, we will impose a baseline benefit level of $b^U = b^R = 0.33$; we will see below that this implies a realistic UI replacement ratio.

We will set the capital depreciation rate at $\delta_k \equiv 0.025$, or approximately 10% per annum, a standard macroeconomic calibration. Our calibration of the job separation rate δ is complicated by the fact that our model of ex ante homogeneous workers is intended to represent the very heterogeneous U.S. economy. Measurements of monthly transition probabilities from unemployment to employment, for white males in the US, include 0.0086 in Marston (1976) and 0.015 in Ehrenberg and Smith (1994). Roughly on the basis of these numbers, we pick $\delta \equiv 0.04$ at quarterly rates. However, the flow rates for the young and for non-whites are substantially higher.[15] Such diversity makes it impossible to calibrate a model to the job loss and job finding rates of the median US worker and still obtain an unemployment rate as high as that in the the US.[16]

[14] Table 5 also describes the parameters relating to discretization. The minimum step size for consumption and assets is 1/12, roughly one twelfth of quarterly per capita value added, given our normalization of the goods unit. The dynamic programming problem considers 425 levels of assets, 41 levels of consumption, and 17 levels of search intensity. The minimum level of asset holdings is a debt of roughly two quarters' average income; this imposes a binding, and presumably realistic, borrowing constraint in equilibrium on a small fraction of young workers.

[15] Note also that we are ignoring the fact that a large fraction of labor market transitions are to and from a third state, "out of the labor force".

[16] Given our job loss rate of 0.04 (rather high for the median worker), the average job finding rate will be roughly 50% per quarter in our baseline equilibrium. Valdivia (1995), on the other hand, chooses a job loss rate of 0.015 per quarter and thus, to obtain an unemployment rate like that of the US, fits a much lower job finding rate of 0.21 (rather low for the typical US worker.) Either calibration represents a compromise, since neither allows for multiple types of workers.

We proceed to show that the parameters of the production function, A and γ, can be identified by attempting to match a number of aggregate variables, taking into account our normalization of the goods variable. We will target an interest rate of 1.5% per quarter, an unemployment rate at $u = 0.06$ (we suppress the distinction between u^{UI} and u^{TOT} for now), labor's share of income equal to 0.65, and an investment rate of $i = 0.2$, which implies average consumption $\bar{c} = 0.8$, and a capital stock of $k = i/(1-\exp(-\delta)) = 8.1$ quarters of value added.[17] Given $u = 0.06$, the employment level is $I^W(1-u) = 0.705$; our benefit level $b^U = b^R = 0.33$ then implies that the tax per worker is

$$\tau \ = \ (I^W ub^U + (1 - I^W)b^R)/n = 0.138$$

Since these tax payments are non-wage benefits, they should be included in labor's share of income, $(w+\tau)/y$. So our implied target value for the wage is

$$w \ = \ (\text{labor's share})y/n \ - \ \tau \ = \ 0.784$$

The replacement ratio, and likewise the ratio of social security benefits to the wage, is then $0.33/0.784 = 0.421$. This is reasonable, since Engen and Gruber (1995) calculate the replacement ratio at 44%.

We must also consider the fraction of output spent on hiring. Barron, Black, and Lowenstein (1989)estimate that approximately one month of labor time (partly time of the hiree, and partly time of pre-existing employees) is spent on a typical hire, including basic job training, in a mostly low-wage

[17]This is somewhat low relative to US data, but we will see later that a low estimate of capital is helpful to reconcile the firm's side of the model with the individual's side.

sample. If we assume that a typical job lasts five years (consistent with our δ), then this implies that 1/60 of the duration of a typical job is devoted to hiring activities. Valuing labor time in accordance with a labor share of 65%, this means that approximately 1% of GDP is spent on recruitment activity, so we will set a target of $h = 0.01$.[18]

The preceding information on the values of δ, δ_k, n, k, h, R, w, and τ now allows us to identify A and γ. Equation (23) below normalizes the goods unit by setting value added to one; (24) and (25) are the Euler equations from the firm's problem, which we have seen before.

$$An^{\gamma}k^{1-\gamma} - h = 1 \tag{23}$$

$$R - \exp(-\delta) = \frac{(1-\exp(-\delta))}{h}\left[A\gamma\left(\frac{k}{n}\right)^{1-\gamma} - w - \tau\right] \tag{24}$$

$$R - \exp(-\delta_k) = A(1-\gamma)\left(\frac{n}{k}\right)^{\gamma} \tag{25}$$

We search for A and γ by minimizing the sum of squared deviations between the left and right hand sides of these three equations; we find that the best values are approximately $A \equiv 0.63$ and $\gamma \equiv 0.67$.[19] Note that our γ is clearly consistent with other studies which, in a competitive equilibrium framework, simply equate labor's share to the elasticity of output with respect to labor.

Next, for our bargaining share parameter, we choose the natural baseline $\beta = 0.5$, implying equal bargaining power for the worker and the firm. We

[18]See also Nickell (1986) and Ehrenberg and Smith (1994). Note however that it is unclear whether we should include job training as a hiring cost when we think of hiring as an input to the matching function.

[19]The second and third equations were scaled up by a factor of 10 to ensure that percentage deviations in all three equations would carry roughly equal weight.

choose the matching elasticity ξ for consistency with Blanchard and Diamond's (1989) study of the relation between unemployment, recruitment, and match formation. They regress aggregate matching rates on unemployment and on vacancies, as proxied by help-wanted advertising, and find elasticity estimates of roughly 0.45 and 0.55, respectively, failing to reject constant returns to scale. We assume vacancies created by firms are directly proportional to firms' hiring expenditure, which means that our exponent ξ on h corresponds to their exponent of 0.55 on vacancies.[20] On the worker's side, the exponent $1-\xi$ on u corresponds to Blanchard and Diamond's elasticity of 0.45 only if unobserved search activity z is uncorrelated with u. Unfortunately, we will see when we compute the model that this assumption is not verified. In a recession, individuals will be poorer and they will face a low matching coefficient π; we find by simulation that both these effects imply *increased* search. Hence Blanchard and Diamond's estimate appears to overstate the effect of u on match formation, but we will not attempt to adjust our parameterization to take this into account.

On the preference side, we set the discount rate at $\rho \equiv 0.015$ to match our target interest rate. We will choose a baseline risk aversion parameter of $\alpha = 0$, implying logarithmic utility, but we will also report sensitivity analyses

[20]Yashiv (1997) regresses aggregate matches on measures of unemployment and vacancies from Israeli employment agency data and obtains results consistent with those of Blanchard and Diamond. However, he also fits the firm's problem by GMM and finds that vacancies are not directly proportional to hiring expenditure; instead, the total cost of hiring is a very convex function of the number of vacancies created. Interestingly, this calls into question all standard general equilibrium matching models which, like this paper, assume constant returns to scale in production and a constant cost of vacancy creation. Unfortunately we cannot pursue this observation further here.

for this controversial parameter. We can now identify the disutility of work D^W from the wage equation (4), rearranged as follows:

$$D^W = \frac{\bar{c}^{\alpha-1}}{1-\beta}\left(w - \beta A \gamma n^{\gamma-1} k^{1-\gamma}\right) = \frac{0.8^{-1}}{0.5}(0.784 - 0.5 * 0.941) = 0.78 \tag{26}$$

This equation implies a tight relationship between the parameterizations of α and of D^W; in our sensitivity analyses with respect to α below, we will vary D^W too in order to ensure a reasonable equilibrium wage.

3.2 Identifying the impact of search effort

We now turn to the parameters which relate search effort to job finding. First, we still have to normalize the unit of search effort, which affects s, π, μ, and D^S, but no other variables; nailing down any one of these quantities determines the scale of the others. We choose a normalization by targetting an equilibrium level of average search effort $\bar{s}$ approximately equal to one. In steady state, total matches must equal total job loss:

$$\begin{aligned} I^W(1-u)(1-\exp(-\delta)) &= \sum_{a,\epsilon,g} \phi_g(a,\epsilon,t)\left[1-\exp(-\pi s_g(a,\epsilon,g)^Z)\right] \\ &\approx I^W u\left[1-\exp(-\pi \bar{s}^Z)\right] \end{aligned}$$

If $\bar{s} = 1$, this approximation would imply that

$$\pi \approx -\log\left(1 - \frac{(1-u)(1-\exp(-\delta))}{u}\right) = 0.95$$

when $u = 0.06$. Then, from equation (12), μ must be given by

$$\mu = \pi\left(\frac{I^W u}{h}\right)^{\xi} \approx 2.2$$

Hence we choose $\mu \equiv 2.2$, which fixes the units of s, π, and D^S.

Our two remaining parameters are D^S, which determines the cost of search and is thus related to the equilibrium level of unemployment, and the elasticity Z, which will govern how strongly unemployment responds to changed labor market policies. Our target unemployment rate is 6%; we will now review several studies showing how unemployment is affected by public policy. Furthermore, note that Z and D^S will affect other observables related to unemployment, such as the response of consumption to job loss. We hope to identify Z and D^S by achieving a reasonable fit between our model and all these aspects of the data.

One study which sheds light on the utility costs of search is Meyer (1990), who looks at changes in job finding as UI benefits expire. In a sample of US workers from 1978 to 1983, Meyer calculated a 50% chance of job finding in the second-to-last quarter of UI eligibility. This probability rose to 61% in the last quarter of eligibility, and to a quarterly rate of 69% over the last six weeks of eligibility.[21] The higher rate of 69% is perhaps a better estimate of the change in individual job finding rates, since the aggregate rise in job finding probability may include a selection effect, as those least likely to find a job are a larger part of the sample at longer spell lengths.

Solon (1985) documents changes in unemployment spells after the imposition of taxes on UI benefits for high-wage workers in 1978, prior to which all benefits had been untaxed. The workers in this sample faced a replacement

[21] These figures are calculated from the weekly job finding rates reported in Table IV of Meyer (1990).

ratio of about 50%, and the new policy exposed them to a tax rate of around 22%-30%, so that their replacement ratio fell by 0.25*0.5 = 12.5 percentage points. Solon estimates that this caused a 1.2 week decline in the length of the average UI-eligible spellfor such workers, about ten percent of the initial average length of one quarter. A fall in spell lengths by ten percent yields a proportionate decrease in the unemployment rate, that is, a fall of 0.006 if unemployment is 0.06. Equivalently, each drop of 0.01 in the replacement ratio should cause a drop of 0.0005 in unemployment.[22]

In another paper, Meyer (1995) studies a series of policy experiments in various U.S. states in the mid-1980s in which UI claimants were paid a cash bonus for finding jobs quickly. Typically, $500 was paid for job finding within the first quarter of unemployment, resulting in a decrease in spell lengths by half a week or by one week. With our quarterly model, the effects of this payment should closely resemble those of the UI benefit level, since both involve a second-quarter payment that only affects search in the first period. In our model, the first period's UI benefit does not directly affect search behavior, while the second period of UI lowers first period search; similarly, a bonus payment affects only first period search, and should have the same dollar-for-dollar impact as the (second period) UI benefit level.For comparability to Solon, note that $500 in 1985 dollars is worth $320 in 1978 dollars, or about $320/$2500 = 0.13 of quarterly income in Solon's context. The drop in spell

[22]Fredriksson and Holmlund (1998) calibrate a similar relationship. They target a partial equilibrium elasticity of unemployment duration with respect to benefits equal to 0.5, citing Layard, Nickell, and Jackman (1991); the discussion above of Solon (1985) implies that this elasticity is 0.4.

Table 3: Effects of D^S when $Z = 0.4$.

	$D^S = 0.1$	$D^S = 0.2$	$D^S = 0.3$	$D^S = 0.4$
Std dev of consumption	0.0695	0.0694	0.0746	0.734
Avg U/E cons ratio	0.9492	0.9508	0.9483	0.9366
Cert eq of cons/avg cons ($e/\bar{c}$)	0.9956	0.9958	0.9951	0.9951
Cons innov due to job loss	-2.81%	-3.50%	-3.43%	-4.11%
Average search ($\bar{s}$)	0.5100	0.3510	0.2549	0.2376
Total unemployment (u^{TOT})	0.0731	0.0765	0.0787	0.0840
1st qtr prob of job finding	0.3571	0.3664	0.3698	0.3477
2nd qtr prob of job finding	0.6384	0.5650	0.5312	0.4785
Post-UI prob of job finding	0.6472	0.5762	0.5438	0.4952
Change in u from raised UI	0.0043	0.0025	0.0021	0.0017
Frac not searching in first qtr	0.0879	0.0294	0.0252	0.0189

lengths is roughly 1/20 of a quarter— that is, 5% of the average spell length— and thus should imply a drop in the unemployment rate of 0.05*0.06 = 0.003. If this is perfectly comparable to a change in the replacement ratio, then a change of 0.01 in the replacement ratio implies a change in the unemployment rate of 0.003/13 = 0.00023, half the effect we estimated from Solon's paper.

In Tables 3 and 4, we illustrate the range of Z and D^S values that best match these empirical observations. Starting with Table 3, we notice that an increase in D^S, by making search more costly, implies an unemployment rate considerably above our target. The effect of lowering D^S at first seems paradoxical, for while the second period probability of job finding rises, the first period probability of job finding falls. The explanation is that low utility costs of search make it very easy to find a job during the second period of unemployment. This diminishes the incentive to search in the first period of unemployment, when another period of UI is still assured; agents then search very hard in the second period of unemployment, so that post-UI unemployment is low. This implies a pattern of job finding that conflicts with the observations of Meyer (1990). With $D^S = 0.1$, the probability of job finding in the first period of unemployment is 36%, while in the second period it rises to 64%, which is much too large an increase in probability. At $D^S = 0.2$, the probabilities are 37% and 57%, respectively; these are both lower than we would like, but they involve a more reasonable jump in job finding.

The second-to-last line of Table 3 shows how the worker's probability of unemployment changes when the UI benefit is raised from 0.33 to 0.36, which is a rise of roughly four percentage points in the replacement ratio.[23] We showed above that according to Solon's data, a 1% rise in the replacement ratio should lead to a change in unemployment of 0.0005; hence we expect a change of 0.002 here. The $D^S = 0.2$ and $D^S = 0.4$ cases match this prediction very well, but unemployment jumps too much, by 0.0043, when $D^S = 0.1$. We conclude that while raising D^S from its baseline level leads to too much unemployment, lowering it makes job finding respond in an unrealistically elastic way to changes in UI benefits.

In Table 4, we investigate the impact of changing Z. As we raise Z, we see a pattern of highly elastic job formation like that discussed previously: first period job finding falls, while second period job finding rises, because job finding is easy enough that people are willing to risk postponing search effort. Also, at $Z = 0.8$, the unemployment rate rises by 0.0038 as b^U is raised from 0.33 to 0.36, almost twice the implied change from Solon (1985). Finally, we

[23] This is calculated as a pure partial equilibrium change in b^U, holding R, π, and w fixed. This should be reasonably comparable to Solon's observations, which refer to the impact, after only one year, of a policy change affecting a minority of workers.

Table 4: Effects of Z when $D^S = 0.2$.

	$Z = 0.2$	$Z = 0.4$	$Z = 0.6$	$Z = 0.8$
Std dev of consumption	0.0693	0.0694	0.0707	0.0702
Avg U/E cons ratio	0.9403	0.9508	0.9603	0.9642
Cert eq of cons/avg cons ($e/\bar{c}$)	0.9957	0.9958	0.9958	0.9959
Cons innov due to job loss	-4.08%	-3.50%	-2.96%	-2.87%
Average search ($\bar{s}$)	0.1506	0.3510	0.5307	0.6461
Total unemployment (u^{TOT})	0.0743	0.0765	0.0760	0.0749
1st qtr prob of job finding	0.4092	0.3664	0.3278	0.3013
2nd qtr prob of job finding	0.5591	0.5650	0.6094	0.6556
Post-UI prob of job finding	0.5697	0.5762	0.6151	0.6597
Change in u from raised UI	0.0043	0.0025	0.0021	0.0038
Frac not searching in first qtr	0.1053	0.0294	0.0221	0.0240

also notice that the consumption innovation upon job loss gets smaller as we raise Z. Gruber (1994) reports that workers' consumption typically falls by 7% upon job loss, so raising Z only worsens an aspect of our model which already fits poorly.[24] The smaller innovation is again related to the ease of job finding; workers need not cut back so much on consumption when they are confident of quickly finding a job.

The only alternative specification which seems to work reasonably well is the case of $Z = 0.2$. Since average search is considerably less than one here, lowering Z *raises* the probability of job finding. Hence unemployment is lower, while the low elasticity of the $Z = 0.2$ case means that job finding does not increase much from the first period of UI to the second; both of these observations help our model fit the data. On the other hand, in this case

[24]The small consumption innovation we find may be partly explained by the separability between consumption and work effort in the utility function. If instead workers need to spend more on consumption when working, observed consumption innovations would be larger than those in the model, even if the model were otherwise correctly calibrated.

unemployment responds quite strongly to a rise in UI, as many agents quit searching entirely during the first period.

On the basis of these various observations, we will use $Z = 0.4$ and $D^S = 0.2$ for our baseline model. We will perform some sensitivity analyses below, but the results are not greatly changed by altering the search specification.[25] Unfortunately, no specification matches the data as closely as we would like. The overall impression is that it is difficult, given the structure of our model, to produce job finding behavior as unresponsive to policy as that observed in the data without also obtaining a u higher than the long run US unemployment rate. It is remarkable that the only successful alternative specification requires that the elasticity parameter relating job finding to search be so low as 0.2. However, several studies have argued for similar elasticities, or remarked that job finding seems quite unresponsive to UI benefits— see Atkinson and Micklewright (1991), Layard, Nickell, and Jackman (1991, p. 255), Fredriksson and Holmlund (1998), and Coles and Masters (1999).

4 Results and conclusions

4.1 Characteristics of the baseline model

Before studying the impact of UI, we describe our baseline equilibrium. In this calibration, there is a benefit payment of 0.33 to the unemployed and retired, which is 34.4% of value added, or 42.9% of the wage. Table 6 shows that equilibrium unemployment is 7.6%, somewhat higher than intended, due

[25] In particular, varying the two parameters in such a way as to keep Z roughly equal to two times D^S, over a moderate range, has little effect on the equilibrium.

to the difficulty of finding parameters which yield low but relatively inelastic unemployment. Most of the unemployed are in their first two quarters of unemployment; the UI-eligible rate of unemployment is 5.9%. The average quarterly probability of job finding is 47.4%, rising from 36.6% in the first period of unemployment to 56.5% and 57.6% thereafter (see Table 8). Most unemployed workers do in fact prefer to have a job; on average only 1.9% of the unemployed choose to set search intensity equal to zero, although in the first period of unemployment almost three percent choose not to search.

The interest rate is 1.58%, close to our target, which shows that our assumptions about asset supply and demand are compatible. The capital stock is 8.3 times value added. Labor's share of value added is 65.7%, including the taxes paid to support worker benefits, which are 10.1% of value added. Investment is 20.5% of value added, and the remaining 13.8% of value added is paid as dividends. Hiring expenditure (not counted in value added) is 1.7% of output. Hence the economy matches our aggregate targets well, except that unemployment and hiring expenditure are both slightly higher than intended.

Tables 7 and 9 document workers' consumption and savings behavior. Average consumption is 0.7633 in units of goods, or 79.5% of value added; its standard deviation is 0.0694. One reason consumption varies across individuals is that it tends to increase with age, rising from 89.9% of average consumption in the first ten years of working life to 109.6% of the average in the last ten years of retirement. Likewise, assets increase over the life cycle, peaking at over twenty-two times quarterly average consumption at retirement. For comparison, Table 10 recalls median asset holding information reported in Hubbard, Skinner, and Zeldes (1995) for different age groups of high-school educated US workers. We look at medians rather than means, and restrict ourselves to a single education group, in order to downplay some of the dispersion in US asset holdings caused by types of individual heterogeneity not analyzed here. Our model generates an asset profile reasonably similar to that of the data, though more sharply peaked.[26]

The other reason for consumption variability, obviously, is unemployment risk. We see in Table 9 that, early in life, consumption of the unemployed is only around 91% of that of the employed; it rises to 96% near retirement. Since workers start with zero assets, they must cut consumption drastically if they become unemployed early in life; later on they are better protected by their stock of assets. We also calculate the average innovation in consumption which occurs as a result of job loss, as a percentage of current average consumption. This is large at the beginning of life, because the young have small buffer stocks, and also at the end of life, when any unemployment spell may take up a large fraction of remaining working time.[27] Similarly, the standard deviation of consumption is also lowest in the middle of life. The lack of a buffer stock makes consumption variable early in life, while near retirement the high variability of consumption is the result of many years of drift in asset

[26]Hubbard et. al. report both total wealth and non-housing wealth. For now we will assume that total wealth is the relevant measure, though it is unclear whether housing wealth can play the consumption smoothing role assumed here.

[27]Engen and Gruber (1995) and Dynarski and Sheffrin (1987) both report evidence suggesting that younger workers may be more responsive to unemployment risk than older workers, but Gruber (1994) reports the opposite.

levels from the cumulative effects of good or bad luck in the labor market.[28] Finally, note that unemployment rates rise with age. This is also mainly a reflection of the larger asset holdings of the old, which make job finding less urgent than it is for the young. First period unemployment is approximately the same at all ages, since the probability of job loss is constant by assumption, but multiperiod spells are more common for the old because of lower search.

In Table 7 we calculate the overall utility value of the consumption distribution in terms of its certainty equivalent. This is the non-random quantity of consumption which would yield the same level of utility (ignoring search and work disutility) as the actual distribution of consumption.[29] We do not find large losses in utility due to consumption variability in this equilibrium; the certainty equivalent of consumption is 99.58% of the level of average consumption. This suggests either that there is little scope for insurance in this economy, or that insurance needs are already well fulfilled at the baseline UI benefit level of 42.9% of the wage.

4.2 Effects of UI in the baseline model

Tables 11 and 12 show the effects of changing the replacement ratio. The $b^U = 0.33$ case is the baseline seen in earlier tables. Raising the benefit from 0.1 to 0.6 amounts to a rise in the replacement ratio from 12.95% to 78.23%,

[28]Growing dispersion in consumption over the lifetime is documented in Deaton and Paxson (1994).

[29]Let average consumption utility in the baseline model be v; note that this does not include search or work disutility. Then the certainty equivalent e satisfies $(1/\alpha)(e+\underline{\chi})^\alpha = v$. If average consumption in the baseline case is $\bar{c}$, then the claim in Table 7 is that $e = 0.9958\bar{c}$. Note also that welfare calculations in this paper are stated in terms of undiscounted averages, that is, cross-sectional averages of current utility in the steady state distribution.

and tax levels must increase from 0.1223 to 0.1654.[30] Table 11 shows that this rise in the replacement ratio increases the unemployment rate from 5.9% to 10.5%, so that value added falls from 0.9691 to 0.9425 in units of goods. This decline in output derives not only from the decline in employment, but also from a decline in the capital stock from 8.1 to 7.8 in units of goods. On the other hand, recruitment costs fall from 2.5% to 0.8% of value added as the UI benefit is increased, so the percentage decrease in value added is considerably smaller than the percentage decrease in employment. We also observe small declines in the interest rate and the wage with higher UI. There are large changes in the matching coefficients π and q as more unemployed workers and less hiring expenditures enter the matching function.

Table 12 demonstrates that the optimal replacement ratio, in terms of steady state average utility, is around 47%, where $b^U = 0.36$. Although this is not very low, the benefits of UI are quantitatively small, and its optimal level is determined by somewhat surprising factors. First, note that average consumption declines from 0.7697 to 0.7499 as the UI benefit is raised from 0.1 to 0.6, while the standard deviation of consumption only declines from 0.0741 to 0.0702. Since we previously saw that the certainty equivalent of consumption, at the baseline replacement ratio, is 99.58% of average consumption, the large effect of UI on average consumption bodes ill for its utility impact. Note also that the ratio of consumption of the unemployed to that of the employed *decreases* as UI is raised, evidence that UI is failing to smooth consumption.

[30]Social security is held constant at $b^R = 0.33$ in our calculcations, so taxes must be positive even when the UI benefit is zero.

Similarly, although the level of search intensity and the innovation in consumption due to job loss decrease as UI is raised from 0.1 to 0.2, they both eventually increase thereafter. Again, this suggests that people are becoming less well insured, due to higher unemployment, when UI is high.

The certainty equivalent calculations in Table 12 show just how small the benefits of UI are in this economy. The table reports the difference between consumption utility at the given level of UI and at the baseline $b^U = 0.33$. These differences are expressed in terms of the certainty equivalent consumption levels, as a fraction of baseline average consumption. The positive signs on these numbers show us that even at a UI benefit of 0.1, workers' consumption utility is worth 0.919% *more*, as a percentage of baseline average consumption, than the consumption utility associated with a benefit of 0.33.[31] It is also interesting to note that the actual change in consumption as b^U is raised from 0.1 to 0.33 is a decrease of 0.84% of baseline average consumption. That is, the change in the certainty equivalent of the consumption distibution is rougly equal to the change in the average level of consumption— the riskiness of the consumption distribution is largely irrelevant. In fact, we will see this repeatedly for the log utility case; the welfare impact on consumption can be deduced by looking at average consumption only, ignoring risk. Thus, since average consumption falls with UI in this simulation, we find that increases in UI steadily decrease consumption utility, and the benefits of UI, if any, must come through other aspects of utility.

[31]Let the certainty equivalent of average consumption utility in the baseline model be e; and let the certainty equivalent when $b^U = 0.1$ be $e_{0.1}$. Then if $\bar{c}$ is average consumption, Table 12 tells us that $(e_{0.1} - e)/\bar{c} = 0.00919$.

For comparability, we express the effects of UI on search (dis)utility and work (dis)utility in the same units as those on consumption utility. That is, we convert the utility changes into equally valuable changes in a non-random quantity of consumption, which we then express as a fraction of baseline average consumption. Though search utility changes less than consumption utility, it goes in the same direction; search utility is 0.128% better at $b^U = 0.1$ than it is at $b^u = 0.33$.[32] Search disutility increases with UI since more search effort must be expended on average when the unemployment rate is higher. On the other hand, less work disutility is suffered when unemployment is higher; this is a gain in welfare, which turns out to be quite large. The table shows that at $b^U = 0.1$, individuals' work disutility is worse, by 1.189% of baseline average consumption, than it is at the baseline.

The net effect on overall utility, from changes in consumption, search, and work, is reported in the final line of the table. The highest utility level observed is at $b^U = 0.36$, when the replacement ratio is 46.7%. However, the net change in utility due to UI is small; the overall welfare gain in going from $b^U = 0.1$ to 0.36 is worth only 0.166% of baseline average consumption. Thus while UI does not appear to substantially harm the economy at low replacement ratios, there is no sign that it has a major positive effect.[33] Moreover, the cause of

[32]Let search utility be $-d$ when $b^U = 0.33$ and $-d_{0.1}$ when $b^U = 0.1$. Let baseline average consumption utility be v with certainty equivalent e. Define $v_d \equiv v - d_{0.1} + d$ and define e_d by $(1/\alpha)(e_d + \underline{\chi})^\alpha = v_d$. Then if $\bar{c}$ is average consumption, Table 12 tells us that $(e_d - e)/\bar{c} = 0.00128$.

[33]Note also that as we increase UI above its optimum, the welfare losses get larger more quickly; there is a net loss worth 0.37% of baseline average consumption as b^U is increased from 0.5 to 0.6.

the mild improvement as UI is raised from 0.1 to 0.36 is not associated with consumption smoothing; instead, it is due to decreased work effort.

To understand this pattern of welfare changes, it is helpful to think back to a classical competitive equilibrium, where the marginal product of labor is equated to the worker's cost of work. In such an economy, if a policy distortion decreases the level of labor used from its optimum, there is a fall in output which is roughly equal in value to the decline in costs borne by the worker, and the net welfare loss is only second order. We can check how close we are to the competitive case by computing the surplus associated with work in our equilibrium; for a competitive model it would be zero. In our model, the marginal product of labor $A\gamma n^{\gamma-1}k^{1-\gamma} = 0.9443$ is the gross gain in output when work occurs, while $D^W/c^{\alpha-1} = 0.5905$ is the gross disutility cost of the work; the match surplus is just the difference, which is 0.3538. Of course, for a worker who has had very bad labor market luck, the surplus from job finding may be much higher. Such individuals do exist in our model, and they benefit greatly from UI, but they are rare enough that the average benefits of UI are not great. For most workers, the gross welfare changes from UI are considerably larger than its net welfare impact.

4.3 Partial equilibrium comparisons

In this section, we conduct two other experiments which help explain the effects of UI. First, we report the worker's partial equilibrium response to UI– that is, the change in worker behavior and well-being when the replacement ratio is raised without any effect on the prices R and w or the job matching coefficient

π. This shows us how much scope there would be for welfare improvements from UI if its imposition had no effect on the equilibrium environment of the worker. Second, we consider the impact of UI when the interest factor R is exogenous, as it would be in a small open economy; this allows us to compare the importance of the effects of UI which operate through the labor market to those which operate through capital accumulation.

Table 13 shows the partial equilibrium effect of changed UI benefits on individual behavior, while holding R, w, and π fixed at their baseline equilibrium values from Table 6.[34] The change in unemployment here allows us to isolate the moral hazard effect: we can ask how much unemployment changes due to decreased willingness to search for jobs, abstracted from any change in job finding rates. In Table 13, the unemployment rate rises from 0.06733 at $b^U = 0.1$ to 0.07648 at $b^U = 0.33$, due to a fall in workers' average search intensity from 0.4648 to 0.3510. In our general equilibrium baseline, seen in Table 11, the corresponding rise is from $u^{TOT} = 0.05877$ to $u^{TOT} = 0.07648$, almost twice as large a change. Hence moral hazard accounts for roughly half the general equilibrium change in the unemployment rate as UI rises. The remainder, necessarily, is caused by changes in firms' hiring expenditure, which declines from 0.0243 to 0.0167 in general equilibrium, leading to a decline in the job finding coefficient π from 1.6 to 1.1. Note also the interesting contrast in search behavior. While in partial equilibrium search falls from 0.4648 to 0.3510, in general equilibrium it rises slightly from 0.3399 at $b^U = 0.1$ to

[34] We only report effects on worker behavior, since it makes no sense to ask how the firm's behavior is changed if we do not close the model with aggregate consistency conditions.

0.3510 at $b^U = 0.33$. Thus we conclude, perhaps surprisingly, that the fall in the matching coefficient π that occurs in the general equilibrium model is leading to a rise in search intensity. This is confirmed by calculating numerical comparative statics for the worker's problem: the elasticity of average search effort with respect to π, evaluated at the baseline equilibrium, is -0.84.

Unlike the general equilibrium version of the model, where average consumption declines as UI is raised, here average consumption rises from 0.7580 at $b^U = 0.1$ to 0.7633 at $b^U = 0.33$. This is no surprise, for raising UI payments without affecting prices or job finding rates makes workers unambiguously better off. Moreover, the average ratio of consumption of the unemployed to that of the employed increases with UI, and the consumption innovation due to job loss decreases with UI, both signs of consumption smoothing. In contrast, in general equilibrium, both measures change less, and the average ratio of consumption of the unemployed to that of the employed actually goes in the wrong direction. Thus, although UI could help smooth consumption in an ideal world where it had no impact on the overall economy, in general equilibrium its tendency to lower the matching coefficient π sufficiently increases the riskiness of the unemployed state that the consumption gap between the unemployed and the employed is not ameliorated.

Another contrast between partial and general equilibrium is seen in saving behavior. In partial equilibrium, the influence of UI on average asset holdings is small and non-monotonic because increased UI both makes the individual wealthier and reduces the risk she faces. In general equilibrium, on the other hand, assets decline strongly as UI rises from 0.1 to 0.33, falling from 8.6623 to

8.3764 in response to the decline in the interest rate from 1.597% to 1.584%. We conclude that savings in our model are more strongly driven by the interest rate than by precautionary saving factors such as the level of UI.

Unsurprisingly, UI is highly beneficial when it has no impact on prices or job finding rates. In partial equilibrium, consumption utility, search disutility, and work disutility are all improved by a rise in the replacement ratio, as workers consume more, consume more smoothly, and search and work less. Since there are no offsetting effects, net benefits are large: workers are better off by 1.353% of baseline average consumption in going from a benefit of 0.1 to 0.33, and would be still better off at higher UI levels. This includes an improvement in consumption utility by 0.759% of baseline average consumption. However, as in our baseline calculation, the certainty equivalent of the change in consumption utility is quite close to the actual change in average consumption, which is an increase of 0.694%; it is again the level of consumption that matters, not its smoothness.

Moving to the case of an economy with fixed R, we find in Table 14 that u, y, h, k, π, and q all change slightly more than they do in general equilibrium. With no change in the interest rate, the main way an increase in UI affects firms is that taxes per worker must rise, so that hiring and investment are less profitable. In general equilibrium, the resulting decline in investment demand would be offset by a fall in the interest rate. A fixed interest rate also means that the total value of the firms, which is the sum of capital k plus the value n/q of hiring, does not equal total assets, as it must in general equilibrium (except at $b^U = 0.33$, which is the case for which fixing $R = 1.015842$ clears markets).

The difference between the value of the firms and total asset holdings is a debt to foreigners, which decreases with UI, as can be seen in the table.

Interestingly, average consumption rises slightly with UI in this experiment. UI increases income of the unemployed, *ceteris paribus*; here, this increase more than offsets the higher probability of unemployment, so that unconditional expected labor market income rises.[35] Also, note that since individuals are net savers, a fall in the interest rate decreases their effective lifetime wealth. Here, the international interest factor R is unchanged by local UI, while in our general equilibrium model, an increase in UI causes R to fall, implying a negative wealth effect. Equivalently, recall that foreign debt decreases with UI, implying that less local output is used up on interest payments to foreigners.

Since consumption grows with UI in this experiment, UI is highly beneficial, and the optimal replacement ratio is at least as large as the highest level shown in Table 15. Raising b^U from 0.1 to 0.33 raises consumption utility by 0.3% of baseline average consumption, while decreasing work disutility by 1.1% of baseline average consumption. We conclude that UI may have important effects through the interest rate; the change in consumption utility when these effects are taken into account is less, by a full 1% of baseline average consumption, than it is when we fix R.

4.4 Sensitivity to parameter changes

To understand the robustness of our results, we now consider several alternative parameterizations. Since the degree of risk aversion is critical for the value of

[35]Expected labor market income $y^W \equiv (1 - u^{TOT})w + u^{UI}b^U$ rises slightly from 0.7304 to 0.7308 as b^U is increased from 0.1 to 0.33.

insurance, and since our logarithmic baseline is on the low side of accepted parameterizations, we will examine the higher risk aversion cases of $\alpha = -1$ and $\alpha = -2$. The wage equation we used in section 3.3 imposes a strong relationship between α and the disutility of work D^W, so we raise disutility to $D^W = 0.98$ for the $\alpha = -1$ case and to $D^W = 1.2$ for the $\alpha = -2$ case to ensure that wages and search behavior remain reasonable in equilibrium.[36] Furthermore, returning to logarithmic utility, we explore the effects of changing our search effort paramaterization, considering the cases $Z = 0.2$ and $D^S = 0.1$, and also $Z = 0.8$ and $D^S = 0.2$; however, these parameters turn out to matter less than the degree of risk aversion.

Tables 16 and 17 show the effects of changes in α. One key effect is that the equilibrium interest rate rises as risk aversion increases. Note that in our baseline, the interest rate is greater than the time discount rate, because workers must be encouraged to accumulate a stock of assets equal to the value of the firms, which requires substantial consumption growth over the life cycle. With an α that is larger in absolute value, workers are not only more risk averse, but also less willing to substitute consumption intertemporally, requiring a higher interest rate to convince them to accumulate sufficient assets. The capital stock and output also fall as risk aversion increases, since firms purchase less capital when the interest rate rises.

Secondly, unemployment is lower. Given their greater aversion to low consumption, workers choose a higher level of search; for $b^U = 0.33$, average search rises from 0.3510 when $\alpha = 0$ to 0.3853 and 0.4273 at $\alpha = -1$ and -2. Hence

[36] These values are chosen by repeating the calculation in equation (26) for the new α.

they find jobs sooner, lowering the unemployment rate, which then raises the job finding rate π and lowers q. Recall from our analysis of the partial equilibrium version of the model that higher π lowers search in this economy; thus the observed increase in search is in fact lower than it would be without the change in π. Also, we observe that firms hire more to make up for the lower rate of matching q.

Obviously, greater risk aversion also implies that workers care more about consumption variation. The ratio of the certainty equivalent of consumption to average consumption declines to 0.9913 in the $\alpha = -1$ case and to 0.9807 when $\alpha = -2$, much lower than our baseline, though not necessarily low enough to ensure large gains from UI. Also, consumption innovations due to job loss are smaller than in the baseline, and the average ratio of unemployed consumption to employed consumption is higher than in the logarithmic utility case; thus we see that individuals are managing to insure themselves more fully in this equilibrium than in the baseline. Since assets are not much higher here than in the baseline, it appears that most of the additional self insurance is coming through higher search intensity.

In the welfare analysis of Table 16, we see that for $\alpha = -1$, self insurance is still powerful enough that UI yields little improvement. As in our baseline, UI leads to a loss in welfare due to lower average consumption, roughly offset by a gain in welfare due to less work effort. Net benefits are small; the optimal replacement ratio is around 25%, but represents a welfare gain of only about 0.17% of average consumption relative to a 10% replacement ratio. However, there is real evidence for welfare gains from consumption smoothing in the

$\alpha = -2$ case. Consumption utility still decreases with UI, but these changes are only about half as large as the decreases in work disutility, leading to a non-trivial net benefit. Also, the ratio of average consumption of the unemployed to that of the employed increases substantially due to UI, while the consumption innovation resulting from job loss gets smaller. Furthermore, we can calculate that the decline in average consumption as UI is increased from 0.1 to 0.33 is 0.537%, while the change in the certainty equivalent of consumption utility is only 0.252%. The large difference in the magnitudes of these two percentage changes is attributable to welfare gains from consumption smoothing.

For $\alpha = -2$, we find a remarkably high optimal replacement ratio— evidently over 100%.[37] Though this contrasting result is due in part to the greater consumption smoothing needs of more risk averse consumers, other issues again appear more important. First, since there is lower unemployment in this equilibrium than in our baseline, raising UI has a relatively smaller tax impact on firms. Increased UI therefore raises unemployment less and decreases consumption less than it does in the baseline model. With a smaller rise in unemployment, there is less tendency for UI to drive up the effective level of risk that workers face; hence raising UI does now lead to consumption smoothing, as we can see from the behavior of the consumption innovation and the ratio of unemployed to employed consumption in Table 17.

Two investment externalities also play a role. First, the effect of UI on the capital stock is much less negative for $\alpha = -2$ than for logarithmic utility.

[37]In principle, a replacement ratio over 100% could be optimal in this model, since the two-quarter time limit on UI receipt implies that at least some workers will exert search effort even when the replacement ratio is over 100%. However, the model was not designed to evaluate such a high replacement ratio, so this result should not be taken literally.

Since lower willingness to shift consumption over time leads to a larger difference between the interest rate and the time discount rate here than in the baseline, there is potential for a larger drop in the interest rate, from 0.01953 to 0.01882 as UI is raised from 0.1 to 0.7. The interest rate decrease allows for a small, non-monotonic change in the capital stock, unlike the monotonic decrease in capital found in the baseline case. Second, notice that the wage, at $w = 0.7013$, is much lower when $\alpha = -2$ than when $\alpha = 0$, suggesting that we have not raised D^W sufficiently to compensate for the change in α (recall that our target wage parameterization was 0.78). This fall in the wage both encourages hiring and discourages search; the result is that hiring costs are a bigger share of output. Thus part of the impact of raising UI is a large decrease in hiring costs, from 4.1% to 1.9% of value added, over the range of UI considered here; consumption, therefore, need not fall so much. In the companion paper which explores the effect of different wage bargaining specifications (Costain 1998), we also find that the economy is quite sensitive to the wage, and that the welfare impact of UI depends greatly on whether it has a larger effect on hiring expenditure or on search effort.

We also tried two different specifications of search effort: lower cost ($Z = 0.02$ and $D^S = 0.1$) and higher elasticity ($Z = 0.8$ and $D^S = 0.2$).[38] Both alternative parameterizations yield a similar pattern of job search shirking. In the $Z = 0.2$, $D^S = 0.1$ case, average search is substantially lower, and a much larger fraction of individuals choose not to search at all. For $Z = 0.8$

[38] The tables reporting these results are suppressed here but are given in the working paper version (Costain 1997b).

and $D^S = 0.2$, average search is higher, but the effects on the equilibrium are similar, with a large spread between the probability of job finding in the first period of unemployment and that in later periods. In both cases, in spite of the initial low search intensity, the late search is effective enough that overall unemployment is lower.

These same tendencies are reflected in the response to unemployment insurance. Both unemployment and average consumption respond more strongly to UI than in the baseline model. Hence there are large gross changes in both the certainty equivalent of work disutility and the certainty equivalent of consumption. As in our previous simulations, however, these two changes largely cancel each other out; net welfare gains from UI are small, and the optimum is at a low level around 20%. We conclude that these specifications imply somewhat too much elasticity of unemployment to the imposition of UI; nonetheless their welfare implications are not very different from our baseline case.

Comparing these specifications, we conclude that changes in the search parameters simply make the fit of the model somewhat worse (exaggerating the response of equilibrium employment to policy changes) without having a substantial impact on the welfare analysis. As for the degree of risk aversion, increases in the absolute value of α help in terms of the model's labor market implications by lowering equilibrium unemployment. On the other hand, though, higher risk aversion implies smaller consumption innovations upon unemployment, only making the fit of the model worse in this regard. Overall there is no obvious reason to prefer the alternative specifications.

4.5 Impatient consumers.

As a final sensitivity check, we also consider a simulation in which consumers have a higher discount rate. Carroll (1997) has claimed that the distributions and dynamics of assets and consumption in the US are matched well by a model of relatively impatient consumers who face risk; this specification results in a large fraction of agents with relatively low wealth, whose consumption responds strongly to current income.

We will implement this specification by fixing the interest rate, and searching for equilibrium over w and π only, as we did in the "fixed R" experiment reported in subsection 4.3. In fact, this experiment will be identical to that in subsection 4.3, fixing the interest rate at its baseline value of 1.5842%, except that we will raise the subjective discount factor from $\rho = 0.015$ to $\rho = 0.02$; all other parameters are kept at their baseline values. We choose to fix the interest rate in this case because otherwise we will either find an unreasonably low total capital stock or an unreasonably high equilibrium interest rate; hence we are forced to assume that some fraction (a large fraction, as it turns out) of total wealth is held by a class of risk neutral agents (capitalists) who, by assumption, have a discount rate of 1.5842%.

Results from this case are reported in Tables 18 and 19. The most basic difference, understandably, is that workers save much less than they do in the baseline model. For $b^U = 0.33$, workers' average asset holdings are only 0.7716 (in goods units), while the value of firms is 8.0842+1.2475=9.3317; the remainder of the value of the firms is held by the risk neutral capitalists. This is a remarkable change from the baseline model in which average asset holdings of workers are 8.3764, equal to the value of the firms. This then explains the other effects that we see in the model. Since workers save much less, on average their consumption is considerably lower over their lifetimes: down to 0.6088 from 0.7633 in the baseline model. Hence workers on average have higher marginal utility, which lowers their wage, as seen in (4), from 0.7702 in the baseline model to 0.7099 under impatience. With a cheaper workforce, firms hire more; recruitment is thus 5.18% of value added, compared with 1.74% in the baseline model, so that employment n and the job finding coefficient π rise, while the hiring coefficient q falls.

Unsurprisingly, since workers have lower buffer stocks of assets, UI plays a greater consumption smoothing role. Notice that the standard deviation of consumption rises from 0.0694 in the baseline model to 0.0982 under impatience. The ratio of the consumption of the unemployed to that of the employed is decreased greatly in the case of impatience to 0.8899, compared with 0.9508 in the baseline, while the consumption innovation due to job loss under impatience is -8.072%, much closer to Gruber's (1997) empirical figure of -7% than is the baseline innovation of only -3.497%. However, the certainty equivalent of consumption is still 98.55% of average consumption.

In the case of impatience, raising UI from 0.01 to 0.6 causes unemployment to rise from 0.04461 to 0.08608. Value added falls relatively little, from 0.9507 to 0.9357, since there is a large drop in recruitment expenditure to offset the decrease in gross output. As in our previous fixed R calculation, workers' consumption *rises* (almost) monotonically from 0.6051 to 0.6206 as UI is increased from 0.1 to 0.6. This is possible in part because hiring incentives are so strong at 0.1 that increased UI causes a large drop in recruitment expenditure. Furthermore, in this version of the model we must also consider the consumption of the capitalists, which they purchase with their dividend income. The increase in the tax rate required to support higher UI lowers firms' profits, so that capitalists' consumption falls from 0.1403 to 0.1190. Hence an increase in UI represents a substantial transfer of income from capitalists to workers, who hold only a small part of the total value of the firms.

In terms of workers' welfare, therefore, UI is extremely beneficial, leading to large welfare improvements from consumption and work effort, together with a small offsetting welfare cost of additional search effort. Considering consumption utility only, the certainty equivalent rises by over 2.5% of average consumption as b^U is increased from 0.1 to 0.6.[39] However, even with buffer stocks as low as they are in this specification, there is no clear evidence that this change in utility is related to consumption smoothing. In fact, the rise in average consumption, from 0.6051 to 0.6306, is also roughly 2.5%. So once again, under log utility, the overall consumption utility change is well proxied by the change in average consumption, without considering higher moments. Taking into account the welfare effects from changes in search and work as well, the benefits of UI are even greater, representing a change in the certainty equivalent of over 4.6% of average consumption.

Of course, this welfare calculation is misleading since it ignores capitalists' loss of consumption. To compute an overall social welfare effect, we

[39] This calculation is performed relative to average consumption when $b^U = 0.33$, which is 0.6088.

could add the change in the certainty equivalent of workers' utility to the change in capitalists' consumption. This might be seen as an upper bound on the welfare weight of capitalists: if they are on average richer than the rest of the population, then any more egalitarian social welfare function would place a lower weight on the change in capitalists' consumption. The certainty equivalent of the change in workers' utility as b^U is raised from 0.1 to 0.6 is $0.04625 * 0.6088 = 0.02816$, while capitalists' consumption falls by 0.02138. Hence even this welfare criterion, which heavily weights capitalists' consumption, shows an overall benefit of 0.00678 consumption units, that is, 0.91% of the total consumption level of 0.6088+0.1335=0.7423 resulting from this increase in UI. Nonetheless, we must still emphasize that this welfare improvement results from a decrease in hiring, and not from consumption smoothing.

4.6 Discussion

Although our results have varied considerably, the primary conclusion we must draw is that our model does not support large consumption smoothing gains from UI. As in Aiyagari (1994), individuals in our model achieve a high degree of consumption self insurance, even with UI as low as 10%. Mandating an unemployment benefit of up to 40% has very little impact— either positive or negative— on workers' well-being. In the baseline, the optimal replacement ratio is around 45%, yet the actual utility gains are only a few tenths of a percent of baseline average consumption, and are quite flat, so that the precise optimum is rather irrelevant. Raising the degree of risk aversion to $\alpha = -2$, though, makes UI much more beneficial, yielding utility gains of about one percent of average consumption and an optimal replacement ratio which appears to be around 100%.

The welfare changes resulting from an increase in the UI benefit usually include a fairly large loss in consumption utility, coupled with a similar decrease in work disutility. At low risk aversion, these two changes tend to cancel, while part of the reason that UI is beneficial in the $\alpha = -2$ case is that the decrease in consumption utility is considerably smaller than the decrease in work disutility, because lower average consumption is partially compensated by less consumption variability. Even here, though, much of the welfare gain from UI is due not to consumption smoothing *per se*, but to search externalities, and to a positive effect on the capital stock due to a lower interest rate. In fact, we almost never observe gains in the consumption portion of utility alone in our general equilibrium calculations.

It is instructive to contrast the behavior of this model with that of a competitive equilibrium near a smooth optimum. The largest impacts, as government policy alters the equilibrium, are offsetting gross changes in consumption and work disutility. In the case of a competitive optimum, these gross changes would cancel, with only a second order welfare impact of UI overall. In the present context, the essential question is how these two gross changes compare. When the consumption smoothing benefits of UI are nontrivial, as in our most risk averse simulation, the loss of consumption utility can be considerably smaller than the decrease of work disutility, implying a substantial overall welfare improvement from UI. Seen from this perspective, we also note that as we increase unemployment (thus making our model less like a competitive optimum) both the costs and the benefits of UI increase. However, the costs are likely to be convex, both in the level of unemployment and in the level of benefits, which suggests that optimal UI will be higher when unemployment is lower— another explanation for the difference between the $\alpha = 0$ and $\alpha = -2$ cases.

A major difference between this model and a competitive model is that in a search model, some inputs are not valued at their marginal products, so that equilibrium need not be efficient and price or policy changes can have first order welfare effects. Even when there is substantial risk aversion, we have found that the impact of UI on the externalities between agents' investment decisions is of much greater welfare significance than is consumption smoothing. As is well known, matching models can in theory produce either too much or too little unemployment; obviously UI will be more beneficial in an economy with too much employment. But this is not the only way in which externalities can affect the optimal level of UI, nor does it seem to be the issue here; for not only the level of employment, but also the relative contributions of search effort and hiring expenditure to match formation, and the relative contributions of capital and labor to output, are important for efficiency.

Hence another important distinction between our logarithmic baseline and the $\alpha = -2$ case is that the latter parameterization implies a low equilibrium wage which leads to a high ratio of hiring expenditure to search effort. Raising UI lowers the ratio of search to hiring, and in doing so it appears to raise efficiency. In fact, we see via several examples in the companion paper, Costain (1998), that the main factor distinguishing the welfare analyses for different wage bargaining solutions is whether raising UI has a larger effect on hiring than on search (which tends to be beneficial) or the reverse (harmful). Hence, although we have not attempted an efficiency analysis along the lines of Hosios (1990) for this complicated model, it appears that our baseline parameterization implies insufficient search effort compared to the amount of hiring expenditure.

The contrast between the small consumption smoothing role of UI and the large search externalities observed in our simulations leads us to reflect on the modelling elements which yield these conclusions. In our baseline, where average asset holdings equal the capital stock, we find a high degree of self insurance, so that the certainty equivalent of consumption utility is 99.58% of average consumption. This explains the small consumption smoothing benefits of UI. However, some evidence suggests that our model may exaggerate equilibrium insurance. The rather high baseline unemployment rate of 7.6% partly reflects a weak incentive to search, due to low risk aversion; indeed, unemployment falls to 6.1% as we raise risk aversion. Consumption innovations upon job loss are smaller here than in the data, and this problem is made worse by increasing risk aversion. Third, we may overstate the actual degree of insurance achieved by workers holding median asset levels, since we assume that all assets are liquid and we ignore other forms of risk. To evaluate the importance of these caveats, we also considered a version of the model with impatient consumers. We found that a small change in the time discount rate (holding fixed the interest rate) drastically altered asset holdings and increased the riskiness of the consumption distribution. Nonetheless, at least for log utility, this did not alter our conclusion that the consumption smoothing welfare gains from UI are small.

While our use of a standard precautionary saving model may understate consumption smoothing benefits, our use of a general equilibrium matching model may overstate the reaction of labor market variables to changes in policies and wages. In our parameterization of the search process we found that it is quite difficult, in the context of a matching model, to obtain worker behavior as inelastic as that observed in microeconomic data. Similarly, we observe large changes in the share of GDP devoted to hiring as we change parameters in the model. While vacancy advertisement is known to be volatile, there seems to be no suggestion in the literature that hiring expenditure forms such a large and variable fraction of output.

A third key aspect of our model is our assumption of *ex ante* homogeneous workers and homogeneous jobs. As we have seen, if identical workers hold the entire capital stock, then we obtain highly insured workers in equilibrium; to break this result we must go to a heterogeneous agent framework with both workers and capitalists. Heterogeneity in labor market transition rates is also potentially important; Pallage and Zimmermann (1997) have argued that this could increase the benefits of UI. By distinguishing good jobs from bad jobs, Acemoglu and Shimer (1999b) find that UI is robustly welfare improving, in contrast to our more ambiguous results.[40]

[40] Acemoglu and Shimer (1999b) treat job matching coefficients exogenously, which eliminates some of the externalities which play a large role in this paper; this is another reason for their less ambiguous results.

There are, of course, good reasons to begin with a baseline model with only one type of agent: this simplifies both the structure of the model and the parameterization, and raises less thorny questions about the appropriate social welfare function. Likewise, it is natural to base a UI policy analysis on a life cycle saving model and a general equilibrium matching model— both macroeconomic workhorses. Whether our sometimes surprising results should cause us to question traditional views of the value of UI, or to question our key modelling elements, is a conundrum better left to the reader and to future research. In particular, further progress on the costs and benefits of UI requires continued improvement in our understanding of the distribution of assets and consumption, and also in the empirical evaluation of matching models.

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Table 5: Baseline parameters

Preferences	T	180	*Matching technology*	I	1
	T^R	60		β	0.5
	α	0		δ	0.04
	ρ	0.015		μ	2.2
	D^W	0.78		ξ	0.55
	D^S	0.2			
	Z	0.4	*Computational parameters*	χ	1/12
				$\underline{\chi}$	1/1200
Production technology	A	0.63		$-A_{min}$	-24χ
	γ	0.67		A_{max}	400χ
	δ_k	0.025		c_{max}	40χ
				σ_{min}	-4
Policies	b^U	0.33		σ	0.5
	b^R	0.33		σ_{max}	4

Table 6: Aggregate implications of baseline model[a]

Replacement ratio (b^U/w)	0.4285
Interest rate ($R-1$)	0.01584
Matching coefficient (π)	1.1174
Value added[b] (y)	0.9596
Wage[b] (w)	0.7702
Unemployment rate (u^{TOT})	0.07648
UI-eligible unemployment rate (u^{UI})	0.05916
Average prob of job finding if unemployed	0.4735
Capital stock / value added (k/y)	8.2838
Labor's share of value added[c]	0.6572
Recruitment expenditures / value added (h/y)	0.0174
Investment expenditures / value added[c] (i/y)	0.2045
Tax collected / value added[c] ($n\tau/y$)	0.1012
Dividend payments / value added[c] (d/y)	0.1383

[a]Time period is one quarter in all calculations.

[b]In units of goods.

[c]Note: wage costs + investment + tax collected + dividends = value added.

Table 7: Distributional implications of baseline model

	Overall	*Employed*	*Unemployed*	*Retired*
Average consumption[a]	0.7633	0.7443	0.7107	0.8281
Std dev of consumption[a]	0.0694	0.0539	0.0712	0.0647
Average assets[a]	8.3764	7.5061	7.1356	11.0724
CE of cons / avg cons[b,c]	0.9958	0.9725	0.9251	1.0816

[a]In units of goods.

[b]CE refers to the certainty equivalent of consumption, which is the constant level of consumption e that yields the same utility as the mean of the consumption utility distribution; see footnote 29.

[c]All columns are divided by overall average consumption $\bar{c}$.

Table 8: Unemployment and search in baseline model

	1st per. of spell	*2nd per. of spell*	*Post-UI*	*Overall*
Unemployment rate	0.03621	0.02294	0.01732	0.07648
Avg prob of job finding	0.3664	0.5650	0.5762	0.4735
Fraction not searching[a]	0.0294	0.0086	0.0124	0.0193

[a]Fraction of each category of unemployed choosing to set search s to zero.

Table 9: Life cycle implications of baseline model

Age range[a]	1–40	41–80	81–120	121–160	161–200	201–240
Conditional avg cons / avg cons[b]	0.8991	0.9588	0.9814	1.0151	1.0492	1.0963
Cons if emp / avg cons[b]	0.9046	0.9622	0.9837	1.0184	1.0399	N.A.
Cons if unemp / avg cons[b]	0.8279	0.9165	0.9534	0.9784	0.9974	N.A.
Std dev cons / avg cons[b]	0.0586	0.0461	0.0468	0.0655	0.0788	0.0846
Cons innovation due to job loss	-3.532%	-2.198%	-1.717%	-2.470%	-2.783%	N.A.
Avg assets / avg cons[b]	2.0546	5.4074	9.6394	15.7986	22.3387	10.6039
Rate of first-period unemp.	0.0364	0.0363	0.0362	0.0361	0.0359	N.A.
Rate of second-period unemp.	0.0204	0.0219	0.0231	0.0244	0.0270	N.A.
Rate of post-UI unemp.	0.0142	0.0148	0.0175	0.0198	0.0232	N.A.

[a]Time period is one quarter; retirement is quarters 181-240.

[b]All columns are divided by overall average consumption $\bar{c} = 0.7633$.

Table 10: Median wealth of high school educated workers[a]

Age	<30	30-39	40-49	50-59	60-69	70+
Wealth in dollars[b]	6855	28300	62600	90300	88506	92500
Wealth / qtrly PI[c]	1.23	5.09	11.26	16.23	15.92	16.63
Non-housing wealth in dollars[b]	4500	8100	15500	39000	38068	17700
Non-housing wealth / qtrly PI[c]	0.8092	1.4566	2.7873	7.0131	6.8455	3.1829

[a]This table is derived from Hubbard, Skinner, Zeldes (1995).

[b]Hubbard, et. al. calculate that annual permanent income is $22244 for this sample.

[c]Wealth figures are expressed as a multiple of quarterly permanent income (PI). Hence if PI is roughly equal to average consumption, then the seventh line of Table 9 can be directly compared to the third line of Table 10.

Table 11: Aggregate effects of UI in baseline model

Unemployment benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36	0.4	0.5	0.6
Replacement ratio (b^U/w)	0.1295	0.2593	0.3893	0.4285	0.4676	0.5199	0.6509	0.7823
Tax per worker[a] (τ)	0.1223	0.1295	0.1376	0.1402	0.1429	0.1466	0.1561	0.1654
Unemployment rate (u^{TOT})	0.05877	0.06599	0.07373	0.07648	0.07932	0.08321	0.09386	0.10483
Value added[a] (y)	0.9691	0.9651	0.9611	0.9596	0.9579	0.9556	0.9492	0.9425
Recruitment costs[a] (h)	0.0243	0.0212	0.0178	0.0167	0.0157	0.0142	0.0108	0.00765
Wage[a] (w)	0.7721	0.7712	0.7705	0.7702	0.7699	0.7694	0.7681	0.7669
Interest rate ($R-1$)	0.01597	0.01593	0.01586	0.01584	0.01582	0.01579	0.01567	0.01551
Capital[a] (k)	8.0618	8.0131	7.9667	7.9487	7.9317	7.9070	7.8496	7.8004
Matching coefficient (π)	1.5857	1.3817	1.1796	1.1174	1.0568	0.9756	0.7830	0.6107
Hiring coefficient (q)	1.1382	1.2927	1.5290	1.6228	1.7281	1.8937	2.4780	3.4421

[a] In units of goods.

Table 12: Distributional effects of UI in baseline model

Unemp benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36	0.4	0.5	0.6
Avg consumption[a] ($\bar{c}$)	0.7697	0.7671	0.7643	0.7633	0.7623	0.7602	0.7555	0.7499
Std dev consumption[a]	0.0741	0.0724	0.0698	0.0694	0.0690	0.0684	0.0685	0.0702
Avg U/E cons ratio	0.9530	0.9514	0.9513	0.9508	0.9495	0.9465	0.9396	0.9257
Cons innovation	-3.677%	-3.617%	-3.478%	-3.497%	-3.446%	-3.610%	-3.691%	-4.164%
Average assets[a]	8.6623	8.5468	8.4113	8.3764	8.3465	8.2616	8.1311	7.9937
Avg search[b] ($\bar{s}$)	0.3399	0.3126	0.3412	0.3510	0.3597	0.3774	0.4408	0.5360
Avg prob of job finding[b]	0.6279	0.5550	0.4926	0.4735	0.4552	0.4320	0.3785	0.3348
Fraction not searching[b]	0.0083	0.0116	0.0174	0.0193	0.0226	0.0255	0.0301	0.0249
CE of cons ut gain[c]	+0.00919	+0.00466	+0.00125	0	-0.00128	-0.00399	-0.01030	-0.01810
CE of search decrease[c]	+0.00128	+0.00093	+0.00025	0	-0.00025	-0.00068	-0.00217	-0.00438
CE of work decrease[c]	-0.01189	-0.00610	-0.00160	0	+0.00166	+0.00394	+0.01019	+0.01668
CE of overall change[c]	-0.00154	-0.00054	-0.00009	0	+0.00013	-0.00075	-0.00239	-0.00609

[a]In units of goods.

[b]Conditional on unemployment. Note search is expressed in units of search effort.

[c]Change in certainty equivalent, as fraction of baseline average consumption $\bar{c}$; see footnotes 31 and 32.

Table 13: Worker's partial equilibrium response to UI

Unemployment benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36
Unemployment rate (u^{TOT})	0.06733	0.07072	0.07451	0.07648	0.07811
Average consumption[a] ($\bar{c}$)	0.7580	0.7610	0.7634	0.7633	0.7635
Std dev of consumption[a]	0.0741	0.0723	0.0701	0.0694	0.0682
Avg U/E cons ratio	0.9381	0.9433	0.9502	0.9508	0.9517
Cons innov due to job loss	-4.564%	-4.080%	-3.468%	-3.497%	-3.441%
Average assets[a]	8.3756	8.4139	8.4091	8.3764	8.3475
Average search[b] ($\bar{s}$)	0.4648	0.4045	0.3644	0.3510	0.3434
Avg prob of job finding[b]	0.5432	0.5252	0.4870	0.4735	0.4627
CE of cons ut gain[c]	-0.00759	-0.00343	+0.00001	0	+0.00036
CE of search decrease[c]	-0.00067	-0.00026	-0.00005	0	+0.00000
CE of work decrease[c]	-0.00532	-0.00335	-0.00114	0	+0.00096
CE of overall change[c]	-0.01353	-0.00702	-0.00119	0	+0.00132

[a]In units of goods.

[b]Conditional on unemployment. Note search is expressed in units of search effort.

[c]Change in certainty equivalent, as fraction of baseline average consumption $\bar{c}$; see footnotes 31 and 32.

Table 14: Aggregate effects of UI: fixed $R = 1.015842$ case

Unemployment benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36
Unemployment rate (u^{TOT})	0.05722	0.06460	0.07342	0.07648	0.07976
Value added[a] (y)	0.9700	0.9662	0.9614	0.9596	0.9575
Recruitment[a] (h)	0.0267	0.0226	0.0182	0.0167	0.0153
Wage[a] (w)	0.7693	0.7699	0.7701	0.7702	0.7702
Matching coefficient (π)	1.6944	1.4479	1.1963	1.1174	1.0404
Hiring coefficient (q)	1.0380	1.2148	1.4981	1.6228	1.7655
Capital[a] (k)	8.1150	8.0515	7.9756	7.9487	7.9210
Value of employment[a] (n/q)	0.6812	0.5775	0.4639	0.4269	0.3909

[a]In units of goods.

Table 15: Distributional effects of UI: fixed $R = 1.105842$ case

Unemployment benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36
Average consumption[a] ($\bar{c}$)	0.7608	0.7625	0.7630	0.7633	0.7633
Std dev consumption[a]	0.0674	0.0684	0.0686	0.0694	0.0701
Avg U/E cons ratio	0.9508	0.9525	0.9516	0.9508	0.9491
Cons innov due to job loss	-4.024%	-3.559%	-3.454	-3.497%	-3.458%
Average assets[a]	8.2395	8.3157	8.3481	8.3764	8.3960
Average search[b] ($\bar{s}$)	0.3248	0.3011	0.3372	0.3510	0.3636
Avg prob of job finding[b]	0.6460	0.5678	0.4949	0.4735	0.4524
CE of cons ut gain[c]	-0.00306	-0.00097	-0.00033	0	-0.00016
CE of search decrease[c]	+0.00124	+0.00111	+0.00031	0	-0.00032
CE of work decrease[c]	-0.01116	-0.00690	-0.00178	0	+0.00192
CE of overall change[c]	-0.01297	-0.00677	-0.00180	0	+0.00143

[a]In units of goods.

[b]Conditional on unemployment. Note search is expressed in units of search effort.

[c]Change in certainty equivalent, as fraction of baseline average consumption $\bar{c}$; see footnotes 31 and 32.

Table 16: Effects of UI when $\alpha = -1$

Unemployment benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36	0.4
Replacement ratio (b^U/w)	0.1327	0.2655	0.3995	0.4400	0.4805	0.5353
Unemployment (u^{TOT})	0.05379	0.05893	0.06697	0.06959	0.07247	0.07583
Value added[a] (y)	0.9586	0.9569	0.9521	0.9504	0.9488	0.9471
Recruitment costs[a] (h)	0.0278	0.0252	0.0227	0.0218	0.0210	0.0197
Interest rate ($R-1$)	0.01701	0.01692	0.01683	0.01681	0.01676	0.01671
Capital[a] (k)	7.8066	7.7873	7.7478	7.7303	7.7198	7.7068
Avg consumption[a] ($\bar{c}$)	0.7661	0.7647	0.7608	0.7595	0.7583	0.7570
Std dev consumption[a]	0.0789	0.0758	0.0728	0.0720	0.0714	0.0702
Avg U/E cons ratio	0.9678	0.9689	0.9678	0.9668	0.9674	0.9668
Cons innov due to job loss	-2.704%	-2.514%	-2.566%	-2.615%	-2.445%	-2.360%
CE of cons ut gain[b,c]	+0.00704	+0.00597	+0.00147	0	-0.00148	-0.00303
CE of search decrease[c]	+0.00040	+0.00038	+0.00015	0	-0.00017	-0.00044
CE of work decrease[c]	-0.00861	-0.00583	-0.00144	0	+0.00159	+0.00344
CE of overall change[c]	-0.00129	+0.00046	+0.00018	0	-0.00007	-0.00005

[a] In units of goods.

[b] The certainty equivalent of consumption, when $b^U = 0.33$, is 99.13% of average consumption.

[c] Change in certainty equivalent, as fraction of average consumption when $b^U = 0.33$; see footnotes 31 and 32.

Table 17: Effects of UI when $\alpha = -2$

Unemp benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.4	0.5	0.6	0.7
Replacement ratio (b^U/w)	0.1420	0.2846	0.4275	0.4706	0.5715	0.7167	0.8610	1.0027
Unemployment (u^{TOT})	0.04848	0.05349	0.05915	0.06116	0.06638	0.07522	0.08307	0.08903
Value added[a] (y)	0.9255	0.9233	0.9211	0.9203	0.9180	0.9142	0.9121	0.9123
Recruitment costs[a] (h)	0.03815	0.03602	0.03333	0.03248	0.03027	0.02666	0.02231	0.01771
Interest rate ($R-1$)	0.01953	0.01946	0.01938	0.01934	0.01927	0.01912	0.01898	0.01882
Capital[a] (k)	7.1914	7.1697	7.1477	7.1407	7.1191	7.0873	7.0607	7.0534
Avg consumption[a] ($\bar{c}$)	0.7480	0.7459	0.7446	0.7440	0.7422	0.7392	0.7371	0.7381
Std dev consumption[a]	0.0932	0.0910	0.0882	0.0873	0.0856	0.0828	0.0795	0.0773
Avg U/E cons ratio	0.9716	0.9721	0.9758	0.9770	0.9786	0.9796	0.9821	0.9809
Cons innovation	-2.941%	-2.853%	-2.359%	-2.195%	-1.942%	-1.687%	-1.209%	-1.125%
CE of cons ut gain[b,c]	+0.00252	+0.00090	+0.00049	0	-0.00163	-0.00457	-0.00623	-0.00394
CE of search decrease[c]	-0.00008	+0.00014	+0.00006	0	-0.00032	-0.00111	-0.00219	-0.00338
CE of work decrease[c]	-0.00591	-0.00358	-0.00093	0	+0.00248	+0.00671	+0.01051	+0.01342
CE of overall change[c]	-0.00352	-0.00255	-0.00038	0	+0.00052	+0.00092	+0.00186	+0.00584

[a] In units of goods.

[b] The certainty equivalent of consumption, when $b^U = 0.33$, is 98.07% of average consumption.

[c] Change in certainty equivalent, as fraction of average consumption when $b^U = 0.33$; see footnotes 31 and 32.

Table 18: Aggregate effects of UI: fixed R and impatient consumers

Unemployment benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36	0.4	0.5	0.6
Unemployment rate (u^{TOT})	0.04461	0.04699	0.05525	0.06074	0.06878	0.07375	0.08288	0.08608
Value added[a] (y)	0.9507	0.9513	0.9474	0.9440	0.9384	0.9360	0.9336	0.9357
Recruitment[a]	0.0593	0.0562	0.0513	0.0489	0.0460	0.0431	0.0360	0.0305
Wage[a] (w)	0.7805	0.7090	0.7096	0.7099	0.7098	0.7102	0.7124	0.7146
Matching coeff (π)	3.0132	2.8425	2.4739	2.2759	2.0662	1.9186	1.6281	1.4561
Hiring coeff (q)	0.4741	0.4990	0.5417	0.5647	0.5950	0.6315	0.7500	0.8817
Capital[a] (k)	8.2230	8.2025	8.1314	8.0842	8.0150	7.9721	7.8936	7.8661
Value of employment[a] (n/q)	1.5115	1.4323	1.3081	1.2475	1.1738	1.1675	0.9171	0.7774
Cons of capitalists[a]	0.1403	0.1401	0.1364	0.1335	0.1300	0.1289	0.1217	0.1190

[a]In units of goods.

Table 19: Distributional effects of UI: fixed R and impatient consumers

Unemp benefit[a] (b^U)	0.1	0.2	0.3	0.33	0.36	0.4	0.5	0.6
Avg consumption[a] ($\bar{c}$)	0.6051	0.6064	0.6081	0.6088	0.6084	0.6093	0.6150	0.6206
Std dev consumption[a]	0.0990	0.0995	0.0989	0.0982	0.0973	0.0976	0.0985	0.0995
Avg U/E cons ratio	0.8810	0.8825	0.8891	0.8899	0.9041	0.8983	0.9052	0.9076
Cons innovation	-10.810%	-9.570%	-8.332%	-8.072%	-7.647%	-8.245%	-6.621%	-5.736%
Average assets[a]	0.7363	0.6474	0.6900	0.7716	0.8506	0.8744	1.0044	1.0161
Average search[b] ($\bar{s}$)	0.3526	0.3158	0.2766	0.2896	0.3004	0.3344	0.4049	0.4373
Avg prob of job finding[b]	0.8398	0.7952	0.6705	0.6063	0.5309	0.4924	0.4339	0.4163
CE of cons ut gain[c,d]	-0.00633	-0.00437	-0.00147	0	-0.00052	+0.00087	+0.01008	+0.01916
CE of search decrease[d]	+0.00027	+0.00041	+0.00034	0	-0.00045	-0.00105	-0.00236	-0.00296
CE of work decrease[d]	-0.00927	-0.00790	-0.00316	0	+0.00465	+0.00754	+0.01287	+0.01474
Worker CE overall[d]	-0.01532	-0.01187	-0.00429	0	+0.00368	+0.00737	+0.02059	+0.03093

[a] In units of goods.

[b] Conditional on unemployment. Note search is expressed in units of search effort.

[c] The certainty equivalent of consumption, when $b^U = 0.33$, is 98.55% of average consumption.

[d] Change in certainty equivalent, as fraction of average consumption when $b^U = 0.33$; see footnotes 31 and 32.