Unemployment Insurance and the Business Cycle: What Adjustments are Needed?

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Abstract

During the 2007 - 2011 economic downturn, the duration that one could collect unemployment insurance (UI) in the United States increased to an unprecedented 99 weeks and the UI benefit amount increased by $25. This paper explores the policy of increasing the generosity of UI during recessions using a model that accounts for the insurance and moral hazard implications of UI, as well as the program's impact on job creation. When limited to adjusting the duration of benefits, a more generous UI system is optimal. However, due to UI's negative impact on job creation, and the increased cost of providing benefits when unemployment is high, the optimal extension is just 1.3 months. When the government adjusts both the benefit amount and its duration, the optimal policy during downturns is a reduction in the replacement rate. This mitigates the decline in job creation and funds an UI extension of 4.3 months.

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1 Introduction

In most developed countries, unemployment insurance (UI) is a static program that remains constant regardless of labor market conditions. The United States, along with Canada, are the only OECD countries that routinely adjust the generosity of their UI programs with the business cycle. For instance, during the 2007 - 2011 labor market downturn, the length of time that UI benefits could be collected in the United States increased to an unprecedented 99 weeks from the standard 26 weeks available under "normal" economic conditions, and the weekly benefit amount increased by $25. From an insurance perspective, losing one's job during a recession is a greater loss than during an expansion, and consequently, a greater benefit may be appropriate. However, it is also known that increasing UI generosity has a negative effect on job search intensity and puts upward pressure on wages leading to lower job creation. Given these benefits and costs, I seek to answer the questions: What structure of benefits over the business cycle is welfare-maximizing, and is the current policy of increasing the generosity of UI during recessions optimal?

To accomplish this, I develop a dynamic search model of the United States labor market which connects two parts of the optimal UI literature. The first takes a partial equilibrium approach to determine the optimal adjustments to UI when job finding rates fall, but does not consider UI's impact on job creation. The second endogenizes job creation, but does not address how the benefit system should adjust with the business cycle. The model I present is unique in that it allows for both.

Similar to studies that use the partial equilibrium approach, one of the main factors driving the optimal UI program in this paper is the moral hazard problem that arises from the inability to monitor the unemployed's job search. Shavell and Weiss's (1979) seminal work shows that a sequence of UI benefits that declines with the length of unemployment provides the necessary incentives to encourage job search, when the government's objective is to maximize welfare, subject to a fixed budget. Although not explicitly modeling firm behavior, Hansen and Imrohoroglu (1992) allow the UI budget to be endogenously determined, similar to this paper. The authors also frame the moral hazard problem in terms of the government's inability to monitor rejections of job offers, as well as allow for private savings. They find that the optimal replacement rate is quite low, just 0.15 in their baseline moral hazard case. Hopenhayn and Nicolini (1997) focus on unobservable search intensity and develop a widely used recursive contract approach to determine the cost-minimizing UI benefit schedule and employment tax, where the policy parameters are contingent on an individual's complete work history. A benefit amount that declines during one's unemployment spell, and a subsequent employment tax that increases with the length of unemployment is optimal and results in utility falling continuously during unemployment. Pavoni (2007) extends this approach by including a guaranteed lower bound on utility, which results in an optimal benefit schedule that falls sharply and includes a one time drop in benefits to a subsistence level. Alvarez-Parra and Sanchez (2009) explicitly model this lower bound by including a hidden labor market where workers can continue to receive UI benefits undetected. In this study, the optimal benefit schedule falls slowly at first to ensure workers search in the formal sector and then falls sharply to zero, allowing workers to derive consumption from the informal sector.

Kiley (2003) and Sanchez (2008) investigate how UI benefits should adjust when jobs become harder to find using a partial equilibrium approach similar to Hopenhayn and Nicolini (1997). Kiley (2003) shows that in order to provide a promised level of utility, the UI benefit schedule should be higher and fall at a slower rate when jobs are harder to find. Sanchez (2008) allows for multiple unemployment spells and also finds that, under plausible conditions, UI benefits should fall at a slower rate during downturns.

In contrast to the partial equilibrium literature, I account for UI's effect on the broader economy. Cahuc and Lehmann (2000), citing Holmlund (1998), state "it is well known that the level of unemployment benefits influences wages, labor cost and labor demand as well as search intensity" (137). These additional effects occur because when UI is more generous the value of unemployment increases, which strengthens the bargaining position of workers. This puts upward pressure on wages which deters job creation, a very undesirable result, particularly in recessions. Consequently, it is not clear that the results from Kiley (2003) and Sanchez (2008) will hold in a wage bargaining framework. Kahn (1987) also suggests that UI may influence the distribution of wages across firms with different layoff rates. In Kahn's (1987) model, firms with a higher layoff rate must compensate workers with a higher wage. A more generous UI benefit reduces the cost of unemployment allowing high layoff firms to lower the required wage premium. While Kahn's (1987) theory is an additional important consideration for designing an optimal UI system, for simplicity I do not allow heterogeneity in the separation rates in this paper.

I extend the search models of Cahuc and Lehmann (2000) and Frederickson and Holmlund (2001) that endogenizes wages and job creation, but do not determine the optimal changes in UI benefits over the business cycle. Cahuc and Lehmann (2000) show that while a declining sequence of benefits creates incentives for greater search, higher benefits for the short-term unemployed gives workers greater bargaining power, leading to higher wages and lower job creation. As a result, the negative effect of a declining sequence of UI benefits on unemployment and its positive effect on welfare is greatly mitigated when wages are endogenous. Frederickson and Holmlund (2001) extend Cahuc and Lehmann's (2000) work by assuming a positive probability of losing UI benefits, and determine the optimal UI system by maximizing a utilitarian welfare function. For reasons similar to Cahuc and Lehmann (2000), with a positive discount rate, it is unclear whether benefits should rise or fall. However, Frederickson and Holmlund (2001) conclude from their numerical exercise that benefits should fall with the duration of unemployment. In a more recent paper, Liu and Zeng (2008) allow for endogenous growth in a search framework. The authors show that more generous UI not only leads to higher unemployment, but also lowers the long-term growth rate. This result follows from the decline in demand that UI induces by decreasing employment. Lower demand, in turn, reduces incentives to conduct research and development leading to a decline in economic growth.

I build upon Cahuc and Lehmann (2000) and Frederickson and Holmlund (2001) in two important ways. First, the economy moves stochastically between recessionary and expansionary states, and the parameters of the benefit system are contingent on these states. Second, I model multiple periods of unemployment, rather than the two tiered structure of Cahuc and Lehmann

(2000) and Frederickson and Holmlund (2001), which both only allow for workers to be short-term or long-term unemployed. Multiple periods of unemployment allow search intensity to vary while collecting UI. This is consistent with Meyer's (1990) empirical results, which suggest that the escape rates from unemployment rise as one nears benefit exhaustion. In addition, since being newly unemployed serves as the opportunity costs to employment, disutility from search effort can influence wages. Also, Karni (1999) is critical of Frederickson and Holmlund's (2001) assumption of an idiosyncratic risk of losing UI benefits as a proxy for UI benefit duration. Multiple unemployment periods allows me to address this criticism by explicitly determining the optimum duration of UI benefits. In addition, I am able to analyze a UI system where benefits vary throughout one's unemployment spell, where Cahuc and Lehmann (2000) and Frederickson and Holmlund (2001) allow for benefits to only differ between the short-term and long-term unemployed.

In this paper, I present numerical experiments using three different unemployment systems. The first is similar to the norm in the United States where only the duration of benefits adjust with the business cycle. In this case, extending benefit duration during a recession is welfare-improving, although the extension is limited. The second system allows for both changes in the duration and level of benefits. In contrast to recent United States policy, a decline in the replacement rate is optimal in order to allow wages to adjust downward, mitigating the loss in jobs caused by the downturn. The last system allows benefits to vary throughout an individual's unemployment spell. The optimal benefit schedule declines during the unemployment spell in expansions and recessions, but the replacement rate in recessions is only higher than in expansions after the second month of unemployment.

2 Background

During every recession over the past half-century, the United States has increased the number of weeks that an individual may collect UI benefits. One way Congress accomplishes this is through Emergency Extended Benefit (EEB) programs, which Congress passes during each recession and specify effective beginning and ending dates (Vroman, Wenger, and Woodbury 2003). Within these dates individuals who exhaust their regular UI benefits receive an extension in the amount set forth by the legislation creating the program (U.S. Department of Labor 2007).

EEB programs differ dramatically in their length and the magnitude of the extension they provide. For instance, the EEB program of the early 2000s ran for a little more than one and half years and provided between 13 - 20 weeks of additional benefits at a cost of $23.4 billion (Nicholson and Needels 2006). In contrast, the Emergency Unemployment Compensation Act of 2008 (EUC08) has provided extensions of between 20 and 53 weeks, depending on the severity of a state's unemployment rate, for more than three years at a cost of over $140 billion (U.S. Department of Labor program statistics as of July, 2011). Additionally, unlike prior downturns where only the duration of benefits has been increased, the American Reinvestment and Recovery Act (ARRA) of 2009 provides an additional $25 in UI benefits a week (U.S. Department of Labor 2007).

In addition to EEB programs, the Federal State Extended Benefit (FSEB) program, which is typically funded equally by the states and the federal government, extends UI benefits up to an additional 13 weeks automatically in states that have an insured unemployment rate (IUR) greater than 5% and 20% higher than the prior two years.[1] A state may also implement a threshold based upon the more widely used total unemployment rate (TUR) that would extend UI benefits a total of 20 weeks if the TUR reaches 8% and is 10% higher than the prior two years (U.S. Department of Labor 2007). Once a state's unemployment rate falls below these thresholds, benefits can no longer be paid even if an individual has not received their full extension under the program (U.S. Department of Labor 2011). Since the ARRA allows for 100% federal funding of the FSEB benefits, many states have elected to implement these optional thresholds and qualify for up to 20

[1] The IUR is the unemployment rate based upon only those collecting UI and the employed that are covered by UI. At the state's option, two additional threshold levels can be implemented, but are not required by the program (Vroman and Woodbury 2004).

weeks of benefits from the FSEB program (U.S. Department of Labor 2007). Together with the EUC08 program, up to an additional 73 weeks of benefits are available in states with high unemployment rates. The wide variation in how benefits are adjusted during recessions, and the large costs of such programs, highlight the need for a greater understanding of the optimal UI adjustment over the business cycle.

3 Model

The model is a discrete time analog to the Pissarides (1991) model, where x' denotes the value of a variable x next period. The main variables and their descriptions can be found in Table 1. The economy consists of a finite measure of infinitely lived workers normalized to unity and an endogenously determined measure of firms. Workers can be either matched with a firm (employed), producing a numeraire good, or unmatched and searching for work (unemployed). Note there is no on the job search. Unmatched workers are categorized by the current duration of their unemployment spell $\{d \in \mathbb{Z} | 1 \leq D\}$. For tractability, these categories are finite, with all workers unemployed D or more periods grouped in category D. Throughout this paper, all workers in this category receive the same benefit, and consequently search intensity does not change after D periods. [2]

The government sets UI policy, which consists of a fixed tax paid by employed workers and a benefit schedule that is contingent on the economy's level of productivity, z, and the duration of one's unemployment spell. High levels of z are associated with an expansion and low levels a recession. All agents in the economy observe z. Consequently, knowledge of z indicates the current level of productivity and benefit schedule. Finally, an admissible policy must set expected

[2]Note that the assumption is of little consequence if D is large enough such that the measure of workers in this category is small. For the numerical experiments with $D = 18$, and the benefit system the calibration uses (see Section 5), the percentage unemployed D or greater periods is just 0.0023% in a persistent expansion and just 0.0063% in recessions. As a result, grouping all workers in D or greater periods together does not meaningfully influence the results.

revenues equal to expected expenditures.

Matching Technology and Worker Flows

A worker unemployed d periods can influence the job finding rate by exerting effort, $e(d)$. It is helpful to think of effort as an input into the production of job applications, with production function $a(e(d)) = e^{\gamma}$ with $\gamma \in (0,1)$. In aggregate, the effective number of applications is $u\bar{a}$, where $\bar{a}$ is the average number of applications generated by the unemployed, u. Firms create jobs by posting vacancies, μ. The total number of matches each period is given by a linear homogeneous function, $M(u\bar{a},\mu)$, and labor market tightness is $\theta = \frac{\mu}{u\bar{a}}$. A worker has a probability $p(\theta, e(d)) = a(e(d))\frac{M(u\bar{a},\mu)}{u\bar{a}} = a(e(d))\alpha(\theta)$ of finding a job and the firm's probability of filling a position is $q(\theta) = \frac{M(u\bar{a},\mu)}{\mu}$ (which implies $\alpha(\theta) = \theta q(\theta)$), where $\alpha'(\theta) > 0$ and $q'(\theta) < 0$. The matching function conforms to $\lim\limits_{\theta\to\infty} \alpha(\theta) = \lim\limits_{\theta\to 0} q(\theta) = \infty$ and $\lim\limits_{\theta\to 0} \alpha(\theta) = \lim\limits_{\theta\to\infty} q(\theta) = 0$. Matches are destroyed exogenously and at random and are fixed with respect to the business cycle. While empirically the United States separation rate is counter-cyclical, Hall (2005) and Shimer (2005) suggest that by far the main driver of unemployment during recessions is the job finding rate and a constant s approximates this aspect of the business cycle. [3]

Figure 1 presents the flows between the various labor market states. In addition, the figure provides the population in each state in brackets, which is also given by the following:

$$u'^{1} = sn \tag{1}$$

$$u'^{d} = u^{d-1}(1 - p(\theta, e(d-1))) \text{ for } d = 2, ..D-1 \tag{2}$$

$$u'^{D} = u^{D-1}(1 - p(\theta, e(D-1))) + u^{D}(1 - p(\theta, e(D))) \tag{3}$$

where u^d is the measure of workers unemployed d periods (or D or greater periods), and n is the measure employed. As the economy oscillates between recession and expansion, the job find-

[3] Results in this paper are driven by the interaction between the optimal UI system over the business cycle, search intensity and job creation, which would be unaffected by conditioning s on z. A simulation which indicates that the results are not sensitive to conditioning s on z, is available from the author.

ing rate increases and unemployment in each state slowly adjusts. It is important to note that, as Pissarides (1991) shows generally, and Section 4 shows specifically, θ immediately adjusts to a single value for each state of the economy and, as a result, is not part of the state space.[4]

Worker and Firm Behavior

As in Cahuc and Lehmann (2000) and Frederickson and Holmlund (2001), workers do not have access to capital markets and consume their entire income each period. Employed workers pay taxes and receive an after-tax income ω from their pretax wage w, and the unemployed receive a benefit, $B(z,d)$. Workers are risk averse with a constant relative risk aversion utility function over consumption, c, equal to $v(c) = \frac{c^{1-\sigma}}{1-\sigma}$, where c is equal to ω and $B(z,d)$ for employed and unemployed workers. Search is costly with a disutility equal to e.

The following Bellman equations characterize the discounted utility for the unemployed d periods, $U(z,d)$, and employed, $W(z)$:

$$\begin{aligned} U(z,d) &= \max_e v(B(z,d)) - e + \beta[p(e,\theta)EW(z') + \\ &\quad (1-p(e,\theta))EU(z',\min(d+1,D))] \end{aligned} \tag{4}$$

$$W(z) = v(\omega) + \beta[(1-s)EW(z') + sEU(z',1)] \tag{5}$$

where $\beta = \frac{1}{1+r}$ is the subjective discount rate shared by workers, firms, and the government. The following first order condition governs effort:

$$-1 + \beta p_e(e(d),\theta)E[W(z') - U(z',\max(d+1,D))] = 0 \tag{6}$$

With $p_{ee} < 0$, the marginal benefit of increasing the job finding probability decreases in effort and intersects a constant marginal cost at most once.

[4] When productivity falls, labor market tightness, θ, falls immediately and, as a result, effort as well. Since initially unemployment will be low, a drop in θ requires a large drop in vacancies. As unemployment increases, vacancies begin to recover, keeping θ constant.

To illustrate how the UI benefit system can influence search intensity in a partial equilibrium sense (fixed θ and w), first notice that $W(z')$ is decreasing in the payroll tax. Consequently, the marginal benefit of effort falls with the tax, decreasing a worker's effort at all unemployment durations. Next, consider how the benefit schedule influences search intensity of a worker who is unemployed $x < D$ periods. Since $EU(z', \max(x+1, D))$ is increasing in UI benefits at durations greater than x, a reduction in $B(z, d)$ at any period $d > x$ increases search intensity in period x. The government could also elicit greater effort through what is known as the entitlement effect. The primary effect of increasing benefits in periods $d \leq x$ is to increase the insurance a worker is entitled to in subsequent unemployment spells. Consequently increasing benefits at these durations increases $W(z')$, leading to greater search in period x. Since raising benefits in periods $d \leq x$ and lowering them in periods $d > x$ both increase effort, a declining sequence of benefits increases e throughout the unemployment spell. Further, for a UI system which includes a constant UI payment for a set duration and a lower benefit thereafter, the value of unemployment falls while effort rises up until the point UI benefits are exhausted. After exhaustion both $U(z, d)$ and e are constant.

The behavior of firms is governed by the discounted value of future profits. For unmatched firms this is given by:

$$V = -k + \beta[q(\theta)EJ(z') + (1 - q(\theta))EV] \tag{7}$$

When unmatched firms incur a cost, k, of maintaining vacancies. With probability $q(\theta)$, the firm will match with a worker and earn discounted expected profits, $EJ(z')$, and with probability $1 - q(\theta)$, the firm will continue unmatched. Discounted profits are given by:

$$J(z) = z - w + \beta[(1 - s)EJ(z') + sE(V - T(z))] \tag{8}$$

When matched, firms earn z and pay pre-tax wages, w. With probability s, the match is destroyed, and with probability $1 - s$ the match continues. As has become standard with search models, free entry implies firms post vacancies until their value in each period is zero (i.e. $V = 0$).

If a separation occurs, firms incur a termination cost, $T(z)$, which is non-transferable to the other agents in the economy. Similar to Silva and Toledo (2005), these costs can be interpreted as a disruption in the production process and may have differential impacts during recessions and expansions. The standard search model has been shown to do a poor job matching the empirical volatilities of key economics series (see Mortensen and Nagypal 2007 for a discussion), and the inclusion of termination costs allows me to ensure realistic movements in wages and unemployment without introducing a lot of additional complexity.

A single wage across the economy is set by firms and insiders (employees) and renegotiated at the beginning of each period through a Nash Bargaining mechanism:

$$\begin{gathered} \max_{w}[W(z) - U(z,1)]^{\phi}[J(z) - (V - T(z))]^{1-\phi} \\ \Rightarrow \frac{\phi[J(z)-(V-T(z))]}{(1-\phi)w} = \frac{[W(z)-U(z,1)]}{v_w w} \end{gathered} \tag{9}$$

where ϕ expresses the relative bargaining power of the two agents, and v_w is the partial derivative of $v(\omega)$ with respect to the gross wage. The fall back position of the firm is the value of the vacancies less the termination costs that firms must pay if they call off negotiations. A worker's fall back position is becoming newly unemployed ($d = 1$) and eligible to collect UI benefits.[5]

Equilibrium and Government

Given a UI policy, level of productivity and initial values for $u^1, ..., u^D$, the equilibrium is described by a vector $\{\theta, w, e(1), ..., e(D), u'^1, ...u'^D\}$ that satisfies (1)-(3), the wage setting equation, (9), the first order condition for search, (6), and the free entry condition. The next section solves the equilibrium in a simpler version which generalizes to the full model.

A benevolent government determines the UI policy that maximizes a utilitarian social wel-

[5]Note that in the United States those that voluntarily separate from employment are ineligible for UI. A fall back position of being eligible for UI implicitly assumes that if negotiations fail, the firm initiates the separation, and the employee is eligible for benefits.

fare function, SW, expressed by:

$$SW = E\left[\sum_{t=t_0}^{\infty}\beta^t\left[n_t v(\omega_t) + \sum_{d}^{D} {u_t}^d(v(B(z,d)) - e_t(d))\right]\right] \tag{10}$$

subject to the equilibrium of the decentralized economy and the constraint that expected government savings, GS, is zero:

$$GS = E_t\sum_{t=t_0}^{\infty}\beta^t n_t(w_t - \omega_t) - E_t\sum_{t=t_0}^{\infty}\beta^t\sum_{d}^{D}{u_t}^d B(z,d) = 0 \tag{11}$$

The maximization begins at t_0 which is far enough in the future such that any transitional dynamics from moving to the optimal policy have already taken place.

4 Model of Short and Long-Term Unemployed

The full model is too complex to derive meaningful analytical results. To provide some intuition on the factors that influence the optimal adjustments to UI over the business cycle, this section utilizes a simplified version of the model, similar to Cahuc and Lehmann (2000) and Frederickson and Holmlund (2001). In this section, z is given and deterministic. Since I examine only steady state results ($z = z'$), I use the notation $B(d) = B(z,d)$. The following simplifying assumptions are also made: (1) $D = 2$, with those unemployed one period ($d = 1$) considered short-term unemployed, collecting UI, and those unemployed more than one period ($d = 2$), long-term unemployed collecting a social assistance (SA) benefit, (2) I simplify the Nash Bargaining mechanism to a surplus sharing rule $\frac{\phi[J(z)-(V-T(z))]}{(1-\phi)} = [W(z) - U(1,z)]$, (3) taxes, τ, are lump sum such that $\omega = w - \tau$, (4) there is no discounting ($r = 0$), and (5) since the primary purpose of termination costs is to assist in the numerical calibration, they are set to zero. Also, note that with $D = 2$, the first order conditions for search, (6), are identical for both the short and long-term unemployed, and consequently, their effort is equivalent.

An equilibrium condition for wages can be determined by using (7) and (8), along with the free entry condition, to derive the following:

$$w = z - \frac{ks}{q(\theta)} \tag{12}$$

Using the definitions for J and $W - U(1) = (W - U(2)) - (U(1) - U(2))$ (see Appendix), together with the surplus rule, yields:

$$\Delta = \frac{\phi k}{(1-\phi)q(\theta)} - \frac{v(\omega) - (v(B(2)) - e) + s(v(B(1)) - v(B(2))}{p+s} + v(B(2)) - v(B(1)) = 0 \tag{13}$$

For a given UI policy and recognizing that τ and (12) define ω, Δ represents one equation in two unknowns, θ and e. The envelope theorem implies $\frac{\partial \Delta}{\partial e} = \frac{\partial W - U(2)}{\partial e} = 0$, and as a result, comparative statics for θ can be drawn solely from implicitly differentiating (13). Doing so indicates $\theta_{B(1)} < 0$, $\theta_{B(2)} < 0$, $\theta_\tau < 0$ and $\theta_z > 0$. Any adjustment to the UI system that increases its generosity (and would necessitate greater taxes), decreases the value of transitioning to work. This gives workers greater bargaining power, requiring firms to pay higher wages, which decreases job creation and labor market tightness. The effect of z on θ is straightforward; greater productivity increases profits, increasing incentives to create jobs and thus labor market tightness.

A moral hazard arises from the government's inability to observe search intensity. Thus, the worker's first order condition, (6), determines equilibrium effort. Decomposing $W - U(2)$ into $(W - U(1)) - (U(2) - U(1))$ and using the wage setting equation, along with definitions of J and $U(2) - U(1)$ (see Appendix), the following equation can be derived:

$$-1 + a'(e)[\frac{\phi k \theta}{(1-\phi)} + \alpha(\theta)(v(B(1)) - v(B(2)))] = 0 \tag{14}$$

Implicitly differentiating (14) and using the comparative statics developed for θ gives $e_{B(2)} < 0$, $e_\tau < 0$, and $e_z > 0$ contingent on $B(1) \geq B(2)$. Increasing the value of unemployment, by increasing $B(2)$, or decreasing the value of employment, by increasing τ, decreases the incentives to search. Higher levels of productivity increase the probability of finding a job, as well as labor earnings, both of which increase the benefits of search. Consequently, taking z as the measure of the state of the economy, effort is pro-cyclical. Since $B(1)$ leads to an increase in effort through the entitlement effect, but a decrease in effort by lowering θ, $e_{B(1)}$ is ambiguous.

As in Frederickson and Holmlund (2001), the government maximizes the utilitarian social welfare function $SW = rnW(z)+ru^1U(z,1)+ru^2U(z,2)$. Substituting the corresponding value functions and taking the limit as r approaches zero, the government's objective is to maximize:

$$SW = nv(\omega) - eu + u^1v(B(1)) + u^2v(B(2)) \tag{15}$$

subject to the government savings equaling zero, $n\tau - u^1B(1) - u^2B(2) = 0$, the equilibrium conditions of the decentralized economy, (12), (13), and (14) as well as the steady state values for the employment and unemployment rates, $n = \frac{p}{s+p}$, $u^1 = \frac{sp}{s+p}$ and $u^2 = \frac{s(1-p)}{s+p}$. Using these definitions, government savings constraint can be written as:

$$GS = p(e,\theta)[\tau - s(B(1) - sB(2))] - sB(2) = 0. \tag{16}$$

The first order conditions for $B(1)$ and $B(2)$, using the fact that (12), (13), and (14) define θ, w, and e, can be written as:

$$\frac{\partial SW}{\partial B(i)} + \frac{\partial SW}{\partial \theta}\theta_{B(i)} + \lambda[\frac{\partial GS}{\partial B(i)} + \frac{\partial GS}{\partial e}e_{B(i)} + \frac{\partial GS}{\partial \theta}\theta_{B(i)}] = 0 \text{ for } i = 1,2 \tag{17}$$

where λ is the multiplier on government savings. Equation (17) states that the marginal effect of providing greater consumption to the unemployed must be weighed against the direct monetary costs of providing additional benefits as well as the UI system's influence on effort and θ. While private individuals internalize all the direct social benefits and costs ($\frac{\partial SW}{\partial e} = \frac{\partial U(i)}{\partial e} = 0$ for $i = 1,2$), the moral hazard arises from workers not internalizing the effect of their search on government savings, $\frac{\partial GS}{\partial e} = p_e(e,\theta)[\tau - s(B(1) - B(2))] > 0$. Search increases the number of employed taxpayers and decreases the number of claimants, which is not considered by workers when choosing e. Consequently, the unemployed's effort is less than the social optimum. Further with $\theta_z > 0$, the effectiveness of search increases during expansions at all levels of e. In contrast to partial equilibrium models, benefits also decrease θ, which increases unemployment. As a result, greater UI benefits during recessions can exacerbate the unemployment problem.

Proposition 1: If a single optimum exists, the optimal insurance scheme involves (1) $B(1) > B(2)$ and (2) a UI benefit, $B(1)$, that increases with z under the reasonable sufficient condition that $\epsilon_{p,z}(u/u(2)) > \epsilon_{e,z}$ where $\epsilon_{i,j}$ is the elasticity of i, with respect to j.

Proof (for more detail see Appendix): The ratio of (17) for $B(1)$ and $B(2)$ can be written as:

$$[\tau - s(B(1) - B(2))]\frac{p}{e}\frac{\gamma^2}{(1-\gamma)}\frac{u}{u(2)} = B(1)^\sigma - B(2)^\sigma \tag{18}$$

For a given tax rate, Equation (18) represents an upward sloping expansion path in the ($B(2)$,$B(1)$) space where the indifference curves of SW are tangent to government savings. The term $p\frac{\gamma^2}{(1-\gamma)}\frac{u}{eu(2)}$ is strictly greater than zero which implies $B(1) > B(2)$. The optimal $B(1)$ and $B(2)$ is given by the intersection of (18) and the budget constraint, (16), which is downward sloping in the ($B(2)$,$B(1)$) space. An increase in z shifts the budget constraint upward, as the government gains more resources from more employed taxpayers, and the expansion path shifts upward as well under the reasonable condition that $\epsilon_{p,z}(u/u(2)) > \epsilon_{e,z}$. The net result is UI benefits increase (decrease) in expansions (recessions), while the effect on SA benefits is ambiguous.

The intuition behind the condition $\epsilon_{p,z}(u/u(2)) > \epsilon_{e,z}$, which comes from differentiating (18) with respect to z, is simple. Productivity and p are positively related and decrease unemployment. With fewer unemployed to benefit from a higher job finding rate, the value of lowering $B(1)$ to increase job creation falls. This is particularly the case if there are few long-term unemployed as represented by the term $u/u(2)$. In addition, as z rises, search becomes more effective at increasing government savings, and through the entitlement effect the government can increase incentives to search by increasing $B(1)$. However, effort also increases with z, and the higher associated disutility lowers the value of unemployment, increasing the benefits of using the UI system to encourage job creation, which suggests a lower $B(1)$. These margins lead to the requirement that $\epsilon_{p,z}(u/u(2)) > \epsilon_{e,z}$ is a sufficient condition for concluding $B(1)$ increases. While the complexity of model does not allow one to show this condition holds unambiguously, it is likely to be the case. Since e increases p and $(u/u(2))$, a higher $\epsilon_{e,z}$ leads to a greater $\epsilon_{p,z}u/u(2)$. In addition, the term $(u/u(2))$ is strictly greater than one, and taking the long-term unemployed to be those over six months, the average value for the United States is 7.11. As a result, $\epsilon_{z,e}$ typically must be more than seven times $\epsilon_{z,p}$ for it to be possible for $B(1)$ to fall (rise) in expansions (recessions).

As in much of the optimal UI literature, workers do not internalize the effect of their search effort on government savings. As a result, a falling sequence of benefits provides incentives to search. However, there are key differences from the existing literature when examining how the benefit system changes with the business cycle. First, proposition 1 suggests that, while adjusting UI with macro conditions is beyond the scope of Cahuc and Lehmann (2000) and Frederickson and Holmlund's (2001) studies, such adjustments are warranted. Further, the standard partial equilibrium approach that Kiley (2003) presents suggests that benefits throughout the unemployment spell should increase in recessions. However, lowering benefits early in the unemployment spell during recessions reflects: (1) the decline in short relative to long-term unemployed, (2) the lower positive effect of effort on government savings and (3) the ability to mitigate lower job creation during recessions by reducing UI benefits. Similar to Kiley (2003), an increase in benefits for the long-term unemployed in recessions may be warranted since the risks of long-term unemployment rise, and the cost, in terms of government savings, of the lower level of effort that higher long-term benefits induces is lower in recessions. However, higher benefits for the long-term unemployed also induce lower job creation (with discounting the effect of long-term benefits on θ is lower than the effect of short-term benefits), and as a result, it is unclear whether long-term benefits should increase during recessions as partial equilibrium models suggest. The ambiguity highlights the importance of the next section, which evaluates the full model numerically using realistic parameter values and UI systems that include benefit duration.

5 Numerical Experiments

This section returns to the full model. In the results to follow, the period length is a month, and I present the UI policy in terms of rates, where τ is the tax rate on wage income, $\omega = w(1-\tau)$, and $b(z,d) = \frac{B(z,d)}{w}$ is the wage replacement rate.

Calibration

Fully parameterizing the model requires values for β, s, ϕ, σ, k,γ and $T(z)$, a functional form for $M(u,\mu)$ and its parameters, and the stochastic process governing the productivity shocks. A summary of the parameter values can be found in Table 2. As a first step, I take several values from United States data and the related literature. Given a standard annual discount factor of 0.95, β is set to 0.996. I assume that z follows a first order Markov process taking values z^l or z^h, with transition matrix $P = \begin{bmatrix} p_{hh} & p_{hl} \\ p_{lh} & p_{ll} \end{bmatrix}$ where $p_{ij} = P(z' = j|z = i)$ for $i = l, h$ and $j = l, h$. I refer to states with $z = z^h$ as high or expansionary states and $z = z^l$ as low or recessionary states. To match the average length of recessions and expansions since 1950 (excluding the 2007 - 2009 recession), p_{hh} is set to 0.982 and p_{ll} to 0.903.

The matching function is Cobb-Douglas with $\alpha(\theta) = A\theta^{\eta}$ (see Petrongolo and Pissarides 2001). As in Frederickson and Holmlund (2001), I do not want policy conclusions to be influenced by inefficiencies in the labor market.[6] As a result, I employ Hosios's (1990) general condition for efficiency, $\eta = \phi$, and set both to 0.5 which is quite common in the literature. I set the coefficient of risk aversion, σ, to 1.37, which is the average of Chetty's (2006) estimates of risk aversion, based on Davis and Henrekson (2004), Prescott (2004), and Blau and Kahn's (2007) macro studies.

The remaining parameters (A, z^h, z^l, γ, k, $T(z^h)$, $T(z^l)$ and s) are set such that the model

[6] As noted by Hosios (1990), additional vacancies impose a negative externality on other firms by decreasing the job filling rate. When η increases, the negative externality of the firms increases. Thus, a social planner would like to limit the number of vacancies as η rises, which can be done by increasing workers' bargaining power. As a result, Hosios (1990) shows a general condition for efficiency is $\eta = \phi$.

matches specific targets. First, I normalize the average productivity to unity and set $T(z^h) = 0$. From Hagedorn and Manovskii (2008), I target an average job filling rate, $q(\theta)$, of 0.71 and an unemployment to vacancy ratio of 0.634. Next, I calibrate to the historic United States average duration of 2.906 months.[7] The unemployment rate for persistently low productivity states targets the average over the last five peak unemployment rates following the recessions prior to 2007. The average of these peaks is 8.8%. Similarly, for persistently high productivity states, the average of the last five troughs is 4.7%. Finally, I target the change in wages to Solon, Barsky, and Parker's (1994) estimate that a one percent increase in the unemployment rate corresponds to a 0.35 percent fall in wages.

To ensure that the model reflects these targets, I first set the benefit system to include a UI wage replacement rate of 0.448, a benefit duration of 6 months (based on Department of Labor data) and a social assistance replacement rate of 0.17, based on Wang and Williamson (1995), which is available after UI benefits are exhausted. Given values for the parameters that have yet to be specified, equilibrium values for θ, w, and $e(1), .., e(d)$ for the high and low productivity states can be determined by solving the non-linear system described by the value equations $(J(z), V, U(z,d), W(z))$, the wage setting equation, (9), free entry condition ($V = 0$), and the first order conditions for search (6). Finally, setting $u'^d = u^d$, the flow equations (1) - (3) solve for $u^1, ..., u^d$ and n in persistently high and low states. The target values are then calculated where averages are based on the weighted average of statistics in persistently high and low states using the ergodic probabilities from the transition matrix for z. I adjust the parameters not already specified until the calibration targets are reached and report their values in Table 2.

Two statistics deserve further discussion. First, while I do not explicitly target the effect of an extension in UI benefits, I do want to ensure that the effect is consistent with the empirical evidence. The weighted average, again using the ergodic probabilities, of the effect of a one month

[7] Based on Current Population Survey (CPS) data from World War II up to 1994. Since many researchers (see Elsby, Ryan, and Solon 2009) point out that the 1994 CPS redesign greatly inflates the average duration of unemployment statistics, I do not use the post-1994 data.

increase in UI benefits is a 0.171 month increase in the duration of unemployment. This is right in the middle of Katz and Meyer's (1990) estimates of 0.16 - 0.18. Secondly, s, which is used to match the calibration targets, also should realistically match the empirical data. From Fujita and Ramey's (2009) estimates, the average separation rate from 1976 to 2005 is 0.020, only somewhat higher than the calibrated value of 0.017. To explore if the results are sensitive to the lower value, I also present simulations with a higher separation rate.

Computational Strategy

I take a simulation approach to determining the optimal benefit scheme. The optimal UI policy must maximize SW, (10) such that, *(1)* it satisfies the budget constraint, (11), with equality; *(2)* in each month equilibrium values of θ, w, and $e(1), ..., e(D)$ are determined by ensuring that $U(z, d)$, $J(z)$ and $W(z)$ (equations (4), (5) and (8)) satisfy the wage setting equation (9), the first order conditions for search (6) and the free entry condition; and *(3)* the flow equations (1) - (3) determine the monthly unemployment rates. I first draw a time series of z's for 600 months using z's transition matrix with the restriction that the proportion of recessionary and expansionary states and the transition between the two states conform to their asymptotic values.

Given a UI policy equilibrium, values for θ, w and $e(1), ..., e(D)$ for each value of z are determined by numerically solving the non-linear system of equations represented by $J(z)$,$U(z, d)$, and $W(z)$, the free entry condition, $V = -k + \beta[q(\theta)EJ(z')] = 0$, the wage setting equation (9) and the first order conditions for search (6). Given the values for $e(1), ...e(D)$, θ and w conditional on each value of z, I create time series based on the monthly values of z. Next, using the simulated time series for $e_t(1), ...e_t(D)$ and θ_t, I derive $u_t^1, ..., u_t^D$ for each month using the flow equations (1) - (3) and a randomly drawn set of starting values $u_0^1, ..., u_0^D$.[8] To ensure that the simulation is not sensitive to these starting values, I drop the first 15 percent of the observations giving a simulated time series of just over 500 months.

[8]The initial values for unemployment are drawn from a beta distribution, and the total level of unemployment is drawn randomly from 0 to 0.13.

Given the simulated times series, it is now possible to evaluate the expected social welfare function (10) and expected government savings. First, I calculate the contribution to the social welfare, sw_t, and government savings, gs_t, at each period:

$$sw_t = n_t v(\omega_t) + \sum_{d=1}^{D} {u_t}^d (v(w_t b(z,d)) - e_t(d)) \tag{19}$$

$$gs_t = n_t w_t \tau - \sum_{d=1}^{D} u_t^d w_t b(d,z) \tag{20}$$

Rather than a single simulation, I need an estimate of the expected discounted time paths of sw_t and gs_t. Fully simulating new samples of 600 months, hundreds of times, is computationally infeasible, so I develop an estimate of the distribution. I sample sw_t, and the corresponding gs_t, with replacement from the original time series to develop 1,500 synthetic time series for sw_t and gs_t. Next, for each time series, I take the sum of the discounted values of sw_t and gs_t to derive a distribution of 1,500 values of social welfare and government savings. The objective function SW, (10), and budget constraint, GS, (11), is the mean of these values.[9]

Using the above steps to calculate the equilibrium values of θ, w, $e(1), ..., e(D)$ and $u^1, ..., u^D$ and then evaluate SW and GS for a given a UI policy, the optimal policy is found using a standard active-set Sequential Quadratic Programming optimization algorithm, where gradients are calculated numerically by perturbing each of the parameters of the UI system (see Fletcher 2008 for further details).

Optimal Unemployment Insurance Systems

This section presents numerical experiments from three benefit systems. The first, which I refer to as *fixed benefit levels*, is similar to the United States system where typically only the duration of benefits adjusts during recessions and the replacement rates are fixed at the calibration

[9] While this method of sampling will not yield the same distribution, even asymptotically, of the true distribution achieved by fully simulating the model, the expectations will be the same. Numerical experiments, available from the author upon request, with more feasible sample sizes, indicate that the means are essentially the same.

levels of 0.44 for UI and 0.17 for social assistance (SA). The second, which I refer to as *variable benefit levels*, allows both the duration and level of benefits to be contingent on the state of the economy. Finally, *unrestricted benefits* approximates a system which allows the government to optimize the level of benefits in each month.

For all three benefit systems I use an approximation. The *fixed* and *variable benefit levels* system each involve paying UI benefits, b_u, for x months and a SA benefit, b_s, thereafter. Since such a function is not differentiable, I approximate it using the following logistic function:

[Place Figure 2 Here]

with $K = 2.03$.[10] The function does not exclude the possibility that unemployment benefits could be exhausted in the middle of a month with workers receiving a portion of their income from UI and a portion from SA. To illustrate, Figure 2 plots an example of the logistic approximation with $b_u = 0.448$, $b_s = 0.170$ and a benefit duration 6.5 months. Along with the logistic approximation, the figure also plots the actual piecewise linear function with a benefit of b_u paid for 6 months, $0.5b_u + 0.5b_s$ paid for the 7th month, and b_s paid for months 7 and greater. The figure shows a very close fit between the approximation and piecewise linear function.

The unrestricted system requires a choice of the replacement rate for each month for each level of z. I take a more parsimonious approach and use a third order chebyshev polynomial, which requires just eight parameters regardless of the size of D, but is still flexible enough to encompass concave, convex, increasing, decreasing and non-monotonic time paths for the replacement rate.

Optimal Unemployment Insurance Systems

Table 4 presents two sets of results for the *fixed benefit levels* system. The first section reports the optimal duration of benefits for a static system when the duration is not contingent on the state of the economy. The second set of results presents the optimal duration, contingent on the productivity level. In addition to the policy parameters, the average unemployment rate, dura-

[10]Setting K to 2.03 is sufficient to ensure a R^2 of 0.99 between the logistic approximation for the UI system the calibration uses and the actual piecewise linear function, suggesting little is lost by using the approximation.

tion of unemployment, wages, θ and percentage unemployed less than 3 months (% d<3) in high and low productivity states are also reported.

Column (1) presents a baseline that uses the parameters from the calibration. The optimal system that is not conditional on the state of the economy provides a duration of almost ten months. Under this system, the average duration during high productivity states averages 3.144 and 4.680 in low states. The unemployment distribution also shifts out significantly during low states, with the percentage of unemployed less than three months falling by 20 percentage points in the low productivity states. These measures point to a need to provide greater insurance against long-term unemployment in recessions. Further, labor market tightness falls by almost two-thirds during a recession, which decreases the job finding rate at all levels of effort, and as a result, effort has a smaller positive effect on government savings in recessions. While these factors suggest increasing the duration of benefits during downturns, in contrast to the partial equilibrium approach, the large drop in θ could be mitigated by providing less generous UI benefits, making it unclear if an extension to UI benefits in recessions is appropriate.

When allowing the duration of benefits to be contingent on the state of the economy, an extension to UI benefits during recessions is optimal, but small. Since benefits early in one's spell cannot be reduced in the *fixed benefit levels* system, the desire to encourage (or not exacerbate) job creation is reflected in the minimal benefit extension the system provides. The baseline model in Column (1) indicates an optimal duration of 9.514 months in the high productivity state and 10.861 months in the low state, an extension of 1.347 months. This extension is much lower than the 3 months provided by the standard FSEB program and the average extension of 3.6 months provided by past EEB programs.[11] Only the initial phases of the EEB programs of the early 1980s and 1990s had similar extensions of 1.8 and 1.6 months (Nicholson and Needels 2006).

In addition to this baseline, the table reports sensitivities to three parameters. Column (2)

[11] Based on the mid-point of the minimum and maximum additional weeks provided by each EEB program reported by Nicholson and Needels (2006).

presents results with a significantly lower level of risk aversion ($\sigma = 0.75$), where the value of insurance falls, and workers are willing to accept more variability in their income. This is apparent in the longer durations of unemployment and higher unemployment rates in this column. The optimal duration of benefits is 1.6 months lower than the baseline for the static system and, in the state contingent system, just a 0.3 months extension during low states is optimal. The need for an extension to UI benefits appears to be sensitive to the level of risk aversion.

Column (3) examines the effects of a larger recessionary shock, which is accomplished by reducing z^l by 10 percent. The optimal static duration system, in this case, is 10.2 months, which reflects the longer unemployment spells in recessions. During low productivity states, the average unemployment rate is 0.50 percentage points higher, and the average duration is a little more than 0.2 months higher than the baseline. Under this scenario, the state contingent optimal UI system has a much larger spread than in the baseline. The extension in a low productivity state is 2.6 months, slightly less than the 3 months provided by the FSEB program.

Finally, to see if the results are sensitive to a separation rate closer to Fujita and Ramey's (2009) estimates, the last column increases s by 20%. The higher separation rate leads to unemployment rates that are 23% and 25% higher in the high and low productivity states, while unemployment duration increases by just 3% and 5%. The optimal duration of 10.152 is similar to Column (3) and slightly higher than in Column (1). In addition, the optimal duration conditional on the state of the economy is also higher in both states than the baseline. However, unlike Column (3) where resources are distributed away from the high to the low state, the extension is a much smaller 1.3 months, since the higher unemployment occurs in both states.

While the optimal duration of benefits during expansions is significantly longer, between 2.0 and 4.2 months, than the standard six months available in the United States during expansions, extensions during recessions range from just 0.3 months to 2.6 months, much smaller than what has typically been provided. Similar to the partial equilibrium literature, it appears that some adjustment to the UI system during recessions is optimal. However, the optimal adjustment is small when restricting changes in UI to the duration of benefits.

Variable Benefit Levels

This section relaxes the constraint that the level of UI and SA benefits remain at their calibrated levels. Table 5 reports the same statistics and sensitivities as in Table 4, along with the state contingent replacement rates. The results suggest a somewhat unclear picture as to whether UI generosity should increase during recessions. The optimal UI system includes an extension to the duration of UI benefits, but as the prior section notes, a lower replacement rate is optimal. The baseline calibration indicates that a duration of UI benefits in expansions of just 4.6 months and a replacement rate of 0.76 is optimal, significantly higher than the United States system. After UI benefits are exhausted, SA benefits are almost double the 0.17 rate the calibration uses. Although the duration is much lower than the fixed benefit system, the higher benefit level leads to a higher unemployment rate. The results for expansions are similar to Frederickson and Holmlund's (2001) no discounting case where they estimate $b_u = 0.72$, $b_s = 0.36$ and a duration of about 3 months with a risk aversion coefficient of two. However, allowing benefits to be contingent on z indicates that in recessions the UI system is quite different and includes an extension to benefits of 4.2 months, but a lower replacement rate of 0.66 for UI benefits and 0.19 for social assistance.

Allowing the replacement rate to adjust provides another tool for the government to smooth consumption, provide incentives for search, and influence job creation. Similar to the *fixed benefit levels* system, longer benefit durations in recessions is appropriate, as more workers are long-term unemployed. While the extension of UI benefits during recessions continues to be consistent with long standing United States policy, the optimal UI system calls for a drop in the UI replacement rate. This runs counter to both the ARRA, which allows for an increase in UI benefits in the most recent recession, as well as partial equilibrium models that suggest UI should unambiguously become more generous for the unemployed in downturns. Increasing benefits early in the unemployment spell increases effort through the entitlement effect. However, it is in expansions, when effort has the greatest effect on government savings, that the government would want to increase the power of the entitlement effect. The ARRA's policy also may be putting upward pressure on wages exacerbating already low job creation. In contrast to the partial equilibrium framework, the optimal UI system that Column (1) presents accounts for this, which further supports a lower replacement rate in recessions. The lower UI benefits makes wages more flexible, declining by 3.5 percent in the low productivity state compared to 2.8 percent for the *fixed benefit system*. Finally, providing the same level of UI benefits is more costly during low versus high productivity states since unemployment is higher. All of these factors contribute to the optimal UI replacement rate being 0.10 lower during recessions.

The results in the remaining three columns of Table 5 are largely consistent with the fixed benefit system. Lower risk aversion, Column (2), lowers the value of insurance, and the optimal policy has both a lower duration and lower replacement rates than Column (1). In Column (3), a steeper recession requires a larger change in UI benefits. The duration during a recession is 0.3 months higher, and the UI and SA replacement rates are 2.1 and 3.8 percentage points higher. The final column presents the results with a higher separation rate. Again in this column there is a higher mass of unemployed workers, and consequently, the UI system is costlier. To alleviate some of the costs, the optimal replacement rates are slightly lower than Column (1). However, with more workers unemployed longer than in the baseline, the optimal duration of benefits in recessions and expansions is slightly higher. Overall, in comparison to Column (1), it appears that the results are not very sensitive to a higher separation rate.

Unrestricted Benefits

Figure 3 presents the optimal UI policy when the government can adjust the replacement rate during each month of unemployment. Panel (a) plots the replacement rates for each period in high and low productivity states. In addition to the replacement rates based on the model I present with the Nash Bargaining mechanism, Panel (a) also plots the optimal replacement rates when wages are exogenous. This is accomplished by eliminating the wage bargaining equation and setting wages to the values that result from the calibration (0.850 in the high state and 0.811 in low state). As a result, the UI system has no effect on wages under this assumption. To illustrate how these wage assumptions influence the optimal UI system, Panel (b) plots the difference in the resulting replacement rates under these two assumptions in high and low productivity states.

Figure 3 indicates that under both wage assumptions it is optimal for benefits to fall with the duration of unemployment, consistent with prior research. However, the optimal schedule differs with the partial equilibrium approach Kiley (2003) uses in two important ways. First, Kiley (2003) shows that benefits should be higher during recessions at all durations. In contrast, the results show that in the beginning of an unemployment spell the replacement rate is lower during recessions in both wage scenarios. The higher benefits early in the unemployment spell provide incentives for greater effort during expansions through the entitlement effect. This is not a part of Kiley's (2003) model which allows for indefinite employment. Since effort generates greater government savings during expansions, the government would like to elicit more search intensity in good versus bad labor markets, which it can do by increasing benefits early in one's unemployment spell. The second difference is in the slopes of the optimal benefit schedule. Similar to Kiley (2003) and Sanchez (2008), benefits fall at a slower rate in recessions early in the unemployment spell, reflecting the need for greater insurance and a lower optimal level of search. However, after six months, benefits in the expansion fall at a slower rate relative to recessions. Thus, while in expansions the incentives to search, in the form of a quickly declining sequence of benefits, come early in the unemployment spell. In recessions these incentives come much later.

The differences between the optimal UI system under the two wage assumptions also highlights the importance of UI's influence on wages and job creation. The lower benefits when wages are endogenous, as depicted in 3(b), allows wages to adjust downward, increasing job creation. In addition, since the unemployed worker's threat point is the value of being newly unemployed, UI benefits early in the spell have the greatest negative impact on job creation. Consequently, the gap between the two optimal replacement rates is greatest early in the unemployment spell. In the high and low states, the optimal replacement rates when wages are endogenous are 11.9 and 12.4 percentage points lower in the first month of unemployment. A worker unemployed six months receives a total of 42% and 65% of monthly wages less in consumption during the course of their spell in low and high productivity states. Further, under endogenous wages, in recessions the replacement rate is below the rate in expansions for the first two months compared to just the first month when wages are exogeneous. This again reflects the fact that when wages are endogenous benefits early in the unemployment spell are particuarly effective in helping to mitigate the lower job creation that occurs during recessions.

Welfare Analysis

In this section, I measure the improvement in welfare for each UI system using the baseline calibration. To measure the welfare-improvement, I first calculate the percentage increase in consumption that all agents need to be indifferent between the standard UI system used in the calibration with six months of benefits, and the optimal UI systems. I then normalize this measure by dividing by the percentage increase in consumption that all agents would need to make them indifferent between the economy with and without recessions (see Lucas 2003 for a discussion of similar measures of the cost of business cycles).

Setting the duration optimally amounts to 2.94% of the total cost of recessions, while allowing the benefit duration to be contingent on productivity increases welfare by only an additional 0.05% of the cost of business cycles. A much greater increase in welfare however is possible by adjusting the benefit levels and duration, which increases welfare an additional 10.96% above the *fixed benefit* system. Further relaxing the structure of the UI benefit schedule and allowing the government to choose the benefit amount in every month of unemployment provides just an additional 0.54% of the total cost of business cycles above that of the *variable benefit levels* system, for a total increase in welfare of 14.49% of the costs of recessions. It appears that moving to a UI system that optimally sets both replacement rates and UI duration in recessions and expansions allows for a much greater increase in welfare than simply adjusting the duration of benefits to its optimal level.

6 Conclusion

UI policy in the United States is unique in the developed world. While most nations have chosen to provide generous benefits that insure the unemployed for long periods regardless of the state of the economy, the United States has chosen to provide benefits for the long-term unemployed (greater than six months) only during economic downturns. In this paper I investigate whether such a policy is welfare-enhancing when unemployment insurance can influence wages and job creation.

I find that adjusting UI benefits with macroeconomic conditions is appropriate. When limited to adjusting just the duration of benefits, an extension during recessions is warranted, although quite small, just 1.3 months. This is less than half the benefits provided by the FSEB program and less than 10% of the extension provided after the 2008 financial crisis. While it is welfare improving to provide greater insurance during labor market downturns, the small extension reflects UI's negative effect on job creation. Further, I find that in contrast to the temporary increase in the level of UI benefits during the most recent downturn, the UI replacement rate should decline in recessions to mitigate the downturn's effect on job creation and fund a longer benefit extension than is optimal when only the duration of benefits is adjusted. Finally, allowing the replacement rate to vary each month confirms past research that benefits should fall during an unemployment spell. However, in contrast to prior work, the optimal replacement rate in recessions is lower than in expansions for the first two months of unemployment.

It is important to note some limitations to this work that are beyond the scope of this paper and may be important for future research. The first is the automatic stabilization benefits of increasing UI over the business cycle, which, if included in the model, would likely increase the benefits of providing more generous benefits during recessions. A second important issue is private savings, which would reduce the value of insurance. Similar to other papers, private savings would reduce the optimal replacement rates, but there is little reason to believe that it would alter the main conclusions. Finally, I have ignored the additional moral hazard of being unable to observe the unemployed rejecting job offers as in Hansen and Imrohoroglu (1992), and the employed voluntarily separating, both of which lead to a denial or reduction of benefits. The inclusion of these additional UI eligibility requirements, as well as allowing the unemployed to negotiate with firms, would alter the threat point in the Nash Bargaining mechanism. In addition to introducing multiple wages which would increase the complexity of the model, the degree that the government monitors voluntary separations and job rejections would determine the degree that UI influences wages and job creation, which would mitigate some of the results derived in this paper.

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7 Tables

Table 1: Key Variable Definitions

Variable	Description	Variable	Description	Variable	Description
u^d	unemployment d periods	n	employment rate	$B(z, d)$	benefit level
s	separation rate	$p(e, \theta)$	job finding rate	e	level of effort
ϕ	bargaining parameter	σ	risk aversion	θ	labor market tightness
$v(c)$	utility function	ω	after tax wage	w	gross wage
z	productivity	k	vacancy cost	$q(\theta)$	job filling rate

Table 2: Parameter Values and Calibration Targets

Parameter (Description)	Value	Source	Parameter (Description)	Value	Source
β (discount rate)	0.996	Cahuc and Lehmann (2000)	$\bar{z}$ (avg. productivity)	1.000	Normalization
p_{hh} (high to high state transition probability)	0.982	Avg. duration of expansions (1950 - 2007Q3)	p_{ll} (low to low state transition probability)	0.903	Avg. duration of recessions (1950 - 2007Q3)
σ (risk aversion)	1.370	Chetty (2006)	b_u (UI replacement rate)	0.448	Department of Labor, 1991
ϕ (bargaining parameter)	0.500	Literature standard	b_s (SA replacement rate)	0.170	Wang and Williamson (1995)
η (elasticity of $p(e,\theta)$ with respect to θ)	0.500	Hosios (1990)			
Calibration Targets					
$u(z^h)$ (state h unemp.)	0.047	Derived from past 5 peaks	$u(z^l)$ (state l unemp.)	0.088	Derived from past 5 troughs
$q(\bar{\theta})$ (job filling rate)	0.710	Hagedorn and Manovskii (2008)	$\bar{u}/\bar{\mu}$ (unemp. to vacancy ratio)	0.634	Hagedorn and Manovskii (2008)
$\frac{w(z^h)}{w(z^l)}$ (h to l state wages)	1.048	Solon et al. (1994)	$\bar{d}$ (avg. unemp. duration)	2.906	Post WWII avg. up until 1994

Notes: Super-scripts h and l indicate values for the variable for the system at rest with high and low productivity.

$\bar{x}$ indicates the weighted average of x.

p_{ii} is calculated as one less one divided by the average length of expansions ($i = 0$) and recessions ($i = 1$).

Table 3: Calibrated Parameters

Parameter	Value	Parameter	Value
A (matching function parameter)	0.373	k (cost of maintaining vacancy)	4.599
z^h (high state productivity)	1.056	z^l (low state productivity)	0.701
γ (elasticity of $p(e,\theta)$ with respect to e)	0.627	s (separation rate)	0.017
$T(z^h)$ (termination cost high state)	0.000	$T(z^l)$ (termination costs low state)	4.985

Table 4: Fixed Benefit Levels

	Baseline		Decline in σ		Decline in z^l		Increase in s	
	(1)		(2)		(3)		(4)	
	High	Low	High	Low	High	Low	High	Low
Static UI System								
Policy Parameters								
Duration of Benefits	9.871		8.281		10.191		10.152	
Tax Rate (τ)	0.028		0.032		0.029		0.035	
Select Outcomes								
Unemployment Rate	0.055	0.091	0.065	0.113	0.055	0.096	0.067	0.114
Duration of Unemployment	3.144	4.680	3.778	5.822	3.172	4.896	3.253	4.912
Market Tightness (θ)	0.318	0.118	0.315	0.114	0.316	0.105	0.303	0.107
Wage (w)	0.851	0.824	0.851	0.830	0.847	0.784	0.831	0.802
% d<3	0.662	0.464	0.584	0.385	0.659	0.446	0.646	0.443
State Contingent UI System								
Policy Parameters								
Duration of Benefits	9.514	10.861	8.141	8.438	9.156	11.805	9.750	10.999
Tax Rate (τ)	0.029		0.032		0.029		0.036	
Select Outcomes								
Unemployment Rate	0.055	0.094	0.065	0.113	0.054	0.101	0.067	0.117
Duration of Unemployment	3.119	4.804	3.764	5.827	3.085	5.073	3.222	5.014
Market Tightness (θ)	0.318	0.117	0.315	0.114	0.317	0.103	0.303	0.106
Wage (w)	0.851	0.828	0.851	0.831	0.846	0.790	0.830	0.805
% d<3	0.666	0.453	0.586	0.385	0.671	0.431	0.650	0.434

Table 5: Variable Benefit Results

	Baseline		Decline in σ		Decline in z^l		Increase in s	
	(1)		(2)		(3)		(4)	
	High	Low	High	Low	High	Low	High	Low
Policy Parameters								
Duration of Benefits	4.581	8.825	4.195	7.241	4.265	9.108	4.616	9.016
UI Benefit	0.760	0.662	0.726	0.579	0.755	0.683	0.743	0.640
SA Benefit	0.325	0.189	0.255	0.172	0.337	0.227	0.319	0.189
Tax Rate (τ)	0.047		0.044		0.048		0.057	
Select Outcomes								
Unemployment Rate	0.063	0.110	0.069	0.120	0.063	0.123	0.076	0.134
Duration of Unemployment	3.558	5.388	4.015	6.096	3.613	5.949	3.620	5.575
Market Tightness (θ)	0.266	0.088	0.288	0.102	0.267	0.074	0.257	0.081
Wage (w)	0.864	0.835	0.859	0.827	0.857	0.807	0.845	0.812
% d<3	0.614	0.401	0.570	0.367	0.614	0.367	0.607	0.388

8 Figures

Figure 1: Employment and Unemployment Flows

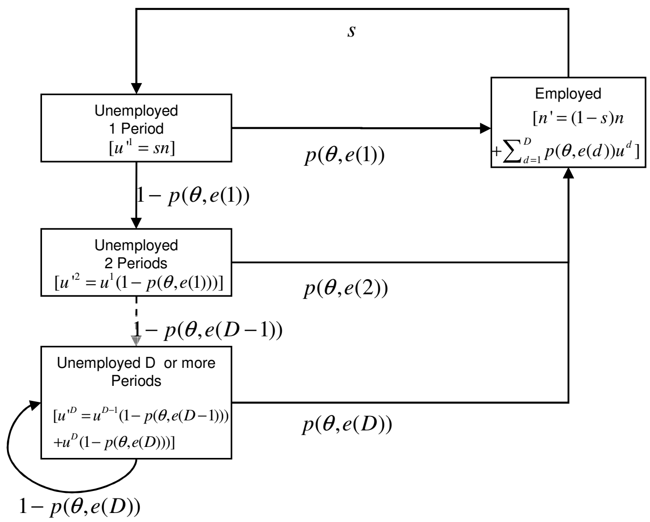


Figure 2: Logistic Approximation of UI System

$b(z,d) = [1 - \frac{1}{1+\exp(-K(\delta-d(z)))}]b_u + [\frac{1}{1+\exp(-K(\delta-d(z)))}]b_s \; z = z^h, z^l$

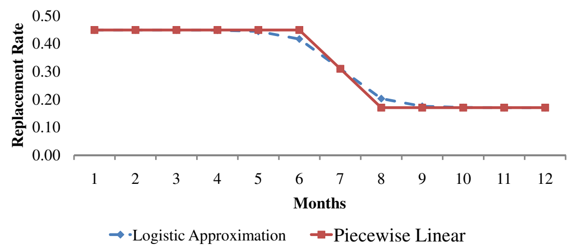
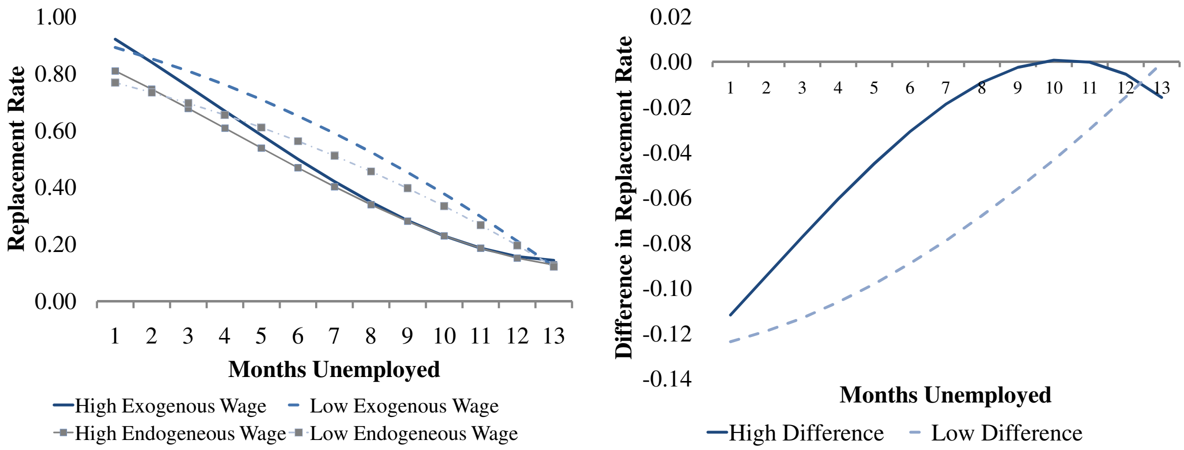


Figure 3: Unrestricted Benefits: Exogenous and Endogenous Wages Assumptions



(a) Replacement Rates

(b) Difference in Replacement Rates

Note: To conduct this analysis, D was set to 16, but the figure presents only the first 13 months. After the 13th month the estimated replacement rates rise slightly. Since the 16th state, $D = 16$, holds all workers unemployed 16 months or longer, the larger mass of workers increases the marginal benefit of providing greater insurance, i.e. a higher replacement rate.

Appendix

Present Value Differences: Imposing symmetry, taking the differences in present values and then taking the limit as r approaches zero yields:

$$W - U(1) = \frac{v(\omega) - [v(B(2)) - e]}{p+s} + p\frac{v(B(2)) - v(B(1))}{p+s} \tag{A1}$$

$$W - U(2) = \frac{v(\omega) - [v(B(2)) - e]}{p+s} + s\frac{v(B(1)) - v(B(2))}{p+s} \tag{A2}$$

$$U(1) - U(2) = v(B(1)) - v(B(2)) \tag{A3}$$

$$J - V = \frac{z-w}{s} \tag{A4}$$

Proposition 1: The ratio of the two first order conditions, after moving $(\frac{\partial SW}{\partial \theta} + \lambda\frac{\partial GS}{\partial \theta})\theta_{B(i)}$ to the right hand side can be expressed as: $\frac{v'(B(2))u(2)+\lambda[-u(2)+p_e(\theta,e)[\tau-s(B(1)-B(2)]e_{B(2)}]}{v'(B(1))u(1)+\lambda[-u(1)+p_e(\theta,e)[\tau-s(B(1)-B(2)]e_{B(1)}]} = \frac{\theta_{B(2)}}{\theta_{B(1)}}$. The definitions for $\theta_{B(1)}$ and $\theta_{B(2)}$ can be derived from Δ (Equation (13)) remembering that the envelope condition gives $\frac{\partial(W-U(1))}{\partial e} = 0$. With $\Delta_\theta = -\frac{\phi}{1-\phi}\frac{k}{q(\theta)^2}q'(\theta) + \frac{p_\theta}{p+s}(W - U(2)) - \frac{1}{(p(e,\theta)+s)}v'(W)\frac{ks}{q(\theta)^2}q'(\theta) > 0$, the comparative statics are $\theta_{B(1)} = -\frac{1}{\Delta_\theta}\frac{p}{p+s}v'(B(1)) < 0$ and $\theta_{B(2)} = -\frac{1}{\Delta_\theta}\frac{1-p}{p+s}v'(B(2)) < 0$. The definitions of $e_{B(1)}$ and $e_{B(2)}$ can be derived by implicitly differentiating (14). First define $\psi = [\frac{\phi k}{(1-\phi)} + \alpha'(\theta)(v(B(1)) - v(B(2)))] > 0$. Making use of the fact that $a''(e)\alpha(\theta)(W - U(2)) = a''(e)/a'(e)$, the comparative statics can be written as $e_{B(1)} = -\frac{a'(e)^2}{a''(e)}[\psi\theta_{B(1)} + a(\theta)v'(B(1))]$ and $e_{B(2)} = -\frac{a'(e)^2}{a''(e)}[\psi\theta_{B(2)} - a(\theta)v'(B(2))]$. Substituting the definitions of $\theta_{B(1)}$, $\theta_{B(2)}$, $e_{B(1)}$ and $e_{B(2)}$ and making use of steady state definitions for n,u^1 and u^2, and the functional forms for $a(e)$ and $v(c)$ yields Equation (18).

Rearranging the budget constraint, such that $B(1) = \frac{\tau}{s} - \frac{u(2)}{u(1)}B(2)$, it is easy to verify that when $B(2) = 0$, $B(1) > 0$, the locus of points that satisfy the budget constraint slopes down in the $(B(2), B(1))$ space while accounting for how $B(2)$ influences $\frac{u(2)}{u(1)}$, and that the budget constraint shifts up (larger $B(1)$ for all $B(2)$) except at $B(2) = 0$. Given these properties, along with the fact that (18) implies $B(1) > B(2)$, it must be the case, that for a single solution for the optimum of $B(1)$ and $B(2)$, (18) is upward sloping. Differentiating (18) with respect to z, for a given UI system, yields the condition $\epsilon_{p,z}u/u(2) > \epsilon_{e,z}$, if the expansion path shifts upward. Consequently, when the condition holds, $B(1)$ unambiguously increases, while the effect on $B(2)$

is ambiguous.