Do Changes in Unemployment Insurance Explain the Emergence of Jobless Recoveries?*

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Abstract

The last three recessions in the United States were followed by jobless recoveries: while labor productivity recovered, unemployment remained high. In this paper we propose and quantitatively evaluate a new explanation for this fact, namely that extensions of unemployment benefits in recessions slow down the recovery of employment. We are motivated by the fact that the duration of unemployment benefits is extended when the unemployment rate is high, and these extensions have become progressively more generous over time. We construct and calibrate an equilibrium search model of the labor market that incorporates these key features of the US unemployment insurance system. We find that the calibrated model is consistent with the facts that recoveries were not jobless prior to 1990 and became jobless thereafter.

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1 Introduction

A central question in macroeconomic analysis of the labor market is whether the cyclical behavior of unemployment can be accounted for by shocks to labor productivity. The emergence of jobless recoveries in the US economy suggests that the answer is negative: while aggregate labor productivity grows following a recession, unemployment remains high. Jobless recoveries are a prominent feature of the recessions of 1990-1991, 2001 and 2007-2009. This empirical fact has attracted significant attention in previous research.[1] It seems to imply that existing models with productivity-driven business cycles cannot explain the emergence of jobless recoveries, and substantial modification to the models is necessary. In this paper, we propose and quantitatively evaluate the hypothesis that cyclical changes in unemployment insurance policy, in conjunction with productivity shocks, can explain the cyclical behavior of unemployment. Specifically, we find that a standard equilibrium search model of the labor market, incorporating the changes in unemployment insurance, is quantitatively consistent with observed unemployment dynamics.

The unemployment insurance system in the United States is characterized by countercyclical generosity of unemployment benefits. Both automatic triggers in existing legislation and discretionary federal policies extend the maximum duration of unemployment benefits in times when the unemployment rate is high. Moreover, we document that such extensions in times of high unemployment have become more generous over the last 50 years. In other words, the generosity of unemployment insurance in recessions has increased relative to its generosity in booms.

To study the implications of this policy for the cyclical behavior of the labor market, we use a variant of the Diamond-Mortensen-Pissarides equilibrium search model with aggregate shocks to labor productivity. Workers and firms in the model match pairwise to produce and bargain over wages. Unemployment benefits increase the unemployment rate through two channels - they discourage firms from posting vacancies by raising the worker outside option, and they discourage workers from searching for existing job vacancies.

If unemployment insurance had been constant, a recovery in productivity in the model would imply a drop in unemployment. However, the actual unemployment insurance system extends the duration of unemployment benefits when unemployment is high. Because

[1] Aaronson, Rissman, and Sullivan (2004) discuss existing explanations that have been proposed for jobless recoveries. Bernanke (2003) attributes jobless recoveries to sluggish aggregate demand. Groshen and Potter (2003) propose structural change as an explanation, and Bachmann (2011) studies the role of labor hoarding. This is by no means an exhaustive list.

unemployment is high in the aftermath of a productivity drop, a recovery in productivity is likely to coincide with an extension of unemployment benefits, which can slow down or even prevent the recovery of employment. We argue that this channel lowers the correlation between productivity and unemployment and has the capacity to explain the emergence of jobless recoveries that we observe.

We evaluate the importance of this channel in our calibrated model by simulating the series of productivity shocks observed in the 1950-2011 and sequentially introducing the unemployment benefit extensions enacted during this period.

The advantage of using a structural model to conduct the analysis is that it enables us to conduct counterfactual experiments with respect to changes in unemployment insurance policy. Specifically, we can quantify the importance of the extensions by asking how the cyclical behavior of unemployment would have been different had the extensions not occurred.

Our paper is related to a recent literature attempting to quantify the importance of unemployment benefit extensions for unemployment in the 2007-2009 recession: Valletta and Kuang (2010), Fujita (2010), Nakajima (2011), Rothstein (2011). However, our paper is the first to link the growing generosity of extensions to the emergence of jobless recoveries, in particular to explain the unemployment experience of the 1990-1991 and 2001 recessions as well as the most recent one.

2 Model Description

2.1 Economic Environment

We consider a Diamond-Mortensen-Pissarides model with aggregate productivity shocks. Time is discrete and the time horizon is infinite. The economy is populated by a unit measure of workers and a larger continuum of firms.

Agents. In any given period, a worker can be either employed (matched with a firm) or unemployed. Workers are risk-neutral expected utility maximizers and have expected lifetime utility

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[x_t - c\left(s_t\right) \right],$$

where $\mathbb{E}_0$ is the period-0 expectation operator, $\beta \in (0,1)$ is the discount factor, x_t denotes consumption in period t, and s_t denotes search effort exerted in period t if unemployed. Only unemployed workers can supply search effort: there is no on-the-job search. The cost of search effort for unemployed workers $c : [0, 1] \to \mathbb{R}$ is twice differentiable, strictly increasing and strictly convex. This cost can be interpreted as either a time cost or a resource cost of search. An unemployed worker produces h, which stands for the combined value of leisure and home production.

Firms are risk-neutral and maximize profits. Workers and firms have the same discount factor β. A firm can be either matched to a worker or vacant. A firm posting a vacancy incurs a flow cost k.

Matching. Unemployed workers and vacancies match in pairs to produce output. The number of new matches in period t equals

$$M\left(S_t u_t, v_t\right),$$

where u_t is the unemployment level in period t, S_t is the average search effort exerted by unemployed workers in period t, and v_t is the measure of vacancies posted in period t. The quantity $N_t = S_t u_t$ represents the measure of efficiency units of worker search.

The matching function M exhibits constant returns to scale, is strictly increasing and strictly concave in both arguments, and has the property that the number of new matches cannot exceed the number of potential matches: $M\left(N, v\right) \leq \min\{N, v\}$ $\forall N, v$. We define

$$\theta_t = \frac{v_t}{N_t}$$

to be the market tightness in period t. We define the functions

$$\begin{aligned} f\left(\theta\right) &= \frac{M\left(N, v\right)}{N} = M\left(1, \theta\right) \qquad \text{and} \\ q\left(\theta\right) &= \frac{M\left(N, v\right)}{v} = M\left(\frac{1}{\theta}, 1\right) \end{aligned}$$

where $f\left(\theta\right)$ is the job-finding probability per efficiency unit of search and $q\left(\theta\right)$ is the probability of filling a vacancy. By the assumptions on M made above, the function $f\left(\theta\right)$ is increasing in θ and $q\left(\theta\right)$ is decreasing in θ. For an individual worker exerting search effort s, the probability of finding a job is $sf\left(\theta\right)$. When workers choose the amount of search effort s, they take as given the aggregate job-finding probability $f\left(\theta\right)$.

Existing matches are exogenously destroyed with a constant job separation probability δ. Thus, any of the $l_t = 1 - u_t$ workers employed in period t has a probability δ of becoming unemployed in period $t + 1$.

Production. All worker-firm matches are identical: the only shocks to labor productivity are aggregate shocks. Specifically, a matched worker-firm pair produces output z_t in period t, where z_t is aggregate labor productivity. We assume that $\ln z_t$ follows an AR(1) process

$$\ln z_t = \rho \ln z_{t-1} + \sigma_\varepsilon \varepsilon_t, \tag{1}$$

where $0 \le \rho < 1$, $\sigma_\varepsilon > 0$, and ε_t are independent and identically distributed standard normal random variables. We will write $z^t = \{z_0, z_1, ..., z_t\}$ to denote the history of shocks up to period t.

2.2 Government Policy

The government levies a constant lump sum tax τ on firm profits and uses its tax revenues to finance unemployment benefits b. Every worker, at each point in time, can be either *eligible* or *ineligible* for unemployment insurance, and receives b only if unemployed and eligible. We assume stochastic benefit expiration, similarly to Fredriksson and Holmlund (2001) and Faig and Zhang (2012). Eligible workers may lose their eligibility if unemployed, and ineligible workers may regain eligibility when employed. Specifically, the eligibility status of a worker evolves as follows:

- A worker who is eligible for unemployment insurance retains his eligibility the following period with probability 1 if employed, and with probability $1 - e_t$ if unemployed; with probability e_t he instead becomes ineligible.
- A worker who is ineligible for unemployment insurance remains ineligible the following period if unemployed, and becomes re-entitled to unemployment insurance with probability r_t if employed.

This assumption is made to mimic the actual system of benefit expiration and re-entitlement in the US while ensuring the stationarity of the workers' and firms' decision problems. Finally, the government policy can potentially depend on the current state of the economy, in particular on the unemployment rate.

2.3 Timing

1. The economy enters period t with some distribution of workers across employment and eligibility states:
    - l_t^E = measure of eligible employed workers;

- l_t^I = measure of ineligible employed workers;
- u_t^E = measure of eligible unemployed workers;
- u_t^I = measure of eligible unemployed workers.

Note that $l_t^E + l_t^I + u_t^E + u_t^I = 1$.

2. The aggregate shock z_t then realizes and is publicly observed. Production and consumption then take place: employed workers get wage w_t^E if eligible for unemployment insurance and w_t^I if ineligible (see below for how wages are determined). Unemployed workers receive $h + b$ if eligible for benefits and h if ineligible.

3. Firms decide how many vacancies to post, at cost k per vacancy. At the same time, unemployed workers choose their search effort s_t at the cost of $c(s_t)$. Letting S_t^E and S_t^I be the search effort exerted by an eligible unemployed worker and an ineligible unemployed worker, respectively, the aggregate search effort is then equal to $S_t^E u_t^E + S_t^I u_t^I$, and the market tightness is therefore equal to

$$\theta_t = \frac{v_t}{S_t^E u_t^E + S_t^I u_t^I} \tag{2}$$

4. $f(\theta)\left(S_t^E u_t^E + S_t^I u_t^I\right)$ workers find jobs. At the same time, a fraction δ of the existing $l_t = l_t^E + l_t^I$ matches are exogenously destroyed.

5. Eligible unemployed workers become ineligible with probability e_t and remain eligible with probability $1 - e_t$. At the same time, ineligible employed workers become eligible with probability r_t and remain ineligible with probability $1 - r_t$.

The laws of motion for the distribution of workers are then given by:

$$l_{t+1}^E = (1-\delta) l_t^E + S_t^E f(\theta_t) u_t^E + r_t \left[(1-\delta) l_t^I + S_t^I f(\theta_t) u_t^I\right] \tag{3}$$

$$l_{t+1}^I = (1-r_t)\left[(1-\delta) l_t^I + S_t^I f(\theta_t) u_t^I\right] \tag{4}$$

$$u_{t+1}^E = (1-e_t)\left[\delta l_t^E + \left(1 - S_t^E f(\theta_t)\right) u_t^E\right] \tag{5}$$

$$u_{t+1}^I = \delta l_t^I + \left(1 - S_t^I f(\theta_t)\right) u_t^I + e_t\left[\delta l_t^E + \left(1 - S_t^E f(\theta_t)\right) u_t^E\right] \tag{6}$$

2.4 Worker Value Functions

We characterize the problem of the worker recursively. The aggregate state of the economy in period t is denoted by $\Omega_t \equiv \left(z_t, l_t^E, l_t^I, u_t^E, u_t^I\right)$. The evolution of the aggregate state is then determined by equations (1), (3)-(6).

A worker entering period t eligible employed receives a wage w_t^E. Then he retains his job with probability $1-\delta$ and loses it with probability δ. If he loses his job, he also loses his eligibility with probability e_t and retains it with probability $1-e_t$.[2]

A worker entering period t as ineligible employed receives a wage w_t^I. Then he retains his job with probability $1-\delta$ and loses it with probability δ. If he retains his job, he becomes eligible the following period with probability r_t and remains ineligible with probability $1-r_t$.

A worker entering period t as eligible unemployed chooses search effort s^E and receives $h+b-c\left(s^E\right)$. He finds a job with probability $s^E f\left(\theta_t\right)$. If he remains unemployed, he loses his eligibility with probability e_t and retains it with probability $1-e_t$.

A worker entering period t as ineligible unemployed chooses search effort s^I and receives $h-c\left(s^I\right)$. He finds a job with probability $s^I f\left(\theta_t\right)$. If he remains unemployed, he also remains ineligible, and if he finds a job, he becomes eligible with probability r_t.

Denote the values of employed workers by W_t^E and W_t^I for eligible and ineligible workers, respectively. Similarly, denote the values of unemployed workers by U_t^E and U_t^I for eligible and ineligible workers, respectively. Then these values satisfy:

[2] We assume that a worker who has just become unemployed may lose his eligibility immediately. This timing assumption does not affect any of the results and is made purely for analytical convenience; we could have alternatively assumed that an eligible worker who just lost his job spends one period as eligible and only then may lose his eligibility.

$$
\begin{aligned}
W_t^E(\Omega_t) &= w_t^E + \beta(1-\delta)\mathbb{E}W_{t+1}^E(\Omega_{t+1}) \\
&\quad + \beta\delta(1-e_t)\mathbb{E}U_{t+1}^E(\Omega_{t+1}) + \beta\delta e_t \mathbb{E}U_{t+1}^I(\Omega_{t+1}) \qquad (7)
\end{aligned}
$$

$$
\begin{aligned}
W_t^I(\Omega_t) &= w_t^I + \beta(1-\delta) r_t \mathbb{E}W_{t+1}^E(\Omega_{t+1}) \\
&\quad + \beta(1-\delta)(1-r_t)\mathbb{E}W_{t+1}^I(\Omega_{t+1}) + \beta\delta\mathbb{E}U_{t+1}^I(\Omega_{t+1}) \qquad (8)
\end{aligned}
$$

$$
\begin{aligned}
U_t^E(\Omega_t) &= \max_{s^E} h + b - c\left(s^E\right) + \beta s^E f(\theta_t)\mathbb{E}W_{t+1}^E(\Omega_{t+1}) \\
&\quad + \beta\left(1 - s^E f(\theta_t)\right)(1-e_t)\mathbb{E}U_{t+1}^E(\Omega_{t+1}) \\
&\quad + \beta\left(1 - s^E f(\theta_t)\right) e_t \mathbb{E}U_{t+1}^I(\Omega_{t+1}) \qquad (9)
\end{aligned}
$$

$$
\begin{aligned}
U_t^I(\Omega_t) &= \max_{s^I} h - c\left(s^I\right) + \beta s^I f(\theta_t) r_t \mathbb{E}W_{t+1}^E(\Omega_{t+1}) \\
&\quad + \beta s^I f(\theta_t)(1-r_t)\mathbb{E}W_{t+1}^I(\Omega_{t+1}) \\
&\quad + \beta\left(1 - s^I f(\theta_t)\right)\mathbb{E}U_{t+1}^I(\Omega_{t+1}) \qquad (10)
\end{aligned}
$$

2.5 Firm Value Functions

A firm matched to an eligible worker receives profits $z_t - \tau - w_t^E$ and retains the worker for the next period with probability $1-\delta$. A firm matched to an ineligible worker receives profits $z_t - \tau - w_t^I$ and retains the worker for the next period with probability $1-\delta$. If it retains the worker, the worker becomes eligible the next period with probability r_t. Denote the value of a vacancy by V_t and denote by J_t^E, J_t^I the values of a firm matched with an eligible and an ineligible worker, respectively. Then the values of a matched firm satisfy:

$$
J_t^E(\Omega_t) = z_t - w_t^E - \tau + \beta(1-\delta)\mathbb{E}J_{t+1}^E(\Omega_{t+1}) + \beta\delta\max\{0, V_t(\Omega_{t+1})\} \qquad (11)
$$

$$
\begin{aligned}
J_t^I(\Omega_t) &= z_t - w_t^I - \tau + \beta(1-\delta)(1-r_t)\mathbb{E}J_{t+1}^I(\Omega_{t+1}) \\
&\quad + \beta(1-\delta) r_t \mathbb{E}J_{t+1}^E(\Omega_{t+1}) + \beta\delta\max\{0, V_t(\Omega_{t+1})\} \qquad (12)
\end{aligned}
$$

A firm posting a vacancy in period t suffers a flow cost k and fills its vacancy with probability $q(\theta_t)$. Let ϖ_t be the probability that, conditional on filling a vacancy, the worker hired by the firm is eligible for benefits. Then the value of a vacancy satisfies:

$$V_t(\Omega_t) = -k + \beta q(\theta_t)\left\{\varpi_t \mathbb{E} J_{t+1}^E(\Omega_{t+1}) + (1-\varpi_t)\mathbb{E} J_{t+1}^I(\Omega_{t+1})\right\} \tag{13}$$

The assumptions made above imply

$$\varpi_t = \frac{S_t^E u_t^E + r_t S_t^I u_t^I}{S_t^E u_t^E + S_t^I u_t^I} \tag{14}$$

Free entry of firms guarantees that the value of a vacancy is always zero in equilibrium, so we will have:

$$k = \beta q(\theta_t)\left\{\varpi_t \mathbb{E} J_{t+1}^E(\Omega_{t+1}) + (1-\varpi_t)\mathbb{E} J_{t+1}^I(\Omega_{t+1})\right\} \tag{15}$$

2.6 Wage Bargaining

We make the assumption, standard in the literature, that wages are determined according to Nash bargaining: the wage is chosen to maximize a weighted product of the worker's surplus and the firm's surplus. An eligible worker's surplus from being employed is defined by $\Delta_t^E = W_t^E - U_t^E$, and an ineligible worker's surplus from being employed is $\Delta_t^E = W_t^E - U_t^E$. Similarly, we define the surplus of a firm employing an eligible worker to be $\Gamma_t^E = J_t^E - V_t$, and for a firm employing an ineligible worker, $\Gamma_t^I = J_t^I - V_t$. The wage w_t^E is chosen to maximize the product

$$\left(\Delta_t^E\right)^{\xi}\left(\Gamma_t^E\right)^{1-\xi} \tag{16}$$

and similarly, the wage w_t^I is chosen to maximize the product

$$\left(\Delta_t^I\right)^{\xi}\left(\Gamma_t^I\right)^{1-\xi}, \tag{17}$$

where $\xi \in (0,1)$ is the worker's bargaining weight. Since the value of a vacancy is always zero, we have $\Gamma_t^i = J_t^i$ for $i = E, I$ and so the first-order conditions for the bargaining problems (16), (17) imply $\Delta_t^E = \xi\left(\Delta_t^E + J_t^E\right)$ and $\Delta_t^I = \xi\left(\Delta_t^I + J_t^I\right)$.

2.7 Equilibrium

We now define the recursive equilibrium of the model.

Definition 1 *Given a policy $(\tau, b, e(\cdot), r(\cdot))$, an equilibrium is a set of functions for wages $w^E(\Omega_t)$, $w^I(\Omega_t)$, search effort $S^E(\Omega_t)$, $S^I(\Omega_t)$, market tightness $\theta(\Omega_t)$, and value functions*

$$\left\{W^E(\Omega_t), W^I(\Omega_t), U^E(\Omega_t), U^I(\Omega_t), J^E(\Omega_t), J^I(\Omega_t), V(\Omega_t)\right\}$$

such that:

1. *The value functions satisfy the worker and firm Bellman equations (7)-(13)*

2. *Optimal search: The search effort S^E solves the maximization problem in (9) for s^E, and the search effort S^I solves the maximization problem in (10) for s^I*

3. *Free entry: The value $V(\Omega_t)$ of a vacant firm is zero for all Ω_t*

4. *Nash bargaining: The wage $w^E(\Omega_t)$ maximizes equation (16), and $w^I(\Omega_t)$ maximizes equation (17)*

5. *Laws of motion: The aggregate state Ω_t evolves according to equations (1), (3)-(6).*

3 Theoretical Analysis

The purpose of this section is to illustrate theoretically the main mechanism of the model. In this section, we make the following simplifying assumptions: (1) $z = \bar{z}$, i.e. we shut down stochastic aggregate productivity; (2) we abstract from search intensity decisions by exogenously setting $S = 1$ for all workers and assuming that search costs are zero;[3] and (3) we assume $r = 1$, that is, a worker who finds a job becomes eligible for benefits immediately.The purpose of this section is to show how a temporary extension of unemployment benefit duration slows down the recovery of employment.

3.1 Steady state equations

We first derive the steady state of this model. All employed workers are now identical with respect to their UI eligibility status, and we denote the value of an employed worker by W_t.

[3]Similarly, we could have kept the job finding rate per efficiency unit of search constant, and thus evaluated the change in search effort in response to an extension of benefits. The qualitative result and the intuition behind it is identical to the analysis presented. Furthermore, since both channels go in the same direction, the response in the full model would be amplified.

The value functions for workers become

$$W_t = w_t + \beta(1-\delta) W_{t+1} + \beta\delta(1-e) U^E_{t+1} + \beta\delta e U^I_{t+1} \tag{18}$$

$$\begin{aligned} U^E_t &= h + b + \beta f(\theta_t) W_{t+1} \\ &\quad + \beta(1-f(\theta_t))(1-e) U^E_{t+1} + \beta(1-f(\theta_t)) e U^I_{t+1} \end{aligned} \tag{19}$$

$$U^I_t = h + \beta f(\theta_t) W_{t+1} + \beta(1-f(\theta_t)) U^I_{t+1} \tag{20}$$

As before, define $\Delta^E_t = W_t - U^E_t$. Also define the surplus for an unemployed worker of being eligible: $\Phi_t = U^E_t - U^I_t$. The laws of motion for these quantities are:

$$\Delta^E_t = w_t - h - b + \beta(1-\delta-f(\theta_t)) \Delta^E_{t+1} + \beta(1-\delta-f(\theta_t)) e\Phi_{t+1} \tag{21}$$

$$\Phi_t = b + \beta(1-f(\theta_t))(1-e)\Phi_{t+1} \tag{22}$$

The flow value for a firm employing a worker is

$$J_t = \bar{z} - w_t - \tau + \beta(1-\delta) J_{t+1} \tag{23}$$

and the free entry condition must hold, so that

$$k = \beta q(\theta_t) J_{t+1} \tag{24}$$

Next, define the total surplus from a match $Y_t = W_t - U^E_t + J_t$, and use the fact that $J_t = (1-\xi) Y_t$ to get

$$Y_t = \bar{z} - h - b - \tau + \beta(1-\delta-\xi f(\theta_t)) Y_{t+1} + \beta(1-\delta-f(\theta_t)) e\Phi_{t+1} \tag{25}$$

And from (24),

$$\begin{aligned} \frac{k}{\beta(1-\xi) q(\theta_t)} &= \bar{z} - h - b - \tau + (1-\delta-\xi f(\theta_{t+1})) \frac{k}{(1-\xi) q(\theta_{t+1})} \\ &\quad + \beta(1-\delta-f(\theta_{t+1})) e\Phi_{t+1} \end{aligned} \tag{26}$$

Equations (22) and (26), together with the laws of motion for employment and the measure of eligible unemployed workers, completely characterize the equilibrium. The steady state of this economy is the unique solution (θ^*, Φ^*) to the system (22), (26) such that $\theta_t = \theta_{t+1} = \theta^*$

and $\Phi_t = \Phi_{t+1} = \Phi^*$:

$$\Phi^* = b + \beta \left(1 - f\left(\theta^*\right)\right)\left(1 - e\right)\Phi^* \tag{27}$$

$$\begin{aligned}\frac{k}{\beta\left(1-\xi\right) q\left(\theta^*\right)} &= \bar{z} - h - b - \tau + \left(1 - \delta - \xi f\left(\theta^*\right)\right)\frac{k}{\left(1-\xi\right) q\left(\theta^*\right)} \\ &\quad + \beta\left(1 - \delta - f\left(\theta^*\right)\right) e\Phi^* \end{aligned} \tag{28}$$

3.2 Transition to steady state

Let l^* be the corresponding steady-state level of employment, which, in the absence of search intensity decisions, must satisfy

$$l^* = \frac{f\left(\theta^*\right)}{\delta + f\left(\theta^*\right)} \tag{29}$$

Suppose the economy is initially at an employment level $l_0 < l^*$. Consider two policy scenarios:

1. The unemployment benefit policy is constant, i.e. the level is always b and the expiration probability is e. The stationary equilibrium of this economy is then characterized by the pair (θ^*, Φ^*), i.e. θ immediately assumes its steady-state value and L adjusts over time to its steady state value.

2. Alternatively, suppose the economy is initially in an extended-benefits regime, which differs from the steady state only in the expiration rate: $\tilde{e} < e$. Every period, with probability $\gamma > 0$ the economy switches to the steady-state regime and remains in the extended-benefits regime with the complementary probability $(1-\gamma)$. In particular, as $t \to \infty$, the economy converges to the steady state with probability 1, but its transition path looks different.[4]

Denote the worker and firm value functions in the steady-state regime by $\left(W^*, U^{E*}, U^{I*}, J^*\right)$ and in the extended-benefits regime by $\left(\tilde{W}, \tilde{U}^E, \tilde{U}^I, \tilde{J}\right)$. Also let w^* and $\tilde{w}$ be the corre-

[4] Alternatively, we could assume that the extended-benefit regime ends deterministically after exactly T periods. The logic of the argument that follows would be exactly the same. The current assumption makes the problem stationary and is more instructive for the exposition.

sponding wages. Then the worker values satisfy:

$$\tilde{W} = \gamma W^* + (1-\gamma)\left\{\tilde{w} + \beta(1-\delta)\tilde{W} + \beta\delta(1-\tilde{e})\tilde{U}^E + \beta\delta\tilde{e}\tilde{U}^I\right\} \tag{30}$$

$$\begin{aligned} \tilde{U}^E &= \gamma U^{E*} + (1-\gamma)\left\{h + b + \beta f\left(\tilde{\theta}\right)\tilde{W}\right. \\ &\quad \left. +\beta\left(1-f\left(\tilde{\theta}\right)\right)(1-\tilde{e})\tilde{U}^E + \beta\left(1-f\left(\tilde{\theta}\right)\right)\tilde{e}\tilde{U}^I\right\} \end{aligned} \tag{31}$$

$$\tilde{U}^I = \gamma U^{I*} + (1-\gamma)\left\{h + \beta f\left(\tilde{\theta}\right)\tilde{W} + \beta\left(1-f\left(\tilde{\theta}\right)\right)\tilde{U}^I\right\} \tag{32}$$

Similarly, the value of a firm is

$$\tilde{J} = \gamma J^* + (1-\gamma)\left\{\bar{z} - \tilde{w} - \tau + \beta(1-\delta)\tilde{J}\right\} \tag{33}$$

Simple algebra then shows that the equilibrium is characterized by an pair $\left(\tilde{\theta}, \tilde{\Phi}\right)$ that satisfies:

$$\tilde{\Phi} = \gamma\Phi^* + (1-\gamma)\left\{b + \beta\left(1-f\left(\tilde{\theta}\right)\right)(1-\tilde{e})\tilde{\Phi}\right\} \tag{34}$$

$$\begin{aligned} \frac{k}{\beta(1-\xi)q(\tilde{\theta})} &= \gamma\frac{k}{\beta(1-\xi)q(\theta^*)} + (1-\gamma)\left\{\bar{z} - h - b - \tau\right. \\ &\quad \left. + \left(1-\delta-\xi f\left(\tilde{\theta}\right)\right)\frac{k}{(1-\xi)q\left(\tilde{\theta}\right)} + \beta\left(1-\delta-f\left(\tilde{\theta}\right)\right)\tilde{e}\tilde{\Phi}\right\} \end{aligned} \tag{35}$$

Equation (34) implies

$$\tilde{e}\tilde{\Phi} = \tilde{e}\frac{\gamma\Phi^* + (1-\gamma)b}{1-\beta(1-\gamma)\left(1-f\left(\tilde{\theta}\right)\right)(1-\tilde{e})} \tag{36}$$

is an increasing function of $\tilde{e}$ and a decreasing function of $\tilde{\theta}$. Then, multiplying equation (35) through by $q\left(\tilde{\theta}\right)$, we get

$$\begin{aligned} \frac{k}{\beta(1-\xi)} &= \gamma\frac{kq(\tilde{\theta})}{\beta(1-\xi)q(\theta^*)} + (1-\gamma)\left\{q\left(\tilde{\theta}\right)[\bar{z} - h - b - \tau] + \right. \\ &\quad \left. + \left(1-\delta-\xi f\left(\tilde{\theta}\right)\right)\frac{k}{(1-\xi)} + \beta\left(1-\delta-f\left(\tilde{\theta}\right)\right)\tilde{e}\tilde{\Phi}q\left(\tilde{\theta}\right)\right\} \end{aligned} \tag{37}$$

Since the right-hand side is increasing in $\tilde{e}$ and decreasing in $\tilde{\theta}$ (after substituting (36)), equation(37) defines $\tilde{\theta}$ as an increasing function of $\tilde{e}$. It is obvious that when $\tilde{e} = e$, we would have $\tilde{\theta} = \theta^*$, $\tilde{\Phi} = \Phi^*$. This proves that when $\tilde{e} < e$, we have $\tilde{\theta} < \theta^*$, i.e. the market tightness is lower and therefore the job-finding rate is lower along the transition path under the extended benefit than under the benchmark. The temporary extension of unemployment benefits therefore slows down the transition of employment from l_0 to l^*. The magnitude of this effect is a quantitative question, which we now proceed to address.

4 Calibration

The model period is taken to be 1 week. We normalize mean weekly productivity to one. We set $b = 0.4$ to match the average replacement rate of unemployment insurance. We pick the tax rate $\tau = 0.023$ so that the government balances its budget on average. We will vary the function $e(\cdot)$ to mimic the variation in benefit duration in the US economy.

For the cost of search, we assume the functional form

$$c(s) = \frac{A}{1+\psi} s^{(1+\psi)} \tag{38}$$

For the matching function, we follow den Haan, Ramey, and Watson (2000) and pick

$$M(N, v) = \frac{Nv}{[N^\lambda + v^\lambda]^{1/\lambda}}$$

The choice of the matching technology is driven by the requirement that the job-finding rate and the job-filling rate always be strictly less than 1. We obtain:

$$f(\theta) = \frac{\theta}{(1+\theta^\lambda)^{1/\lambda}}$$

$$q(\theta) = \frac{1}{(1+\theta^\lambda)^{1/\lambda}}$$

Following Shimer (2005), labor productivity z_t is taken to mean real output per person in the non-farm business sector. This measure of productivity is taken from the quarterly data constructed by the BLS. We also use the seasonally adjusted unemployment series constructed by the BLS, and measure vacancies using the seasonally adjusted help-wanted index constructed by the Conference Board.

We set the discount factor $\beta = 0.99^{1/12}$, implying a yearly discount rate of 4%. The parameters for the productivity shock process are estimated, at the weekly level, to be

$\rho = 0.9895$ and $\sigma_\varepsilon = 0.0034$. The job separation parameter δ is set to 0.0081 to match the average weekly job separation rate. We set $k = 0.58$ following Hagedorn and Manovskii (2008), who estimate the combined capital and labor costs of vacancy creation to be 58% of weekly labor productivity.

This leaves five parameters to be calibrated: (1) the value h of non-market activity; (2) the worker bargaining weight ξ; (3) the matching function parameter λ; (4) the level coefficient of the search cost function A; and (5) the curvature parameter of the search cost function ψ. We calibrate these parameters following the procedure in Mitman and Rabinovich (2011). We target: (1) the average vacancy unemployment ratio; (2) the average job finding rate; (3) the standard deviation of the vacancy unemployment ratio; (4) the micro-elasticity of unemployment duration with respect to benefit level; and (5) elasticity of job finding rate with respect to the vacancy unemployment ratio[5]. Table 1 reports the calibrated parameters.

Table 1: Internally Calibrated Parameters

	Parameter	Value
h	Value of non-market activity	0.87
ξ	Bargaining power	0.08
λ	Matching parameter	0.49
A	Disutility of search	3.60
ψ	Search cost curvature	4.80

5 Policy Experiment

In order to determine to what extent unemployment benefit extensions played a role in the jobless recoveries from 1992 onwards, we simulate our model from 1951 forward. Over that time period, as discussed in Section C, there were 19 changes to UI benefit duration (excluding extensions and reauthorizations). In order to deal with this large number of policy changes and still solve a stochastic weekly model we make the following simplifying assumptions: (1) We assume that all policy changes are unanticipated, or equivalently zero probability events and (2) We assume that all agents in the model believe that the policy changes are permanent when enacted. We will, however, investigate the consequences of relaxing these two assumptions. Specifically, in the future we will consider two additional cases: (1) the length of the period for which an extension will remain in effect is announced together with the extension (as is the case with actual federal legislation), and agents believe

[5]Calibration details: To be completed.

that the extension will not be renewed after the statutory expiration date; (2) agents believe that, after the statutory expiration date, the extension will be renewed with some (potentially state-dependent) probability, since in reality discretionary renewals do take place.

The exogenous input to the model is labor productivity. We construct the labor productivity series using output per worker as reported by the BLS. We HP filter the quarter data with a smoothing parameter of 1600, then compute the log deviation from the filtered series. We then construct a smooth weekly series such that the quarterly average of the weekly series matches the quarterly detrended series. We take the unemployment rate in December 1950 as the initial condition and then simulate the model forward feeding in the constructed series for productivity. The equilibrium is thus a rational expectations one, but not one with future foresight over productivity realizations. At dates which correspond to policy changes, we implement the policy change and simulate the model forward allowing the unemployment rate to evolve endogenously.

6 Results

6.1 Jobless Recoveries

The simulated model is able to account for key features of the post-war labor market. In figure 3, we plot the unemployment rate generated from the model and that observed in the data. The model with the implemented US unemployment benefit policy generates volatility of unemployment on the order of what is seen in the data. The correlation between the two series is 0.67; however, restricting attention from 1970 onwards the correlation between model unemployment and data is 0.80.

We next investigate whether the model is consistent with the emergence of jobless recoveries. In figure 4, we plot the change in employment - actual and predicted by the model - relative to the NBER peak before the 1973-1975, 1980 and 1981-1982 recessions. The model replicates the response of employment over those periods quite well. Next, in figure 5, we similarly plot the change in employment for the 1990-1991, 2001 and 2007-2009 recessions. The model is able to replicate the observation that, unlike the previous three recessions, the recovery of productivity was not matched in this case by a rapid rise in employment.

Finally, we examine the role of unemployment benefit extensions in generating this result. To do so, we perform a counterfactual experiment where we shut down all the extensions except the EB program (which results in extensions of up to 13 or 20 weeks). The result is shown in Figure 6 for the 1990-1991, 2001 and 2007-2009 recessions. The figure illustrates that the model without the additional extensions cannot generate jobless recoveries: employment recovers much faster in the model than it does in the data. Unemployment benefit extensions are thus quantitatively important for explaining the cyclical behavior of employment.

6.2 The Beveridge Curve in the Great Recession

The model is also able to successfully replicate the counterclockwise movement in the Beveridge curve in the Great Recession. The model and data curves are plottined in figure 7. (DISCUSSION TO BE COMPLETED.)

6.3 Robustness

TO BE COMPLETED.

7 Conclusion

TO BE COMPLETED.

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A Tables and Figures

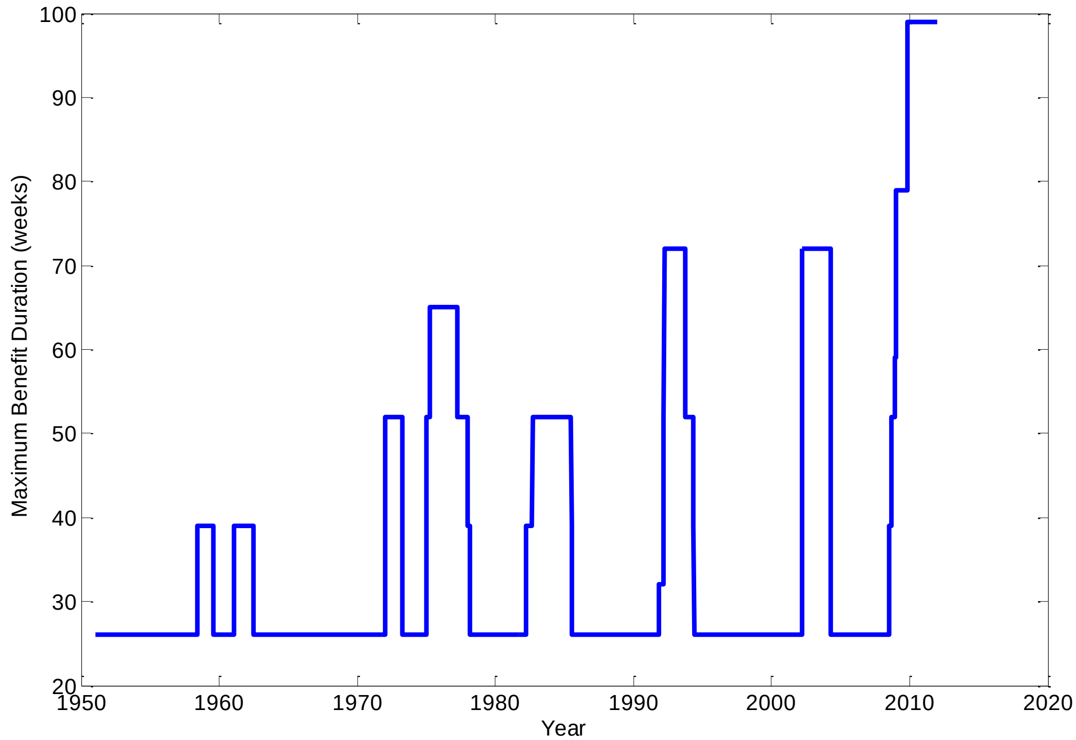

Figure 1: Maximum possible benefit duration available during the Post-War period. The extensions include a combination of discretionary federal extensions and the state-federal extended benefits program.

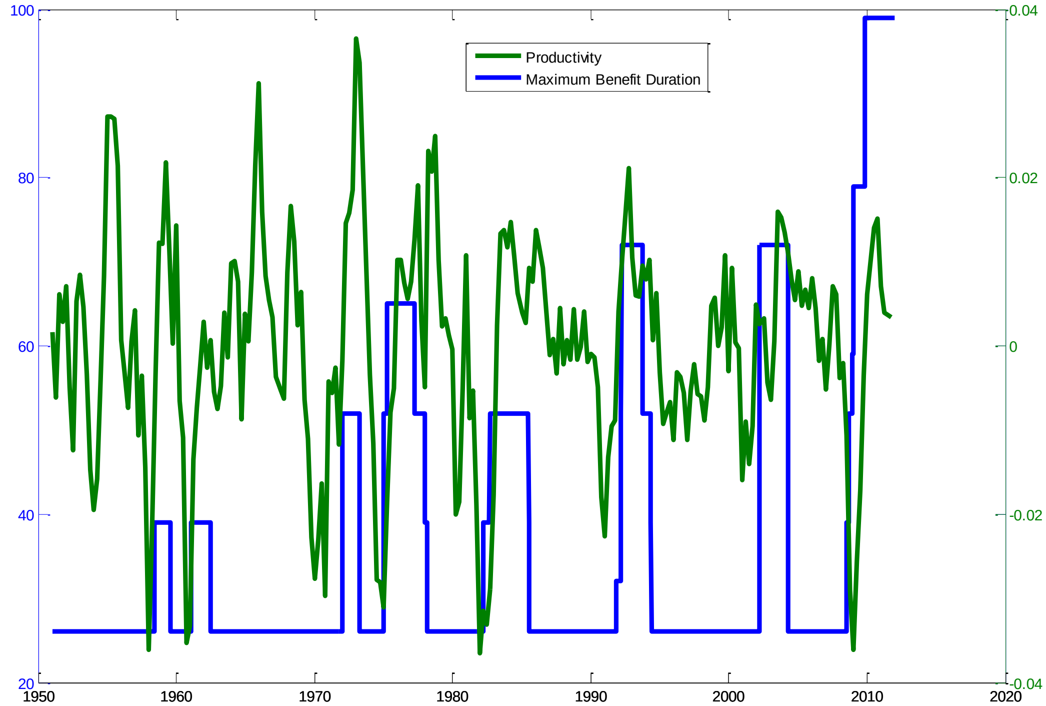

Figure 2: Maximum possible benefit duration available during the Post-War period and productivity. Productivity is calculate as log deviation from HP filtered trend of output per worker in the non-farm business sector reported by the Bureau of Labor Statistics. In the recessions follow the 1981-1982 recession, benefit extensions were more likely to occur after productivity had already begun to recover.

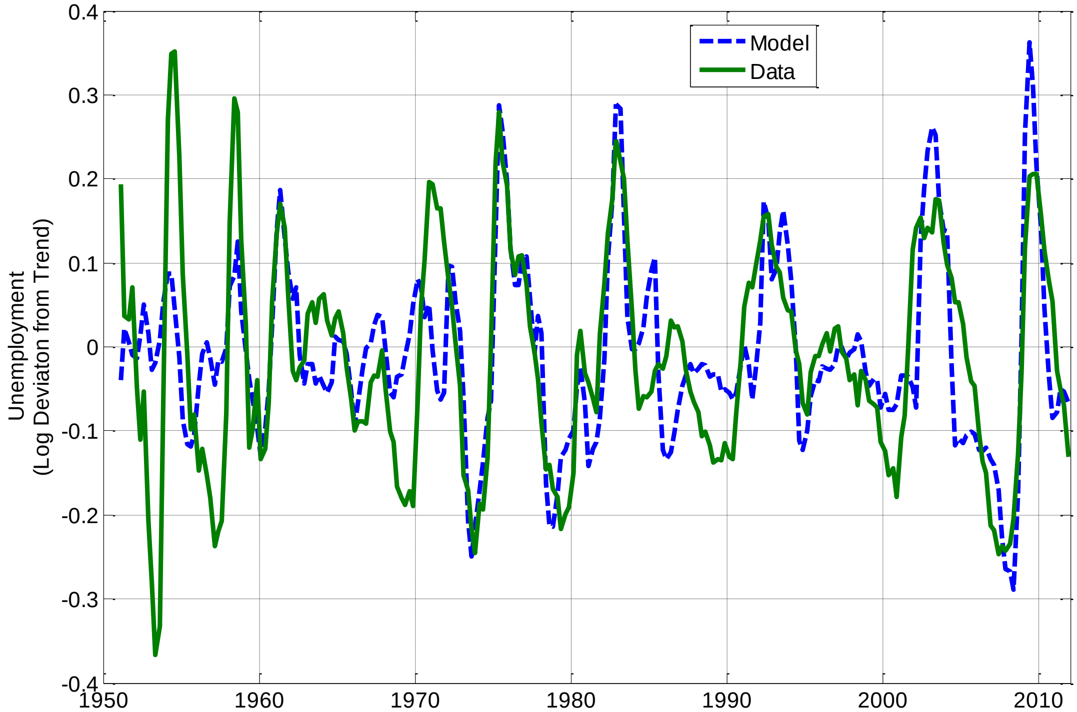

Figure 3: Simulated and actual unemployment from January 1951 through December 2011. Both series are quarterly averages of log deviations from HP filtered trend. The correlation between the two series is 0.67, from 1970 onwards the correlation is 0.80.

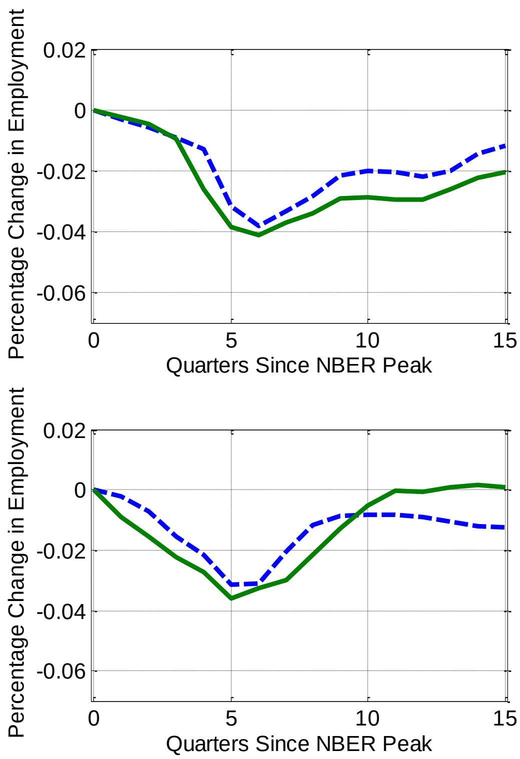

Figure 4: Simulated and actual percentage change in employment from NBER peak before the 1973-75, 1980 and 1981-82 recessions. The dashed blue line is the model and green line is the data. Data and model are not filtered.

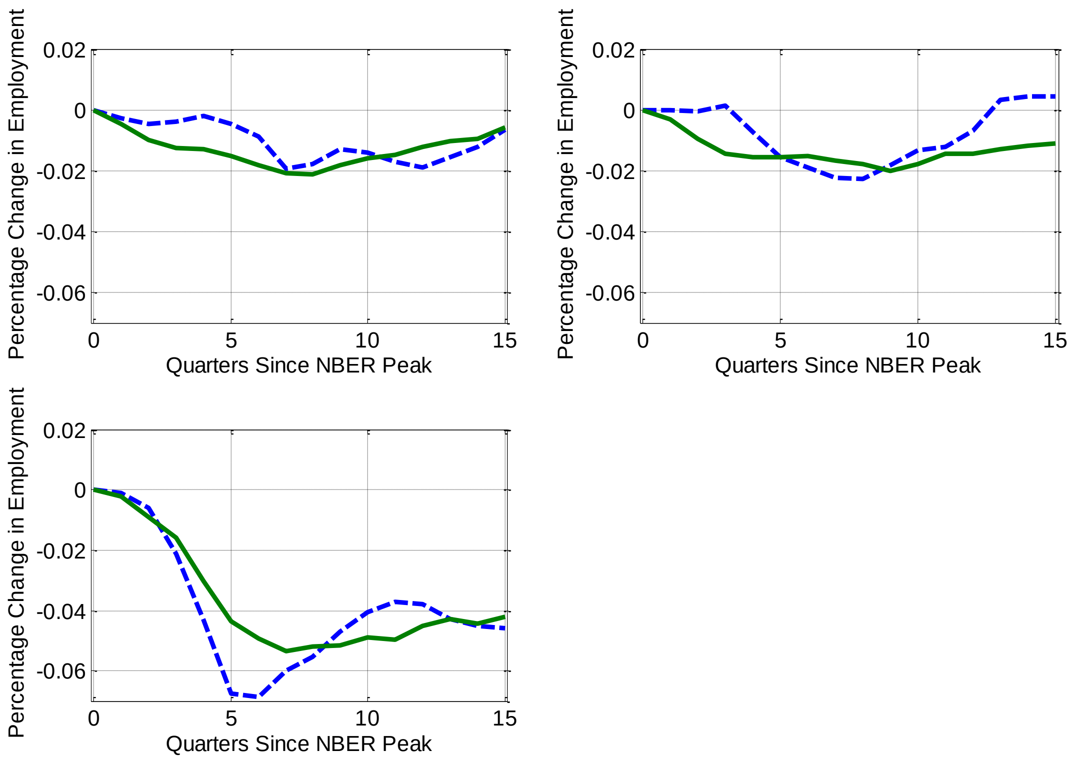

Figure 5: Simulated and actual percentage change in employment from NBER peak before the 1990-91, 2001 and 2007-09 recessions. The dashed blue line is the model and green line is the data. Data and model are not filtered.

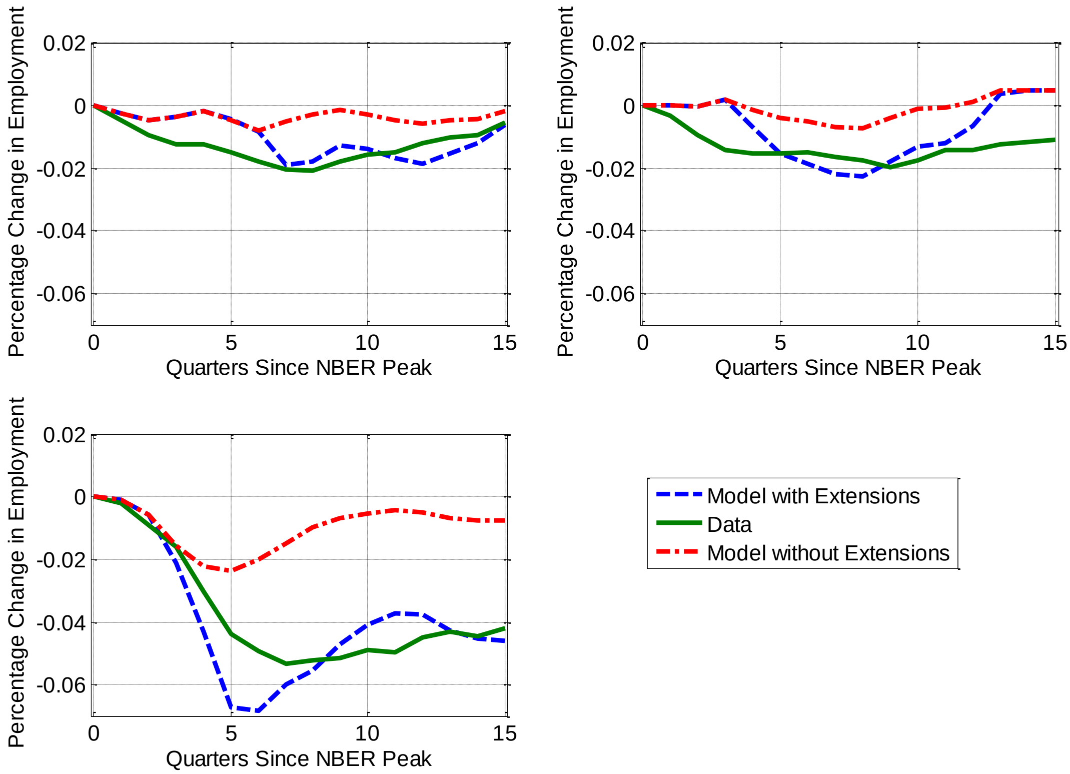

Figure 6: Simulated, actual and counterfactual percentage change in employment from NBER peak before the 1990-91, 2001 and 2007-09 recessions. In the counterfactual simulation only the EB program is active (resulting in extensions of up to 13 or 20 weeks). The difference between the model and counterfactual plots represents the contribution of the discretionary extensions to the change in employment. The dashed blue line is the model with discretionary extensions, the green line is the data and the dot-dashed red line is the counterfactual model. Data and model are not filtered.

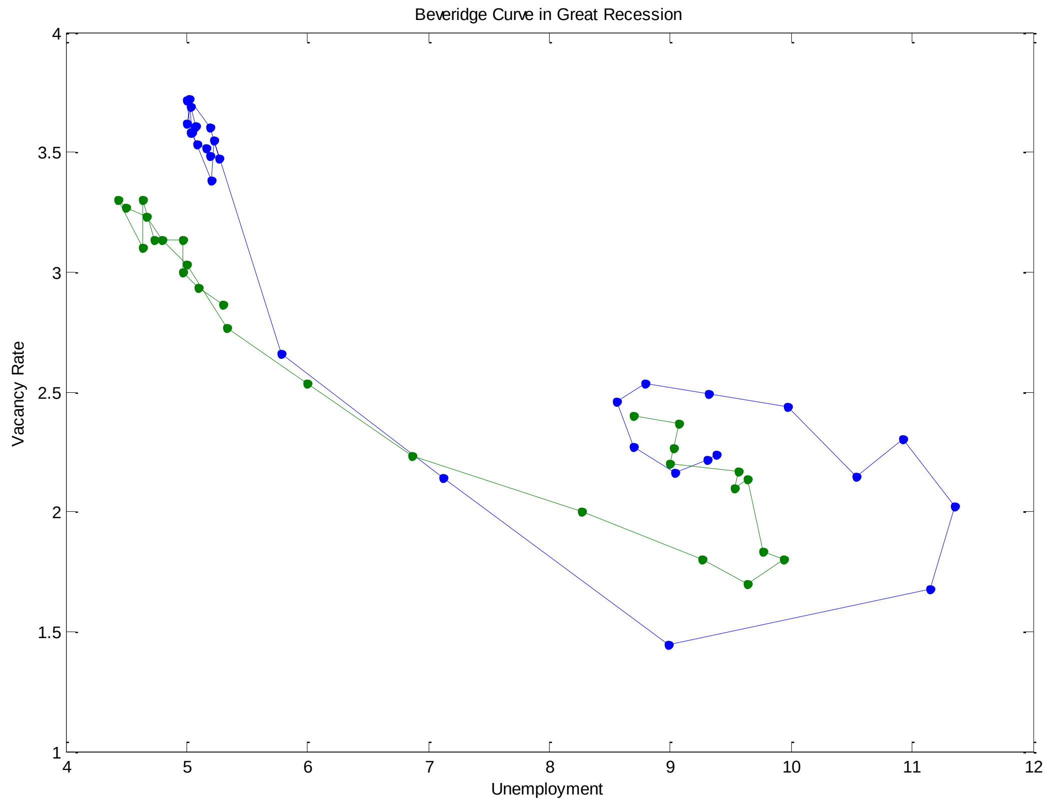

Figure 7: Simulated and actual Beveridge curve from January 2005 through December 2011. The unemployment and vacancy rates come from the BLS JOLTS database. Both series are plotted as quarterly averages of monthly (JOLTS) and weekly (model) data. Data and model are not filtered.

B Appendix

C The Post-War US Unemployment Insurance System: An Overview

By the late 1950s, most unemployment insurance systems in U.S. states offered 26 weeks of benefits to newly displaced workers. The deep recession of 1957-58, however, prompted the federal government to lengthen the duration of benefits available. Under the Temporary Unemployment Compensation Act (TUC), the federal government offered interest free loans to states in order to provide up to 13 additional weeks of benefits. Seventeen states opted to participate in the program, which lasted from June of 1958 until June of 1959.

The first federally financed extension of unemployment benefits occurred during the 1960-1961 recession. The federal government passed the Temporary Extended Unemployment Compensation Act (TEUC). Whereas TUC was a voluntary program, TEUC was mandatory for all states and provided up to 13 weeks of additional benefits to unemployed workers from April 1961 until June 1962. The extra weeks of benefits were entirely financed by the federal government (which raised the Federal Unemployment Tax to offset the extensions).

Guided by TUC and TEUC the federal government sought to develop an automatic system of extending unemployment benefits during recessions. In 1970 the Employment Security Amendments developed the Extended Benefits (EB) program, which would provide additional weeks of benefits to states experiencing high unemployment. The EB program is a state-federal partnership, with the costs of the extended benefits shared equally between the state and federal government. The EB program provided up to 13 weeks of additional benefits. The extended benefits can be "triggered" nationally when the unemployment rate crossed certain thresholds, or triggered within individual states when the state level unemployment crosses certain thresholds[6].

Following the recession of 1969-1970, in addition to additional benefits provided by the EB program, the federal government passed the Emergency Unemployment Compensation Act of 1971 (EUCA) which provided for an additional 13 weeks of benefits to states with high unemployment financed fully by the federal government. Thus, unemployed workers could receive up to 52 weeks of benefits under the regular, EB and EUCA programs[7]. The EUCA provided benefits from January 1972 through March 1973.

During the 1973-1975 recession the federal government passed the Federal Supplemental Benefits (FSB) program, which was in effect from January 1975 through October 1977. The program initially provided for 13 weeks of additional benefits financed from the federal government, but was amended to provide 26 weeks of benefits in March 1975. The EB program triggered on nationwide from February 1975 through December 1977. Thus, from March 1975 through October 1977 displaced workers could receive a total of 65 weeks of benefits (26 state + 13 EB + 26 FSB).

In 1980 and 1981 through the Omnibus Reconciliation Acts of those years, the federal government altered the EB program. It eliminated the national trigger for EB, and raised the

[6] Full details: To be completed.

[7] The triggers under EUCA were different than under the EB program. Thus some states only qualified for EB, others only for EUCA and some for both EB and EUCA.

thresholds for the state level triggers. In addition, it imposed stricter eligibility requirements for unemployed workers to receive benefits under the EB program.

During the 1981-1982 recession, the federal government established the Federal Supplemental Compensation (FSC) program in September of 1982. The tightening of the EB program under the OBRA legislation made roughly half of states ineligible to additional benefits under that program. FSC was amended several times from 1982 through early 1985. For the majority of the program duration, it provided up to 14 additional weeks of benefits financed by the federal government. Thus, the maximum weeks of benefits that could be received were 53 (26 state + 13 EB + 14 FSC).

After the 1990-1991 recession, the federal government passed the Emergency Unemployment Compensation (EUC) Act of 1991. The extension was amended several times from 1991 through 1994 providing at various times an additional 20, 26, 33 or 15 additional weeks of benefits. The benefits were financed entirely by the federal government. The maximum weeks of benefits that an individual could have received was 72 (26 state + 13 EB + 33 EUC). In addition, the EB program was amended to increase the maximum number of weeks payable. States with unemployment rates above 8% would now receive 20 weeks of benefits instead of 13.

In March 2002, after the 2001 recession, the federal government passed the Temporary Extended Unemployment Compensation (TEUC) act. The act provided up to 26 additional weeks of federally financed unemployment benefits through March of 2004. The maximum weeks of benefits that an individual could have received was 72 (26 state + 13 EB + 26 EUC).

During the 2007-2009, the federal government passed the Emergency Unemployment Compensation (EUC08) Act of 2008. The program initially provided up to 13 weeks of additional benefits financed by the federal government. The EUC08 has been amended 8 times to day, gradually raising the maximum additional benefits provided by the federal government to 53 weeks, making to total compensation that an unemployed worker could receive 99 weeks (26 state + 20 EB + 53 EUC08). The program is currently set to expire at the end of February 2012, but at the time of this writing the federal government seemed poised to extend the benefits through the end of 2012.

Beginning in the 1950s, federal unemployment benefit extensions in recessions have become increasingly generous. This is illustrated in Figure 1, where we plot the time path of maximum benefit duration from 1950 to 2011. In Figure 2 we plot the time path of maximum benefit duration together with the time series for aggregate labor productivity. This figure illustrates that, in the recessions following the 1981-982 recession, benefit extensions were more likely to occur *after* productivity had already begun to recover. As explained above, increasing generosity of benefits during a rise of productivity can potentially offset the effects of a productivity recovery. It is exactly this increasing generosity and how it has affected unemployment that we investigate quantitatively in this paper.