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A Quantitative Analysis of Unemployment Benefit Extensions

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Abstract

This paper measures the effect of extensions of unemployment insurance (UI) benefits on the unemployment rate using a calibrated structural model that features job search and consumption-saving decision, skill depreciation, UI eligibility, and UI benefit extensions that capture what has happened during the current downturn. I find that the extensions of UI benefits contributed to an increase in the unemployment rate by 1.2 percentage points, which is about a quarter of an observed increase during the current downturn (a 5.1 percentage point increase from 4.8 percent at the end of 2007 to 9.9 percent in the fall of 2009). Among the remaining 3.9 percentage points, 2.4 percentage points are due to the large increase in the separation rate, while the staggering job-finding probability contributes 1.4 percentage points. The last extension in December 2010 moderately slows down the recovery of the unemployment rate. Specifically, the model indicates that the last extension keeps the unemployment rate higher by up to 0.4 percentage point during 2011.

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1 Introduction

This paper measures the effect of extensions of unemployment insurance (UI) benefits on the unemployment rate using a calibrated structural model of job search. Facing the most severe recession since the Great Depression, the U.S. government enacted a series of extensions of UI benefits that provide an unemployed worker with the maximum of 99 weeks of UI benefits, compared with the regular duration of 26 weeks. While these extensions are one of the responses to the unemployment rate that reached 10 percent in late 2009, which was the second time this happened since 1982-83 in the postwar U.S. history, it is also possible that the extensions themselves contributed to the rising unemployment rate by encouraging jobless workers to remain unemployed so that they received the UI benefits for an extended duration and by discouraging the unemployed to search for a job intensively.

Although there are existing attempts to measure the effect of UI benefit extensions on the unemployment rate, this paper is the only one that uses a structural model to answer the question. The structural approach employed in this paper has two distinctive advantages. First, although the maximum duration of 99 weeks is often seen in the headlines, it does not mean that all unemployed workers are eligible for the maximum duration. To the contrary, the maximum duration of UI benefits for each jobless worker is increased gradually with a series of extensions. Moreover, the extensions are temporary. Using a structural model and replicating the extensions in the model allow me to take into account the gradual and temporary nature of the extensions. Second, with a calibrated structural model at hand, I can implement counterfactual experiments. For example, I will evaluate how the last extension in December 2010 affects the path of the unemployment rate in the future.

I find that the ongoing extensions of UI benefits contributed to an increase in the unemployment rate by 1.2 percentage points. Since the unemployment rate went up by 5.1 percentage points, from 4.8 percent before the current downturn started at the end of 2007 to 9.9 percent in the fall of 2009, the contribution of the series of UI benefit extensions is close to a quarter (24 percent). Among the remaining 3.9 percentage points, 2.4 percentage points are due to the large increase in the separation rate, while the staggering job-finding probability contributes by 1.4 percentage points. I also find that the last extension slows down the recovery of the unemployment rate; the model indicates that the last extension in December of 2010 keeps the unemployment rate higher, by up to 0.4 percentage point during 2011, and the economy reaches an unemployment rate of 6 percent one month later because of the last extension.

There are other studies that use the empirical approach to quantify the effect of UI benefit extensions on the unemployment rate and the number obtained in this paper (1.2 percentage points) is within the range of estimates obtained by other studies. Valletta and Kuang (2010) use the Current Population Survey (CPS) and measure the increase in the number of involuntary job losers as well as the average duration of unemployment of the job losers during the current downturn in order to quantify the impact that UI benefit extensions have on the unemployment rate. The increase in the number of involuntary job losers affects the unemployment rate strongly because they tend to stay in the labor force and search for a job. They conclude that the UI benefit extensions contribute to a modest 0.4 percentage point to the unemployment rate when it reached 10 percent. Since they do not explicitly consider the behavioral channel by which the job search intensity is discouraged by generous UI benefits, their estimate probably under-estimates the overall impact of the extensions. Fujita (2010b) estimates the escape probabilities from unemployment during 2004-2007 and during 2009-2010 and uses the changes in the escape probabilities, especially the changes in the "spikes" around the time of UI benefit exhaustion, to quantify the effect of UI benefit extensions on the unemployment rate. He finds that UI benefit extensions contribute to an increase of 0.8-1.8 percentage points to the unemployment rate. He also quantifies the relative importance of the lower job finding rate (escape to employment) and the lower probability of exiting the labor force (escape to out-of-labor-force), and finds that the latter is much less significant. His finding support the abstraction of the labor force participation decision in the model used in this paper.

There is a long list of literature that tries try to quantify the effect of the level and duration of UI benefits on unemployment duration. Regarding the level of UI benefits, existing estimates are in the rage of a 0.5-1.5 week increase in average duration of UI-eligible workers associated with a 10 percentage point increase in the replacement rate of UI benefits. All estimates listed below are obtained by estimating the hazard function out of unemployment, but the difference arises because of the data, estimation methodology, and the sample period. Hamermesh (1977) concludes that "the best estimate – if one chooses a single figure – is that a 10 percentage point increase in the gross replacement rate leads to an increase in the duration of insured unemployment of about half a week when labor markets are tight." Moffitt and Nicholson (1982) find that a 10 percentage point increase in the replacement rate is associated with an increase in unemployment duration of about 0.8-1.0 week. Meyer (1990) estimates the effect to be an increase of 1.0-1.5 weeks of average unemployment duration. Moffitt (1985) obtains the effect to be a 0.5 week increase in potential duration.

Regarding the effect of an increase in the duration of UI benefits on the average unemployment spell, existing estimates are in the range of a 0.1-0.2 week increase in average unemployment duration in response to a one-week increase in the duration of UI benefits. Moffitt (1985) estimates the effect of a one-week extension of UI benefits to be about a 0.15 week increase in the average unemployment spell of UI recipients. Moffitt and Nicholson (1982) estimate the effect to be 0.1 week. The estimate obtained by Katz and Meyer (1990) is a 0.16-0.20 week increase in the average duration of unemployment spells by UI recipients. More recently, Card and Levine (2000) obtain the smallest estimate. They use the UI benefit extension of 13 weeks in New Jersey that lasted for six months and estimate the effect of a one-week increase in UI benefits on the average unemployment duration to be 0.08 week.

The strength of the response of unemployment duration or the unemployment rate to changes in either the level or duration of UI benefits has a strong policy implication because it affects the optimal properties of the UI system. Simply put, the stronger this moral hazard effect from more generous UI system is, the less generous the optimal UI benefit should be. The literature identifies three kinds of benefits from UI – (1) consumption smoothing, (2) the liquidity effect on search intensity, and (3) better resulting matches because jobless workers are less desperate when they have generous UI benefits – and two kinds of costs from unemployment insurance – (1) moral hazard and (2) skill depreciation. Gruber (1997) studies the positive role of UI for consumption smoothing. He estimates that, in the absence of UI, the consumption of the unemployed would fall by 22 percent, which is three times the average fall in the presence of the UI program. The liquidity effect is emphasized by Chetty (2008), and the positive effect on the match quality is analyzed by Diamond (1981) and more recently by Acemoglu and Shimer (2000) using a structural macroeconomic model. The skill depreciation is the main focus of Ljungqvist and Sargent (1998) in explaining the dynamics of unemployment in Europe. Fujita (2011) incorporates skill depreciation in the standard labor search framework.

The model used in this paper is based on the model developed by Mortensen (1977) and Chetty (2008). While the model abstract from the decision of accepting an offer, the model is extended in the following ways: First, a stylized version of UI benefit extensions is introduced and the equilibrium transition path involving policy changes and time-varying separation and job-finding rates is solved. Second, skill depreciation during unemployment spells is introduced. Third, eligibility for UI benefits is taken into account to capture the fact that only about half of the unemployed are receiving UI benefits in normal times. Fourth, the number of vacancy postings is endogenized in the standard way of the Mortensen-Pissarides model (Pissarides (1985), Mortensen and Pissarides (1994)).

The rest of the paper is proceeds as follows. In Section 2, I describe the ongoing extensions of UI benefit and discuss how they are stylized to be incorporated into the model. Section 3 presents the model. Section 4 discusses how the model is calibrated. Section 5 describes the computational methods used to solve the model. Section 6 presents the results based on the steady-state analysis. Section 7 presents the main results of the paper, using equilibrium transition analysis. Section 8 concludes.

2 Unemployment Benefit Extension: Facts

Although standard UI benefits last 26 weeks in most states, the government often enacts extensions of UI benefits during economic downturns.[1] There are two types of extensions, both of which have been activated during the current downturn. Remember that, under both types of extensions, the level of benefits is the same as the level for the regular benefits.

The first type of extension is called the extended benefits (EB) program. It is a permanent program that is automatically activated for a state whenever the unemployment rate of that state reaches a certain level.[2] The EB program provides an additional 13 or 20 weeks of UI benefits for most states if the unemployment rate of the state exceeds 6.5 percent or 8.0 percent, respectively. Currently, a majority of states qualify for the 20 weeks of extended UI benefits under the EB program. To give the idea of the approximate timing when the extended UI benefits under the EB program became available, let's use the national average unemployment rate. The national average unemployment rate exceeded the threshold for the 13 weeks of extended benefits under the EB program (6.5 percent) in November 2008. The national unemployment rate went above the threshold for 20 weeks of extended benefits under the EB program (8.0 percent) in March 2009. Since then, the national average unemployment rate remained above the threshold for the 20-week UI benefit extension.

The second type of extension is not automatic; Congress enacts this type of extension temporarily in response to severe downturns. The latest program in this category, the Emergency Unemployment Compensation program (EUC08), represents the eighth time Congress has cre-

[1] This section is based on the description of UI benefit extensions by Fujita (2010a)

[2] To be more precise, the three-month average of the unemployment rate of the state is used.

Table 1: Recent Extensions of UI Benefits.[1]

Date	Description
June 30, 2008	The EUC08 program was introduced. The maximum duration of the additional benefits under the program was 13 weeks. It is called Tier-1 of extended UI benefits. The expiration date was set for March 28, 2009.
November 21, 2008	The maximum entitlement under Tier-1 was extended from 13 to 20 weeks. Tier-2, which provides a maximum of 13 weeks of additional UI benefits in states with an unemployment rate of at least 6 percent, was introduced. The expiration date remained at March 28, 2009.
February 17, 2009	As part of the American Economic Recovery and Reinvestment Act, the expiration date was pushed back to December 26, 2009. The act also included a provision to pay an additional weekly benefit of 25 dollars to those receiving extended UI benefits under the EUC08.
November 6, 2009	The duration of additional UI benefits was substantially expanded. Tier-1 remained 20 weeks, but Tier-2 was expanded to 14 weeks and no longer depends on the state unemployment rate. A newly introduced Tier-3 provides an additional 13 weeks of benefits for those in states with an unemployment rate of at least 6 percent, and another newly introduced Tier-4 provides an additional six weeks for states with an unemployment rate higher than 8.5 percent. The expiration date was fixed at December 26, 2009.
December 19, 2009	The expiration date was pushed back to February 28, 2010, without changing the existing tier structure.
March 2, 2010	The expiration date was pushed back to March 31, 2010, without changing the existing tier structure.
April 15, 2010	The expiration date was pushed back to June 2, 2010, without changing the existing tier structure.
June 22, 2010	The expiration date was pushed back to November 30, 2010, without changing the existing tier structure.
December 17, 2010	The expiration date was pushed back to January 3, 2012 without changing the existing tier structure.

[1] Mainly baaed on Fujita (2010a), "The Chronology of the Emergency Unemployment Compensation Program (EUC08)."

ated such a program.[3] EUC08 was signed into law in June 2008. Initially, the maximum duration of extended UI benefits under the program was 13 weeks, but it has been extended several times since then. As of January 2011, the EUC08 and subsequent expansions provided extended ben-

[3] Congress enacted temporary extensions of UI benefits in 1958, 1961, 1971, 1974, 1982, 1991, 2002, and 2008 so far. See Whittaker (2008) for more details about past extensions.

efits for up to 53 weeks. Combining the extensions under EUC08 (53 weeks) with the regular benefits (26 weeks) and the EB (20 weeks), an unemployed worker is entitled to UI benefits for up to 99 weeks in total. See Table 1 for a summary of the original EUC08 and the subsequent expansions and extensions.

Typically, the additional UI benefits under the EB program can be used after an unemployed worker exhausts all the tiers under the EUC08. Therefore, I refer to the additional benefits under the EB program as Tier-5. Also for ease of notation, I will refer to the regular UI benefits as Tier-0.

Let me make three remarks about the nature of the ongoing extensions implemented in response to the current downturn. First, it is very generous compared with the past extensions. For example, before the current extensions, the most generous ones in the past provided about 60 weeks of benefits compared with the current extensions of up to 99 weeks.

Second, the EUC08 was gradually expanded. It is not as if an unemployed workers were eligible for 99 weeks of UI benefits from the first time the EUC08 was enacted. Instead, as of June 2008 when the EUC08 was introduced, the available extension was only 13 weeks of additional UI benefits. It took a year and a half since the first EUC08 was enacted until the maximum of 99 weeks of additional UI benefits became available. In the main experiment of the paper, I will take into account the gradual nature of the ongoing extensions.

Third, although the number 99 is widely cited to describe the generosity of the ongoing extensions, not all unemployed workers actually enjoy the full 99 weeks of extended UI benefits. In order to understand how many weeks of extended UI benefits an unemployed worker is actually entitled to, one needs to understand the tier structure and what the expiration date means. For example, let's consider the extension enacted on June 22, 2010. The extension did not change the existing tier structure, but it pushed back the expiration date by 23 weeks to November 30, 2010. This means that an unemployed worker cannot move up the tier that he is in as of November 30, 2010. If he is receiving UI benefits under Tier-1 as of November 30, the end of Tier-1 is the end of the UI benefits for him. In other words, except for unemployed workers who are close to exhausting Tier-0 (the regular UI benefits of 26 weeks), the unemployed workers who were receiving Tier-0 benefits as of the implementation of the extension (June 22) can only go up to Tier-1, as they will never exhaust Tier-1 benefits by the expiration date. Those who just started receiving the regular UI benefits actually will not qualify even for Tier-1 under the extension because they will not exhaust the 26-week regular benefit (Tier-0) by the expiration date, which is 23 weeks ahead of the day of the extensions. Considering the typical distance between the date when an UI benefit extension is enacted and the associated expiration date (the last five extensions on average have 20 weeks before the expiration date), and the duration of each tier (Tiers-0 to 4 have on average 19 weeks), each extension typically allows unemployed workers to go up just one tier from the one that they are receiving at the time of each extension. The stylized version of UI benefit extensions in the model developed in this paper will capture this temporary nature of the ongoing extensions.

3 Model

I start by describing the environment and then move on to characterize the worker's and the firm's problem and the equilibrium. Since I will characterize the worker's and the firm's problem recursively, I omit the time script from individual state and choice variables and use a prime to denote the variable in the next period. At the end of this section, I will define the competitive equilibrium and then the steady-state competitive equilibrium. I conduct the analysis based on comparison of steady states in Section 6, and then move on to the transition analysis in Section 7.

3.1 Preferences

Time is discrete and infinite and starts from period 1. The model is inhibited by a mass of infinitely lived workers and firms. Workers maximize expected lifetime utility. Utility is time separable, with the time discount factor β. Period utility depends on consumption of goods, c, and search intensity, s. The expected utility of a worker takes the following form:

$$\mathbb{E}_0 \sum_{t=1}^{\infty} \beta^t \; u(c_t, s_t) \tag{1}$$

3.2 Labor Market

The employment status of a worker is represented by u. Workers can be either employed $u = 0$ or unemployed $u > 0$. When a worker is unemployed, u represents the length of the ongoing unemployment spells: how many periods the worker has been unemployed. An unemployed worker receives unemployment insurance benefits if he is eligible and can search for a job. Denote s, S, and V as the individual search effort, aggregate search effort of all (unemployed) workers, and total number of vacancies posted, respectively. There is an aggregate matching function M that takes S and V and outputs the number of new matches created, M. Specifically:

$$M_t = f_t(S_t, V_t) = \overline{\mu}\mu_t f^m(S_t, V_t) \tag{2}$$

where $\overline{\mu}$ is the average matching efficiency, and μ_t is the loading factor for the matching efficiency in period t. We can also define the matching probabilities per *search effort*, f_t^s, and per vacancy, f_t^v, as follows:

$$f_t^s(S_t, V_t) = \frac{f_t(S_t, V_t)}{S_t} \tag{3}$$

$$f_t^v(S_t, V_t) = \frac{f_t(S_t, V_t)}{V_t} \tag{4}$$

When an unemployed worker searches with an intensity s, the probability of finding a job is $f_t^s s$. Assuming constant returns to scale matching function, the labor market tightness, $\ell_t = \frac{V_t}{S_t}$, is sufficient to determine both f_t^s and f_t^v without knowing S_t and V_t themselves. The labor market tightness is the key equilibrium object.

A matched pair of a worker and a firm produces consumption goods as output. The labor productivity is characterized by $w_t h$, where w_t is the market wage rate in period t, and h is the human capital of the worker, with $h \in \{h_1, h_2, ..., h_H\}$ where $h_1 < h_2 < h_3 < ... < h_H$. Human capital changes according to a transition probability $\pi^h_{u,h,h'}$ where u is the employment status. The transition of h for unemployed workers ($u > 0$) is intended to capture skill depreciation during an unemployment spell. The transition of human capital for employed workers ($u = 0$)

captures skill acquisition while working. The output is shared between the worker and the firm in the match. In particular, ω is denoted as the share of the output received by the worker. The firm gets the share $1-\omega$. Therefore, the wage of a worker is $w_t h(1-\omega)$.

Job separation is exogenous and characterized by separation probability λ_t. Separation probability is the same across all workers, but can be time varying.

3.3 Financial Market

Workers can save and, potentially, borrow to smooth consumption over time. Markets are incomplete in the sense that workers cannot trade state-contingent securities. Let k denote the asset holdings of a worker. The interest rate associated with the asset in period t is r_t. Workers are subject to a borrowing constraint $k \geq \underline{k}$.

3.4 Unemployment Insurance Program

The government runs the UI program. The UI program is characterized by $\{b, q, B(x,y)\}$, where b is the amount of UI benefits, q is the amount of non-UI benefits that are available for unemployed workers who are either (i) ineligible for UI benefits or (ii) eligible but have exhausted UI benefits, and $B(x,y)$ represents how many periods a worker of type y in Tier-x is eligible to receive UI benefits. y represents the eligibility for UI benefits. Workers with $y=0$ are ineligible and cannot receive any UI benefits. In other words, $B(x,0)=0$ for $\forall x$. Workers with $y=1$ in Tier-x are eligible and can receive UI benefits until $B(x,1)$ periods. If a worker with the eligibility status y is unemployed for $u(>0)$ periods, and the worker is in Tier-x, the worker receives UI benefits if $u \leq B(x,y)$, and the worker receives q if $u > B(x,y)$. x takes the value between 0 and X. As will be clear when calibrating the model, $x=0$ indicates the regular UI benefits, and $x>0$ indicates that a worker is eligible for extended UI benefits.

Furthermore, for a notational convenience, I define a function $\xi(x,u,y)$, which specifies the benefits available for a worker of type (u,x,y). Specifically:

$$\xi(x,u,y) = \begin{cases} 0 & \text{if } u = 0 \\ b & \text{if } 0 < u \leq B(x,y) \\ q & \text{if } u > B(x,y) \end{cases} \tag{5}$$

The eligibility status y does not change during an unemployment spell, i.e., $y' = y$ if $u > 0$. When a worker finds a new job and becomes employed ($u=0$), the worker loses the eligibility for UI benefits, i.e., y becomes $y=0$ upon finding a job. An employed worker without eligibility ($y=0$) becomes eligible ($y'=1$) with a probability η. This is a simple way to capture that a worker becomes eligible for UI benefits after working for a certain period and contributing sufficiently to the UI program. Once an employed worker becomes eligible ($y=1$), the worker never loses the eligibility until the worker loses a job and finds a new job. To ease notation, I use a short-hand notation $\pi^y_{y,y'}$ for the transition probability with respect to y for employed ($u=0$) workers.

3.5 UI Benefit Extension

An extension of UI benefits basically gives an additional duration of UI benefits for the unemployed who are exhausting the existing benefits under the current Tier-x. In the model, An extension of UI benefits is modeled as shifting x of unemployed workers, in particular to a higher

x that is associated with a longer duration of UI benefits. Meanwhile, when a worker becomes employed, it is assumed that x of the worker reverts back to 0 (which means no additional UI benefits once the worker becomes employed). As for workers who are employed at the time of an extension, I assume that those workers do not benefit from extensions, for simplicity. In reality, some workers who lose their job relatively soon after an extension is implemented could benefit from the extension. However, since there is no separation decision and the separation probability will be calibrated to be low, not many employed workers benefit from an extension. Therefore, no extension for employed workers at the time of an extension is a reasonable assumption.

Specifically, an extension in period t is defined by a function $x' = E_t(x, u)$, which takes the worker of unemployment duration u and currently eligible for Tier-x into a new Tier-x'. If there is no extension in period t, $E_t(x, u) = x$. If there is an extension in period t, and for example, the extension upgrades workers in Tier-0 (no extension) to Tier-1 (first available extension), $E_t(0, u) = 1$.

3.6 Worker's Problem

In this section, the problem of a worker is characterized using a recursive formulation. The individual state of a worker is represented by (x, h, u, y, k). The problem of an employed ($u = 0$) worker can be defined recursively as follows:

$$W_t(x, h, u = 0, y, k) =$$
$$\max_{k' \geq \underline{k}} \left\{ u(c, 0) + \beta \sum_{h'} \pi^h_{u,h,h'} \pi^y_{y,y'} \left((1 - \lambda_t) V_{t+1}(x, h', 0, y', k') + \lambda_t W_{t+1}(x, h', 1, y', k') \right) \right\} \tag{6}$$

subject to:

$$c + k' = (1 + r_t)k + w_t h(1 - \omega) \tag{7}$$

Equation (6) is the Bellman equation. Equation (7) is the budget constraint. Notice three things: First, employment status u does not change at $u = 0$ if the worker remains employed, but changes to $u = 1$ (first period of unemployment) if separation occurs with probability λ_t. Second, search intensity (s) is zero, i.e., there is no job search or job-to-job transition. Third, workers do not expect x to change; in other words, all extensions of UI benefits are a complete surprise to workers. In the steady-state equilibrium, x does not change.

Similarly, the problem of an unemployed worker with the unemployment duration of $u > 0$ can be defined recursively as follows:

$$W_t(x, h, u > 0, y, k) =$$
$$\max_{k' \geq \underline{k}, s} \left\{ u(c, s) + \beta \sum_{h'} \pi_{u,h,h'} \left(f^s_t s W_{t+1}(0, h', 0, 0, k') + (1 - f^s_t s) W_{t+1}(x, h', u + 1, y, k') \right) \right\} \tag{8}$$

subject to:

$$c + k' = (1 + r_t)k + \xi(x, u, y) \tag{9}$$

$$s \in \left[0, \frac{1}{f_t^s}\right] \tag{10}$$

Equation (8) is the Bellman equation. Equation (9) is the budget constraint. Equation (10) is the constraint for the search intensity decision. s is bounded from above by $1/f_t^s$ to make sure that the probability of finding a job never exceeds 1. Notice four things: First, if an unemployed worker chooses a search effort of s, the worker will find a job with probability $f_t^s s$. Second, the tier of a worker (x) who finds a new job changes to $x' = 0$ (eligible for no extension). Third, y' becomes 0 if the worker finds a job, while y' remains y if the worker fails to land a job. Fourth, it is necessary to know the sequence of labor market tightness $\{\ell_t\}_{t=1}^{\infty}$ to know the sequence of the job finding probability.

The Bellman equations (6) and (8) characterize the optimal value functions $W_t(x, h, u, y, k)$ and associated optimal decision rules $k' = g_t^k(x, h, u, y, k)$ and $s = g_t^s(x, h, u, y, k)$.

For notational convenience, let $\mathbf{M}$ be the space of an individual state, i.e., $(x, h, u, y, k) \in \mathbf{M}$. Let $\mathcal{M}$ be the Borel σ-*algebra* generated by $\mathbf{M}$, and m the probability measure defined over $\mathcal{M}$. I will use a probability space $(\mathbf{M}, \mathcal{M}, \mathbf{m})$ to represent a type distribution of heterogeneous workers.

3.7 Firm's Problem

Since the per-period profit of a matched firm depends only on period t and the human capital of the worker h, the value of a matched firm can be recursively defined as follows:[4]

$$F_t(h) = w_t h \omega + \frac{1}{1 + r_t} \sum_{h'} \pi_{0,h,h'}(1 - \lambda_t) F_{t+1}(h') \tag{11}$$

As for unmatched firms, free entry of firms is assumed; unmatched firms can enter the labor market by posting a vacancy at the flow vacancy posting cost of κ. Therefore, the free entry condition in period t can be denoted as follows:

$$0 = -\kappa + \frac{f_t^v}{1 + r_t} \frac{\int_{\mathcal{M}} \sum_{h'} \pi_{1,h,h'} F_{t+1}(h') g_t^s(x, h, u, y, k) dm_t}{\int_{\mathcal{M}} g_t^s(x, h, u, y, k) dm_t} \tag{12}$$

An unmatched firm pays κ to post a vacancy, and with probability f_t^v, the vacancy gets matched and the firm becomes matched in the next period. The value in the next period is discounted by the interest rate r_t. The last fraction in Equation (12) represents the expected value of the unmatched firm, weighted by the search effort chosen by different types of workers. Notice that, thanks to the constant returns to scale of the aggregate matching function, labor market tightness ℓ_t can be obtained from the free entry condition (12) for period t.

[4] The value of a matched firm depends only on the human capital of the worker matched and not on other elements of the type of the worker because of the assumption that the bargaining outcome is characterized by a constant ω. In general, where the Nash bargaining solution is used, the bargaining solution depends on all elements of the worker's type, including asset holding. For a more general bargaining setup, see Krusell et al. (2010) and Nakajima (2010).

3.8 Equilibrium

I will first define the competitive equilibrium, then move on to define the steady-state competitive equilibrium.

Definition 1 (Competitive equilibrium) *Given an unemployment insurance policy $\{b, q, B(x, y)\}$, a sequence of time-varying parameters $\{\mu_t, \lambda_t\}_{t=1}^{\infty}$, prices $\{r_t, w_t\}_{t=1}^{\infty}$ and extensions $\{E_t(x, u)\}_{t=1}^{\infty}$, and the initial type distribution of workers m_0, a competitive equilibrium is a sequence of labor market tightness $\{\ell_t\}_{t=1}^{\infty}$,value functions $W_t(x, h, u, y, k)$, $F_t(h)$, optimal decision rules $k' = g_t^k(x, h, u, y, k)$, and $s = g_t^s(x, h, u, y, k)$, and probability measures $\{m_t\}_{t=1}^{\infty}$, such that:*

1. *Given $\{\ell_t\}_{t=1}^{\infty}$, $W_t(x, h, u, y, k)$ is a solution to the Bellman equations (6) and (8). $k' = g_t^k(x, h, u, y, k)$ and $s = g_t^s(x, h, u, y, k)$ are the associated optimal decision rules for all periods.*

2. *Given $\{\ell_t\}_{t=1}^{\infty}$, $F_t(h)$ is a solution to the Bellman equation (11) for all periods.*

3. *Given the initial measure m_0, the sequence of measure of workers $\{m_t\}_{t=1}^{\infty}$ is consistent with the transition function implied by the stochastic processes for h and y; the job turnover process implied by separation probability $\{\lambda_t\}_{t=1}^{\infty}$; job finding probability, which is computed from labor market tightness $\{\ell_t\}_{t=1}^{\infty}$ and the match-efficiency loading factor $\{\mu_t\}_{t=1}^{\infty}$; optimal decision rules $s = g_t^s(x, h, u, y, k)$ and $k' = g_t^k(x, h, u, y, k)$; and the sequence of extensions $\{E_t(x, u)\}_{t=1}^{\infty}$.*

4. *Labor market tightness $\{\ell_t\}_{t=1}^{\infty}$ is consistent with free entry condition (12) for each period.*

Definition 2 (Steady-state competitive equilibrium) *A steady-state competitive equilibrium is a competitive equilibrium where labor market tightness, type distribution, value functions, and optimal decision rules are time-invariant.*

4 Calibration

Table 2 summarizes the calibration of parameter values. Since the main focus of the model is the labor market status transition, one period is set as one week. Period 1 in the model corresponds to the last week of 2007, which was about the beginning of the last recession. I first calibrate the *initial steady state* in this section. The initial steady state is the starting point of the transition analysis and is intended to capture the average state of the U.S. economy, especially shortly before the recent recession and the associated unemployment benefit extension took place. Since I calibrate the steady-state economy, I will omit the time script from all variables below. I will discuss the calibration of the baseline transition path in Section 4.6 and Section 4.7.

4.1 Preferences

I use the following separable functional form for the period utility function:

$$u(c, s) = \frac{c^{1-\sigma}}{1-\sigma} - \gamma \frac{s^{1+\phi}}{1+\phi} \tag{13}$$

Table 2: Summary of Calibration: Initial Steady State

Parameter	Value	Remark
β	0.9885	Time discount factor. Match median liquid asset holding.
σ	2.0000	Coefficient of relative risk aversion.
γ	94.360	Match average time spent on job search.
ϕ	1.7000	Match unemployment duration elasticity.
$\overline{\mu}$	1.8633	Match job finding probability.
μ	1.0000	Normalization (will be changed in the transition analysis).
α	0.7200	Estimate of Shimer (2005).
h_1	0.8690	Fujita (2011).
h_2	1.1500	Fujita (2011).
$\pi_{u,h,h'}$	–	See Section 4.2. From Fujita (2011).
λ	0.0028	Average separation rate.
ω	0.9700	Worker's share of surplus.
κ	13076	Match the unemployment rate of 4.77 percent.
$\underline{k}$	0.0000	No borrowing allowed.
ρ_b	0.4350	Replacement rate of UI benefits. From Gruber (1998).
ρ_q	49.700	Average weekly benefits under the Food Stamp Program.
η	0.0050	Match proportion of unemployed receiving UI benefits.
r	0.0006	From Acemoglu and Shimer (2000). Annual interest rate of 3 percent.
w	736.00	Average weekly earnings.

The separability between utility from consumption and (dis-)utility from search intensity is also employed by Chetty (2008). σ is calibrated to be 2, which is the widely accepted value in the literature. γ is calibrated such that, on average, s, the time spent on job search is 3 percent of disposable time. This calibration procedure yields $\gamma = 94.36$. ϕ is the most important parameter because ϕ is the key determinant of how search effort responds to a change in benefits of finding a job and benefits of remaining unemployed. I calibrate ϕ to be 1.7. With the calibrated value of $\phi = 1.7$, the responses of the average duration of unemployment to changes in policy implied by the model are within the range of available estimates from empirical analysis. I will discuss more on this issue in Section 6. Considering the importance of ϕ in driving the main results of the paper, I will investigate the sensitivity of the main results under a different value of ϕ in Section 7.3. The discount factor, β, is calibrated such that the median worker has a liquid asset of 2600 dollars. This number is computed by Chetty (2008).[5] As a result, β is calibrated to be 0.9885.

[5] See Table 1. The median gross liquid wealth of workers in the Survey of Income and Program Participation (SIPP) sample is 1763 dollars in 1990 dollars. Using the Consumer Price Index (CPI), it is converted into 2600 dollars in 2005.

4.2 Labor Market

The aggregate matching function takes the Cobb-Douglas form, which is widely accepted in the literature.

$$M = f_t(S, V) = \overline{\mu}\mu_t S^{\alpha} V^{1-\alpha} \tag{14}$$

The average matching efficiency, $\overline{\mu}$, is calibrated such that the job finding probability in the model is comparable to data. During 2005-2007, the average weekly job-finding probability is 0.0559 according to Current Population Survey (CPS). The process yields $\overline{\mu} = 1.8633$. The loading factor to the matching efficiency μ is normalized to one in the steady state. The curvature parameter of the matching function α is calibrated to be 0.72, which is the estimate of Shimer (2005). I will investigate the sensitivity of the main results with respect to a different value of α in Section 7.3 for the following two reasons. First, there is wide range of estimates of α. According to Petrongolo and Pissarides (2001), estimates of α that are obtained using variety of methods and data range between 0.12 and 0.81.[6] Second, α is estimated for a model without search intensity decision.

The calibration of the parameters associated with human capital is based on Fujita (2011). Using Survey of Income and Program Participation (SIPP) 1996 and 2001 panels, he computed that the average earnings loss after an unemployment spell of 1-2 months, 2-5 months, and more than 6 months is 0.023, 0.021, 0.142, respectively. In other words, the earnings loss associated with long-term unemployment is substantial (as large as 14 percent), although the computed overall average earnings loss (0.043) masks such substantial decline.[7] Based on his empirical findings, he calibrates a model with human capital depreciation while the worker is unemployed using two levels of human capital. I use his calibration and set $H = 2$, $h_1 = 0.869$, and $h_2 = 1.150$. In terms of the transition probabilities, I follow Fujita (2011) and set $\pi_{u=0,2,2} = 1.0$ (no skill depreciation during employment), $\pi_{u=0,1,2} = 0.004$ (low-skilled workers become highly skilled on average after five years of unemployment), $\pi_{u>0,1,1} = 1.0$ (no skill accumulation during unemployment), and $\pi_{u>0,2,1} = 0.0975$ (monthly skill loss probability of 0.39).

The weekly separation rate, λ, is set at 0.0028. According to the CPS, this is the average weekly transition probability from employment to unemployment during 2005-2007. Together with the job-finding rate of 0.0559, the implied steady-state unemployment rate is 4.77 percent. This is lower than the post-war average (5.67 percent), but very close to the level just at the end of 2007, when the last recession started.

The parameter pertaining to the share of surplus, ω, is set at 97 percent. The number corresponds to the large size of the earnings of workers relative to the firm's profits and is used by Shimer (2005), Hagedorn and Manovskii (2008), and Nakajima (2010).

I normalize the ratio of vacancies to the aggregate search effort, which is called the labor market tightness, to be one in the steady state. The cost of posting a vacancy, κ, is calibrated such that this is the case in the steady-state equilibrium. The procedure yields $\kappa = 13076$ dollars.

[6] See Table 3 of Petrongolo and Pissarides (2001).

[7] Alba-Ramirez and Freeman (1990) calculate that a year of joblessness reduced the earnings of workers by about 3 percent, using data of Spanish workers (ECVT) in 1985.

4.3 Financial Market

The borrowing limit $\underline{k}$ is set at zero, i.e., no borrowing is allowed. This is the same assumption as in Acemoglu and Shimer (2000).

4.4 Unemployment Insurance Program

In calibrating the level of UI benefits, I use a replacement ratio ρ_b. The level of UI benefits, b, is set such that b is the fraction ρ_b of the average labor income in the steady state. ρ_b is set at 0.435, which is the mean replacement ratio across states, computed by Gruber (1998).[8]

In pinning down the amount of non-UI benefits, q, I use the average benefits under the Food Stamp Program (Supplemental Nutrition Assistance Program). According to the U.S. Department of Health and Human Services (2008), average monthly benefit per person under the Food Stamp Program was 92.6 dollars in 2005, and the average number of family members was 2.3. Therefore, the average weekly benefit per family in 2005 was 49.7 dollars. This is the calibrated value of q.

In the initial steady state, there is no UI benefit extension. Therefore, $x = 0$ for all workers. $B(x = 0, 1)$ is set at 26 weeks, which is the duration of regular UI benefits for a majority of states.

The probability of an ineligible employed worker becoming eligible for UI benefits, η, is calibrated to match the average proportion of unemployed workers who are receiving UI benefits. Those receiving UI benefits are those who are eligible for UI benefits and have not exhausted the benefits yet. Historically, the proportion of unemployed workers receiving UI benefits fluctuates substantially, between 30 percent to 45 percent, and it is strongly countercyclical. The cyclicality is due to the cyclicality of the proportion of firings, which itself is countercyclical, and the extensions of UI benefits, which are made available during severe recessions. In the recent downturn, the proportion of recipients of UI benefits among all unemployed workers increases dramatically, from around 36 percent in 2005-2007 to 66 percent in 2008-2009, with the highest at about 70 percent. The question of which number should be used as a calibration target is crucially important for the main exercise of the paper because the proportion directly determines how many workers are affected by changes in duration and level of UI benefits. Since I am interested in measuring the effect of UI benefit extensions on the unemployment rate during the ongoing downturn, and there is no endogenous mechanism in the model to generate the increase in the proportion of UI eligible unemployment during downturns except for due to extensions, I use 55 percent as the calibration target in the initial steady state. With 55 percent as the calibration target in the initial steady state, approximately 70 percent of unemployed workers receive UI benefits when the proportion is at its highest along the baseline transition path.[9] Once I choose the target for the proportion of UI benefit recipients, I pin down η such that the proportion of unemployed workers receiving UI benefits in the initial steady state is 55 percent. The calibration strategy generates $\eta = 0.0050$ at a weekly frequency.

[8] See Table A1 of Gruber (1998). I take a simple average of the replacement ratios across all states. The median ratio is 0.422.

[9] This is not an easy calibration because I need to implement the transition analysis with a different target for the proportion of UI benefit recipients in the initial steady state.

Table 3: Tiers of Unemployment Insurance Benefits in the Model[1]

Tier	Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Weeks	26	20	14	13	13	13
Cumulative weeks	26	46	60	73	86	99

[1] Tier-0 corresponds to the regular UI benefits. Tiers-1 to 4 correspond to Tiers-1 to 4 of the EUC08. Tier-5 corresponds to the extended benefits under the EB program.

Table 4: Extensions of Unemployment Insurance Benefits in the Model

No	Period	Year/Month/Week	Description
1	27	2008/June/5th	Tier-1 is introduced.
2	48	2008/Nov/4th	Tier-2 is introduced.
3	60	2009/Feb/3rd	Tier-3 is introduced.
4	74	2009/May/4th	Tier-4 is introduced.
5	98	2009/Nov/2nd	Tier-5 is introduced.
6	112	2010/Feb/3rd	Tiers 1-5 UI benefits extended.
7	126	2010/May/4th	Tiers 1-5 UI benefits extended.
8	140	2010/Aug/5th	Tiers 1-5 UI benefits extended.
9	154	2010/Dec/1st	Tiers 1-5 UI benefits extended.

4.5 Prices

The weekly interest rate is set at $r = 0.0006$, which corresponds to an annual interest rate of 3 percent. The value is used by Acemoglu and Shimer (2000). The wage rate is set at $w = 736$, which is the median weekly earnings of all workers in 2005 dollars, according to the CPS.

4.6 UI Benefit Extensions

I model the ongoing extensions of UI benefits, which are described in detail in Section 2, in a stylized fashion. Specifically, I assume five tiers of extended UI benefits, in addition to the regular UI benefits (which is labeled Tier-0). Table 3 summarizes the tiers. Tier-0 (regular UI) is available for all workers and provides up to 26 weeks of benefits. This is the only tier available in the initial steady state. Tiers 1 to 4 correspond to Tiers 1 to 4 of the EUC08. Tier 5 in the model corresponds to the EB program, which was made available to most states during the recent downturn and can be used when an unemployed worker exhausts all the benefits under the EUC08. In total, a worker who is eligible for up to Tier 5 benefits can receive 99 weeks of UI benefits, like currently unemployed workers in the U.S. economy. I average the length of Tier-4 and Tier-5 in the model, which makes the duration of Tiers 3-5 to be 13 weeks each.

Extensions of UI benefits in the model are intended to capture the key characteristics of

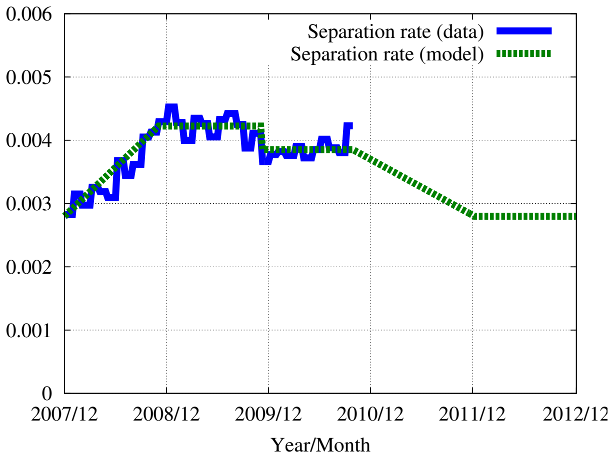


Figure 1: Separation Rate.

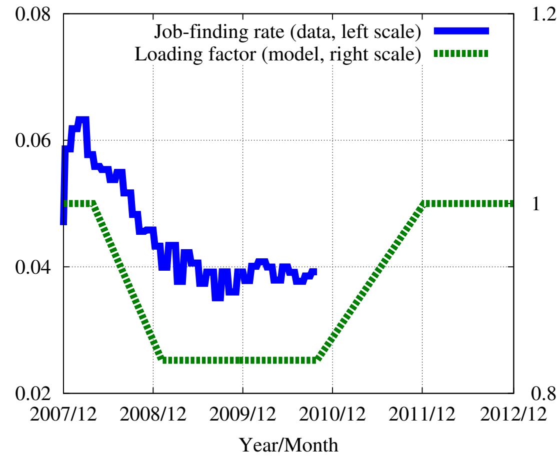


Figure 2: Job finding Rate.

EUC08 and its subsequent expansions and extensions in a stylized manner. Table 4 summarizes the UI benefit extensions in the model. There are nine extensions in the model in total, like in the U.S. economy so far. Each of the first five extensions introduces an additional tier, one by one. For example, when Tier-2 is introduced in period 48, all the workers who are eligible for (and most likely receiving) Tier-1 benefits become eligible for Tier-2 benefits as well. Workers who are eligible only for Tier-0 (regular) benefits become eligible for Tier-1 benefits. Employed workers do not become eligible for any additional benefits; when they become unemployed, they are eligible only for the Tier-0 (regular) benefits. Similar things take place until the fifth extension. The dates of the first five extensions roughly correspond to the dates of the original EUC08, its expansions, and the dates when the two levels of the EBs are activated.

The remaining four extensions extend only the existing additional UI benefits. These correspond to the last four extensions in the U.S., which also extend the existing additional UI benefits without adding new tiers. Although the length of intervals between each extension in the U.S. economy was not similar, I assume that all extensions in the model take place with the uniform interval of 24 weeks. The last extension in the model, which took place in December 2010, corresponds to the most recent extension implemented in December 2010.

4.7 Transition Path

In the transition analysis, I focus on the changes in the separation rate, λ_t and the loading factor for the matching efficiency, μ_t, and leave the interest rate, r_t, and wage rate, w_t, constant at the initial steady-state level over time. The time-varying separation rate is calibrated using the actual separation rate computed using the CPS. Figure 1 compares the transition rate from employment to unemployment (separation rate) during 2007 to 2009, and the smoothed version which is used as a model input. We can see that the separation rate increased sharply from the end of 2007 to the end of 2008 and that it remained high since the end of 2008. The input used for the model captures the trend during 2007-2008. Moreover, in the model, the separation probability is assumed to gradually come down to the steady-state level by the end of 2011 and remain at the level after that.

The transition rate from unemployment to employment (job-finding rate) during 2007 to 2009, calculated from the CPS, is shown in Figure 2. The job-finding probability also dropped sharply from early 2008 to early 2009 and remained at a low level since then. However, there is no straightforward conversion between the job-finding probability to the loading factor for the matching efficiency, which is the input for the model, because the job-finding probability is determined not only by the matching efficiency, but the search effort and the number of vacancies posted, both of which are endogenously determined. In order to create the loading factor that is used as an input for the transition analysis, I assume that the level of the loading factor drops from early 2008 till early 2009 from the steady-state level of 1, remains at the low level until the end of 2009, and gradually recovers back to the steady-state level until the end of 2011, and then remaining at the steady-state level after that. The low level of the loading factor is calibrated such that, in the baseline transition analysis, the unemployment rate goes up to around 10 percent in late 2009, which is the highest level observed during the recent downturn so far. In the baseline transition analysis, it turns out that, with a 16.5 percent drop in the loading factor (from 1.00 to 0.835), the model can generate a rise in the unemployment rate as large as observed in the data.

5 Computation

The model does not have an analytical solution and thus is solved numerically.[10] I first briefly describe the solution method of the steady-state equilibrium and then describe the solution method for transition analysis.

Given a guess of steady-state labor market tightness ℓ^0, an individual worker's problem is solved using value function iteration; I keep iterating the value function using the Bellman equations until the distance between the guessed and the updated value functions is smaller than a predetermined tolerance criteria. In terms of the continuous state k, I discretize the space of k. Once convergence of the value function iteration is achieved, I use the associated optimal decision rules to simulate the model. I simulate the model forward until a stationary type distribution of workers is obtained; the type distribution of workers ceases to change between one period to the next. Once a stationary type distribution is obtained, I can compute the labor market tightness ℓ^1 implied by the free entry condition (12). If the distance between ℓ^0 and ℓ^1 is smaller than a predetermined criteria, a steady-state equilibrium is obtained. Otherwise, update the guess of labor market tightness and start over with a new guess ℓ^0.

Equilibrium of a heterogeneous-agent model with a deterministic transition has been solved.[11] The innovation of the current paper is that there are multiple policy changes along the deterministic transition path, while, to the best of my knowledge, all existing models assume one policy change in the initial period. Indeed, in the transition analysis of this paper, there are nine policy changes (extensions of UI benefits) assumed in addition to the changes in time-varying parameters in the initial period. This adds complication in solving the equilibrium of the model. For simplicity, let me describe the case in which (1) in period 1, the path of time-varying parameters $\{\mu_t, \lambda_t\}_{t=1}^{\infty}$ is revealed, and (2) in period 27, the first extension is implemented. The solution

[10] More details about the computation of heterogeneous-agent models in the steady-state equilibrium, as well as those with equilibrium transition, can be found in Ríos-Rull (1999).

[11] For example, see Conesa and Krueger (1999).

method of the model with more than one policy change is a straightforward extension of the method described below.

First, an equilibrium with deterministic transition with only the change in time-varying parameters in period 1 is solved. This is a standard problem. Value function is solved backward, assuming that, in period T, the time-varying parameters go back to their steady-state values and that the economy goes back to the initial steady state. T has to be large enough to guarantee that the simulated economy reverts back to the state that is close to the steady state in period T. Specifically, the equilibrium is solved as follows. Guess the path of labor market tightness $\{\ell_t^0\}_{t=1}^T$. With the guess, the sequence of time-varying parameters, and the value function in period $T+1$ (which is assumed to be the steady-state values), a worker's problem can be solved backward, starting from period T and going all the way back to period 1. Optimal decision rules are obtained as well. Firm's value can be obtained similarly, using backward induction. Now the type distribution is simulated forward. The initial type distribution is assumed to be the one pertaining to the steady state. The distribution can be simulated forward using the optimal decision rules. Once the simulation is done, I can use the free entry condition for each period to obtain the updated guess of labor market tightness $\{\ell_t^1\}_{t=1}^T$. If the distance between the old and the new guesses is smaller than a predetermined tolerance level, an equilibrium associated with the first extension is obtained. Otherwise, the guess is updated, and I must start over.

In the existing models with only one time change in time-varying parameters, this is the end of the story. But there is a policy change in period 27 here. How do we deal with it? Notice that the simulation results from period 1 to period 27 are not affected by the policy change in period 27, since I assume that the policy change is unexpected by the agents. Therefore, in this step, we can use the type distribution in period 27 obtained in the previous step as the initial distribution, but notice that, due to the extension of UI benefits, some workers shift their type, specifically their Tier-x. So the adjustment of the type distribution in period 27 obtained in the previous step that is consistent with the UI benefit extension is needed. After the type distribution is adjusted, I can proceed as I did in the first step. Guess a sequence of labor market tightness between period 27 and T, $\{\ell_t^0\}_{t=27}^T$. Again assuming that the economy converges back to the steady state in period T, we can use backward induction to solve the value functions of workers and firms, and obtain optimal decision rules for each period. Notice that the effect of the extension gradually dies out as workers who find a job after the extension is implemented no longer benefit from the extension. Also notice that, in this step, we solve only up to period 27 (when the policy change is revealed). Once the economy is simulated from period 27 to period T, we can obtain an updated guess of the sequence of labor market tightness $\{\ell_t^1\}_{t=27}^T$. We keep iteration over the sequence of labor market tightness until a convergence is obtained.

The actual simulated transition path, which will be shown in Section 7, is a combination of what is obtained under the first regime (during period 1-26) and under the second regime (during period 27 to T). Notice that, even though the transition path of period 27 to T under the first regime is not a part of the final output, it must be solved because workers and firms make their decision assuming that the labor market tightness of period 27 to T under the first regime is realized in the future, when they make their decisions between period 1 and 26.

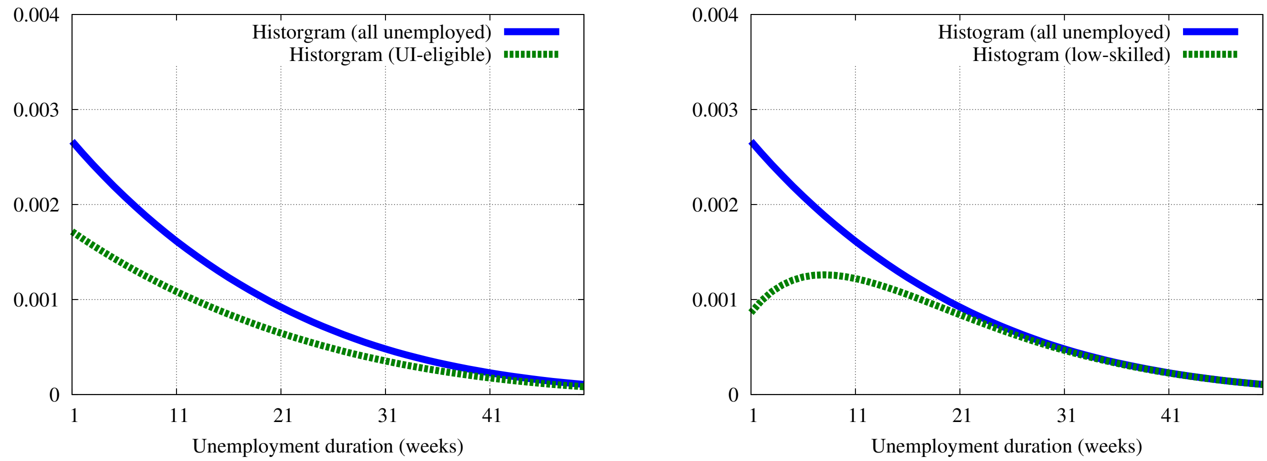
Table 5: Effect of Changes in Unemployment Insurance Policy

Economy	Initial	+10%	+20 weeks	+73 weeks	$+\infty$ weeks
Replacement rate	0.4350	0.5350	0.4350	0.4350	0.4350
Duration of UI benefits (weeks)	26	26	46	99	∞
Unemployment rate (U)	0.0477	0.0489	0.0531	0.0650	0.0708
UI-eligible	0.0327	0.0340	0.0383	0.0505	0.0563
Receiving benefits	0.0262	0.0269	0.0357	0.0500	0.0563
(% of U)	55.00	54.89	67.27	76.90	79.57
Exhausted benefits	0.0064	0.0071	0.0026	0.0005	–
UI-ineligible	0.0150	0.0150	0.0148	0.0145	0.0145
Median duration (all, weeks)	12.00	12.00	13.00	17.00	20.00
Mean duration (all, weeks)	15.59	15.96	17.62	24.07	28.89
Mean duration (UI-eligible)	16.30	16.81	19.03	27.00	32.73
Mean duration (UI-ineligible)	14.07	14.03	13.97	13.92	13.92
Aggregate search effort (S)	1.4310	1.4295	1.4239	1.4072	1.3987
Average search effort (s)	0.0300	0.0292	0.0268	0.0216	0.0198
Vacancies (V)	1.4310	1.4284	1.4202	1.3994	1.3904
Market tightness (V/S)	1.0000	0.9993	0.9974	0.9945	0.9941
Market tightness (V/U)	1.0000	0.9733	0.8915	0.7176	0.6550
Job-finding rate	0.0559	0.0544	0.0499	0.0403	0.0368
Separation rate	0.0028	0.0028	0.0028	0.0028	0.0028
Mean asset (2005 dollar)	2672	2120	1905	1834	1819
Median asset (2005 dollar)	2600	1100	700	700	700
Mean income (2005 dollar)	753	754	750	744	741
Mean labor income (2005 dollar)	779	779	778	776	776
UI benefits (2005 dollar)	320	394	320	320	320
Non-UI benefits (2005 dollar)	50	50	50	50	50
Proportion of low skilled	0.3443	0.3467	0.3538	0.3682	0.3729
Proportion of high skilled	0.6557	0.6533	0.6462	0.6318	0.6271

6 Results: Steady State

6.1 Properties of the Initial Steady State

In this section, I first describe the properties of the initial steady-state economy and then investigate the effect of changes in the unemployment insurance policy using steady-state comparison. Table 5 summarizes the results. Let us start from the first column, which shows the properties of the calibrated initial steady-state economy. The unemployment rate is 4.77 percent, which is



(a) UI eligibility

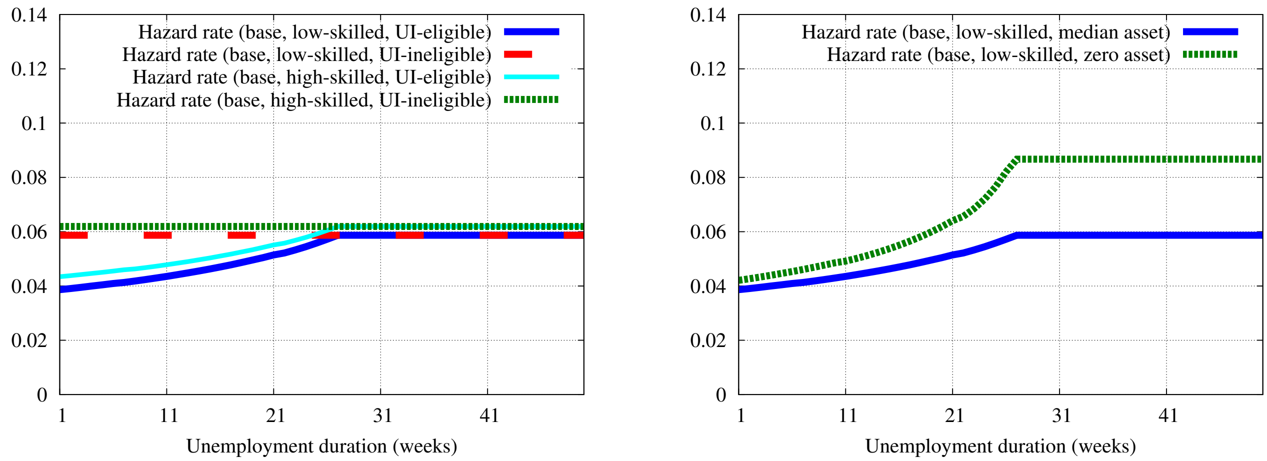
(b) Human capital

Figure 3: Distribution of Unemployment Duration.

about the average during 2005-2007. Among the unemployed workers, 3.3 percent are eligible to receive regular UI benefits (up to 26 weeks), and 1.5 percent are ineligible. Among the eligible unemployed workers, 2.6 percent are receiving the UI benefits, and 0.6 percent have already exhausted the benefits, meaning that they are unemployed for longer than 26 weeks. The proportion of unemployed workers receiving UI benefits over total number of unemployed workers is 55 percent. The median and mean unemployment duration of all unemployed workers is 12 weeks and 15.6 weeks, respectively. In the initial steady state, two definitions of labor market tightness (V/S and V/U) are normalized to 1, and the average search effort is calibrated to be 0.03. The weekly job-finding and separation rates are calibrated to be 5.59 percent and 0.28 percent, respectively. The median asset holding is calibrated to be 2600 dollars. The mean asset holding turns out to be 2672 dollars. The mean labor income of employed workers is 779 dollars, while an unemployed worker receives 320 dollars if he is receiving UI benefits and 50 dollars if he is either ineligible for UI benefits or the benefits have been exhausted. 34 percent of workers are low skilled.

Figure 3 shows the distribution of unemployment duration in the initial steady-state economy. Panel (a) also shows the distribution of UI-eligible workers. The number of UI eligible unemployed workers declines more slowly than the total number of unemployed workers because unemployed workers who are not eligible for UI benefits search more intensely and exit from unemployment relatively faster. Panel (b) shows the distribution of low-skilled unemployed workers. The total number of unemployed workers declines faster than the number of low-skilled unemployed workers. Indeed, the number of low-skilled unemployed workers increases at a relatively shorter duration of unemployment. This is partly because high-skilled unemployed workers search more intensely to exit unemployment before their skills depreciate and partly because unemployed workers experience skill depreciation and become low-skilled.

Figure 4 shows the weekly hazard rates (exit probability from unemployment conditional on unemployment duration) for the different types of workers. Panel (a) exhibits the hazard rates



(a) Human capital and UI eligibility

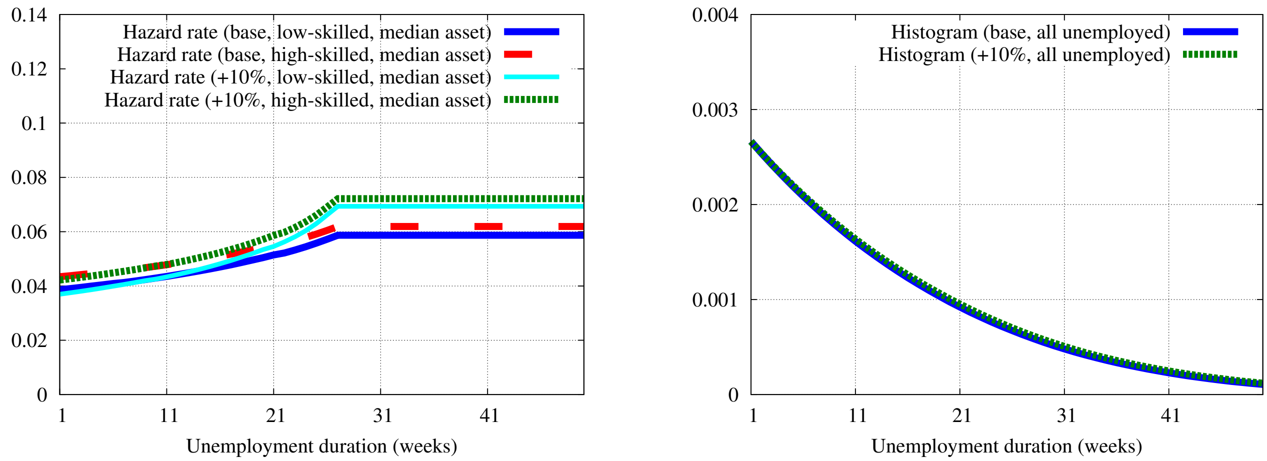
(b) Asset holding

Figure 4: Weekly Hazard Rates.

for high-skilled and low-skilled unemployed workers with median asset holding. Since high-skilled workers lose more by remaining unemployed, they search with more intensity and exit unemployment with a higher probability. The two straight horizontal lines show the hazard rates of unemployed workers who are not eligible for UI benefits. Since they do not exhaust UI benefits and, therefore, keep receiving the non-UI benefits permanently, their search effort does not change regardless of how long they are unemployed, conditional on asset holding level. When UI-eligible workers exhaust UI benefits, their search effort, and thus the hazard rates, will be the same as those of ineligible unemployed workers. Panel (b) exhibits how hazard rates are affected by asset holding. When there is a borrowing constraint, unemployed workers are more desperate in searching if they are close to the constraint, and thus their consumption is constrained by it. Chetty (2008) emphasizes the effect by distinguishing from the standard moral hazard effect. In panel (b), the line below is the hazard rate for low-skilled UI eligible unemployed workers with median asset holdings (same as in panel (a)), and the line above is for the same type of unemployed workers with zero asset holdings. Since the borrowing constraint is set at zero, their consumption is constrained by the current income. As you can see in panel (b), the search intensity, and thus the hazard rate, are higher when asset holding is lower. Combining panels (a) and (b), the overall hazard rates go up with unemployment duration partly because unemployed workers become more desperate as they approach the maximum duration of UI benefits and partly because they exhaust their assets, which make them more desperate.

6.2 Policy Experiments: Changes in UI Benefit Policy

The second column of Table 5 shows the effect of increasing the replacement rate of unemployment insurance benefits by 10 percentage points. I use 10 percentage points because various empirical estimates are available for the response of the average unemployment duration to a 10 percentage point increase in the replacement rate. In 2005 dollars, the unemployment insurance benefit increases from 320 dollars to 394 dollars per week by a 10 percentage point increase in the



(a) Hazard rates

(b) Unemployment duration distribution

Figure 5: Experiment: Replacement Rate Raised by 10 Percentage Points.

replacement rate. The duration of UI benefits is fixed at 26 weeks. Most important, the mean duration of unemployment among UI-eligible unemployed workers increases by about 0.5 week, from 16.3 to 16.8 weeks. The response of the average duration is at the lower bound of the range of empirical estimates of 0.5-1.5 weeks, which I discussed in Section 1. Since the model is calibrated to generate the lower bound of the range of the estimated response, the calibration can be considered as conservative. The longer unemployment duration is caused by a disincentive effect; more generous UI benefits discourage the search efforts of workers who are eligible for UI benefits. Since UI-ineligible workers are not directly affected by the policy change, the increase in the average duration of all unemployed workers is smaller (+0.4 weeks) than for the UI-eligible workers (+0.5 weeks). The unemployment rate increases from the baseline rate of 4.77 percent to 4.89 percent. While the average search effort declines (-2.7 percent), the number of unemployed workers increases (+2.5 percent), resulting in a slight decline in the aggregate search effort (-0.1 percent). Since the decline in the aggregate search effort is relatively small, the decline in vacancies is also relatively small at -0.2 percent. As a result, *true* labor market tightness (V/S) declines by -0.1 percent. It is worth noting that *measured* labor market tightness (V/U) drops more than the drop in V/S (-2.7 percent) because the measure labor market tightness does not take into account the declining search effort. More generous UI benefits also discourage precautionary savings. The average asset holding drops from 2672 dollars to 2120 dollars. Although I do not consider the general equilibrium effect from declining aggregate saving, this could have a negative effect on output, in addition to the one caused by a lower employment rate.

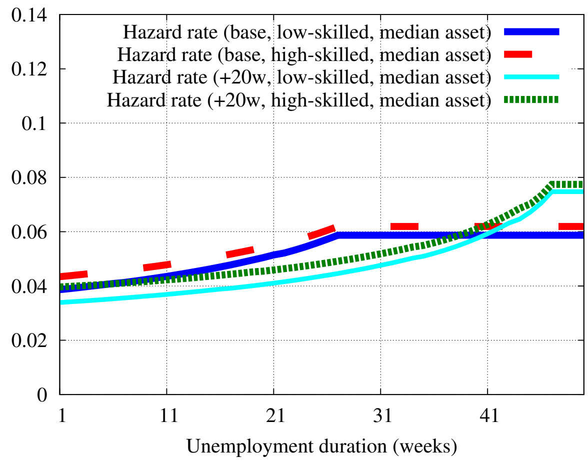
Figure 5 shows how hazard rates and unemployment duration distribution change by increasing the replacement rate by 10 percentage points. Interestingly, the changes in hazard rates are not monotonic; hazard rates for both low-skilled and high-skilled unemployed workers shift down for relatively short unemployment durations, but both shift up for longer unemployment durations. Because of the more generous level of UI benefits, when the benefits are exhausted, the loss is larger. Remember that the non-UI benefits are held constant. Because of the non-monotonic response of the hazard rates, unemployment duration distribution does not change substantially by increasing the replacement by 10 percentage points.

The third to fifth columns show the effect of increased duration of UI benefits, by 20, 73, and infinite weeks, respectively. The 20-week increase is chosen because various empirical estimates are available for the response of the average duration to a 20-week increase in benefit duration. The 73-week increase is chosen because the addition of 73 weeks makes the total duration 99 weeks, which is the longest duration available in the current U.S. economy, and how the economy is affected by the currently implemented extensions is the main question of the current paper. This experiment is also intended to show that a steady-state analysis can be misleading because the extensions that are currently in place are very different from the steady state where all workers expect 99 weeks of UI benefits when they become unemployed, although the potential maximum duration of UI benefits is currently 99 weeks. The last column is associated with an economy with permanent UI benefits.

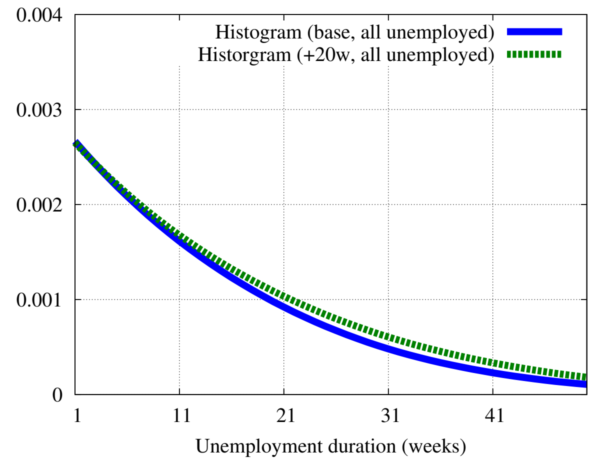
Let us start from the 20-week increase. The average duration of unemployment among UI-eligible unemployed workers increases by about 2.7 weeks, from 16.3 to 19.0 weeks. This means that a one-week increase of UI benefit duration is associated with an increase of the average UI-insured duration by 0.135 weeks. The response of the average duration is approximately in the middle of the range of empirical estimates of 0.1-0.2, which I discussed in Section 1. The overall average of unemployment duration increases by 2.0 weeks. The unemployment rate goes up to 5.3 percent (0.5 percentage point increase). As discussed in the paragraph above, the *true* labor market tightness (V/S) declines (-0.3 percent) less than the *observed* labor market tightness (V/U) (-10.9 percent) because the observed labor market tightness does not account for the reduced search effort (-10.7 percent). The job-finding rate declines from 5.6 percent per week to 5.0 percent. Mean asset holding declines from 2672 dollars to 1905 dollars, as the precautionary saving motive is weakened by the longer availability of UI benefits. A longer duration of unemployment shifts the composition of skilled and unskilled workers; as the more generous UI benefit duration discourages the search effort and induces unemployed workers to remain unemployed longer, more workers lose their skills during unemployment spells. As a result, the proportion of high-skilled workers in the economy drops from 66 percent in the initial steady state to 65 percent, which lowers the average wage of workers from 779 dollars to 778 dollars.

Figure 6 shows how hazard rates and unemployment duration distribution change by increasing the duration of UI benefits by 20 weeks. As in the case of an increased replacement rate, the changes in the hazard rates are not monotonic. The hazard rates are lower in an economy with longer duration of UI benefits for most part of unemployment durations. However, as unemployed workers are getting closer and closer to exhausting UI benefits, the hazard rates rise more than in the initial steady state. The unemployment duration distribution shifts up noticeably, reflecting the strong moral hazard effect induced by a longer duration of UI benefits.

When the UI benefit duration is further increased to 99 weeks, and then infinite weeks, the effect observed in the 20-week extension is further strengthened. When the UI benefits are available for 99 weeks, the mean duration of unemployment among all unemployed workers becomes 24.1 weeks, and the unemployment rate rises to 6.5 percent. In the steady-state comparison, an



(a) Hazard rates



(b) Unemployment duration distribution

Figure 6: Experiment: Duration of UI Benefits Increased by 20 Weeks.

increase in the UI benefit duration from 26 to 99 weeks increases the unemployment rate by 1.7 percentage points, from 4.8 percent to 6.5 percent. However, as I will show in the next section, this is misleading as the effect of the current UI extensions on the unemployment rate, because of its gradual and temporary nature of the ongoing extensions of UI benefits. The difference between the changes in the *true* labor market tightness (−0.6 percent) and *observed* labor market tightness (−28.2 percent) widens further as the average search effort drops further (−28.0 percent). In the limit case in which UI benefits are available permanently, the average duration of unemployment becomes 28.9 weeks, and the unemployment rate soars to 7.1 percent.

7 Results: Transition

7.1 Baseline Scenario

Figures 7 and 8 summarize the baseline equilibrium transition path generated by the model. Figure 7 covers labor market variables, while Figure 8 covers income, consumption, and asset holding. The figures cover the period between December 2007 and December 2012. As discussed in Section 4.7, the actual data on separation rates up until late 2010 are used as inputs. The path of the loading factor to matching efficiency up until late 2010 is calibrated so that the path of the unemployment rate generated by the model replicates the observed path of the unemployment rate so far. After late 2010, both the separation rates and the loading factor are assumed to gradually go back to their steady-state levels by the end of 2011 and then remain at their steady-state levels. In terms of information, in the last week of December 2007, when the economy is assumed to be in a steady state, the entire path of time-varying parameters $\{\mu_t, \lambda_t\}_{t=1}^{\infty}$ is revealed to all agents. In other words, it is a perfect foresight equilibrium in terms of time-varying parameters. Besides, each of the policy changes (there are nine UI benefit extensions in the baseline transition path) are a complete surprise to the agents. Between June 2008 and December 2010, a total of nine UI benefit extensions are implemented. One can see them as the sudden changes in some of the panels in Figure 7. In December 2012 (the last period in the panels), the economy is still on its gradual way back to the steady state.

Panel (a) of Figure 7 compares the unemployment rate in the data and the one generated by the model. They are close to each other; both increase sharply between the end of 2007 to 2009 and remain high at slightly below 10 percent since then. The closeness is not a result; the loading factor of the matching efficiency is calibrated to achieve it. As there are no more UI benefit extensions, and both the loading factor and separation rate are assumed to gradually revert back to their respective steady-state levels, the unemployment rate in the model is predicted to gradually go back to its steady-state level of 4.77 percent. Panel (b) shows the aggregate and the average search effort. The average search effort drops sharply every time a new extension is executed. The average search effort also remains low between 2008 and 2010, due to congestion (high number of unemployed) and a low search efficiency (the loading factor remains low). On the other hand, the aggregate search effort stays higher than the steady-state level, since the number of unemployed workers is substantially higher than the initial steady-state level during the transition. This naturally causes a high level of vacancy postings during the transition (panel (c)). The model does not do a good job in this dimension thus far, since the observed vacancy posting remained low during the period in the data. One possible explanation is that the model does not capture the shock to the aggregate demand; a negative demand shock might prevent firms from increasing the number of vacancies even though the number of workers searching for a job increased substantially during the downturn. However, the main result of the paper, which is the effect of UI benefit extensions on the unemployment rate is probably not substantially affected, since what is important is how the number of vacancies declines in response to a lower aggregate search effort induced by the UI benefit extensions. An alternative approach is to fix the job-finding rate per search effort and not to allow the job-finding rate to respond to the UI benefit extensions. Since the job-finding rate does change under this alternative approach, the contribution of the UI benefit extensions to the unemployment rate would be smaller.

Panel (d) compares the two definitions of labor market tightness. The first is the *true* labor market tightness, which is the ratio between the number of vacancies and the aggregate search effort (V/S). The other is the *observed* labor market tightness, which is defined as the ratio between the number of vacancies and the unemployment rate. The latter does not take into account the changes in search effort, which are not observed. Both drop at the beginning of the transition path from the steady-state level of 1, as the higher separation rate in the future, which reduces the value of a match, is revealed. At the end of the transition, both are on their way to go back to their respective steady-state levels. The difference arises when the search effort is discouraged by a series of extensions. Each of the nine extensions gives disincentive to the search effort and brings the true labor market tightness down, while the observed labor market tightness is little affected. The diversion between the two definitions of the labor market tightness implies that the changing search efficiency could account for at least a part of the recent movement of the Beveridge curve; the declining search effort appears as the rightward shift of the Beveridge curve if the search effort is not taken into account. Panel (e) exhibits the separation and job-finding rates during the transition. The separation rate is exogenously set and calibrated from the data. The job-finding probability tracks the pattern of the loading factor of the search efficiency (Figure 2), but declines more than the loading factor as the aggregate search effort drops when UI benefit extensions discourage workers to search intensely. Finally, panel (f) shows the mean duration of unemployment in both the model and the data. In the model, as extensions are in effect and the matching efficiency declines, the search effort is discouraged, and the mean duration continues to increase. The effect is stronger for UI-eligible unemployed workers because unemployed workers who are ineligible for UI benefits are not affected by extensions. Since about 70 percent of the unemployed workers are receiving UI benefits during the simulated downturn, the rise in the mean unemployment duration among UI-eligible workers mainly characterizes the mean unemployment duration of all unemployed workers. Compared with the data, the model successfully generates the hump in the mean unemployment duration, but the magnitude is weaker than in data; the mean unemployment duration reached 35 weeks in the data, while the highest duration that the model generates is 27 weeks.

Panel (a) of Figure 8 shows the path of the average consumption. Consumption drops precipitately in the first period when the transition path of the time-varying parameters is revealed. More specifically, since it is revealed that the separation rate and matching efficiency will drop and stay low for awhile, consumption adjusts downward to the revised expected lifetime income. However, when the series of extensions start being implemented from mid-2008, average consumption is adjusted upward, as unemployed workers expect to receive higher benefits (UI benefits instead of non-UI benefits) during most of an unemployment spell. Panel (b) shows the path of the mean asset holding. The mean asset holding keeps rising after the path of time-varying parameters is revealed. The mean asset holding increases from 2672 dollars to 5148 dollars during 2008-2009 and then reverts back to the initial steady-state level gradually after 2009. It is an optimal response of precautionary savings to a higher risk of separation and a longer unemployment spell. It is interesting to note that the saving rate has remained high in the U.S. economy since the recent downturn started. Increased savings are often attributed to the deleveraging from the state of excess borrowing, but this increase can also be rationalized as the increased precautionary savings in response to a higher labor market risk. Panel (c) exhibits the proportion of high-skilled workers in the economy. As the unemployment duration becomes longer (see Figure 7, panel (f)), more workers experience skill depreciation. As a result, the proportion of high-skilled workers declines from the steady-state level of 66 percent to 58 percent in 2011 and slowly recovers after that. The average labor income (panel (d)) reflects the transition of the proportion of skilled workers. The average weekly labor income slowly declines from its steady-state level of 779 dollars to 765 dollars, and slowly goes back to the steady-state level.

In order to decompose the effect of UI benefit extensions, the time-varying separation rate, and the time-varying loading factor to the matching efficiency, which affects the job finding rate, I run a variety of counterfactual experiments. Figure 9 summarizes the results from counterfactual experiments. Panel (a) shows (i) the unemployment rate in the data, (ii) the unemployment rate under the baseline transition path (which is calibrated to replicate the data), (iii) the counterfactual path without UI benefit extensions, and (iv) the counterfactual path without UI benefit extensions and changes in the loading factor. The comparison between (ii) and (iii) tells the contribution of the UI benefit extensions. The comparison between (iii) and (iv) implies the contribution of the time-varying loading factor, and the deviation of (iv) from the steady-state level of the unemployment rate (4.77 percent) implies the effect of the time-varying separation rate. Panel (b) shows these differences; Panel (b) shows the contribution to the unemployment rate from the UI benefit extensions, the changes in the separation rate, and the changes in the matching efficiency and the resulting job-finding rate. I look at the average contribution between September 2008, when the unemployment rate in the data reached 9.7 percent, and December 2010, when the unemployment rate remained high and the latest data was available. The unemployment rate in the baseline transition analysis during the period is 9.87 percent, which is close to the average unemployment rate in the data (9.7 percent). Compared with the initial level of the unemployment rate (4.77 percent), the size of the increase is 5.10 percent. In the alternative experiment without the UI benefit extensions, the average unemployment rate during the same period is 8.63 percent, implying that the contribution from the UI benefits extensions is 1.23 percentage points. This is about 24 percent of the total increase in the unemployment rate. In the economy without the UI benefit extensions but with the time-varying loading factor to the matching efficiency (the average unemployment rate of 8.63 percent), and the economy without either (7.20 percent), the difference in the average unemployment rate is 1.43 percentage points. This is the implied contribution from the time-varying matching efficiency, or the job-finding rate. Compared with the size of the overall change in the unemployment rate, the contribution is 28 percent. The difference between the average unemployment rate of the economy with the time-varying separation rate (7.20 percent) and the steady-state unemployment rate (4.77 percent) is the contribution from the higher separation rate. The magnitude is 2.43 percentage points, or 48 percent of the overall change in the unemployment rate.

What is also striking are the changes in the relative contribution from the three elements over the simulation period. In particular, the contribution from the UI benefit extensions has been increasing. This can be seen in panel (b) of Figure 9. From 2007 until 2009 when the unemployment rate was rising, a large majority of the rise in the unemployment rate was coming from increasing separations. However, as the UI benefit extensions started being enacted, the contribution from the UI benefit extensions continued to rise. As of the end of 2010, the contribution from the UI benefit extensions reaches 1.4 percentage points, while the contribution from the separation and the job-finding rates are 2.0 and 1.5 percentage points, respectively. This change of composition is due to the fact that the separation rate shifted down in 2010 (See Figure 1), while UI benefits extensions are continuously renewed.

The effect from the UI benefit extensions to the unemployment rate is significantly affected by the economic condition. This is shown in panel (b) of Figure 9 as "UI benefits extensions (alternative)." In particular, I show the changes in the unemployment rate when only the UI benefit extensions are implemented without the changing separation rate or the loading factor from their steady-state levels. The effect of the extensions on the unemployment rate is measured to be smaller than the number computed above. On average between August 2008 and December 2010, the contribution is 0.75 percentage point instead of 1.23 percentage points. The main reason is that a higher separation pushes more workers into unemployment, which makes the effect of discouraged search efforts on the unemployment rate greater.

Finally, remember that the effect of extending the duration of UI benefits up to 99 weeks on the unemployment rate is 1.7 percentage points in the steady-state analysis (Table 5). The difference from the transition analysis (1.2 percentage points) highlights the importance of taking the gradual and temporary nature of the ongoing UI extensions in evaluating its implications.

In other words, if the currently available duration of UI benefits were made permanent, the unemployment rate would be pushed up further by 0.5 percentage point.

7.2 Policy Experiments: Counterfactual UI Benefit Extensions

The last UI benefit extension was agreed between the President and Congress in December 2010. This last extension does not increase the maximum duration of UI benefits (which remains at 99 weeks), but it allows those who did not exhaust the maximum duration of benefits and at the same time did not qualify for some of benefits because of the deadline to apply for a higher tier. The focus of the discussion regarding the last extension was mainly its implication on government finances, especially after the outstanding balance of the government debt soared with series of fiscal stimuli, and how it helps the long-term unemployed. Although both issues are important, the extension also has a negative effect on the search effort, which is the main focus of the current paper. In trying to quantify the effect, I run a counterfactual experiment in the model economy where the last extension in the model is not implemented. Panel (a) of Figure 10 compares the dynamics of the unemployment rate under the baseline transition path, where all nine extensions are implemented, and under the counterfactual transition path, where the last extension (December 2010) is not implemented. As you can see, when the labor market condition improves (by assumption) and the economy reverts back to its steady state, the last extension keeps the unemployment rate higher during the transition. In other words, the decline in the unemployment rate would be faster in the counterfactual case without the last extension. The difference in the unemployment rate is at most 0.4 percentage point during mid-2011 and 0.3 percentage point on average in 2011. While the unemployment rate in the baseline case reaches 6 percent in January 2012, the economy will achieve a 6 percent unemployment rate one month earlier (December 2011) under the counterfactual scenario without the last extension. Needless to say, in evaluating the last extension, one has to compare the cost of slower recovery shown here, with the insurance provided to those who are unemployed, and fiscal implications. This is left for future research. Finally, the extreme case in which no UI benefit extension is implemented is shown in panel (b) of Figure 10. In that scenario, the highest unemployment rate during the recent downturn would have been around 9 percent instead of 10 percent. As of December 2010, the unemployment rate under the counterfactual scenario is about 8 percent, as the contribution to a higher unemployment rate by UI benefit extensions increases.

7.3 Sensitivity Analysis

I explore the sensitivity of the main results, which is the effect of UI benefit extensions on the unemployment rate, regarding the most important parameter, ϕ, and the curvature parameter of the matching function, α. Table 6 summarizes the results. Let's start from ϕ (second column). ϕ determines the strength of the response in terms of the search effort to the returns from search. In the baseline calibration, ϕ is calibrated to be 1.7. With the baseline calibration, the mean unemployment duration by UI-eligible unemployed workers increases by 0.5 weeks when the replacement rate of UI benefits is increased by 10 percentage points. A response of 0.5 weeks is the lower bound of the existing empirical estimates, although Hamermesh (1977) argues that it is the best point estimate. In an alternative calibration, I set $\phi = 1.0$. The response of the mean unemployment duration becomes 0.7 weeks, which is higher than 0.5 weeks, but still within the range of existing empirical estimates (0.5-1.5 weeks). Under this alternative calibration, what

Table 6: Sensitivity Analysis

Economy	Baseline	$\phi = 1.0$	$\alpha = 0.5$
Δ in unemployment duration of UI-eligible			
10% Δ in replacement ratio	0.51	0.70	0.52
1 week Δ in UI benefit duration	0.14	0.18	0.14
Δ in the unemployment rate during 2008			
Total (percentage points)	5.1	5.1	5.0
Due to UI benefit extensions	1.2	1.7	1.3
Due to Δ in separation rate	2.4	2.6	2.8
Due to Δ in job finding rate	1.4	0.7	0.9

is the contribution of UI benefit extensions to the observed increase in the unemployment rate? The answer is 1.7 percentage points, which is about a third of the total observed increase in unemployment in 2008. Importantly, the number is substantially higher than the baseline result of 1.2 percentage points. The contribution from the loading factor to matching efficiency, or the job-finding rate is reduced by half (1.4 to 0.7 percentage points). This is because the drop in the loading factor is calibrated to be substantially smaller in the alternative calibration to match the same level of the unemployment rate, with the stronger disincentive effect from UI benefit extensions.

In the third column, the sensitivity analysis with respect to α is shown. The changes in the average unemployment duration by UI-eligible workers in the alternative model with $\alpha = 0.5$ are quite similar to the changes in the baseline model. In terms of the main result of the paper, which is the contribution of the UI benefit extensions to the unemployment rate, the alternative model with $\alpha = 0.5$ generates a 1.3 percentage point increase instead of the baseline result of a 1.2 percentage point increase. In the alternative model, the contribution of the time-varying loading factor to matching efficiency, or the job-finding rate, is smaller; the contribution declines from the baseline number of 1.4 percentage points to 0.9 percentage point. The contribution of the time-varying separation rate also becomes greater in the alternative model; the contribution of the changes in the separation rate is 2.8 percentage points instead of 2.4 percentage points.

8 Conclusion

This paper measures the effect of extensions of UI benefits on the unemployment rate using a calibrated structural model that features job search and consumption-saving decision, skill depreciation, UI eligibility, and a series of UI benefit extensions that capture the UI benefit extensions that have been enacted during the current downturn. By using a structural model, I can capture the effect of UI benefit extensions on the unemployment rate and other macroeconomic aggregates, properly taking into account the gradual and temporary nature of the recent extensions. Moreover, a structural model enables counterfactual experiments. I find that the extensions of UI benefits contributed to an increase in the unemployment rate by 1.2 percentage points, with a baseline conservative calibration. Since unemployment went up by 5.1 percentage points, from 4.8 percent before the current downturn started at the end of 2007 to 9.9 percent in the fall of 2009, the contribution of the series of UI benefit extensions is about a quarter (24 percent). Among the remaining 3.9 percentage points, 2.4 percentage points are due to the large increase in the separation rate, while the staggering job-finding probability contributes 1.4 percentage points. I also find that the last extension moderately slows down the recovery of the unemployment rate. Specifically, the model indicates that the last extension keeps the unemployment rate higher by up to 0.4 percentage point during 2011.

Three directions of future research are worth mentioning. First, the model in this paper can be extended to a general equilibrium model with the production sector, the labor force participation decision, and the government budget constraint. The decline in the search effort has a general equilibrium effect, as employment declines while capital stock increases. Introducing the labor force participation decision also allows us to investigate the discouraged worker effect. Second, the model can be used to study the optimal UI program. The moral hazard effect of generous UI benefits has been studied extensively because it has a strong implication on the optimal design of the UI program; generally, a stronger moral hazard effect implies the optimal UI benefits to be less generous. The model developed in this paper can be used to investigate the optimal UI program using a calibrated structural model. Although there are attempts to investigate the optimal UI program, an analysis with a carefully calibrated structural model has an advantage as the key to answer the question is to compare the relative importance of different effects. Third, there is an ongoing discussion about identifying structural and cyclical changes in unemployment. In order to address the issue, the model can be extended by introducing elements that could change the structural unemployment, such as changes in technology, distribution of skills, demography, permanent policy, or family structure.

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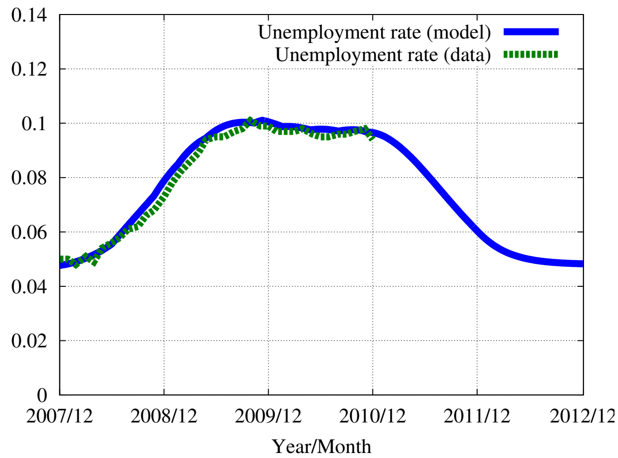
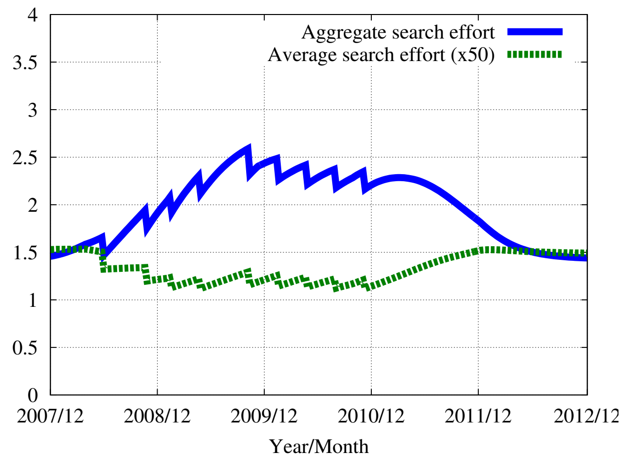
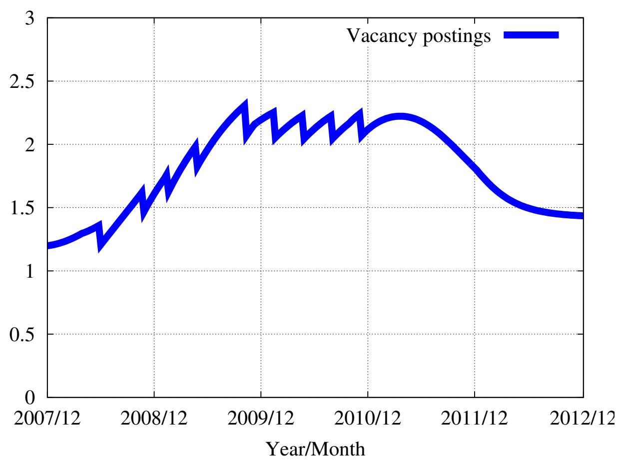


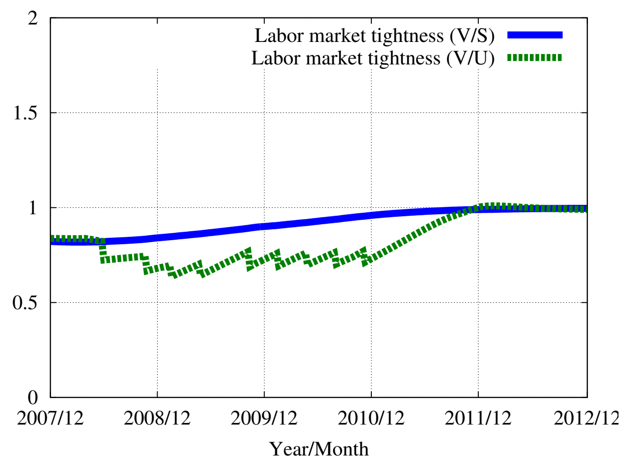
(a) Unemployment rate



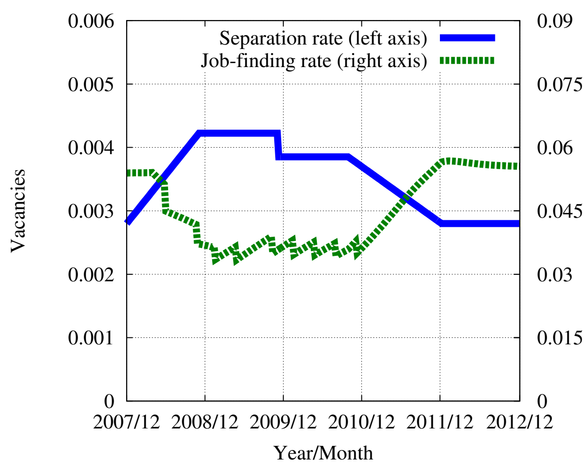
(b) Search effort



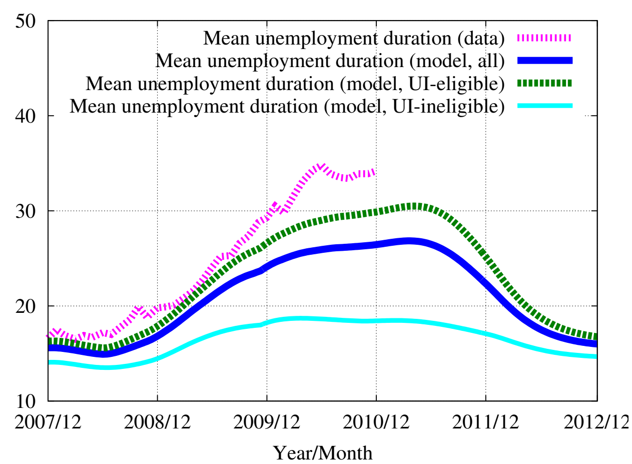
(c) Vacancies



(d) Labor market tightness

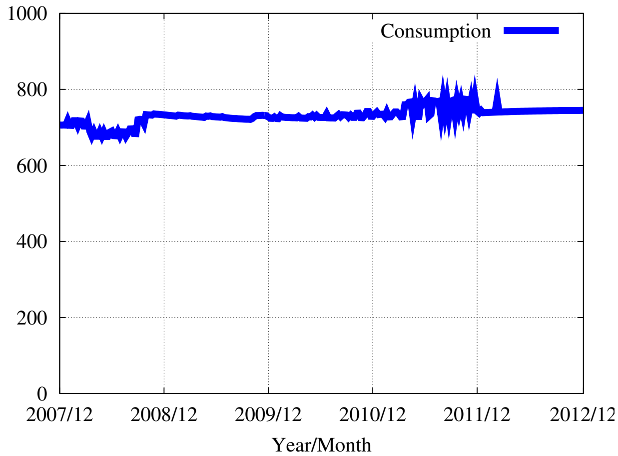


(e) Transition rates

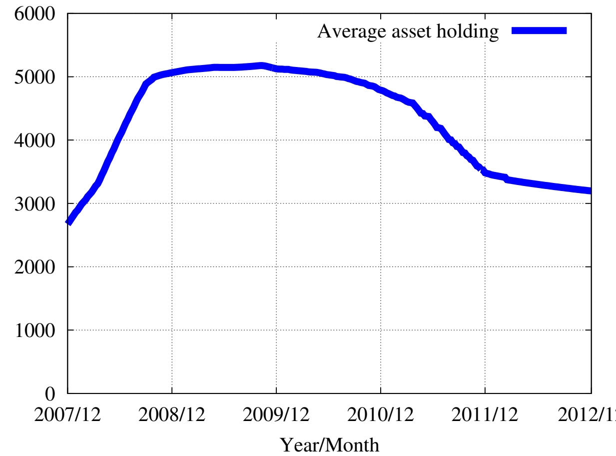


(f) Mean unemployment duration

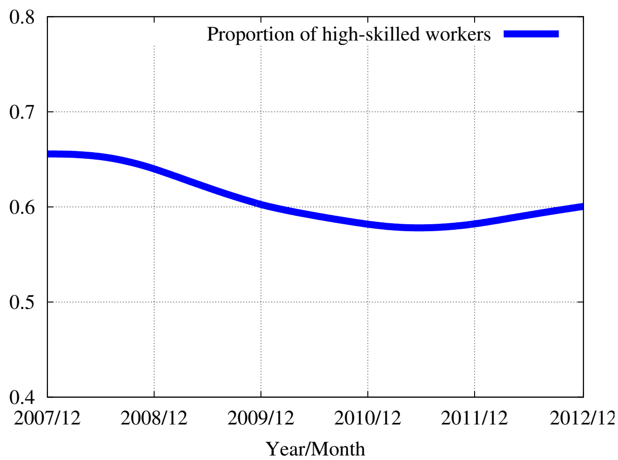
Figure 7: Transition (2007/12-2012/12): Labor Market Variables.



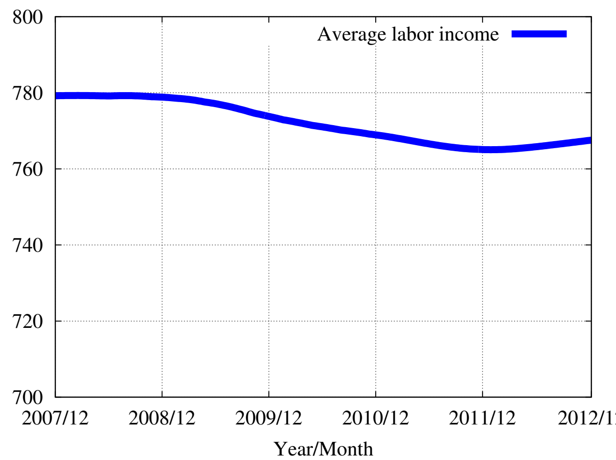
(a) Consumption



(b) Average asset holding

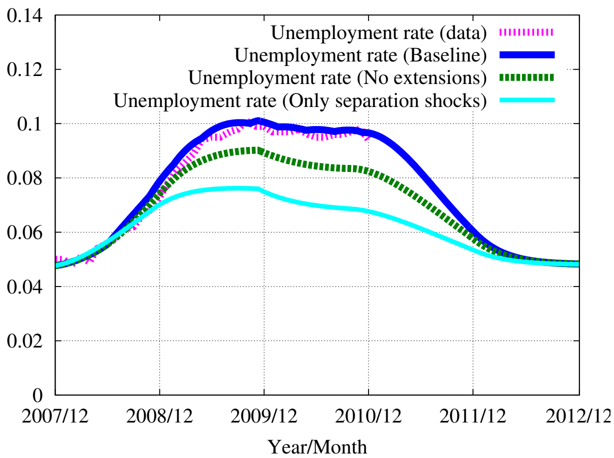


(c) Proportion of high-skill

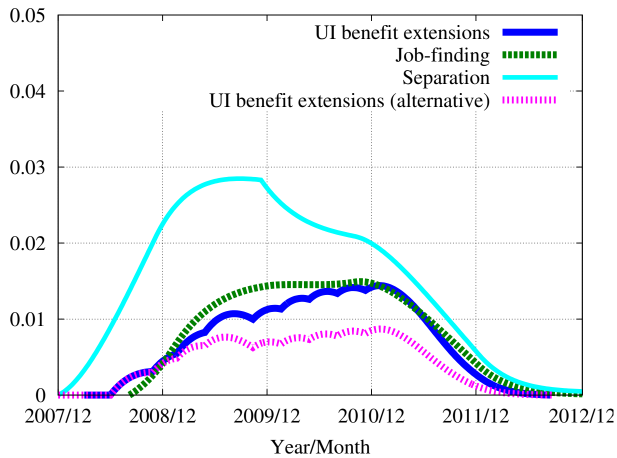


(d) Labor income

Figure 8: Transition (2007/12-2012/12): Income, Consumption, and Savings.

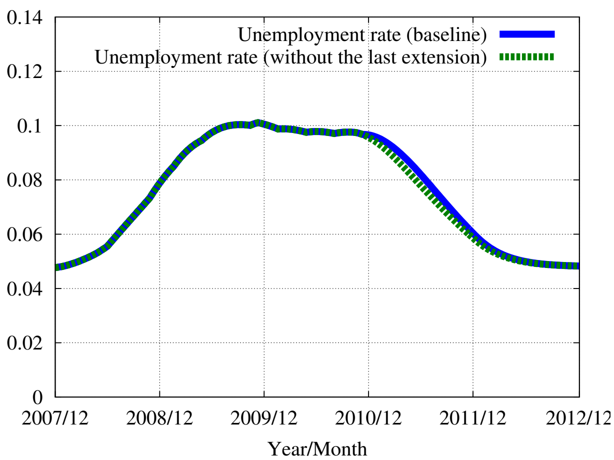


(a) Cumulative differences

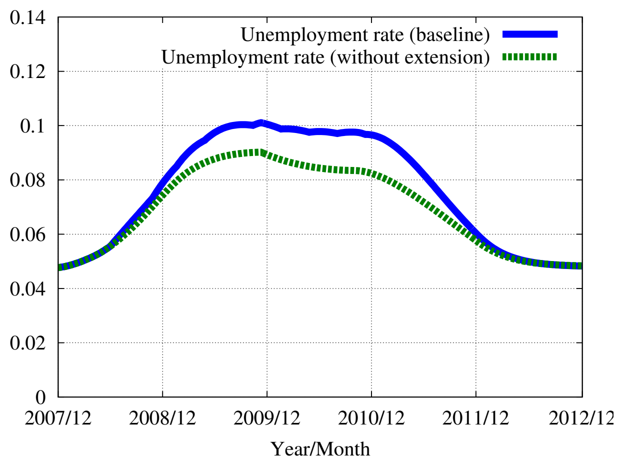


(b) Contribution of each element

Figure 9: Decomposition of the Unemployment Rate.



(a) Without the last extension



(b) No extension at all

Figure 10: Counterfactual Experiment: Without UI Benefit Extension.