

# Unemployment benefits extensions at the zero lower bound on nominal interest rate

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September 16, 2014

## Abstract

*In this paper we investigate the impact of the recent US unemployment benefits extension on the labor market dynamics when the nominal interest rate is held at the zero lower bound (ZLB). Using a New Keynesian model, our quantitative experiments suggest that, in contrast to the existing literature that ignores the liquidity trap situation, the unemployment benefits extension has reduced unemployment by 0.7 percentage point on average. The inflationary pressure caused by the benefits extension reduces the real interest rate and offsets the job search effects and the fall in firms' vacancies posting resulting from the increase in wages. Outside the ZLB, it has adverse effects on unemployment. Furthermore, the ZLB explains 0.9 percentage point of the rise in unemployment.*

**Keywords:** Zero lower bound, New Keynesian models, Search and Matching frictions, Monetary policy, Unemployment benefits extensions.

**JEL Classification:** E24, E31, E32, E43, E52, E62

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# 1 Introduction

Following the dramatic increase of the US unemployment rate during the Great Recession, policy makers have triggered an unprecedent unemployment insurance (UI) benefits extension. The maximum benefits duration has increased from 26 weeks to 99 weeks in some states (see Figure 4). This policy has been frequently pointed out as an important factor in exacerbating unemployment because it reduces job search and job acceptance. However, most of the discussion has left aside the economic environment in which the policy has been conducted. The fall in aggregate demand and deflation have driven the economy in a liquidity trap where the nominal interest rate is pinned at the zero lower bound (ZLB). Several studies show that when the monetary policy loses traction, the impact of various fiscal policies can be quantitatively and qualitatively different ([Eggertsson \(2010\)](#), [Christiano et al. \(2011\)](#), [Erceg & Lindé \(2014\)](#)). Therefore, the role of the benefits extension as a fiscal stimulus must be questioned. In this paper we use a New Keynesian DSGE model with labor market *a la* Diamond-Mortensen-Pissarides (DMP) to investigate the extent to which the benefits extension is responsible for the increase in unemployment when the behavior of the nominal interest rate is taken into account. We exploit aggregate Data on unemployment insurance to quantify the stimulus plan and perform counterfactual experiments to identify the effects of unemployment benefits and the ZLB.

The UI extension has been widely criticized on behalf of the standard disincentive effects on job search decisions. [Barro \(2010\)](#), for instance, argues that it subsidized unemployment and led to insufficient job search and job acceptance. According to his own calculations *the jobless rate could be as low as 6.8%, instead of 9.5%, if jobless benefits hadn't been extended to 99 weeks*. Empirical studies found, however, a much more modest value. [Rothstein \(2011\)](#) shows that UI extensions raised the unemployment rate in early 2011 by only about 0.1 to 0.5 percentage point with only a small impact on workers' job search decisions. [Fujita \(2011\)](#) found an increase in unemployment by about 0.8 to 1.8 percentage points and [Farber & Valtetta \(2013\)](#) by 0.4 pp. Interestingly, [Hagedorn et al. \(2013\)](#) show that the response of the job finding rate mainly explains the persistent increase in unemployment while the search intensity plays little role. They argue that the wage pressure induced by the benefits extension would have reduced the incentive for firms to invest in job creation. In a general equilibrium framework, [Nakajima \(2012\)](#) found that the 2009 UI extension has raised the unemployment rate by 1.4 percentage points. On the opposite side, [Krugman \(2013\)](#) argues that slashing unemployment benefits - which would have the side effect of reducing incomes and hence consumer spending - would not create more jobs but only make the situation worse because employment is limited by demand, not supply.

Do extended benefits have different effects in a liquidity trap? In the litera-

ture presented above, the study of unemployment benefits abstracts from the liquidity trap situation and macro models assume that the recession is driven by productivity shocks. This is at odds with the data since negative supply shocks cause an inflationary pressure and can not affect the interest rate in a way that mimics the financial market turmoils. As mentioned by [Hall \(2013\)](#), the high level of the real interest rate discourages employers to put resources in all type of investment in a liquidity trap. In particular, it decreases employers' expected payoff from taking on new workers, thereby reducing hirings. On the other side, the role of fiscal policies has received a renewed interest since the transmission mechanisms are highly affected in a liquidity trap. For instance, [Christiano et al. \(2011\)](#) and [Carrillo & Poilly \(2013\)](#) documented that the government spending multiplier is larger (than one) when the ZLB on nominal interest rate binds. [Eggertsson \(2011\)](#) shows that an increase in labor supply when the ZLB binds raises the real interest rate which lowers output. This is what he calls the "paradox of toil". When the nominal rate reaches the ZLB, a policy that prompts households to work less may have positive effects on the economy. In general, [Eggertsson \(2010\)](#) argues that the impact of a fiscal intervention hinges on its ability to create an inflationary pressure because it reduces the real interest rate. Last but not least, [Hall \(2012\)](#) portrays the relation between inflation, unemployment and the ZLB during the Great recession. He shows that this interaction is of a great importance for explaining the rise in unemployment and the low decline in inflation. We argue that labor market frictions and the behavior of inflation are keys for quantifying the impact of the UI benefits extensions.

If, as mentioned by [Hagedorn et al. \(2013\)](#), the UI extension has increased wages, its effects on unemployment are non-trivial in a liquidity trap due to the inflation channel. On one hand, it lowers the search intensity and increases wages which makes employers less prone to invest in job creation. On the other hand, the increase in wages involves an inflationary pressure which reduces the real interest rate. The overall impact depends on whether the latter effect dominates the former. Our results suggest that the outcome of the UI extension is strongly linked to the response of the real interest rate. While an increase in unemployment benefits always raises the unemployment rate in normal times, it may have opposite effects in a liquidity trap. The counterfactual experiment shows that the unemployment benefits extension has reduced unemployment when the nominal interest rate had reached the ZLB. Since the benefits extension has been triggered before the nominal interest rate reached the ZLB, it has slightly increased unemployment early in the crisis but reduced it thereafter. From the beginning of 2008 to the mid of 2013, the unemployment rate would have been 0.7 pp higher in the absence of the UI extension. We perform a robustness analysis in which we use an alternative calibration for unemployment benefits. We also modify the elasticity of job search and the elasticity of real wage to unemployment benefits. It is shown that the UI

extension, even in the worst case considered, has reduced unemployment. In addition, we show that the ZLB accounts for 16% of the rise in unemployment.

The rest of the paper is organized as follows. Section 2 is devoted to the presentation of the New Keynesian DSGE model. Section 3 addresses calibration. Simulations and counterfactual experiments are presented in Section 4. Section 5 concludes. We provide a separate appendix describing the model, the calibration and the solution method.

## 2 The model

We use a baseline New Keynesian DSGE model with search and matching frictions ([Mortensen & Pissarides \(1994\)](#)). The model is characterized by nominal price rigidities (Rotemberg's style), monopolistic competition and a feedback Taylor rule for monetary policy. We focus on workers flows between employment and unemployment. Time is discrete and our economy is populated by homogeneous workers and firms. Producing firms are large and employ many workers as their only input into the production process. Labor may be adjusted through the extensive margin (employment), individual hours are fixed. Wages are the outcome of a bilateral Nash bargaining process between each large firm and each worker. We calibrate the model on US data. Aggregate shocks to the discount factor fuel up the cycle.

### 2.1 The labor market

The search process and recruiting activities are costly and time-consuming for firms and workers. A job may either be filled and productive, or unfilled and unproductive. To fill their vacant jobs, firms publish adverts and screen workers, incurring hiring expenditures. Workers are identical and they may either be employed or unemployed. The number of matches,  $m_t$ , is given by the following CES matching function<sup>1</sup>:

$$m_t = \left( (e_t s_t)^{-\gamma} + v_t^{-\gamma} \right)^{-\frac{1}{\gamma}} \leq \min(e_t s_t, v_t) \quad (1)$$

where  $v_t \geq 0$  denotes the mass of vacancies,  $s_t \geq 0$  represents the mass of searching workers and  $e_t \geq 0$  stands for the endogenous search effort. The labor force,  $L$ , is assumed to be constant over time. Assuming  $L = 1$  allows us to treat aggregate labor market variables in number and rate without distinction. The matching function (1) is increasing and concave in its two arguments. A

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<sup>1</sup>The use of a CES matching function ensures that the job finding and filling probabilities remain below 1.

vacancy is filled with probability  $q_t = m_t/v_t$  and the job finding probability per efficiency units of worker search is  $f_t = m_t/(e_t s_t)$ .

## 2.2 The sequence of events

Following Hall (2005), we abstract from job destruction decisions by assuming that in each period a fixed proportion of existing jobs is exogenously destroyed at rate  $\rho^x$ .  $n_t$  denotes employment in period  $t$ . It has two components: new and old workers. New employment relationships are formed through the matching process in period  $t$ . The number of job seekers is given by:

$$s_t = 1 - (1 - \rho^x)n_{t-1} \quad (2)$$

This definition has two major consequences. First, it allows workers who lose their job in period  $t$  to have a probability of being employed in the same period. Second, it allows the model to make a distinction between job seekers and unemployed workers  $u_t = 1 - n_t$ . The latter receive unemployment benefits. The employment law of motion is given by:

$$n_t = (1 - \rho^x)n_{t-1} + m_t \quad (3)$$

## 2.3 The representative household

There is a continuum of identical households indexed by  $i \in [0, 1]$ . Each household may be viewed as a large family. There is a perfect risk sharing, family members pool their incomes (labor incomes and unemployment benefits) that are equally redistributed. We suppose that households have preference over different consumption varieties. Good varieties are indexed by  $j \in [0, 1]$ . Each household maximizes the aggregate consumption using a Dixit-Stiglitz aggregator of differentiated goods  $c_{jt}$  and faces the following demand function<sup>2</sup>:

$$c_{jt} = \left( \frac{p_{jt}}{p_t} \right)^{-\epsilon} c_t \quad (4)$$

which describes the optimal level of  $c_{jt}$  and where  $c_t$  is aggregate consumption. The nominal price index is defined by  $p_t = \left[ \int_0^1 p_{jt}^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}$ . The second problem that households solve is the maximization of aggregate consumption  $c_t$ :

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<sup>2</sup>We skip intermediary equations since they are standard.

$$\max_{\Omega_t^H} E_0 \sum_{t=0}^{\infty} \left( \prod_{k=0}^t \beta_k \right) \left[ \frac{c_t^{1-\sigma}}{1-\sigma} + \ell(1-n_t) \right] \quad (5)$$

$n_t$  is the level of employment supplied by households.  $\sigma > 0$  denotes the coefficient of risk aversion.  $\beta_t$  represents a discount factor shock.  $\ell$  is the utility derived from unemployment (leisure and home production<sup>3</sup>). The representative household chooses the set of processes  $\Omega_t^H = \{c_t, e_t, d_t, n_t\}_{t=0}^{\infty}$  taking as given the set of processes  $\{p_t, w_t, i_t, f_t\}_{t=0}^{\infty}$  and the initial wealth ( $d_0$ ) so as to maximize their utility subject to the budget constraint:

$$p_t s_t k(e_t) + p_t c_t + d_t = d_{t-1}(1 + i_{t-1}) + w_t n_t + (1 - n_t) b_t + \Pi_t + T_t \quad (6)$$

and the law of motion of employment:

$$n_t = (1 - \rho^x) n_{t-1} + f_t s_t e_t \quad (7)$$

$$s_t = 1 - (1 - \rho^x) n_{t-1} \quad (8)$$

$k(e_t)$  is the cost of searching a job for a job seeker.  $d_t$  is the household's holding of one-period domestic bonds. The corresponding nominal interest rate is  $i_t$ .  $w_t$  is the nominal wage level.  $\Pi_t$  represents profits from holding shares in producing firms.  $T_t$  is a lump-sum tax and  $b_t$  denotes unemployment benefits. The optimality conditions of the household's problem are:

$$\begin{aligned} \varphi_t &= \lambda_t \left( w_t^R - b_t^R \right) - \ell \\ &\quad + E_t \beta_{t+1} (1 - \rho^x) (k(e_{t+1}) \lambda_{t+1} + (1 - f_{t+1} e_{t+1}) \varphi_{t+1}) \end{aligned} \quad (9)$$

$$\lambda_t = c_t^{-\sigma} \quad (10)$$

$$\lambda_t = (1 + i_t) E_t \beta_{t+1} \lambda_{t+1} \frac{p_t}{p_{t+1}} \quad (11)$$

$$k'(e_t) = \varphi_t \frac{f_t}{\lambda_t} \quad (12)$$

Equation (9) is the marginal value of employment for a worker.  $w_t^R = w_t / p_t$  and  $b_t^R = b_t / p_t$  denote the real wage and the real unemployment benefits level respectively.  $\lambda_t$  is the Lagrange multiplier on the budget constraint. Equation (11) defines the standard Euler equation and (12) stands for the optimal searching strategy.

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<sup>3</sup>In a previous version of the paper we also consider a desutility of working:  $-\frac{\ell n_t^{1+\phi}}{1+\phi}$  with  $\phi$  being the inverse of the Frisch elasticity, instead of the home production:  $+\ell(1 - n_t)$ . All our results remain unchanged.

## 2.4 Firms

There is a continuum of producers in a monopolistically competitive market indexed by  $j$ . They use labor as their only input and sell output to the representative household. They face quadratic price adjustment costs (Rotemberg-style). The production of a firm  $j$  is a linear function of employment  $n_{jt}$  (with  $\int_0^1 n_{jt} dj = n_t$ ):

$$y_{jt} = n_{jt} \quad (13)$$

The optimization problem of the firm  $j$  consists in choosing the set of processes  $\Omega_{jt}^F = \{v_{jt}, p_{jt}, n_t\}_{t=0}^\infty$  taking as given the set of processes  $\{p_t, w_{jt}, q_t\}_{t=0}^\infty$ . Each  $j$  producer maximizes the following intertemporal function:

$$\max_{\Omega_t^P} E_0 \sum_{t=0}^{\infty} \left( \prod_{k=0}^t \beta_k \right) \frac{\lambda_t}{\lambda_0} \Pi_{jt} \quad (14)$$

where  $\Pi_{jt} = \left[ \frac{p_{jt}}{p_t} y_{jt} - \frac{w_{jt}}{p_t} n_{jt} - \kappa v_{jt} - y_t \Gamma^\pi(p_{jt}) \right]$

subject to the production function (13) and the following evolution of employment:

$$n_{jt} = (1 - \rho^x) n_{jt-1} + q_t v_{jt} \quad (15)$$

$\frac{p_{jt}}{p_t}$  is the relative price which coincides with the marginal cost. Adjusting prices incurs a cost :

$$\Gamma^\pi(p_{jt}) = \frac{\psi}{2} \left( \frac{p_{jt}}{\pi p_{jt-1}} - 1 \right)^2 \quad (16)$$

This cost is assumed to be proportional to the output level  $y_t$ . Inflation is defined as the gross inflation rate  $\pi_t = p_t / p_{t-1}$ .  $\psi$  is the price adjustment cost parameter and  $\pi$  is the steady state inflation. Hiring is costly and incurs a cost  $\kappa$  per vacancy posted (with  $\int_0^1 v_{jt} dj = v_t$ ). It is paid by the firm as long as the job remains unfilled. Since all firms choose the same price and the same number of vacancies in equilibrium we can drop the index  $j$  by symmetry. The optimality conditions of the above problem are:

$$q_t \mu_t = \kappa \quad (17)$$

$$\mu_t = mc_t - w_t^R + (1 - \rho^x) E_t \beta_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \mu_{t+1} \quad (18)$$

$$0 = (1 - \epsilon) + \epsilon mc_t - \psi \frac{\pi_t}{\pi} \left( \frac{\pi_t}{\pi} - 1 \right) \\ + E_t \beta_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \psi \frac{\pi_{t+1}}{\pi} \left( \frac{\pi_{t+1}}{\pi} - 1 \right) \frac{y_{t+1}}{y_t} \quad (19)$$

where  $\mu_t$  is the Lagrangian multiplier associated with the employment evolution that gives the expected marginal value of a job for the firm<sup>4</sup>.  $mc_t$  is the Lagrange multiplier associated with the individual consumption demand. Combining the two first-order conditions (17) and (18) gives the job creation condition:

$$\frac{\kappa}{q_t} = mc_t - w_t^R + (1 - \rho^x) E_t \beta_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \frac{\kappa}{q_{t+1}} \quad (20)$$

This condition shows that the expected gain from hiring a new worker is equal to the average cost of search (which is the marginal cost of a vacancy times the average duration of a vacancy  $1/q_t$ ).

#### 2.4.1 Wage setting

In equilibrium filled jobs generate a return (the firm's marginal value of the job  $\mu_t$  plus the worker's marginal value of the job  $\varphi_t$ ) greater than the surplus from a vacant job and from an unemployed worker. Nominal wages are determined through an individual Nash bargaining process between each worker and his employer who share the total surplus of the match. The outcome of the bargaining process is given by the solution of the following maximization problem:

$$\max_{w_t} \left( \frac{\varphi_t}{\lambda_t} \right)^{1-\xi} \mu_t^\xi \quad (21)$$

The optimality condition of the above problem is given by:

$$\xi \frac{\varphi_t}{\lambda_t} = (1 - \xi) \mu_t \quad (22)$$

where  $\xi \in [0, 1]$  and  $1 - \xi$  denote the firms and workers bargaining power respectively. Using the definition of  $\mu_t$  and  $\varphi_t$ , we have

$$w_t^R = (1 - \xi) \left( mc_t + E_t \beta_{t+1} \frac{\lambda_{t+1}}{\lambda_t} (1 - \rho^x) \kappa \theta_{t+1} e_{t+1} \right) + \xi z_t \quad (23)$$

$$z_t = b_t^R + \frac{\ell}{\lambda_t} - E_t \beta_{t+1} (1 - \rho^x) \frac{\lambda_{t+1}}{\lambda_t} k(e_{t+1}) \quad (24)$$

As it is standard in matching models, the real wage is a weighted sum of the worker's outside option  $z_t$  (unemployment benefits, leisure and cost of search) and their contribution to the product (productivity and the saving of vacancies costs).

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<sup>4</sup>It is obtained by taking the derivative of (14) w.r.t  $n_t$ .

## 2.5 The monetary and fiscal authorities

We assume that the central bank adjusts the nominal interest rate  $i_t$  in response to deviations of inflation and output from their steady-state value according to a Taylor-type rule:

$$1 + i_t = \begin{cases} (1 + i_{t-1})^{\rho_i} \left( \frac{\pi}{\beta} \left( \frac{\pi_t}{\pi} \right)^{\rho_\pi} \left( \frac{y_t}{y} \right)^{\rho_y} \right)^{1-\rho_i} & \text{if } i_t > 0 \\ 1 & \text{otherwise} \end{cases} \quad (25)$$

We assume that unemployment benefits are proportional to the aggregate wage and obey the following rule:

$$b_t^R = \tau_t w_t^R \quad (26)$$

where  $\tau_t$  is the replacement rate that follows an AR(1) process. The fiscal authority finances unemployment benefits  $b_t^R$  through the lump-sum tax  $T_t$ . Formally the fiscal budget rule satisfies:

$$d_t + b_t(1 - n_t) = (1 + i_{t-1})d_{t-1} + T_t. \quad (27)$$

## 2.6 Market clearing

The aggregation of individual profits  $\Pi_t$  is given by:

$$\Pi_t = p_t y_t - n_t w_t - p_t y_t \Gamma_t^\pi \quad (28)$$

Equation (27) together with the budget constraint (6) and the profit (28) gives the aggregate resource constraint:

$$y_t \left[ 1 - \frac{\psi}{2} \left( \frac{\pi_t}{\pi} - 1 \right)^2 \right] = c_t + \kappa v_t + s_t k(e_t) \quad (29)$$

## 3 Model calibration

We assume quarterly frequencies in our calibration. The benchmark calibration follows [Hagedorn & Manovskii \(2008\)](#), [Christiano et al. \(2011\)](#), [Fernández-Villaverde et al. \(2012\)](#) and [Gust et al. \(2012\)](#). The model is solved using a Parameterized Expectation Algorithm (PEA)<sup>5</sup> as in [Albertini et al. \(2014\)](#). It

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<sup>5</sup> The ZLB can not be accurately studied using linear-approximation methods, see [Braun et al. \(2012\)](#) for comparison. A full description of the algorithm is provided in the separate appendix.

approximates policy rules and expectation functions by orthogonal polynomials. This algorithm is well-suited to approximate accurately kinks in decision rules.

**Preferences:** We set the steady state discount factor to 0.996 which gives an annual risk-free rate of 1.6%. This value is in the middle range of [Erceg & Lindé \(2014\)](#) and [Hall \(2012\)](#) ( $\beta = 0.995$ ) and [Eggertsson \(2010\)](#) ( $\beta = 0.997$ ). Following [Fernández-Villaverde et al. \(2012\)](#), the elasticity of substitution between goods is  $\varepsilon = 6$  which gives a gross markup of about 1.2.  $\beta_t$  follows an AR(1) process:  $\log \beta_t = \rho_\beta \log \beta_{t-1} + (1 - \rho_\beta) \log \beta + \sigma_\beta \varepsilon_t^\beta$  where  $\rho_\beta = 0.85$  and  $\sigma_\beta = 0.0025$  are calibrated to match the average time spent of the nominal interest rate at the ZLB of 5%.

**Monetary policy:** Inflation at the steady state is about 2% on an annual basis on average, which implies  $\pi = 1.005$  at quarterly frequencies. With  $\beta$  being equal to 0.996, the Euler equation involves an annual steady state nominal interest rate of 3.66%. Following the standard approach we assume that  $\psi = 90$ . It corresponds to a Calvo parameter of 0.75 when  $\varepsilon = 6$  in the log-linearized Phillips Curve. From [Gust et al. \(2012\)](#), who estimate a DSGE model with ZLB, we set  $\rho_\pi = 1.5$  and  $\rho_y = 0.5$ .  $\rho_i$  is set to match the path of the nominal interest rate over 1998Q4-2013Q2, especially the liquidity trap period. We found that  $\rho_i = 0.6$ . It is lower than conventional values found in estimations but it is still consistent with the rapid decline in the interest rate in 2008.

**Labor market, stocks and flows:** The US unemployment rate  $u$  is set to 5.5%, corresponding to an average over the last three decades. We set the probability of being unemployed  $\rho^x = 10.61\%$  as in the data (BLS). At the steady state, the number of matches must be equal to the number of separations:  $m = \rho^x n$  with  $n = 1 - u = 0.945$ . We get the number of job seekers from the definition  $s = 1 - (1 - \rho^x)n$ . Setting  $e = 1$ , involves a job finding rate  $f = m/(es) = 64.6\%$ . The implied unemployment duration is equal to 20.15 weeks, a value a little bit higher than the one reported by the BLS. The implied hiring rate  $m/n = 10.61\%$  is close to the data (10.65%). Following [Andolfatto \(1996\)](#), the rate at which a firm fills a vacancy is about 0.9. From the CES matching function,  $\gamma$  is calculated in such a way that  $q = 0.9$ . We get  $v = m/q$ .

**Unemployment insurance and the value of non-market activities:** The quantitative evaluation of the unemployment benefits extension will be achieved by increasing the replacement rate. We discuss in section 4.3 the reasons why our experiment is a good proxy for the extended benefits program and how we link the observed variations in the benefits duration to the replacement rate. For now, the response of the labor market to an increase in UI benefits

has to be consistent with empirical estimates. We target the long-run elasticity of unemployment duration with respect to the UI generosity in normal times (outside the ZLB environments and without any shock on the discount factor). Meyer (1990) shows that a 10 percent increase in benefits is associated with a decrease in the hazard rate between 5.3 and 8.8 percent. We take the average: 7.05. It means that the elasticity of unemployment duration with respect to the level of unemployment benefits  $b_t$  must be around 0.7. Let  $D_t^u = 1/(f_t e_t)$  be the unemployment duration. The elasticity is defined as:

$$\mathcal{E}(D_t^u, b_t) = \frac{\sum_{j=1}^t (1+i)^{-j} (D_j^u - D^u)}{\sum_{j=1}^t (1+i)^{-j} (b_j - b)} \frac{b}{D^u} \quad (30)$$

where  $(1+i)$  is the steady state nominal interest rate,  $D^u$  and  $b$  denote the steady state of unemployment duration and unemployment benefits respectively. This definition follows Leeper et al. (2009) and Carrillo & Poilly (2013) who calculate the *cumulative government spending multiplier*<sup>6</sup>. It measures the expected and discounted marginal change in unemployment duration due to an increase in unemployment benefits  $j$ -periods ahead in time. This definition is worthwhile since it takes into account the cumulative effects and the persistence of UI benefits.

The elasticity is driven by two important parameters: the level of the replacement rate and the search cost curvature. The latter governs the response of the search effort to an increase in unemployment benefits. We calibrate the replacement rate and pin down the search cost curvature so as to match our target. The replacement rate calculated by DOLETA (2014)<sup>7</sup> is about 0.4. As mentioned by Hall & Milgrom (2008), this is an upper bound because a significant proportion of unemployed workers are not insured or do not receive any benefits. Using Merz (1995) specification, the cost of search takes the form:  $k(e) = k_0 e^\eta$  with  $k_0 > 0$  and  $\eta > 1$ . The implied value of  $\eta$  that matches our target is  $\eta = 1.1$ . We come back later to the calibration of  $\eta$  and  $\tau$  in our robustness analysis.

The replacement ratio  $\tau_t$  follows an AR(1) process:  $\log \tau_t = \rho_\tau \log \tau_{t-1} + (1 - \rho_\tau) \log \tau + \sigma_\tau \varepsilon_t^\tau$ ,  $\varepsilon_t^\tau \sim \mathcal{N}(0, 1)$ . We impose the steady state replacement ratio to be equal to  $\tau = 0.4$  as mentioned previously. We follow Christiano et al. (2011) and Fernández-Villaverde et al. (2012) to calibrate the shock process. They consider a government spending shock but  $\tau_t$  can be viewed as a specific government spending shock. They set  $\rho_\tau = 0.8$  and  $\sigma_\tau = 0.0025$ .  $\rho_\tau$  and  $\sigma_\tau$  have little incidence on the size of the elasticity.

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<sup>6</sup>The difference between our definition and theirs is that we multiply the expression by  $\frac{b}{D^u}$  to get the elasticity.

<sup>7</sup><https://ows.doleta.gov/unemploy/Chartbook/a16.asp>

In Figure 2 we simulate the model and compute  $\mathcal{E}(D_t^u, b_t)$ . We draw a shock  $\varepsilon^\tau$  from the normal distribution and compute the path of  $D_t^u$  and  $b_t$ . Since  $D_t^u - D^u$  and  $b_t - b$  tend both to zero as time goes by, the elasticity stabilizes. We target the long-run value. We repeat this procedure 10000 times. At each step of the bootstrap we draw a new value for the shock. We compute 95% confident intervals. The elasticity is about 0.45 on impact and slowly converges to 0.7 as time goes by.

We calibrate the rest of the parameters such that the value of non-market activities ( $z$ ) is in line with [Hagedorn & Manovskii \(2008\)](#). To reproduce the volatility of unemployment and vacancies, they assume that the ratio of non-market activities over the productivity is equal to 95.5%. For the sake of comparison, we follow their approach but our demand-driven fluctuation setup does not require a small surplus calibration to match the volatility of unemployment and vacancies. Furthermore, we do have monopolistic competition.  $z$  cannot be directly compared to the steady state productivity (which is equal to one) because it is multiplied by the marginal cost. We instead focus on the ratio of non-market activities over the real wage. We target a ratio of 95%. We impose  $\xi = 0.5$ , according to [Pissarides & Petrongolo \(2001\)](#).  $\ell$  is pinned down to achieve this results<sup>8</sup>. The remaining parameters  $\kappa$  and  $k_0$  are set to balance the wage equation (24) and the optimal search strategy equation (12). It is shown that the costs of posting vacancies  $\kappa v$  are about 1% of the GDP, consistent with calibrations that focus on this ratio rather than the value of non-market activity. The calibration is summarized in Table 1.

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<sup>8</sup>The implied ratio  $z/mc$  is found to be equal to 93.3%.

Variables	Symbol	Value	Source
Discount factor	$\beta$	0.996	0.016 annual risk-free rate
Elast. of subst. between goods	$\epsilon$	6.00	Markup of 20 percent (FGQR)
Steady state inflation	$\pi$	1.005	Target 2 percent annual
Autocorr. coefficient	$\rho_\beta$	0.85	Target ZLB spells
Std. of $\beta_t$	$\sigma_\beta$	0.0025	Target 5 percent at the ZLB
Vacancy posting costs	$\kappa$	0.10	Get $\kappa v \simeq 0.01y$
Value of non-market activities	$z$	0.78	Deduced
Leisure and home production	$\ell$	0.48	Target $z/w \simeq 0.95$
Search cost curvature	$\eta$	1.10	Target $\mathcal{E}(D_t^u, b_t) = 0.7, t \rightarrow \infty$
Replacement rate	$\rho^R$	0.40	<a href="#">DOLETA (2014)</a>
Matching frictions	$\gamma$	2.74	Target $q \simeq 0.9$
Worker bargaining power	$\xi$	0.50	PP
Price adjustment	$\psi$	90.00	$\simeq$ Calvo 0.75
Response to inflation	$\rho_\pi$	1.50	GLPS
Response to output	$\rho_y$	0.50	GLPS
Interest rate smoothing	$\rho_i$	0.60	Target ZLB spells
Autocorr. coefficient $b_t$	$\rho_b$	0.80	CER
Std. of $b_t$	$\sigma_b$	0.0025	CER

Table 1: **PARAMETERS FOR THE BENCHMARK PP:** [Pissarides & Petrongolo \(2001\)](#), CER: [Christiano et al. \(2011\)](#), GLPS: [Gust et al. \(2012\)](#), FGQR: [Fernández-Villaverde et al. \(2012\)](#).

## How well do the model match the data?

In order to simulate various policy experiments the model has to be empirically relevant, especially regarding the magnitude of labor market fluctuations. The ability of the DMP model to reproduce the cyclical behavior of key labor market variables has received an important attention. [Shimer \(2005\)](#) and [Hall \(2005\)](#) argued that the model in its standard form is clearly unable to generate substantial fluctuations in unemployment, vacancies and the labor market tightness as compared to the data. The reason is that wages absorb most of the variations coming from productivity shocks. However, many economists and institutions have cast some doubts on the movements of productivity as a main driver for business cycle fluctuations, especially over the last three recessions in the US. [Albertini & Poirier \(2014\)](#) questioned the importance of the productivity shock and the discount factor shock for labor market fluctuations. In an estimated matching model they show that the bulk of variations in unemployment and vacancies is mostly explained by disturbances pertaining to the discount factor. They also show that the discount factor shock generates a relative (to output) labor market volatility consistent with the data. These results do not rely on a specific calibration *à la* [Hagedorn & Manovskii \(2008\)](#)

since the chosen value of non-market activities represents 50% of the wage.

To evaluate whether the model succeeds in reproducing key business cycle facts, we simulate the moments (Table 2). In our demand-driven fluctuations setup the relative volatility of unemployment, vacancies and the tightness is well reproduced. Focusing on the labor market equation (20), the basic mechanism behind the discount factor shock lies in the movements of the expected value of a job. The shock directly impacts the payoff to job creation. As firms experience drastic variations in the expected payoff from hiring a new worker, they adjust job openings very sharply. In models with TFP shocks the job productivity and the wage rate move in the same direction. The difference between both is very small which implies less variations in the expected gain from hiring a new worker. This effect is absent in our setup since the discount factor shock directly impacts the expected hiring costs and generates large fluctuation in the tightness.

The model generates a negative correlation between unemployment and vacancies that is needed to reproduce the Beveridge curve. Furthermore, the use of non-linear methods highlights the asymmetries implied by the model. They are almost identical to those found in the data except for vacancies. We perform various numerical experiments<sup>9</sup> to disentangle the mechanisms. We show that the ZLB explains about two thirds of the asymmetries. The rest being explained by the CES matching function, the convexity of the search cost function and the quadratic price adjustment cost. The ZLB amplifies the absolute volatility of the labor market but lets the relative volatility unchanged.

Variables	Symbol	Data	Benchmark calibration
<b>RELATIVE STANDARD DEVIATIONS</b>			
Unemployment	$u_t$	10.75	16.70
Vacancies	$v_t$	10.72	11.11
Tightness	$\theta_t$	21.14	25.56
<b>SKEWNESS</b>			
Unemployment	$u_t$	0.12	0.12
Vacancies	$v_t$	-0.51	-0.11
Tightness	$\theta_t$	-0.26	-0.19
<b>CORRELATION</b>			
Unemployment, Vacancies	$u_t, v_t$	-0.94	-0.68

Table 2: *Cyclical properties of the model.* US statistics are computed using a quarterly HP-filtered data from 2000Q1:2013Q2 with smoothing parameters 1600. The model is simulated  $10^5$  times. We discard the first 2000 observations. Standard deviations are relative to output.

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<sup>9</sup>These results are available upon request.

## 4 Simulation

### 4.1 How does the ZLB impact the economy?

We first present some preliminary results on the ZLB. To understand how the ZLB impacts the labor market, we compute the response of the variables following a sufficiently large demand shock to send the economy to the ZLB (see Figure 1). The size of the shock is calibrated to match the observed increase in unemployment. It reached 10% in October 2009. In our model such a shock involves a fall in output of 5% and a fall in the quarterly gross inflation rate of about 1.2%, that is broadly consistent with the data. The implied ZLB spell is equal to five quarters. Firms cut vacancies by around 45% which is a similar decrease in the data between 2007Q4 and 2009Q4. The real interest rate decreases on impact and gently returns to its equilibrium value.

The red dotted line shows the response of the variables when the nominal interest rate is not constrained by the ZLB<sup>10</sup>. It is shown that the ZLB amplifies the propagation of the labor market downturn. Without any binding constraint, the nominal interest rate falls to -1% which implies a stronger decrease in the real interest rate. This makes the expected payoff to an employer from hiring new workers higher. It reduces the decrease in employers' incentives to invest in job creation and to open vacancies. The fast stabilization in real wage dampens the decrease in the marginal cost and the deflationary pressure. On the supply side of the labor market, it increases the workers' marginal value of a job. This involves a lower decline in the search intensity. The overall impact on unemployment is negative. When the economy is not constrained by the ZLB, the unemployment rate increases less on impact (about 2 percentage points lower) and return more rapidly to its equilibrium value. The same is true for the drop in output and in consumption.

### 4.2 Elasticity of unemployment with respect to UI benefits

Before running the counterfactual experiments, we show preliminary results on the response of the unemployment duration resulting from a one-period and temporary increase in the replacement rate. To make a clear comparison, the elasticity at the ZLB is computed as follows:

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<sup>10</sup>Variables expressed in rate do not have the same level initially. The reason is that agents' expectations about liquidity trap have permanent effects on aggregate variables. Indeed, given the distribution of shocks, if agents do not consider that the economy may fall in a liquidity trap they modify their consumption and labor choices. Linear approximation methods do not capture these effects.

$$\mathcal{E}^{ZLB}(D_t^u, b_t) = \frac{\sum_{j=1}^t (1+i)^{-j} (D_{\beta,\tau,j}^u - D_{\beta,j}^u)}{\sum_{j=1}^t (1+i)^{-j} (b_{\beta,\tau,j} - b_{\beta,j})} \frac{b_{\beta,j}}{D_{\beta,j}^u} \quad (31)$$

$D_{\beta,\tau,t}^u$  and  $b_{\beta,\tau,t}$  are the responses of the unemployment duration and UI benefits respectively to a shock on the discount factor and on the replacement rate. Variables without subscript  $\tau$  correspond to the impulse responses to a discount factor shock only. This definition allows to measure the impact of the policy shock conditional on the aggregate state of the economy defined by the size of the demand shock.

In the standard DMP model, an increase in the unemployment benefits raises the workers' outside option, which is the present value of being unemployed. It strengthens workers' bargaining position and allows them to claim for higher wages. In addition, the decrease in workers' search intensity reduces the job finding rate and the firms' bargaining positions because it increases the outside option. Firms become less prone to hire workers and cut the number of vacant jobs. The labor market tightness falls and the unemployment rate and the unemployment duration both increase. This is the basic story in normal circumstances. We call these mechanisms the "*standard effects*" of UI. In that case, the elasticity (solid black dotted line in Figure 2) jumps above its long-run level and continues to increase due to the cumulated effects. A rise in unemployment benefits by 1% increases unemployment duration by 0.45% in the short-run and 0.7% in the long-run.

At the ZLB, a rise in unemployment benefits may increase output and lower unemployment. The intuition is as follows. Unemployment benefits increase real wages. On one side, it reduces the search intensity and the incentive for firms to hire workers. But on the other side, it curbs the decline of the marginal cost and the deflationary spiral induced by the preference shock, which dampens the increase in the real interest rate. Indeed, the liquidity trap is characterized by a zero nominal interest rate and a fall of inflation or deflation. The real interest rate is too high compared to the value that clears the market. As a consequence, the size of the elasticity hinges on 1) the size of the recessionary shock that drives the deflationary spiral and 2) the ability of unemployment benefits to create sufficient inflationary pressures to lower the real rate. The solid black dotted line in Figure 2 shows that a 1% increase in UI benefits reduces the unemployment duration by 1.8% in the short-run. Since the economy escapes the liquidity trap after 5 quarters, the standard effects of unemployment benefits dominates and the elasticity declines. The cumulated elasticity returns to a higher value (-0.25% in the long-run).

Figure 3 shows that the elasticity may be highly non-linear in the size of the demand shock (solid black line). It remains barely unchanged as long as the discount factor is too small to push the economy in a liquidity trap. If the nom-

inal interest rate lasts at least 4 quarters at the ZLB, the fiscal policy is likely to reduce the unemployment duration. The long-run elasticity can be easily lower than minus one, meaning that increasing UI benefits by 1% reduce unemployment duration by more than one percent. If the nominal interest rate remains only few periods at the ZLB, the decrease in the real interest rate does not offset the disincentive effect of unemployment benefits on search and hiring activities. The elasticity is still positive but lower than in normal times (no discount factor shock). It is worth noting that, without any constraint on the nominal interest rate (black dotted line), the elasticity increases in bad times. The higher the recessionary shock the larger the elasticity<sup>11</sup>. During economic downturns the standard effects of UI dominate the fall in the real interest rate. The intuition is that agents do not internalize the probability to enter the liquidity trap. Any increase in UI benefits is likely to worsen the situation simply because the inflation channel is muted. It will only increase the burden of labor cost in recession without lowering the real interest rate substantially. This is an important result since the state of the economy and the ZLB strongly matters for the level of the elasticity.

### 4.3 Counterfactual analysis

We now perform the counterfactual analysis based on the observed unemployment path. We investigate three alternative scenarios. We wonder what would have been the path of the economy in the absence of 1) the unemployment benefits extension, 2) the ZLB and, 3) the ZLB and the unemployment benefits extension. The methodology is as follows:

- We build a time series for the replacement rate shock based on variations in the maximum benefits eligibility duration.
- Given the replacement rate shock, we solve for the path of the discount factor shock that makes the simulated series of the unemployment rate as close as possible to its empirical counterpart.
- Given the path of the two shocks, we simulate the path of the endogenous variables under the three alternative scenarios.

Up to now we have considered a shock on the replacement rate but the benefits extension has been achieved through an increase in the maximum duration of benefits that insured unemployed are allowed to claim for. We argue that it can be viewed as an increase in the aggregate replacement rate and not only for practical reasons. Indeed, the mechanism relies explicitly on the

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<sup>11</sup>As previously, the elasticities are not the same outside the ZLB because of the expectations effects coming from the ZLB.

rise in the workers' outside option that results from an increase in UI generosity. Models with eligible and non-eligible unemployed workers for unemployment benefits<sup>12</sup> (Moyen & Stahler (2012) and Mitman & Rabinovich (2011)) gives the same outcomes. The outside option is increasing with respect to the difference between the expected payoffs (eligible minus non-eligible for benefits). Reducing the transition rate at which eligible workers lose their eligibility pushes an upward pressure on the outside option. The impact depends on the difference between the two value functions or, equivalently, the average payoff from unemployment. A rise in the replacement rate may achieve the same disturbance because it involves a higher expected value from unemployment. For this reason, a shock on the replacement rate in our model seems to be a good and tractable candidate to proxy the extended UI benefits.

However, it boils down to the following question: by how much the replacement rate must increase given the observed increase in benefits duration? Said differently, what is the size of the replacement rate shock needed to be a *good proxy* for the UI benefits extension? The use of benefits duration for the determination of the replacement rate index has been widely used by the OECD and Layard et al. (2005) for international comparisons. Basically, the gross replacement rate (ratio to the proportion of workers' wages replaced by UI benefits) is combined with the benefits duration in order to determine a net replacement rate<sup>13</sup>. We use a very simple version of their methodology by considering the following linear relationship:

$$\tau_t = \phi_0 + \phi_1(D_t^{\max} - \bar{D}^{\max}) \quad (32)$$

where  $D_t^{\max}$  is the maximum benefits duration at time  $t$ .  $\bar{D}^{\max}$  stands for the maximum benefits duration in the absence of any specific program. It is equal to 26 weeks under the regular Unemployment Compensation (UC) program. By definition, the Y-intercept  $\phi_0$  is equal to the steady state replacement rate  $\tau$ .  $\phi_1$  is more problematic since we do not have any direct information. Our strategy is to use micro-elasticity estimates of unemployment duration with respect to the benefits duration in the US before the Great Recession. Using these estimates, one can determine by how much would a 64 week extension<sup>14</sup> raise the unemployment duration in normal times. We then search for the increase

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<sup>12</sup>In some studies, the definitions *short-term unemployed* and *long-term unemployed* are used to make a distinction between workers with high and low replacement ratio respectively.

<sup>13</sup>See appendix A for details.

<sup>14</sup>The benefits extension is based on two programs: the Extended Benefits program (EB) and the Emergency unemployment compensation (EUC08). It is important to note that if the "99 weeks" of benefits are often put forward, the maximum duration we obtain by aggregating each state is 90 weeks (see Figure 4). Starting from the standard 26 weeks, the policy corresponds to a 64 week extension and not a 73 week extension. See appendix A for calculation of the maximum benefits duration series.

in the replacement rate shock needed to generate this increase. We deduce  $\phi_1$  such that a 64 week extension reproduces the increase in the replacement rate and, as a consequence, matches the increase in the unemployment duration. [Card & Levine \(2000\)](#) show that a one week increase in benefit duration increases the average unemployment duration by 0.1 to 0.2 weeks. It leads to an increase in the unemployment duration by 6.4 to 13 weeks. We target the lower bound. The upper bound amplifies the quantitative impact, not the qualitative effects of our experiments. By choosing the lower bound we underly the minimum effects of the policy. The implied permanent increase in the replacement rate is about 7%.  $\phi_1 = 0.005$  matches this target.

The path of the discount factor shock (obtained by simulations) and the replacement rate shock (calculated using equation (32)) are depicted in Figure 5. The replacement rate increases slightly during the 2001 recession because of the automatic adjustments triggered under the Extended Benefits program. It increases sharply in 2008 due to the Extended Benefits program and the Emergency Unemployment Compensation. The discount factor shock is well below zero at the beginning of the sample but experiences a brutal increase during the Great recession. [Hall \(2013\)](#) find a similar shape using the S&P stock market index (SP500) as a proxy for the discount rate.

Figure 6 shows the simulated path for macroeconomic time series. Despite the remarkable simplicity of the model, the fit of the aggregate variables is surprisingly good. Recall that we only use one shock to reproduce the historical unemployment rate, the rest of the macroeconomic series being simulated. Although not as large as in the data, the fall in gross inflation is matched reasonably well. One important reason is the introduction of the unemployment benefits shock. It raises the real wage and the marginal cost which offset the deflation induced by the discount factor shock. The simulated nominal interest rate behaves similarly to the one observed in the data without any need for an implausible deflation. The reason is that taking into account the movements in unemployment in the Taylor rule (recall that  $y_t = 1 - u_t$ ) pushes the nominal interest rate down to the ZLB. In other words, the ZLB is reached because the sharp increase in unemployment compensates the lower decline in inflation<sup>15</sup>. It hits the ZLB just one quarter later but stays at the ZLB until the end of our sample period. The ability of the model to reproduce the path of macroeconomic variables echoes to [Hall \(2012\)](#) results where the interaction between labor market frictions, the behavior of inflation, and the ZLB are important for the understanding of the Great Recession. The simulated fall in vacancies<sup>16</sup> in

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<sup>15</sup>The Federal Reserve also reports a strong link between the behavior of the interest rate and unemployment: “*the Committee also reaffirmed its expectation that the current exceptionally low target range for the federal funds rate of 0 to 1/4 percent will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent.*”, press release, December 18, 2013

<sup>16</sup>We use the Help-wanted advertising index [Barnichon \(2010\)](#) as a proxy for vacancies. Since it is normalized as a base 100 we compute the growth rate to make the series comparable.

2008 is not as severe as in the data but still acceptable.

The alternative scenarios are presented in Figure 7 and in the first column of Table 3. The first counterfactual scenario (red dotted line) consists in removing the unemployment benefits extension. In line with previous experiments, the unemployment benefits extension is far from having exacerbated the rise in unemployment. As the path of inflation suggests, the inflationary pressure caused by the rise in the replacement rate breaks the increase in the real interest rate. In turn, this effect offsets the decline in search intensity and the rise in real wages that prompts employers to post fewer vacancies. Unemployment would have been 0.7 percentage point higher on average with a maximum of 1.5 pp in the absence of the labor market policy. It is important to note that the rise in unemployment benefits has been triggered in 2008 Q1 while the nominal interest rate reached the ZLB in 2009 Q1. During this period the unemployment rate would have decreased in the absence of the benefits extension<sup>17</sup>. In addition, our model enters in a liquidity trap one quarter after the official federal fund rate, amplifying this effect. By including these periods in the calculation of the average variation in unemployment, we voluntarily underestimate the decline in unemployment induced by the benefits extension.

Second, given the path of the shocks, an economy without ZLB would have experienced lower unemployment (blue circled line). For instance, a fall in the nominal interest rate to -0.25% would have damped the rise in unemployment by about 1.9 percentage points in 2010. Starting from a 4.5% unemployment rate, the ZLB accounts for at most 35% of the rise in unemployment and 16% on average. The intuition is that a downward adjustment of  $i_t$  would have prevented the real interest rate from a rapid increase. As a consequence, the lower decline in employers' expected payoff from taking on new workers would have fostered the labor market recovery. The ZLB has a small but positive impact on wages and inflation.

Last but not least, we remove both the ZLB and the variation in unemployment benefits in order to disentangle the role of unemployment benefits from the ZLB. The mechanisms here echoes to the standard effects of unemployment benefits in normal circumstances. Not having increased unemployment benefits would have translated into a downward pressure on real wages (about 1.3% lower) without raising the real interest rate. Consequently, the increase in employers' surplus would have fostered the job creation. The unemployment rate would have declined by about 3 percentage points (green squared line) in the trough of the recession and 1.5 pp on average. This may seems an overstatement. Indeed, this would suggest that the benefits extension explains most of the rise in unemployment, leaving little explanatory power to the cri-

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<sup>17</sup>It is difficult to see this by visual inspection on Figure 7 but the red dotted line is below the benchmark response (black dotted line) of unemployment during the period 2008 Q1 : 2009 Q1.

sis itself. The large deviations of unemployment are consistent with Hagedorn et al. (2013) results. They find that the unemployment benefits extension is responsible for a 3.6 percentage points increase in the unemployment rate. The intuition behind their results is that the rise in unemployment has triggered the increase in unemployment benefits which, by feedback, has further increased unemployment and so on. Through the disincentive effects of UI on search and hirings, the increase in unemployment has been amplified by the response of the UI to the variations in unemployment. However, by leaving the contribution of the interest rate aside, they ignore an important channel through which the response of unemployment may differ substantially. The differences between the benchmark and our three alternative scenarios are huge. Thus, we argue that the macroeconomic conditions in which the policy is conducted are crucial for the understanding of the policy effects.

Variables	Baseline calibration		Low RR calibration $\tau = 0.15$		Rigid wages $a = 0.384$		Search calibration $\psi_s = 3$	
	mean	max	mean	max	mean	max	mean	max
<b>SCENARIO 1: NO UB VS BENCHMARK</b>								
$\Delta u$ in pp.	0.7	1.5	0.4	1.0	0.4	0.8	0.3	0.7
$\Delta w^R$ in %	-4.2	-6.6	-2.9	-4.6	-1.1	-1.7	-3.9	-6.1
<b>SCENARIO 2: NO ZLB VS BENCHMARK</b>								
$\Delta u$ in pp.	-0.9	-1.8	-1.1	-2.1	-0.9	-1.7	-1.2	-2.2
$\Delta w^R$ in %	1.1	2.1	1.3	2.4	0.3	0.6	1.8	3.2
<b>SCENARIO 3: NO UB, NO ZLB VS BENCHMARK</b>								
$\Delta u$ in pp.	-1.7	-2.8	-1.7	-2.8	-1.1	-2.0	-1.9	-3.1
$\Delta w^R$ in %	-1.3	-2.3	-0.4	-1.2	-0.6	-0.9	-0.4	-1.6

Table 3: *Robustness analysis*. Average variations of unemployment  $u$  (in percentage point) and wage  $w^R$  (in percentage) in the three alternative scenarios. The average is calculated from 2008Q1, date at which the extended benefits programs starts, to 2013Q2. UB: unemployment benefits extension. Reading (second column): In the baseline calibration (Table 1), the unemployment rate would have been 0.7 pp higher on average if the unemployment benefits extension had not been triggered.

#### 4.4 Robustness of results

We check the robustness of the preceding analysis. We focus on key parameters that we consider important for our results: the long-run level of the replacement rate, the response of wages and the response of the search intensity. Table 3 shows the variations in unemployment and wages that result from scenario 1, 2, and 3 and expresses them as a function of the benchmark case<sup>18</sup>

<sup>18</sup>The black dotted line in Figure 7

#### 4.4.1 Alternative value for the replacement rate

So far, the calibration of the replacement rate is at the upper bound of empirical estimates. According to the [DOLETA \(2014\)](#), the fraction of unemployed workers receiving benefits is far from being equal to one<sup>19</sup>. It varies from 35% to 70% with an average of 45% over the period 2002Q1 - 2013Q2. We target the lower bound which gives  $\tau = 0.15$ . To avoid important changes in the steady state we recalculate the value of the home production  $\ell$  and the cost of posting vacancies such that the wage  $w^R$  and the value of non-market activities  $z$  remain unchanged. In addition, we do not change the size of the replacement rate shock for the sake of comparison. The average rise in unemployment induced by a constant replacement rate (scenario 1) is smaller: 0.4 pp. The low value of the replacement rate generates a smaller shock which propagate less through the inflation channel. On the other side, unemployment become more sensitive to the ZLB constraint. The fall in unemployment that results from scenario 2 is larger. Combining the two in scenario 3 involves the same decline in unemployment as in the baseline calibration.

#### 4.4.2 Response of wages

The quantitative magnitude of the inflation channel is tightly linked to how much wages rise in response to unemployment benefits. There is no direct answer to this question because reemployment wages are the outcome of multiple effects. For instance, [Acemoglu & Shimer \(1999\)](#) argue that UI may encourage workers to apply to high wage jobs which increases productivity and allows employees to claim for higher wages. In our baseline calibration, scenario 1 implies a 4.2% fall in wages while scenario 3 implies a smaller decline: 1.3%. [Hagedorn et al. \(2013\)](#) found that “a county with 70 weeks of benefits has a 0.3% higher level of wages than a county with 50 weeks of benefits, everything else equal”. Given this estimate, the benefits extension implies an increase in wages of about 1.1%. We target this variation in the scenario 1 instead of scenario 3 such that the inflation channel is minimized as much as possible. To avoid changes in the steady state, we introduce a real wage rigidity in the form of a wage norm as in [Shimer \(2005\)](#):

$$w_t^* = aw^R + (1 - a)w_t^R \quad (33)$$

where  $a$  stands for the degree of real wage rigidity and  $w_t^*$  is the wage rate in the economy. It is a weighted sum of the Nash bargained wage  $w_t^R$  and the constant  $w^R$  (the steady state level). A degree of real wage rigidity of 0.384 hits the mark of the target (scenario 1, column 6). Basically, more wage rigidities reduce the inflationary pressure but also the negative impact of wages that

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<sup>19</sup>It excludes non-eligible unemployed workers for benefits and UI take-up problems *i.e.* unemployment benefits not collected by eligible unemployment workers for alternative reasons.

prompts firms to post fewer vacancies. The two effects cancel out. As shown by equation (12), the search intensity effect will also be reduced due to the decline in the sensitivity of the workers' marginal value (equation (9)) to unemployment benefits. In that case, the unemployment gains from the benefits extension are equal to 0.4 pp on average. But this is a lower bound because if we assume that the 1.1% increase in wage corresponds to the scenario 3, the gains would be almost as high as those found in the baseline calibration.

#### 4.4.3 Search intensity channel

In our benchmark calibration the cost of search is almost a linear function in  $e_t$ , leaving to the job search an important role in explaining the elasticity of unemployment to UI benefits. [Rothstein \(2011\)](#) and [Farber & Valletta \(2013\)](#) estimates that the job search elasticity with respect to UI is rather small. We tackle this issue by setting the search intensity curvature  $\eta = 3$ . In this case, changing the effort devoted to search becomes very costly. We check in our simulations that  $e_t$  remains stable during the last recession. If the search intensity effects are muted, the unemployment benefits extension would have avoided a 0.3 percentage point increase in unemployment on average. This is way smaller than what the baseline calibration shows. In scenario 2, unemployment becomes more sensitive to the ZLB constraint because employers can no longer use the decline in search intensity as a threat to lower wages. Wages are relatively higher which means that loosening the ZLB constraint offsets larger real interest rate effects. This result is reflected in scenario 3 where the unemployment rate would have dropped by two percentage points on average. Therefore, we found much more moderate gains from the UI at the ZLB and larger losses (higher unemployment) from the UI when the nominal interest rate is not constrained.

## 5 Conclusion

The novelty of the present paper is to investigate the extent to which the unprecedented unemployment benefits extension is responsible for the strong increase in unemployment during the Great Recession. The disincentive aspect of UI has been frequently pointed out as an important source of excessive unemployment but has never been studied in an economy characterized by high real interest rates. We argue that the interaction between the unemployment benefits extension and the ZLB are crucial for the quantitative evaluation of the policy. We show that the ZLB explains about 0.9 percentage point of the increase in unemployment following the recession. When the nominal interest rate is held at the ZLB, the impact of unemployment benefits on firms willingness to hire is ambiguous. It depends on whether the inflationary pressure

that reduces real interest rates offsets the disincentive effect of unemployment benefits extensions on hirings.

For a broad variety of calibrated parameters, it is shown that the UI extension, even in the worst case considered, does not cause an increase in unemployment as long as the interest rate is held at the ZLB. Using a standard calibration, a rise in unemployment benefits reduces (not increases!) unemployment. The ZLB mutes the adverse consequences of the unemployment benefits extensions. By loosening the ZLB our results are in line with previous studies on the UI extension. However when the ZLB is taken into account, the unemployment rate would have been 0.7 percentage point higher without any increase in the UI generosity. These results go in opposite directions to previous studies that abstract from the liquidity trap effects. More generally, we highlight the importance of the macroeconomic conditions, especially the behavior of the interest rate and aggregate demand, for a quantitative evaluation of unemployment benefits extensions.

We are aware that the present contribution uses a very simple and probably too stylized model. It can be extended in many directions in order to provide a better robustness analysis of UI extensions. It seems crucial to investigate alternative wage structures, the role of labor market participation, the behavior of layoffs, the heterogeneity among workers and firms and other sources of frictions as in [Carrillo & Poilly \(2013\)](#). In addition, we have left completely aside the normative implications. The welfare gains (losses) could imply different policy recommendations. For instance, [Mitman & Rabinovich \(2011\)](#) show that the path of optimal unemployment benefits is pro-cyclical while [Moyen & Stahler \(2012\)](#) and [Landais et al. \(2010\)](#) found the opposite. However, these issues are beyond the scope of this paper.

**Acknowledgment** We thank the editor and the two anonymous referees for their fruitful comments and suggestions. We also thank seminars and conferences participants at the SaM workshop, T2M, the ETEPP Winter School, Konstanz doctoral workshop in macroeconomics, AFSE, GDRE, European Labour markets and the Economic Crisis conference and to the seminars in Humboldt University, Evry University, the Deutsche Bundesbank, Universidad de Barcelona and Cergy-Pontoise for their helpful comments on an earlier version of this paper. We are also grateful to Xavier Fairise, François Langot, Stéphane Moyen, Céline Poilly, Ferhat Mihoubi, Thepthida Sopraseuth, Michael Burda and DOLETA (Stapleton Kevin and Kim Hyunchung) for their helpful advices. Finally, we thank Maud Bossard, Marina Eliceche, Falk Mazelis and Lusine Nazaretyan for the proofreading of the article. This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk". The usual disclaimer applies.

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## A Unemployment insurance benefits extension

States unemployment insurance and the federal government have adjusted unemployment benefits through the duration margin. In normal circumstances and under the regular program: *Unemployment Compensation (UC)*, an eligible unemployed worker may receive unemployment benefits up to 26 weeks in most states. During economic downturn, automatic benefits extensions are

triggered under the *Extended Benefits (EB)* program. The duration is 13 or 20 weeks depending on the state's insured unemployment rate (IUR) or the total unemployment rate (TUR). In addition, the *Emergency Unemployment Compensation (EUC08)* has been launched in 2008 and has been redefined in the ARRA context in 2009. It also increases the maximum benefits duration. Four waves called « Tiers » have been implemented. The first one (Tiers I) is effective without any conditions on states' experience with unemployment. Tiers II, III and IV require a condition on the IUR and/or TUR to be effective. The maximum benefits duration for each state implied by the EB and the EUC08 is provided by DOLETA<sup>20</sup> at weekly frequencies. The sum of these three programs gives the maximum benefits duration for each state  $j$ :

$$D_{jt}^{\max} = UC_{jt} + EB_{jt} + EUC08_{jt} \quad (34)$$

The total maximum benefits duration is given by averaging using a weight for each state  $j$ :

$$D_t^{\max} = \sum_{j=1}^{52} \frac{U_{jt}}{U_t^{us}} [UC_{jt} + EB_{jt} + EUC08_{jt}] \quad (35)$$

$U_{jt}$  and  $U_t^{us}$  denote the number of insured unemployed in state  $j$  and in the US respectively. EB regulations are reported in Table 5. EUC08 regulations are reported in Table 4. Given the maximum benefits duration series, we calculate  $\phi_1$  in equation (32) such that  $\phi_0 + \phi_1 \max(D_t^{\max} - \bar{D}^{\max})$  is equal to the level of  $\tau_t$  required to increase the unemployment duration by 6.4 weeks in normal times and in the long-run. The duration and the replacement rate shock we obtain are depicted in Figure 4 and 5.

## OECD replacement rate calculation

The use of unemployment benefits duration for the determination of the replacement rate index is widely used by the [OECD \(2006\)](#) and [Layard et al. \(2005\)](#) for international comparisons. Basically, they determine the benefit replacement ratio by the following formula:

$$\tau = \frac{0.6(2^{nd} \text{and } 3^{rd} \text{year RR}) + 0.4(4^{th} \text{and } 5^{th} \text{year RR})}{(1^{st} \text{year RR})}$$

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<sup>20</sup>The website: [http://ows.doleta.gov/unemploy/claims\\_arch.asp](http://ows.doleta.gov/unemploy/claims_arch.asp). We use data from each state except Virgin Island for which we do not have the entire time series. We therefore have 52 states.

where RR stands for replacement ratio. RR combines the gross replacement rate (50%) and the number of weeks an unemployed worker receives unemployment benefits during the  $j$ -th year ( $j = 1, \dots, 5$ ) of unemployment. The gross replacement rate is the ratio to the proportion of workers' wages replaced by UI benefits. This methodology determines a replacement rate through a duration, which is useful for our purpose. The RR in year 2 to year 5 are divided by the first year RR. This takes into account the declining profile of benefits. We adapt these two assumptions because we do not perform any international comparisons and we aim at capturing the essential characteristic in a simple way.

Start Date	Program Extension of EUC08	End Date	Maximum Weeks
July 2008	13 weeks for all states	November 2008	13
November 2008	Tier I - 20 weeks for all states Tier II - 13 weeks for states with TUR > 6%	November 2009	20 + 13
November 2009	Tier I - 20 weeks for all states Tier II - 14 weeks for all states Tier III - 13 weeks if states TUR $\geq$ 6% Tier IV - 6 weeks if states TUR $\geq$ 8.5%	February 2012	20 + 14 + 13 + 6
February 2012	Tier I - 20 weeks for all states Tier II - 14 weeks for all states Tier III - 13 weeks if states TUR $\geq$ 6% Tier IV - 6 weeks if states TUR $\geq$ 8.5% (16 weeks if no active EB and TUR $\geq$ 8.5)	September 2012	20 + 14 + 13 + 6
May 2012	Tier I - 20 weeks for all states Tier II - 14 weeks if states TUR $\geq$ 6% Tier III - 13 weeks if states TUR $\geq$ 7% Tier IV - 6 weeks if states TUR $\geq$ 9%	September 2013	20 + 14 + 13 + 6
September 2012	Tier I - 14 weeks for all states Tier II - 14 weeks if states TUR $\geq$ 6% Tier III - 9 weeks if states TUR $\geq$ 7% Tier IV - 10 weeks if states TUR $\geq$ 9%	December 2013	14 + 14 + 9 + 10

Table 4: EMERGENCY UNEMPLOYMENT COMPENSATION 2008 (EUC08). Source: DOLETA, [Whittaker & Isaacs \(2013\)](#).

The 1<sup>st</sup> 13 weeks of EB can be triggered on via a 5% 13 week IUR if the IUR is equal to or greater than 120% of the prior 2 years' averaged IUR over the same 13 week period OR via a 6% 13 week IUR with no lookback. The 6% IUR option however is optional and as of now 12 states do not have this option enabled. The TUR triggers are completely optional and while most states do have the TUR option in effect now, many simply adjusted their law when EB was made 100% federally funded and have plans to drop it once 100% federal funding is over at the end of CY 2013. Those triggers are 6.5% and 110% of any of the prior 3 years (reverts to the prior 2 years at the end of CY 2013 as well) for 13 weeks of benefits and 8% and 110% of any of the prior 3 years (also reverts to 2 at end of CY 2013) for 20 weeks of benefits. The 5% IUR at 120% average of the prior 2 years corresponding IUR's is not optional, while all other triggers are. As mentioned above, many states adopted the TUR trigger options when congress made EB 100% federally funded back in 2009. If congress does not extend that provision most of those states have plans to drop the TUR option.

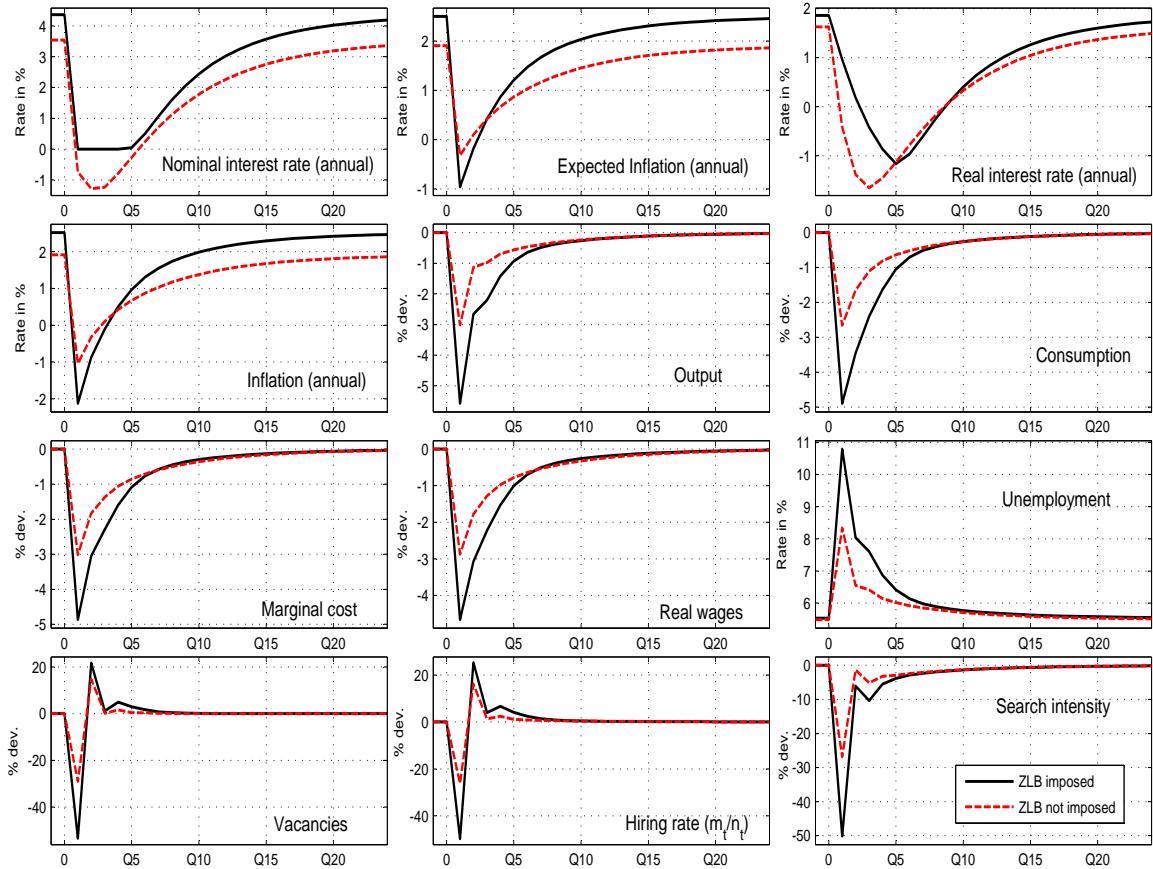
Table 5: EXTENDED BENEFITS PROGRAM (EB). *Source: DOLETA.*

## B Data sources

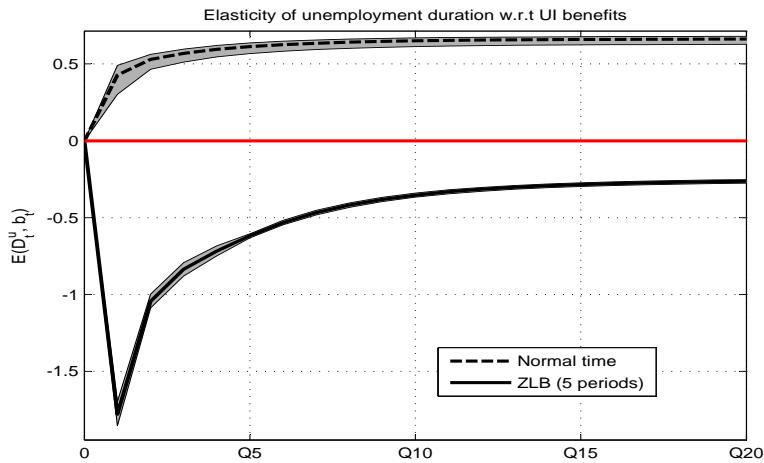
Variables	Type	Source	Code
Unemployment rate	Rate, s.a, 16 years and over	Bureau of Labor Statistics (BLS)	LNS14000000
Vacancies	Composite Help-Wanted index	<a href="#">Barnichon (2010)</a>	Composite HWI
Hirings rate	Rate, s.a, total nonfarm Hirings/Employment	Bureau of Labor Statistics (BLS)	JTS00000000HIR
Nominal interest rate	Rate, Effective Federal Funds Rate, Monthly, Not s.a	Federal Reserve Bank of St. Louis (FRED)	FEDFUNDS
Gross inflation rate	Rate, GDP: Implicit Price Deflator, Quarterly, s.a Index 2005=100, Growth	Federal Reserve Bank of St. Louis (FRED)	GDPDEF
Insured Unemployment	Number Weekly Claims Report Quarterly, Average, s.a	Department of Labor & Training Administration (Doleta)	CCSA
Total Unemployed	Thousands of Persons Quarterly, average, s.a	Bureau of Labor Statistics (BLS)	UNEMPLOY
Employment	Level, Civilian, s.a 16 years and over Quarterly	Federal Reserve Bank of St. Louis (BLS)	LNS12000000

Table 6: *Data source and definitions.*

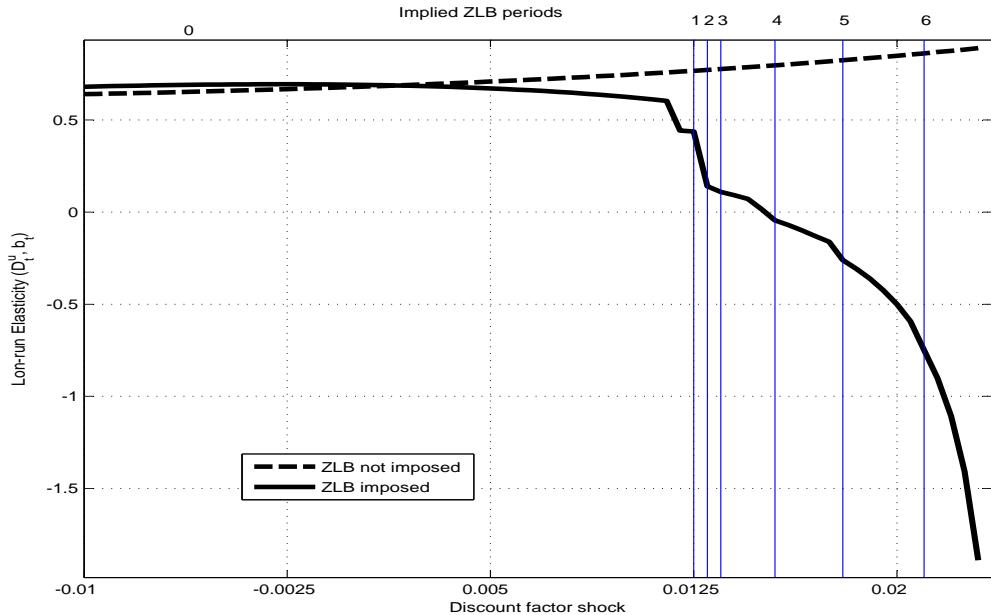
## C Figures



**Figure 1: Impulse response functions - ZLB vs no ZLB.** We simulate the response of the economy to a positive (recessionary) and temporary discount factor shock that sends the nominal interest rate to zero for 5 quarters. The “ZLB not imposed” case (red dotted line) is such that the nominal interest rate falls below zero. Long-run level may differ due to the expectation effects.



**Figure 2: Elasticity of unemployment duration with respect to UI benefits.** It displays the response of the elasticities to an increase in unemployment benefits. We replicate 10000 responses of the elasticity by drawing random shocks  $|\varepsilon_t^\tau|$  from its distribution to build 95% confident intervals (gray shaded area). Thick lines are averages. For the ZLB case, the economy is also hit at the same time by a discount factor shock that sends the nominal interest rate to zero for 5 quarters.



**Figure 3: Elasticity of unemployment duration with respect to UI benefits as a function of the discount factor shock.** In the two cases, we simulate the response of the unemployment benefits and the unemployment duration to a simultaneous one-period shock on the discount factor (values are displayed on the x-axis) and on the replacement rate. We compute the elasticities according to equation (31) and focus on the long-run value. The “ZLB not imposed” case allows the nominal interest rate to fall below zero. The implied ZLB duration on the top x-axis only applies to the “ZLB imposed” case. For each discount factor shock, we replicate 10000 responses of the elasticity by drawing random shocks  $|\varepsilon_t^\tau|$  from its distribution and we average the responses.

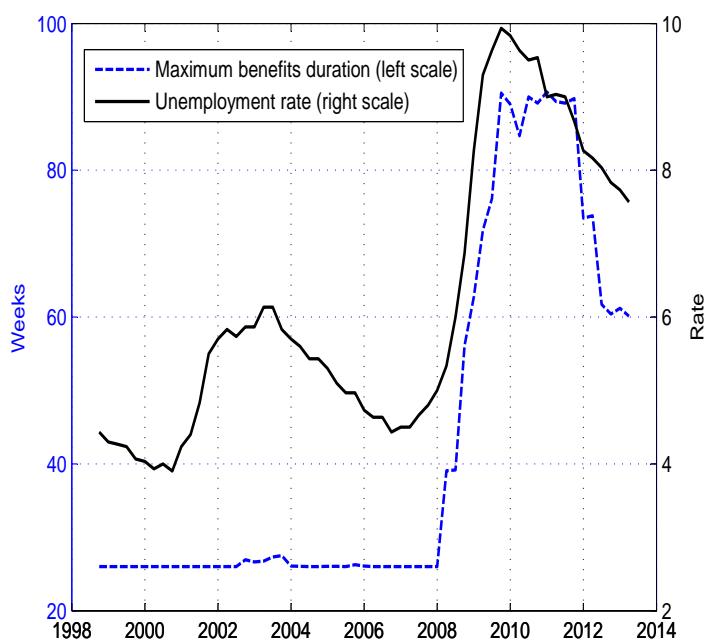
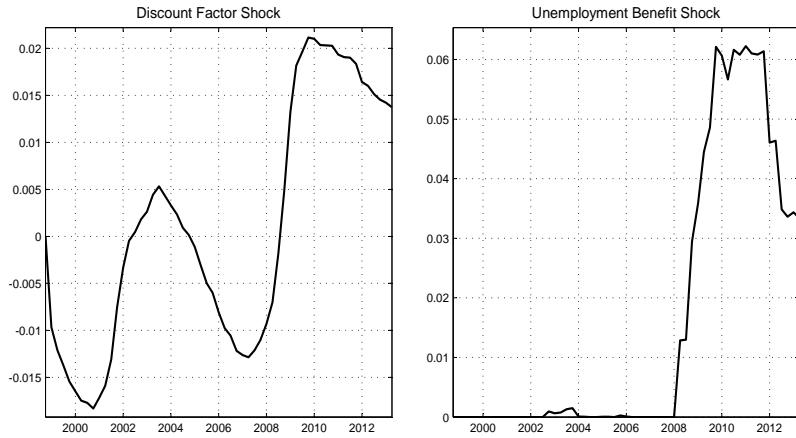
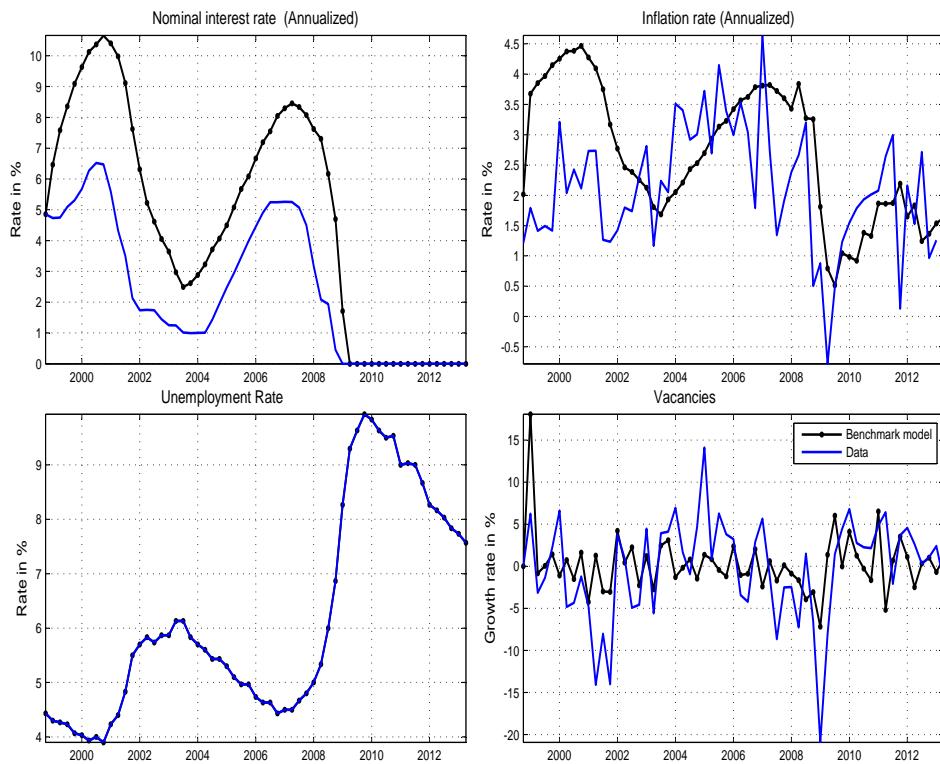


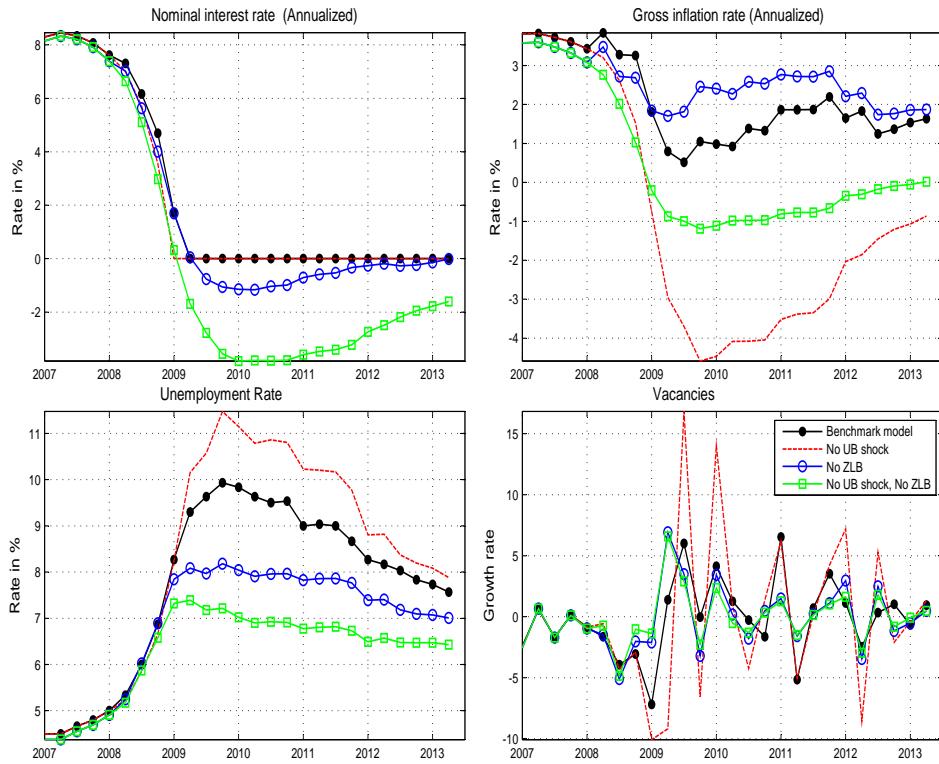
Figure 4: *Unemployment and the maximum UI benefits duration.*



**Figure 5: Path of the shocks.** The path of the replacement rate is computed using equation (32) and the definition of the AR(1) process. Given the replacement rate shock, we solve for the path of the discount factor shock that makes the simulated series of the unemployment rate as close as possible to its empirical counterpart.



**Figure 6: Simulated series vs Data.** Given the path of the two shocks (Figure 5), we simulate the path of the endogenous variables.



**Figure 7: Counterfactual analysis.** Given the discount factor shock (Figure 5), we simulate the response of the variables under the three alternative scenarios. UB: unemployment benefits extension.