The Unemployment Policies during the Great Recession and over the Business Cycle*

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Abstract

By introducing a labor market with search frictions into a Kiyotaki-Moore model, I find that when the zero lower bound on the nominal interest rate is binding, the extended unemployment benefits could slightly alleviate the big decline in output and the big rise in unemployment caused by a liquidity shock through mitigating current consumption decline. However, the unemployment benefits shock could slow down the recovery mainly through discouraging the labor demand, and the extent depends on how long the extended benefits program lasts. But without the zero lower bound, both the extended unemployment benefits shock and policy can make the recession deeper. In the regular recessions, countercyclical unemployment benefits and compensation for vacancy posting can enhance social welfare in response to different shocks. The combination of the unemployment benefits policy and the compensation for vacancies enhance social welfare more than using the unemployment benefits policy alone, since not only aggregate demand but also firm's labor demand is essential for the economy to recover. The financial frictions have an essential effect on how strongly the unemployment policies respond to shocks.

Keywords: unemployment policies, financial friction, zero lower bound

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1 Introduction

Most people believe that the recent recession was aggravated by the crash in financial markets and a liquidity shock resulting from the bankruptcy of several financial intermediaries such as Lehman Brothers. Output decreased significantly, unemployment climbed to a surprisingly high level and is experiencing a very slow recovery, and the stock market declined dramatically. The federal funds rate collapsed to zero at the end of 2008, which made the traditional tools of monetary policy ineffective. In order to stimulate the economy and decrease the unemployment rate, various alternative policies have been used.

One of the policy tools has involved unemployment benefits, which were extended to 99 weeks from 26 weeks. Net reserves of the State Unemployment Insurance program trust fund balance decreased to −$25 billion at the end of June 2011 from $39.7 billion at the end of June 2008, and total unemployment benefits paid by the government increased from $13.6 billion in 2008Q3 to $40.4 billion in 2010Q2.

The the effectiveness of the unemployment benefits policy is widely debated. Two main questions I want to answer in this paper are: Have the extended unemployment benefits benefited the economy during the Great Recession? What kinds of unemployment policies are helpful in enhancing the social welfare during regular recessions? Several subsequent and more specific questions would be: Did providing more benefits to the unemployed workers stimulate the economy or contribute to the persistently high unemployment rate in the Great Recession? Should the unemployment benefits be countercyclical or procyclical? Besides the unemployment benefits policy, is a policy on compensating for vacancies during recession good for the labor market and the whole economy? Do the existence of the zero lower bound and financial friction affect the optimal unemployment policies?

In order to address the problem on the impacts of the extended unemployment benefits during the Great Recession, a model describes a financial crisis like the Great Recession is

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needed. Del Negro et al. (2011) developed a useful New Keynesian model for this purpose, extending the ideas in Kiyotaki and Moore (2008) to develop an empirically usable dynamic stochastic general equilibrium model. However, there is no unemployment in that model and no basis for discussing policy tools such as extended unemployment benefits. In this paper, I add a labor market with matching frictions and endogenous separation to their model.

Financial market frictions in this paper take the same form as in Del Negro et al. (2011). Entrepreneurs face two constraints on the financing of new investment projects: a borrowing constraint on issuing new equity and a resaleability constraint on selling existing equity holdings. A shock to the resaleability constraint is referred as a liquidity shock. Baseline policies are implemented via a simple interest rate rule constrained by the zero bound, constant unemployment benefits, and zero compensation on vacancy postings.

Recently, there have been many influential studies on the unemployment policies. Papers like Moyen and Stahler (2012), Nakajima (2012), and Valletta and Kuang (2010) examine the role of unemployment benefits over business cycles. Landais, Michaillat, and Saez (2010) analyzed optimal unemployment insurance over the business cycle in a search model. Hagedorn, Karahan, Manovskii, and Mitman (2013) investigated the effect of the extended unemployment benefits during the Great Recession and got the conclusion the the extended unemployment benefits program had negative effect on the labor market. Lalive, Landais, and Zweimuller (2013) studied the market externalities of large unemployment insurance extension programs. Contrast to my paper, all these studies are either purely empirical or in an environment without the presence of financial frictions and the zero lower bound on the nominal interest rate, which are essential both for fitting the Great Recession and for the effects of policies.

The main contributions of this paper are summarized as follows. I introduce labor market search frictions into a New Keynesian model with financial frictions and zero lower bound on the nominal interest rate to evaluate the effectiveness of the extended unemployment benefits during the Great Recession, and distinguish the potential difference of the unemployment benefits shock and policy. Optimal unemployment policies in regular recessions are also investigated. Another important aspect of this paper is that the impacts of the zero lower bound, financial frictions and different types of shocks on the optimal unemployment polices are documented.

The main results of this paper are as follows. First, I find that the effects of the unemployment benefits shock and unemployment benefits policy are different. At the zero lower bound, extended unemployment benefits policy could be a useful tool for mitigating the decline in consumption and benefiting output slightly and speeding up the labor market recovery. However, an extended unemployment benefits shock slows down the recovery. How long the extended unemployment benefits program lasts is essential for the recovery speed. Third, without the zero lower bound constraint, both the extended unemployment benefits shock and policy deepen the recession, however, speed up the recovery. Third, the optimal unemployment benefits policy and vacancy posting compensation policy are both countercyclical. Fourth, coutercyclical compensation on vacancy postings can enhance the social welfare because it makes firms have stronger incentive to post vacancies and offer more opportunities to the unemployed workers, which help the labor market recover more quickly. Fifth, in a model with no financial frictions, the optimal unemployment policies respond to news in a significantly smaller magnitude. Since there is no amplification effect from the binding borrowing constraint or liquidity issues in posting vacancies, and as a result, the economy is less volatile and the welfare loss caused by the same shocks is smaller.

The rest of the paper is organized as follows: Section 2 is the model setup, Section 3 is the calibration, Section 4 is the analysis and results, and Section 5 is the conclusion and policy implications.

2 Model

The main framework of the model comes from Kiyotaki and Moore (2008) and Del Negro et al. (2011). There are five types of agents: entrepreneurs in household, workers in household, capital producers, intermediate good firms, and final good firms.

2.1 Households

There is a representative household in the economy, and there are a continuum of members, indexed by i, measured on $[0, 1]$, in the household. At the beginning of each period, χ fraction of the household members are selected to be entrepreneurs through an i.i.d. random draw, and the rest $1 - \chi$ fraction of members are workers. That is, the probability of becoming an entrepreneur for a household member in a particular period is χ. In each period, the household members are re-numbered, so that a member $i \in [0, 1 - \chi]$ is a worker and a member $i \in (1 - \chi, 1]$ is an entrepreneur. Entrepreneurs have the opportunity to invest on capital, but they cannot supply labor. Workers supply labor but have no chance to invest on capital. Since not all workers are hired in each period, the workers are also re-numbered, so that a worker $i \in [0, U_t)$ is unemployed, and a worker $i \in [U_t, 1 - \chi]$ is employed.

People in a household bring back their purchases on consumption goods $C_t(i)$, and these goods are equally distributed among all members. Utility thus depends on the sum of all the consumption goods in the household:

$$C_t = \int_0^1 C_t(i) di. \tag{1}$$

Consumption C_t is also a CES function over a continuum of goods with elasticity of substitution ϵ^p,

$$C_t = [\int_0^1 (C_{\widetilde{j}t})^{\frac{\epsilon^p - 1}{\epsilon^p}} d\widetilde{j}]^{\frac{\epsilon^p}{\epsilon^p - 1}}, \epsilon^p > 1,$$

where $\widetilde{j}$ is the index of the differentiated final consumption goods.

Each member holds an equal share of the household's assets (bonds and equities). The household does not make the labor supply decision. All unemployed members search on the job market and the frictional search and matching process determines who is employed. Following Ravenna and Walsh (2011), the representative household's utility depends on the total consumption composed by the consumption of market financial goods C_t and home production $w^u(1 - N_t)$:

$$C_t^{total} = C_t + w^u U_t.$$

The representative household maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t^{total})^{1-\sigma}}{1-\sigma} \tag{2}$$

$s.t.$

$$\begin{aligned} & C_t^{total} + p_t^I I_t + q_t(S_t - I_t - (1-\delta)S_{t-1}) + \frac{B_t}{p_t} = \\ & r_t^K S_{t-1} + \int_{U_t}^{1-\chi} Y_{it}^L di + \int_0^{U_t} G_t^u di + \frac{r_{t-1}B_{t-1}}{p_t} + D_t + D_t^I - T_t \end{aligned} \tag{3}$$

The inter-temporal discount factor is β, and the relative risk aversion is σ.

Unlike Smets and Wouters (2007), I don't include the intensive margin of employment because Gertler, Sala and Trigari (2008) find that most of the cyclical variation in employment in the United States is on the extensive margin and including the intensive margin does not affect the model very much. Following the convention in the literature (such as de Hann et al. (2000)), they are considered as a part of the total unemployment compensation which appears in the household's budget constraint as part of the household's income.

The price for the consumption good is p_t, and the gross nominal interest rate controlled by the Federal Reserve is r_t. The investment on capital is represented by I_t, and the cost of a unit of new investment in terms of the consumption goods is p_t^I. The dividends from the final good sector and the capital producers are D_t and D_t^I respectively, and the lump-sum tax is

T_t. Household's disposable real labor income earned by member i is represented by Y^L_{it}. The total unemployment compensation is the unemployment benefits paid by the government, G^u_t.

In period t, the household's assets include government bonds B_{t-1}, capital K^H_{t-1}, and claims on other households' capital S^O_{t-1}. Households' liabilities include claims on own capital sold to other households S^I_{t-1}. The net equity held by the household S_{t-1} is defined as

$$S_{t-1} = S^O_{t-1} + K^H_{t-1} - S^I_{t-1} \tag{4}$$

The rental return on capital is r^K_t, and the price of capital and equities in terms of a consumption good is q_t. The depreciation rate of capital is δ, which means both the claims on own capital and other households' capital depreciate at rate δ in each period.

There are two financial frictions, which are the same as those proposed by Del Negro et al. (2011). One is the borrowing constraint, which means each entrepreneur can only issue new equities up to a fraction θ of his investment $I_t(i)$. The other is the resaleability constraint, which implies that a household member can only sell a fraction ϕ_t of his equity holdings. The smaller θ and ϕ_t are, the more frictional the financial market is. The liquidity shock mentioned in this paper is a shock to ϕ_t.

The equity on own capital held by member $i \in (1-\chi, 1]$ evolves according to

$$S^I_t(i) \leq (1-\delta)S^I_{t-1} + \theta I_t(i) + (1-\delta)\phi_t(K^H_{t-1} - S^I_{t-1}), \tag{5}$$

where $\theta I_t(i) + (1-\delta)\phi_t(K^H_{t-1} - S^I_{t-1})$ is the maximum amount of the new issued equity, and the new issued equity could be separated into two parts: the claims on new investment, which gives up to $\theta I_t(i)$, and mortgaging capital that is not mortgaged before, which gives up to $(1-\delta)\phi_t(K^H_{t-1} - S^I_{t-1})$. And the equity on other households' capital held by member i evolves according to

$$S^O_t(i) \geq (1-\delta)S^O_{t-1} - (1-\delta)\phi_t S^O_{t-1}, \tag{6}$$

since the entrepreneur cannot sell more than a fraction ϕ_t of holdings of others' equity. The above two inequalities on equity together with the definition of the net equity give us the evolution of the net equity

$$S_t(i) \geq (1-\theta)I_t(i) + (1-\phi_t)(1-\delta)S_{t-1} \tag{7}$$

The government bond is "liquid" and not constrained by the resaleability constraint. Only the government can issue the liquid asset and households can only take a long position in it:

$$B_t(i) \geq 0. \tag{8}$$

The equity holdings, bond holdings, and capital stock of the household depend on each member's decision:

$$S_t = \int_0^1 S_t(i)di = (1-\theta)I_t + (1-\phi_t)(1-\delta)S_{t-1} \tag{9}$$

$$B_t = \int_0^1 B_t(i)di \tag{10}$$

$$K_t^H = (1-\delta)K_{t-1}^H + \int_0^1 I_t(i)di \tag{11}$$

where $I(i) = 0$ for $i \in [0, 1-\chi]$.

The amount of investment can be derived from the entrepreneur's decision. The budget constraint for the entrepreneurs is:

$$\begin{aligned} &C_t^{total}(i) + p_t^I I_t(i) + q_t(S_t(i) - I_t(i) - (1-\delta)S_{t-1}(i)) + \frac{B_t(i)}{p_t} \\ =&r_t^K S_{t-1}(i) + \frac{r_{t-1}B_{t-1}(i)}{p_t} + D_t + D_t^I - T_t \end{aligned} \tag{12}$$

Since we have the assumption that the equity price q_t is greater than the cost of newly produced capital p_t^I, in order to maximize the household's utility, the entrepreneurs try their best to invest on new capitals. That is, they sell all bond holdings, borrow until the borrowing constraint binds, mortgage equity holdings to the upper bound, and buy no consumption good:

$$S_t(i) = (1-\theta)I_t(i) + (1-\phi_t)(1-\delta)S_{t-1} \tag{13}$$

$$B_t(i) = 0 \tag{14}$$

$$C_t(i) = 0 \tag{15}$$

where $i \in (1-\chi, 1]$.

Substituting these into the budget constraint for the entrepreneurs gives us the investment of each entrepreneur:

$$I_t(i) = \frac{[r_t^K + (1-\delta)q_t\phi_t]S_{t-1} + \frac{r_{t-1}B_{t-1}}{p_t} + D_t + D_t^I - T_t}{p_t^I - \theta q_t}. \tag{16}$$

Since only the entrepreneurs can invest, the aggregate investment is

$$I_t = \int_{1-\chi}^{1} I_t(i)di = \chi \frac{[r_t^K + (1-\delta)q_t\phi_t]S_{t-1} + \frac{r_{t-1}B_{t-1}}{p_t} + D_t + D_t^I - T_t}{p_t^I - \theta q_t}. \tag{17}$$

Households choose C_t^{total}, I_t, S_t and B_t to maximize the utility. The first order conditions are:

$$C_t^{total}: \; Ctotal_t^{-\sigma} = \lambda_{1t} \tag{18}$$

$$I_t: \; \lambda_{1t}(q_t - p_t^I) = \lambda_{2t} \tag{19}$$

$$S_t: \; q_t\lambda_{1t} = \beta\mathbb{E}_t\{\lambda_{1t+1}[r_{t+1}^K + (1-\delta)q_{t+1}] + \lambda_{2t+1}\frac{\chi[r_{t+1}^K + (1-\delta)\phi_{t+1}q_{t+1}]}{p_{t+1}^I - \theta q_{t+1}}\} \tag{20}$$

$$B_t: \; \lambda_{1t} = \beta\mathbb{E}_t[\frac{r_t}{\pi_{t+1}}(\lambda_{1t+1} + \lambda_{2t+1}\frac{\chi}{p_{t+1}^I - \theta q_{t+1}})] \tag{21}$$

where λ_{1t} and λ_{2t} are the Lagrangian multipliers for the budget constraint (3) and the equity evolution (9) respectively. Our previous assumption $q_t > p_t^I$ ensures that λ_{2t} is positive, I need to assume $q_t > p_t^I$. This means the price of equity is bigger than the newly installed capital.

Since we know the household decision on S_t, B_t, and C_t from the first order conditions, as well as the solution for entrepreneurs from (13) to (15), constraints (1), (9), and (10) determine workers' choices on consumption, equity holding, and bond holding. We can check that these choices satisfy the constraint (7) and (8) for workers.

2.2 Capital Producer

Capital producers can convert consumption goods into investment goods. Producing capital is costly, and the adjustment cost $\psi(\cdot)$ depends on the deviations of actual investment from its steady-state value I. The adjustment cost function also satisfies $\psi(1) = 0$, $\psi'(1) = 0$, and $\psi''(1) > 0$. The capital producers choose the amount of investment goods produced I_t to maximize their profits

$$D_t^I = \{p_t^I - [1 + \psi(\frac{I_t}{I})]\}I_t. \tag{22}$$

Capital producers are perfectly competitive, and sell the investment goods to entrepreneurs at given price p_t^I.

The first order condition for capital producer's maximization problem is:

$$p_t^I = 1 + \psi(\frac{I_t}{I}) + \psi'(\frac{I_t}{I})\frac{I_t}{I} \tag{23}$$

2.3 Intermediate Goods Sector

2.3.1 First Specification: Labor Market with Endogenous Separation and Real Wage Rigidity

The intermediate goods sector is perfectly competitive, and each firm hires one worker and rents capital to produce identical intermediate goods. The production function of the matched firms follows

$$Y(a_{jt}) = za_{jt}K_{jt}^{\alpha}. \tag{24}$$

The common technology z is normalized to be 1. Match-specific productivity a_{jt} is a random variable, which follows a Lognormal distribution with mean 0 and standard deviation 0.15 (den Hann et al., 2000). Intermediate goods are sold in a competitive market at given price p'_t.

At the beginning of period t, there are N_t matched workers and firms retaining from last period; $U_t = 1 - \chi - N_t$ workers are unmatched. First, new entrepreneurs are randomly selected from all household members. χ fraction of old entrepreneurs are still entrepreneurs, and the rest $(1-\chi)\chi$ old entrepreneurs become unemployed workers. χ fraction of matched workers become entrepreneurs, and the number of remaining matches becomes $(1-\chi)N_t$. The number of new entrepreneurs from originally unemployed workers is χU_t. Now the number of new entrepreneur is still χ, and the new unemployment is $(1-\chi)\chi + U_t - \chi U_t = U_t + \chi N_t$.

The remaining $(1-\chi)N_t$ matched workers at the start of period t travel to their places of employment. At that point, with an exogenous probability $0 \leq \rho^x < 1$ the match is terminated. The remaining $(1-\rho^x)(1-\chi)N_t$ pairs of matched workers and firms, indexed by j, jointly observe the match-specific productivity a_{jt}, and then decide whether to continue the match. If a_{jt} is larger than some threshold $\widetilde{a}_{jt}$, the match continues and production occurs. Since all the intermediate good firms are identical ex ante, we can eliminate the subscript j. All the matches with match-specific productivity lower than $\widetilde{a}_t$ are endogenously terminated. So the endogenous separation rate is given by

$$\rho_t^n = F(\widetilde{a}_t) = \int_{-\infty}^{\widetilde{a}_t} f(a_t)da_t \tag{25}$$

Finally, the number of remaining matches is $(1-\chi)(1-\rho^x)(1-\rho_t^n)N_t$. The total separation rate is $\rho_t = 1 - (1-\chi)(1-\rho^x)(1-\rho_t^n)$.

The number of new matches in period t is M_t. These new matches don't produce any good in the current period, but could only enter production in the next period after surviving from both exogenous and endogenous separations. The total number of matches evolves according to:

$$N_{t+1} = (1 - \rho_{t+1})(N_t + M_t). \tag{26}$$

The number of new matches in period t depends on the amount of vacancies posted by the firms, V_t, and the number of unemployed workers, U_t. The matching function $M_t(U_t, V_t)$ takes the form $EU_t^{\zeta} V_t^{1-\zeta}$, where E is the scale parameter standing for the aggregate matching efficiency.

The probability of a worker finding a job (the job-finding rate) is given by

$$\rho_t^w = \frac{M_t(U_t, V_t)}{U_t} = E\tau_t^{1-\zeta}, \tag{27}$$

and the probability of a vacancy being filled (the vacancy-filling rate) is

$$\rho_t^f = \frac{M_t(U_t, V_t)}{V_t} = E\tau_t^{-\zeta}, \tag{28}$$

where $\tau_t = V_t/U_t$ represents the labor market tightness.

The firms survived from separations choose capital optimally by maximizing

$$\frac{z_t a_{jt} K_{jt}^{\alpha}}{\mu_t} - r_t^k K_{jt}.$$

where $\mu_t = p_t/p_t'$ is the markup. The optimal capital is

$$K^*(a_{jt}) = (\frac{\alpha z a_{jt}}{\mu_t r_t^k})^{\frac{1}{1-\alpha}}. \tag{29}$$

Unmatched firms seeking workers have to pay a cost, γ, to post a vacancy. The vacancy could be filled with probability ρ_t^f, and the filled vacancy could be separated with probability $1 - \rho_{t+1}$ before entering production. The unmatched firm will post a vacancy only when the discounted expected future value of doing so is bigger than or equal the cost. Free entry ensures that unmatched firms post vacancies until

$$\gamma = \beta \rho_t^f \mathbb{E}_t [\frac{\widetilde{\lambda}_{1t+1}}{\widetilde{\lambda}_{1t}} (1 - \rho_{t+1}) J_{t+1}], \tag{30}$$

where J_{t+1} is the expected future value of a matched firm, which is identical for all firms.

The value of a matched firm with match-specific productivity a_{jt} could be expressed as the net profit obtained from this period's production plus the discounted expected future value of the firm:

$$J_t(a_{jt}) = \frac{Y(a_{jt})}{\mu_t} - Y^L(a_{jt}) - r_t^k K^*(a_{jt}) + \beta \mathbb{E}_t [\frac{\widetilde{\lambda}_{1t+1}}{\widetilde{\lambda}_{1t}} (1 - \rho_{t+1}) J_{t+1}], \tag{31}$$

where $Y(a_{jt})/\mu_t$ is the firm's revenue from selling the intermediate goods evaluated in terms of final goods, and $Y^L(a_{jt})$ is the real wage of the worker in terms of final goods.

A matched worker's value, $H_t(a_{jt})$, is equal to the real wage he can get from the work this period, and plus the discounted future value of the work:

$$H_t(a_{jt}) = Y^L(a_{jt}) + \beta \mathbb{E}_t \{\frac{\widetilde{\lambda}_{1t+1}}{\widetilde{\lambda}_{1t}} [(1 - \rho_{t+1}) H_{t+1} + \rho_{t+1} W_{t+1}]\}, \tag{32}$$

where W_t is the value of an unemployed worker:

$$W_t = G_t^u + \beta \mathbb{E}_t \{\frac{\widetilde{\lambda}_{1t+1}}{\widetilde{\lambda}_{1t}} [(1 - \rho_{t+1}) \rho_t^w H_{t+1} + (1 - (1 - \rho_{t+1}) \rho_t^w) W_{t+1}]\}. \tag{33}$$

The value of the unemployed worker includes the total unemployment compensation this period and expected income either being employed or not in the future.

The economic surplus of a match is $J_t(a_{jt}) + H_t(a_{jt}) - W_t$. When there is no real wage rigidity, the surplus is divided between the firm and worker through Nash bargaining, and the bargaining power of the worker is Θ. The notional real wage resulting from the Nash bargaining is:

$$Y^{L^*}(a_{jt}) = \Theta[\frac{Y(a_{jt})}{\mu_t} - r_t^k K^*(a_{jt}) + \gamma\tau_t] + (1-\Theta)G_t^u.$$

However, when there exists a wage norm, and the real wage is rigid in the sense that it depends on the wage norm, the real wage could be expressed as weighted average of the notional wage and the steady state value of the real wage:

$$Y^L(a_{jt}) = \eta[\Theta(\frac{Y(a_{jt})}{\mu_t} - r_t^k K^*(a_{jt}) + \gamma\tau_t) + (1-\Theta)G_t^u] + (1-\eta)Y^L.$$

The real wage rigidity index is η. If η=0, the real wage is solely determined by the steady state surplus, and if $\eta = 1$, the real wage is perfectly flexible.

How is the endogenous separation decision made? That is, how is the threshold of match-specific productivity, $\widetilde{a}_t$, determined? The critical value of a_t below which separation takes place is given by $J_t(\widetilde{a}_t) = 0$. Substituting the real wage and capital used at $\widetilde{a}_t$ into firm's value, the separation threshold is determined by the following equation:

$$\frac{Y(\widetilde{a}_t)}{\mu_t} - Y^L(\widetilde{a}_t) - r_t^k K^*(\widetilde{a}_t) + \frac{\gamma}{\rho_t^f} = 0. \tag{34}$$

Define the average capital used in production as follows:

$$K_t^* = \int_{\widetilde{a}_t}^{a_{max}} K^*(a_{jt}) \frac{f(a_t)}{1-F(\widetilde{a}_t)} da_t. \tag{35}$$

The aggregate output of the intermediate goods sector is:

$$Y_t = N_t \frac{\mu_t r_t^k}{\alpha} K_t^*. \tag{36}$$

The average real wage is defined as:

$$
\begin{aligned}
Y_t^L &= \int_{\widetilde{a}_t}^{a_{max}} Y^L(a_{jt}) \frac{f(a_t)}{1-F(\widetilde{a}_t)} da_t \\
&= \eta[\Theta(\frac{1-\alpha}{\alpha} r_t^k K_t^* + \gamma\tau_t) + (1-\Theta)G_t^u] + (1-\eta)Y^L.
\end{aligned}
\tag{37}
$$

2.4 Government

In order to close the model, we need to specify government policies. Baseline policies include conventional monetary policy, constant government spending and constant unemployment benefits.

Conventional monetary policy follows a standard feedback rule, and the nominal interest rate cannot be lower than 0:

$$
\widehat{r}_t = \max\{\phi_\pi \widehat{\pi}_t, -\overline{r} + 1\}, \tag{38}
$$

where $\widehat{x}_t$ is the log-deviation from steady state value. Government spending is assumed to be proportional to output, $G = g_y Y$. Regular unemployment benefits paid by the government is also constant and proportional to the steady state average real wage, $G^u = g^u_{y^L} Y^L$.

Besides the baseline policy, characterized by the regular unemployment benefits, there are two versions of extended unemployment benefits program, which describe the changes in the unemployment benefits.

One is the unemployment benefits changes follow a given rule, for example, the benefits change according to the unemployment rate:

$$
\widehat{g_t^u} = \gamma^u * \widehat{u}_t.
$$

In the paper, I call this rule "unemployment benefits policy". The extended benefits programs (EB) can be treated as a counterpart of this kind of unemployment benefits policy in the real economy. EB is a permanent program, triggered when some conditions are satisfied, for example, the state unemployment rate reaches a certain level. And people who exhaust the regular unemployment insurance (UI) can get additional up to 13 weeks benefits. From the model aspect, agents with rational expectation in the model fully aware when and in how large scale the policy will be implemented, and it is a part of their information set.

The other version of the extended unemployment benefits is the regular unemployment benefits can be hit by an unemployment benefits shock, $\epsilon_t^{G^u}$, under which the change in the unemployment benefits follows an AR(1) process,

$$\widehat{g}_t^u = \rho^{G^u} \widehat{g}_{t-1}^u + \epsilon_t^{G^u}, \tag{39}$$

where $\epsilon_t^{G^u}$ is the initial response of unemployment benefits to the liquidity shock,

$$\epsilon_t^{G^u} = \begin{cases} \epsilon_1^{G^u} (> 0) & t = 1 \\ 0 & \text{otherwise} \end{cases} .$$

In the real world, the emergency unemployment compensation programs (EUC) can be taken as the unemployment benefits shock, since different from the EB, they are temporary programs. The federal government steps in to create EUC programs because the triggers of EB are very restrictive, and sometimes it's hard for some states to qualify EB. So there are no setting rules to follow or to predict when the EUC program will be created and how large will the program be. Although agents in the economy could get some information on these programs, there are a lot of uncertainties, for example, how long the program will last, and it's hard to find a specific rule connecting the EUC with the economic fundamentals directly. Besides EUC, other unexpected sudden changes in unemployment benefits are treated as unemployment benefits shocks as well.

Government budget constraint is of the form:

$$G_t + G_t^u + \frac{r_{t-1} B_{t-1}}{p_t} = T_t + \frac{B_t}{p_t}. \tag{40}$$

Taxes adjust to the government net debt position:

$$T_t - T = \psi^T(\frac{r_{t-1}B_{t-1}}{p_t} - \frac{rB}{p}). \tag{41}$$

Since ψ^T is small, the adjustment of taxes is gradual, government needs to finance its purchases of private equity, fiscal expansion and extended unemployment benefits by issuing government bonds.

2.5 Market Equilibrium

In the equilibrium, capital stock is owned by households and government:

$$K_t^H = S_t, \tag{42}$$

and capital stock equals the capital used by the intermediate good firms:

$$K_{t-1}^H = N_t K_t^*. \tag{43}$$

Output equals households' demand for consumption, investment and government consumption and the cost of posting vacancies:

$$Y_t = C_t + [1 + \Psi(\frac{I_t}{I})]I_t + G_t + \gamma V_t. \tag{44}$$

3 Calibration

Table 1 gives the calibrated values of parameters that are standard in other New Keynesian models with financial frictions. All these parameters are chosen following Del Negro et al. (2011). The discount factor β is 0.99, capital share α in the production function is 0.4, and the relative risk aversion parameter in the utility function is set to be 1. The quarterly depreciation rate of capital is 0.025, and investment adjustment cost parameter $\psi''(1)$ is 1. The coefficient on inflation in the interest rate rule is 1.5. The average duration of price and wage stickiness is four quarters, so the Calvo parameter for price setting ω is 0.75 and wage rigidity parameter η is 0.38. The elasticity of substitution among differentiated final goods ϵ^p is 11, which implies the steady state markup μ is 1.1. 5% of the population are randomly chosen to be entrepreneurs in each period. Let $L_t \equiv \frac{B_t}{p_t}$ be the real value of the government bonds. The ratio between real value of the government bonds and annual GDP $\frac{L}{4Y}$ is 0.4 at steady state. The coefficient in the tax rule is 0.1. Financial friction parameters ϕ and θ are set to 0.207, so that the annual steady-state interest rate is 2.2%.

Table 2 includes parameters characterizing labor market frictions and alternative policy interventions, most of which are set according to Zhang (2014). In that paper, I used Bayesian methods to estimate a monetary DSGE model with endogenous separation, frictional labor market, and several shocks. The total job separation rate is 10.5%, the threshold of match-specific productivity for the endogenous separation is 0.74, workers' bargaining power on wages is 0.36, quarterly job-finding rate is 0.7, steady state labor market tightness is 0.74, and the replacement rate of the unemployment benefits is 0.4. The total unemployment compensation implied by the estimation is 0.72, and this value is used here in the model with exogenous separation and nominal wage rigidity. The elasticity of the matching function is set to 0.5, and matching specific productivity is assumed to be log normally distributed with mean 0 and standard deviation 0.15. The estimated persistence of the unemployment benefits shock, $\rho^{G^u} = 0.97$, is used in this paper to characterize the extended unemployment benefits as well. The government spending - output ratio is set to 0.18.

The remaining alternative policy parameters, which didn't appear in Zhang (2014) are calibrated to match the data. Regular unemployment benefits keep constant if there is no extended unemployment benefits program. That is, $\epsilon_t^{G^u}$ is always 0. In response to the financial crisis, Emergency Unemployment Compensation 2008 (EUC08) was implemented. Total unemployment benefits paid by the government were $13.6 billion during 2008Q3, and this number spiked to \$40.4 billion during 2010Q2. Normalizing the logarithm of the value in 2008Q3 to be 0, the log-deviation of the 2010Q2 value is 110%. Although part of the increase of the government payoffs was induced by the EB programs, which is considered the unemployment benefits policy as described in the model setup, for simplicity, I just neglect that part and assume all the increased payoffs come from an unemployment benefits shock and the increase in unemployment. The size of the initial change in unemployment benefits paid to each unemployed worker, $\epsilon_1^{G^u}$, is calibrated at 0.5, so that the change in total unemployment benefits is 110%. I tried the unemployment benefits shocks of smaller sizes, the results turn out to be similar.

4 Results

In this section, I firstly investigate the effects of the extended unemployment benefits shock in the baseline model, which is built and calibrated to mimic the Great Recession, and then explore the effects of an extended unemployment benefits policy and the potential impacts of the zero lower bound on the nominal interest rate on the effects of the extended unemployment benefits. Optimal simple rules of unemployment policies, which combine the extended unemployment benefits and compensation for vacancy postings, are also investigated. The Potential effects of financial friction on the responsiveness of unemployment policies are also discussed at the end.

4.1 The Unemployment Benefits During the Great Recession

4.1.1 The Effect of the Extended Unemployment Benefits Shock during the Great Recession

At $t = 1$, a one-time unexpected negative liquidity shock hits the economy, and after that there is no other shock. And the liquidity evolves following a known AR(1) process: $\widehat{\phi}_t = \rho^\phi \widehat{\phi}_{t-1} + \epsilon_t^\phi$. The shock tightens the entrepreneurs' resaleability constraint, and the fraction of existing equity holdings that can be sold, ϕ_t, drops by 60%. The autocorrelation parameter of the exogenous shock is 0.833, which means the expected duration of the shock is 6 quarters.

The red solid lines in Figure 1 are the responses of the main macroeconomic variables to this negative liquidity shock when no extended unemployment benefits are provided. The fall in liquidity limits the entrepreneurs' ability to buy investment capital, so investment drops by 15%. Less liquidity also decreases the value of equities held by the households, q_t, which is consistent with what we observe during the Great Recession. The zero lower bound and sticky prices together will lead to expectations of deflation, and inflation falls by almost 4%. Since the nominal interest rate is bounded at zero, the real interest rate, $\widehat{rr}_t = \widehat{r}_t - \mathbb{E}_t\widehat{\pi}_{t+1}$, increases, which depresses consumption. The decrease in investment and consumption together causes the huge drop in output (around 9%). This decline in output is accompanied by a 6-percentage-point rise in the unemployment rate.

The blue dashed lines represent the responses of the main macroeconomic variables to this negative liquidity shock when there is an extended unemployment benefits shock. Most previous studies have concluded that extended unemployment benefits would be harmful in the sense that higher government compensation for unemployment may reduce the effort the unemployed put into finding a new job, increase workers' required wage, and discourage firms from hiring more workers. Surprisingly, our model implies the opposite result when the zero lower bound is binding. In response to a negative liquidity shock, an increase in unemployment benefits has a small positive effect on output. Although this seems to contradict the previous studies and our intuition, it can still be well explained within our model.

The positive effects of extended unemployment benefits come from two aspects. The first is extended unemployment benefits can raise household income and boost consumption. The second aspect is its ability to pull the nominal interest rate away from the zero lower bound more quickly. Extended unemployment benefits can affect the nominal interest rate in a positive way, and this is not a special characteristic of my model, but very common and straightforward in any standard New Keynesian framework. When there is an increase in unemployment benefits, the required wage will increase correspondingly, which causes a rise in real marginal cost. The increase in the real wage makes labor relatively more expensive than capital, hence firms prefer to use more capital to substitute for labor. As a result, the rental return for capital increases and raises the real marginal cost further. From the New Keynesian Phillips Curve that represents inflation as an increasing function of real marginal cost, we can expect an increase in inflation, and this increase in inflation transfers to an increase in (or at the zero lower bound, an upward pressure on) the nominal interest rate through the Taylor' rule. So when an extended unemployment benefits program is implemented in response to a negative liquidity shock, there will be less deflation and hence less downward pressure on the nominal interest rate. This shortens the time the economy spends at the zero lower bound and helps the economy get out of the liquidity trap more quickly. After escaping from the zero lower bound, the effect of extended unemployment benefits keeps working and even drives the nominal interest rate to be higher than the level before the crisis. The size of the extended unemployment benefits shock that generates the responses represented by the blue dashed lines in Figure 1, is calibrated as I mentioned before. That is, the total amount of the unemployment benefits paid by the government increases by 110%. Output is more than 1% higher and consumption is 2% higher immediately after the liquidity shock compared with the baseline case. The time the economy spends at the zero lower bound is much shorter. The unemployment rate also raises less after the liquidity shock.

Although extended unemployment benefits have a positive effect on the economy immediately after the negative liquidity shock, its effects on the recovery are adverse. The main reason is higher unemployment benefits push up the required wage and discourage firms to post vacancies. Comparing with the "no extended unemployment benefits" case, vacancies are 3% lower. The size of the negative effect of the unemployment benefits shock depends on how persistent the shock is. The longer the benefits shock lasts, the bigger the negative effect is. That is, the size of the extended benefits should match the concurrent unemployment. If the unemployment rate has already declined a lot, but the extended benefits are still very high, the "unnecessary" benefits would push the required wage up and discourage firms to post new vacancies. The plots of the left panel of Figure 3 report the labor market tightness and job-finding rate under a liquidity shock at the zero lower bound. The blue dashed lines represent the responses when there is an extended unemployment benefits shock, and red solid lines are the baseline case without any extended unemployment benefits. When there is unemployment benefits shock, the labor market tightness is lower than the case without any extended benefits during the recovery process, which supports the argument that the extended unemployment benefits shock discourages firms to hire new workers and results in insufficient vacancies during the recession.

4.1.2 The Effect of the Unemployment Benefits Policy during the Great Recession

From the previous analysis, we know that the persistence of the extended benefits program is very important. To avoid providing unnecessary benefits, it's meaningful to try the case where the extended benefits track the unemployment rate closely. In this experiment, there is no unemployment benefits shock, but the unemployment benefits change follows Eq (45) and the initial rise of the unemployment benefits in response to the liquidity shock is also 50%, the same as the initial rise of the unemployment benefits shock. To match the initial rise, γ^u is calibrated to be 5. The key advantage of the unemployment benefits policy is it offers additional compensation to unemployed workers according to the concurrent labor market condition, which could avoid the cases with unnecessary or insufficient compensation.

The blue dashed lines in Figure 2 show the impulse responses of the main variables. Under this setup, the increase in the unemployment benefits also slightly relieves the declines in output and consumption and results in lower unemployment rate. The difference from the case with unemployment benefits shock is that the recovery here is faster. The reason is that the estimated unemployment benefits shock is highly persistent, so several periods after the liquidity shock the benefits are too high given the level of unemployment. Then its detrimental effects on discouraging labor demand and pushing up inflation will overcome its beneficial effect on stimulating aggregate demand.

The plots of the right panel of Figure 3 report the labor market tightness and job-finding rate under a liquidity shock at the zero lower bound. The blue dashed lines represent the responses when there is an extended unemployment benefits policy, and red solid lines are the baseline case without any extended unemployment benefits. Since according to the policy, the extended benefits decrease proportionally to the decrease in the unemployment rate, we don't see any low-tightness or low-job-finding-rate period during the recovery.

4.1.3 The Role of the Zero Lower Bound

The zero lower bound plays a very important role both theoretically and practically. Previous studies (such as Del Negro et al. (2011)) have found that away from the zero lower bound, a negative liquidity shock will not cause a smaller decrease in output. In this sense, the zero lower bound works as an amplification mechanism for the liquidity shock. Then how does the zero lower bound affect the impacts of extended unemployment benefits either result from a shock or a policy?

The presence of the zero lower bound is very important for the effect of extended unemployment benefits in the model with endogenous separation and real wage rigidity. As seen above, in the presence of the zero lower bound, extended unemployment benefits can be helpful for preventing output and consumption from decreasing further because it increases the total income of household and have some stimulative effect on aggregate demand, which makes the economy stuck in the liquidity trap not as deeply as the case without any unemployment benefits changes.

But when the zero lower bound is not binding, this advantage disappears. Without the zero lower bound, the conventional monetary policy works perfectly, and lower inflation will induce lower nominal interest rate, which have stimulative effect on the economy. Since higher unemployment benefits have a positive effect on inflation and nominal interest rate, the stimulative effect of monetary policy will be smaller when the extended unemployment benefits policy is implemented.

Figure **??** and 5 presents the impulse responses of variables under the same liquidity shock as previous section without the zero lower bound on the nominal interest rate. In both figures, the recessions are deeper but recover faster when there are extended unemployment benefits.

Another interesting result is the equity price changes in the opposite direction when the unemployment benefits are extended either through a shock or a policy. This reveals another positive aspect of extended unemployment benefits when the zero lower bound is not binding. At the same time, it has negative effect when the zero lower bound is not binding. The extended unemployment benefits push up the inflation and nominal interest rate; so that the real interest rate, that is the real return to government bond, increase. This makes the government bond more attractive and increases the demand for government bond. Given the household's wealth level, an increase in the demand for government bond can crowd out their demand for equity. This decline in equity demand causes the decrease in equity price. Since government bonds are liquid assets, holding more government bonds gives entrepreneurs more liquidity to invest on capital in the following periods. This explains why in longer horizon, the extended unemployment benefits can speed up the recovery. This does not happen in the case with the zero lower bound because when the nominal interest rate hits the zero lower bound, even without any increase in the unemployment benefits, the real interest rate is positive, which attracts a lot of demand for government bonds, and crowds out the demands for private equity. The equity price decreases under the liquidity shock even without the extended unemployment benefits at the zero lower bound. Although the extended unemployment benefits push up the inflation, the nominal rate still stays at the zero lower bound, which makes the real interest rate lower than the case without extended unemployment benefits. As a result, at the zero lower bound extended unemployment benefits cause that the demand for private equity won't be crowded out as much and the equity price decreases less. Hence, the recovery process is slower due to the inadequate liquidity.

Table **??** reports the welfare loss under a liquidity shock with different combination of unemployment policies both at and away from the zero lower bound. Comparing columns in the same row of the table, it's easy to find the rule that with the zero lower bound unemployment policies are more effective in enhancing the welfare. Combining with the impulse responses, we know this is because at the zero lower bound, the stimulative effect of extended unemployment benefits dominates its detrimental effects on the economy.

4.2 Optimal Simple Rules for the Unemployment Policies

4.2.1 Optimal Simple Rules under Different Shocks

I investigate two types of simple rules for unemployment policies in this paper: one is the unemployment benefits policy, and the other is the compensation for vacancy postings policy, since labor demand is also an essential element for the labor market recovery according to previous analysis. I assume the changes in unemployment benefits are proportional to the changes in the unemployment rate, and the change in vacancy posting compensation is proportional to vacancies. That is,

$$\widehat{g_t^u} = \gamma^u * \widehat{u}_t \tag{45}$$

and

$$\widehat{g_t^v} = \gamma^v * \widehat{v}_t. \tag{46}$$

The period-loss function is set to follow Ravenna and Walsh (2009):

$$L_t = \pi_t^2 + \lambda_0 \widetilde{c}_t^2 + \lambda_1 \widetilde{\theta}_t^2, \tag{47}$$

where $\widetilde{x}_t \equiv \widehat{x}_t - \widehat{x}_t^{flexprice}$, $\lambda_0 = \sigma(1-\beta\omega)(1-\omega)/(\epsilon^p\omega)$ and $\lambda_1 = (1-\alpha)(1-\beta\omega)(1-\omega)\gamma\overline{V}/(\overline{C}\epsilon^p\omega)$.

Under different structural shocks, the sizes of the optimal policies are different. However, they maintain the same signs. The unemployment benefits are more generous when the unemployment rate is higher than the steady state level, and the compensation for vacancy posting are higher when firms post less vacancies than the steady state level. Table **??** reports the optimal coefficients in the unemployment policies, γ^u and γ^v, under different shocks.

The optimal γ^v under liquidity shock, preference shock, and investment shock are much bigger than those under other shocks in absolute values. Liquidity shock and preference shock have larger impact on the liquidity level of the economy, which limits the entrepreneurs' ability to invest on new capital, and investment shock directly affect the capital producers' profit in producing new capital goods. Insufficient investment on capital can largely increase the cost of using capital in production and reduce firms' value, which is the expected benefit of posting new vacancies when taking the vacancy filling rate as given. Under a constant vacancy posting cost, fewer firms have incentive to post vacancies when the expected benefits of doing so are small. In this case, insufficient labor demand is the main problem of the slow recovery in the labor market, and more subsidies on vacancy posting can help the economy get out of recessions more quickly.

4.2.2 Extended Unemployment Benefits Only or the Combination of Extended Unemployment Benefits and Subsiding Vacancy Postings

In this part, I investigate whether the combination of unemployment benefits policy and subsidies on vacancy postings is a good choice, and compare it with the case where only the unemployment benefits policy is available. I just take the liquidity shock and technology shock as examples, and results are reported in Table 5.

If the unemployment benefits policy is the only available tool, the optimal benefits respond even more strongly to the unemployment rate, and the resulting welfare is lower than the case with implementing both unemployment benefits policy and compensation for vacancy posting policy. This result implies that besides the labor supply and aggregate demand side, labor demand side is also important for the economy. Stimulating labor supply by subsidizing vacancy posting is helpful for generating faster recovery.

4.2.3 Financial Frictions and the Optimal Simple Rules

Financial frictions and liquidity shocks are introduced into the model to mimic the Great Recession. Are the financial frictions important for the above results? I considered a standard New Keynesian model with labor market frictions without any frictions in the financial market (the model is the same as the one used in Zhang (2014)). Table 6 reports the coefficients for optimal simple rules. It's easy to notice that the magnitudes of γ^u and γ^v are significantly smaller than the case with financial frictions. Without the amplification effect caused by financial frictions, the labor market conditions won't get too bad. So there is no need for large scale government intervention.

Financial frictions make the labor market situation worse during recessions from two aspects. One is the financial frictions amplify shocks and make the whole economy, including the labor market, more volatile. Volatility is exactly what we don't want according to the welfare loss function. In order to smooth the high volatile economy, the unemployment policies have to respond more strongly to labor market fluctuations. The second channel through which the financial frictions affect the labor market is making vacancy posting more costly during recessions. Since all firms are owned by households, vacancy posting cost paid by the firms is essentially liquidity of the households. When there are financial frictions, which means some of the asset hold by the households is illiquid, the vacancy posting cost becomes more valuable from the aspect of liquidity. Although the vacancy posting cost is set to be constant, its liquidity value is absolutely larger during recessions. This makes the firms especially hesitate to post new vacancies during recessions, which slows down the recovery of the labor market, and hence, the recovery of the whole economy.

5 Conclusion and Policy Implication

From studying the model with liquidity friction and labor market frictions, the results I can get are in Four folds. First, during the Great Recession, extended unemployment benefits mitigate the big decline in the economy caused by a liquidity shock when the zero lower bound is binding, and the unemployment benefits shock slows down the recovery process. The size of the negative effect of the unemployment benefits shock on the recovery process depends on the persistence of the shock. The longer the EUC program lasts, the larger the negative effect is. Second, without the zero lower bound, the extended unemployment benefits can induce deeper recession. Third, a countercyclical unemployment benefits program together with countercyclical compensation for vacancy posting can enhance the social welfare under different structural shocks. Forth, if the compensation for vacancy posting is not available, the optimal unemployment benefits respond even more strongly to unemployment, which yield higher welfare than the case without any unemployment policy, but lower welfare than the case with both unemployment benefits policy and subsidies in vacancy posting. Five, financial frictions raise the volatility of the economy and make the vacancy posting more costly during recessions, so without financial frictions, the optimal unemployment policies respond to shocks in a much smaller magnitude.

The policy implications of the previous analysis are: first, countercyclical unemployment benefits and compensation for vacancy posting are beneficial for social welfare; second, the persistence of the unemployment benefits shock, corresponding to the length of the Emergency Unemployment Compensation Program, affect the labor market recovery essentially; third, following an unemployment benefits policy rule could avoid providing unnecessary benefits; and four, compensation for vacancy posting is also beneficial for the labor market recovery, especially facing financial market shocks, and could be used together with the unemployment benefits policy.

References

[1] Andolfatto, D.. (1996). "Business Cycles and Labor Market Search." *American Economic Review*, 86, 112-132.

[2] Andrea Ajello. "Financial Intermediation, Investment Dynamics and Business Cycle Fluctuations." *Working Paper Series, Northwestern University.*

[3] Barlevy, Gadi. (2011). "Evaluating the Role of Labor Market Mismatch in Rising Unemployment." *Economic Perspectives*, 35(3), 82-96.

[4] Barnichon, Regis, and Andrew Figura. (2011). "What Drives Matching Efficiency? A Tale of Composition and Dispersion." *Finance and Economics Discussion 2011-10*, Board of Governors of the Federal Reserve System.

[5] Blanchard, Olivier, and Jordi Gali. (2006). "A New-Keynesian Model with Unemployment." *MIT, mimeo.*

[6] Chen, Han, Vasco Curdia, and Andrea Ferrero. (2011). "The Macroeconomic Effects of Large Scale Assets Purchase Programs." *Working Paper Series, Federal Reserve Bank of New York.*

[7] Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. (2005). "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy*, 113(1), 1-45.

[8] Christiano, Lawrence J., Martin Eichenbaum, and Sergio Rebelo. 2012. "When is the Government Spending Multiplier Larger?" *working paper.*

[9] Christiano, Lawrence J., Mathias Trabandt, and Karl Walentin. (2011). "Introducing Financial Frictions and Unemployment into a Small Open Economy Model." *Journal of Economic, Dynamics and Control*, forthcoming.

[10] Cogan, John F., Tobias Cwik, John B. Taylor, and Volker Wieland. (2010). "New Keynesian versus Old Keynesian Government Spending Multipliers." *Journal of Economic Dynamics and Control*, 34(3), 281-295.

[11] Costain, James S., and Michael Reiter. (2008). "Business Cycles, Unemployment Insurance, and the Calibration of Matching Models." *Journal of Economic Dynamics and Control*, 32(4), 1120-1155.

[12] Curdia, Vasco, and Michael Woodford. (2009a). "Credit Frictions and Optimal Monetary Policy." *Mimeo, Federal Reserve Bank of New York and Columbia University.*

[13] Curdia, Vasco, and Michael Woodford. (2009b). "Conventional and Unconventional Monetary Policy." *Federal Reserve Bank of New York Staff Reports 404.*

[14] Cwik, Tobias, and Volker Wieland. (2011). "Keynesian Government Spending Multipliers and Spillovers in the Euro Area". *Economic Policy*, 26(67), 493-549.

[15] Del Negro, Marco, Gauti Eggertsson, Andrea Ferrero, and Nobuhiro Kiyotaki. (2011). "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities." *Federal Reserve Bank of New York, Staff Reports*, No. 520.

[16] Den Hann, Wouter, Garey Ramey, and Joe Watson. (2000). "Job Destruction and Propagation of Shocks." *American Economic Review*, 90(3), 482-498.

[17] Diamond, Peter. (2011). "Unemployment, Vacancies, Wages." *American Economic Review*, 101(4), 1045-1072.

[18] Dickens, William T.. (2010). "Has the Recession Increased the NAIRU?" *working paper.*

[19] Eggertsson, Gauti. (2008). "Great Expectations and the End of the Depression." *American Economic Review*, 98(4), 1476-1516.

[20] Eggertsson, Gauti. (2009). "What Fiscal Policy is Effective at Zero Interest Rate?" *New York Fed Staff Report*.

[21] Eggertsson, Gauti, and Michael Woodford. (2003). "The Zero Bound on Interest Rates and Optimal Monetary Policy." *Brookings Papers on Economic Activity*, 34(1), 139-235.

[22] Elsby, Michael, Bart Hobijn, Aysegul Sahin, and Robert G. Valletta. (2011). "The Labor Market in the Great Recession: an Update." *Brookings Papers on Economic Activity*, 103, 353-371.

[23] Fujita, Shigeru. (2010). "Economic Effects of the Unemployment Insurance Benefits." *Federal Reserve Bank of Philadelphia Business Review*, 2010 Fourth Quarter, 20-27.

[24] Fujita, Shigeru, and Garey Ramey. (2011). "Exogenous vs. Endogenous Separation." *American Economic Journal - Macroeconomics*, forthcoming.

[25] Furlanetto, Francesco, and Nicolas Groshenny. (2012). "Mismatch Shocks and Unemployment During the Great Recession." *CAMA working paper series*, 34/2012.

[26] Gali, Jordi, Frank Smets, and Rafael Wouters. (2010). "Unemployment in an Estimated New Keynesian Model." prepared for the *NBER Macroeconomics Annual 2011.*

[27] Gertler, Mark, and Nobuhiro Kiyotaki. (2010). "Financial Intermediation and Credit Policy in Business Cycle Analysis." *Handbook of Monetary Economics*, Vol. 3, Elsevier, Chapter 11, 547-599.

[28] Gertler, Mark, and Peter Karadi. "A Model of Unconventional Monetary Policy." (2011). *Journal of Monetary Economics*, 58(1), 17-34.

[29] Gertler, Mark, Luca Sala, Antonella Trigari. (2008). "An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining." *Journal of Money, Credit and Banking*, 40(8), 1713-1764.

[30] Gertler, Mark, and Antonella Trigari. (2009). "Unemployment Fluctuations with Staggered Nash Wage Bargaining." *Journal of Political Economy*, 117(1), 38-86.

[31] Groshenny, Nicolas. (2012). "Monetary Policy, Inflation and Unemployment: In Defense of the Federal Reserves." *Macroeconomic Dynamics*, forthcoming.

[32] Hagedorn, Marcus, and Iourii Manovskii. (2008). "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited." *American Economic Review*, 98(4), 1692-1706.

[33] Hall, Robert. (2005). "Employment Fluctuations with Equilibrium Wage Stickiness." *American Economic Review*, Vol. 95, No. 1, 50-65.

[34] Kiyotaki, Nobuhiro, and Jonh Moore. (1998). "Credit Cycles." *Journal of Political Economy*, 1997, 105(2), 211-248.

[35] Kiyotaki, Nobuhiro, and Jonh Moore. (2008). "Liquidity, Business Cycles, and Monetary Policy." *Mimeo, Princeton University.*

[36] Krause, Michael, and Thomas Lubik. (2007). "The (Ir)relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions." *Journal of Monetary Economics*, 54, 706-727.

[37] Lalive, Rafael, Camille Landais, and Josef Zweimuller. (2013). "Market Externalities of Large Unemployment Insurance Extension Programs."

[38] Landais, Camille, Pascal Michaillat, and Emmanuel Saez. (2011). "Optimal Unemployment Insurance over the Business Cycle." NBER Working Paper 16526.

[39] Liu, Zheng, Pengfei Wang, and Tao Zha. (2010). "Do Credit Constraints Amplify Macroeconomic Fluctuations?" *working paper*, Federal Reserve Bank of Atlanta.

[40] Mian, Atif, and Amir Sufi. (2012). "What Explains High Unemployment? The Aggregate Demand Channel." *NBER working paper*.

[41] Michaillat, Pascal. (2011). "Do Matching Frictions Explain Unemployment? Not in Bad Times." *American Economic Review*, forthcoming.

[42] Mortensen, Dale, and Christopher Pissarides. (1994). "Job Creation and Job Destruction in the Theory of Unemployment." *Review of Economic Studies*, 61, 397-415.

[43] Moyen, Stephane, and Nikolai Stahler. (2012). "Unemployment Insurance and the Business Cycle: Should Benefit Entitlement Duration React to the Cycle?" *Macroeconomic Dynamics*, forthcoming.

[44] Nakajima, Makoto. "A Quantitative Analysis of Unemployment Benefits Extensions." *Journal of Monetary Economics*, 59(7), 686-702.

[45] Pissarides, Christopher A. (2000). "Equilibrium Unemployment Theory." Second edition. *The MIT Press*.

[46] Ravenna, Federico, and Carl Walsh. (2008). "Vacancies, Unemployment and the Phillips Curve." *European Economic Review*, 52, 1494-1521.

[47] Ravenna, Federico, and Carl Walsh. (2011). "Welfare-based Optimal Monetary Policy with Unemployment and Sticky Prices: a Linear-quadratic Framework." *American Economic Journal: Macroeconomics*, 3, 130-162.

[48] Sahin, Aysegul, Joseph Song, Giorgio Topa, and Giovanni L. Violante. (2012). "Mismatch Unemployment." *working paper*, Federal Reserve Bank of New York.

[49] Rudebusch, Glenn D. (2009). "The Fed's Monetary Policy Response to the Current Crisis." *Federal Reserve Bank of San Francisco Economic Letter* .

[50] Shi, Shouyong. (2011). "Liquidity, Assets, and Business Cycles." *Mimeo*, University of Toronto.

[51] Shimer, Rober. (2005). "The Cyclical Behavior of Equilibrium Unemployment and Vacancies." *American Economic Review*, 95(1), 25-49.

[52] Smets, Frank, and Rafael Wouters. (2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." *American Economic Review*, Vol 97 No. 3, 586-606.

[53] Sveen, Tommy, and Lutz Weinke. (2007). "New Keynesian Perspectives on Labor Market Dynamics." *Journal of Monetary Economics*, 55, 921-930.

[54] Sveen, Tommy, and Lutz Weinke. (2009). "Inflation and Labor Market Dynamics Revisited." *Journal of Monetary Economics*, 56,1096-1100.

[55] Taylor, John B., and John C. Williams. (2009). "A Black Swan in the Money Market." *American Economic Journal: Macroeconimcs*, 1(1), 58-83.

[56] Tasci, Murat, and John Lindner. (2010). "Has the Beveridge Curve Shifted?" *Economic Trends, Federal Reserve Bank of Cleveland*.

[57] Trigari, Antonella. (2006). "The Role of Search Frictions and Bargaining for Inflation Dynamics." *IGIER working paper*, No.304.

[58] Trigari, Antonella. (2009). "Equilibrium Unemployment, Job Flows, and Inflation Dynamics." *Journal of Money, Credit and Banking*, Vol. 41, Issue 1, 1-33.

[59] Valletta, Robert G., and Katherine Kuang. (2010). "Is Structural Unemployment on the Rise?" *FRBSF Economic Letter*, 2010-34.

[60] Veracierto, Marcelo. (2011). "Worker Flows and Matching Efficiency." *Economic Perspectives*, 35(4), 147-169.

[61] Walsh, Carl E.. (2005). "Labor market Search, Sticky Prices, and Interest Rate Policies." *Review of Economic Dynamics*, 8 (2005), 829-849.

[62] Whittaker, Julie. (2008). "Extending Unemployment Compensation Benefits During Recessions." *Congressional Research Service Report*, RL34340.

[63] Weidner, Justin, and John C. Williams. (2011). "What is the New Normal Unemployment Rate?" *FRBSF Economic Letter*. 2011-05.

[64] Woodfor, Michael. (2010). "Simple Analytics of the Government Expenditure Multiplier" *NBER Working Paper*, No. 15714.

[65] Yashiv, Eran. (2007). "Labor Search and Matching in Macroeconomics." *European Economic Review*, 51, 1859-1895.

[66] Zhang, Ji. (2012). "Extended Unemployment Benefits and Matching Efficiency in an Estimated DSGE Model with Labor Market Search and Matching Frictions." *Working Paper*, University of California, San Diego.

A Tables and Figures

Table 1: Calibrated Values for Parameters Agreed with Del Negro et al. (2011)

Standard parameters		
β	=0.99	Discount factor
α	=0.4	Capital share
σ	=1	Relative risk aversion
δ	=0.025	Depreciation rate
ϵ^p	=11	Elasticity of substitution
ω	=0.75	Price Calvo probability
Financial friction parameters		
$\phi(=\theta)$	=0.207	Resaleability/Borrowing constraint parameter for entrepreneurs
$\psi''(1)$	=1	Investment adjustment cost parameter
χ	=0.05	Probability of investment opportunity
$\frac{L}{4Y}$	=0.4	Steady-state liquidity-GDP ratio
ϵ_1^ϕ	=0.6	Size of the liquidity shock
ρ^ϕ	=0.833	Persistence of the liquidity shock
Baseline policy parameters		
ϕ_π	=1.5	Taylor rule coefficient
ψ^T	=0.1	Transfer rule coefficient

1. All the above parameters are calibrated following Del Negro et al. (2011).

Table 2: Calibrated Values of Non-Standard Parameters

Labor market parameters		
ζ	=0.5	Elasticity of matching function
W	=0.36	Workers' Bargaining power
ρ	=0.105	Total separation rate
ρ^w	=0.7	Steady-state job-finding rate
σ_a	=0.15	Standard deviation of match-specific productivity
$\widetilde{a}$	=0.74	Steady-state threshold of productivity
τ	=0.74	Steady-state labor market tightness
η	=0.38	Real/Nominal wage rigidity
Steady state policy parameters		
g_y	=0.18	Steady state government spending - output ratio
$g^u_{y^L}$	=0.4	Replacement rate
ρ^{Gu}	=0.97	Persistence of the unemployment benefits change

1. The size of initial unemployment benefits change (which didn't appear in Zhang (2014)) is calibrated to match the data. All other parameters are calibrated following Zhang (2014).

Table 3: Welfare Loss under a Liquidity Shock with Different Sizes of Unemployment Policies both at and away from the ZLB

		Welfare w/ ZLB		Welfare w/o ZLB	
γ^u	γ^v	$\mathbb{W}$	$\frac{\mathbb{W}}{\mathbb{W}_0}$	$\mathbb{W}$	$\frac{\mathbb{W}}{\mathbb{W}_0}$
0	0	-0.4557	1.0000	-0.1626	1.0000
0.5	0	-0.3992	0.8760	-0.1798	1.1058
1	0	-0.3610	0.7922	-0.1967	1.2097
3	0	-0.2558	0.5613	-0.2016	1.2399
5	0	-0.1942	0.4262	-0.1580	0.9717
7	0	-0.1596	0.3502	-0.1309	0.8050
0.5	-0.1	-0.3982	0.8738	-0.1966	1.2091
1	-0.1	-0.3598	0.7896	-0.2133	1.3118
3	-0.1	-0.2481	0.5444	-0.2040	1.2546
5	-0.1	-0.1866	0.4095	-0.1568	0.9643
7	-0.1	-0.1562	0.3428	-0.1289	0.7927

1. The size of the liquidity shock is 0.6, which can lower the nominal interest rate to hit the zero lower bound.
2. The 3rd column is the welfare loss under different policy combinations when there is a zero lower bound in the model.
3. The 4th column is the ratios between welfare loss under some policy combinations ($\mathbb{W}$) and the welfare loss when no policy ($\mathbb{W}_0$) is implemented in a model with the zero lower bound.
4. The 5rd column is the welfare loss under different policy combinations when there is no zero lower bound in the model.
5. The 6th column is the ratios between welfare loss under some policy combinations ($\mathbb{W}$) and the welfare loss when no policy ($\mathbb{W}_0$) is implemented in a model without the zero lower bound.

Table 4: Optimal Simple Rules for Unemployment Policies under Different Shocks

	γ^u	γ^v
Liquidity shock	4.94	-15.63
Technology shock	5.01	-1.74
Preference shock	11.77	-6.51
Gov. spending shock	5.72	-0.41
Investment shock	0.35	-5.00
Monetary shock	3.14	-0.11

1. Coefficients of optimal simple rules for unemployment benefits and compensation on vacancies are chosen under different shocks. The shock sizes are normalized to be 0.1.

Table 5: Unemployment Benefits Vs. Unemployment Benefits + Compensation on Vacancies

		γ^u	γ^v	welfare
Liquidity shock	optimal γ_1^u and γ_1^v	4.94	-15.63	-9.40E-03
	optimal γ_2^u when $\gamma_2^v \equiv 0$	20.77	0	-1.23E-02
	$\gamma_3^u = \gamma_1^u$ and $\gamma_3^v \equiv 0$	4.94	0	-2.65E-02
	$\gamma_4^u = 0$ and $\gamma_4^v = 0$	0	0	-2.71E-02
Technology shock	optimal γ_1^u and γ_1^v	5.01	-1.74	-3.245E-03
	optimal γ_2^u when $\gamma_2^v \equiv 0$	5.46	0	-3.311E-03
	$\gamma_3^u = \gamma_1^u$ and $\gamma_3^v \equiv 0$	5.01	0	-3.312E-03
	$\gamma_4^u = 0$ and $\gamma_4^v = 0$	0	0	-4.028E-03

1. Case 1 (optimal γ_1^u and γ_1^v): when both the unemployment benefits policy and compensation on vacancies policy are available, γ_1^u and γ_1^v are the optimal values for the simple rules.
2. Case 2 (optimal γ_2^u when $\gamma_2^v \equiv 0$): when only the unemployment benefits policy is available, γ_2^u is the optimal value for the simple rule.
3. Case 3 ($\gamma_3^u = \gamma_1^u$ and $\gamma_3^v \equiv 0$): when only the unemployment benefits policy is available, γ_3^u is simply set to the optimal value in Case 1.
4. Case 4 ($\gamma_4^u = 0$ and $\gamma_4^v = 0$): no policy is implemented.

Table 6: Optimal Simple Rules for Unemployment Policies in a Model without Financial Frictions

	γ^u	γ^v
Technology shock	0.07	-0.43
Preference shock	0.30	-0.18
Gov. spending shock	0.11	0
Investment shock	0.24	-0.40
Monetary shock	0.30	-0.20

1. Coefficients of optimal simple rules for unemployment benefits and compensation on vacancies are chosen under different shocks. The shock sizes are normalized to be 0.1.

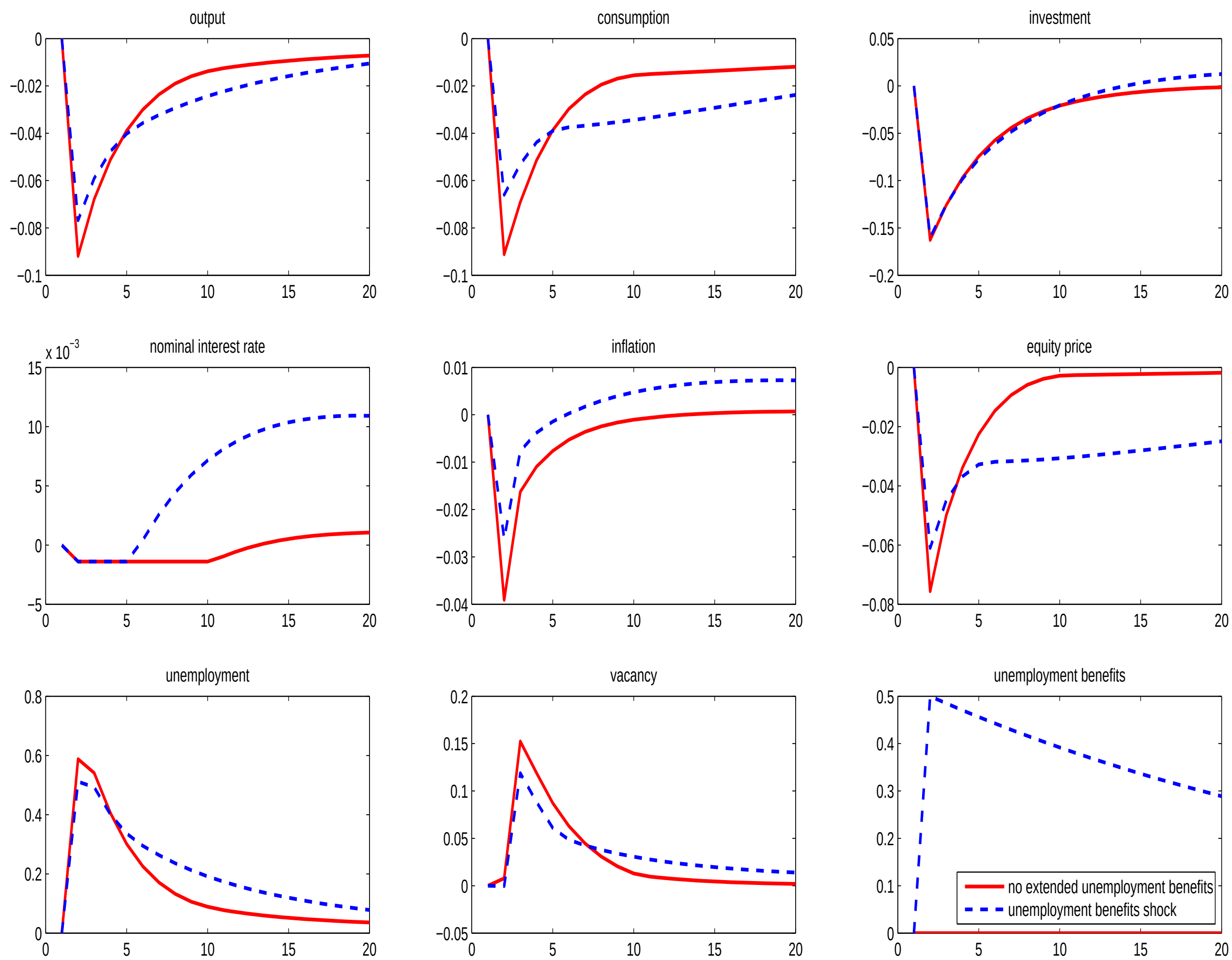

Figure 1: The Role of Extended Unemployment Benefits Shock in the Response to a Liquidity Shock at the ZLB.

NOTE: The solid lines show the impulse responses after a liquidity shock in the model with the zero lower bound for the nominal interest rate. The dashed lines are the corresponding responses with extended unemployment benefits after the liquidity shock. The X-axis gives time horizon in quarters. In graphs for the annual nominal interest rate and unemployment rate, the Y-axis represents level deviation, and in graphs for other variables, it represents log-deviation.

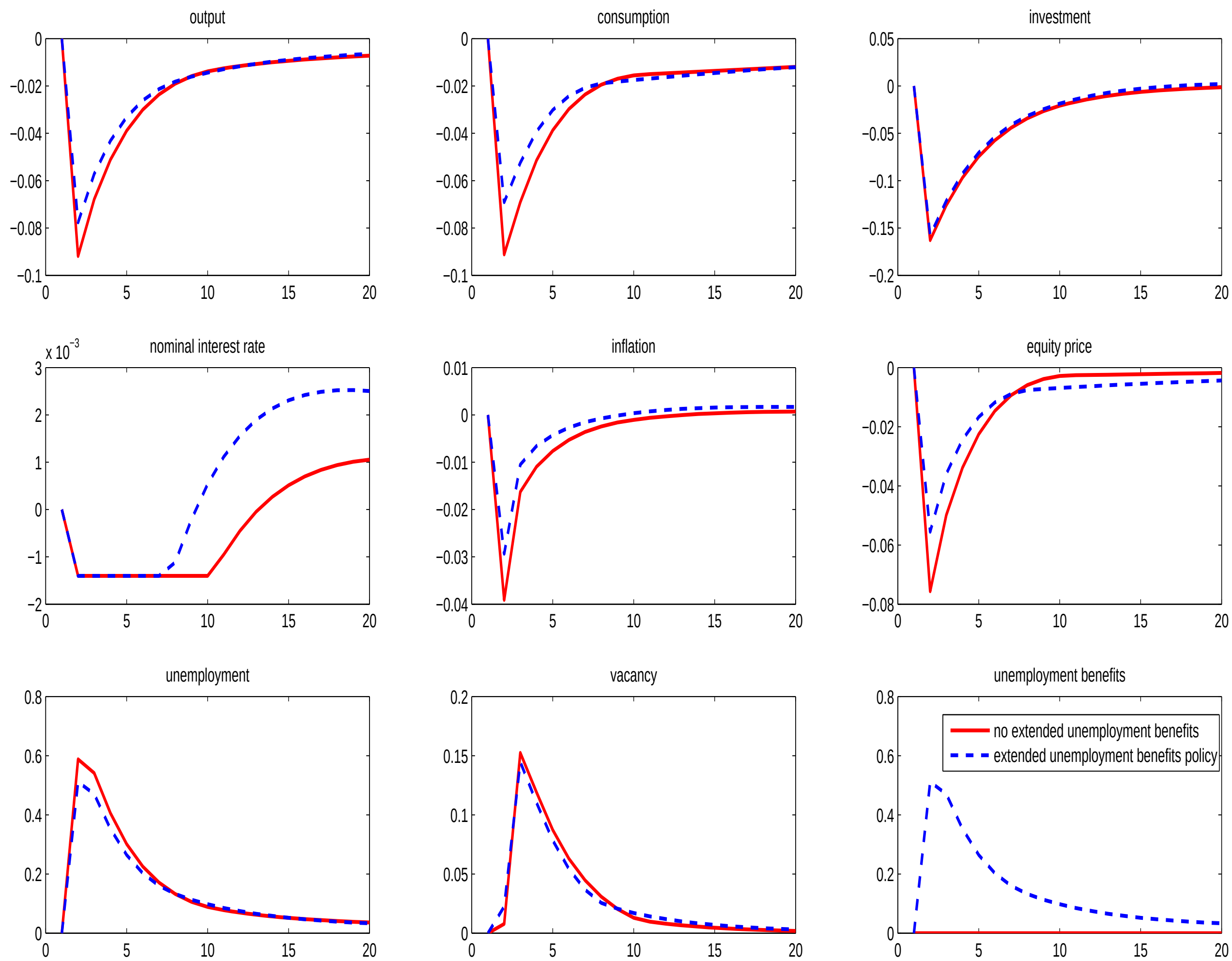

Figure 2: The Role of Extended Unemployment Benefits Policy in the Response to a Liquidity Shock at the ZLB.
NOTE: The solid lines show the impulse responses after a liquidity shock in the model with the zero lower bound for the nominal interest rate. The dashed lines are the corresponding responses with extended unemployment benefits after the liquidity shock. The X-axis gives time horizon in quarters. In graphs for the annual nominal interest rate and unemployment rate, the Y-axis represents level deviation, and in graphs for other variables, it represents log-deviation.

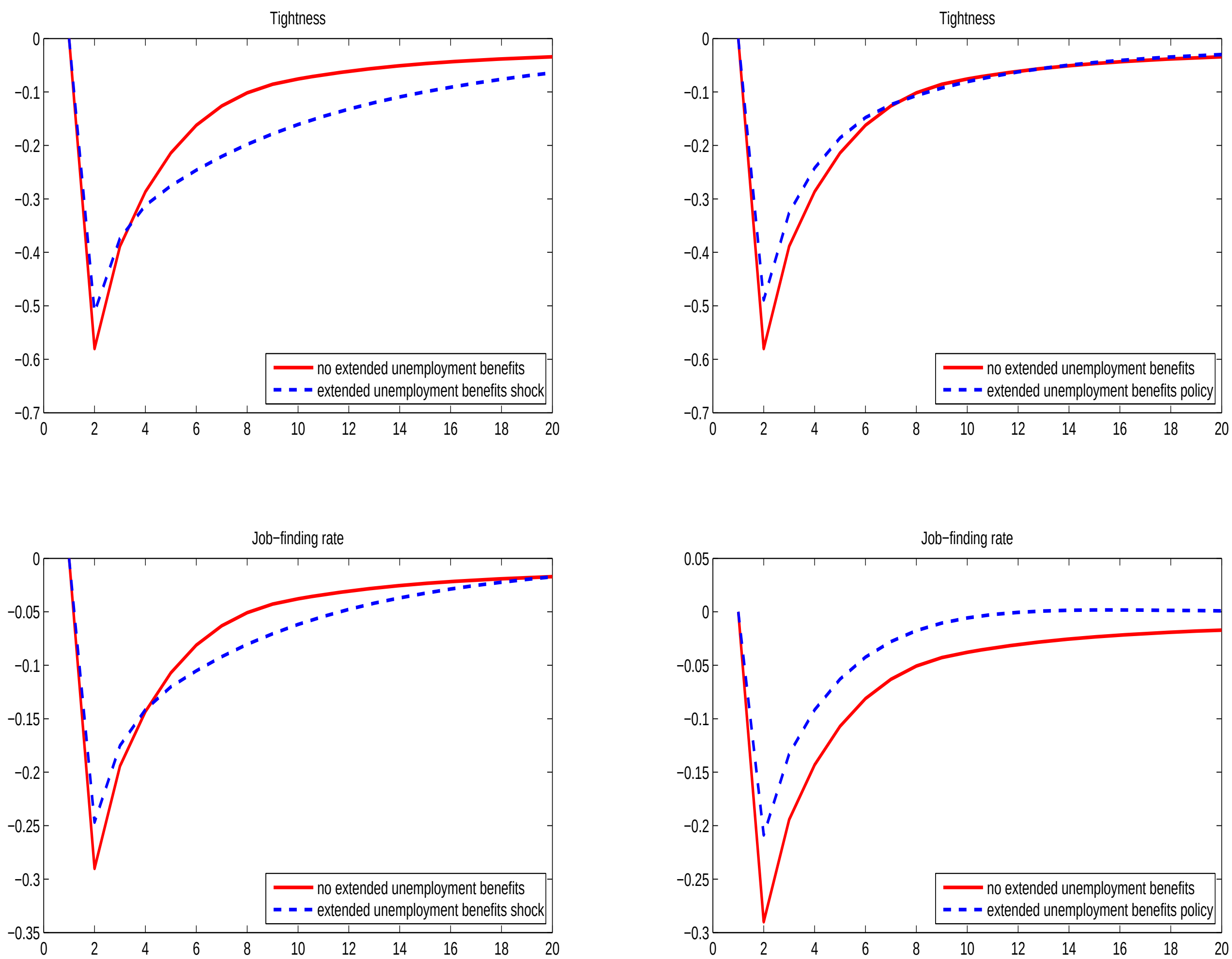

Figure 3: The Labor Market Tightness and Job-finding Rate in the Response to a Liquidity Shock at the ZLB.

NOTE: The solid lines show the impulse responses after a liquidity shock in the model with the zero lower bound for the nominal interest rate. The dashed lines are the corresponding responses with extended unemployment benefits (either shock or policy) after the liquidity shock. The X-axis gives time horizon in quarters. In graphs for the annual nominal interest rate and unemployment rate, the Y-axis represents level deviation, and in graphs for other variables, it represents log-deviation.

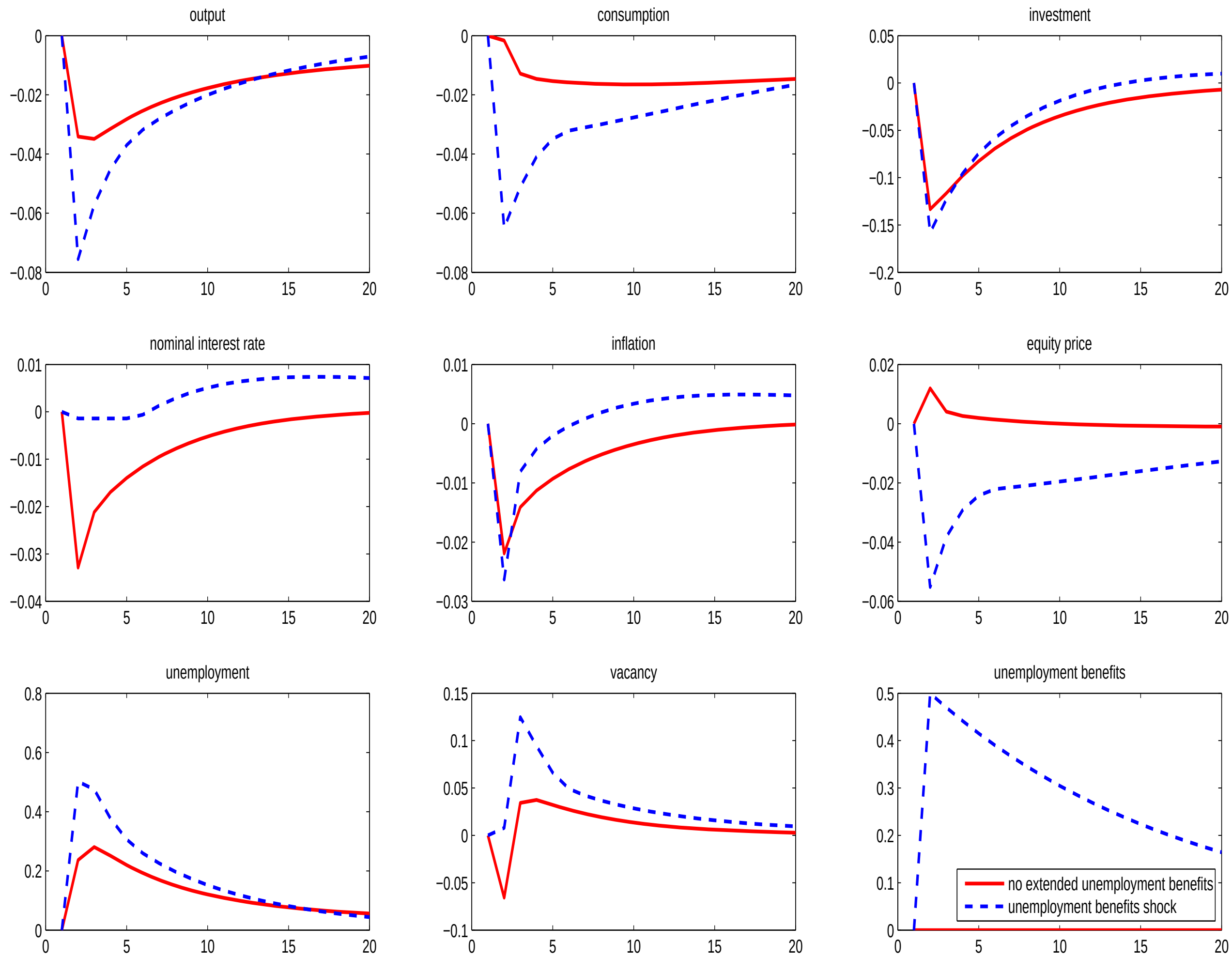

Figure 4: The Role of Extended Unemployment Benefits Shock in the Response to a Liquidity Shock without the ZLB.
NOTE: The solid lines show the impulse responses after a liquidity shock in the model without the zero lower bound for the nominal interest rate. The dashed lines are the corresponding responses with extended unemployment benefits shock after the liquidity shock. The X-axis gives time horizon in quarters. In graphs for the annual nominal interest rate and unemployment rate, the Y-axis represents level deviation, and in graphs for other variables, it represents log-deviation.

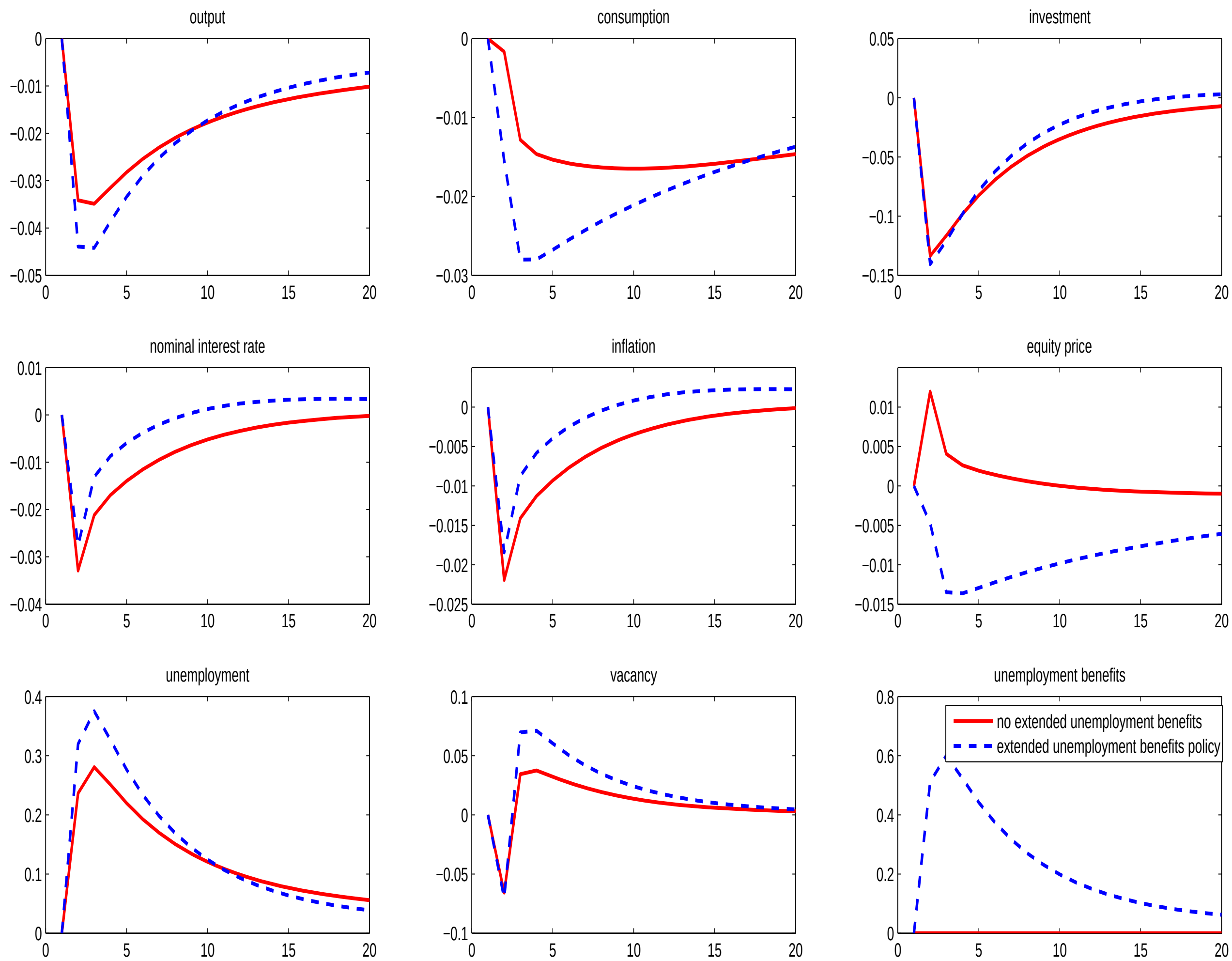

Figure 5: The Role of Extended Unemployment Benefits Policy in the Response to a Liquidity Shock without the ZLB.

NOTE: The solid lines show the impulse responses after a liquidity shock in the model without the zero lower bound for the nominal interest rate. The dashed lines are the corresponding responses with extended unemployment benefits after the liquidity shock. The X-axis gives time horizon in quarters. In graphs for the annual nominal interest rate and unemployment rate, the Y-axis represents level deviation, and in graphs for other variables, it represents log-deviation.