Contributions

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Fiscal stimulus and unemployment dynamics

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Abstract:
Focusing on both hiring and firing margins, this paper revisits effects of fiscal stimulus on unemployment. We develop a DSGE model with search frictions where job separation is endogenously determined. The predictions of the model are in contrast with earlier studies that assume exogenous separation. Our model can capture the empirical pattern of responses of the job finding, separation, and unemployment rates to a government spending shock, obtained from a structural VAR model with the US data. However, our model fails to capture the response of vacancies and the volatility of unemployment. We discuss the roles of cyclical movements of matching efficiency and labor force participation to fix this model's shortcoming.

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1 Introduction

Recently, a number of studies examine effects of fiscal expansion on unemployment in dynamic stochastic general equilibrium (DSGE) models (Brückner and Pappa 2012; Campolmi, Faia, and Winkler 2011; Monacelli, Perotti, and Trigari 2010; Yuan and Li 2000). They incorporate labor search frictions into an otherwise standard DSGE model and study effects of fiscal stimulus in the form of government spending and hiring subsidies on the economy. One of common features of these studies is exogenous job separation. They assume that while a worker's transition rate from unemployment to employment is endogenously determined through a matching market, employed workers lose their jobs merely due to exogenous separation shocks. However, recent empirical studies demonstrate that unemployment dynamics is determined by both inflow and outflow rates of unemployment. These studies find large variations in both inflow and outflow rates over business cycles (Elsby, Michaels, and Solon 2009; Fujita and Ramey 2009).[1] This suggests that taking into account both hiring and firing margins is important to study effects of fiscal policies on unemployment.

This paper revisits effects of fiscal stimulus on unemployment and employment by focusing on both hiring and firing margins. We develop a DSGE model with search frictions in which workers' transitions between employment and unemployment are endogenously determined. Our model demonstrates that an increase in government spending increases the job finding rate and reduces the separation rate, lowering unemployment. It also shows that a positive government spending shock reduces vacancies.

The predictions of our model are in contrast with earlier studies that assume exogenous job separation. First, while both models with and without endogenous separation generate a similar pattern of responses of unemployment to a positive government spending shock, the model with endogenous separation generates a larger impact on unemployment than the model without endogenous separation. Second, while a positive government spending shock increases vacancies in the model without endogenous separation, it reduces vacancies in the model with endogenous separation.

The above distinctions are the consequence of both i) the relatively large responsiveness of the separation margin and ii) the feed-back effect of job separation on job creation. In the model with endogenous separation, a positive government spending shock substantially reduces the number of job seekers by lowering job separation, which in turn makes vacancy posting less attractive. However, the reduction in separation is large enough to compensate the reduction in job creation and thus reduces unemployment.

In order to examine whether the quantitative predictions of the model are supported by the data, we empirically study the effects of a government spending shock on the US labor market by using a structural vector autoregressive (SVAR) model. Data show that an increase in government spending increases the job finding rate and reduces the separation rate, lowering unemployment. This suggests that it is important to take both

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hiring and firing margins into account when ones analyze the effect of fiscal stimuli on the labor market. The predictions of the model with endogenous separation model are consistent with these observations. However, the response of vacancies to the government spending shock in the model with endogenous separation are not in line with those of the SVAR model. In order to understand the sources of such discrepancy, we discuss the roles of the cyclical movements of matching efficiency and labor supply through labor force participation.

We also study the effect of fiscal stimulus in the form of a hiring subsidy on the labor market.[2] The most striking finding is that the firing margin plays an important role in determining the effect of the hiring subsidy. While a positive hiring subsidy shock reduces unemployment in the model without endogenous separation, it increases unemployment in our model. On one hand, when the hiring subsidy increases, it increases firm's incentive to post vacancies by reducing the cost of posting vacancies, lowering unemployment. On the other hand, it induces more separation by reducing the opportunity cost of continuing existing matches. Under the plausible parameter values, the latter effect dominates the former one. As a result, the positive hiring subsidy shock increases unemployment.

Our work is related to a number of recent papers that study effects of fiscal policies on the labor market. Conventional wisdom says that an increase in government expenditures reduces the unemployment rate. Monacelli, Perotti, and Trigari (2010) estimate a SVAR model and obtain a similar conclusion for the US. They also demonstrate that a New Keynesian (NK) model with search frictions is able to match their empirical observations. In contrast, Yuan and Li (2000) estimate an alternative SVAR model still with the US data and obtain the opposite result that an increase in government expenditures reduces employment. To interpret their findings, they build a real business cycle model with search frictions and extensive and intensive margins. Using data from several OECD countries, Brückner and Pappa (2012) demonstrate that in most cases, an increase in government spending increases the unemployment rate. They build a NK model with search frictions and workers' participation choices to reproduce the data. None of these papers considers the hiring subsidy and endogenous job separation.

By considering hiring subsidies, this paper is close to Campolmi, Faia, and Winkler (2011) and Faia, Lechthaler, and Merkl (2013). To study the effects of hiring subsidies, Campolmi, Faia, and Winkler (2011) develop a NK model with search frictions and endogenous participation, assuming job separation is exogenous. Thus, our paper can be viewed as a complement to Campolmi, Faia, and Winkler (2011). Faia, Lechthaler, and Merkl (2013) also analyze the role of hiring subsides in a NK model with a screening mechanism of heterogeneous workers, which delivers endogenous separation. The main difference between Faia, Lechthaler, and Merkl (2013) and our paper is that they consider a firing cost that dampens the increase of the job separation rate following an increase in hiring subsidies. Besides, our focus is on the effects of fiscal stimuli on the labor market dynamics, but theirs is on computing fiscal multiplier.

The remainder of the paper is organized as follows. Section 2 describes the theoretical model. We develop a DSGE model with labor market frictions and endogenous job separation. In Section 3, we calibrate the model and present the quantitative results of effects of a government spending shock on the economy. In Section 4, we empirically examine the effect of a government spending shock on the US labor market by using a structural VAR model and compare the SVAR results with the predictions of the theoretical models. Section 5 explores the roles of matching efficiency and labor force participation in our model. We also examine the effect of a hiring subsidy shock on the economy. Section 6 concludes.

2 The model

This section presents a DSGE model with labor market frictions in which job separation is endogenously determined.[3] Using this model, we study the effects of fiscal stimuli, in the forms of government spending and a hiring subsidy, on the economy.

Environment An economy consists of households, firms and the government. Each household consists of a continuum of infinitely-lived members normalized to one. They search for jobs when unemployed, while they supply labor services and earn wages when employed. Firms hire workers in a frictional labor market and produce outputs by using capital and labor. Firms sell their products to households in a competitive market. Employment is the outcome of workers' and firms' search behavior, while wages and labor supply are outcomes of a bargaining process. Time is discrete.

In our model, job separation is endogenously determined. Jobs differ by idiosyncratic costs of a non-productive intermediate input that we call an operating cost. When the cost is too high, production is not profitable. Thus, a firm-worker pair chooses a reservation cost and destroys the job when the operating cost is above the reservation cost.[4]

Firm's problem Production takes place when one firm is matched with one worker. When a firm hires a worker, the firm produces output according to a constant-returns-to-scale production function $y_t = A_t f(k_t, h_t)$, where A_t is an aggregate productivity common to all firms, k_t is capital per worker, and h_t is hours worked per worker.

We assume that in order to produce output, a firm-worker pair needs to pay an operating cost x_t besides labor and capital renting costs. The operating cost is idiosyncratic to each match. The match-specific operating cost x_t is assumed to be independent and identically distributed across firms and time, with a cumulative distribution function $\Gamma : [\underline{x}, \tilde{x}] \to [0, 1]$. Every period an existing match draws a new idiosyncratic cost and decides whether producing output at the new level of cost or terminating the employment relationship. Each match chooses a reservation value $\tilde{x}$; if the match-specific cost falls below $\tilde{x}$, it continue producing output.

Besides endogenous separation, a match might be terminated for an exogenous reason in any given period. Let ρ^x denote the probability of exogenous separation, which is assumed to be independent of the idiosyncratic cost, x. When job separation occurs, either endogenously or exogenously, production does not take place and the firm can either reopen a job as a new vacancy or withdraw from the labor market, while the worker becomes unemployed.[5]

Labor market The labor market is frictional. Firms and workers cannot meet instantaneously but must go through a time-consuming search process. The labor market is modeled in the style of the search and matching model developed by Mortensen and Pissarides (1994). The number of successful job matches is determined by the matching function $m_t = m(u_t, v_t)$, where u_t is the number of unemployed workers searching for jobs in the period t, and v_t is the number of vacancies posted. The matching function is continuous, twice differentiable, increasing in its arguments, and exhibits constant returns to scale. The probability that a firm with a vacancy is matched with a worker is given by $m(u_t/v_t, 1) \equiv q(\theta_t)$, where $\theta_t \equiv v_t/u_t$ is labor market tightness. Then, the probability that an unemployed worker is matched with a firm with a vacant job is $m(1, v_t/u_t) = \theta_t q(\theta_t) = p(\theta_t)$. Note that both firms and workers take q_t and p_t as given. It is assumed that workers and firms that are matched in period t begin active employment relationship at the beginning of period $t + 1$.

Timing of the model The timing of the model is as follows. At the beginning of each period, every firm with a filled job draws an idiosyncratic cost and observes whether or not an exogenous separation shock hits the job. After observing all the shocks, the firm-worker pair may choose to separate endogenously. If either exogenous or endogenous separation takes place, the firm-worker pair does not produce anything in the period. After job separation occurs, the levels of employment and unemployment are determined. At the point, matched firms start production, and unemployed workers search for jobs. At the end of the period, wages are paid, the firm's profits are distributed to the households, and households make consumption decisions.

Household's problem A representative household consists of a continuum of individuals of mass one. A member of the household is either employed or unemployed. In period t, a fraction n_t of the household's members are employed, and the rest, $u_t = 1 - n_t$, are unemployed. Following Merz (1995), we assume that family members perfectly insure each other against fluctuations in consumption.

The household's expected life time utility is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \Phi_0 n_t \frac{h_t^{1+\mu}}{1+\mu} \right], \tag{1}$$

where $\beta \in (0, 1)$ is the household's subjective discount factor, C_t is consumption of the household, and h_t is the individual hours worked. $\Phi_0 > 0$ measures the disutility of working, μ is the inverse of the Frisch elasticity of labor supply, and $1/\sigma$ is the intertemporal elasticity of substitution.

Employed household members earn wages, and unemployed household members receive unemployment benefits z from the government. The household receives profits Π from firms and pays lump sum taxes τ to the government. The household consumes C_t and accumulates capital K_{t+1} through investment I_t according to $K_{t+1} = (1 - \delta) K_t + I_t$, where δ is the depreciation rate. The budget constraint of the representative household is

$$C_t + K_{t+1} + \tau_t = \bar{W}_t + u_t z + (1 - \delta) K_t + r_t K_t + \Pi_t,$$

where r_t denotes the real rental rate of capital and $\bar{W}$ is the total wage income for the household, which will be explained latter.

The household chooses C_t and K_{t+1} to maximize (1) subject to its budget constraint. Let λ_t be the Lagrange multiplier on the budget constraint. Then, the household's problem yields following first-order conditions:

$$C_t^{-\sigma} = \lambda_t, \tag{2}$$

$$\lambda_t = \beta \mathbb{E}_t \lambda_{t+1} \left(1 - \delta + r_{t+1}\right). \tag{3}$$

Value functions The problems of firms and workers are characterized by the Bellman equations. The value of a filled job with an idiosyncratic operating cost x_t, $\mathcal{J}_t(x_t)$, satisfies

$$\begin{aligned}\mathcal{J}_t(x_t) = \max_{k_t} \Bigg\{ & A_t f(k_t, h_t) - w_t(x_t) h_t - r_t k_t - x_t + \mathbb{E}_t \beta_t \Bigg[(1-\rho^x) \int_{\underline{x}}^{\tilde{x}_{t+1}} \mathcal{J}_{t+1}(x_{t+1}) d\Gamma(x_{t+1}) \\ & + \left[1 - (1-\rho^x)\Gamma(\tilde{x}_{t+1})\right] \mathcal{V}_{t+1} \Bigg] \Bigg\},\end{aligned} \tag{4}$$

where $\beta_t = \beta \lambda_{t+1}/\lambda_t$ is the stochastic discount factor, $w_t(x_t)$ is wage paid to the employee, and $\mathcal{V}$ is the value of a firm with a vacant job. The value $\mathcal{J}_t(x_t)$ is determined by several factors. During the current period, a firm with a filled job produces $A_t f(k_t, h_t)$ and pays wages $w_t(x_t)h_t$, the rental cost of capital $r_t k_t$, and the operating cost x_t. In the following period, if the match is not destroyed by an exogenous shock and if the idiosyncratic cost is below the reservation value $\tilde{x}_{t+1}$, the match continues and the firm obtains $\mathcal{J}_{t+1}(x_{t+1})$; otherwise, the match is destroyed and the firm gets the value of posting a vacancy $\mathcal{V}_{t+1}$.

The first-order condition for the capital is

$$A_t f_k(k_t, h_t) = r_t. \tag{5}$$

This implies that the optimal capital is chosen to equate the marginal product of capital to the capital rental rate.

The value of a firm with a vacant job is

$$\mathcal{V}_t = -(1-\tau_t^v)\gamma + \mathbb{E}_t \beta_t \left\{ q_t (1-\rho^x) \int_{\underline{x}}^{\tilde{x}_{t+1}} \mathcal{J}_{t+1}(x_{t+1}) d\Gamma(x_{t+1}) + \left[1 - q_t(1-\rho^x)\Gamma(\tilde{x}_{t+1})\right] \mathcal{V}_{t+1} \right\}, \tag{6}$$

where γ is a flow cost of posting a vacancy and τ_t^v is a subsidy to the cost of posting the vacancy.[6]

In equilibrium, all profit opportunities from new jobs are exploited so that the following free entry condition holds:

$$\mathcal{V}_t = 0.$$

Total profits of firms in the economy are defined as follows:

$$\Pi_t = \left[A_t f(k_t, h_t) - r_t k_t\right] n_t - \bar{x}_t - \bar{W}_t - (1-\tau_t^v)\gamma v_t,$$

where $\bar{x}_t = \frac{n_t}{\Gamma(\tilde{x}_t)} \int_{\underline{x}}^{\tilde{x}_t} x d\Gamma(x)$ is total operating costs. Total wages paid to the workers are defined as the average wage, conditional on working, times the number of employed workers and working hours. Thus,

$$\bar{W}_t = \frac{n_t h_t}{\Gamma(\tilde{x}_t)} \int_{\underline{x}}^{\tilde{x}_t} w_t(x_t) d\Gamma(x).$$

We now turn to the worker's side. The value of an employed worker in a job with idiosyncratic cost x_t, $\mathcal{W}_t(x_t)$, is characterized by the following Bellman equation:

$$\begin{aligned}\mathcal{W}_t(x_t) = w_t(x_t) h_t - \frac{\Phi(h_t)}{\lambda_t} + \mathbb{E}_t \beta_t \Bigg\{ & (1-\rho^x) \int_{\underline{x}}^{\tilde{x}_{t+1}} \mathcal{W}_{t+1}(x_{t+1}) d\Gamma(x_{t+1}) \\ & + \left[1 - (1-\rho^x)\Gamma(\tilde{x}_{t+1})\right] \mathcal{U}_{t+1} \Bigg\},\end{aligned} \tag{7}$$

where $\mathcal{U}$ is the value of an unemployed worker and $\Phi(h_t)/\lambda_t = \Phi_0 h_t^{1+\mu}/\lambda_t\,(1+\mu)$ is the disutility from supplying labor in terms of consumption. The value of an employed worker is composed of the wage, the disutility

from supplying labor, and the continuation value, which is the value of being employed if the match is not destroyed, or the value of being unemployed if it is destroyed.

The value of an unemployed worker is

$$\mathcal{U}_t = z + \mathbb{E}_t\beta_t \left\{ p_t(1-\rho^x) \int_{\underline{x}}^{\tilde{x}_{t+1}} \mathcal{W}_{t+1}(x_{t+1}) d\Gamma(x_{t+1}) + \left[1 - p_t(1-\rho^x)\Gamma(\tilde{x}_{t+1})\right] \mathcal{U}_{t+1} \right\}. \tag{8}$$

In the current period, an unemployed worker receives the unemployment benefit z and searches for a job. With probability p_t, she matches with a firm posting a vacancy. If the match is not destroyed by the exogenous shock and the idiosyncratic cost is below the reservation value $\tilde{x}_{t+1}$, the worker will be employed in the following period and obtain the value of being employed; otherwise, she remains unemployed and obtains the value of being unemployed.

Wage determination and hours choice Wages and hours worked are determined as the outcome of a bilateral bargaining process between workers and firms. In each period, firms and workers negotiate through Nash bargains. Thus, wage and hours worked are chosen to maximizes the Nash product:

$$\max_{w_t(x_t), h_t} \left(\mathcal{W}_t(x_t) - \mathcal{U}_t\right)^{\eta} \left(\mathcal{J}_t(x_t) - \mathcal{V}_t\right)^{1-\eta},$$

where $\eta \in (0,1)$ denotes a worker's bargaining power.

The first-order conditions with respect to $w(x)$ and h yield the wage equation

$$w_t(x_t)h_t = \eta\left[A_t f(k_t, h_t) - x_t - r_t k_t + (1-\tau_t^v)\gamma\theta_t\right] + (1-\eta)\left(\frac{\Phi(h_t)}{\lambda_t} + z\right), \tag{9}$$

and the hours supply equation

$$A_t f_h(k_t, h_t) = \frac{\Phi'(h_t)}{\lambda_t}. \tag{10}$$

The wage equation is similar to that in the typical search-and-matching model.[7] The wage is a weighted average of the marginal revenue product and the cost of replacing the worker, and the outside option of the worker, which consists of unemployment benefits and the marginal disutility of labor. The hours supply equation states that hours of work are determined by equalizing the marginal product of hours and the worker's marginal rate of substitution between leisure and consumption.

Job separation and creation A match is destroyed when the idiosyncratic cost is so high that the match surplus is less than zero. Let $\mathcal{S}(x)$ be the joint gross return from a match with idiosyncratic cost x. Then, the match surplus function is given by

$$\mathcal{S}_t(x_t) = \mathcal{J}_t(x_t) + \mathcal{W}_t(x_t) - \mathcal{U}_t - \mathcal{V}_t. \tag{11}$$

Using equations (4), (7), (8), and (11) with the free entry condition, we obtain

$$\begin{aligned} \mathcal{S}_t(x_t) = {} & A_t f(k_t, h_t) - x_t - r_t k_t - \frac{\Phi(h_t)}{\lambda_t} - z \\ & + \mathbb{E}_t\beta_t\left(1 - p_t\eta\right)\left(1-\rho^x\right) \int_{\underline{x}}^{\tilde{x}_{t+1}} \mathcal{S}_{t+1}(x_{t+1}) d\Gamma(x_{t+1}). \end{aligned} \tag{12}$$

Since the surplus function $\mathcal{S}_t(x_t)$ is strictly decreasing in x_t, the firm and the worker choose a reservation policy, i.e., they will continue their match if $\mathcal{S}_t(x_t) \geq 0$ but stop if $\mathcal{S}_t(x_t) < 0$. Thus, separation takes place at $x_t \geq \tilde{x}_t$, where $\tilde{x}_t$ is defined by $\mathcal{S}_t(\tilde{x}_t) = 0$. Note that the reservation value at the time the match is formed is the same as the one at match dissolution.

Evaluating (12) at $x_t = \tilde{x}_t$, we obtain the expression for the reservation threshold:

$$A_t f(k_t, h_t) - \tilde{x}_t - r_t k_t + \mathbb{E}_t\beta_t\left(1 - p_t\eta\right)\left(1-\rho^x\right) \int_{\underline{x}}^{\tilde{x}_{t+1}} \mathcal{S}_{t+1}(x_{t+1}) d\Gamma(x_{t+1}) = z + \frac{\Phi(h_t)}{\lambda_t}. \tag{13}$$

We refer to this as the job destruction condition. The left-hand side of (13) is the marginal value of job continuation under the reservation value $\tilde{x}$. The first three terms represent the current productivity gain, and the fourth term is the option value of retaining an existing job. The right-hand side of (13) is the marginal value of destruction (or the marginal opportunity cost of continuation) of a job. The job destruction condition says that the optimal reservation value $\tilde{x}$ should be set so that the marginal benefits of continuing or destructing a job are equal.

By using (4), (6), and the free entry condition, we have the following job creation condition:

$$\frac{(1-\tau_t^v)\gamma}{q_t} = (1-\rho^x)\mathbb{E}_t\beta_t \int_{\underline{x}}^{\tilde{x}_{t+1}} \left[A_{t+1}f(k_{t+1},h_{t+1}) - x_{t+1} - w_{t+1}(x_{t+1})h_{t+1} - r_{t+1}k_{t+1} + (1-\tau_{t+1}^v)\gamma/q_{t+1}\right] d\Gamma(x_{t+1}). \tag{14}$$

The job creation condition states that expected cost of posting a vacancy, the left-hand side of (14), is equal to the firm's share of the expected new surplus from a new job match, the right-hand side of (14).

Labor market dynamics Let N_t be the number of employed workers at the beginning of the period t. Then, the evolution of N_t is given by

$$N_{t+1} = (1-\rho^x)\,\Gamma(\tilde{x}_t)N_t + m_t = n_t + m_t. \tag{15}$$

Note that due to endogenous and exogenous separation, the number of employed workers who produce output in the period t is $n_t = (1-\rho^x)\,\Gamma(\tilde{x}_t)N_t$.

The number of unemployed workers is determined by

$$u_t = 1 - (1-\rho^x)\,\Gamma(\tilde{x}_t)N_t = 1 - n_t. \tag{16}$$

The job finding rate and the separation rate are given by p_t and $\rho^x + (1-\rho^x)\,(1-\Gamma(\tilde{x}_t))$, respectively.

Government policy and resource constraint The government finances government spending G_t, unemployment benefits $u_t z$, and the subsidy to the cost of posting vacancies $\tau_t^v \gamma v_t$ by imposing the lump-sum tax τ_t to households. The government budget constraint is thus given by

$$\tau_t = G_t + u_t z + \tau_t^v \gamma v_t. \tag{17}$$

The government spending, G_t, follows the exogenous stochastic processes:

$$\log(G_t) = (1-\rho_G)\log(G^*) + \rho_G \log(G_{t-1}) + \varepsilon_{G,t},$$

where ρ_G is the persistency coefficient, G^* is the steady-state government spending, and $\varepsilon_{G,t}$ is the i.i.d. innovation. Similarly, the hiring subsidy takes the following form:

$$\log(\tau_t^v) = (1-\rho_{\tau^v})\log(\tau^{v*}) + \rho_{\tau^v}\log(\tau_{t-1}^v) + \varepsilon_{\tau^v,t},$$

where ρ_{τ^v} is the persistency coefficient, τ^{v*} is the steady-state hiring subsidy, and $\varepsilon_{\tau^v,t}$ is the i.i.d. innovation.

Aggregate output and capital are obtained by

$$Y_t = n_t y_t, \tag{18}$$

$$K_t = n_t k_t, \tag{19}$$

respectively.

By combining the household and government budget constraint as well as profits of firms, we have the resource constraint of the economy

$$C_t + K_{t+1} - (1-\delta)\,K_t + G_t + \gamma v_t + \bar{x}_t = Y_t, \tag{20}$$

which implies that aggregate production must equal private and public demand.

Equilibrium A competitive equilibrium is a set of prices $\{r_t, w_t(x_t)\}_{t=0}^{\infty}$ and an allocation $\{Y_t, K_{t+1}, C_t, k_t, n_t, u_t, v_t, \theta_t, \tilde{x}_t, h_t\}_{t=0}^{\infty}$ which satisfy that

i. agents optimize, i.e. the household's optimal conditions (2) and (3), value functions and the free entry condition, the capital rental condition (5), the hours condition (10), the wage equation (9), and the job destruction condition (13) are satisfied;

ii. the resource constraint (20), aggregate capital and output equations (18)-(19), and labor equations (15) and (16);

iii. the government budget constraint (17).

3 Quantitative analysis

In this section, we examine the dynamic responses of our model economy to a government spending shock. We first calibrate the model to match several dimensions of the US data. We then solve the model by approximating the equilibrium conditions around a non-stochastic steady state and simulate it. We also examine the contribution of endogenous separation by contrasting our model to that without endogenous separation. This examination helps us clarify the role of endogenous separation when the government conducts a fiscal stimulus policy.

3.1 Basic calibration

In order to study effects of fiscal stimuli on labor market variables, we calibrate the model to match certain US economy facts. Specifically, we set the steady-state vacancy-unemployment ratio, the job-finding rate, and the separation rate to the average values observed in the US economy. We choose the model period to be 1 month.[8] We set the discount factor $\beta = 0.996$ to match the annual real interest rate of approximately 4 percent. The relative risk aversion parameter σ is set to 2. We calibrate Φ_0 such that the implied steady-state value of hours worked is $1/3$. We set $\mu = 2$ implying the elasticity of intertemporal substitution in the hours supply of 0.5, which is consistent with evidence for the US.

We assume that the matching function takes the Cobb-Douglas form, given by $m(u_t, v_t) = m_0 u_t^{\xi} v_t^{1-\xi}$, where m_0 is the matching constant and ξ is the matching elasticity with respect to unemployment. The elasticity parameter ξ is set to 0.6, as suggested by Petrongolo and Pissarides (2001). We assume that the worker's bargaining power η is 0.5, as has become standard in the literature.

We target the steady-state vacancy-unemployment ratio to 0.72, as reported by Pissarides (2009).[9] Monthly transitions data from Shimer (2005) gives a mean value of 0.594 for the job finding rate and 0.036 for the job separation rate between 1960 and 2004. In order to pin down the scale parameter m_0, we combine the monthly job finding rate with the vacancy-unemployment ratio.

We now turn to parameters related to job separation. Silva and Toledo (2009) use evidence provided by Davis, Faberman, and Haltiwanger (2006) and Nagypál (2004) to determine the exogenous and endogenous components of the separation rate. They assume that endogenous job separation accounts for, on average, 35% of total separations. Since we target a total separation rate of 0.036, we set the monthly exogenous separation rate at $\rho^x = 0.0234$. Following Mortensen and Pissarides (1994), we assume that the idiosyncratic cost distribution Γ is uniform in the range $[0, \zeta]$, so that $\Gamma(x) = x/\zeta$. The parameter ζ is chosen to match the monthly endogenous job separation rate. See Pissarides (2007) and Elsby and Michaels (2008) for the similar calibration strategy.

The production function is specified by $y = Ak^{\alpha}h^{1-\alpha}$. We normalize $A = 1$ and set the capital share $\alpha = 1/3$. The standard annual capital depreciation rate is 10%, so we set the value of δ to $0.1/12$. Following Shimer (2005), the vacancy cost γ is obtained from the steady-state solution of the model.

We target the unemployment benefits z to be 40 percent of the average wage of employed workers in the economy.[10] Following Campolmi, Faia, and Winkler (2011), we set the steady-state value for government spending to output ratio $G/Y = 0.15$ and the steady-state level of the hiring subsidy $\tau^{v*} = 0.01$. Based on the data, the autocorrelations of government spending ρ_G is set to $0.9^{1/3}$. Since there is no direct estimate on the persistency coefficient of the hiring subsidy ρ_{τ^v}, following Campolmi, Faia, and Winkler (2011), we assume that it takes the same value of the government spending. Thus, we set $\rho_{\tau^v} = 0.9^{1/3}$. The parameter values of the model are summarized in Table 1.

Table 1: Parameter values.

Parameter	Description	Value	Source/target
β	Discount factor	0.996	Data

δ	Depreciation rate	0.1/12	Data
A	Aggregate productivity	1.0	Normalization
α	Parameter in production function	0.333	Data
m_0	Matching efficiency	0.68	Job-finding rate
ξ	Matching elasticity	0.6	Petrongolo and Pissarides (2001)
ρ^x	Exogenous separation rate	0.023	65% of total separations
ζ	The upper support of Γ	0.678	35% of total separations
σ	Relative risk aversion parameter	2.0	See text
Φ	Disutility of labor	64.31	Set to target $h = 1/3$
μ	Frisch elasticity	2.0	See text
z	Unemployment benefits	0.324	Replacement rate 40%
η	Worker's bargaining power	0.5	See text
γ	Vacancy cost	0.134	$v - u$ ratio
τ^{v*}	Hiring subsidy rate	0.01	See text
ρ_G	Government spending autoregressive parameter	$0.9^{1/3}$	See text
ρ_{τ^v}	Hiring subsidy autoregressive parameter	$0.9^{1/3}$	See text

Selected endogenous variables in the steady state under the calibrated parameter values are reported in Table 2. Labor market tightness, the job-finding rate, the separation rate are equal to their target values.

Table 2: Model solutions.

Variables	Description	Solution
θ	Labor market tightness	0.72
$\tilde{x}$	Reservation cost	0.67
u	Unemployment rate	0.059
v	Vacancy	0.042
n	Employment rate	0.941
p	Job-finding rate	0.594
$-$	Separation rate	0.036
h	Hours worked	0.333
C	Aggregate consumption	0.696
G	Government spending	0.244
T	Lump-sum tax	0.263
Y	Aggregate output	1.625
I	Aggregate investment	0.365

3.2 Effects of a government spending shock

We now study dynamic responses of the economy to a government spending shock. The solid lines in Figure 1 display impulse responses of relevant variables to an increase in government spending corresponding to 1 percent of steady state output. All responses are expressed in percentage deviations from respective steady-state values, with the exception of the unemployment rate, the vacancy rate, the job finding rate, and the separation rate, which are expressed in absolute percentage points.

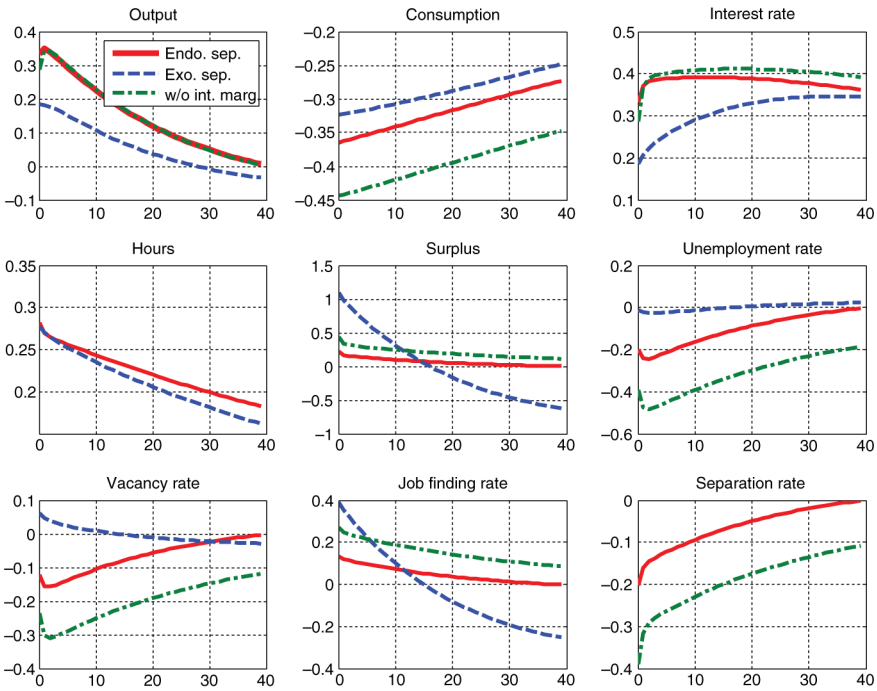

Figure 1: Dynamic responses of the economy to a positive government spending shock.
Notes: The solid lines labeled "Endo. Sep" plot the impulse responses to a positive government spending shock in our model. The dashed lines labeled "Exo. Sep" plot the impulse responses in the model without endogenous job separation. The dash-dotted line labeled "w/o int. marg" plot the impulse responses in the model with fixed hours worked ($h = 1/3$). The horizontal axis represents months after the shock. All responses are expressed in percentage deviations from respective steady-state values, with the exception of the unemployment rate, the vacancy rate, the job finding rate, and the separation rate, which are expressed in absolute percentage points.

An increase in government spending raises output and hours worked per worker. On impact, both output and hours worked per worker rise, and in the following periods, they decrease and gradually return to their steady-state values. A negative wealth effect increases hours worked per worker, leading to higher output that each match produces. Furthermore, as seen below, the increase in government spending raises the employment level, which further increases total output of the economy. Due to the negative wealth effect, the positive government spending shock crowds out private consumption.

We now turn to see the dynamic responses of labor market variables to the government spending shock. The positive government spending shock reduces the unemployment rate and vacancies significantly. It also increases the job finding rate and reduces the separation rate.

These movements in labor market variables can be explained as follows. The positive government spending shock induces a negative wealth effect that raises the value of the match's surplus by reducing the value of non-work activity, in particular by reducing the component associated with the disutility from labor supply. The higher surplus, shared between the firm and the worker by Nash bargaining, in turn raises job creation and reduces job destruction, when other things equal. However, the reduction in job seekers associated with the lower job separation reduces the probability that a firm with a vacancy finds a worker and thus discourages hiring. Under the baseline calibration, job creation goes down, but the reduction in separation is large enough to reduce unemployment.[11]

3.2.1 The role of endogenous job separation

We now examine how incorporation of endogenous job separation alters the effect of the government spending shock on the labor market. To this end, we develop a version of our model in which separation takes place due to only exogenous shocks and simulate a quantitative version of the model using our calibration strategy.[12] The results are also shown in Figure 1.

The striking finding is that the responses of the model economies with and without endogenous job separation are different. First, the pattern of responses of vacancies differs between two models. While the positive government spending shock reduces vacancies in the model with endogenous separation, it increases vacancies in the model without endogenous separation. This can be explained as follows. In the model with endogenous separation, a positive government spending shock makes vacancy posting less attractive because it lowers job

separation and thus brings out a side effect in reducing the number of job seekers. In contrast, such a side effect is not assumed in the exogenous separation model.

Second, when government spending increases, the model with endogenous job separation generates a larger impact on unemployment than the model without endogenous separation. In the endogenous separation model, unemployment falls by about 0.24 percentage points at the peak. On the other hand, it falls by about 0.025 percentage points at the peak in the model without endogenous separation. It is also important to note that the response of the job finding rate in the model with endogenous job separation is smaller than that in the model without endogenous job separation. While the job finding rate increases by about 0.13 percentage points at the peak in the model with endogenous job separation, it increases by about 0.39 percentage points at the peak in the model without endogenous job separation. This is because a reduction in job seekers associated with the lower job separation discourages hiring and thus reduces the job finding rate in the model with endogenous job separation.

3.2.2 Role of the intensive margin

In our model, a baseline transmission mechanism of the government spending shock is an increase in the value of match's surplus due to the negative wealth effect. The negative wealth effect associated with a rise in government spending reduces the leisure cost of supplying hours of work, increasing the match's surplus. A key to this channel is having adjustment of the labor input at the intensive margin, since this introduces a benefit from being unemployed expressed in leisure gains, which affects the value of the match's surplus.

We now study the role of the intensive margin to our results. In Figure 1, we present the responses of an economy that is otherwise identical to our benchmark model expect for the assumption of the hours worked channel. Specifically, we consider a version of our model with fixed hours worked per worker. The value of hours worked is set to 1/3, the same to our benchmark model.

Qualitatively, the models with and without the hours worked decision display a similar pattern in response to a government spending shock. However, their sizes of impact are different. Figure 1 shows that the responses of labor market variables in our baseline model are smaller than those in the model with fixed hours worked. This is because an increase in the match's surplus due to the negative wealth effect in our baseline model is smaller than that in the model with fixed hours worked. In our baseline model, the negative wealth increases hours worked per worker. This lowers the match's surplus by increasing the disutility from supplying hours of work.

3.2.3 Role of persistence

As Faia, Lechthaler, and Merkl (2013) argue, while the time series data of government spending is fairly persistent in normal times, the government might use the counter-cyclical fiscal policy in a discretionary and episodic fashion during extreme recessions. Thus, it is worth studying how the degree of persistence of fiscal policies affects the labor market in a model with endogenous separation.

Figure 2 displays dynamic responses of labor market variables to a government spending shock for three different values of ρ_g: $0.75^{1/3}$ (low), $0.90^{1/3}$ (middle), and $0.95^{1/3}$ (high). The result shows that effects of the government spending shock on labor market variables depend on the degree of persistence. When the shock is short-lived, the size of the impact of the government spending shock on labor market variables becomes smaller. This result is in line with Mayer, Moyen, and Stähler (2010) where job separation is purely exogenous.

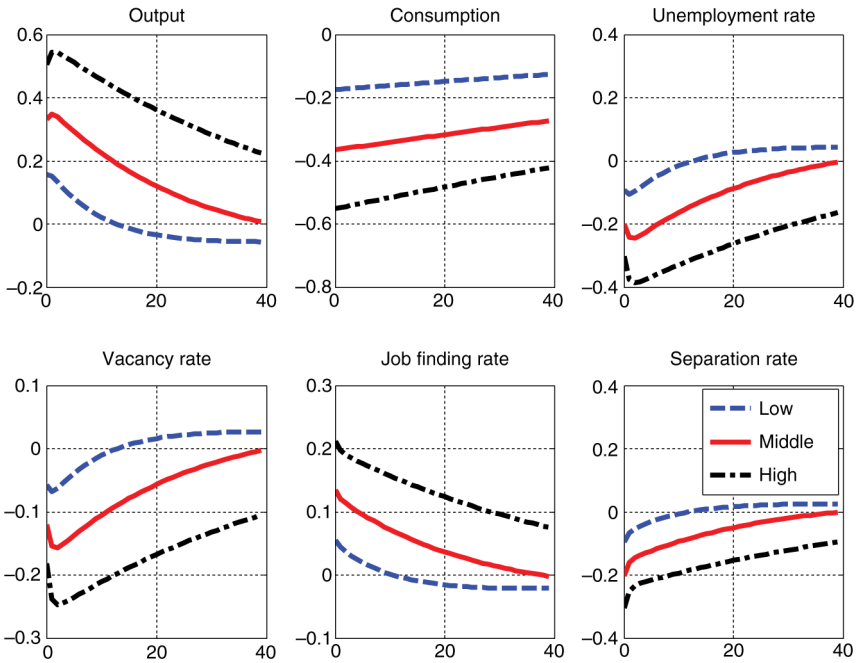

Figure 2: The role of the degree of persistence of government spending shocks.
Notes: The solid line labeled "middle" plots the impulse response of a variable of interest to a positive government spending shock with $\rho = 0.9^{1/3}$. The dashed line labeled "low" plots the impulse response to a positive government spending shock with $\rho = 0.75^{1/3}$. The dash-dotted line labeled "high" plots the impulse response to a positive government spending shock with $\rho = 0.95^{1/3}$. The horizontal axis represents months after the shock. All responses are expressed in percentage deviations from respective steady-state values, with the exception of the unemployment rate, the vacancy rate, the job finding rate, and the separation rate, which are expressed in absolute percentage points.

4 Empirical evidence

Our theoretical model predicts that an increase in government spending increases the job finding rate and reduces the separation rate, lowering unemployment. It also shows that a positive government spending shock reduces vacancies, which is in contrast to the prediction of the model without endogenous separation. We now confront the predictions of our model with the time series properties of the US data and discuss whether it is necessary to take a firing margin into account when one examines the effect of fiscal stimulus on the labor market.

Using a SVAR model, we now empirically examine the effects of a government spending shock on the US labor market. Following Blanchard and Perotti (2002), we identify the government spending shock by assuming that government spending is not contemporaneously affected by all variables in the model.[13] This identification scheme is implemented by ordering government spending first in a SVAR model and using a Choleski decomposition.

We consider a SVAR model consisting of ten variables: real per-capita government spending, real per-capita gross domestic product (GDP), real per-capita private consumption, the nominal interest rate on 3-month T-bills, hours worked per worker, the real wage, the unemployment rate, the vacancy rate, the job finding rate, and the separation rate.[14] Variables not expressed as a rate are logged.

We obtain quarterly data on government spending, GDP, private consumption, the nominal interest rate from the Federal Reserve Economic Data of Federal Reserve Bank of St. Louis. The real wage is obtained by dividing compensation per hour from the BLS by the GDP deflator. Hours worked per worker are obtained by dividing hours of all persons by the civilian noninstitutional population. The unemployment rate is the quarterly average of seasonally adjusted monthly data constructed by the Bureau of Labor Statistics (BLS) from the Current Population Survey (CPS). The vacancy rate is constructed from a composite Help-Wanted Index of Barnichon (2010). [15] The job finding and separation rates are constructed from the CPS short-term unemployment rate and the CPS unemployment data by using the method of Shimer (2012).

The sample period is 1954:4-2016:4. Based on Akaike information criteria, the lag length of the SVAR model is set to four.[16] In addition to a constant term, the SVAR model includes a quadratic trend and a dummy variable identifying the post great recession period.[17] Following Monacelli, Perotti, and Trigari (2010), we also include three Ramey-Shapiro war dummy variable and its lags up to 4.

Figure 3 shows that the impulse responses of the relevant variables to the government spending shock with 90% confidence bands constructed by the bootstrap method. The shock to government spending is normalized to one percent of GDP. We show the impulse response functions for a horizon of 20 quarters.

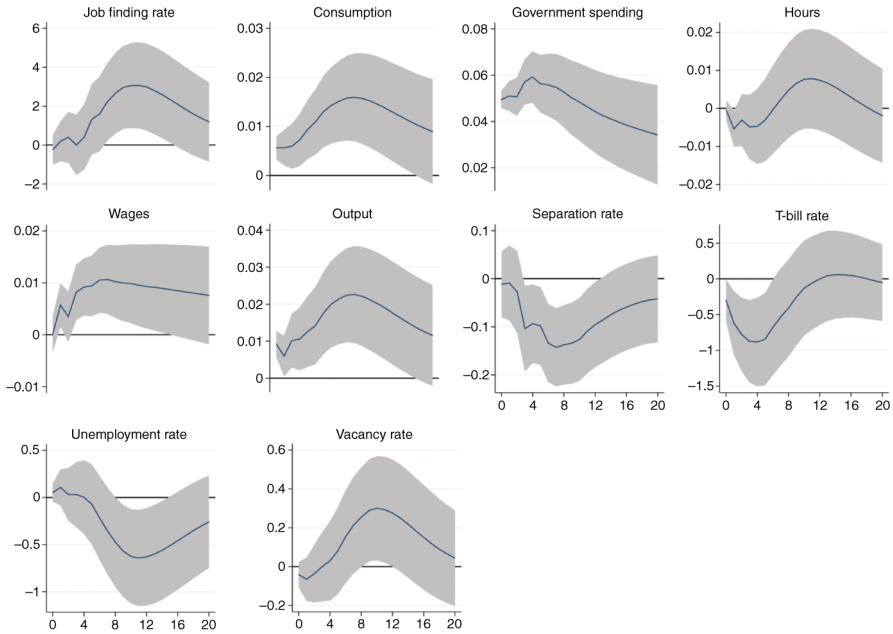

Figure 3: The dynamic effects of a positive government spending shock.
Notes: The shock to government spending is normalized to one percentage point of GDP. The horizontal axis represents quarters after the shock. The vertical axes of the job finding rate, the job separation rate, the unemployment rate, the vacancy rate, and the 3-month T-Bill rate are in unit of percentage points; all other variables are in unit of percentage deviation from their mean values. Shadow areas indicate the 90 percent confidence bands, constructed by the bootstrap method. Sample period covers 1954:4-2016:4.

The government spending shock increases both GDP and consumption. It also increases the real wage. The hours of work per employee do not change significantly. Our theoretical model can capture the pattern of responses of output and the real wages to a positive government spending shock. However, our theoretical model fails to account for the consumption dynamics in the data.[18]

We now turn to see the effects of the government spending on labor market variables. The expansionary government spending shock reduces the unemployment rate and increases the vacancy rate. Note that both responses are statistically significant at peak.[19] It also increases the job finding rate and reduces the separation rate. The job finding rate increases by 3.06 percentage points at peak. The separation rate decreases by 0.14 percentage points at peak. Both responses are statistically significant at peak. These findings suggest that taking into account both hiring and firing margins is crucial to study the effect of fiscal stimulus on the labor market.

Comparing the prediction of the theoretical model with the results of SVAR, we find that the model fails to capture the response of vacancies. This is related to the shortcoming of the endogenous job separation model. It is well known that a search-matching model with endogenous job separation often fails to reproduce the observed negative relationship between unemployment and vacancies, i.e., the Beveridge curve conditional on technology shocks. Our finding implies that this is also the case of a government spending shock and suggests that our model misses some elements to capture the observed vacancy dynamics.

The candidates of fixing this problem include matching efficiency and labor supply through labor force participation.[20] An expansionary fiscal policy can raise matching efficiency due to, for example, more efficient labor reallocation and more recruiting efforts, and thus encourage firms to post more vacancies. Similarly, fiscal expansion could lead to higher labor participation and thus expand the pool of job seekers. This additional labor supply encourages firms to post more vacancies. In the next section, we will discuss whether these two factors improve our baseline model to generate empirically consistent vacancy dynamics in response to the government spending shock.

5 Discussion

In this section, we first discuss the roles of cyclical movements of matching efficiency and labor force participation. We then examine the effect of a hiring subsidy shock on the labor market variables in the model with

endogenous job separation. We also calculate unemployment multipliers for both government spending and hiring subsidy policies.

5.1 The role of matching efficiency

Our model with endogenous job separation fails to capture the response of vacancies to a government spending shock in the SVAR model. We now consider a missing element which could allow the model with endogenous separation capture the empirically consistent vacancy dynamics.

An important candidate is matching efficiency. Recently, a number of studies show the importance of matching efficiency to understand the unemployment dynamics (e.g., Barnichon and Figura 2015; Hall and Schulhofer-Wohl 2018). If an expansionary government spending shock can raise matching efficiency, it facilitates firms to find job seekers and thus increases firms' incentive to post more vacancies. This helps the model with endogenous separation to predict the empirically consistent vacancy response to the government spending shock.

In order to examine the role of matching efficiency, we now assume that government spending affects matching efficiency. This is a reasonable assumption since some types of government spending, such as active labor market policies, could improve the functioning of the labor market and increase matching efficiency. Thus, we consider the following matching function

$$m(u_t, v_t) = m_0 \left(\frac{G_t}{G}\right)^{\omega} u_t^{\xi} v_t^{1-\xi},$$

where G is the government spending in steady state and $\omega \geq 0$. When $\omega = 0$, the government spending does not affect matching efficiency, and the model is identical to our baseline specification. Further, as the value of ω does not affect model's steady-state solutions, we can keep our calibration strategy. This means that we can still use our benchmark parameter values for numerical analysis of this extended model.

Figure 4 shows the impact of an expansionary government spending shock on selected labor market variables, when $\omega = 0$, 0.12, and 0.15. In principle, a higher value of ω, i.e., higher matching efficiency, mitigates the negative impact of the government spending shock on the vacancy rate. When $\omega = 0.12$, consistent with our empirical findings, the positive government shock increases the vacancy rate while it reduces both separation and unemployment rates. However, when $\omega = 0.15$, although the responses of the unemployment and vacancy rates are in line with those of the SVAR model, the model fails to capture the reasonable response of the separation rate.

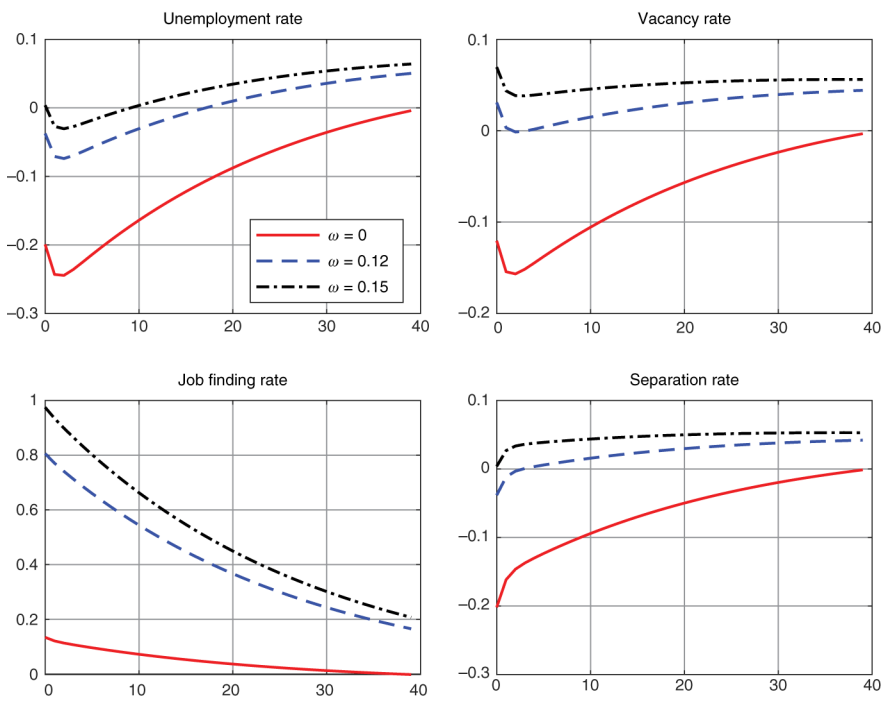

Figure 4: The role of matching efficiency.
Notes: The solid, dashed, and dash-dotted lines labeled plot the impulse responses of variables of interest to a positive government spending shock when $\omega = 0$, 0.12, and 0.15, respectively. The horizontal axis represents months after the shock.

The positive response of the separation rate is due to higher matching efficiency. While the positive government spending shock reduces the separation rate by increasing match surplus, higher matching efficiency associated with the fiscal policy shock raises the outside option of a firm by reducing the cost of hiring a new worker and thus leads to higher separation. If the latter effect dominates, the separation rate increases in response to the positive government spending shock.

This exercise shows that matching efficiency can play an important role when we examine the impact of the government spending shock on the labor market. If an expansionary fiscal policy increases matching efficiency, the model with endogenous separation could generate empirically consistent predictions on labor market variables. However, as there are counteracting effects of the government spending shock on both vacancies and separation, the prediction of the model highly depends on parameter values. Thus, a careful calibration is warranted.

5.2 Role of labor force participation

The cyclical movement of labor supply through labor force participation may help the model with endogenous separation to generate the empirically consistent vacancy dynamics in response to the government spending shock. An expansionary government spending can attract workers in not in labor force into the labor force and thus increases the number of job seekers. This additional supply of job seekers will encourage firms to post more vacancies.

Like most of DSGE models with labor market frictions, our model assumes exogenous labor participation. However, recent empirical studies find that movements in the labor force accounts for 1/4 to 1/3 of the cyclical variation in the unemployment rate (Barnichon and Figura 2010; Elsby, Hobijn, and Sahin 2015). This suggests that it is important to take the labor participation decision into account if one wants to examine the characteristics of the labor market thoroughly.[21]

However, developing a DSGE model with both endogenous job separation and labor participation is beyond the scope of this paper and left for our future research.[22] Instead of providing a comprehensive model, we only provide some intuition about how the incorporation of endogenous labor participation can change the current model's prediction.

In a model with both endogenous separation and labor force participation, an expansionary fiscal policy might induce firms to increase their vacancies, since such a policy could encourage labor participation and thus expand the pool of job seekers. As a result, the unemployment will further reduce along with the lower job separation, coming from the mechanism of endogenous separation. However, the above intuition is not complete in that we missed out the advanced impact on unemployment due to increased labor participation. Further, similar to the case of pro-cyclical matching efficiency, due to the increase in job seekers, the reduction of job separation in response to the government spending shock may be dampened. This weakens the effect of the government spending shock to lower unemployment. Since there are several counteracting effects on unemployment, whether or not an expansionary fiscal policy leads to lower unemployment depends on parameter values and a careful calibration is called for.

5.3 The effect of the hiring subsidy

We examine the dynamic responses of our economy to a hiring subsidy shock. Figure 5 shows impulse responses of labor market variables to a one percentage point increase in the subsidy to the cost of posting a vacancy.

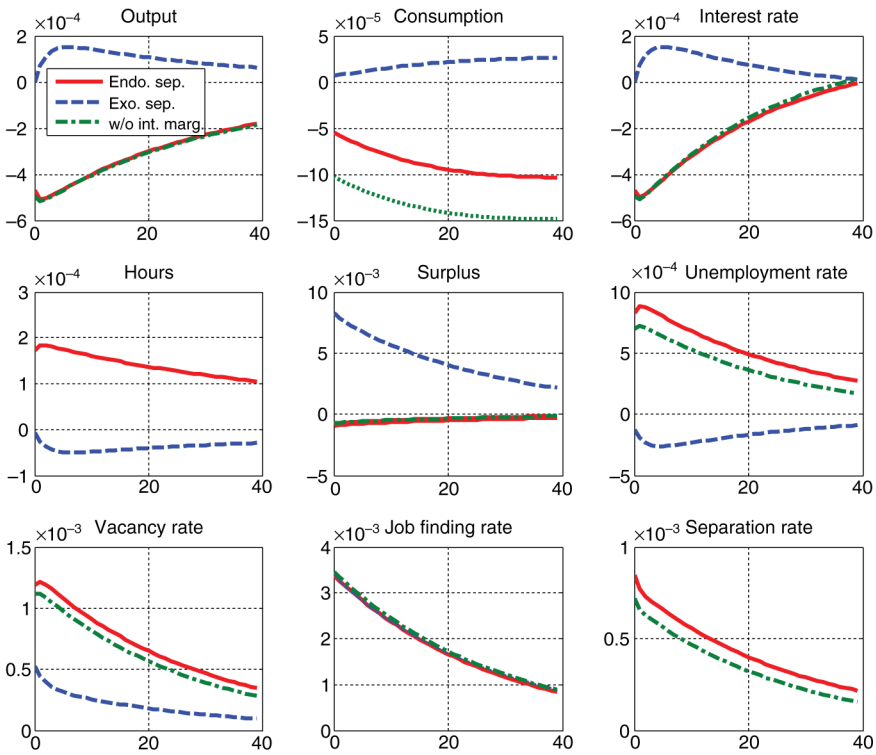

Figure 5: Dynamic responses of the economy to a positive hiring subsidy shock.
Notes: The solid lines labeled "Endo. Sep" plot the impulse responses to a positive hiring subsidy shock in our model. The dashed lines labeled "Exo. Sep" plot the impulse responses in the model without endogenous job separation. The horizontal axis represents months after the shock. All responses are expressed in percentage deviations from respective steady-state values, with the exception of the unemployment rate, the vacancy rate, the job finding rate, and the separation rate, which are expressed in absolute percentage points.

An increase in the hiring subsidy leads to higher job creation and higher job separation. The rise in job separation is due to the fact that the hiring subsidy makes separation less costly as it reduces the search cost to be paid to find a new match in the case of separation. In this case, the response of the separation margin reinforces the response of the hiring margin by expanding the pool of job seekers. However, under the calibrated parameter values, the increment of job separation exceeds that of job creation, and thus unemployment increases.

In order to assess the contribution of endogenous job separation to our results, we study effects of the hiring subsidy shock in the model without endogenous job separation. Results are also shown in Figure 5.

The most striking finding is that predictions of models with and without endogenous job separation are incompatible with respect to the response of unemployment. The model without endogenous job separation predicts a decreased unemployment in response to the positive hiring subsidy shock, which is opposite to what the model with endogenous job separation predicts.

This difference is due to the incorporation of endogenous job separation. Endogenous job separation gives rise to a new channel through which a positive hiring subsidy shock increases unemployment: an increased separation rate. When the hiring subsidy increases, the cost of posting vacancies falls. A decrease in job creation cost also reduces the opportunity cost of continuation of an existing job. This induces more separation, leading to a higher unemployment.

Equally important, although both models predict an increase in vacancies in response to positive hiring subsidy shocks, their sizes of the impact differ. As seen in Figure 5, the model with endogenous separation generates a larger impact of the hiring subsidy shock on vacancies than the model without endogenous separation. This is because, in the model with endogenous separation, an increase in unemployment due to the shock expands the number of job seekers and facilitates firms to find workers. This induces more vacancy postings.

It is worth examining whether our model's predictions are empirically plausible. However, empirical evidence about effects of hiring subsidies on employment is still limited. Early studies found that federal programs in the US, "New Jobs Tax Credit", had a positive impact on employment growth (Perloff and Wachter 1979; Bishop 1981). Recently, Neumark and Grijalva (2017) provide evidence on the effects of state hiring credits on job growth in the US. They find that many types of hiring credits have no positive effects on job growth, but some specific types of hiring credits such as those targeting the unemployed appear to boost job growth. In contrast, Cahuc, Carcillo, and Barbanchon (2019) show that hiring credits implemented during the Great Recession

had significant positive employment effects in France by using comprehensive firm-level administrative data. To examine whether the prediction of our model is empirically plausible, more empirical evidence is called for.

5.4 Fiscal multipliers

In the literature, some studies argue that hiring subsidies deliver larger multipliers than government spending. However, this result is usually obtained in models without endogenous separation. We now compute unemployment multipliers for both traditional increases in government spending and increases in hiring subsidies in our model, and compare our results with those in the model without endogenous separation.

Following Faia, Lechthaler, and Merkl (2013), we compute the net present value fiscal multipliers:

$$UMulti_{t,t+j} = \frac{\sum_{i=1}^{j} \beta^{i-1} (u_{t+i} - u)}{\sum_{i=1}^{j} \beta^{i-1} (\Omega_{t+i} - \Omega)},$$

where $\Omega_t = G_t$ for the government spending multiplier, while $\Omega_t = \gamma v \tau_t^v$ for the hiring subsidy multiplier. The variables without time subscript denote the steady state values of them.

Figure 6 shows the results. When separation is merely due to exogenous shocks, the unemployment multiplier for hiring subsidies is larger (in absolute value) than that for government spending. This implies that hiring subsidies are more effective than government spending if the fiscal authority is concerned about unemployment. This result is in line with the existing studies, such as Campolmi, Faia, and Winkler (2011). However, once the assumption of exogenous separation is relaxed, the prominence of hiring subsidies does not hold anymore. In the model with endogenous separation, an increase in hiring subsidies instead *increases* unemployment, and thus the unemployment multiplier is positive. On the other hand, as in the model without endogenous separation, a positive government shock reduces unemployment.

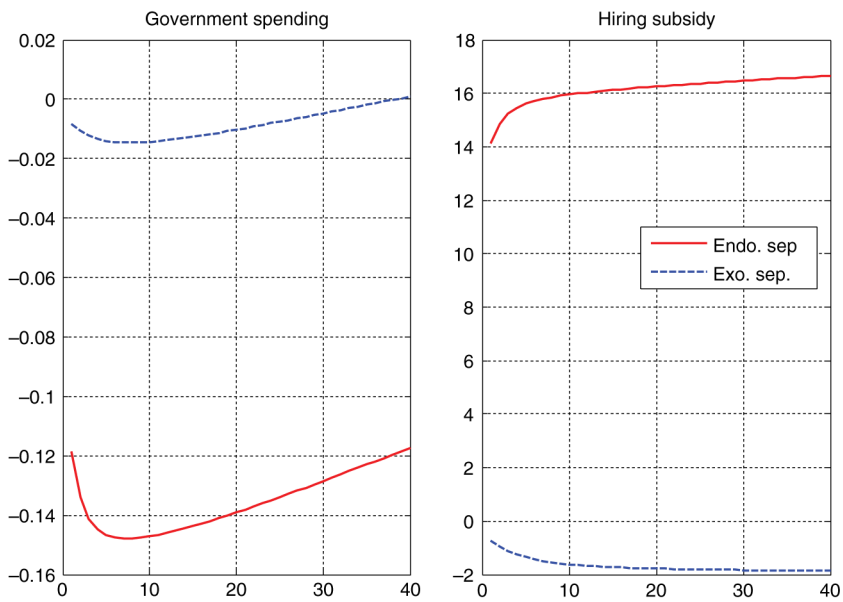

Figure 6: Unemployment multipliers.
Notes: The solid lines labeled "Endo. Sep" plot the unemployment multipliers in our model. The dashed lines labeled "Exo. Sep" plot the unemployment multipliers in the model without endogenous job separation. The horizontal axis represents months after the shock.

6 Conclusion

Recent empirical studies of the US labor market suggest that in order to study the unemployment dynamics, it is important to take into account both hiring and firing margins. Focusing on both hiring and firing margins, this paper studies the effects of fiscal stimulus on the labor market. We develop a DSGE model with search frictions in which job separation is endogenously determined and study the effect of a government spending shock on the economy.

The predictions of our model are in contrast with earlier studies that assume exogenous job separation. First, our model generates a larger size of the impact of a government spending shock on labor market variables than the model without endogenous job separation. Second, while a positive government spending increases vacancies in models without endogenous job separation, it reduces vacancies in our model.

In order to examine whether the quantitative predictions of the model is supported by the data, we empirically study the effects of a government spending shock on the US labor market by using a SVAR model. Our empirical analysis demonstrates that an increase in government spending increases the job finding rate and reduces the separation rate, lowering the unemployment rate. This finding suggests that it is important to take account of both hiring and firing margins when ones analyze the effect of fiscal stimulus on the labor market. However, by comparing the estimates of SVAR and the predictions of the theoretical model, we find that our model currently fails to capture the response of vacancies and the volatility of unemployment. To fix this problem, we consider the roles of the cyclical movements of matching efficiency and labor supply via labor force participation.

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Notes

1 Recently, several studies investigate the contribution of inflow and outflows rates to the unemployment variability over the business cycle. For the United States, Hall (2005) and Shimer (2012) claim that the outflow rate dominates and the inflow rate is acyclical. In contrast, Elsby, Michaels, and Solon (2009) and Fujita and Ramey (2009) find a greater role for inflow rates that account for around half of cyclical changes in unemployment. Further, Ahn (2016) and Ahn and Hamilton (2016) shed light on the crucial role of inflows in the evolvement of unemployment rate during the Great Recession. For European countries, Petrongolo and Pissarides (2008) and Elsby, Michaels, and Solon (2009) find approximately a 50:50 inflow/outflow split to unemployment variation.

2 Most of the stimulus policies undertaken in the aftermath of the Great Recession took the form of labor market subsides. Those expenditures indeed account for 50–80% of the total fiscal stimuli depending on countries. An important example is the HIRE Act in the US.

3 Andolfatto (1996) and Merz (1995) consider a stochastic real business cycle model with search frictions and exogenous job separation. Den Haan, Ramey, and Watson (2000) develop a dynamic general equilibrium model with search frictions and endogenous job separation and study propagation of aggregate shocks. While they focus on cyclical behavior of labor market variables, this paper studies effects of fiscal stimuli on the labor market.

4 We incorporate endogenous separation by having idiosyncratic additive operational costs as opposed to multiplicative idiosyncratic productivity as seen in Mortensen and Pissarides (1994). This is because multiplicative idiosyncratic productivity would lead to heterogeneity in hours of work per worker across matches, while the additive idiosyncratic operational cost leads to homogenous hours of work across matches.

5 Note that in equilibrium firms are indifferent between these two options due to free entry.

6 As Campolmi, Faia, and Winkler (2011) suggested, fiscal stimuli have taken various forms in practice. In the aftermath of the 2007–2008 crisis, expansionary fiscal packages implemented in various countries were largely devoted to facilitate job creation. The American Jobs Act passed by the Obama administration is an example. Following Campolmi, Faia, and Winkler (2011), we incorporate subsidies to the cost of positing vacancies in order to study effects of fiscal policies targeted particularly at the labor market.

7 See, for example, Mortensen and Pissarides (1994) and Pissarides (2000).

8 As Monacelli, Perotti, and Trigari (2010) argue, the job finding rate in the US is quite high, so unemployed workers on average find a job within a quarter. In order to capture this feature, we choose to calibrate the model at a monthly frequency.

9 The sample mean for the vacancy-unemployment ratio in 1960–2006 is derived by using JOLTS data since December 2000 and the Help-Wanted Index adjusted to the JOLTS units of measurement before then.

10 This parameter has been the subject of some discussion. Shimer (2005) sets $z/\bar{w} = 0.4$, where $\bar{w}$ is the average worker's wage, in order to capture the unemployment benefits. Hagedorn and Manovskii (2008) argue that Shimer's choice of the value of the opportunity cost of employment is too low because it does not allow for the value of leisure, home production, or unemployment benefits. They calibrate the opportunity cost of employment and the worker's bargaining power to match the observed cyclical response of wages and average profit rate. Their results are $z/\bar{w} = 0.955$ and $\eta = 0.052$. Mortensen and Nagypál (2007) criticize Hagedorn and Manovskii (2008) for using these parameters because these parameters yield workers a gain of 2.8% inflow utility by going from unemployment to employment. Hall and Milgrom (2008) use the empirical literature on household consumption and labor supply and estimate the value of $z/\bar{w} = 0.71$.

11 Our results are in contrast to Yuan and Li (2000) that find that an expansionary fiscal policy shock reduces employment in a DSGE model with search frictions. There are two main reasons why our model generates the opposite results. First, in our model, an expansionary government shock lowers job separation, leading to higher employment. Second, under our wage determination mechanism, the negative wealth effect increases the surplus by reducing the leisure cost of supplying labor.
12 Note that the two economies share the same steady-state values of the vacancy-unemployment ratio, the job-finding rate, and the separation rate.
13 Monacelli, Perotti, and Trigari (2010) and Brückner and Pappa (2012) use this identification approach to investigate the effect of government spending on the labor market. Galí, David Lóez-Salido, and Vallés. (2007) and Perotti (2007) also use the restriction that government spending does not contemporaneously react to changes in macroeconomic variables to identify fiscal shocks.
14 Government spending is defined as the sum of government consumption expenditures and gross investment.
15 Barnichon (2010) builds a vacancy positing index that captures the behavior of total "print" and "online" help-wanted advertising, by combining the print-Help-Wanted Index and the online- Help-Wanted Index. We thank Regis Barnichon for generously sharing his data with us.
16 We checked the robustness of our results by using a VAR with up to four lags. Impulse responses from VAR models with less lag length are similar to those in our benchmark specification.
17 Following Brückner and Pappa (2012), we include the quadratic trend. The results do not change if we include a linear trend. Further, our results hold without dummy variables
18 Although our model cannot empirically consistent responses of consumption, the prediction that government spending shock crowds out consumption is in line with that of a standard neoclassical model (see, for example, Baxter and King 1993). The improvement in tracing the actual consumption dynamics is left for our future research. A number of studies consider mechanisms that make consumption responses in theory become consistent with the data. See for example, Galí, David Lóez-Salido, and Vallés. (2007) and Linnemann (2006).
19 Similar to Monacelli, Perotti, and Trigari (2010), this paper finds that an expansionary government spending shock significantly reduces the unemployment rate in the US. However, it is important to note that this result may depend on the data used for the estimation. Brückner and Pappa (2012) find that unemployment increases in response to a positive fiscal policy shock in the US. They show that the difference in the sample period used for the estimation yields different response of unemployment to the fiscal shock.
20 Incorporation of the firing cost is another candidate as it may mitigate the increase of job separation following an increase in government spending. As seen in Faia, Lechthaler, and Merkl (2013), the consideration of the firing cost would be important for analyzing European countries where employment protection is relatively strict. Since we focus on the US labor market where employment protection is less strict, we leave this channel as future research.
21 Krusell et al. (2017) develop a model of the aggregate labor market that features both standard labor supply forces and frictions in order to study the cyclical properties of gross worker flows across the three labor market states: employment, unemployment, and nonparticipation.
22 Brückner and Pappa (2012) and Campolmi, Faia, and Winkler (2011) emphasize the role of labor participation when they study the effects of expansionary fiscal policy on the labor market. In particular, using DSGE models with labor frictions, they demonstrate how an increase in government purchase could raise unemployment by encouraging inactive workers to enter the labor market. However, it is important to note that they assume exogenous job separation since the endogenous labor participation is the focal point of their study.

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