Review of Economic Analysis 18 (2026) 37-63 1973-3909/2026037

Vacancy Fluctuations in a Macroeconomic Model with a Strategic Labor Input Target

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This study investigates the effects of changes in job-filling and job-separation rates on economic fluctuations using an efficiency wage model. It introduces a relationship between labor input and the strategic labor input target into the model. This framework enables us to analyze situations in which vacancies exist, along with employment and unemployment. In this study, the outward shift in the Beveridge curve is attributed to a decline in the job-filling rate and/or an increase in the job-separation rate. An analysis of responses to a positive productivity shock indicates that the changes in vacancies in response to the shock do not necessarily lead to employment changes but depend on the job-separation rate. This finding highlights the need to examine not only the change in vacancies but also the job-separation rate when discussing economic policies.

Keywords: Beveridge Curve, Efficiency Wage, Employment Fluctuations, Job Vacancies

JEL Classifications: E24, E32, J33

1 Introduction

At the macroeconomic level, job vacancies are a critical indicator for discussing or making economic policies because they reflect labor market conditions. At the organizational level, job vacancies play a crucial role in ensuring the necessary amount of employment. However, vacancies may not always be filled due to disagreements over employment contracts. Cabo and Martín-Román (2019), Goux et al. (2001), and Nickell (1986) have discussed employment fluctuations using dynamic models of labor demand, whereas Chiarini and Piselli (2005), Lindé (2009), and Mitra et al. (2019) have analyzed them using dynamic general equilibrium models. However, the employment fluctuations analyzed in these frameworks do not correspond to the changes in vacancies. This gap in the literature highlights the need for a framework to analyze changes in vacancies to formulate appropriate economic policies.

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In this context, this study analyzes vacancies using a model based on the efficiency wage model of Collard and de la Croix (2000). The change in vacancies can be analyzed by introducing the idea of a firm's strategic labor input target. This target takes into account filling a vacancy and leaving a job to employ adequate labor. The vacancies are expressed as the difference between the strategic labor input target and employment. In this study, the firm adjusts labor input to maximize profit by choosing the strategic labor input target, whereas in the standard model, it chooses labor input.

In efficiency wage models, even if there is excess supply in the labor market, firms do not reduce the wage because labor productivity depends positively on it. Four types of models are found in the literature: shirking, adverse selection, labor turnover, and gift exchanges. In the shirking model, firms pay higher wages to prevent workers from slacking because of the higher cost of lost income (e.g., Gomme, 1999; Martin and Wang, 2020; Shapiro and Stiglitz, 1984). In the adverse selection model, firms hire the best workers by offering higher wages (Weiss, 1980). In the labor turnover model, firms pay higher wages to reduce labor turnover and save on training and hiring costs (e.g., Campbell III, 1994; Salop, 1979; Stiglitz, 1974). In the gift exchange model, employees work harder in return for higher pay from firms (e.g., Akerlof, 1982; Collard and de la Croix, 2000; Danthine and Kurmann, 2004; de la Croix et al., 2009; Tripier, 2006). The present study extends the gift exchange model and analyzes how vacancies behave in response to a temporary positive productivity shock.

This study finds that the responses of the other variables to a productivity shock are consistent with the reactions of the standard efficiency wage model, which considers both employment and unemployment. In the search and matching literature, employment, unemployment, and vacancies coexist in the wage posting (Burdett and Mortensen, 1998; Coles, 2001; Mortensen, 2003) or wage bargaining models (Cahuc et al., 2006; Mortensen and Pissarides, 1994; Pissarides, 2000). By introducing a relationship between labor input and the strategic labor input target into the efficiency wage model, this study depicts a situation in which vacancies exist alongside employment and unemployment. Many studies, such as those by Leduc and Liu (2016) and Zanetti (2019), assume the Cobb–Douglas function in the matching function; the matches depend on the number of unemployed workers and vacancies. In this study, the current labor input depends on vacancies and the labor input in the previous period.

The study makes several contributions. First, it allows us to analyze situations in which vacancies exist in addition to the employment and unemployment in the efficiency wage model by introducing the relationship between labor input and the strategic labor input target. In the steady state, the Beveridge curve is obtained, which presents the inverse relationship between unemployment and vacancies, as shown in studies by Barlevy et al. (2024), Elsby et al. (2015), and Duffy and Jenkins (2024). A decline in the job-filling rate and/or an increase in the job-separation rate causes an outward shift in the Beveridge curve. Second, the simulations predict how the job-filling and job-separation rates influence the changes in employment and vacancies in response to the productivity shock. The responses to the shock in terms of employment and vacancies are not affected by the change in the job-filling rate. Furthermore, the response of employment is not affected by the change in the job-separation rate, while the response of vacancies reduces when the job-separation rate is higher. In this situation, the change in the response of employment is not observed even if the firm increases vacancies significantly. This indicates that focusing only on the changes in vacancies without paying attention to the changes in job-separation rate can lead to the formulation of inadequate economic policies. Finally, the numerical analysis shows that if effort sensitivity to the wage-to-alternative wage ratio is lower, or if effort sensitivity to the current-to-previous wage ratio is higher, then the responses of employment, the strategic labor input target, and vacancies are amplified. In addition to the Collard and de la Croix (2000) model analysis, the study demonstrates the behavior of vacancies.

The remainder of this paper proceeds as follows. Section 2 presents the dynamic general equilibrium model and derives the Beveridge curve. Section 3 investigates the dynamics of the model by conducting a numerical analysis. Section 4 concludes the paper.

2 The model

In this section, we provide a macroeconomic model with a strategic labor input target and discuss the Beveridge curve. This framework is based on Collard and de la Croix's (2000) efficiency wage model of the gift exchange type, which we extend to investigate changes in job vacancies.

The economy consists of a representative household and firm. The representative household maximizes the following utility:

$$\sum_{t=0}^{\infty} \beta^t \left\{ logC_t - d_t \left[e_t - \phi - \gamma log\left(\frac{w_t}{w_t^a}\right) - \psi log\left(\frac{w_t}{w_{t-1}}\right) \right]^2 \right\}$$

where $0 < \beta < 1$ is the discount factor, C_t consumption, e_t effort, w_t the wage rate, and w_t^a the alternative wage rate. The parameter $\phi > 0$ denotes the effort level that the household is willing to provide, $\gamma > 0$ expresses effort sensitivity to the wage-to-alternative wage ratio, and $\psi > 0$ represents effort sensitivity to the current-to-previous wage ratio. We assume that d_t is a dummy variable: $d_t = 1$ if labor is employed and $d_t = 0$ otherwise. If we assume $\gamma = 0$, then employment in the steady state cannot be expressed parametrically. If we assume $\psi = 0$, then employment remains constant over the business cycle.

The household's budget constraint is

$$C_t + I_t = R_t K_t + w_t - w_t U_t \tag{1}$$

where I_t is investment, R_t is the rental rate of capital, K_t is capital, U_t is the unemployment rate, and $w_t U_t$ is the unemployment insurance payment. We assume that $U_t = 1 - L_t$, where L_t is employment. The household supplies one unit of labor inelastically. We assume that an unemployment insurance system exists, and the risk-averse household chooses to have full insurance. The household receives $w_t - w_t U_t$ whether the agent is employed or unemployed, when all agents pay the insurance premium $w_t U_t$ to the insurance company, and unemployed individuals receive the insurance benefit. If the unemployment insurance system is not assumed, then the household's optimization problem would be complicated because the agent can be employed or unemployed. The household history in the labor market should be considered to solve the optimization problem in this case. Tripier (2006) assumes a similar utility function and unemployment insurance system.

The law of motion for capital stock is as follows:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{2}$$

where $0 < \delta < 1$ denotes the depreciation rate of capital. From Equations (1) and (2), the constraint can be expressed as

$$K_{t+1} = (R_t + 1 - \delta)K_t + w_t - w_t U_t - C_t \tag{3}$$

The household maximizes its utility subject to Equation (3). We assume K_0 as given. The first-order conditions for C_t, e_t, and K_{t+1} are as follows:

$$\frac{1}{C_t} = \Lambda_t \tag{4}$$

$$e_t = \phi + \gamma log\left(\frac{w_t}{w_t^a}\right) + \psi log\left(\frac{w_t}{w_{t-1}}\right) \tag{5}$$

$$1 = \beta \frac{\Lambda_{t+1}}{\Lambda_t}(R_{t+1} + 1 - \delta) \tag{6}$$

where Λ_t is the Lagrange multiplier. The effort is large when the wage-to-alternative wage ratio is high and/or the current-to-previous wage ratio is high. We impose the following transversality condition:

$$\lim_{t\to\infty} \beta^t \Lambda_t K_{t+1} = 0$$

From Equations (4) and (6), the following Euler equation is obtained

$$\frac{C_{t+1}}{C_t} = \beta(R_{t+1} + 1 - \delta) \tag{7}$$

The representative firm produces Y_t, according to the following Cobb–Douglas production function:

$$Y_t = A_t K_t^{\alpha} (e_t L_t)^{1-\alpha} \tag{8}$$

where $0 < \alpha < 1$ is the capital share in production and A_t is productivity. We assume that productivity follows a first-order autoregressive process.

$$logA_t = \rho logA_{t-1} + \varepsilon_t \tag{9}$$

where ρ is the autoregressive parameter and ε_t the shock to productivity.

To analyze the fluctuations in vacancies, we introduce the idea of the strategic labor input target into the model. We assume that the firm adjusts labor input L_t through adjusting the strategic labor input target S_t, considering the filling of vacancies and separations, and recognizing that not all vacancies V_t will be filled. The vacancies are assumed as follows:

$$V_t = S_t - L_{t-1} \tag{10}$$

Assuming λ is the job-filling rate (λ of vacancies are filled), new hires are denoted by $\lambda(S_t - L_{t-1})$. Furthermore, if μ is the job-separation rate (μ of the employment departs), then separations are denoted by μL_{t-1}. The labor input is expressed as $L_t = \lambda(S_t - L_{t-1}) - \mu L_{t-1} + L_{t-1}$, and transformed as follows:

$$L_t = \lambda(S_t - L_{t-1}) + (1-\mu)L_{t-1} \tag{11}$$

Equation (11) means that L_t is the sum of new hires and those employees who do not leave.

The firm's profit is

$$\pi_t = A_t K_t^{\alpha} (e_t L_t)^{1-\alpha} - R_t K_t - w_t L_t$$

The firm chooses K_t, w_t, and S_t to maximize profit, subject to Equations (5) and (11) as follows:

$$R_t = \alpha \frac{Y_t}{K_t} \tag{12}$$

$$L_t = (1-\alpha) \frac{Y_t}{e_t} \left(\frac{\gamma + \psi}{w_t} \right) \tag{13}$$

$$w_t = (1-\alpha) \frac{Y_t}{L_t} \tag{14}$$

Using Equation (13) to eliminate $(1-\alpha)Y_t/(w_t L_t)$ from Equation (14), the effort level is obtained as follows:

$$e_t = \gamma + \psi \tag{15}$$

The effort level depends only on constant parameters. From Equations (5) and (15), the firm controls the wage such that effort is constant over time. Moreover, Equation (15) corresponds to a transformation of the Solow condition in which the elasticity of effort with respect to the wage equals 1 as $e(w_t) = e'(w_t)w_t$. The alternative wage is assumed as

$$w_t^a = w_t L_t \tag{16}$$

which is the average labor income.

The equilibrium in the goods market is

$$C_t + I_t = Y_t \tag{17}$$

The model comprises variables Y_t, C_t, I_t, K_t, L_t, S_t, V_t, R_t, w_t, w_t^a, e_t, and A_t. The system of equations defining the model consists of Equations (2), (5), (7)–(12), and (14)–(17). This model enables us to analyze situations in which vacancies exist in addition to employment and unemployment in the efficiency wage model. The appendix presents the steady-state values.

In the steady state, we obtain the unemployment rate U and vacancies V as follows:

$$U = 1 - L = 1 - exp\left(\frac{\phi-\psi}{\gamma} - 1\right) \tag{18}$$

$$V = S - L = \frac{\mu}{\lambda} exp\left(\frac{\phi-\psi}{\gamma} - 1\right) \tag{19}$$

where L and S are the steady-state values of labor input and the strategic labor input target, respectively. From Equations (18) and (19), we obtain the following negative relationship between unemployment and vacancies:

$$U = 1 - \frac{\lambda}{\mu} V \tag{20}$$

which is a Beveridge curve. Equation (20) shows that the changes in λ and μ cause the Beveridge curve to change. As Duffy and Jenkins (2024) note, an outward shift in the Beveridge curve is associated with an increase in the mismatches in skills, an increase in separation, and changes in worker search efforts. In this study, the outward shift in the Beveridge curve is attributed to a decline in the job-filling rate and/or an increase in the job-separation rate.

Proposition 1

A decrease in the job-filling rate and/or an increase in the job-separation rate causes an outward shift in the Beveridge curve.

Labor market dynamics during the COVID-19 pandemic and the subsequent recovery have been extensively studied. Pizzinelli and Shibata (2023) find that while mismatch temporarily increased in the United States and the United Kingdom during the second and third quarters of 2020, it played only a limited role in slowing the pace of employment recovery. They argue that, given the high level of vacancies, factors underlying the decline in labor supply are likely to play an important role. Consolo and Petroulakis (2024) also show that mismatch in unemployment was not a significant factor for the pandemic recession. Regarding the recovery period, Barlevy et al. (2024) argue that it was characterized by both a rapid rise in labor demand and a substantial increase in workers actively searching for new job opportunities. Crump et al. (2024) point out that quits increased as people left their jobs to search for new opportunities. Figura and Waller (2024) point out that job vacancies increased markedly as economic activities restarted, and severe labor shortages resulted from decreased immigration and labor force participation. The authors show that, since early 2022, job vacancies have declined significantly while unemployment has remained largely unchanged. This little change in unemployment is also observed in the labor markets of advanced economies, which experienced a marked increase in vacancies during the pandemic.

Barlevy et al. (2024) also discuss the shifts in the Beveridge curve from 1970 to 2023 in the United States. According to their study, the Beveridge curve shifted outward largely after the pandemic in March 2020 due to an increase in unemployment inflows and then moved back inward owing to rehiring. An increase in the number of employed workers looking for a new job led to increased competition between the unemployed and employed, shifting the Beveridge curve outward since early 2021. Conversely, a decrease in workers' willingness to switch jobs led to an inward shift of the Beveridge curve from early 2022. Our model is in line with the Beveridge curve shifts during the pandemic recovery. As Equation (20) shows, the rise in μ shifts the Beveridge curve outward, and the decline in μ shifts the curve inward.

From Equations (2), (5), (7), (8), (10)–(12), and (14)–(17), we obtain the following log-linearized model:

$$\widehat{K}_{t+1} = (1-\delta)\widehat{K}_t + \frac{I}{K}\hat{I}_t \tag{21}$$

$$\widehat{w}_t = \frac{e}{\gamma+\psi}\hat{e}_t + \frac{\gamma}{\gamma+\psi}\widehat{w_t^a} + \frac{\psi}{\gamma+\psi}\widehat{w}_{t-1} \tag{22}$$

$$\hat{C}_{t+1} = \beta R\hat{R}_{t+1} + \hat{C}_t \tag{23}$$

$$\hat{Y}_t = \hat{A}_t + \alpha\hat{K}_t + (1-\alpha)\hat{e}_t + (1-\alpha)\hat{L}_t \tag{24}$$

$$\hat{V}_t = \frac{S}{V}\,\hat{S}_t - \frac{L}{V}\hat{L}_{t-1} \tag{25}$$

$$\hat{S}_t = \frac{1}{\lambda+\mu}\hat{L}_t + \left(1-\frac{1}{\lambda+\mu}\right)\hat{L}_{t-1} \tag{26}$$

$$\hat{R}_t = \hat{Y}_t - \hat{K}_t \tag{27}$$

$$\hat{L}_t = \hat{Y}_t - \hat{w}_t \tag{28}$$

$$\hat{e}_t = 0 \tag{29}$$

$$\widehat{w_t^a} = \hat{w}_t + \hat{L}_t \tag{30}$$

$$\hat{I}_t = \frac{Y}{I}\hat{Y}_t - \frac{C}{I}\hat{C}_t \tag{31}$$

where the variables with a hat represent a deviation from the steady state (e.g., $\hat{L}_t = (L_t - L)/L$), and the variables without subscript t are the steady-state values. The responses to the productivity shock are determined by Equations (21)–(31). Additionally, from Equations (25) and (26), the response of vacancies is expressed as follows:

$$\hat{V}_t = \left(\frac{1}{\lambda+\mu}\right)\frac{S}{V}\hat{L}_t + \left[\left(1-\frac{1}{\lambda+\mu}\right)\frac{S}{V} - \frac{L}{V}\right]\hat{L}_{t-1} \tag{32}$$

From Equations (26) and (32), and the steady-state value, the responses of the strategic labor input target and vacancies depend on the job-filling and job-separation rates.

3 Numerical experiments

We conduct numerical analysis to investigate the effects of changes in the job-filling and job-separation rates on labor market fluctuations when a shock to productivity occurs. We also analyze the effects on labor market fluctuations of effort sensitivity to the wage-to-alternative wage and current-to-previous wage ratios.

3.1 Baseline simulation

Following Collard and de la Croix (2000), we set the parameters, except for the parameters λ and μ, as displayed in Table 1. Parameters λ and μ are set to 0.9594 and 0.0985, respectively, in the baseline simulation. To set λ, we use the estimation results that the average daily job-

Table 1. Model parameters

Parameter		Value
α	Capital share in production	0.36
β	Discount factor	0.99
δ	Depreciation rate of capital	0.025
λ	Job-filling rate	0.9594
μ	Job-separation rate	0.0985
γ	Effort sensitivity to the wage-to-alternative wage ratio	0.9
ψ	Effort sensitivity to the current-to-previous wage ratio	2.8

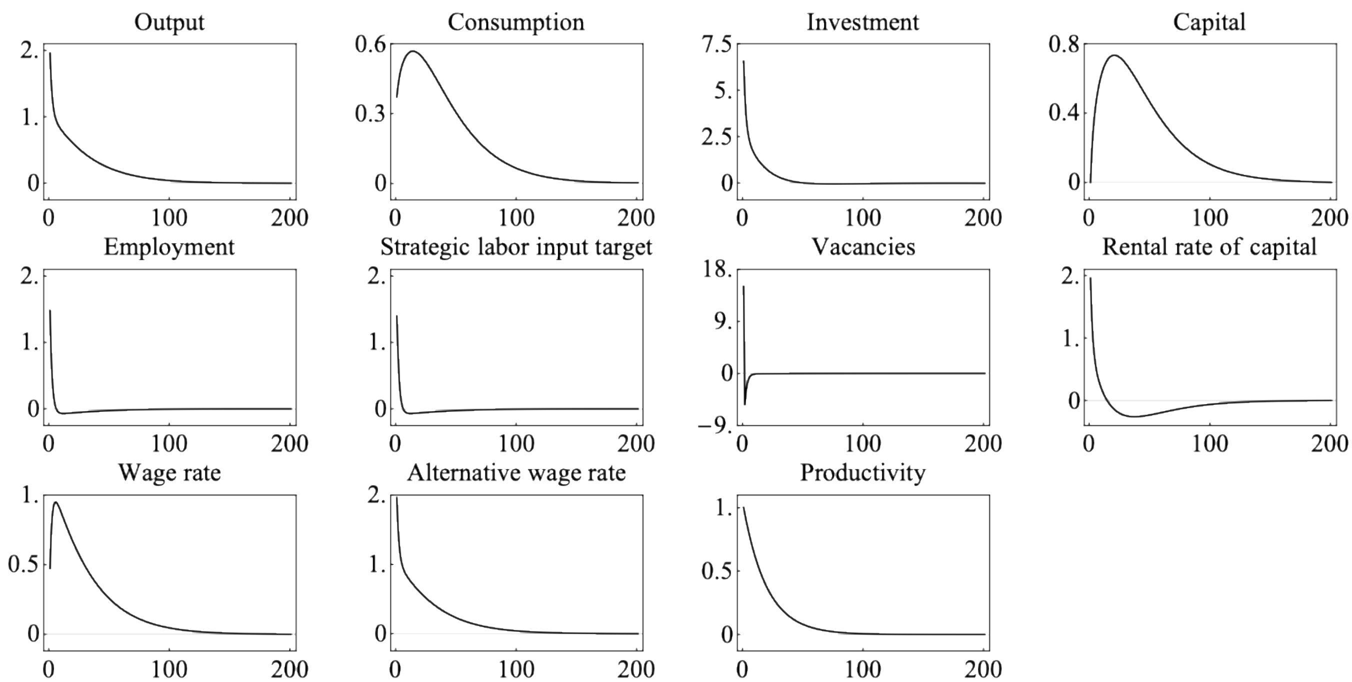
filling rate is 0.052, as estimated by Davis et al. (2013) using the Job Openings and Labor Turnover Survey (JOLTS) data. Assuming that three months consist of 60 business days, the quarterly job-filling rate is set to $1-(1-0.052)^{60} \approx 0.9594$. Leduc and Liu (2020) set the monthly job-separation rate to 0.034 by using the JOLTS data. The quarterly job-separation rate is set at $1-(1-0.034)^{3} \approx 0.0985$. From Equations (5), (15), and (16), in the steady state, we obtain $\phi = \gamma(logL + 1) + \psi$. The parameter ϕ is set such that L is 0.9. In the baseline simulation, ϕ is set to 3.60518. Assuming $\varepsilon_t = 0$ and $A_t = A_{t-1} = A$ in the steady state, the steady-state productivity $A = 1$ is obtained from Equation (9).

We assume a positive temporary shock and a positive permanent shock to productivity. The temporary shock is assumed to increase productivity by 1% in period 0, that is, ε_0 is set to 0.01, and the ε_t in the other periods are 0. Following Collard and de la Croix (2000), an autoregressive parameter ρ is set to 0.95. The permanent shock is assumed to increase productivity by 1% in period 0 and maintain it at that level thereafter, that is, ε_0 is set to 0.01, ε_t in the other periods are 0, and $\rho = 1.0$.

Figure 1 presents the responses to a productivity shock. Productivity increases in period 0 and gradually returns to the steady state, according to Equation (9). The marginal products of capital and labor increase due to the positive productivity shock. The increase in the demand for capital and labor increases capital and employment, which increases output. To increase labor input, the firm expands the strategic labor input target by considering the filling vacancies and separations. The vacancies, or the difference between the strategic labor input target and employment, increase. The increase in the demand for capital increases the rental rate of capital. Furthermore, the wage increases because the firm adjusts it to maintain a constant level of effort. If the firm does not raise the wage, effort decreases as the alternative wage increases, as shown in Equations (5) and (16). A higher income induces higher consumption and investment.

The responses of the variables are similar to those in standard business cycle models: output, consumption, investment, capital, employment, rental rate of capital, and wages, all increase with the increase in productivity. This model is distinctive in that the firm raises the wage to avoid a lower effort level. In addition to the analysis in Collard and de la Croix (2000), this model can examine vacancies in response to a productivity shock by introducing the relationship between labor input and the strategic labor input target. The simulation results also indicate a decrease in the unemployment rate and an increase in vacancies when the positive shock occurs.

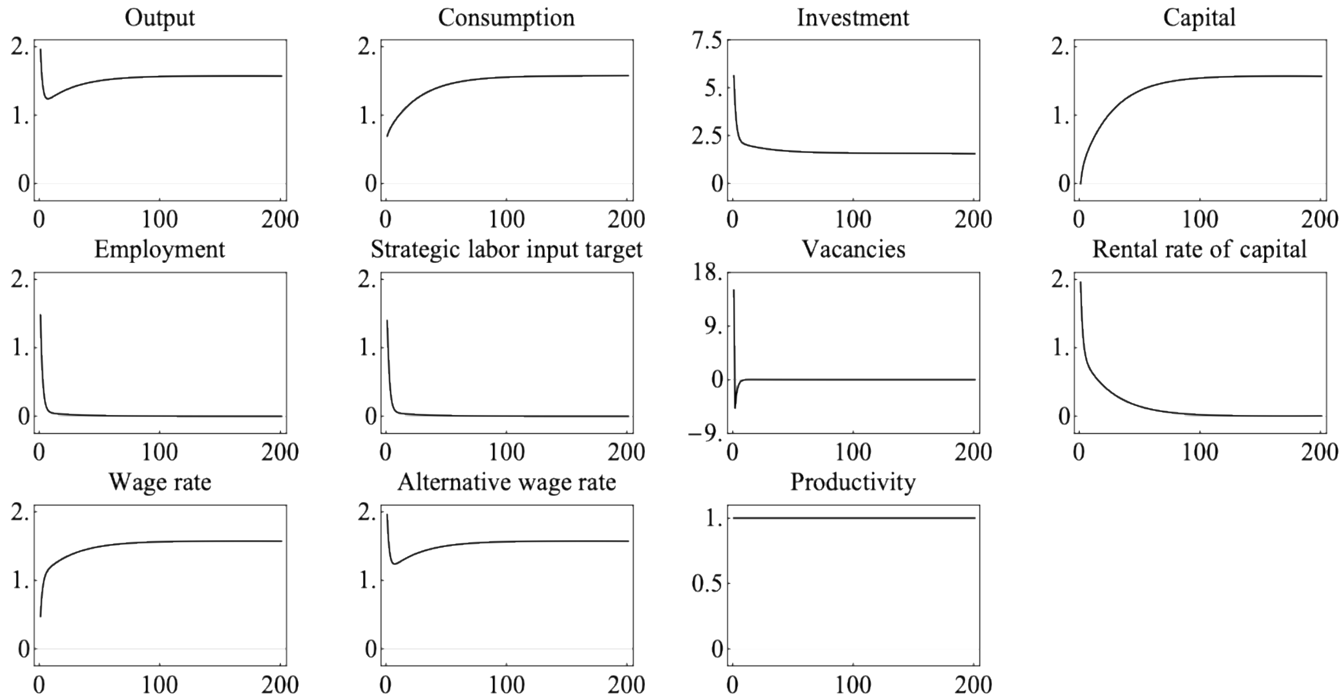
Fig. 1. Responses to a temporary productivity shock



Notes: The horizontal and vertical axes represent time and percentage changes, respectively. The solid lines represent the percentage deviations of the variables from their steady-state values when the productivity shock occurs. A positive temporary productivity shock leads to an increase in all variables.

Figure 2 shows the responses to a permanent shock. Productivity increases in period 0 and remains at that level thereafter. Similar to the case of the temporary productivity shock, the rise in productivity increases all variables.

Fig. 2. Responses to a permanent productivity shock

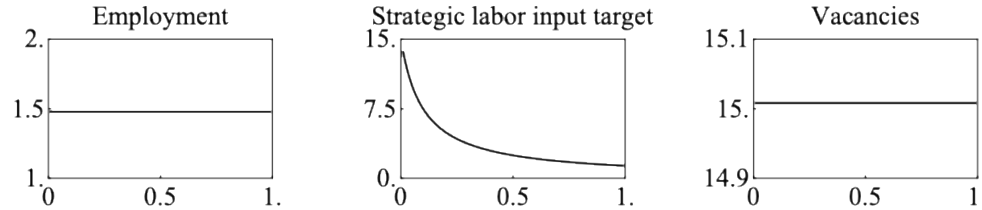


Notes: The horizontal and vertical axes represent time and percentage changes, respectively. The solid lines represent the percentage deviations of the variables from their steady-state values when the productivity shock occurs. A positive permanent productivity shock leads to an increase in all variables

3.2 Changes in job-filling and separation rates

We analyze the effects of changes in the job-filling and separation rates on labor market fluctuations. Figure 3 shows the relationship between λ and the responses to a temporary productivity shock in the model during the shock period. We assume that μ is 0.0985, while λ ranges from 0.01 to 0.99. The other parameters are the same as those in Subsection 3.1. The numerical simulation indicates that a higher λ reduces the response of the strategic labor input target, while those of employment and vacancies are not observed. From Equation (26), the response of the strategic labor input target in period 0 is given by $\hat{S}_0 = [1/(\lambda + \mu)]\hat{L}_0$, because L_{-1} is the steady-state value of employment and $\hat{L}_{-1} = 0$. From Equations (21)–(31) and steady-state values, the response of employment $\hat{L}_0$ is not affected by a change in λ. Therefore, an increase in λ reduces $\hat{S}_0$. From Equation (32) and $\hat{L}_{-1} = 0$, we obtain $\hat{V}_0 = [1/(\lambda + \mu)](S/V)\hat{L}_0$. From $S/V = 1 + \lambda/\mu$, we obtain $\hat{V}_0 = (1/\mu)\hat{L}_0$. Therefore, the effect of change in λ on $\hat{V}_0$ is not observed.

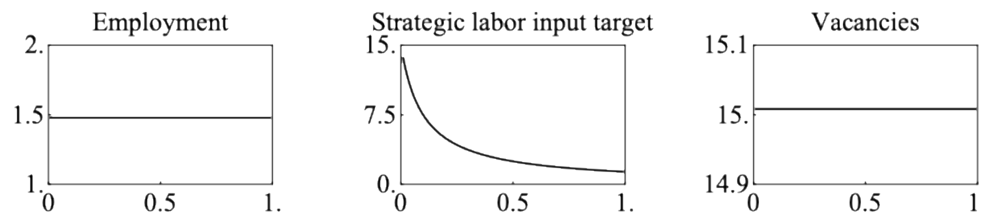
Fig. 3. Job-filling rate and responses to a temporary productivity shock



Notes: The horizontal and vertical axes represent λ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. A higher job-filling rate reduces the response of the strategic labor input target, while a change in the responses of employment and vacancies is not observed.

Figure 4 shows the relationship between λ and the responses to a permanent productivity shock in the model during the shock period. We assume that μ is 0.0985, while λ ranges from 0.01 to 0.99. The other parameters are the same as those in Subsection 3.1. Similar to the case with a temporary productivity shock, the numerical simulation indicates that a higher λ reduces the response of the strategic labor input target, while the responses of employment and vacancies remain unaffected.

Fig. 4. Job-filling rate and responses to a permanent productivity shock



Notes: The horizontal and vertical axes represent λ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. A higher job-filling rate reduces the response of the strategic labor input target, while a change in the responses of employment and vacancies is not observed.

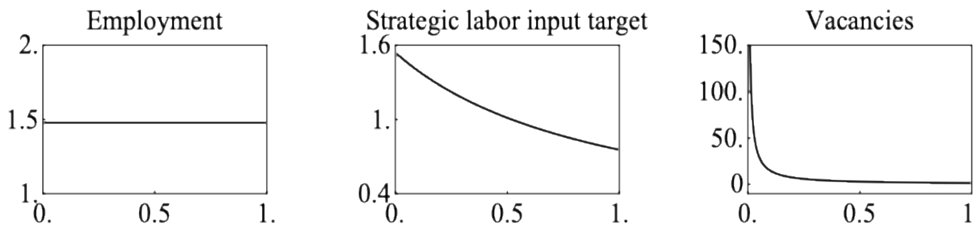
Proposition 2

Assuming that the job-filling rate is higher, the response of the strategic labor input target is reduced, while a change in the responses of employment and vacancies is not observed.

Figure 5 shows the relationship between μ and the responses to a temporary productivity shock in the model during the shock period. The parameter λ is set to 0.9594, while μ ranges from

0.01 to 0.99. The other parameters are the same as those in Subsection 3.1. The numerical simulation indicates that a higher μ reduces the responses of the strategic labor input target and vacancies. As in the case of λ, an increase in μ does not affect the responses of employment $\hat{L}_0$. An increase in μ reduces the strategic labor input target $\hat{S}_0 = [1/(\lambda+\mu)]\hat{L}_0$. From $\hat{V}_0 = (1/\mu)\hat{L}_0$, an increase in μ leads to decreases in $\hat{V}_0$.

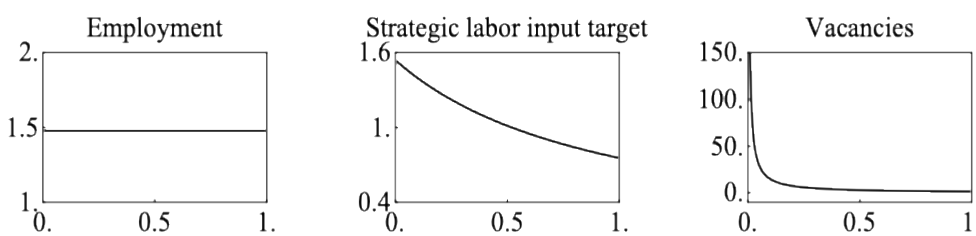
Fig. 5. Job-separation rate and responses to a temporary productivity shock



Notes: The horizontal and vertical axes represent μ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. A higher job-separation rate reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed.

Figure 6 shows the relationship between μ and the responses to a permanent productivity shock in the model during the shock period. The parameter λ is set to 0.9594, while μ ranges from 0.01 to 0.99. The other parameters are the same as those in Subsection 3.1. Similar to the case with a temporary productivity shock, the numerical simulation indicates that a higher μ reduces the responses of the strategic labor input target and vacancies. The response of employment is not affected by the change in μ.

Fig. 6. Job-separation rate and responses to a permanent productivity shock



Notes: The horizontal and vertical axes represent μ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. A higher job-separation rate reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed.

Proposition 3

Assuming that the job-separation rate is higher, the responses of the strategic labor input target and vacancies are reduced, while a change in the response of employment is not observed.

The results indicate the need to examine not only the change in vacancies but also the job-separation rate when formulating or discussing economic policies. If we focus only on a significant increase in vacancies, even though μ is low, we anticipate a significant increase in employment. If so, an adequate economic policy for reducing the unemployment rate cannot be implemented because the significant increase in vacancies can be caused by the low μ.

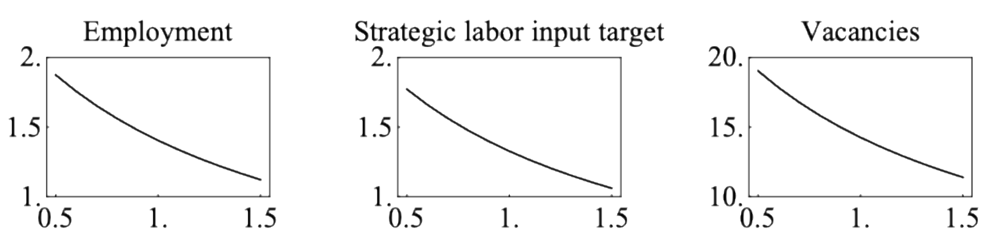
Although the increase in productivity presents an increase in employment in this study, Mandelman and Zanetti (2014) demonstrate a negative response of labor input to a positive productivity shock because of an increase in hiring costs through the increase in productivity. Mumtaz and Zanetti (2016) show that a positive productivity shock makes a larger output possible with fewer labor inputs, which reduces employment. These findings are in line with Galí's (1999) estimation results. Therefore, extending this model to study the negative response of employment should be necessary.

3.3 Effect of changes in effort sensitivity on wage rates

As shown in Equation (5), the large effort is driven by the high ratios of the wage to the alternative wage and of the current wage to the previous wage. We analyze how effort sensitivity of these ratios affects labor market fluctuations.

Figure 7 shows the relationship between γ and the responses to a temporary productivity shock in the model during the shock period.

Fig. 7. Effort sensitivity to the wage-to-alternative wage ratio and responses to a temporary productivity shock



Notes: The horizontal and vertical axes represent γ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. As γ increases, the responses of the variables are reduced.

The parameter γ ranges from 0.5 to 1.5. The other parameters are the same as those in Subsection 3.1. An increase in effort sensitivity to the wage-to-alternative wage ratio reduces the responses of employment, the strategic labor input target, and vacancies.

In Equation (5), the large γ indicates a high weight of the wage-to-alternative wage ratio. From Equations (5) and (16), the weight of the inverse of employment is high when γ is large. If employment increases, the effort level decreases significantly. Therefore, the response of the strategic labor input target is smaller to reduce the response of employment, and the response of vacancies is reduced.

Figure 8 shows the relationship between γ and the responses to a permanent productivity shock in the model during the shock period. The parameter γ ranges from 0.5 to 1.5. The other parameters are the same as those in Subsection 3.1. Similar to the case of the temporary productivity shock, an increase in effort sensitivity to the wage-to-alternative wage ratio reduces the responses of employment, the strategic labor input target, and vacancies.

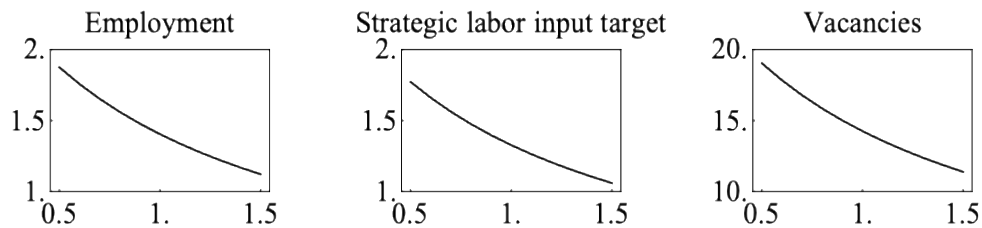
Proposition 4

Assuming that effort sensitivity to the wage-to-alternative wage ratio is higher, the responses of employment, the strategic labor input target, and vacancies are reduced.

Figure 9 shows the relationship between ψ and the responses to a temporary productivity shock in the model during the shock period. The parameter ψ ranges from 0.5 to 3.5. The other parameters are the same as those in Subsection 3.1. An increase in effort sensitivity to the current-to-previous wage ratio amplifies the responses of employment, the strategic labor input target, and vacancies. In Equation (5), the large ψ indicates the large weight of the current-to-previous wage ratio. Even if the wage rate does not increase much, the effort level increases significantly. From Equations (5), (15), and (16), the response of employment is large enough to keep the effort constant in situations where changes in wages exert a greater influence on effort. The response of the strategic labor input target is larger in order to significantly increase employment, and the response of vacancies is amplified.

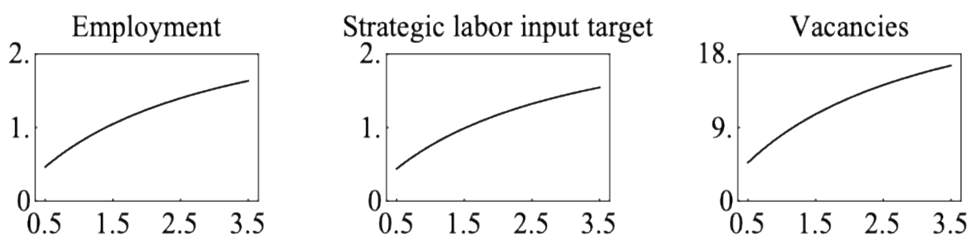
Figure 10 shows the relationship between ψ and the responses to a permanent productivity shock in the model during the shock period. The parameter ψ ranges from 0.5 to 3.5. The other parameters are the same as those in Subsection 3.1. Similar to the case of the temporary productivity shock, an increase in effort sensitivity to the current-to-previous wage ratio amplifies the responses of employment, the strategic labor input target, and vacancies.

Fig. 8. Effort sensitivity to the wage-to-alternative wage ratio and responses to a permanent productivity shock



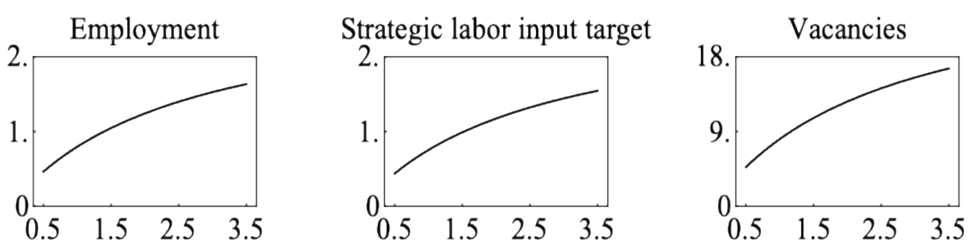
Notes: The horizontal and vertical axes represent γ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. As γ increases, the responses of the variables are reduced.

Fig. 9. Effort sensitivity to the current-to-previous wage ratio and response to a temporary productivity shock



Notes: The horizontal and vertical axes represent ψ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. As ψ increases, the responses of the variables are amplified.

Fig. 10. Effort sensitivity to the current-to-previous wage ratio and responses to a permanent productivity shock



Notes: The horizontal and vertical axes represent ψ and percentage changes, respectively. The lines represent the percentage deviations of the variables from the steady-state values. As ψ increases, the responses of the variables are amplified.

Proposition 5

Assuming that effort sensitivity to the current-to-previous wage ratio is higher, the responses of employment, the strategic labor input target, and vacancies are amplified.

This study shows the effects of changes in γ and ψ on not only employment fluctuations but also vacancies by introducing the relationship between the labor input and the strategic labor input target. The responses of employment and vacancies to the productivity shock are amplified by the decrease in γ and the increase in ψ in the model simulations. The results for the alternative parameter values are discussed in Appendix B, and those for productivity shocks of different magnitudes are discussed in Appendix C.

4. Conclusions

The introduction of the relationship between the labor input and the strategic labor input target into the macroeconomic model allows for an analysis of the Beveridge curve and changes in vacancies, in addition to the employment dynamics. Our model shows that a decrease in the job-filling rate and/or an increase in the job-separation rate causes an outward shift in the Beveridge curve. It explains the Beveridge curve shifts during the COVID-19 pandemic recovery. The rise in the job-separation rate due to the increase in the number of employed workers searching for a new job shifts the Beveridge curve outward, and the decline in this rate caused by the decrease in workers' willingness to switch jobs shifts the curve inward. This result highlights the importance of paying attention to the job-separation rate in formulating economic policies.

This study shows a higher job-filling rate reduces the response of the strategic labor input target, while a change in the responses of employment and vacancies is not observed. Furthermore, a higher job-separation rate reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed. If we focus only on the significant increase in vacancies, even if the job-separation rate is lower, we may anticipate a significant increase in employment. The economic policy would then be inadequate in terms of reducing the unemployment rate because the substantial changes in vacancies in response to the shock do not lead to significant employment changes in this situation. Thus, not only changes in vacancies but also the job-separation rate must be considered when making or discussing economic policies. Additionally, the analysis indicates that if effort sensitivity to the wage-to-alternative wage ratio is higher, the responses of employment, the strategic labor input target, and vacancies are reduced. If effort sensitivity to the current-to-previous wage ratio is higher, the responses of the variables are amplified.

Certain issues remain unresolved. The job-filling and job-separation rates, the main parameters in this study, can be influenced by wage gaps arising from factors such as firm or household heterogeneity. Firms that pay relatively higher wages are expected to have higher job-filling rates and lower job-separation rates, and vice versa. The increase in the response of wage gaps to the shock is likely to amplify the response of these rates as well. Additionally, an increase in matching efficiency and recruiting intensity may raise the job-filling rate, and an increase in the willingness to switch jobs may increase the job-separation rate. Similarly, an increase in the willingness to work is likely to increase the job-filling rate and decrease the job-separation rate. Thus, examining the underlying decision-making mechanisms is crucial. Although a positive productivity shock increases employment in our study, some studies have demonstrated a negative response of labor input to a positive productivity shock. Therefore, extending this model to study the negative responses to employment will be necessary.

Future studies could extend the model to heterogeneous households and firms to investigate endogenous job-filling and separation rates, as well as to analyze how changes in labor market institutions affect the response of employment.

Appendix A: The model in steady state

In the steady state, from Equations (2), (5), (7)–(12), and (14)–(17), we obtain

$$I = \delta K \quad \text{(A1)}$$

$$e = \phi + \gamma log\left(\frac{w}{w^{a}}\right) \quad \text{(A2)}$$

$$1 = \beta(R + 1 - \delta) \quad \text{(A3)}$$

$$Y = AK^{\alpha}(eL)^{1-\alpha} \quad \text{(A4)}$$

$$V = S - L \quad \text{(A5)}$$

$$logA = \rho logA \quad \text{(A6)}$$

$$L = \left(\frac{\lambda}{\lambda+\mu}\right)S \quad \text{(A7)}$$

$$R = \alpha\frac{Y}{K} \quad \text{(A8)}$$

$$w = (1-\alpha)\frac{Y}{L} \quad \text{(A9)}$$

$$e = \gamma + \psi \quad \text{(A10)}$$

$$w^{a} = wL \quad \text{(A11)}$$

$$C + I = Y \quad \text{(A12)}$$

where Y, C, I, K, L, S, V, R, w, w^a, e, and A are the steady-state values. From Equation (A6), we obtain $A = 1$. By substituting Equations (A10) and (A11) into Equation (A2) to eliminate e and w^a, we obtain $logL = (\phi - \psi)/\gamma - 1$. From $exp(logL) = L$, we transform $logL = (\phi - \psi)/\gamma - 1$ as follows:

$$L = exp\left(\frac{\phi-\psi}{\gamma} - 1\right) \tag{A13}$$

Using Equation (A13) to eliminate L from Eq. (A7), we obtain S as follows:

$$S = \left(1 + \frac{\mu}{\lambda}\right) exp\left(\frac{\phi-\psi}{\gamma} - 1\right) \tag{A14}$$

From Equations (A5), (A13), and (A14), we obtain V as follows:

$$V = \frac{\mu}{\lambda} exp\left(\frac{\phi-\psi}{\gamma} - 1\right)$$

From Equation (A3), we obtain R as follows:

$$R = \beta^{-1} + \delta - 1 \tag{A15}$$

Using Equations (A8) and (A10), and $A = 1$ to eliminate Y/K, e, and A from Equation (A4), we obtain $K/L = \{R/[\alpha(\gamma + \psi)^{1-\alpha}]\}^{-1/(1-\alpha)}$. By substituting Equation (A15) into this equation, we obtain

$$\frac{K}{L} = \left[\frac{\beta^{-1}+\delta-1}{\alpha(\gamma+\psi)^{1-\alpha}}\right]^{\frac{-1}{1-\alpha}} \tag{A16}$$

Using Equation (A13) to eliminate L from Equation (A16), we obtain K. By substituting K into Equation (A1), we obtain I. By substituting Equation (A10), Equation (A13), $A = 1$, and K into Equation (A4), we obtain Y. Using Equation (A10) and $A = 1$ to eliminate e and A from Equation (A4), we obtain

$$\frac{Y}{L} = (\gamma + \psi)^{1-\alpha} \left(\frac{K}{L}\right)^{\alpha} \tag{A17}$$

From Equations (A9), (A16), and (A17), we obtain w. By substituting Equation (A13) and w into Equation (A11), we obtain w^a. Using Equation (A12) to eliminate I from Equation (A1) and multiplying $1/L$, we obtain

$$\frac{C}{L} = \frac{Y}{L} + \delta\frac{K}{L} \tag{A18}$$

From Equations (A13) and (A16)–(A18), we obtain C.

Appendix B: Robustness of the numerical experiments under alternative parameter values

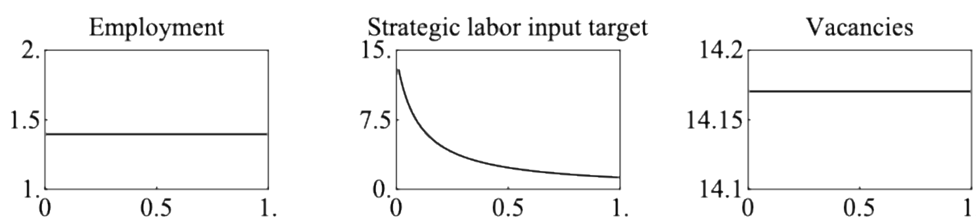
We analyze the effects of changes in λ, μ, γ, and ψ on labor market fluctuations under alternative parameter values. Following Chéron and Langot (2004), parameters α, β, and δ are set to 0.4, 0.985, and 0.012, respectively. The parameter ϕ is set such that L is 0.9.

Figure B1 shows the relationship between λ and the responses to a temporary productivity shock in the model during the shock period. We assume that λ ranges from 0.01 to 0.99. The parameters μ, γ, and ψ are the same as those in Subsection 3.1. Similar to the results in Subsection 3.2, the numerical simulation indicates that a higher λ reduces the response of the strategic labor input target, while a change in the response of employment and vacancies is not observed.

Figure B2 shows the relationship between μ and the responses to a temporary productivity shock in the model during the shock period. We assume that μ ranges from 0.01 to 0.99. The parameters λ, γ, and ψ are the same as those in Subsection 3.1. Similar to the results in Subsection 3.2, the numerical simulation indicates that a higher μ reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed.

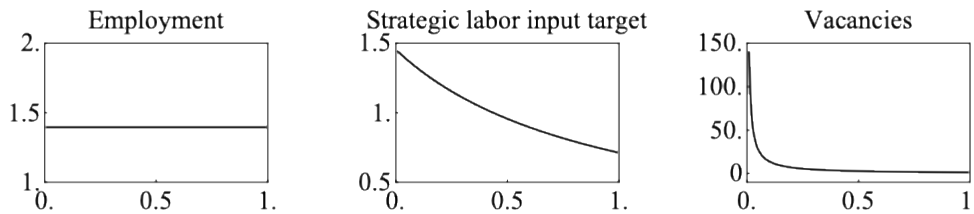
Figure B3 shows the relationship between γ and the responses to a temporary productivity shock in the model during the shock period. The parameter γ ranges from 0.5 to 1.5. The parameters λ, μ, and ψ are the same as those in Subsection 3.1. Similar to the results in Subsection 3.3, an increase in effort sensitivity to the wage-to-alternative wage ratio reduces the responses of employment, the strategic labor input target, and vacancies.

Fig. B1. Job-filling rate and responses to a temporary productivity shock with alternative parameter values



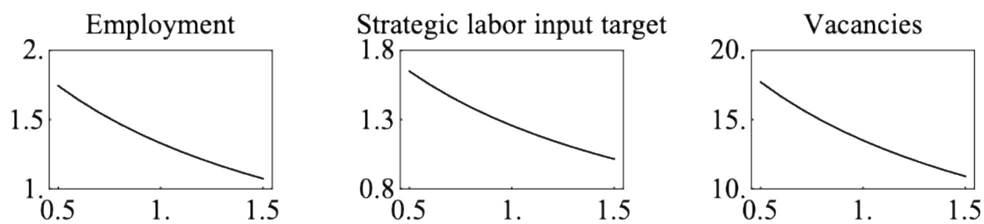
Notes: The horizontal and vertical axes represent λ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. A higher job-filling rate reduces the response of the strategic labor input target, while a change in the responses of employment and vacancies is not observed.

Fig. B2. Job-separation rate and responses to a temporary productivity shock with alternative parameter values



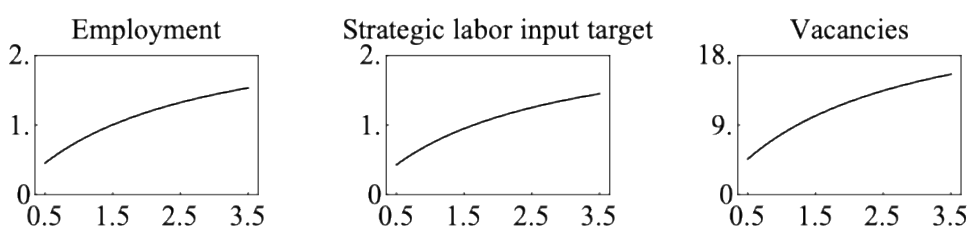
Notes: The horizontal and vertical axes represent μ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. A higher job-separation rate reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed.

Fig. B3. Effort sensitivity to the wage-to-alternativewage ratio and responses to a temporary productivity shock with alternative parameter values



Notes: The horizontal and vertical axes represent γ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. As γ increases, the responses of the variables are reduced.

Fig. B4. Effort sensitivity to the current-to-previous-wage ratio and response to a temporary productivity shock with alternative parameter values



Notes: The horizontal and vertical axes represent ψ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. As ψ increases, the responses of the variables are amplified.

Figure B4 above shows the relationship between ψ and the responses to a temporary productivity shock in the model during the shock period. The parameter ψ ranges from 0.5 to 3.5. The parameters λ, μ, and γ are the same as those in Subsection 3.1. Similar to the results in Subsection 3.3, an increase in effort sensitivity to the current-to-previous wage ratio amplifies the responses of employment, the strategic labor input target, and vacancies.

Appendix C: Robustness of the numerical experiments under productivity shocks of different magnitudes

We investigate labor market fluctuations under productivity shocks of different magnitudes. The temporary productivity shocks are assumed to increase by 1%, 3%, and 5% in period 0, respectively.

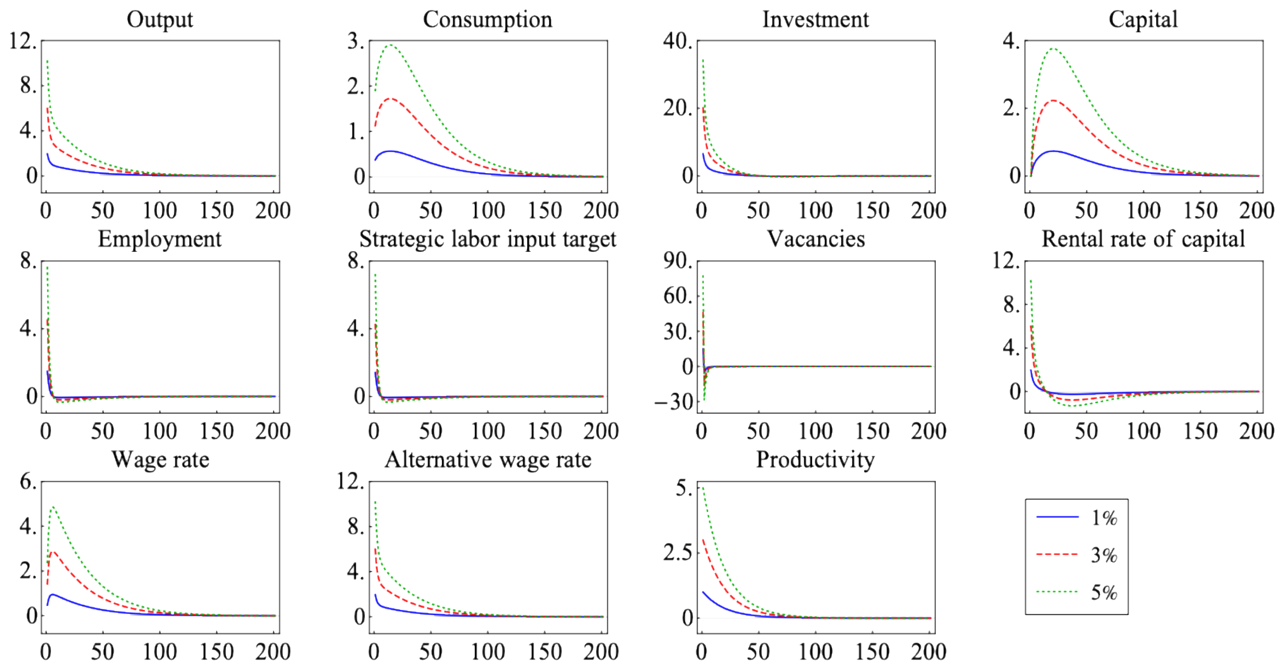
Figure C1 shows the responses to the productivity shocks. The parameter ϕ is set such that L is 0.9. The other parameter values are the same as those in Subsection 3.1. A large productivity shock amplifies the fluctuations. The responses of all variables are positive, as in Subsection 3.1.

We also analyze the effects of changes in λ, μ, γ, and ψ on labor market fluctuations under productivity shocks of different magnitudes. Figure C2 shows the relationship between λ and the responses to temporary productivity shocks in the model during the shock period. We assume that λ ranges from 0.01 to 0.99. The parameter ϕ is set such that L is 0.9, with other parameters the same as those in Subsection 3.1. The numerical simulation indicates that a higher λ reduces the response of the strategic labor input target, while a change in the responses of employment and vacancies is not observed. The relationship between λ and the responses remains unchanged across productivity shocks of different magnitudes.

Figure C3 shows the relationship between μ and the responses to temporary productivity shocks in the model during the shock period. We assume that μ ranges from 0.01 to 0.99. The parameter ϕ is set such that L is 0.9. The other parameters are the same as those in Subsection 3.1. The numerical simulation indicates that a higher μ reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed. Thus, the relationship between μ and the responses remains unchanged across productivity shocks of different magnitudes.

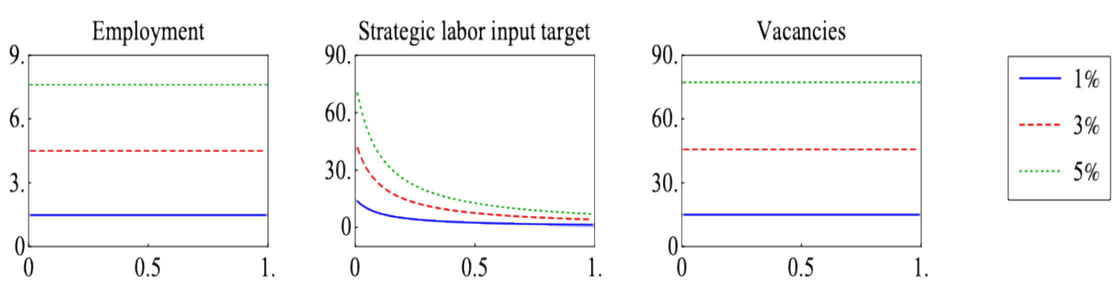
Figure C4 shows the relationship between γ and the responses to temporary productivity shocks in the model during the shock period. The parameter γ ranges from 0.5 to 1.5. The parameter ϕ is set such that L is 0.9. The other parameters are the same as those in Subsection 3.1. An increase in effort sensitivity to the wage-to-alternative wage ratio reduces the responses of employment, the strategic labor input target, and vacancies. Thus, the relationship between γ and the responses remains unchanged across productivity shocks of different magnitudes.

Fig. C1. Responses to temporary productivity shocks



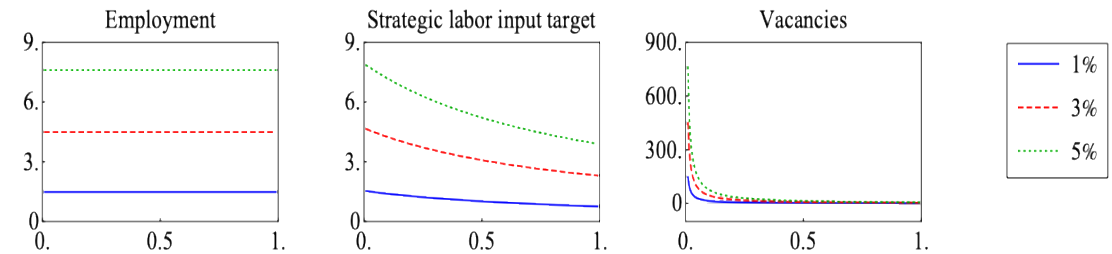
Notes: The horizontal and vertical axes represent time and percentage changes, respectively. The lines represent the variables' percentage deviations from their steady-state values when the productivity shock occurs. A large productivity shock amplifies their response.

Fig. C2. Job-filling rate and responses to temporary productivity shocks



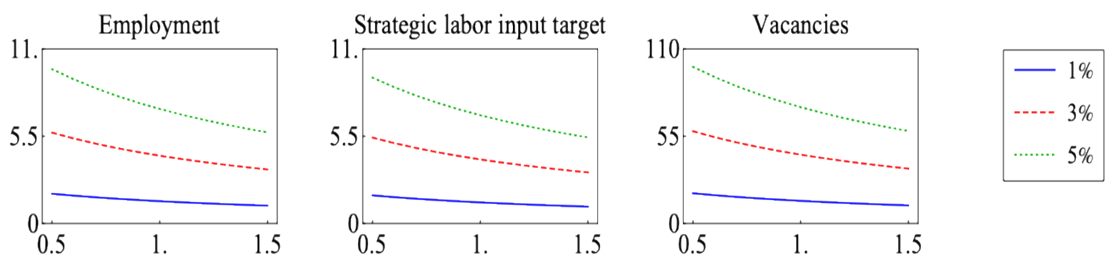
Notes: The horizontal and vertical axes represent λ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. A higher job-filling rate reduces the response of the strategic labor input target, while a change in the responses of employment and vacancies is not observed.

Fig. C3. Job-separation rate and responses to temporary productivity shocks



Notes: The horizontal and vertical axes represent μ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. A higher job-separation rate reduces the responses of the strategic labor input target and vacancies, while a change in the response of employment is not observed.

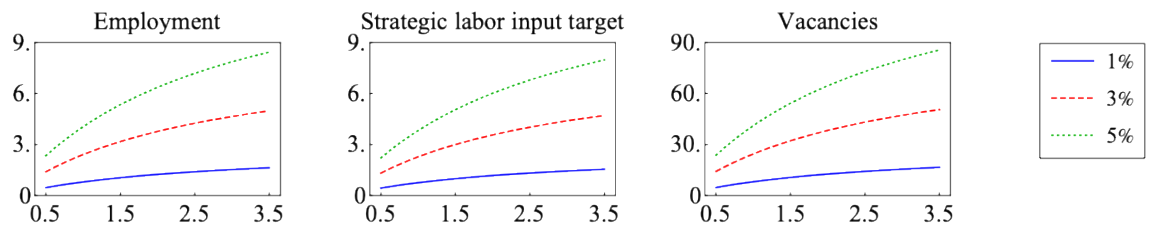
Fig. C4. Effort sensitivity to the wage-to-alternative wage ratio and responses to temporary productivity shocks



Notes: The horizontal and vertical axes represent γ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. As γ increases, the responses of the variables are reduced.

Figure C5 shows the relationship between ψ and the responses to a temporary productivity shock in the model during the shock period. The parameter ψ ranges from 0.5 to 3.5. The parameter ϕ is set such that L is 0.9. The other parameters are the same as those in Subsection 3.1. An increase in effort sensitivity to the current-to-previous wage ratio amplifies the responses of employment, the strategic labor input target, and vacancies. Thus, the relationship between ψ and the responses remains unchanged across productivity shocks of different magnitudes.

Fig. C5. Effort sensitivity to the ratio of the current-to-previous wage ratio and responses to temporary productivity shocks



Notes: The horizontal and vertical axes represent ψ and percentage changes, respectively. The lines represent the percentage deviations of the variables during the shock period from the steady-state values. As ψ increases, the responses of the variables are amplified.

References

Akerlof, George A. (1982), Labor contracts as partial gift exchange, *The Quarterly Journal of Economics*, 97, 543–569.

Barlevy, Gadi, R. Jason Faberman, Bart Hobijn and Ayşegül Şahin (2024), The shifting reasons for Beveridge curve shifts, *Journal of Economic Perspectives*, 38, 83–106.

Burdett, Kenneth and Dale T. Mortensen (1998), Wage differentials, employer size, and unemployment, *International Economic Review*, 39, 257–273.

Cabo, Francisco and Angel Martín-Román (2019), Dynamic collective bargaining and labor adjustment costs, *Journal of Economics*, 126, 103–133.

Cahuc, Pierre, Fabien Postel-Vinay and Jean-Marc Robin (2006), Wage bargaining with on-the-job search: Theory and evidence, *Econometrica*, 74, 323–364.

Campbell III, Carl M. (1994), Wage change and the quit behavior of workers: Implications for efficiency wage theory, *Southern Economic Journal*, 61, 133–148.

Chéron, Arnaud and Francois Langot (2004), Labor market search and real business cycles: reconciling Nash bargaining with the real wage dynamics, *Review of Economic Dynamics*, 7, 476–493.

Chiarini, Bruno and Paolo Piselli (2005), Business cycle, unemployment benefits and productivity shocks, *Journal of Macroeconomics*, 27, 670–690.

Coles, Melvyn G. (2001), Equilibrium wage dispersion, firm size, and growth, *Review of Economic Dynamics*, 4, 159–187.

Collard, Fabrice and David de la Croix (2000), Gift exchange and the business cycle: The fair wage strikes Back, *Review of Economic Dynamics*, 3, 166–193.

Consolo, Agostino and Filippos Petroulakis (2024), Did COVID-19 induce a reallocation wave? *Economica*, 91, 1349–1390.

Crump, Richard K., Stefano Eusepi, Marc Giannoni and Ayşegül Şahin (2024) The unemployment-inflation trade-off revisited: The Phillips curve in COVID times, *Journal of Monetary Economics*, 145, 1–19.

Danthine, Jean-Pierre and André Kurmann (2004), Fair wages in a New Keynesian model of the business cycle, *Review of Economic Dynamics*, 7, 107–142.

Davis, Steven J., R. Jason Faberman and John C. Haltiwanger (2013), The establishment-level behavior of vacancies and hiring, *The Quarterly Journal of Economics*, 128, 581–622.

de la Croix, David, Gregory de Walque and Rafael Wouters (2009), A note on inflation persistence in a fair wage model of the business cycle, *Macroeconomic Dynamics*, 13, 673–684.

Duffy, John and Brian C. Jenkins (2024), Search, unemployment, and the Beveridge curve: Experimental evidence, *Labour Economics*, 87, 1–14.

Elsby, Michael W.L., Ryan Michaels and David Ratner (2015), The Beveridge curve: A survey, *Journal of Economic Literature*, 53, 571–630.

Galí, Jordi (1999), Technology, employment, and the business cycle: Do technology shocks explain aggregate fluctuations? *American Economic Review*, 89, 249–271.

Gomme, Paul (1999) Shirking, unemployment and aggregate fluctuations, *International Economic Review*, 40, 3–21.

Goux, Dominique, Eric Maurin and Marianne Pauchet (2001), Fixed-term contracts and the dynamics of labour demand, *European Economic Review*, 45, 533–552.

Figura, Andrew and Chris Waller (2024), What does the Beveridge curve tell us about the likelihood of soft landing? *Journal of Economic Dynamics and Control*, 169, 1–17.

Leduc, Sylvain and Zheng Liu (2016), Uncertainty shocks are aggregate demand shocks, *Journal of Monetary Economics*, 82, 20–35.

Leduc, Sylvain and Zheng Liu (2020), The weak job recovery in a macro model of search and recruiting intensity, *American Economic Journal: Macroeconomics*, 12, 310–343.

Lindé, Jesper (2009), The effects of permanent technology shocks on hours: Can the RBC-model fit the VAR evidence? *Journal of Economic Dynamics and Control*, 33, 597–613.

Mandelman, Federico S. and Francesco Zanetti (2014), Flexible prices, labor market frictions and the response of employment to technology shocks, *Labour Economics*, 26, 94–102.

Martin, Christopher and Bingsong Wang (2020), Search, shirking and labor market volatility, *Journal of Macroeconomics*, 66, 1–14.

Mitra, Kaushik, George W. Evans and Seppo Honkapohja (2019), Fiscal policy multipliers in an RBC model with learning, *Macroeconomic Dynamics*, 23, 240–283.

Mortensen, Dale T. (2003), *Wage dispersion: Why are similar workers paid differently?* MIT Press, Cambridge, Massachusetts, London, England.

Mortensen, Dale T. and Christopher A. Pissarides (1994), Job creation and job destruction in the theory of unemployment, *Review of Economic Studies*, 61, 397–415.

Mumtaz, Haroon and Francesco Zanetti (2016), The effect of labor and financial frictions on aggregate fluctuations, *Macroeconomic Dynamics*, 20, 313–341.

Nickell, Stephen J. (1986), Dynamic models of labour demand, in Orley C. Ashenfelter and Richard Layard (eds.), *Handbook of Labor Economics*, Vol I. Elsevier, 473–522.

Pissarides, Christopher A. (2000), *Equilibrium Unemployment Theory*, second ed. MIT Press, Cambridge, Massachusetts, London, England.

Pizzinelli, Carlo and Ippei Shibata (2023), Has COVID-19 induced labor market mismatch? Evidence from the US and the UK, *Labour Economics*, 81, 1–20.

Salop, Steven C. (1979), A model of the natural rate of unemployment, *American Economic Review*, 69(1), 117–125.

Shapiro, Carl and Joseph E. Stiglitz (1984), Equilibrium unemployment as a worker discipline device, *American Economic Review*, 74, 433–444.

Stiglitz, Joseph E. (1974), Alternative theories of wage determination and unemployment in LDC's: The labor turnover model, *The Quarterly Journal of Economics*, 88, 194–227.

Tripier, Fabien (2006), Sticky prices, fair wages, and the co-movements of unemployment and labor productivity growth, *Journal of Economic Dynamics and Control*, 30, 2749–2774.

Weiss, Andrew (1980), Job queues and layoffs in labor markets with flexible wages. *Journal of Political Economy*, 88, 526–538.

Zanetti, Francesco (2019), Financial shocks, job destruction shocks, and labor market fluctuations, *Macroeconomic Dynamics*, 23, 1137–1165.