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Economic fluctuations in a model with an overlapping structure of employment[1]

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Abstract: This study presents a dynamic general equilibrium model with an explicit employment period and investigates economic fluctuations to a temporary productivity shock. Numerical experiments indicate oscillatory responses of new hiring and employment to the shock which are not observed in a standard flexible price model. The explicit employment period constructs an overlapping structure of employment which results in the oscillatory response. This study also examines the effects of change in employment period to economic fluctuations and shows that the variations in new hiring are higher when the employment period is long.

Keywords: economic fluctuations, employment, employment period, oscillatory response.

JEL codes: E24, E32, J20.

Introduction

This study investigates the economic fluctuations to a positive shock in productivity using a dynamic general equilibrium (DGE) model with an explicit employment period. In a standard flexible price model, new hiring and employment are increased if a positive shock in productivity occurs. Moreover, Faia and Rossi (2013), Mandelman and Zanetti (2014) and Mumtaz and Zanetti (2016) indicate a negative reaction of employment to a positive shock in productivity. However, this study shows that a positive shock in productivity leads to an oscillatory response of employment, that is, both positive and negative responses to the shock throughout the planning periods.

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This study finds that the assumption of the explicit employment period creates an overlapping structure of employment and it provides the oscillatory response despite the shock being a temporary increase in productivity. The result is in line with the studies on economic fluctuations. Zipperer and Skott (2011) show cyclical employment behaviours. Faccini and Bondibene (2012) point out a cyclical response of unemployment.

The cyclical movements have been also studied in the theoretical literature. Kolasa, Rubaszek, and Walerych (2021) analyze the impact of working time flexibility on the cyclical movements in unemployment, and indicate that the increase in flexibility amplifies the movements using a search and matching framework. Krusell, Mukoyama, Rogerson, and Şahin (2020) document the cyclical movements in employment, unemployment and non-participation and show that the properties using a model with the shocks to TFP and labor market frictions. Shapiro and Olivero (2020) present a search framework and show that the endogenous labour force participation amplifies the cyclical labour market dynamics to financial shocks.

The relationship between the duration of the employment period and economic fluctuations is analyzed in this study. The assumption of an explicit employment period enables the examination of the relationship. This study finds that the variations in new hiring are higher when the employment period is long. A longer employment period lowers the ratio of new hiring to employment; the firm then needs a significant change in new hiring to optimally adjust the employment level corresponding to the shock.

The remainder of this paper is organized as follows. Section 1 sets up the DGE model with an explicit employment period. Section 2 investigates the relationship between the duration of the employment period and economic fluctuations. The effects of the Frisch elasticity of labour supply and quit rate on economic fluctuations are also studied in the section. Last section concludes the paper.

1. Model

This study extends the model presented in Matsue (2018) which is a dynamic labour demand model with the explicit employment period to the DGE model. It is supposed that the economy consists of firms and households.

1.1. Firms

The representative firm combines capital K_t and employment L_t to produce Y_t, according to a Cobb-Douglas production function:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}, \; t = 0, 1, \ldots, T \tag{1}$$

where $0 < \alpha < 1$ and $A_t > 0$ is an exogenous productivity parameter. Suppose that employment in period t is the sum of new hires h_j in the periods from $t - n$ to t, who do not quit:

$$L_t = \sum_{i=0}^{n} (1-\sigma)^i h_{t-i},\ t = 0, 1, \ldots, T \tag{2}$$

where $0 < \sigma < 1$ is the quit rate and $n + 1$ is the employment period. Then, it is assumed that $0 \leq n \leq T$. A new hire is distinguished by when workers are hired and the employment duration is explicit. Figure 1 shows the relationship between new hires and employment with $n = 2$. The employment in period t is composed of new hires in period $t - 2$, $t - 1$, and t. The change in h_0 brings the change in L_0, L_1, and L_2.

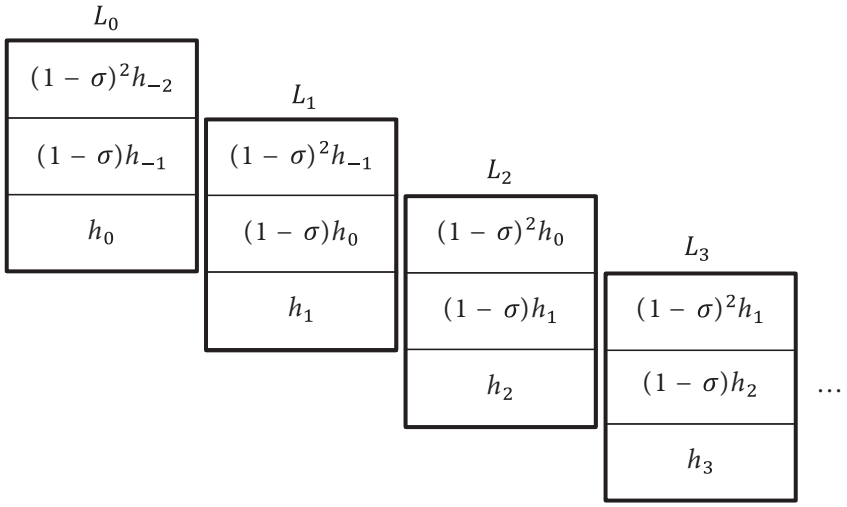

Figure 1. New hiring and employment with $n = 2$
Source: Own work.

It is assumed, in many macroeconomic studies, that employment in period t is the sum of the employees who do not leave the job in period $t - 1$ and the new hires in period t, that is, $L_t = (1 - \sigma_L)L_{t-1} + h_t$, where $0 < \sigma_L < 1$ is the job destruction rate. The distinction of new hiring is not considered in this expression. If $\sigma = 1$ and $\sigma_L = 1$ or $n = 0$ and $\sigma_L = 1$ are supposed, then the two employment transitions are the same, that is, $L_t = h_t$.

The firm chooses K_t and h_t to maximize the following profit:

$$V = \sum_{t=0}^{T} \beta^t \left[A_t K_t^{\alpha} \left\{ \sum_{i=0}^{n} (1-\sigma)^i h_{t-i} \right\}^{1-\alpha} - R_t K_t - w_t \sum_{i=0}^{n} (1-\sigma)^i h_{t-i} \right]$$

where $0 < \beta < 1$ is the discount factor, R_t is the rental rate of capital, and w_t is the wage rate. The first-order conditions for profit maximization are as follows:

$$R_t = \alpha A_t K_t^{\alpha-1}\left[\sum_{i=0}^{n}(1-\sigma)^i h_{t-i}\right]^{1-\alpha}, t = 0, 1, \ldots, T \tag{3}$$

$$\sum_{j=t}^{t+n}\beta^{j-t}(1-\sigma)^{j-t}w_j = \sum_{j=t}^{t+n}\beta^{j-t}(1-\sigma)^{j-t}(1-\alpha)A_j K_j^{\alpha}\left[\sum_{i=0}^{n}(1-\sigma)^i h_{j-i}\right]^{-\alpha}, t = 0, 1, \ldots, T-n \tag{4}$$

where equations (3) and (4) indicate the marginal cost equal to the marginal product. If it is assumed that all workers quit at the end of the period when they are hired ($\sigma = 1$) or the employment period is one ($n = 0$), then the first-order conditions are expressed by the variables in period t.

1.2. Households

Suppose that the utility function of the representative household is given as follows:

$$U = \sum_{t=0}^{T}\beta^t\left[logC_t - \chi\frac{L_t^{1+\phi}}{1+\phi}\right]$$

where $\chi > 0$ is the disutility of working, $1/\phi$ is the Frisch elasticity of labor supply, and C_t is the consumption. The same type of the utility function is assumed in Blanchard and Galí (2010).

The household supplies capital and labor to the firm, and it receives return to capital and wage. The household's budget constraint is the following:

$$C_t + I_t = R_t K_t + w_t L_t, t = 0, 1, \ldots, T \tag{5}$$

The law of motion of the capital stock is as follows:

$$K_{t+1} = (1 - \delta)K_t + I_t, t = 0, 1, \ldots, T \tag{6}$$

where is $0 < \delta < 1$ the depreciation rate of capital.

The households maximize U subject to equations (5) and (6). From the first-order conditions for utility maximization, the following is obtained:

$$\frac{w_t}{C_t} = \chi L_t^{\phi}, t = 0, 1, \ldots, T \tag{7}$$

$$\frac{C_{t+1}}{C_t} = \beta(R_{t+1} - \delta + 1),\ t = 0, 1, \ldots, T-1 \tag{8}$$

Equations (7) and (8) correspond to the labour supply equation and the Euler equation, respectively.

1.3. Equilibrium

The equilibrium on the goods market is the following:

$$C_t + I_t = Y_t,\ t = 0, 1, \ldots, T \tag{9}$$

It is assumed that K_0 and K_{T+1} are given when $n \geq 0$. In addition, the initial values h_{-n}, h_{-n+1}, …, and h_{-1} and the terminal values h_{T-n+1}, h_{T-n+2}, …, and h_T are given when $n \geq 1$. The DGE that consists of $(Y_0, Y_1, \ldots, Y_T)$, $(C_0, C_1, \ldots, C_T)$, $(I_0, I_1, \ldots, I_T)$, $(K_0, K_1, \ldots, K_{T+1})$, $(L_0, L_1, \ldots, L_T)$, $(h_{-n}, h_{-n+1}, \ldots, h_T)$, $(R_0, R_1, \ldots, R_T)$, and $(w_0, w_1, \ldots, w_T)$ is determined by equations (1)–(4) and (6)–(9). The number of variables and equations are $8T + 7 - n$, respectively.

2. Numerical experiments and results

This section investigates the economic fluctuations to a positive productivity shock through a numerical analysis.

2.1. Parameterization

It is assumed that the model period is set to one year. The discount factor β is set at 0.96 and the annual depreciation rate δ is set at 0.1. If it is assumed that the quarterly discount factor is 0.99, then the annual discount factor is $0.99^4 \approx 0.96$. Moreover, if it is assumed that the quarterly depreciation rate is 0.025, then the annual depreciation rate is $1 - (1 - 0.025)^4 \approx 0.1$. The disutility of working χ is set to 1.0. These parameter values are widely used in the macroeconomic literature. The inverse Frisch elasticity of labour supply ϕ is 1.0, which is the same value used by Blanchard and Galí (2010). The quit rate σ is 0.15, which is the same as that of Cabo and Martín-Román (2019). As is the case with Dufourt, Nishimura, and Venditti (2015), α is set to 0.3. The initial productivity level is set to 1.0. It is assumed that $K_0 = K_{T+1} = K$ and $h_{-n} = h_{-n+1} = \ldots = h_{-1} = h_{T-n+1} = h_{T-n+2} = \ldots = h_T = h$, which are the steady-state values of capital and new hiring, respectively. In the steady-state, $Y_{t+1} = Y_t = Y$, $C_{t+1} = C_t = C$, $I_{t+1} = I_t = I$, $K_{t+1} = K_t = K$, $L_{t+1} = L_t = L$, $h_{t+1} = h_t = h$, $R_{t+1} = R_t = R$, $w_{t+1} = w_t = w$, and $A_{t+1} = A_t = A$ are obtained. Then, from equations (1)–(4) and (6)–(9), the steady-state values are obtained.

2.2. Employment period and economic fluctuations

The employment period is expressed by $n + 1$, and the cases of $n = 0$, $n = 1$, $n = 2$, and $n = 3$ are examined in the analysis.

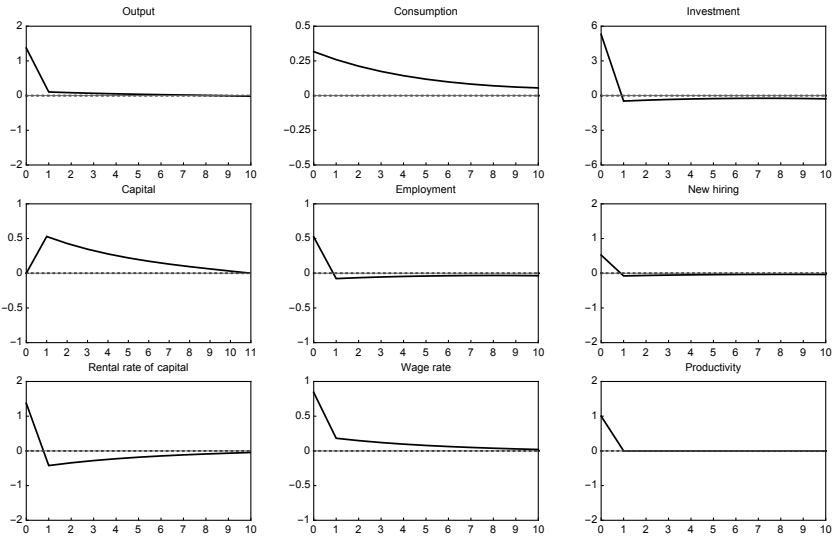

Figure 2. Response to the productivity shock with $n = 0$
Source: Own work.

It is supposed that a positive temporary shock in productivity occurs in period 0: the productivity level increases by 1% in period 0 and returns to the initial level in period 1. In the numerical experiments, it is assumed that $T = 10$. Figure 2 depicts the reaction to the shock when $n = 0$, which is the case of $L_t = h_t$. The solid line expresses the percentage deviation of the variables when the shock takes place from their steady-state values, and the dotted line shows the case without the shock. The positive productivity shock increases output, the marginal product of capital, and the marginal product of labour. Capital, employment, rental rate of capital and wage rate are then raised by the increase in the demand for capital and labour. Consumption and investment are increased by an increase in income.

Figures 3–5 show the reaction to the shock when $n = 1$, $n = 2$, and $n = 3$, respectively. The solid line expresses the percentage deviation of the variables when the shock takes place from their steady-state values and the dotted line shows the case without the shock. It is assumed as follows: $h_{-1} = h_{10}$ is given if $n = 1$, $h_{-2} = h_{-1} = h_9 = h_{10}$ is given if $n = 2$, and $h_{-3} = h_{-2} = h_{-1} = h_8 = h_9 = h_{10}$ is given if $n = 3$. An oscillatory response is shown in the cases of $n = 1$, $n = 2$, and $n = 3$. The response is particularly observed in the movements of new hiring. The employment is adjusted by both increasing and decreasing new hiring even though the shock is a temporary increase in productivity. The DGE

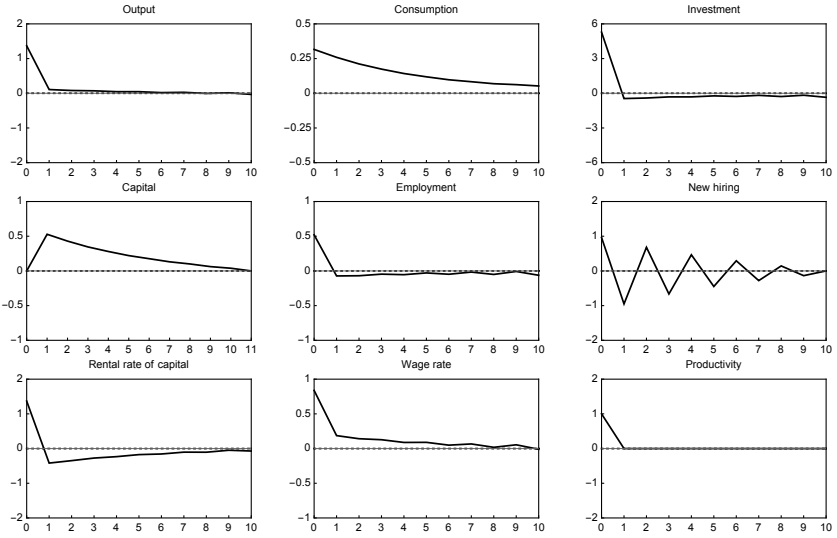

Figure 3. Response to the productivity shock with $n = 1$
Source: Own work.

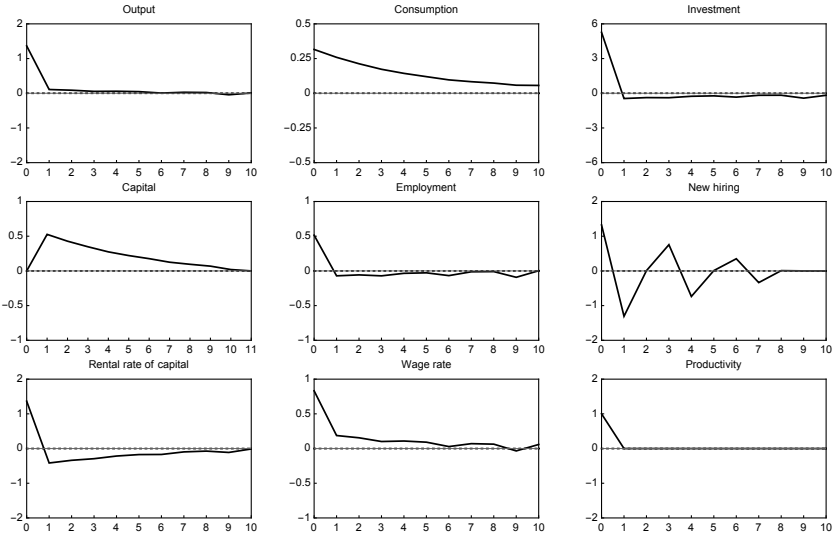

Figure 4. Response to the productivity shock with $n = 2$
Source: Own work.

framework with the explicit employment period has a property similar to the dynamic labour demand model with the explicit employment period discussed in Matsue (2018).

The workers are employed for multiple periods when $n \geq 1$, and the employment periods are overlapped in this situation. The increase in new hiring in period 0 increases employment not only in period 0 but also in subsequent

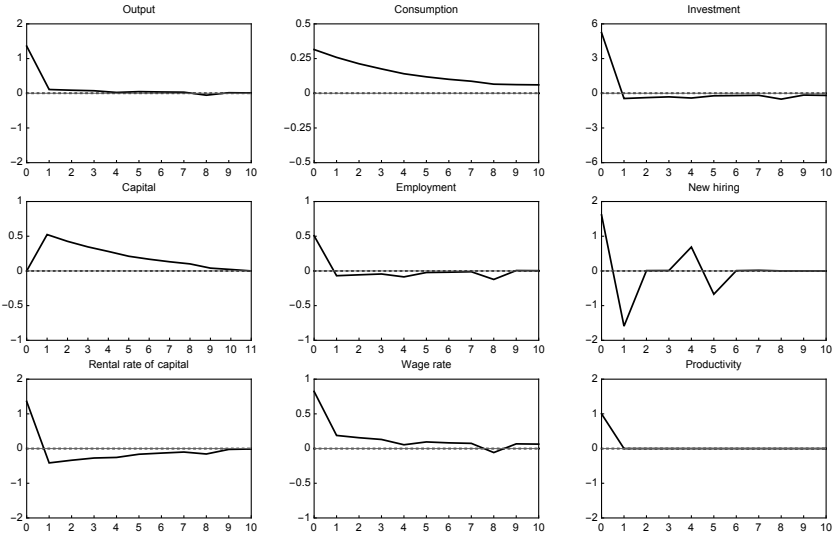

Figure 5. Response to the productivity shock with $n = 3$
Source: Own work.

periods, and the firm should decrease new hiring to avoid hiring excess labour in subsequent periods. Thereafter, the firm needs to increase new hiring again because the decrease in new hiring brings a lack of employment. These adjustments are repeated throughout the planning periods. As a result, the oscillatory response is observed.

Proposition 1
A temporary shock in productivity brings about oscillatory responses in a dynamic general equilibrium model with an explicit employment period.

Figures 2–5 show that the percentage change in new hiring is high when the employment period is long. The increase in the employment period lowers the ratio of new hires to employees in each period. Then the firm needs a high percentage change in new hiring in order to achieve a similar level of employment as when the employment period is short.

Proposition 2
A longer employment period amplifies fluctuations in new hiring.

2.3. Labour supply and quit rate

We discuss the effects of change in the inverse Frisch elasticity of labour supply ϕ and the quit rate σ on economic fluctuations. The other parameters are the same as those in previous part. It is also assumed that the temporary productivity shock takes place at period 0.

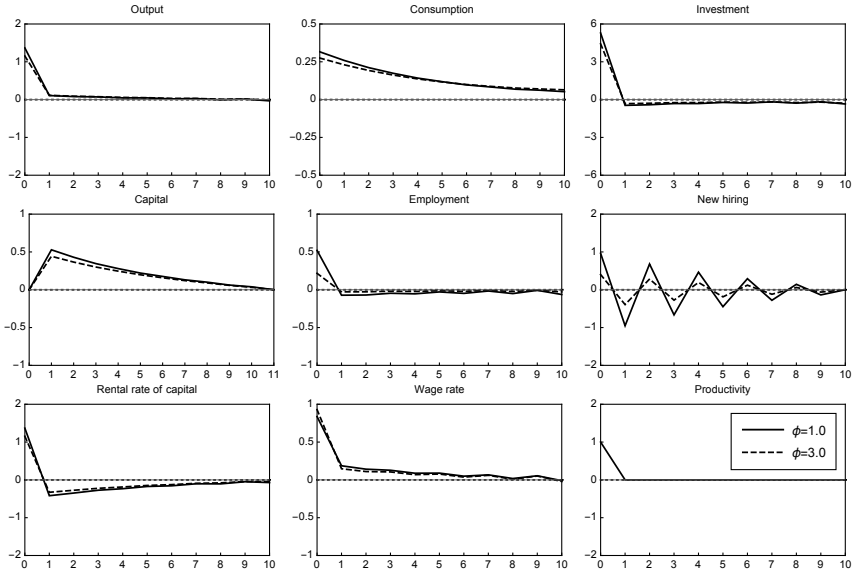

Figure 6. Response to the productivity shock with $\phi = 1.0$ and $\phi = 3.0$
Source: Own work.

Figure 6 shows the reaction to the shock when $n = 1$. The solid line expresses the case with $\phi = 1.0$, the dashed line represents the case with $\phi = 3.0$, and the dotted line shows the case without the shock. The increasing in ϕ reduces the

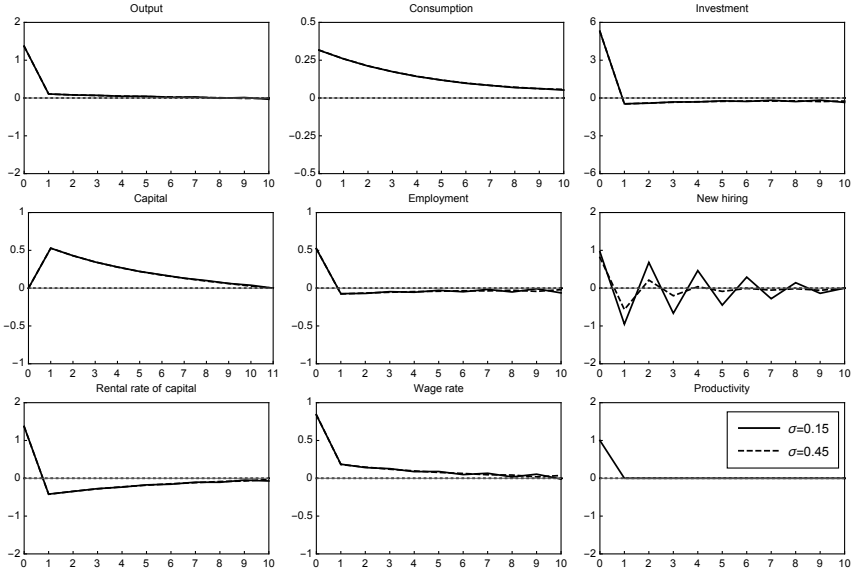

Figure 7. Response to the productivity shock with $\sigma = 0.15$ and $\sigma = 0.45$
Source: Own work.

Frisch elasticity of labour supply. The responses of variables with $\phi = 3.0$ are lower than for the case with $\phi = 1.0$, except for the response of wage rate. The oscillatory response is also observed in this case.

Figure 7 shows the reaction to the shock when $n = 1$. The solid line expresses the case with $\sigma = 0.15$, the dashed line represents the case with $\sigma = 0.45$, and the dotted line shows the case without the shock. The response of new hiring is reduced when the large σ is supposed. The change in quit rate have a limited impact on the behaviour of other variables. If it is assumed that $\sigma = 1$, then the model with $n \geq 1$ is the same with the case of $n = 0$. Therefore, the reaction is the same with Figure 2 when $\sigma = 1$.

Conclusions

This study presents a DGE framework with an explicit employment period. In the numerical experiments, the oscillatory response to the temporary productivity shock regarding new hiring and employment are observed. The numerical experiments also show that the shock causes significant fluctuations in new hiring when the employment period is long.

In the labour market analysis, the effects of some frictions such as labour adjustment costs and trade unions on fluctuations in employment are investigated. This framework could be extended to examine the frictions.

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