Employment fluctuations in a dynamic model with long-term and short-term contracts

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18 December 2019

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May 2022

Abstract

Fluctuations in employment are a central issue in labour market literature, and they have been investigated in many empirical and theoretical studies. This study constructs a model with adjustment costs and explicit employment contract duration and analyses the employment fluctuations in a productivity shock. The long- and short-term contracts differ in the stickiness of employment adjustments and explicit employment duration. The model shows an oscillatory behaviour of employment in the shock, which is not observed in an adjustment cost model. Our study shows that a high adjustment cost leads to a high short-term employment ratio and a decrease in employment fluctuations. The adjustment cost helps to smooth employment fluctuations, which is consistent with the result in a standard dynamic labour demand model. In addition, this study shows that a high quit rate leads to high variations in long- and short-term employment due to shock and results in high employment fluctuations.

JEL classification: E24; J23; J32; J41; D90

Keywords: employment dynamics; dynamic labour demand; labour market institutions; adjustment cost; employment duration

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*The author acknowledges financial support from JSPS KAKENHI Grant Number JP18K12808.

1. Introduction

Labour market institutions are reformed frequently, which affects employment dynamics. Short-term contracts, such as fixed-term contracts (FTCs) and temporary agency work, are part of labour market institutions and are adopted in numerous countries.[1] Portugal and Varejão (2009) point out that FTCs are used to save costs, screen for permanent positions, and for temporary replacements. Givord and Wilner (2015) focus on the differences in short-term contracts in respect of career prospects and show that FTCs are used as stepping stones to permanent positions. Nunziata and Staffolani (2007), using data from European countries, discover the same role of FTCs. Moreover, Faccini (2014) shows that the transition of temporary workers to permanent positions is frequent in most European countries.

In some studies on dual labour market theory, heterogeneous labour is represented as having different employment adjustment costs. If the difference in contract durations could be interpreted as a difference in adjustment costs, then another framework is not required. However, the nature of dynamics of the models with explicit employment contract durations is different from the nature of dynamics of the adjustment cost model, as pointed out in Matsue (2018). This study constructs a model not only with adjustment costs but also explicit employment contract durations and analyses employment fluctuations through numerical experiments.

Some studies investigate the relationship between employment protection legislation (EPL) and temporary jobs. Banker et al. (2013) note that the strictness of EPL is a reliable proxy variable for labour adjustment costs. The results, based on the analysis of data from some OECD countries, show that a stricter EPL is associated with higher stickiness. Centeno and Novo (2012) analyse the effects of employment protection of permanent contracts in the Portuguese labour market, and indicate that stringent protection increases dependence on FTCs. Hijzen et al. (2017) investigate the effects of employment protection on the composition of the labour force and turnover in Italy and show that the incidence of temporary work increased when firms faced more stringent employment protection for permanent contracts. Sala et al. (2012) point out that the proportion of temporary contracts tends to be high when the EPL on permanent contracts are relatively high, the firing costs are high, or the renewal and duration of temporary contracts are limited in OECD countries.

The relationship between EPL and fluctuations in employment has also been studied. Gnocchi et al. (2015) examine the labour market reforms from the 1970s to 2000s in some OECD countries and point out that the reforms relaxing EPL increase employment volatility. Faccini and Bondibene (2012) study

[1]Cahuc et al. (2016) explain the regulations on the temporary contracts in some OECD countries. The temporary employment incidence and composition in OECD countries are listed in OECD (2017), p. 205. Also, the shares of temporary employment in total employment in the European countries are listed in Eichhorst et al. (2017), p. 4, and this share in the US is described in Yang (2018), p. 412. The shares of temporary workers by industry and country in some European countries are shown in Damiani et al. (2016), p. 596.

labour market institutions and the cyclical behaviour of unemployment rates in OECD countries. The findings indicate that the EPL for workers reduces the volatility of unemployment rates. Sala et al. (2012) show that the higher the cost of firing temporary and permanent employees and the more severely limited the use of FTCs, the lower the fluctuations in unemployment in the simulation analysis. By contrast, the empirical evidences on Okun's law does not show conclusive results. Ball et al. (2019) and Ball et al. (2017) find little relationship between employment protection and the Okun's coefficient; that is, strong employment protection does not reduce the effects of the change in output on fluctuations in the unemployment rate. Bande and Martín-Román (2018) and Porras-Arena and Martín-Román (2019) investigate Okun's coefficients for Spanish regions and discover high variations in unemployment rates despite equal employment protection.

In a theoretical analysis of an economy in which long- and short-term contracts coexist, the differences between the contracts include stickiness of employment adjustments, employment duration, and types of jobs and skills. Berton and Garibaldi (2012) assume that permanent employment depends on worker turnover, whereas a firm can fire the temporarily employed at will. Blanchard and Landier (2002) suppose that firms hire workers in entry-level jobs, who are then retained in a regular job if not laid off. According to Caggese and Cuñat (2008), Cahuc et al. (2016) and Cahuc and Postel-Vinay (2002), permanent contracts do not have a predetermined duration, and firms must pay a firing cost if they fire those in permanent employment; however, temporary contracts stipulate a fixed duration, and firms do not incur firing costs at the end of the contracts. Yang (2018) also assumes that firms pay a fixed firing cost when firing permanent employees. Smith (2007) supposes that the difference between permanent and temporary jobs is that the duration of a permanent contract is infinite, whereas that of a temporary contract is finite.

This study also assumes that the difference between long- and short-term contracts relates to the stickiness of employment adjustments and employment duration and analyses the responses of employment to productivity shock. The duration of long-term contracts is two periods, and that of short-term contracts is one period. Matsue (2018) focuses on the fixed employment duration and produces two types of dynamic labour demand models: one with FTCs, and the other with indefinite term contracts (ITCs). The study shows that an expected productivity shock causes an oscillatory behaviour of employment in the FTC model but not in the ITC model. This study shows that the same property in the FTC model is also observed when long- and short-term employment coexist. This assumption about the long- and short-term contracts is also discussed by Macho-Stadler et al. (2014).

In the numerical analysis, we investigate the effects of adjustment costs for long-term employment on fluctuations in labour demand. We find that the responses of long-term new hiring, long-term employment, short-term employment, and total employment are small when firms pay a high adjustment cost. The adjustment cost plays a role in smoothing employment fluctuations. Moreover, the fluctuations in short-term employment are more than those in long-term employment, which is in line with Caggese and Cuñat (2008) and Yang (2018). Caggese and Cuñat (2008) indicate, using Italian data, that the fluctuations in fixed-term employment are more than those in permanent employment. Yang (2018) shows that high volatility in temporary employment is observed in the US labour market. In addition, the effects of the quit rate on employment fluctuations are analysed. We find that the responses of long-term employment, short-term employment, and total employment to a shock are large when the quit rate is high.

The contributions of this study are as follows: the theoretical analysis indicates that the short-term employment ratio is raised by the increase in adjustment cost in a steady-state; we confirm that a productivity shock causes an oscillatory behaviour of employment in the model where long- and short-term employment coexist; the model shows that the productivity shock causes large employment fluctuations when the adjustment cost is low or quit rate is high. The framework may be one method for analysing the dual labour market.

The rest of the paper is organised as follows. Section 2 sets up a simple model and discusses its properties. Section 3 extends the model and investigates the effects of adjustment cost and quit rate on fluctuations in labour demand. Section 4 concludes the study.

2. Simple model

Consider a dynamic model that can analyse the economy in which long- and short-term contracts coexist. A firm plans its production during the finite period T. The inputs to production are long-term employment L_t^l and short-term employment L_t^s. The objective function of the firm takes the following form:

$$V = \sum_{t=0}^{T} \beta^t \left[F\left(L_t^l, L_t^s; A_t\right) - w^l L_t^l - w^s L_t^s\right],$$

where $0 < \beta < 1$ is a discount factor, $A_t > 0$ is a productivity parameter, $w^l > 0$ is the wage of a long-term contract, and $w^s > 0$ is the wage of a short-term contract. It is assumed that the firm enters a long-term contract or a short-term contract with labour: The term of long-term contracts is two periods, and that of short-term contracts is one period. Then, the long-term employment at period t is the sum of the long-term new hiring at period t and $t-1$, that is $L_t^l = h_t^l + h_{t-1}^l$. The short-term employment at period t is equal to the short-term new hiring at period t, that is $L_t^s = h_t^s$. Further, h_{-1}^l, h_0^l, h_T^l and h_{T+1}^l are given as also L_0^l and L_{T+1}^l are given. The firm decides the number of newly hired workers $\left(h_1^l, h_2^l, \cdots, h_{T-1}^l\right)$ and $\left(h_0^s, h_1^s, \cdots, h_T^s\right)$ to maximise V. The same assumption of contract duration is discussed in Macho-Stadler et al. (2014). First-order conditions for long-term employment are as follows:

$$\sum_{i=t}^{t+1} \beta^i F_{L^l}(L_i^l, L_i^s; A_i) = \sum_{i=t}^{t+1} \beta^i w^l, t = 1,2,\cdots,T-1. \tag{1}$$

First-order conditions for short-term employment are as follows:

$$F_{L^s}(L_t^l, L_t^s; A_t) = w^s, t = 0,1,\cdots,T. \tag{2}$$

The left-hand sides of Equations (1) and (2) express the marginal product of labour, and the right-hand sides express the marginal cost of labour. Short-term employment is chosen by a firm to maximise its current profit because there is no intertemporal element.

Suppose that the production function is a multiplicative form that satisfies $F_{L^l} > 0$, $F_{L^lL^l} < 0$, $F_{L^lL^s} > 0$, $F_{L^s} > 0$, $F_{L^sL^s} < 0$, $F_{L^sL^l} > 0$, $F_A > 0$, $F_{L^lA} > 0$, and $F_{L^sA} > 0$. Then, Equation (2) is transformed as follows:

$$L_t^s = G(L_t^l;\ A_t), t = 0,1,\cdots,T. \tag{3}$$

Substituting Equation (3) into Equation (1), we have the following:

$$\sum_{i=t}^{t+1} \beta^i F_{L^l}(L_i^l; A_i) = \sum_{i=t}^{t+1} \beta^i w^l, t = 1,2,\cdots,T-1. \tag{4}$$

From Equations (3), (4), and $dL_t^l = dh_t^l + dh_{t-1}^l$, we obtain results of the comparative dynamics.

Let us specify that the planning period equals 5, that is, $T = 4$. The model structure is illustrated in Figure 1. At the periods 0 and 5, the long-term new hiring is given by: $\bar{h}_{-1}^l$, $\bar{h}_0^l$, $\bar{h}_4^l$, $\bar{h}_5^l$. At period 0, the long-term employment L_0^l is a sum of the long-term new hiring $\bar{h}_0^l$ and $\bar{h}_{-1}^l$, who are hired at periods 0 and -1, respectively. The short-term employment at period 0 is equal to short-term new hiring at period 0, that is $L_0^s = h_0^s$. Then, the total employment at period 0 is the sum of the long-term employment L_0^l and short-term employment L_0^s. Similarly, at period 1, the long-term employment L_1^l equals to the sum of h_1^l and $\bar{h}_0^l$. The short-term employment at period 1 is $L_1^s = h_1^s$. Then, the total employment at period 1 equals the sum of L_1^l and L_1^s. The long-term, short-term, and total employment in the other period follow the same structure.

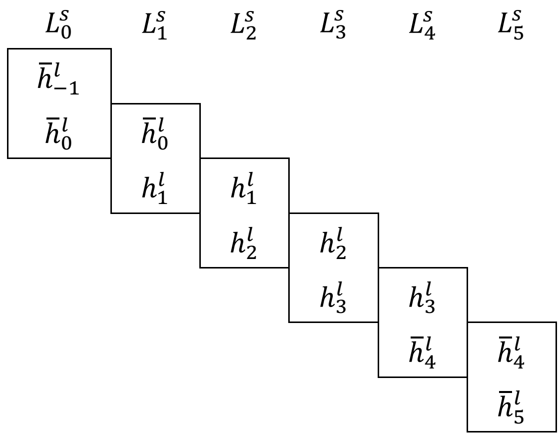

Figure 1. The model with $T = 4$

Table 1. The effects of the change in A_i on h_j^l

	h_1^l	h_2^l	h_3^l
A_1	$+$	$-$	$+$
A_2	$+$	$+$	$-$
A_3	$-$	$+$	$+$
A_4	$+$	$-$	$+$

Table 2. The effects of the change in A_i on L_j^l

	L_1^l	L_2^l	L_3^l	L_4^l
A_1	$+$	$+$	$-$	$+$
A_2	$+$	$+$	$+$	$-$
A_3	$-$	$+$	$+$	$+$
A_4	$+$	$-$	$+$	$+$

Table 3. The effects of the change in A_i on L_j^s

	L_1^s	L_2^s	L_3^s	L_4^s
A_1	$+$	$+$	$-$	$+$
A_2	$+$	$+$	$+$	$-$
A_3	$-$	$+$	$+$	$+$
A_4	$+$	$-$	$+$	$+$

Table 4. The effects of the change in A_i on $L_j^l + L_j^s$

	$L_1^l + L_1^s$	$L_2^l + L_2^s$	$L_3^l + L_3^s$	$L_4^l + L_4^s$
A_1	$+$	$+$	$-$	$+$
A_2	$+$	$+$	$+$	$-$
A_3	$-$	$+$	$+$	$+$
A_4	$+$	$-$	$+$	$+$

Suppose that an expected temporary positive productivity shock takes place. Then the comparative dynamic results are summarised in Tables 1–4. The signs in the tables express the effects of the change in A_i on h_j^l, L_j^l, L_j^s, $L_j^l + L_j^s$, that is $sign(dh_j^l/dA_i)$, $sign(dL_j^l/dA_i)$, $sign(dL_j^s/dA_i)$, and $sign(d(L_j^l + L_j^s)/dA_i)$. In the planning periods, the firm both increases and decreases each type of employment despite the positive productivity shock. If the positive productivity shock takes place at period 1, the firm increases h_1^l to increase L_1^l. Then, if the firm does not decrease h_2^l, the firm undertakes too much long-term employment at period 2 because $L_2^l = h_2^l + h_1^l$. Similarly, the firm increases h_3^l to avoid too little long-term employment at period 3. The short-term employment is also adjusted to the change in long-term employment. These decisions lead to an oscillatory behaviour of employment. Both long- and short-term employment face the same change. Matsue (2018) also shows the oscillatory behaviour of labour demand using a dynamic labour demand model. The input is only labour, and the firm makes a fixed-term contract with labour in the model. The same mechanism of labour adjustment is discussed in Matsue (2018). The results in this study indicate that this behaviour is also observed in the model with long- and short-term employment.

In the dynamic labour demand literature, adjustment cost models are widely used.[2] As pointed out by Matsue (2018), they do not show oscillatory behaviour. If a positive shock takes place, the firm increases new hiring to adjust the total employment for the period. Then, the firm does not decrease employment during planning periods.

3. Numerical experiments

To consider the effects of changes in adjustment cost and quit rate on employment dynamics, we extend the model discussed in Section 2.

3.1 Baseline model

It is assumed that the firm incurs an adjustment cost and the long-term employment quits are at a constant rate at the end of the period in which he/she is hired. The adjustment cost includes, for example, the cost of advertising job positions, interviewing, and training. The objective function of the firm takes the following form:

$$V = \sum_{t=0}^{T} \beta^t \left[F\left(L_t^l, L_t^s; A_t\right) - w^l L_t^l - w^s L_t^s - \frac{1}{2}\tau\left(h_t^l\right)^2 \right],$$

where $\tau > 0$ is the adjustment cost of long-term new hiring. This type of adjustment cost function is also discussed in Cabo and Martín-Román (2019), Campbell and Orszag (1998), and Galí and van Rens (2010).[3] The long-term employment at period t is the sum of the long-term new hiring at period t and the long-term new hires at $t-1$ who did not quit, that is $L_t^l = h_t^l + (1-\delta)h_{t-1}^l$, where $0 < \delta < 1$ is the quit rate. The short-term employment at period t is short-term new hiring at period t, that is $L_t^s = h_t^s$. Also, h_{-1}^l, h_0^l, h_T^l and h_{T+1}^l are given; then L_0^l and L_{T+1}^l are given. The firm decides the number of newly hired workers $\left(h_1^l, h_2^l, \cdots, h_{T-1}^l\right)$ and $(L_0^s, L_1^s, \cdots, L_T^s)$ to maximise V. First-order

[2]Bentolila and Saint-Paul (1994) and Saint-Paul (1996) discuss dynamic labour demand models with adjustment costs. Cabo and Martín-Román (2019) discuss the dynamic labour demand literature in detail. Hamermesh and Pfann (1996) expound the property of the adjustment cost model.

[3]Some studies using quadratic adjustment costs are listed in Appendix A.

conditions for long-term employment are as follows:

$$\sum_{i=t}^{t+1} \beta^i F_{L^l}(L_i^l, L_i^s; A_i) = \beta^t(w^l + \tau h_t^l) + \beta^{t+1}(1-\delta)w^l, t = 1,2,\cdots,T-1. \quad (5)$$

First-order conditions for short-term employment are as follows:

$$F_{L^s}(L_t^l, L_t^s; A_t) = w^s, t = 0,1,\cdots,T. \quad (6)$$

In the numerical analysis, we suppose that the production function is $F(L_t^l, L_t^s; A_t) = A_t(L_t^l)^\alpha (L_t^s)^\gamma$, $\alpha > 0$, $\gamma > 0$ and $0 < \alpha + \gamma < 1$. Then, Equation (5) is as follows.

$$\sum_{i=t}^{t+1} \beta^i \alpha(1-\delta)^{i-t} A_i[h_i^l + (1-\delta)h_{i-1}^l]^{\alpha-1}(L_i^s)^\gamma$$
$$= \beta^t(w^l + \tau h_t^l) + \beta^{t+1}(1-\delta)w^l, t = 1,2,\cdots,T-1, \quad (7)$$

where $L_t^l = h_t^l + (1-\delta)h_{t-1}^l$. Similarly, Equation (6) is as follows.

$$\gamma A_t[h_t^l + (1-\delta)h_{t-1}^l]^\alpha (L_t^s)^{\gamma-1} = w^s, t = 0,1,\cdots,T. \quad (8)$$

We consider the case of $T = 10$. The discount factor β is set to 0.96. The adjustment cost parameter τ is 0.1 and the quit rate δ is 0.15, which are the same as the values used in Cabo and Martín-Román (2019).[4] The parameters α and γ are set to 0.4. The wage rates w^l and w^s are set to 0.5. The initial productivity level A is 1.0. It is supposed that h_{-1}^l, h_0^l, h_{10}^l and h_{11}^l are set to the steady-state value of long-term new hiring, and L_0^l and L_{11}^l are the steady-state values of long-term employment.[5] The steady-state value of short-term employment ratio $L^s/(L^l + L^s)$ is 0.5046.

Suppose that the temporary productivity shock takes place at period 1: The productivity increases by one percent at period 1 and then returns to the original at period 2. The results of the baseline simulation are presented in Figure 2. The short-term employment is more volatile than long-term employment, which is in line with Caggese and Cuñat (2008) and Yang (2018). Caggese and Cuñat (2008) indicate, using Italian data, that the fluctuations in fixed-term employment are more than those in permanent employment. Yang (2018) shows that high volatility of temporary employment is observed in the US labour market.

If it is assumed that all long-term employment quit at the end of the first period in which they are hired ($\delta = 1$), there are no adjustment costs ($\tau = 0$) and no wage differences ($w^l = w^s$), and parameters in production function are the same ($\alpha = \gamma$), then the difference between long- and short-term employment does not exist. Then, the firm adjusts employment only during the shock, and the response of long-term employment equals that of short-term employment.

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[4]See Cabo and Martín-Román (2019), p. 122, footnote 26. Blatter et al. (2012) show a histogram of average hiring costs to fill a vacancy using Swiss administrative firm-level survey data (p. 26). Booth and Francesconi (2000) indicate that 8.88% of men and 9.47% of women in full-time employment voluntarily quit their jobs each year in Britain (p. 178, 180). Fairise and Fève (2006) suppose that the quit rate equals to 0.015, which roughly matches the average destruction rate in the US manufacturing sector from 1972 to 1993 (p. 101). Silva and Toledo (2009) analyse the US labour market and assume an exogenous separation probability in the simulation (p. 85). Goux et al. (2001) use French data and show that the voluntary quit rate is about 4% of the work force each year (p. 547).

[5]The steady-state value, and are shown in Appendix B.

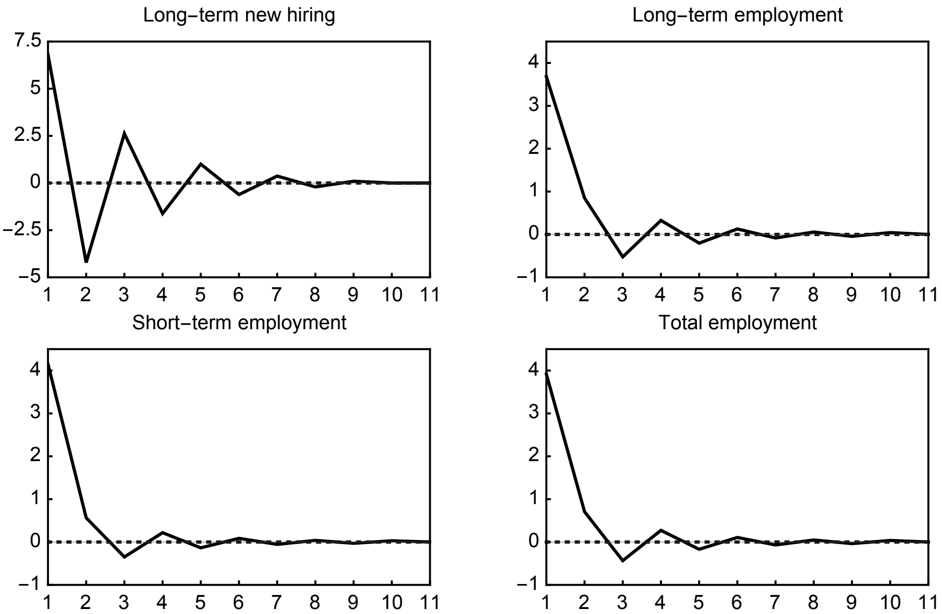

Figure 2. Employment response in baseline simulations

Note: The solid line shows the percentage deviation of the variables from their steady-state values when the temporary productivity shock takes place. The dotted line represents the case without the shock.

3.2 Adjustment cost and fluctuations in labour demand

In this section, we present an analysis of the effects of the adjustment cost on employment dynamics. The same parameters are used in the baseline simulation except for the adjustment cost, which is now set as $\tau = 0.3$. It is also assumed that the temporary productivity shock takes place at period 1, which has a one percent increase in productivity.

The short-term employment ratio in the steady-state is 0.5123, which is larger than in the baseline case. The high adjustment cost results in the model's high short-term employment ratio. The result is supported by the literature on labour market institutions. The strictness of EPL is one of the proxy variables for labour adjustment costs. Centeno and Novo (2012) indicate that stringent protection increases dependence on FTCs. Hijzen et al. (2017) point out that temporary contracts increase when the employment protection for permanent contracts is strict. Sala et al. (2012) show that the proportion of temporary contracts tends to be high when the EPL on permanent contracts are at a relatively high level.

The results of numerical experiments are presented in Figure 3. The responses of all variables are smaller than those in the baseline simulations. The adjustment cost plays a role in smoothing the employment fluctuations, which is similar to the result found in the literature on dynamic labour demand (e.g., Nickell, 1986). Moreover, the simulation results agree with those presented by Faccini and

Bondibene (2012). This indicates that the EPL for permanent workers reduces the volatility of unemployment rates.

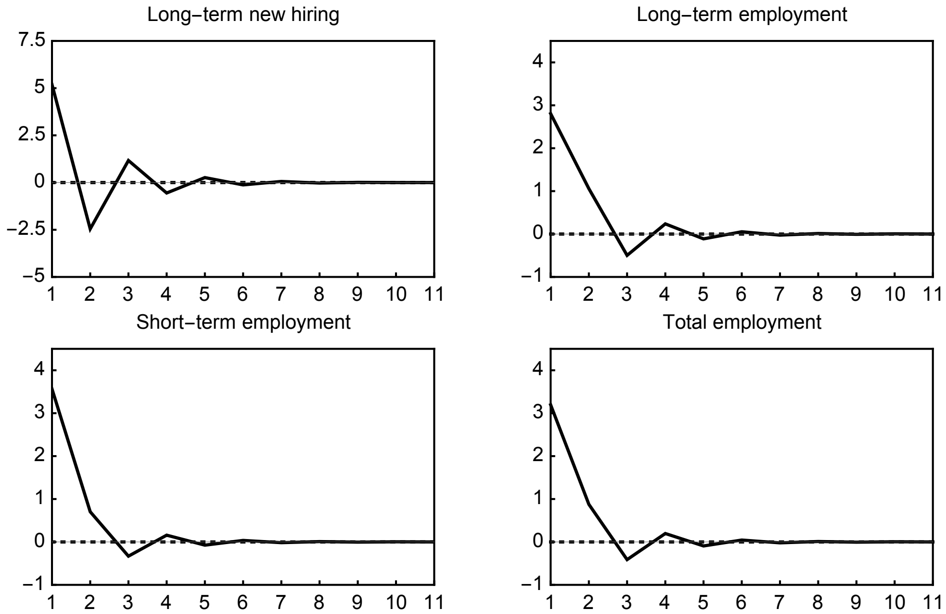

Figure 3. Employment response with high adjustment cost

Note: The solid line shows the percentage deviation of the variables from their steady-state values when the temporary productivity shock takes place. The dotted line represents the case without the shock.

3.3 Quit rate and fluctuations in labour demand

Let us analyse the relationship between the quit rate and employment fluctuations. The same parameters are used in the baseline simulations except for the quit rate, which is now set as $\delta = 0.45$. It is also supposed that the temporary productivity shock takes place at period 1, which has a one percent increase in productivity.

The short-term employment ratio in the steady-state is 0.5063, which is larger than in the baseline case. The results of the numerical experiments are presented in Figure 4. The responses of long-term employment, short-term employment, and total employment are larger than that of the baseline simulations, whereas the response of long-term new hiring is smaller. The firm increases long- and short-term employment substantially. Thus, when the quit rate is high, the volatility of total employment increases.

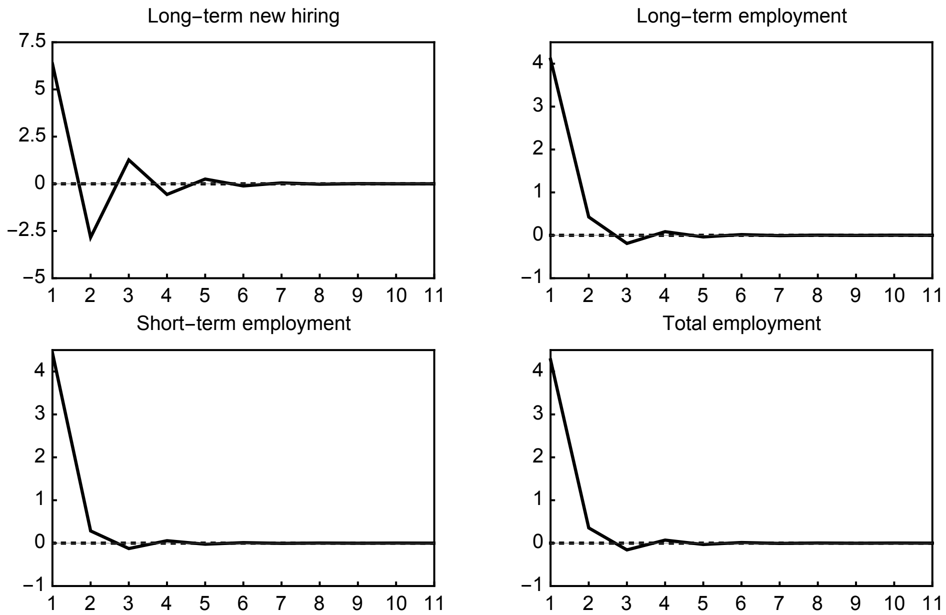

Figure 4. Employment response with a higher quit rate

Note: The solid line shows the percentage deviation of the variables from their steady-state values when the temporary productivity shock takes place. The dotted line represents the case without the shock.

4. Concluding remarks

The relationship between the composition of the labour force and employment dynamics has been investigated in a number of studies. This study presents a framework that can analyse an economy in which long- and short-term contracts coexist. The theoretical analysis suggests that a productivity shock causes an oscillatory behaviour of employment in the model with long- and short-term employment. We also investigate the effects of adjustment cost and quit rate on fluctuations in labour demand through numerical experiments. The model shows that the response of employment to the productivity shock is small when the adjustment cost is high or the quit rate is low.

This study has some limitations. The model in this study is restricted to a simple case in which the term of long-term contracts is only two periods. It should be analysed further using more scenarios. In this study, we focus on the labour demand side. The model can be extended to consider the supply side of labour. Future research should focus on these issues in greater depth.

Appendix A. Quadratic adjustment costs

The adjustment costs include, for example, costs of advertising job positions, interviewing, training, disruption of production cost, and severance pay. They are expressed as an adjustment cost function in theoretical and empirical models. In the literature, a quadratic adjustment cost function is frequently assumed. Then, the adjustment costs depend on some variables, as shown in Table A1. Variables in the table indicate the components of adjustment costs. The adjustment cost functions are formulated in various forms. Lapatinas (2009) also discusses other adjustment cost models: quadratic adjustment costs and disruption of production costs model, quadratic adjustment costs and fixed costs model, and quadratic adjustment costs, fixed costs, and disruption of production costs model.

Table A1. Quadratic labour adjustment costs

Literature	Variables
Akıncı and Chahrour (2018)	Growth rate of working hours.
Belo et al. (2014)	Output, firing, hiring and employment level.
Bloom (2009)	Firing, hiring and employment level.
Cabo and Martín-Román (2019)	Firing, hiring and wage.
Campbell and Orszag (1998)	Firing and hiring.
Cooper and Willis (2009)	Employment growth and employment level.
Fairise and Fève (2006)	Hiring, turnover and employment level.
Galí and van Rens (2010)	Firing and hiring.
Hall (2004)	Employment growth, employment level and wage/product price.
Ju et al. (2014)	Difference between employment level and steady-state level of employment.
Lapatinas (2009)	Employment growth and employment level.
Vogel (2017)	Wage and change in employment level.

Appendix B. Steady-state values in numerical experiments

To consider the steady-state value of long-term employment, we assume that $h_{t+1}^l = h_t^l = h^l$, $L^l = (2-\delta)h^l$, $L_t^s = L^s$ and $A_{t+1} = A_t = A$ in Equation (7). Then, the following equation is obtained.

$$L^l = \left(\frac{[1+\beta(1-\delta)]\alpha(2-\delta)A(L^s)^\gamma}{[1+\beta(1-\delta)](2-\delta)w^l+\tau L^l}\right)^{\frac{1}{1-\alpha}} \quad \text{(A1)}$$

From $L^l = (2-\delta)h^l$, Equation (A1) is transformed as follows.

$$h^l = \left(\frac{[1+\beta(1-\delta)]\alpha(2-\delta)A(L^s)^\gamma}{[1+\beta(1-\delta)](2-\delta)w^l+\tau L^l}\right)^{\frac{1}{1-\alpha}} \frac{1}{2-\delta}, \quad \text{(A2)}$$

which is the steady-state value of long-term new hiring. It is supposed that $h_{t+1}^l = h_t^l = h^l$, $L^l = (2-\delta)h^l$, $L_t^s = L^s$ and $A_t = A$ in Equation (8). Then, we can transform the equation as follows.

$$L^s = \left(\frac{\gamma A}{w^s}\right)^{\frac{1}{1-\gamma}} \left(L^l\right)^{\frac{\alpha}{1-\gamma}}, \quad \text{(A3)}$$

which is the steady-state value of short-term employment. From Equations (A1)–(A3), we obtain the steady-state value of h^l, L^l and L^s in the numerical experiments.

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