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

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Abstract

Fluctuations in employment are one of the central issues in the labor market literature and have been investigated in a number of empirical and theoretical studies. This study presents a dynamic framework that can analyze the economy in which long-term and short-term contracts coexist. The particular differences between long-term and short-term contracts are stickiness of employment adjustments and explicit employment duration. The simulation results show that the large short-term employment ratio and the high quit rate lead to the high variations in employment. Moreover, they indicate that the large adjustment cost and the long employment duration bring about decreased employment fluctuations.

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

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

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1. Introduction

Labor market institutions are reformed frequently, which affects employment dynamics. Short-term contracts such as fixed-term contracts (FTC) and temporary agency work are part of labor market institutions and they are adopted in many countries.[1] Portugal and Varejão (2009) point out that FTC are used for saving costs, screening for permanent positions, and temporary replacement. Givord and Wilner (2015) focus on the differences in short-term contracts in the context of the career prospects; using French data, they show that FTC are used as stepping stones to permanent positions. Nunziata and Staffolani (2007), using data from some European countries, also find the same role for FTC. Moreover, Faccini (2013) shows that the transitions of temporary workers to permanent positions are frequent in most European countries.

Some studies investigate the relationship between employment protection legislation (EPL) and temporary jobs. OECD (2017) points out that the strict employment protection for regular workers promotes using temporary contracts in OECD countries. Centeno and Novo (2012) analyze the effects of employment protection of open-ended contracts in the Portuguese labor market and indicate that stringent protection increases dependence on FTC. Hijzen et al. (2017) investigate the effects of employment protection on the composition of the labor force and turnover in Italy and show that temporary contracts are increased when firms face more stringent employment protection for permanent contracts. Moreover, Banker et al. (2013) point out that the strictness of EPL is a reliable proxy variable for labor adjustment costs. The results, based on the analysis of data from some OECD countries, show that the stricter EPL is related to higher stickiness.

The relationship between EPL and fluctuations in employment has also been studied. Gnocchi et al. (2015) examine the labor market reforms from the 1970s to the 2000s in some OECD countries and point out that the reforms relaxing EPL increase employment volatility. Faccini and Bondibene (2012) study the labor market institutions and cyclical behavior of the unemployment rate in OECD countries. Their findings indicate that the EPL for permanent workers reduces the volatility of unemployment rates. In addition, the employment fluctuations are studied from different perspectives. OECD (2017) indicates that the response of unemployment rates to aggregate demand shock is amplified when there is a high incidence of temporary work. de Serres and Murtin (2013) show that increases in the share of temporary workers brings high variations in unemployment.

In a theoretical analysis of an economy in which long-term and short-term contracts coexist, the difference between the contracts are assumed when focusing on factors such as stickiness of

[1]Cahuc et al. (2016) explain the regulations about the temporary contracts in some OECD countries.

employment adjustments, employment duration, and types of jobs and skills. Berton and Garibaldi (2012) assume that decreasing permanent employment depends on worker turnover, whereas the firm can fire the temporary employment at will. Blanchard and Landier (2002) suppose that firms hire workers in entry-level jobs, who are then retained in a regular job if they are not laid off. In Cahuc et al. (2016), Cahuc and Postel-Vinay (2002), and Caggese and Cuñat (2008), the permanent contracts do not have predetermined duration, firms pay a firing cost if they fire those in permanent employment, temporary contracts stipulate a fixed duration, and the firms do not incur firing costs at the end of the contracts. Smith (2007) supposes that the difference between permanent and temporary jobs is that the duration of permanent contract is infinite, whereas that of temporary contract is finite. Yang (2017) assumes that firms pay a fixed firing cost when they fire non-temporary workers and supposes a difference in labor productivity.

This paper also assumes the difference between long-term and short-term contracts focusing on stickiness of employment adjustments and employment duration, and analyzes the employment fluctuations. In the baseline model, it is assumed that the firm makes an agreement for a long-term or a short-term contract with labor: The duration of long-term contracts is two periods and the duration of short-term contracts is one period. The assumption about the long-term and short-term contracts is also discussed in Macho-Stadler et al. (2014). Moreover, Matsue (2018) focuses on the fixed employment duration and produces two types of dynamic labor demand models: One with FTC and the other with indefinite term contracts (ITC). It shows that an expected productivity shock does not cause the oscillatory behavior of employment in the ITC model, while it does in the FTC model. This paper shows that the same property in the FTC model is also observed in the model when long-term and short-term employment coexist.

In the simulation analysis, we first investigate the relationship between short-term employment ratio and fluctuations in labor demand. It shows that high variations in long-term and short-term employment lead to high variations in total employment when the short-term employment ratio is large, which is consistent with OECD (2017) and de Serres and Murtin (2013). Second, the effects of the adjustment cost for long-term employment on fluctuations in labor demand are analyzed. It indicates that the fluctuations in long-term new hiring, long-term employment, short-term employment and total employment with no adjustment cost case is more volatile than that with an adjustment cost case, which is consistent with Faccini and Bondibene (2012). The adjustment cost plays a role in smoothing the employment fluctuations. Moreover, the fluctuations in short-term employment is more volatile than that of long-term employment when the firm incurs the adjustment cost, which is supported by Caggese and Cuñat (2008) and Yang (2017). Third, the higher volatility of long-term new hiring, long-term employment, short-term employment and total employment are obtained when the voluntary quit rate is high. Finally, we examine the relationship between employment duration and fluctuations in labor demand. The assumption of explicit employment duration enables us to analyze the effects of extending employment duration on employment dynamics. It corresponds to, for example, retirement extension. Then, the fluctuations in long-term new hiring, long-term employment, short-term employment, and total employment are decreased when the employment duration is extended.

The rest of the paper is organized as follows. Section 2 sets up a simple model and discusses its properties. Section 3 extends the model and investigates, using simulation analysis, the effects of change in employment ratio, adjustment cost, voluntary quit rate, and employment duration on fluctuations in labor demand. Section 4 concludes the paper.

2. Simple model

Consider a dynamic model that can analyze the economy in which long-term and short-term contracts coexist. A firm plans its production during the finite time 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:

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

where $0 < \beta < 1$ is a discount factor, $A_t > 0$ is 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 into a long-term contract or a short-term contract with labor: The term of long-term contracts is two periods and the term of short-term contracts is one period. Then, the long-term employment at period t is 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 the short-term new hiring at period t, that is $L_t^s = h_t^s$. Also, h_0^l, h_{-1}^l, h_{T+1}^l and h_T^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 $\left(h_0^s, h_1^s, \cdots, h_T^s\right)$ to maximize V. The same assumption of contract duration is discussed in Macho-Stadler et al. (2014). First-order conditions for long-term employment is as follows:

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

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

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

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

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

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

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

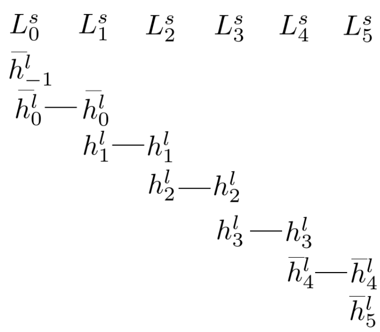


Fig. 1 The model with $T = 4$

Let us specify the planning period equals 5, that is, $T = 4$. The model structure is illustrated in Figure 1. In the periods at 0 and 5, the long-term new hiring is given: $\bar{h}_{-1}^l$, $\bar{h}_0^l$, $\bar{h}_4^l$, $\bar{h}_5^l$. In the period at 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 a 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, in the period at 1, the long-term employment L_1^l equals to 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 are the same structure.

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 as summarized in Tables 1–4. The sign 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 employment in spite of the positive productivity shock that takes place. 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 employs 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 together with the change in long-term employment. These decisions lead to the oscillatory behavior of employment. The long-term and short-term employment face the same change. Matsue (2018) also indicates the oscillatory behavior of labor demand using a dynamic labor demand model. The input is only labor, and then the firm makes an agreement for a fixed-term contract with labor in the model. The same mechanism of labor adjustment is discussed in the paper. The results in this paper indicate that the behavior is also observed in the model with long-term and short-term employment.

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

3. Numerical experiments

To consider the effects of change in adjustment cost, voluntary quit rate, and employment duration on employment dynamics, we extend the model in section 2. Moreover, the relationship between short-term employment ratio and employment dynamics is analyzed using the model.

3.1. Baseline model

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

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

where $\tau > 0$ is the adjustment cost of long-term new hiring. This type of adjustment cost function is

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

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 hire at $t-1$ who does not quit, that is $L_t^l = h_t^l + (1-\delta)h_{t-1}^l$. 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_0^l, h_{-1}^l, h_{T+1}^l and h_T^l are given, then L_0^l and L_{T+1}^l are given. The firm decides the number of newly hired workers $(h_1^l, h_2^l, \cdots, h_{T-1}^l)$ and $(h_0^s, h_1^s, \cdots, h_T^s)$ to maximize V. First-order conditions for long-term employment are as follows:

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

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

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

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, (5) is as follows.

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

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

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

Then, (8) is expressed as follows:

$$L_t^s = \left(\frac{\gamma A_t}{w^s}\right)^{\frac{1}{1-\gamma}} \left[h_t^l + (1-\delta)h_{t-1}^l\right]^{\frac{\alpha}{1-\gamma}}, t = 0,1,\cdots,T. \quad (9)$$

Substitute (9) into (7) to eliminate L_t^s.

$$\sum_{i=t}^{t+1} \beta^i \alpha (1-\delta)^{i-t} \left(\frac{\gamma}{w^s}\right)^{\frac{\gamma}{1-\gamma}} A_i^{\frac{1}{1-\gamma}} \left[h_i^l + (1-\delta)h_{i-1}^l\right]^{\frac{-1+\alpha+\gamma}{1-\gamma}}$$
$$= \beta^t(w^l + \tau h_t^l) + \beta^{t+1}(1-\delta)w^l, t = 1,2,\cdots,T-1. \quad (10)$$

Suppose that the firm plans for production from period 0 to 10 ($T = 10$). In the beginning of the planning period, it is assumed that the economy is at a steady state. Then, the long-term employment at period 0 is $\bar{L}_0^l = \bar{h}_0^l + (1-\delta)\bar{h}_{-1}^l = 100$. The terminal condition is long-term employment $\bar{L}_{11}^l = \bar{h}_{11}^l + (1-\delta)\bar{h}_{10}^l = 100$.[4] The baseline parameters are set as in Table 5. The adjustment cost parameter τ and the quit rate δ are the same values used in Cabo and Martín-Román (2019).[5] The parameters α and γ are set in order to generate a steady state short-term employment

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

[4]The derivation of steady state value $\bar{h}_{-1}^l = \bar{h}_0^l = \bar{h}_{10}^l = \bar{h}_{11}^l = h^l$ and L^s, and the derivation of initial productivity level are shown in Appendix B.

[5]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)

ratio ($L^s/(L^l+L^s)$) equals 0.11 (11%). The steady state short-term employment ratio roughly matches the ratio of OECD weighted average discussed in OECD (2017).[6] OECD (2015) indicates that the temporary workers' hourly wages are around 70% of the median hourly wages of permanent workers in some OECD countries.[7] Then, we set $w^l = 1.0$ and $w^s = 0.7$. Additionally, the discount factor $\beta = 0.96$ is assumed.

Table 5. Baseline parameters

Parameter		Value
α	Parameters in production function	0.686083
γ	Parameters in production function	0.014927
β	Discount factor	0.96
w^l	Wage of long-term employment	1.0
w^s	Wage of short-term employment	0.7
δ	Voluntary quit rate	0.15
τ	Adjustment cost	0.1

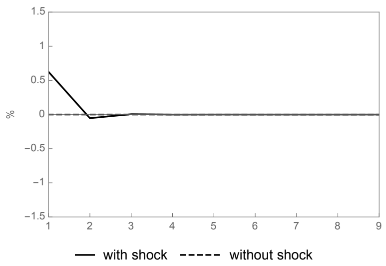
The initial productivity level is 23.6953, which is chosen by having $\bar{L}_0^l = 100$. Suppose that the expected temporary productivity shock takes place at period 1: The productivity increases one percent at period 1 and then returns at period 2. The baseline simulation results are represented in Figure 2, which shows the deviation of long-term new hiring, long-term employment, short-term employment, and total employment when the positive shock takes place from their steady state values, respectively. It is observed that the deviations are the largest at the shock period, and all variables then gradually return to each steady state value. In the steady state, the long-term new hiring and short-term employment are hired as much as the labor who quits. The employment fluctuations and steady state values in the baseline simulations are shown in Table 6. The fluctuations in employment are measured by using the coefficient of variation (CV). The short-term employment is more volatile than long-term employment, which matches empirical evidence. Caggese and Cuñat (2008) indicate that the

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) analyze the US labor market and assume an exogenous separation probability is 0.065 in the simulation (p.85). Goux et al. (2001) show that the voluntary quit rate is about 4% of the work force each year, which use French data (p.547).

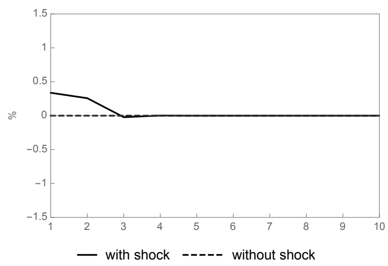
[6] See OECD (2017), p.205. Also, the shares of temporary employment in total employment in European countries are listed in Eichhorst et al. (2017), page 4 of 17, and the share in the US is described in Yang (2017), p.5. The shares of temporary workers by industry and country in some European countries are shown in Damiani et al. (2016), p.596.

[7] See OECD (2015), p.153.

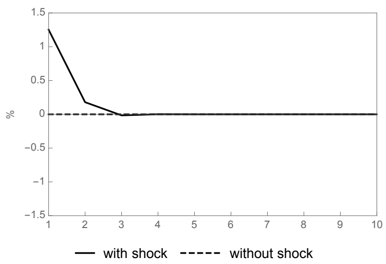
fluctuations in fixed-term employment are more volatile than that of permanent employment using Italian data. Yang (2017) shows that the high volatility of temporary employment is observed in the US labor market.



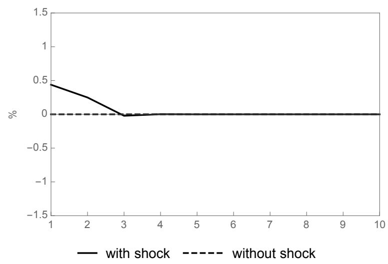
(a) Long-term new hiring



(b) Long-term employment



(c) Short-term employment



(d) Total employment

Fig. 2 Employment fluctuations in baseline simulations

Table 6. Steady state values and CV in baseline simulation

	h_t^l	L_t^l	$L_t^s = h_t^s$	$L_t^l + L_t^s$
Steady state	54.0541	100	12.3596	112.3596
CV	0.00210697	0.00128038	0.00393852	0.00152591

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

3.2. Short-term employment ratio and fluctuations in labor demand

One of the main interests of this paper is to analyze the effect of increasing short-term employment ratio on employment dynamics. Consider the situation produced when a firm has a large short-term employment ratio. It is assumed that the steady state short-term employment ratio ($L^s/(L^l + L^s)$) is 0.2 (20%) or 0.3 (30%). The same parameters are used in the baseline simulation except for the parameters in production function α and γ: If $\alpha = 0.6704929$ and $\gamma = 0.0295071$, then the steady state short-term employment ratio is 0.2, and if $\alpha = 0.650895$ and $\gamma = 0.049105$, then the steady state short-term employment ratio is 0.3. It is supposed that the expected temporary productivity shock takes place at period 1, which is a one percent increase in productivity.

Table 7. Steady state values and CV with short-term employment ratio is 0.2 (20 %)

	h_t^l	L_t^l	$L_t^s = h_t^s$	$L_t^l + L_t^s$
Steady state	54.0541	100	25	125
CV	0.00213306	0.00129531	0.00398957	0.00176652

The employment fluctuations and steady state values with employment ratio equaling 0.2 are shown in Table 7. The initial productivity level is 24.5967, which is chosen by having $\bar{L}_0^l = 100$.[8] The fluctuations in long-term new hiring, long-term employment, short-term employment, and total employment are more volatile than that of baseline simulations. Moreover, the high variations in long-term and short-term employment lead to the high variations in total employment.

Table 8. Steady state values and CV with short-term employment ratio is 0.3 (30 %)

	h_t^l	L_t^l	$L_t^s = h_t^s$	$L_t^l + L_t^s$
Steady state	54.0541	100	42.8571	142.8571
CV	0.00217063	0.00131706	0.00406251	0.00206182

The employment fluctuations and steady state values with short-term employment ratio equaling 0.3 are shown in Table 8. The initial productivity level is 25.3551, which is chosen by having $\bar{L}_0^l = 100$. The fluctuations in all variables are more volatile than when short-term employment ratio equals 0.2. The firm copes with the shock by making a large adjustment in employment when the short-term

[8]The derivation of steady state value h^l and L^s, and the derivation of initial productivity level are the same as the baseline model, which is shown in Appendix B.

employment ratio is large. In other words, the employment fluctuations are easily influenced by the shock when the short-term employment ratio is large. OECD (2017) indicates that the response of the unemployment rate to aggregate demand shock is amplified when temporary work is at high incidence. de Serres and Murtin (2013) show that the increasing share of temporary workers brings high variations of unemployment. The simulation results could be supported by these findings.

3.3. Adjustment cost and fluctuations in labor demand

In this section, we present an analysis of the effects of adjustment cost on employment dynamics. The same parameters are used in the baseline simulation except for the adjustment cost $\tau = 0$. The initial productivity level is 6.0828, which is chosen by having $\bar{L}_0^l = 100$.[9] It is assumed that the expected temporary productivity shock takes place at period 1, which is a one percent increase in productivity.

(a) Long-term new hiring (b) Long-term employment

(c) Short-term employment (d) Total employment

Fig. 3 Employment fluctuations without adjustment cost

Table 9. Steady state values and CV without adjustment cost

	h_t^l	L_t^l	$L_t^s = h_t^s$	$L_t^l + L_t^s$
Steady state	54.0541	100	3.10812	103.108
CV	0.0371019	0.0105709	0.01058	0.0105709

[9]The derivation of steady state value h^l and L^s, and the derivation of initial productivity level are the same as the baseline model (Appendix B).

The simulation results are represented in Figure 3, which shows the deviation of long-term new hiring, long-term employment, short-term employment, and total employment when the positive shock takes place from their steady state values. It shows that all variables fluctuate in the planning periods. The employment fluctuations and steady state values with no adjustment cost case are shown in Table 9. The steady state short-term employment ratio ($L^s/(L^l + L^s)$) is 0.0301 (3.01%), which is lower than the baseline case. The fluctuations in long-term and short-term employment are comparable to the level in the no adjustment cost case. Both the fluctuations in long-term and short-term employment with no adjustment cost case are more volatile than that of the baseline simulations. The adjustment cost plays a role in smoothing the employment fluctuations, which is the same result found in the literature on dynamic labor demand (e.g., Nickell 1986). Moreover, the simulation results could be supported by Faccini and Bondibene (2012), who indicate that the EPL for permanent workers reduces the volatility of unemployment rates.

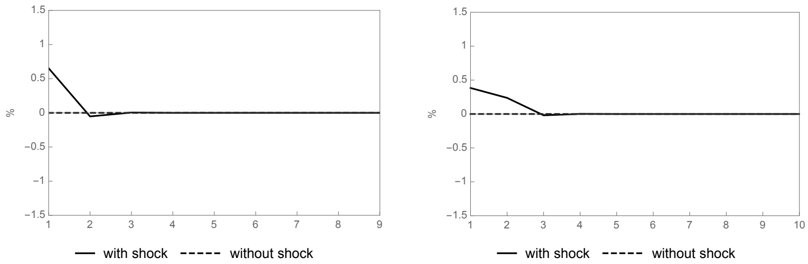
3.4. Quit rate and fluctuations in labor demand

Let us analyze the relationship between voluntary quit rate and employment fluctuations. The same parameters are used in the baseline simulations except for the quit rate $\delta = 0.3$. The initial productivity level is 26.8714, which is chosen by having $\bar{L}_0^l = 100$.[10] The productivity is at a higher level than that of the baseline case. It is supposed that the expected temporary productivity shock takes place at period 1, which is a one percent increase in productivity.

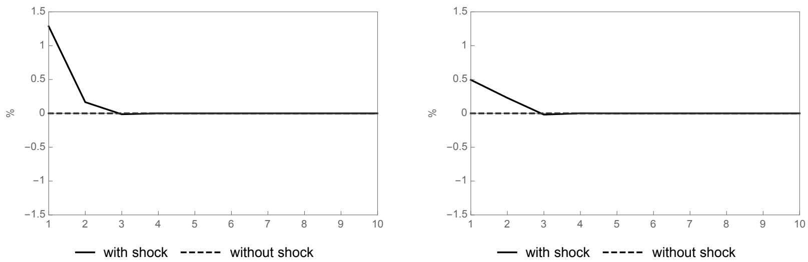
The simulation results are described in Figure 4, which shows the deviation of long-term new hiring, long-term employment, short-term employment, and total employment when the positive shock takes place from their steady state values. The same behavior in the baseline simulations are observed. The employment fluctuations and steady state values with high quit rate are shown in Table 10. The steady state short-term employment ratio ($L^s/(L^l + L^s)$) is 0.123 (12.3%), which is higher than that of the baseline case. The fluctuations in long-term new hiring, long-term employment, short-term employment, and total employment are more volatile than that of the baseline simulations. In this situation, many long-term employees quit at the end of the first period in which they are hired. Then, the firm greatly increases the long-term new hiring to increase the long-term employment greatly in the period in which the shock takes place, and it brings a high variation of long-term new hiring and long-term employment. The fluctuations in short-term employment also increase with the change in long-term employment. Therefore, the higher volatility of total employment is obtained when the quit

[10]The derivation of steady state value h^l and L^s, and the derivation of initial productivity level are same as the baseline model (Appendix B).

rate is high.



(a) Long-term new hiring (b) Long-term employment



(c) Short-term employment (d) Total employment

Fig. 4 Employment fluctuations with quit rate is 0.3

Table 10. Steady state values and CV with quit rate is 0.3

	h_t^l	L_t^l	$L_t^s = h_t^s$	$L_t^l + L_t^s$
Steady state	58.8235	100	14.043	114.043
CV	0.00220049	0.0013644	0.00403859	0.00165749

3.5. Employment duration and fluctuations in labor demand

In this section, we discuss the relationship between employment duration and employment dynamics. The retirement extension, for example, corresponds to the analysis in this section. In addition to the analysis in common with the previous studies about dynamic labor demand, the assumption of the explicit employment duration enables us to analyze the effects of extending employment duration on employment dynamics.

The objective function of a firm is the same as in the baseline model. The long-term employment at period t is the sum of the long-term new hiring at period t, $t-1$ and $t-2$. Then, the constant rate δ of new hiring quits a job in the end of each period, that is, $L_t^l = h_t^l + (1-\delta)h_{t-1}^l + (1-\delta)^2 h_{t-2}^l$. 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_0^l, h_{-1}^l, h_{-2}^l, h_{T+1}^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 $\left(h_1^l, h_2^l, \cdots, h_{T-2}^l\right)$ and $(h_0^s, h_1^s, \cdots, h_T^s)$ to maximize V. First-order conditions for long-term employment are as follows:

$$\sum_{i=t}^{t+2} \beta^i F_{L^l}\left(L_i^l, L_i^s; A_i\right) = \beta^t(w^l + \tau h_t^l) + \beta^{t+1}(1-\delta)w^l + \beta^{t+2}(1-\delta)^2 w^l,$$
$$t = 1,2,\cdots,T-2. \qquad (11)$$

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

$$F_{L^s}\left(L_t^l, L_t^s; A_t\right) = w^s, t = 0,1,\cdots,T. \qquad (12)$$

It is assumed that the production function is the same as previous section $F\left(L_t^l, L_t^s; A_t\right) = A_t\left(L_t^l\right)^\alpha (L_t^s)^\gamma$, then (11) is as follows.

$$\sum_{i=t}^{t+2} \beta^i \alpha(1-\delta)^{i-t} A_i\left[h_i^l + (1-\delta)h_{i-1}^l + (1-\delta)^2 h_{i-2}^l\right]^{\alpha-1}(L_i^s)^\gamma$$
$$= \beta^t(w^l + \tau h_t^l) + \beta^{t+1}(1-\delta)w^l + \beta^{t+2}(1-\delta)^2 w^l,$$
$$t = 1,2,\cdots,T-2, \qquad (13)$$

where $L_t^l = h_t^l + (1-\delta)h_{t-1}^l + (1-\delta)^2 h_{t-2}^l$. Similarly, (12) is transformed as follows.

$$\gamma A_t\left[h_t^l + (1-\delta)h_{t-1}^l + (1-\delta)^2 h_{t-1}^l\right]^\alpha (L_t^s)^{\gamma-1} = w^s, t = 0,1,\cdots,T. \qquad (14)$$

Then, (14) is expressed as follows:

$$L_t^s = \left(\frac{\gamma A_t}{w^s}\right)^{\frac{1}{1-\gamma}}\left[h_t^l + (1-\delta)h_{t-1}^l + (1-\delta)^2 h_{t-2}^l\right]^{\frac{\alpha}{1-\gamma}}, t = 0,1,\cdots,T. \qquad (15)$$

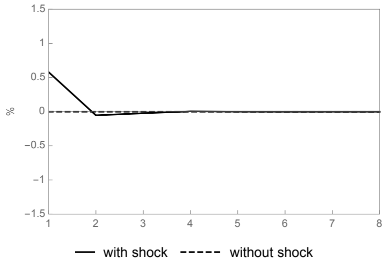
Substituting (15) into (13) to eliminate L_t^s, we obtain:

$$\sum_{i=t}^{t+2} \beta^i \alpha(1-\delta)^{i-t}\left(\frac{\gamma}{w^s}\right)^{\frac{\gamma}{1-\gamma}} A_i^{\frac{1}{1-\gamma}}\left[h_i^l + (1-\delta)h_{i-1}^l + (1-\delta)^2 h_{i-2}^l\right]^{\frac{-1+\alpha+\gamma}{1-\gamma}}$$
$$= \beta^t(w^l + \tau h_t^l) + \beta^{t+1}(1-\delta)w^l + \beta^{t+2}(1-\delta)^2 w^l,$$
$$t = 1,2,\cdots,T-2. \qquad (16)$$

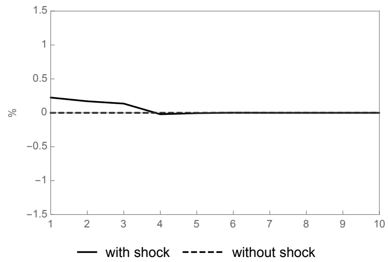
As in the previous sections, if $\delta = 1$, $\tau = 0$, $w^l = w^s$ and $\alpha = \gamma$ are assumed, then the difference between long-term and short-term employment does not exist.

The same parameters are used in the baseline simulation, which is listed in Table 5. In the beginning of the planning period, the economy is at a steady state. It is assumed that the long-term employment at period 0 is $\bar{L}_0^l = \bar{h}_0^l + (1-\delta)\bar{h}_{-1}^l + (1-\delta)^2\bar{h}_{-2}^l = 100$. The terminal condition is long-term employment $\bar{L}_{11}^l = \bar{h}_{11}^l + (1-\delta)\bar{h}_{10}^l + (1-\delta)^2\bar{h}_9^l = 100$. The initial productivity level is 15.3922, which is chosen by having $\bar{L}_0^l = 100$.[11] Similarly to the previous sections, it is supposed that the expected temporary productivity shock takes place at period 1, which is a one percent increase in productivity.

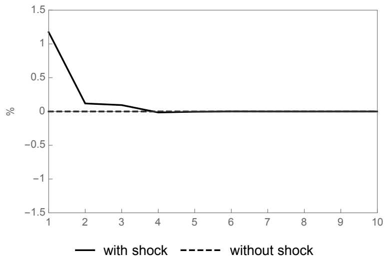
[11]The derivation of steady state value $\bar{h}_{-2}^l = \bar{h}_{-1}^l = \bar{h}_0^l = \bar{h}_9^l = \bar{h}_{10}^l = \bar{h}_{11}^l = h^l$ and L^s, and the derivation of initial productivity level are shown in Appendix C.



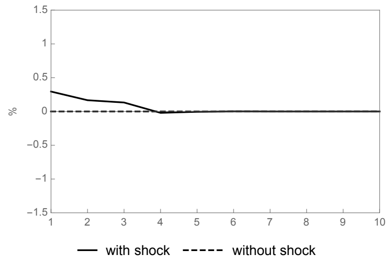
(a) Long-term new hiring



(b) Long-term employment



(c) Short-term employment



(d) Total employment

Fig. 5 Employment fluctuations with long-term employment duration lasts three periods

Table 11. Steady state values and CV with long-term employment duration is three periods

	h_t^l	L_t^l	$L_t^s = h_t^s$	$L_t^l + L_t^s$
Steady state	38.8727	100	7.97629	107.97629
CV	0.00209041	0.000899301	0.00366559	0.00105506

The simulation results are described in Figure 5, which shows the deviation of long-term new hiring, long-term employment, short-term employment, and total employment when a positive shock takes place from their steady state values. In the planning periods, as is the case with the long-term employment works for two periods, the firm both increases and decreases employment in spite of the positive productivity shock. Moreover, it is observed that the shock is absorbed in longer periods when the employment duration is longer. The employment fluctuations and steady state values with longer contract durations are shown in Table 11. The steady state short-term employment ratio $(L^s/(L^l + L^s))$ is 0.0739 (7.39%), which is lower than the baseline case. The variations in long-term new hiring, long-term employment, short-term employment and total employment are smaller than that of baseline simulations. The firm copes with the shock by making a small adjustment in long-term new hiring. Then, the lower fluctuations in long-term employment are observed. In addition, the short-term employment is adjusted together with the change in long-term employment. Therefore, a lower volatility of total employment is obtained.

4. Concluding remarks

The relationship between the composition of the labor force and employment dynamics has been investigated in a number of studies. This paper presents a framework that can analyze an economy in which long-term and short-term contracts coexist, and explains some facts about employment dynamics. We investigate the effects of change in short-term employment ratio, adjustment cost, voluntary quit rate, and employment duration on fluctuations in labor demand by simulation analysis. The model shows that the large short-term employment ratio and the high quit rate lead to the high variations in employment. Moreover, it indicates that the large adjustment cost and long employment duration decrease fluctuations in employment.

The model in this study is restricted to a simple case in which the term of long-term contracts is only two or three periods. It should be analyzed further using a more general case. In this paper, we focus on the labor demand side. The model can be extended to consider the supply side of labor. Additional study of these issues should be undertaken in future research.

Appendix A. Quadratic adjustment costs

Table A1. Quadratic labor adjustment costs

Literatures	Variables
Akinci 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.

The adjustment costs include, for example, 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 demonstrate that the adjustment costs depend upon which variables are used in each study. The adjustment cost functions are formulated in various forms.

Lapatinas (2009) also discusses the 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.

Appendix B. Steady state values in baseline model

It is assumed that the initial productivity level of A equals the steady state value of A in the baseline simulations. Suppose 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 (7), we can transform the equation as follows.

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

Suppose 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 (9), we can transform the equation as follows.

$$L^s = \left(\frac{\gamma A}{w^s}\right)^{\frac{1}{1-\gamma}} (L^l)^{\frac{\alpha}{1-\gamma}}, \qquad \text{(A2)}$$

which is the steady state value of short-term employment. Substitute (A2) into (A1) to eliminate L_t^s. Then, the steady state value of A is obtained.

$$A = \left(\frac{[1+\beta(1-\delta)](2-\delta)w^l + \tau L^l}{[1+\beta(1-\delta)]\alpha(2-\delta)\left(L^l\right)^{\alpha-1}}\right)^{1-\gamma} \left(\frac{1}{L^l}\right)^{\alpha\gamma} \left(\frac{w^s}{\gamma}\right)^{\gamma} \qquad \text{(A3)}$$

To consider the steady state value of long-term new hiring h^l, 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 (7). Then, the following equation is obtained.

$$L^l = \left(\frac{[1+\beta(1-\delta)]\alpha(2-\delta)A(L^s)^{\gamma}}{[1+\beta(1-\delta)](2-\delta)w^l + \tau L^l}\right)^{\frac{1}{1-\alpha}} \qquad \text{(A4)}$$

From $L^l = (2-\delta)h^l$, (A4) is transformed as follows.

$$h^l = \left(\frac{[1+\beta(1-\delta)]\alpha(2-\delta)A(L^s)^{\gamma}}{[1+\beta(1-\delta)](2-\delta)w^l + \tau L^l}\right)^{\frac{1}{1-\alpha}} \frac{1}{2-\delta}, \qquad \text{(A5)}$$

which is the steady state value of long-term new hiring. From (A2), (A3) and (A5), we obtain the steady state value of h^l, L^s and A in the baseline simulations. Then, we suppose that $L^l = \bar{L}_0^l = \bar{L}_{11}^l = 100$.

Appendix C. Steady state values in the model with longer employment duration

It is assumed that the initial productivity level of A equals the steady state value of A in the model with longer employment duration. In the model, the long-term employment work for 3 period. Suppose that $h_{t+1}^l = h_t^l = h^l$, $L^l = (3 - 3\delta + \delta^2)h^l$, $L_t^s = L^s$ and $A_{t+1} = A_t = A$ in (13), we have the following.

$$A = \frac{[1+\beta(1-\delta)+\beta^2(1-\delta)^2](3-3\delta+\delta^2)w^l+\tau L^l}{[1+\beta(1-\delta)+\beta^2(1-\delta)^2]\alpha(3-3\delta+\delta^2)(L^l)^{\alpha-1}(L^s)^\gamma} \tag{A6}$$

Suppose that $h_{t+1}^l = h_t^l = h^l$, $L^l = (3 - 3\delta + \delta^2)h^l$, $L_t^s = L^s$ and $A_t = A$ in (15), we can transform the equation as follows.

$$L^s = \left(\frac{\gamma A}{w^s}\right)^{\frac{1}{1-\gamma}} (L^l)^{\frac{\alpha}{1-\gamma}}, \tag{A7}$$

which is the steady state value of short-term employment. Substitute (A7) into (A6) to eliminate L_t^s. Then, we have the steady state value of A.

$$A = \left(\frac{[1+\beta(1-\delta)+\beta^2(1-\delta)^2](3-3\delta+\delta^2)w^l+\tau L^l}{[1+\beta(1-\delta)+\beta^2(1-\delta)^2]\alpha(3-3\delta+\delta^2)(L^l)^{\alpha-1}}\right)^{1-\gamma} \left(\frac{1}{L^l}\right)^{\alpha\gamma} \left(\frac{w^s}{\gamma}\right)^\gamma \tag{A8}$$

In order to derive steady state value of h^l, we assume $h_{t+1}^l = h_t^l = h^l$, $L^l = (3 - 3\delta + \delta^2)h^l$, $L_t^s = L^s$ and $A_{t+1} = A_t = A$ in (13). Then, we can transform the equation as follows.

$$L^l = \left(\frac{[1+\beta(1-\delta)+\beta^2(1-\delta)^2]\alpha(3-3\delta+\delta^2)A(L^s)^\gamma}{[1+\beta(1-\delta)+\beta^2(1-\delta)^2](3-3\delta+\delta^2)w^l+\tau L^l}\right)^{\frac{1}{1-\alpha}} \tag{A9}$$

From $L^l = (3 - 3\delta + \delta^2)h^l$ and (A9), the steady state value of long-term new hiring is obtained.

$$h^l = \left(\frac{[1+\beta(1-\delta)+\beta^2(1-\delta)^2]\alpha(3-3\delta+\delta^2)A(L^s)^\gamma}{[1+\beta(1-\delta)+\beta^2(1-\delta)^2](3-3\delta+\delta^2)w^l+\tau L^l}\right)^{\frac{1}{1-\alpha}} \frac{1}{3-3\delta+\delta^2} \tag{A10}$$

From (A7), (A8) and (A10), we obtain the steady state value of h^l, L^s and A in the simulations with longer employment duration. Then, we suppose that $L^l = \bar{L}_0^l = \bar{L}_{11}^l = 100$.

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