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―Empirical Evidence from Japanese Industry Data

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The Estimation of Asymmetric Adjustment Costs for the Number of Workers and Working Hours
—Empirical Evidence from Japanese Industry Data*

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Abstract

In this paper, we investigate the asymmetry of adjustment costs for labour. Using monthly data on Japanese industries, we estimate a model of dynamic labour demand that incorporates adjustment costs for hiring and firing workers, and for changing working hours. Our estimates suggest the following. (1) It is more costly to fire workers than to hire them in all industries. (2) This asymmetry between hiring and firing costs is more important for production sectors than for non-production sectors. (3) It is much less costly to adjust working hours than to adjust the number of workers.

Keywords: Adjustment costs; Dynamic labour demand; Working hours
JEL Classification: J23; J32

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1. Introduction

The structure of adjustment costs for labour has been investigated in many studies. When firms experience a shock in their technology or product demand, they adjust the labour force, given these adjustment costs. Therefore, to understand firms' employment adjustment, it is important to estimate the structure of adjustment costs for labour.

Early empirical research on firms' employment adjustment typically assumes that adjustment costs are symmetric, convex and quadratic. Hence, dynamic labour demand is described by a single partial adjustment equation. However, there are several problems with these assumptions. A problem with the assumption of symmetry is that it implies that hiring and firing cost functions are equal.[§] Jaramillo et al. (1993) estimate Euler equations for a dynamic labour demand model that allows for asymmetry between hiring and firing. Based on panel data on Italian firms, their empirical study rejects the hypothesis of symmetric adjustment costs. Pfann and Palm (1993) also found that adjustment costs are asymmetric by using time series data on the manufacturing sectors of the Netherlands and the UK. More recently, in the context of fixed-term contracts, which can be adjusted more cheaply than permanent contracts, Goux et al. (2001) have investigated the structure of adjustment costs (the asymmetry of adjustment costs for permanent employees and the relative costs of adjustment for workers on fixed-term contracts.) However, none of the papers has investigated the structure of adjustment costs when firms can adjust employment by changing working hours.

In the context of the Japanese labour market, numerous attempts have been made by researchers to investigate employment adjustment. Their main objectives were to compare Japanese employment adjustment patterns with those of other countries. That is, is adjustment in Japan slower than in other countries? Do Japanese companies adjust hours more than the number of workers? However, most studies use the partial adjustment model, which is problematic, as has already been mentioned.[**] Although there are many studies of European countries, little is known about the structure of adjustment costs in Japan.[††]

In this paper, we assume that firms adjust not only the number of workers but also working hours, and that both incur adjustment costs. We derive the Euler equation for working hours and the number of workers, similarly to Goux et al. (2001), without specifying the production

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§ Another problem is the assumption of smooth adjustment costs. The non-differentiability of adjustment costs causes a discontinuity in the firm's decision rule. Hamermesh (1989) argued that labour demand has lumpy adjustment costs at the individual plant level. However, at the aggregate level, adjustment costs can appear continuous. In this paper, since we use macro data, the discontinuity in labour demand can be ignored.

** See, for example, Ohtake (1988) and Muramatsu (1991). Abraham and Houseman (1989) investigate differences in adjusting the number of workers and working hours in the USA and Japan, but do not specify an employment-adjustment model.

†† Hildreth and Ohtake (1998) examine the discreteness of labour demand by using data provided by a Japanese company.

function. Goux et al. (2001) assume that the labour force is the sum of permanent workers and those on fixed-term contracts, which implies that the marginal productivities of the two types of worker are equivalent. Therefore, the estimable Euler equation can be derived without specifying the production function. In our model, the labour force is the product of working hours per worker and the number of workers. By using monthly data on Japanese industries from 1992 to 2004, we investigate the structure of adjustment costs. These costs are represented by measures of asymmetry between hiring and firing costs, and by the relative costs of changing working hours and the number of workers. Hence, we re-evaluate Japanese features of employment adjustment.

The structure of the paper is as follows. In the next section, we develop the dynamic model of labour demand on which our empirical work is based. In section 3, we describe the data used and report the empirical results. In section 4, we present a summary and conclusions.

2. The Model

We start by assuming the form of the technology. Let H_t and N_t denote, respectively, working hours per worker and the number of workers that a representative firm hires. Thus, $H_t N_t$ is the firm's effective labour force. We assume that the firm has a production function $f(H_t N_t, \varepsilon_t)$, with $f' > 0$ and $f'' < 0$. The term ε_t represents a productivity shock observed at the beginning of period t.

The risk-neutral firm adjusts working hours and the number of workers, after the realized current shock is observed, in order to maximize the present discounted value of expected profits, V, over an infinite horizon. The firm's optimization problem is as follows:

$$V(H_{t-1}, N_{t-1}) = \max_{h_t^+, h_t^-, a_t, s_t} F(H_t N_t, \epsilon_t) - w_t H_t N_t - C_{H^+}(h_t^+) - C_{H^-}(h_t^-)$$
$$- C_A(a_t) - C_S(s_t) + \delta E_t[V(H_t, N_t)] \quad (1)$$

subject to

$$H_t - H_{t-1} = h_t^+ - h_t^-, \quad (2)$$

$$N_t - N_{t-1} = a_t - s_t, \quad (3)$$

$$H_t,\ N_t,\ h_t^+,\ h_t^-,\ a_t,\ s_t \geq 0, \quad (4)$$

where E_t denotes expectations at the end of period t. The parameter δ is a discount factor and w_t is the wage per working hour. C_I and $I \in \{H+, H-, A, S\}$, respectively, represent the costs of increasing working hours, h_t^+, reducing working hours, h_t^-, hiring workers, a_t, and firing workers, s_t. For each I, the function C_I is assumed to be differentiable and strictly convex. We also assume that $C'_{H+}(0) = C'_{H-}(0)$ and $C'_A(0) = C'_S(0)$ so that the costs of adjusting working hours and the number of workers are differentiable at zero.

Solving this problem yields the following Euler equations for working hours and the number of workers, respectively:

$$E_t[M_t N_t - \{C'_{H+}(h_t^+) - C'_{H-}(h_t^-)\} + \delta\{C'_{H+}(h_{t+1}^+) - C'_{H-}(h_{t+1}^-)\}] = 0 \quad (5)$$

$$E_t[M_t H_t - \{C'_A(a_t) - C'_S(s_t)\} + \delta\{C'_A(a_{t+1}) - C'_S(s_{t+1})\}] = 0 \qquad (6)$$

where $M_t \equiv F'(t) - w_t$. When both adjustment costs, C_I, are strictly increasing, the firm will not choose both h_t^+ and h_t^- to be positive, and neither will it choose a_t and s_t.‡

We assume the following quadratic form for all adjustment costs:

$$C_I(x) = \frac{1}{2}c_I x^2, \quad \forall x \geq 0 \text{ and } \forall I \in \{H+, H-, A, S\}. \qquad (7)$$

Given these specifications, the Euler equations (5) and (6) can be combined to yield:

$$E_t\left[(\hat{a}_t - \hat{s}_t) - \frac{c_S - c_A}{2c_N}(\hat{a}_t + \hat{s}_t) - \frac{c_{h+}}{c_N}\hat{h}_t^+ + \frac{c_{h-}}{c_N}\hat{h}_t^-\right] = 0 \qquad (8)$$

where $c_N \equiv (c_A + c_S)/2$, $\hat{a}_t \equiv (a_t - \delta a_{t+1})/H_t$, $\hat{s}_t \equiv (s_t - \delta s_{t+1})/H_t$,

‡ However, if either C_{H+} and C_{H-} (C_A and C_S) is decreasing, the firm may choose both h_t^+ and h_t^- (or a_t and s_t) to be positive. Note that, since the adjustment costs, C_I, are strictly convex, if each C_I is increasing, the second-order conditions are satisfied. Otherwise, satisfaction of the second-order conditions is not guaranteed.

$\hat{h}_t^+ \equiv (h_t^+ - \delta h_{t+1}^+)/N_t$ and $\hat{h}_t^- \equiv (h_t^- - \delta h_{t+1}^-)/N_t$. The $(c_S - c_A)/2c_N$ parameter measures the asymmetry between the costs of hiring and firing workers. That $-1 < (c_S - c_A)/2c_N < 1$ implies $c_A > 0$ and $c_S > 0$. The terms c_{H+}/c_N and c_{H-}/c_N measure the relative costs of adjusting working hours for a given number of workers.

3. Empirical Analysis

In this section, we present parameter estimates for equation (8). We use seasonally unadjusted monthly data for Japanese industry from January 1992 to January 2004, as reported in the Monthly Labour Survey by the Ministry of Health, Labour and Welfare. We use indices of working hours, H, and the number of workers, N, which are normalized to 100 in 2000. The variables a and s are represented by the numbers of acquisitions and separations. Although s represents the number of layoffs, data on layoffs by industry are not available. Separations include voluntary quits. The terms h^+ and h^- represent the net flow of working hours, H.

To estimate the parameters of the Euler equation (8), we use Generalized Method of Moments (GMM), following Goux et al. (2001). The GMM estimates are obtained by using the standard two-stage instrumental variables method. We use the following lagged values of the forcing variable and a constant term as instrumental variables:

$$1,\ \hat{a}_{t-Lag} - \hat{s}_{t-Lag},\ \hat{a}_{t-Lag} + \hat{s}_{t-Lag},\ \hat{h}^+_{t-Lag},\ \hat{h}^-_{t-Lag}.$$

Lag indicates the number of lags used for a variable, based on monthly data. For example, if *Lag* = 1, the variable x_{t-1} is used, whereas x_{t-1} and x_{t-2} are used if *Lag* = 1, 2. Tables 1 and 2 report the empirical results from GMM. The discount rate, δ, is chosen to equal 0.99 in Table 1 and 0.95 in Table 2, but results are robust to variations in the discount rate.

In the industries sampled, the estimate of $(c_S - c_A)/2c_N$ is positive, and less than unity. This implies: (1) hiring and firing costs, C_A and C_S, are positive, so that c_N is positive; and (2) the costs of adjusting the number of workers are asymmetric, with firing costs exceeding hiring costs. Further, the estimates of c_{H+}/c_N and c_{H-}/c_N are both positive but small relative to $(c_S - c_A)/2c_N$. This suggests that it is significantly cheaper to change working hours than the number of workers.

We get similar results when we focus on each industry. The costs of adjusting the number of workers are asymmetric in all industries. However, the asymmetry in costs appears to differ between production sectors (such as construction and manufacturing) and non-production sectors (such as transport and communications, finance and insurance, real estate and services). For the production sectors, the estimated $(c_S - c_A)/2c_N$ is about 0.5, whereas the corresponding estimate for the non-production sectors is 0.3.

For most industries, the estimates of c_{H+}/c_N and c_{H-}/c_N are small. This implies that it is much less costly to adjust working hours than the number of workers. For some sectors (electricity, gas, heating supplies and water, transport and communications, finance and insurance and services), one component of the relative costs of working hours, c_{H+}/c_N, c_{H-}/c_N, is significantly less than zero (from about –0.05 to –0.17). This implies that either C_{H+} or C_{H-} may be negative, since the parameter c_N is positive in all industries. As mentioned in the previous section, if one of these is negative, the firms in those sectors may increase their working hours and, at the same time, reduce those costs. A possible interpretation is that firms may apply different working hours policies to different groups of workers. In our model, we assume that workers are homogeneous although, in practice, workers are heterogeneous. Firms in the sector may increase the working hours of some workers and reduce those of other workers.

4. Conclusion

In this paper, we derived an estimable Euler equation for working hours and the number of workers, similarly to Goux et al. (2002), without specifying the production function. Using data on Japanese industries from 1992 to 2004, we estimated a model of dynamic labour demand in which there are adjustment costs of changing the number of workers and their working hours.

Our results indicate that it is more costly to fire workers than to hire them, in all industries, and firing during recessions is more difficult than the hiring during upturns. We also found that the asymmetry between hiring and firing costs is more important for production sectors than for non-production sectors. This result is consistent with the empirical findings of Phann and Palm (1993), obtained using data on the Dutch and UK manufacturing sectors. Finally, since adjustment costs for working hours are small relative to those for the number of workers, firms typically adjust working hours.

Appendix

In this Appendix, we solve the optimization problem (1) in the text, and derive the estimating equation (5). First, we define W as follows:

$$W = F(H_t N_t, \epsilon_t) - w_t H_t N_t - C_{H+}(h_t^+) - C_{H-}(h_t^-) - C_A(a_t) - C_S(s_t) + \delta E_t[V(H_t, N_t)].$$

The problem in (1) is to maximize W for h_t^+, h_t^-, a_t, s_t given the constraints, which are the transition equations, (2) and (3), and the non-negativity restrictions, (4). That is:

$$V(H_{t-1}, N_{t-1}) = \max_{h_t^+, h_t^-, a_t, s_t} W \tag{9}$$

$$\text{subject to} \qquad H_t - H_{t-1} = h_t^+ - h_t^-, \tag{10}$$

$$N_t - N_{t-1} = a_t - s_t, \tag{11}$$

$$H_t,\ N_t,\ h_t^+,\ h_t^-,\ a_t,\ s_t\ \geq 0, \tag{12}$$

Differentiating W with respect to each variable and taking account of (2) and (3) yields:

$$\frac{\partial W}{\partial h_t^+} = M_t N_t - C'_{H+}(h_t^+) + \delta E_t\left[\frac{\partial V(H_t, N_t)}{\partial H_t}\right], \tag{13}$$

$$\frac{\partial W}{\partial h_t^-} = -M_t N_t - C'_{H-}(h_t^-) - \delta E_t\left[\frac{\partial V(H_t, N_t)}{\partial H_t}\right], \tag{14}$$

$$\frac{\partial W}{\partial a_t} = M_t H_t - C'_A(a_t) + \delta E_t\left[\frac{\partial V(H_t, N_t)}{\partial N_t}\right], \tag{15}$$

$$\frac{\partial W}{\partial s_t} = -M_t H_t - C'_S(s_t) - \delta E_t\left[\frac{\partial V(H_t, N_t)}{\partial N_t}\right]. \tag{16}$$

where $M_t \equiv \partial F(H_t N_t, \varepsilon_t)/\partial(H_t N_t) - w_t$. The Kuhn-Tucker conditions are $\partial W/\partial h^+ \leq 0$, $\partial W/\partial h^- \leq 0$, $\partial W/\partial a \leq 0$, $\partial W/\partial s \leq 0$ with the complementary-slackness proviso that $h^+(\partial W/\partial h^+) = 0$, $h^-(\partial W/\partial h^-) = 0$, $a(\partial W/\partial a) = 0$, $s(\partial W/\partial s) = 0$, respectively. When each adjustment cost, C_I, is strictly increasing, the firm will not choose both h_t^+ and h_t^- to be positive, and neither will it choose both a_t and s_t. However, if either C_{H+} or C_{H-} (C_A and C_S) is decreasing, the firm may choose both h_t^+ and h_t^-

(or a_t and s_t) to be positive.

By differentiating both sides of (9) with respect of H_{t-1} and N_{t-1}, we have the following:

$$\frac{\partial V(H_{t-1}, N_{t-1})}{\partial H_{t-1}} = M_t N_t + \delta E_t \left[\frac{\partial V(H_t, N_t)}{\partial H_t} \right] \qquad (17)$$

$$\frac{\partial V(H_{t-1}, N_{t-1})}{\partial N_{t-1}} = M_t H_t + \delta E_t \left[\frac{\partial V(H_t, N_t)}{\partial N_t} \right] \qquad (18)$$

Using the above Kuhn-Tucker conditions and (17) and (18), we can derive following Euler equations for working hours and for the number of workers:

$$M_t N_t - \{C'_{H+}(h_t^+) - C'_{H-}(h_t^-)\} + \delta\{C'_{H+}(h_{t+1}^+) - C'_{H-}(h_{t+1}^-)\} = 0 \qquad (19)$$

$$M_t H_t - \{C'_A(a_t) - C'_S(s_t)\} + \delta\{C'_A(a_{t+1}) - C'_S(s_{t+1})\} = 0 \qquad (20)$$

Specifying each adjustment cost function as quadratic, as in (7), and dividing (19) and (20) by N_t and H_t respectively, yields the Euler equations:

$$M_t - c_{h+}\hat{h}_t^+ + c_{h-}\hat{h}_t^- = 0 \qquad (21)$$

$$M_t - c_A \hat{a}_t + c_S \hat{s}_t = 0 \qquad (22)$$

where

$$\hat{a}_t \equiv (a_t - \delta a_{t+1})/H_t, \hat{s}_t \equiv (s_t - \delta s_{t+1})/H_t, \hat{h}_t^+ \equiv (h_t^+ - \delta h_{t+1}^+)/N_t, \hat{h}_t^- \equiv (h_t^- - \delta h_{t+1}^-)/N_t$$

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Combining equations (21) and (22) yields:

$$E_t \left[(\hat{a}_t - \hat{s}_t) - \frac{c_S - c_A}{2c_N}(\hat{a}_t + \hat{s}_t) - \frac{c_{h+}}{c_N}\hat{h}_t^+ + \frac{c_{h-}}{c_N}\hat{h}_t^- \right] = 0 \qquad (23)$$

where $c_N \equiv (c_A + c_S)/2$.

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Table 1: The estimation results of parameter ($\delta = 0.990$)

	Industry covered	Construction	Manufacturing	Electricity, Gas, Heat supply and Water	Transports and Communications	Wholesale and Retail trade, eating and drinking places	Financing and Insurance	Real estate	Services
$\frac{c_S - c_A}{2c_N}$	0.342*	0.467*	0.506*	0.210*	0.256*	0.444*	0.339*	0.348*	0.270*
	(0.013)	(0.028)	(0.036)	(0.049)	(0.030)	(0.028)	(0.032)	(0.046)	(0.008)
$\frac{c_{H+}}{c_L}$	0.022*	0.069*	0.014*	0.087*	-0.114*	-0.008	-0.164*	0.067*	0.030*
	(0.003)	(0.016)	(0.003)	(0.024)	(0.032)	(0.011)	(0.023)	(0.024)	(0.005)
$\frac{c_{H-}}{c_L}$	0.012*	0.005	0.011*	-0.051	0.111*	0.034*	0.114*	-0.050*	-0.215
	(0.003)	(0.011)	(0.003)	(0.035)	(0.027)	(0.007)	(0.036)	(0.023)	(0.005)
const	0.000*	0.000*	0.000*	0.000	0.000	0.000*	0.000	0.000*	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
J	5.999	4.759	6.013	5.728	5.184	6.078	5.321	5.539	6.218
P-value	(0.306)	(0.446)	(0.305)	(0.334)	(0.394)	(0.299)	(0.378)	(0.354)	(0.286)
Lag	24,25	24,25	24,25	25,26	27,28	24,25	12,13	13,14	24,25
$\frac{c_S - c_A}{2c_N}$	0.338*	0.471*	0.518*	0.221*	0.241*	0.431*	0.343*	0.340*	0.268*
	(0.010)	(0.017)	(0.023)	(0.041)	(0.020)	(0.023)	(0.029)	(0.041)	(0.005)
$\frac{c_{H+}}{c_L}$	0.024*	0.064*	0.013*	0.072*	-0.092*	0.002	-0.155*	0.063*	0.029*
	(0.002)	(0.011)	(0.002)	(0.021)	(0.016)	(0.007)	(0.020)	(0.023)	(0.003)
$\frac{c_{H-}}{c_L}$	0.011*	0.004	0.012*	-0.054*	0.116*	0.031*	0.111*	-0.040*	0.001
	(0.002)	(0.011)	(0.002)	(0.022)	(0.014)	(0.005)	(0.026)	(0.019)	(0.004)
const	0.000*	0.000*	0.000*	0.000	0.000	0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
J	6.484	5.199	6.378	6.302	5.534	6.621	7.194	7.768	6.330
P-value	(0.691)	(0.817)	(0.702)	(0.709)	(0.786)	(0.677)	(0.617)	(0.558)	(0.706)
Lag	24,25,26	24,25,26	24,25,26	25,26,27	27,28,29	24,25,26	12,13,14	13,14,15	24,25,26

Note: Numbers in parentheses are the standard errors of the parameters. The * indicates that the coefficient is significant at the 5% level. *const* denotes the constant term. *Lag* indicates the number of lags used for the instrumental variable, based on the forcing variable. *J* denotes the J-test statistics. The p-value is the probability value associated with the J-test.

Table 2: The estimation results of parameter ($\delta = 0.999$)

	Industry covered	Construction	Manufacturing	Electricity, Gas, Heat supply and Water	Transports and Communications	Wholesale and Retail trade, eating and drinking places	Financing and Insurance	Real estate	Services
$\frac{c_S - c_A}{2c_N}$	0.342*	0.467*	0.506*	0.210*	0.256*	0.444*	0.339*	0.348*	0.264*
	(0.013)	(0.028)	(0.036)	(0.049)	(0.030)	(0.028)	(0.032)	(0.046)	(0.013)
$\frac{c_{H+}}{c_L}$	0.022*	0.069*	0.014*	0.087*	-0.114*	-0.008	-0.164*	0.067*	0.070*
	(0.003)	(0.016)	(0.003)	(0.024)	(0.032)	(0.011)	(0.023)	(0.024)	(0.014)
$\frac{c_{H-}}{c_L}$	0.012*	0.005	0.011*	-0.051	0.111*	0.034*	0.114*	-0.050*	-0.047*
	(0.003)	(0.011)	(0.003)	(0.035)	(0.027)	(0.007)	(0.036)	(0.023)	(0.015)
$const$	0.000	0.000*	0.000*	-0.000	0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
J	5.999	4.763	6.013	5.728	5.184	6.079	5.322	5.539	5.533
P-value	(0.306)	(0.445)	(0.305)	(0.334)	(0.394)	(0.299)	(0.378)	(0.353)	(0.354)
Lag	24,25	24,25	24,25	25,26	27,28	24,25	12,13	13,14	25,26
$\frac{c_S - c_A}{2c_N}$	0.338*	0.471*	0.518*	0.221*	0.241*	0.431*	0.343*	0.340*	0.253*
	(0.010)	(0.017)	(0.023)	(0.041)	(0.020)	(0.023)	(0.029)	(0.041)	(0.004)
$\frac{c_{H+}}{c_L}$	0.024*	0.064*	0.013*	0.072*	-0.092*	0.002	-0.155*	0.063*	0.029*
	(0.002)	(0.011)	(0.002)	(0.021)	(0.016)	(0.007)	(0.020)	(0.023)	(0.004)
$\frac{c_{H-}}{c_L}$	0.011*	0.004	0.012*	-0.054*	0.116*	0.031*	0.111*	-0.040*	0.001
	(0.002)	(0.011)	(0.002)	(0.022)	(0.014)	(0.005)	(0.026)	(0.019)	(0.004)
$const$	0.000	0.000*	0.000*	-0.000	0.000	-0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
J	6.484	5.198	6.378	6.302	5.534	6.621	7.194	7.773	6.270
P-value	(0.691)	(0.817)	(0.702)	(0.709)	(0.785)	(0.677)	(0.617)	(0.557)	(0.713)
Lag	24,25,26	24,25,26	24,25,26	25,26,27	27,28,29	24,25,26	12,13,14	13,14,15	24,25,26