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ADJUSTMENT COSTS IN STAGNANT AND RAPIDLY GROWING INDUSTRIES*

Shinichiro NAKAMURA

Abstract: We analyze the pattern of adjustment costs of two Japanese industries with remarkably different growth performances: the stagnant (or "structurally depressive" as was once designated by the Japanese government) textile industry and the dynamic electrical machinery industry, using a translog dynamic factor demand model with adjustment costs. To explicitly take into account the prevalence of long-term employment in Japan, this model treats the number of workers as a quasi-fixed factor, and overtime hours of work per worker as a variable factor. The estimation results obtained for time series data for 1960–85 using 3SLS indicate that the pattern of adjustment costs is indeed remarkably different between the two industries. The textile industry shows a significant fixity in capital stock and a very weak fixity in workers. In contrast to this, in the electrical machinery industry workers and capital stock have a similar significant degree of fixity. Overall, when adjusted for different growth rates, adjustment costs have a higher share of the variable cost in the stagnant textile industry (1.7 percent) than in the dynamic electrical machinery industry (0.7 percent), indicating that the adjustment cost is more serious in stagnant industries rather than growing industries. The electrical machinery industry appears to have been able to solve the adjustment problem in the course of its high growth process, while the stagnant textile industry seems to have had difficulty in adjusting quasi fixed inputs, especially capital stock, to its optimum level.

1. INTRODUCTION

The main concern of this paper is to analyze the difference, if any, in the pattern of adjustment costs between two Japanese industries with remarkably different growth patterns: the stagnant (or "structurally depressive" as was once designated by the Japanese government) textile industry and the dynamic electrical machinery industry.

Table 1 compares the growth pattern for the period of 1960–85 of the two industries with respect to gross output, capital stock, the number of workers, and material together with the share of overtime hours in total hours of work. While electrical machinery industry experienced a two digit growth rate in output over

* An earlier version of this paper was presented at the NBER Summer Institute Workshop on Productivity and R & D, Cambridge, Massachusetts, July 1989, I would like to thank participants of the workshop, Shujiro Urata and an anonymous referee for helpful comments.

TABLE 1. GROWTH PATTERN OF THE JAPANESE TEXTILE AND ELECTRICAL MACHINERY INDUSTRY: 1960–1985.

	Maean annual growth rate of:				Share of overtime in total hours of work
	output	capital	workers	material	
Textile					
60–70	9.26	7.40	0.49	7.04	5.44
70–80	1.85	3.48	−3.27	0.68	4.82
80–85	2.16	3.84	−3.21	1.45	5.79
60–85	4.70	5.02	−1.64	3.29	5.25
Electrical machinery					
60–70	19.47	15.50	8.81	18.12	9.31
70–80	10.64	7.96	1.25	7.44	7.85
80–85	19.11	13.76	7.12	16.45	10.58
60–85	15.75	12.31	5.14	13.44	8.96

the sample period, the mean growth rate of textile industry was less than five percent. Of the three aggregate inputs considered, the number of workers has the lowest growth rate in both the industries, capital stock has the highest growth rate in the textile industry, and material has the highest rate in the electrical machinery industry. The number of workers in the textile industry decreased over the sample period by 40 percent while in the electrical machinery industry it increased by 160 percent. In 1965, the shares of textile industry and electrical machinery industry in total manufacturing employment were 15 percent and 8 percent, respectively. By 1985, however, their relative position reversed with the share of textile dropping to 8 percent and that of electrical machinery climbing to 15 percent.

If the technology of adjustment is similar among industries, the marginal adjustment cost would be much higher in electrical machinery industry than in textile industry, reflecting the greater need for reorganization and retraining in the former due to its higher growth rates in capital and labor. On the other hand, an industry with lower adjustment costs is likely to be more efficient than the one with higher adjustment costs, because it can attain the long-run optimum more easily, and thus appears to be able to grow faster than the latter. This implies the possible existence of a difference in the technology of adjustments between stagnant and dynamic industries. This issue is related to recently raised discussions by Dore (1986) and Morrison (1988) on flexibility and growth of an industry or the whole economy.

In this paper, I apply a dynamic factor demand model of Nakamura (1991) to the two Japanese industries to analyze the difference in their pattern of adjustment costs. The prevalence of long-term or life-time employment is a well known feature of the Japanese industrial relations (see Hashimoto and Raisian (1985)). As a result of this practice, short-run adjustments in labor input are mostly made by changing overtime hours of work without changing the level of employment (see Tachibanaki (1987)). To explicitly take into account these specific features of the Japanese economy, this model treats the number of workers as a quasi-fixed factor, and overtime hours of work per worker as a variable factor. Capital stock and workers are quasi-fixed because of adjustment costs associated with a change in their levels. The firm makes short-run adjustments by changing the level of material input and overtime hours of employed workers.

Table 1 shows that in both the industries the share of overtime in total hours of work decreased in the seventies compared to the sixties, and again increased in the first half of the eighties. This movement corresponds to the change in the level of output growth. The electrical machinery industry has a higher growth rate and a higher dependence on overtime throughout the period. Overtime thus appears to be sensitive to the level of output growth both over time and across industries.

The derivation of the model is considered in the next section. Empirical results are discussed in Section 3, and Section 4 contains concluding remarks.

2. THE MODEL

We consider a representative firm producing one output, using capital, labor, and material, the production function of which is:

$$Y = F(K, N, H, O, M, t, \Delta K, \Delta N) \tag{1}$$

where Y is output, K is capital stock, N is the number of workers, H is scheduled hours of work, O is non-negative overtime hours of work, M is material, t is time, ΔK and ΔN are the rates of change in K and N over two successive periods which are defined later. F is subject to the usual regularity conditions of production functions with adjustment costs.

Scheduled hours of work are quite stable over the sample period, although it has a slightly decreasing tendency. It seems safe to say that scheduled hours of work depends on many socioeconomic factors which are exogenous to the firm. We treat scheduled hours of work as an exogenous variable throughout this paper (Muramatsu (1980) uses the same assumption).

Since the labor input consists of workers, scheduled hours of work, and overtime, we need a corresponding decomposition of total labor cost. We assume that the total labor cost is given by

$$\text{total labor cost} = (PH(c_0 + H) + c_1)N + PO\,O\,N + v \tag{2}$$

where c_0 and c_1 are parameters representing the overhead cost which is independent of the hours of work, PH and PO are the hourly wage rate for scheduled hours of work and for overtime hours of work, respectively, and v is a error term. We assume both PH and PO are exogenous to the firm, $PO > PH$, and that overtime is evenly distributed among workers.[1] The first term of the righ-hand side of (2)

[1] The even distribution of overtime among workers is also assumed by Shapiro (1986) and Bernanke (1986), but not by Bils (1987).

represents the fixed cost of employing N workers, while the second term represents the variable component of labor costs. Since N is fixed, the variable cost associated with a unit change in O is not PO but $PO\,N$.

The short-run costs, CV, consist of material costs and overtime payments. We assume that in the short-run the firm minimizes CV for a given set of variable factor prices, quasi-fixed inputs, scheduled hours of work, and output subject to the production function (1). CV is then given by the restricted cost function G:

$$\begin{aligned} CV &= \min_{\{M,O\}} [PM\,M + PO^*\,O \mid F(K, N, H, O, M, t, \Delta K, \Delta N) \geq Y] \\ &= G(PM, PO^*, Y, K, N, H, t, \Delta K, \Delta N) \end{aligned} \tag{3}$$

where PM is the price of material, $PO^* \equiv PO\,N$, G is increasing in Y, PM, PO^*, ΔK and ΔN, concave and linear homogeneous in PM and PO^*, decreasing in t, H, K, and N, and convex in K, N, ΔK and ΔN. It is well known that G contains all information on F (Brown and Christensen (1981)).

The long-run optimization problem of the firm with respect to capital stock and workers is intertemporal due to the dynamic nature of the model represented by the adjustment costs. We use the standard assumption that the firm minimizes the expected value of the future stream of total costs for given information on factor prices and output. The total cost at time t, CT_t, is the sum of CV, investment expenditure, and the quasi-fixed labor cost:

$$CT_t = CV_t + PI_t(K_t - (1-\delta)K_{t-1}) + (c_1 + PH(c_0 + H))N \tag{4}$$

where PI_t is the acquisition price of capital stock, δ is the constant rate of depreciation. The intertemporal optimization problem is:

$$\min_{\{K,N\}} E_t \sum_{i=0}^{\infty} R_{t+i} CT_{t+i} \tag{5}$$

subject to (3) and K_{t-1} and N_{t-1} given, where E_t denotes expectation conditional on information available at time t, and R_{t+i} is the rate of discount applied at t for expenditures at $t+i$, $i \geq 0$,

$$R_{t+i} = \prod_{j=t+1}^{t+i} r_{j-1}\,,$$

where $r_t = 1/(1+\gamma_t)$ with γ_t being the required rate of return from periods t to $t+1$. The evolution of K and N over time will then be described by the first order conditions of (5) (Euler equations), the initial conditions, and the transversality conditions which are given by:

$$\lim_{T \to \infty} R_{t+T} \cdot \frac{\partial CT_{t+T}}{\partial K_{t+T}} \cdot K_{t+T} = 0$$

$$\lim_{T \to \infty} R_{t+T} \cdot \frac{\partial CT_{t+T}}{\partial N_{t+T}} \cdot N_{t+T} = 0$$

We now specify the restricted cost function G. Since our data are an annual time seires for twenty-six years, a fully flexible form cannot be estimated because of the shortage of degrees of freedom. We use the following truncated translog function with symmetric adjustment costs:

$$\begin{aligned}\ln(CV/PO^*) = {} & a + a_M \ln(PM/PO^*) + a_Y \ln Y + a_T t + 0.5 a_{YY} (\ln Y)^2 \\ & + a_{YM} \ln(PM/PO^*) \ln Y + a_K \ln K + a_N \ln N \\ & + (a_{MK} \ln K + a_{MN} \ln N) \ln(PM/PO^*) \\ & + 0.5[a_{KK}(\ln K)^2 + a_{NN}(\ln N)^2] + a_{KN} \ln K \ln N \\ & + 0.5\{b_{KK}[\ln(K/(1-\delta)K_{-1})]^2 + b_{NN}[\ln(N/N_{-1})]^2\} \qquad (6)\end{aligned}$$

The formulation here makes the marginal adjustment cost linear in percentage changes rather than absolute changes in quasi-fixed inputs. This is desirable because of the considerable increase in the size of electrical machinery industry (the size of output in 1985 is about 27 times that of 1960). Based on findings of Nadiri and Prucha (1988), Shapiro (1986) and Morrison (1988), the cross effect parameter, say b_{KN} is set to zero. Since the scheduled hours of work shows very little variation in the data, we approximate it by the constant term and time trend in this formulation.

Application of Shephard's lemma to (6) yields the short-run demand for material and overtime in the form of the cost share equations:

$$WM \equiv PM\, M/CV = a_M + a_{YM} \ln Y + a_{MK} \ln K + a_{MN} \ln N \qquad (7a)$$

$$WO = PO^*\, O/CV = 1 - a_M - a_{YM} \ln Y - a_{MK} \ln K - a_{MN} \ln N \qquad (7b)$$

Inserting (4) and (6) into (5), we get the Euler equations for K and N respectively as:

$$\begin{aligned}E_t\{ & [a_K + a_{KK} \ln K_t + a_{KN} \ln N_t + a_{MK} \ln(PM_t/PO_t^*) \\ & + b_{KK} \ln(K_t/(1-\delta)K_{t-1})]CV_t/K_t - r_t b_{KK} \ln(K_{t+1}/(1-\delta)K_t)CV_{t+1}/K_t \\ & + PI_t - R_t PI_{t+1}(1-\delta)\} = 0 \qquad (8a)\end{aligned}$$

$$\begin{aligned}E_t\{ & [a_K + a_{KN} \ln K_t + a_{NN} \ln N_t + a_{MN} \ln(PM_t/PO_t^*) + b_{NN} \ln(N_t/N_{t-1})]CV_t/N_t \\ & - r_t b_{NN} \ln(N_{t+1}/N_t)CV_{t+1}/N_t + c_1 + PH_t(c_0 + H_t) + PO_t O_t\} = 0 \qquad (8b)\end{aligned}$$

These equations state that, in expectation, the net effect on the cost stream from the marginal unit of each of the quasi-fixed inputs is zero. In the case of (8b), the net effect consists of the variable cost savings, $[a_N + a_{KN} \ln K_t + a_{KN} \ln N_t + a_{KN} \ln(PM_t/PO_t^*)]CV_t/N_t$, the overtime wage cost, $PO_t O_t$, the regular wage cost, $c_t + PH_t(c_0 + H_t)$, the current adjustment cost, $b_{NN} \ln(N_t/N_{t-1})CV_t/N_t$, and the discounted savings in future adjustment costs, $r_t b_{NN} \ln(N_{t+1}/N_t)CV_{t+1}/N_t$, resulting from hiring the labor now rather than in the future.

3. EMPIRICAL RESULTS

We estimate the Euler equations (8) together with the restricted cost function (6) and the share equation (7b) for time seires data 1960–1985 on the Japanese textile and electrical machinery industries. Appendix A gives a detailed description of the data sources and the variables used in the model.

The translog form (6) allows for general scale effects. According to detailed empirical studies of Yoshioka (1989) on Japanese manufacturing industries, the electrical machinery industry exhibits increasing returns, whereas the textile industry follows constant returns to scale. I therefore impose for textile industry the condition of constant returns to scale, while for electrical machinery industry no such restriction is imposed. With this condition imposed, (6) becomes

$$\begin{aligned}\ln(CV/PO^*) = {} & a + a_M \ln(PM/PO^*) + \ln Y + a_T t + a_K \ln(K/Y) + a_N \ln(N/Y) \\ & + (a_{MK} \ln(K/Y) + a_{MN} \ln(N/Y)) \ln (PM/PO^*) \\ & + 0.5[a_{KK}(\ln(K/Y))^2 + a_{NN}(\ln(N/Y))^2] + a_{KN} \ln(K/Y) \ln(N/Y) \\ & + 0.5\{b_{KK}[\ln(K/(1-\delta)K_{-1})]^2 + b_{NN}[\ln(N/N_{-1})]^2\} \qquad (6')\end{aligned}$$

The general method of moments (GMM) estimator of Hansen (1982) provides a suitable estimation procedure. We replace the unobservable conditional expectations in the Euler equations with actual values and the zeros on the right-hand side with a vector of error terms. Further, the variable cost function and the share equation are augmented by additive error terms which represent measurement error, optimization error, and/or technological shocks. If the model is correct and expectations are rational, the error terms represent forecast errors and are orthogonal to anything known by the firm in period t.

We assume that the error terms are homoscedastic and serially uncorrected (case (i) of Hansen (1982, p. 1043)), and use the three stage least squares estimator (3SLS). We use a set of instrumental variables that does not include any current variables appearing in the cost function, share function, and the Euler equations. The instruments are a constant, lagged values of the quantity of output, workers, and capital stock, as well as lagged values of the price of output, material, and scheduled hourly wage rate, and the rate of discount.

Table 2 presents estimation results.[2] The estimated model satisfies the regularity conditions at all points within the sample for each of the two industries. Furthermore, the estimated adjustment parameters are significant for both industries and factors. The adjustment parameters of capital and workers are of the same magnitude in electrical machinery, while in textile the adjustment parameter of capital is about nine times that of workers.

[2] The result for electrical machinery was taken from Nakamura (1991). The parameters a and a_K were set to zero based on test results using the D statistic of Newey and West, while c_1 was set to zero because it was insignificant and had a wrong sign in a preliminary single equation estimation.

TABLE 2. ESTIMATED PARAMETERS OF THE DYNAMIC FACTOR DEMAND MODEL

	Textile		Electrical machinery	
	estimates	t-values	estimates	t-values
a	−0.9109	−12.73		
a_M	1.0373	69.13	0.7674	18.73
a_{MM}	−0.0072	−1.27	0.0076	4.19
a_Y			1.2999	22.75
a_T	−0.0322	−15.80	−0.0460	−6.77
a_{YM}			−0.0284	−5.89
a_K	0.0244	0.18		
a_N	−0.1800	−3.08	−0.5695	−3.68
a_{KK}	0.1114	0.60	0.0375	2.66
a_{NN}	0.0985	3.59	0.1147	3.77
a_{KN}	0.0570	1.25	−0.0577	−3.47
a_{MK}	0.0339	3.85	0.0327	5.38
a_{MN}	0.0276	3.43	0.0266	5.36
b_{NN}	0.2510	2.02	0.7168	3.16
b_{KK}	2.2623	1.93	0.7307	2.42
c_0	194.2800	3.92	623.0100	19.17
c_1	0.1084	3.96		
J (d.f)*	49.6689	(25)	42.3250	(26)

* The J statistic is distributed as chi-squared with $N-K$ degrees of freedom, where N is the number of instruments and K is the number of parameters estimated. The number of instruments here is 40 (8 times 5 equations) and the number of parameters is 15 for the unrestricted model and 14 for the restricted model.

The J-satistic of Hansen (1982) indicates that the over-identification restrictions of the model are rejected at the one percent level for the textile industry but not for the electrical machinery industry. The results are thus of a mixed nature. We note that rejection of the over-identification restrictions is rather common in the empirical literature. (See Pindyck and Rotemberg (1983) for an example.) Note, however, that the chi square result of the J statistic needs stochastic stationarity of all the variables in the model, a property which may not be satisfied in the present model.

I next turn to the analysis of implications of the estimated adjustment cost parameters. The marginal adjustment cost of capital, $MADC_K$, and workers, $MADC_N$, is respectively given by

$$MADC_K = (b_{KK} \ln(K_t/(1-\delta)K_{t-1})CV_t/K_t) \tag{9a}$$

$$MADC_N = (b_{NN} \ln(N_t/N_{t-1})CV_t/N_t) \tag{9b}$$

The ratio of marginal adjustment costs to the unit price of each of the quasi fixed inputs gives a measure of the degree of variability of the input. If the ratio is zero, the input is perfectly variable. Moreover, the higher the ratio the lower the degree of variability. We also use the following as a measure of the overall significance of adjustment costs

$$ADC = \exp\{0.5[b_{KK}(\ln(K_t/(1-\delta)K_{t-1}))^2 + b_{NN}(\ln(N_t/N_{t-1}))^2]\} \tag{10}$$

that gives the ratio by which adjustment costs increase the variable cost.

Since adjustment costs depend on input growth rates, we need to take into account the difference in input growth rates for interindustry comparisons. In Table 3, the numbers in column (1) give the results evaluated at the sample mean (absolute mean growth rate) of each industry, while the numbers in column (2) give the results evaluated at the mean absolute growth rate of the two industries. We use the numbers in column (2) for interindustry comparisons.

In the textile industry, evaluated at sample means, the ratio of marginal adjustment costs of capital stock to the acquiring price of new asset is 0.21 and the ratio of marginal adjustment costs of workers to the wage rate is 0.02. The adjustment cost of a unit of additional capital is thus about 20 percent of the acquisition price, while the marginal adjustment cost of an additional worker is 2 percent of the annual wage rate. Capital stock has a significantly higher degree of quasi-fixedness than workers. As for the overall significance, adjustment costs raise the variable cost 0.7 percent on the average.

In electrical machinery industry, evaluated at sample means, the ratio of marginal adjustment costs of capital stock to the acquiring price of new asset is 0.22 and the ratio of marginal adjustment costs of workers to the wage rate is 0.17. In sharp contrast to textile industry, capital stock and workers have a similar degree of quasi-fixedness. Adjustment costs raise the variable cost 1.4 percent on the average. Although this value is twice that of textile industry, a direct comparison cannot be made because of the considerable difference in the growth rates of the two industries. I conclude that textile is characterized by a significant fixity in capital stock and a low fixity in workers, whereas electrical machinery is characterized by a significant fixity in both capital stock and workers.

We now turn to interindustry comparisons using the figures in column (2) of Table 3 which are adjusted for the difference in input growth rates. The degree of fixity of capital stock now becomes 0.35 in textile and 0.15 in electrical machinery, indicating that capital stock has a higher degree of fixity in textile industry. As for workers, the degree of fixity becomes 0.02 in textile and 0.12 in electrical machinery, and indicates that even after adjusted for different growth rates workers have a considerably higher degree of fixity in electrical machinery. The rate of increase in the variable cost due to adjustment costs is now 1.7 percent for textile and 0.7 percent for electrical machinery. We conclude that when adjusted for different growth rates, textile has higher adjustment costs due solely to its higher fixity of capital stock.

Table 4 shows the estimates of several short-run and long-run elasticities evaluated at the sample mean values of the exogenous variables. The short-run refers to the situation where the level of quasi-fixed inputs remains unchanged,

TABLE 3. COMPARISON OF ADJUSTMENT COSTS BETWEEN TEXTILE AND ELECTRICAL MACHINERY*

	Textile		Electrical machinery	
	(1)	(2)	(1)	(2)
a. $MADC_K$	0.1477	0.2497	0.1846	0.1308
b. $MADC_N$	0.02	0.0279	0.2279	0.1712
c. $MADC_K$/price of investment good	0.2091	0.3537	0.2219	0.1574
d. $MADC_N$/wage rate	0.0169	0.0235	0.1663	0.1249
e. ADC	1.0072	1.0169	1.0141	1.0072

* $MADC_K$: marginal adjustment costs of capital.
$MADC_N$: marginal adjustment costs of workers.
ADC: the ratio of increase in variable costs due to adjustment costs.
The numbers in column (1) were obtained by evaluating at the sample mean values of each industry, and the numbers in column (2) by evaluating at the mean growth rate of two industries (capital 13.4 percent, employment 4.05 percent). We use the numbers in column (2) for comparing the two industries.

TABLE 4. ESTIMATED SHORT-RUN AND LONG-RUN ELASTICITIES*

	Textile	El. machine		Textile	El. machine
SE_{MM}	−0.0267	−0.0132	E_{NM}	0.5292	0.5512
SE_{OO}	−0.9391	−0.6185	E_{NO}	0.0363	0.1040
SS_{MO}	0.9576	0.6317	E_{MK}	0.0181	0.0206
SRT	0.6883	0.7710	E_{MN}	0.2012	0.0501
PGY	2.11	3.55	E_{MM}	−0.2211	−0.0613
E_{YK}	0.0870	0.0716	E_{MO}	−0.0000	−0.0094
E_{YN}	0.2673	0.1780	E_{OK}	0.7659	1.1063
E_{YM}	0.6331	0.7552	E_{ON}	0.6731	1.0351
E_{YO}	0.0180	0.0161	E_{OM}	−0.0008	−1.0322
E_{KK}	−0.5484	−0.6848	E_{OO}	−1.4505	−1.1093
E_{KN}	0.2780	−0.1543	LS_{KN}	1.0397	−0.8848
E_{KM}	0.1459	0.5629	LS_{KM}	0.2304	0.7610
E_{KO}	0.1268	0.2761	LS_{KO}	7.0481	17.5337
E_{NK}	0.0905	−0.0621	LS_{NK}	0.8358	0.7452
E_{NN}	−0.6512	−0.5931	LS_{NO}	2.0157	6.6044

* Evaluated at the sample mean values of the exogenous variables.
SE_{ij}: short-run elasticity of demand for i with respect to the price of j, $i,j=\{M, O\}$.
SS_{MO}: short-run elasticity of substitution between M and O.
SRT: short-run scale elasticity.
PGY: growth rate of TFP.
E_{ij}: long-run elasticity of demand for i with respect to the price of j, $i,j=\{K, N, M, O\}$.
E_{Yj}: long-run elasticity of output with respect to the price of $j=\{K, N, M, O\}$.
S_{ij}: long-run elasticity of substitution between i and j, $i,j=\{K, N, M, O\}$.

and the long-run to that where all the adjustments including those involving the level of quasi-fixed inputs have been completed.

The short-run price elasticities, ES_{ij}, $i, j = O, M$, indicate that the demand for material is quite price inelastic, while overtime is more elastic. The short-run scale elasticity, *SRT*, measures the effect on output of a proportionate increase in material and overtime hours with capital stock and the number of workers fixed. This is 0.69 for the textile industry and 0.77 for the electrical machinery industry, and indicates significant short-run diseconomies of scale in both the industries. Material and overtime overshoot their long-run equilibrium values in the short-run to compensate for the sluggish adjustment of the quasi-fixed factors.

E_{Yi}, $i = K, N, M, O$, is the output elasticity with respect to input i, which is given by

$$E_{Yi} = -\partial \ln CV/\partial \ln X_i (\partial \ln CV/\partial \ln Y)^{-1} \qquad i = K, N$$

$$E_{Yi} = P_i X_i / CV (\partial \ln CV/\partial \ln Y)^{-1} \qquad i = M, O\,.$$

For both the industries, material has the largest effect on output (0.63 for textile industry and 0.76 for electrical machinery industry) followed by workers (0.26 and 0.18), and capital stock (0.09 and 0.07), and overtime the smallest effect (0.018 and 0.016). The long-run return to scale is unity for textile by assumption, and turns out to be 1.0209 for electrical machinery which is consistent with Yoshioka (1989). The rate of TFP growth is 2.11 for textile and 3.55 for electrical machinery.

E_{ij} is the long-run price elasticity of the demand for input i with respect to a change in the price of input j, $i, j = K, N, M, O$, which were obtained following the procedure of Brown and Christensen (1981) using long-run optimum values generated by the model. Similarly, LS_{ij} refers to the long-run elasticity of substitution between inputs i and j. Own price elasticity indicates that overtime is most price elastic with the own elasticity exceeding unity, that material is least elastic, and that capital and workers are in between. Turning to cross price and substitution elasticities, we find that capital and workers are substitutes in textile but complements in electrical machinery while material is a substitute for capital and labor in both industries. This finding is qualitatively consistent with that of Nadiri and Prucha (1990) obtained by using a different model and a different set of data on the Japanese electrical machinery industry. Overtime is fairly substitutable to both workers and capital stock, and is a complement of material in both the industries.

4. CONCLUDING REMARKS

In this paper, I applied a dynamic factor demand model with adjustment costs for capital stock and workers to two Japanese industries with strikingly different growth patterns: the stagnant textile industry and the dynamic electrical machinery industry. The estimation results indicate that the pattern of adjustment costs is indeed remarkably different between the two industries. The textile industry shows a significant fixity in capital stock and a weak fixity in terms of employment. In contrast to this pattern, the electrical machinery industry is characterized by a similar degree of fixity between workers and capital stock. Adjustment for different growth rates reveals that capital stock is indeed more fixed in textile while workers are more fixed in electrical machinery.

The higher degree of fixity of capital stock in textile is consistent with the fact that the industry was plagued by overcapacity for most of the sample period. To cope with this situation, a number of governmental industrial policies were introduced, which included direct controls over productivity capacity (see Dore (1986)), indicating that the level of capital stock was far from optimum.

The size of establishments in electrical machinery industry is on the average larger than textile industry, and the life time employment is known to be more common among large establishments than small ones (Hashimoto and Raisian (1986). The higher labor fixity in electrical machinery can be partly explained by this difference in employment patterns. The lower labor fixity in textile can be also due to government policy measures applied to the industry to reduce its level of employment, an example of which is temporally layoffs with government reimbursement (see Dore (1986) and Shinozuka (1989)).

Another factor of the observed difference in the adjustment cost of employment will be higher skill levels of workers in electrical machinery due to its higher R & D intensities. Electrical machinery is the most R & D intensive industry in the Japanese manufacturing with its R & D expenditure in 1983 making up 4.7 percent of its sales and 31.1 percent of the total corporate R & D expenditure, while for textile the corresponding figures are about 1 percent. Furthermore, in 1983 the share of regular researchers in total employment is 6.2 percent in electrical machinery while it is only 1.6 percent in textile, indicating considerable differences in skill levels of the two industries. Higher skill levels will incur higher employment and intramural training costs, resulting in higher adjustment costs of changing the level of employment.

The very high R & D intensity of the electrical machinery industry also seems to provide an explanation of its lower capital fixity. As pointed out by Aoki (1984), Japanese electrical machinery firms extensively use the strategy of outsourcing their production to subsidiary or subcontract firms: the typical firms outsource their standard mass-produced products to their subsidiary or subcontract firms, and specialize in R & D activities and production of high valued products. This practice together with the manufacture-supplier relationships in Japan appear to lower the fixity of capital stock in the electrical machinery industry (see Suzuki (1991) for further details of this point).

When it comes to its overall effects as a cost component, the adjustment cost has a larger share of the variable cost in the stagnant textile inudstry (1.7 percent) than in the dynamic electrical machinery industry (0.7 percent) due solely to its high fixity in capital stock. As far as the present data are concerned, the adjustment cost is more serious in stagnant industries rather than growing industries. The electrical machinery industry appears to have been able to solve the adjustment problem in the course of its high growth process, while the stagnant textile industry seems to have had difficulty in adjusting quasi fixed inputs, especially capital stock, to its optimum level.

Still, with only two industries included in the analysis, it is surely too early to draw any conclusion about the relationship between adjustment costs and the growth patterns of an industry or a firm. Application of the model to more industries or panel data of firms will be a promising future direction for research. One should also be aware of the partial equilibrium nature of the model, and the resulting limitations in the scope of the analysis. In particular, in analyzing issues of employment adjustments using the above model, it will be extremely important to incorporate also a model of household labor supply.

APPENDIX A: DATA

The data on capital stock (K), gross output (Y), material (M), and workers (N), price indices of gross output (PY) and material (PM), and average annual wage rate are taken from Saito and Tokutsu (1989). Kuroda and Yoshioka (1985, Table 3) provide the rate of depreciation.

"Basic Survey on Wage Structure" published annually by the Japanese ministry of Labor gives data on monthly scheduled and evertime hours of work, scheduled earnings, and allowance for overtime. We transform these montly figures into the yearly figures H and O by multiplying by 12. The scheduled and overtime wage rates were respectively obtained by dividing scheduled earnings by scheduled hours of work, and by dividing allowance for overtime by overtime hours of work.

The required rate of return τ is the mean of lending rates by commercial banks minus the rate of increase in the price index of private final consumption plus a constant risk premium of 11.6 percent per year. This value of premium is the mean excess return of the short-run money market (call money rate) of the stock market and of corporate bonds for the period 1966–1980, taken from Yonezawa and Maru (1984, p. 92). The lending rate is from Annals of Economic Statistics, Bank of Japan, and the price index of private final consumption is from National Income Statistics. The acquisition price of capital stock (PI) is the price index of private corporate investment form National Income Statistics.

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