Short-run Employment Functions for the Japanese, Korean, and Taiwanese Manufacturing Industries: An Interrelated Factor Demand Model*

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The purpose of this paper is to estimate a dynamic employment function in the interrelated factor demand model for the high growth economies of Japan, Korea and Taiwan. Some of important findings show particularly marked differences in the short-run adjustments of production labor among the countries concerned. The output elasticities of the Japanese and Taiwanese labor markets are significantly lower than that of Korea. It is the Korean labor market that exhibits fast adjustments of production labor in the short-run. In contrast, the stable condition of the Japanese labor market is mainly due to the slow adjustment of the production labor. The short-run overadjustment of the production labor in Korea represented by the high output elasticity, together with the low level of wage elasticity, suggests that the production labor market absorbed substantial burdens of the factor market adjustments from output fluctuations. In addition, the estimated cross adjustment coefficients are generally found to be much higher for the NICs of Taiwan and Korea than those of Japan, which implies that dynamic intermarket spillover effects in these countries are stronger than those of Japan.

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I. Introduction

There has been exceptional growth performance of Asian countries like Japan, Korea and Taiwan for the last three decades, which some economists tend to describe in a set of "East Asian Model."[1] However, Japan is much more advanced economically while Korea and Taiwan are commonly included in the Asian NICs or so-called "Gang of Four" in which Singapore and Hong Kong are often included together. Kutznets (1988) recently shows that these three countries are characterized by a number of common economic factors, such as high growth rates and high investment ratios, an export-orientation and successful government intervention in their industrial policies, and in particular, efficient functioning of the competitive labor market which was considered one of most important reasons for such impressive performance. Fields (1982) also argues that in the labor markets of the Asian NICs there is relatively weak or virtually no union power to push wages up and firms are generally allowed to set up wages so as to maximize employment.[2] There have been some serious research interests on the Japanese labor market in comparison with Europe and the U.S. However, we can find hardly any studies on labor market functioning of NICs such as Korea and Taiwan in comparison to Japan. Therefore, we attempt to look into the labor market performances of three East Asian countries by estimating short-run employment functions of manufacturing industries.

Development experiences for these three countries fitted well in the theoretical model of Lewis' unlimited supply of labor and Fei-Ranis' dual economy framework for their development pattern on the one hand and their government's outward looking export-oriented strategy on the other. In this regard, the conventional turning point theory showed significant structural changes of the labor market for these countries and empirically showed that each country passed its turning point in the late 1950s or earlier in Japan, the late 1960s in Taiwan and the mid-1970s or late 1960s in Korea.[3] In

[1]Kutznets (1988).

[2]See Fields (1982).

[3]The timing of turning points for Japan and Korea has not been agreed upon among economists. See Lewis (1958), Fei and Ranis (1964), Minami (1970) for Japan, and Bai (1982), Ranis (1975) and Kim (1985) for Korea and Taiwan.

the early stage of economic development, these countries adopted an export-oriented policy with labor-intensive industries. Before the turning point, economic growth was led by labor-intensive light industries and the supply of unskilled labor was assumed to be unlimited. After the turning point, major difficulty in labor market became the shortage of unskilled and skilled workers in various sectors. The short-run functioning of their labor markets would then be largely determined and dominated by the forces of demand rather than those of supply.

As each economy passed its turning point, its industrial policy shifted toward heavy manufacturing industries. The demand for skilled workers increased and shortage of these workers resulted in substantial wage increases. Since each country could no longer maintain the wage advantages from labor-intensive light industries after the turning point, each government strongly fostered capital-intensive heavy industries. Following this structual change, it was widely observed that the relative ratio of nonproduction to production workers has been increased.[4] As the capital intensity of manufacturing sectors grew rapidly, corresponding increase in nonproduction workers has been precipitated. Due to this increase in the nonproduction workers, the short-run adjustments of employment from output variations would slow down.

Moreover, there occur plenty of disequilibrium factors in the labor market for high growth economies.[5] Since output variations of the high growth cause substantial transaction costs for instantaneous adjustments in both labor and capital markets, as was indicated by Nadiri and Rosen (1969, 1973), most firms are not expected to remain along the equilibrium path at every point of time.[6] This implies that the cross effect of disequilibrium of one factor market on the other would be considerable in the high growth open economies like Japan, Korea and Taiwan.

Empirical studies on short-run employment functions in developed industrial economies have typically been concerned with the short-

[4]By the study of Delehanty (1968) on the U.S. manufacturing sector since World War II, this was mainly due to the savings of production labor and the complementarity between nonproduction labor and capital.

[5]For example, see Ranis (1989) for Korea and Taiwan and Bronfenbrenner (1970) for Japan.

[6]Transaction costs contain searching, hiring, training and layoff costs in labor market as well as costs associated with searching, waiting, installation and replacement of equipment in capital market.

run relationship between aggregate employment and output. Much of the interest in this relationship stems from the observation that while employment levels in developed industrial economies have varied cyclically through time, they have not varied to the same degree as output has fluctuated. Such behavior of employment brings about pronounced cyclical fluctuations in labor productivity. A major theoretical issue raised by previous studies in the short-run employment functions is that the elasticity of labor demand with respect to output is extremely low. This result is interpreted as implying that there are short-run increasing returns to labor.[7] This empirical finding was viewed as being inconsistent with the traditional firm theory. Numerous explanations for this paradox have been attempted.[8]

However, most of empirical researches on this short-run relationship, as is pointed out by Morrison and Berndt (1981), were largely based on ad hoc models with constant and exogenous partial adjustment assumptions. Thus, there has been a substantial need to build a dynamic model to analyze the disequilibrium of labor market in the presence of adjustments costs of interrelated factor demand. Recently, Mohen, Nadiri and Prucha (1986) have developed a fairly general model to analyze these various dynamic aspects of factor markets. This model has several important features for the empirical applications. First, it generates the short-run and long-run solutions for factor demands within a unified framework. Second, this model develops the adjustment process of each factor as the outcome of firm's explicit dynamic optimization process, so that the speed of adjustment of quasi-fixed factors to their long-run equilibrium is endogenous. Thus, it enables us to calculate long-run elasticities as well as short-run elasticities. Third, it allows the factor demands of two quasi-fixed factors to be interrelated both in the short-run and long-run, so that it is possible to analyze the effect of disequilibrium of one factor market to another. Therefore, these features of the model permit us to investigate more closely the relative importance of the quantity and price adjustment as well as the short-run relationship of ouput and employment for each labor market of these high-growth economies by focusing on the labor

[7]A good survey on this empirical result is presented by Fair (1969).

[8]These attempts can be classified into three major groups: i) the decreasing cost rationalization, ii) an aggregation or output-compositional explanation, iii) the labor hoarding justification. See Morrison and Berndt (1979).

market adjustment and flexibility.[9]

For these purposes, we estimate the interrelated factor demand functions with nonproduction (skilled) labor and capital as quasi-fixed factors and production (unskilled) labor and material as variable factors for these three countries' manufacturing sectors. We attempt to calculate the output elasticities and own- and cross-price elasticities of production and nonproduction labor respectively. The interrelatedness aspect of the model permits us to investigate the effect of intermarket adjustment among two quasi-fixed factor markets, capital market and nonproduction labor market. In this way, we can analyze the interaction of these two factor markets in dynamic sense and find the significance of the intermarket adjustment for these three rapidly growing Asian countries.

The paper is organized as follows: the basic model and its econometric specification are presented in the Section II. Section III gives empirical results of the model and interpretation. Using the estimation parameters of factor demand functions for three countries, output and price elasticities of production and nonproduction labor and own- and cross-adjustment speed of quasi-fixed inputs are calculated and interpreted. Section IV contains concluding remarks with some suggestions for the future research.

II. The Basic Model

Recent studies for the demand for labor present the model based on production functions or cost functions and specify labor as one of the several factors.[10] The demand for labor is derived demand for given ouptut and other factors from the underlying structure of production or cost. By using the flexible functional forms of production and cost, various interesting results of the own- and cross-price elasticities of inputs have been reported. Some studies attempt to make models based on firms' dynamic optimization in the presence of adjustment costs. They are Denny, Fuss and Waverman (1981), Morrison and Berndt (1981). These approaches have some shortcomings in that they cannot deal with the interrelatedness of serveral factor demands because of complicated solutions derived from dynamic optimization.

Some other studies attempt to build certain features of model to

[9]For the typical study in this line, see Hashimoto and Raisian (1988).

[10]For the survey of labor demand studies, see Hamermesh (1986) and Nickell (1986).

combine the interrelatedeness of factor demands and the process of dynamic optimization.[11] These models are more general by nature although they require some techniques in estimating the parameters of these models. The studies along this line are Epstein and Yatchew (1985), Nadiri and Prucha (1985), Prucha and Nadiri (1986) and Mohen, Nadiri and Prucha (1986).

Another line of labor demand studies can be presented in terms of heterogeneity of labor. These studies have disaggregated labor into several types by some characteristics. The most frequent disaggregations are made in terms of skill such as nonproduction labor and production labor. Recently, Pindyck and Rotemberg (1983) have derived a model of demands for nonproduction labor and production labor in a manner consistent with dynamic optimization. This model considers both the interrelatedness of factors and the cost of adjustment, but this model cannot obtain the explicit solution of the endogenous variables for convenient estimations of a complete system of production structures. This shortcoming can be solved by the idea of Epstein and Yatchew (1985) and Mohen, Nadiri and Prucha (1986). We follow this idea to derive the system of interrelated factor demand equations derived from the process of firm's dynamic optimization in the presence of adjustment costs. We assume that the total manufacturing sector of a country behaves like a typical competitive firm, pursuing profit maximization. This firm uses two variable factors and two quasi-fixed factors in producing a single output and pays the adjustment cost of quasi-fixed factors. We assume that the firm's technology is described as the following general production function.

$$y_t = F(v_t, x_{t-1}, \Delta x_t ; T_t) \tag{1}$$

where y_t is output, $v_t = [v_{1t}, v_{2t}]'$ is the vector of variable factors, and $x_t = [x_{1t}, x_{2t}]'$ is the vector of stocks of the quasi-fixed factors at the end of period. The vector $\Delta x_t = x_t - x_{t-1}$ represents internal adjustment costs which bring about output diminution, and T_t is technology index, which is assumed to change uniformly in the process of time path, that is, T_t equals time variable t.

Factor markets are assumed to be perfectly competitive. In this case we can describe firm's production technology in terms of the normalized restricted cost function defined as $G(w_t, x_{t-1}, \Delta x_t, y_t ; t)$

[11]For the recent theoretical arguments of dynamic factor demand model, see Kokkelenberg and Bischoff (1986).

$= \hat{v}_{1t} + w_t \hat{v}_{2t}$ where $\hat{v}_{1t}$ and $\hat{v}_{2t}$ denote the cost-minimizing variable factors and w_t denotes the price of the second variable input v_{2t} normalized by that of the first variable input v_{1t}.

According to Lau (1976), the function $G(\cdot)$ has the following properties: 1) $G(\cdot)$ is decreasing in x_t and increasing in $|\Delta x_t|$, w_t and y_t ($\partial G/\partial x_t < 0$, $\partial G/\partial |\Delta x_i| > 0$, $\partial G/\partial w_t > 0$, $\partial G/\partial y_t > 0$, $i = 1, 2$); 2) $G(\cdot)$ is concave in w_t; 3) $G(\cdot)$ is convex in x_t and Δx_t; 4) $\partial G(\cdot)/\partial w_t = \hat{v}_{2t}$, the cost-minimizing factor level. In our empirical analysis we take production labor, l_t, and material, m_t, as the first and second variable factors and stocks of nonproduction labor, n_t, and stocks of capital, k_t, as the first and second quasi-fixed factors. The variable w_t is then the real wage rate of production labor normalized by the price of materials.

The functional form of $G(\cdot)$ in our model is assumed to take the following form which has constant returns to scale technology.[12]

$$
\begin{aligned}
G(w_t, x_{t-1}, \Delta x_t, y_t, t) &= G(w_t, x_{t-1}/y_t, \Delta x_t/y_t, t)y_t \\
&= y_t[\alpha_0 + \alpha_w w_t + \alpha_{ww} w_t^2/2 + \alpha_{tw} w_t t + \alpha_t t] \\
&\quad + \alpha_n n_{t-1} + \alpha_k k_{t-1} + \alpha_{nn}(n_{t-1}{}^2/y_t)/2 \\
&\quad + \alpha_{kk}(k_{t-1}{}^2/y_t)/2 + \alpha_{nk} n_{t-1} k_{t-1}/y_t \\
&\quad + \dot{\alpha}_n \Delta n_t + \dot{\alpha}_k \Delta k_t + g_{nn}(\Delta n_t^2/y_t)/2 \\
&\quad + g_{kk}(\Delta k_t^2/y_t)/2 + g_{nk}(\Delta n_t \Delta k_t)/y_t \\
&\quad + \alpha_{wn} w_t n_{t-1} + \alpha_{wk} w_t k_{t-1} + \dot{\alpha}_{wn} w_t \Delta n_t \\
&\quad + \dot{\alpha}_{wk} w_t \Delta k_t + \dot{\alpha}_{nn} n_{t-1} \Delta n_t + \dot{\alpha}_{kk} k_{t-1} \Delta k_t \\
&\quad + \dot{\alpha}_{nk} n_{t-1} \Delta k_t + \dot{\alpha}_{kn} k_{t-1} \Delta n_t + \alpha_{tn} n_{t-1} t \\
&\quad + \alpha_{tk} k_{t-1} t + \dot{\alpha}_{tn} \Delta n_t t + \dot{\alpha}_{tk} \Delta k_t t
\end{aligned}
\tag{2}
$$

We assume that marginal adjustment costs of quasi-fixed factors are zero at a steady state, where $\Delta n_t = \Delta k_t = 0$. These assumptions will be satisfied if and only if the following restrictions are imposed.[13]

$$
\begin{aligned}
&\dot{\alpha}_n = \dot{\alpha}_k = \dot{\alpha}_{wn} = \dot{\alpha}_{wk} = \dot{\alpha}_{nn} \\
&= \dot{\alpha}_{kk} = \dot{\alpha}_{nk} = \dot{\alpha}_{kn} = \dot{\alpha}_{tn} = \dot{\alpha}_{tk} = 0
\end{aligned}
\tag{3}
$$

Following Mohen, Nadiri and Prucha (1986), we assume $g_{nk} = 0$,

[12]This functional form has a quadratic form in all arguments except time variable, t. We assume that the coefficient of t^2 equals zero. This is the same as the model of Mohen, Nadiri and Prucha (1986) except including time variable.

[13]For the explanation of these condition, see Denny, Fuss and Waverman (1981) and Morrison and Berndt (1981).

which implies separability in adjustment costs of quasi-fixed factors. Note that $\alpha_{nk} \neq 0$, which means non-separability of quasi-fixed factors.[14] We denote the real discount rate, the corporate tax rate, the depreciation rate of capital and the depreciation rate of unskilled labor as r_t, u_t, δ_n and δ_k respectively.

The firm's objective is to find input paths such that the present value of future cost stream is minimized for given n_{t-1} and k_{t-1}, and subject to production technology (1). We assume static expectations on relative factor prices, output, and the given technology.

Under static expectations of exogenous variables, the firm's optimization problem at period t can be stated as follows.

$$\begin{aligned} \underset{\{n_{t+s},\, k_{t+s}\}_{t=0}^{\infty}}{\mathrm{Min}} \sum_{s=0}^{\infty} \{ & [G(t+s) + q_{nt} I_{n,t+s}](1-u_t) \\ & + q_{kt} I_{k,t+s}\} (1+r_t)^{-s} \end{aligned} \tag{4}$$

where $G(t+s) = G(w_t, n_{t+s-1}, k_{t+s-1}, \Delta n_{t+s}, \Delta k_{t+s}, y_t, t+s)$, q_{nt} and q_{kt} are respectively the normalized acquisition prices of skilled labor and capital, and $I_{n,t+s} = n_{t+s} - (1-\delta_n) n_{t+s-1}$ and $I_{k,t+s} = k_{t+s} - (1-\delta_k) k_{t+s-1}$. We assume $\delta_n = 0$.

The following set of Euler equations is necessary conditions to solve this dynamic programming problem.

$$\begin{aligned} -Bx_{t+s+1} + [A + (2+r_t)B] & x_{t+s} \\ - (1+r_t)Bx_{t+s-1} & = a_t \end{aligned} \tag{5}$$

$$\text{where } B = \begin{bmatrix} g_{nn} & 0 \\ 0 & g_{kk} \end{bmatrix}, \quad A = \begin{bmatrix} \alpha_{nn} & \alpha_{nk} \\ \alpha_{nk} & \alpha_{kk} \end{bmatrix}$$

$$\text{and } a_t = - \begin{bmatrix} \alpha_k + \alpha_{wn} w_t + \alpha_{tn} t + c_{nt} \\ \alpha_k + \alpha_{wk} w_t + \alpha_{tk} t + c_{kt} \end{bmatrix} y_t$$

$$\text{with } c_{nt} = q_{nt} r_t \text{ and } c_{kt} = q_{kt}(r_t + \delta_k)/(1-u_t).$$

Treadway (1974) has shown that this type of solution can be interpreted as a flexible accelerator as follows.

$$\Delta x_t = M(x_t^* - x_{t-1}),\ x_t^* = A^{-1} a_t,\ M = \begin{bmatrix} m_{nn} & m_{nk} \\ m_{kn} & m_{kk} \end{bmatrix} \tag{6}$$

[14]Distinguished from this assumption, the separability assumption is being employed in the models specified in continuous forms for empirical applications because in the process of solving this dynamic programming problem they cannot lead to the explicit equations of endogenous variables to estimate the parameters of the models. See Denny, Fuss and Waverman (1981).

where $x_t^* = [n_t^* \quad k_t^*]'$ is the steady state solution of (4).

The matrix of adjustment coefficients M has to satisfy the following matrix equation.

$$BM^2 + (A + r_t B)M - A = 0 \tag{7}$$

According to Mohen, Nadiri and Purcha (1986), we define the matrix C as follows.

$$C = -BM = \begin{bmatrix} c_{nn} & c_{nk} \\ c_{nk} & c_{kk} \end{bmatrix} \tag{8}$$

Then we can express A and D in terms of B and C.[15]

$$A = C - (1 + r)[B - B(C + B)^{-1}B] \tag{9}$$

$$D = B^{-1} + (1 + r)(C - rB)^{-1} = \begin{bmatrix} d_{nn} & d_{nk} \\ d_{nk} & d_{kk} \end{bmatrix} \tag{10}$$

Substituting (9) and (10) into (7) we can write the demand equations for the quasi-fixed factors in the following forms:

$$\begin{aligned} n_t = {} & d_{nn}a_{nt} + d_{nk}a_{kt} + (c_{nn}/g_{nn} + 1)n_{t-1} \\ & + (c_{nk}/g_{nn})k_{t-1} \end{aligned} \tag{11}$$

$$\begin{aligned} k_t = {} & d_{nk}a_{nt} + d_{kk}a_{kt} + (c_{kn}/g_{kk})n_{t-1} \\ & + (c_{kk}/g_{kk} + 1)k_{t-1} \end{aligned} \tag{12}$$

We can derive the demand equations for two variable factors from the normalized restricted cost function using Shephard's lemma, $l_t = \partial G(t)/\partial w_t$, $m_t = G(t) - w_t l_t$.

$$\begin{aligned} l_t = {} & (\alpha_w + \alpha_{ww}w_t + \alpha_{tw}t)y_t \\ & + \alpha_{wn}n_{t-1} + \alpha_{wk}k_{t-1} \end{aligned} \tag{13}$$

$$\begin{aligned} m_t = {} & (\alpha_0 - \alpha_{ww}w_t^2/2 + \alpha_t t)y_t + \alpha_n n_{t-1} \\ & + \alpha_k k_{t-1} + \alpha_{nn}^2 n_{t-1}/(2y_t) \\ & + \alpha_{kk}k_{t-1}^2/(2y_t) + \alpha_{nk}n_{t-1}k_{t-1}/y_t \\ & + g_{nn}\Delta n_t^2/(2y_t) + g_{kk}\Delta k_t^2/(2y_t) \\ & + \alpha_{tn}n_{t-1}t + \alpha_{tk}k_{t-1}t \end{aligned} \tag{14}$$

[15]For the derivation of these expressions (9) and (10), we have to use the idea of Prucha and Nadiri (1986), $(I - M)[I - r(I - M)]^{-1}B^{-1} = -(1/r)[B^{-1} + (1/r)\{C - (1 - r)/r\} B^{-1}]$. This idea is similar to that of Epstein and Yatchew (1985). For the explicit expressions for A and D, see Nadiri and Prucha (1985) or the appendix of Mohen, Nadıri and Prucha (1986).

The four equations we have to estimate consist of two equations (11) and (12), and two modified equations of (13) and (14), where α_{kk}, α_{nn}, α_{nk}, d_{kk}, d_{nn} and d_{nk} are replaced by c_{kk}, c_{nk}, c_{nn}, g_{kk} and g_{nn}.

III. Empirical Results

In this section we state briefly sources of data and present empirical results of the model. The data that we use for empirical estimation of the factor demand model are composed of the total manufacturing sectors of three countries for the period from 1971 to 1985 for Japan and from 1973 to 1987 for both Taiwan and Korea. Current terms of output, capital and materials are transformed into real values by using the respective appropriate deflators. Production labor is measured in terms of total manhours worked and nonproduction labor is measured in terms of the number of workers employed at the end of each year.[16] For the empirical results to be comparable among countries, all data are transformed on a dollar base. The sources of the data are described in detail in the Appendix.

A. Parameter Estimates

The estimation of this model has been done by the method of full information maximum likelihood (FIML). For parameter computation we use the Davidson-Fletcher-Powell minimization technique in the software package of TSP, version 4.0. The parameter estimates of our model are presented in Table 1.

The empirical results of the model are quite good for each country. Most t-values of estimated coefficients for Japan and Korea are statistically significant, but some for Taiwan are relatively less significant. Durbin-Watson statistics show that most estimated equations have inconclusive evidences of autocorrelation.[17] This

[16]In this model nonproduction and production labor are measured differently. Nonproduction labor is measured in terms of stocks at the end of each period and production labor is measured in terms of manhours worked. This is because we intend to follow the assumption of our model that nonproduction labor is quasi-fixed and production labor is variable in the short run. Since total man hours worked consist of regular and overtime hours, of which the economic behaviors of these two types of hours are not same, as was indicated by a referee, but this was not done in this study due to the unavailability of appropriate data for three countries concerned.

[17]It is viewed as desirable to correct the autocorrelation in this model, but the nonlinearity of simultaneous equations may make this correction difficult.

TABLE 1
FIML PARAMETER ESTIMATES OF THE DYNAMIC INTERRELATED FACTOR DEMAND MODEL FOR THE TOTAL MANUFACTURING SECTORS OF JAPAN FOR 1971-85, AND TAIWAN AND KOREA FOR 1973-87[1]

Parameter	Japan		Taiwan		Korea	
α_0	1.087	(4.832)	4.629	(4.009)	1.398	(7.881)
α_k	−3.470	(−2.135)	3.396	(1.979)	−1.556	(−3.183)
α_n	−1.000	(−3.029)	−11.127	(−4.115)	−0.480	(−0.897)
c_{nn}	−5.898	(−2.399)	−7.380	(−1.930)	−2.395	(−8.323)
c_{kk}	−7.766	(−2.401)	−4.788	(−3.100)	−2.475	(−4.247)
c_{nk}	0.869	(1.698)	1.453	(1.220)	0.808	(1.976)
g_{nn}	18.345	(1.437)	11.846	(1.396)	4.339	(4.017)
g_{kk}	14.690	(1.607)	11.698	(1.491)	8.393	(3.650)
α_w	0.078	(2.127)	1.165	(3.168)	1.051	(13.139)
α_{ww}	−0.056	(−1.965)	−0.159	(−1.705)	−0.027	(−1.063)
α_{wn}	0.501	(7.428)	1.805	(4.007)	−0.372	(−4.852)
α_{wk}	−0.166	(−4.740)	−1.345	(−4.156)	−0.741	(−8.470)
α_t	0.145	(3.126)	0.102	(0.781)	0.021	(0.980)
α_{tw}	0.005	(3.487)	0.030	(1.198)	0.032	(4.769)
α_{tn}	−0.008	(−0.380)	0.226	(1.499)	−0.098	(−4.776)
α_{tk}	−0.297	(−3.180)	−0.419	(−4.192)	0.086	(3.126)
log of LF^2	168.094		120.199		145.581	
	R^2	$D.W.$	R^2	$D.W.$	R^2	$D.W.$
n equation	0.995	0.943	0.991	0.624	0.993	1.245
k equation	0.996	0.881	0.993	0.987	0.996	0.978
l equation	0.996	1.107	0.991	0.281	0.965	0.755
m equation	0.981	1.160	0.979	0.878	0.993	1.023

Note : 1. R^2s are calculated as unity minus the ratio of the residual sum of squares to the total sum of squares. Asymptotic t-values are given in parentheses.
2. LF means likelihood function.

model also satisfies all restrictions from the convexity of $G(\cdot)$ in x_t and Δx_t and concavity in w_t in three countries.[18]

B. Output and Price Elasticities of Demand for Labor

Now let us consider the short-run, intermediate-run and long-run responses of production and nonproduction labor to the changes of exogenous prices and output. The short-run elasticities measure the first period response when the firm is adjusting its capital and

[18] Those restrictions are $\alpha_{kk} > 0$, $\alpha_{nn} > 0$, $\alpha_{kk}\alpha_{nn} - \alpha_{nk}^2 > 0$, $g_{kk} > 0$, $g_{nn} > 0$ and $\alpha_{ww} < 0$.

nonproduction labor and consequently incurs the costs of adjustment but operating with the initial levels of these stocks.

We calculate various elasticities of production and nonproduction labor with respect to the unnormalized price of materials, production labor, capital, nonproduction labor, and output, which are denoted as w_m, w_1, c_k, c_n and y_t.

Let $\hat{x}_{t+s} = [\hat{x}_{1,t+s}, \hat{x}_{2,t+s}]'$ with $s = 1, 2, \cdots, \infty$ be the optimal input sequence of the quasi-fixed factors defined by (6). We then have the following equations.

$$\begin{aligned} \hat{x}_t &= Mx_t^* + (I - M)x_{t-1} \\ \hat{x}_{t+1} &= Mx_t^* + (I - M)x_t \\ \hat{x}_{t+\infty} &= x_t^* \end{aligned} \tag{15}$$

We refer to the elasticities of $\hat{x}_{jt}$, $\hat{x}_{j,t+1}$ and x_{jt}^* with respect to input prices and output, respectively, as the short run, intermediate run and long run elasticities of the jth quasi-fixed factors. We denote them $\varepsilon_{x_jz}^S$, $\varepsilon_{x_jz}^I$ and $\varepsilon_{x_jz}^L$, where $z = w_{mt}$, w_{lt}, c_{kt}, c_{nt} and y_t.

$$\begin{aligned} \varepsilon_{x_jz}^S &= (\partial \hat{x}_{jt}/\partial z)(z/\hat{x}_{jt}) \\ \varepsilon_{x_jz}^I &= (\partial \hat{x}_{j,t+1}/\partial z)(z/\hat{x}_{j,t+1}) \\ \varepsilon_{x_jz}^L &= (\partial x_{jt}^*/\partial z)(z/x_{jt}^*) \end{aligned} \tag{16}$$

Let $v_{t+s} = [\hat{v}_{1,t+s}, \hat{v}_{2,t+s}]'$ be the sequence of optimal variable inputs associated with $\hat{x}_{t+s}$ for $s = 1, 2, \cdots, \infty$. Let us write $\hat{v}_{it}$, $\hat{v}_{i,t+1}$ and v_{it}^* as the value of v_{it} in which x_{t-1}, $\hat{x}_t$ and x_t^* are substituted for one arguement x_{t-1} of v_{it} equation. Using $\hat{v}_{it}$, $\hat{v}_{i,t+1}$ and $v_{i,t}^*$, we also calculate the short-run, intermediate-run and long-run elasticities of the ith variable factors with respect to input prices and output defined as follows.

$$\begin{aligned} \varepsilon_{v_iz}^S &= (\partial \hat{v}_{it}/\partial z)(z/\hat{v}_{it}) \\ \varepsilon_{v_iz}^I &= (\partial \hat{v}_{i,t+1}/\partial z)(z/\hat{v}_{i,t+1}) \\ \varepsilon_{v_iz}^L &= (\partial v_{it}^*/\partial z)(z/v_{it}^*) \end{aligned} \tag{17}$$

In this model the quasi-fixed factors do not adjust immediately to their long-run equilibrium values. Therefore, some of the variable factors have to overshoot in the short-run. That is, the short-run elasticities of some variable factors have to be larger than the long-run output elasticities.

We present output and own-price elasticities of production and nonproduction labor for the Japanese, Taiwanese and Korean manufacturing in Table 2. All of output elasticities have the positive

TABLE 2
OUTPUT AND OWN-PRICE ELASTICITIES OF PRODUCTION AND NONPRODUCTION LABOR OF THE TOTAL MANUFACTURING SECTORS IN JAPAN, TAIWAN AND KOREA: SAMPLE AVERAGES[1]

Elasticity estimate	Japan			Taiwan[3]			Korea[4]		
	SR	*IR*	*LR*	*SR*	*IR*	*LR*	*SR*	*IR*	*LR*
ε_{ny}[2]	0.18	0.41	1.00	0.43	0.72	1.00	0.31	0.51	1.00
ε_{ly}	0.51	0.43	1.00	0.74	1.03	1.00	2.20	2.06	1.00
ε_{nn}	−0.33	−0.56	−1.08	−0.10	−0.16	−0.20	−0.36	−0.53	−0.78
ε_{ll}	−0.42	−0.65	−1.15	−0.12	−0.30	−0.50	−0.05	−0.45	−1.23

Note : 1. For the range of the respective periods, see Table 4, footnote 1.
2. $\varepsilon_{iy} = (\partial i/\partial y)(y/i)$, where $i = n, k, l$ and m, $\varepsilon_{ii} = (\partial x_i/\partial c_i)(c_i/x_i)$, $_{i=n,k}$ where x_i is a i-th quasi-fixed factor and c_i is the user cost of x_i, and $\varepsilon_{jj} = (\partial v_j/\partial w_j)(w_j/v_j)$, $_{j=l,m}$ where v_j is a j-th variable factor and w_j is the price of v_j.
3. For the intermediate-run output elasticity estimates of Taiwanese sectors, the annual estimates from 1973 to 1976 are excluded and for the intermediate-run own-price elasticity estimates of Taiwanese manufacturing, 1974's values are excluded in the process of averaging because of the instability of them.
4. The averages of Korean long-run own-price elasticities estimates are calculated, excluding the estimates over the period 1973-76 because those values are very unstable and the averages over total period may be misleading.

signs and all of own-price elasticities have the negative signs in all the countries concerned, which are expected from economic theory. The estimated results and implications are as follows.

There have been distinct hoarding phenomena of nonproduction labor for all three countries in the short-run as their output elasticities are shown far less than unity. These results are consistent with increasing returns to labor in the short-run which is also observed in the other industrial countries.[19] In comparison to the study of Morrison and Berndt (1981), short-run, intermediate-run and long-run output elasticities of nonproduction labor for three countries are higher than those of the U.S.

While Japanese estimates are somewhat higher than the U.S. re-

[19]According to Morrison and Berndt (1981), it is shown that short-run increasing returns to labor in the U.S. are due not to the effects of production labor but to those of nonproduction labor. By Mohen, Nadiri and Prucha (1986), the total labor demands for Japanese and German manufacturing show the same phenomena of increasing returns to labor.

sults, the magnitudes of Taiwanese and Korean estimates are much larger than those of United States. This may reflect the fact that the manufacturing sectors in newly industrialized economies do have considerable flexibility of adjustment in nonproduction labor in response to output fluctuations. This fact should be related to the low specific human capital and weakly organized labors in Taiwan and Korea.

It has been generally known that labor market adjustments in Japan rely more heavily upon hours of work than employment. Our results show that the low sensitivity of Japanese labors to output change will be due not only to the low adjustment of nonproduction labor but also to the slow adjustment of total manhour of production labor.[20] This is also confirmed in the low output elasticity estimated for the Japanese production labor, that is production manhours, in our study.[21] While both the production labor for Japan and Taiwan are turned out to be hoarded in the short-run, Korean production labor overshoots strongly its long-run values. In the similar way, the U.S. production labor in the study of Morrison and Berndt (1981) show an overshooting in the short-run.

Our Japanese results show that there has been a job stability even in the production labor market in comparison to other countries.[22] This is due to the Japanese wage system in which the wage rate is determined by employees' tenures and ages. This result is also in line with the study of Hashimoto and Raisian (1988). They show that employment variability for a given variability in real output in the U.S. is nearly 50 percent greater than that of Japan during the peiod 1951-83. In this sense Japanese production labor seems to have received much benefits from the life-time employment system because of the relative insignificance of skill in the determination of wage rates. From the result that short-run output elas-

[20]Considering Tachibanachi's (1987) suggestion that the adjustment speed of Japanese labor market by employment has been increasing for some recent years especially after the two oil crises, we can conjecture that the relative importance of hours worked to employment has been getting lower in the labor market adjustment than before. Particularly, this phenomena may be related to the reluctance of Japanese production workers for overtime. We owe this interpretation to a refree.

[21]Among three countries, output elasticities of two kinds of labor in the Japanese manufacturing seem to be inelastic partly due to the internal adjustment within firms in comparison with the other countries. For the explanation of Japanese firm's behavior of labor adjustment, see Tachibanachi (1987).

[22]Abrahm and Houseman (1989) have shown that Japanese workers appear to enjoy a greater employment stability than U.S. workers.

ticities of the Korean production labor are much higher than those of Japan, we can indicate that Korean production labor and manhours bear relatively heavy burdens of output variation, which reflects the job instability of this labor during cyclical variations.

It is indicated that since the mid-1970s Korean manufacturing firms have faced gradually high capital costs and inefficiency and therefore had to rely heavily on the adjustment of the production labor and manhours in response to the rapid output growth because its wage rates have been maintained in the very low level due to weakly organized labors and the government policy. Compared with the case of Korea, the Taiwanese manufacturing has maintained the capital efficiency to some degree and has felt less burdens of the capital cost, so that they have received less pressures to absorb costs of the production labor at low wage rates in response to their rapid output growth.[23]

For all three countries, short-run and long-run own-price elasticities of nonproduction and production labor are generally much lower than those of the U.S. results in the Morrison and Berndt (1981). These Japanese results are in line with Muramatsu (1985), whose conclusion shows that Japanese real wage elasticities are much lower than those of the U.S. Our results also show that Korean estimates of the wage elasticity are lower than Japanese, while those of Taiwan are the lowest among them. Therefore, we can conclude that the wage effects of employment on the production labor are turned out to be weaker in three Asian countries than in the U.S. In particular, Taiwan and Korea have much weaker wage effects on labor demand. This result seems to be closely related to the incompetitiveness of labor market and special wage determination systems by tenures and ages for these countries. From the above mentioned results, we can indicate that both quantity and price adjustments of labor are very low in Japan in comparison with the U.S. results and quantity adjustments of labor for the Taiwanese and Korean manufacturing are generally much stronger than their labor price adjustments.[24]

[23]These interpretations are consistent with Hong's (1988) arguement that Korea's capital market has been more distorted in favor of capital-intensive sectors than that of Taiwan.

[24]The insensitivity or rigidity of wage on labor demands in three countries implies that the wage rates of these countries may not play appropriate roles as market signals to labor demand adjustment. This implication is closely related to labor market distortions or segmentations in these countries. For the labor market distortions and segmentations of three countries, see Tachibanachi (1987), Hong (1988) and Lee (1980).

TABLE 3

SHORT-RUN, INTERMEDIATE-RUN AND LONG-RUN CROSS-PRICE ELASTICITIES OF PRODUCTION AND NONPRODUCTION LABOR IN THE TOTAL MANUFACTURING SECTORS: AVERAGES OVER 1973-1987 FOR TAIWAN AND KOREA, AND 1971-85 FOR JAPAN

Elasticity	Japan			Taiwan			Korea[1]		
estimate	*SR*	*IR*	*LR*	*SR*	*IR*[3]	*LR*	*SR*	*IR*	*LR*
ε_{nk}[2]	−0.07	−0.12	−0.29	−0.08	−0.15	−0.28	−0.23	−0.42	−0.81
ε_{nl}	−0.16	−0.27	−0.51	−0.08	−0.09	−0.05	0.29	0.48	0.89
ε_{nm}	0.55	0.95	1.87	0.26	0.38	0.54	0.29	0.46	0.69
ε_{lk}	0.00	0.01	−0.16	0.00	0.11	0.26	0.00	0.44	1.25
ε_{ln}	0.00	−0.40	−1.35	0.00	−0.04	−0.04	0.00	0.25	0.74
ε_{lm}	0.42	1.04	2.96	0.12	0.25	1.22	0.05	−0.24	−0.16
ε_{kn}	−0.03	−0.05	−0.10	−0.07	−0.13	−0.26	−0.12	−0.22	−0.52
ε_{kl}	0.00	0.00	−0.02	0.15	0.23	0.38	0.28	0.48	0.99
ε_{mn}	0.00	0.20	0.77	0.00	0.21	0.58	0.00	0.19	0.68
ε_{ml}	0.06	0.15	0.42	0.15	0.31	0.51	0.04	−0.16	−0.87

Note : 1. For the excluded period in calculating Korea's long-run elasticities, see Table 5, footnote 1.

2. $\varepsilon_{ij} = (\partial i/\partial j)(j/i)$, where $i = k, n, l$ and m, and $j = c_k, c_n, w_l$ and w_m.

3. These intermediate-run elasticity estimates are averaged from the elasticity estimates over the period 1974-87.

We present the short-run, intermediate-run and long-run cross-price elasticities of production and nonproduction labor in the Table 3. Some interesting points are as follows.

First, nonproduction labor and capital in three countries are complements, which is consistent with Griliches' (1969) results on the capital-skill complementarity hypothesis. Our results are in line with most previous studies of Berndt and Christensen (1974), Clark and Freeman (1977), and Morrison and Berndt (1981).

Second, production labor and capital are substitutes in the cases of Taiwan and Korea, but complements only in the long-run for Japan. Most previous studies for the U.S. show that those factors are substitutes.[25]

Third, production and nonproduction labor are complements in Japan and Taiwan while substitutes in Korea. Korean results are in

[25]In particular, the cross-elasticities between two kinds of labor and capital for Korea are higher than those of Japan and Taiwan. This implies that intermarket spillover effects in the Korean factor market are much stronger than those in the Japanese and Taiwanese factor markets. These phenomena are consistent with the results for the speed of adjustments dicussed in the following section.

line with the studies of Clark and Freeman (1977), and Morrison and Berndt (1981). Fourth, nonproduction labor and materials are substitutes for all three contries. Production labor and materials are substitutes for Japan and Taiwan. They are complements only in the intermediate- and long-run for Korea.

C. The Speed of Factor Adjustments

We can also derive the estimates of adjustment coefficients for m_{nn}, m_{nk}, m_{kn}, and m_{kk} from the Table 3. Some interesting points are as follows.

The own-adjustment coefficients are significantly different across countries. In Japan the own-adjustment coefficient for nonproduction labor, m_{nn}, is much lower than the own-adjustment coefficient for capital, m_{kk}, but in Taiwan and Korea the reverse results are found. In Japan the own-adjustment coefficient for nonproduction labor is lower by approximately 40% than that for capital, whereas in Taiwan and Korea that coefficient for nonproduction labor is by approximately 55% to 80% higher than that for capital. The lifetime employment system of Japanese labor market and high level of expenditure to human capital investment appear to bring about slower speed of adjustment for skilled labor. However, we can indicate that those firms in Korea and Taiwan have paid relatively high internal costs of adjustment for capital because of the existence of high market interest rate in relatively large informal markets. The search costs of capital should be high in distorted dual capital markets of both countries which have faced inefficient financial practices in the private and public sectors.

Furthermore, we can conjecture that both Korean and Taiwanese labor markets are more competitive than Japanese labor market in that Korean and Taiwanese firms need relatively lower-skilled labor and have more active incentive systems for their worker's compensations and more flexible labor contract behaviors than Japanese firms. Our result of speed of adjustment for labor in Japan is higher than those of other advanced countries. According to Tachibanachi (1987), previous studies have shown that the U.S. and British labor adjustment speeds are higher than those of Japan. Those coefficients range roughly from 0.4 to 0.6 in the U.S. and from 0.2 to 0.3 in the United Kingdom, while Japanese coefficients are 0.1 by Muramatsu (1983) and 0.04-0.06 by Shinozuka and Ishihara (1977). The Japanese estimates for the nonproduction labor are much higher

TABLE 4
FIML ESTIMATES OF OWN- AND CROSS-ADJUSTMENT COEFFICIENTS OF CAPITAL AND NONPRODUCTION LABOR IN THE TOTAL MANUFACTURING SECTORS OF JAPAN, TAIWAN AND KOREA: AVERAGES OVER THE TOTAL PERIOD[1]

Adjustment coefficient	Japan	Taiwan	Korea
m_{nn}	0.322 (3.356)	0.623 (4.728)	0.552 (7.138)
m_{nk}	−0.047(−2.085)	−0.123(−2.502)	−0.186(−2.685)
m_{kn}	−0.059(−1.515)	−0.124(−1.447)	−0.096(−1.938)
m_{kk}	0.529 (3.694)	0.409 (2.495)	0.295 (3.516)

Note : 1. Asymptotic t-values are given in parentheses.

than those of other countries. This may look surprising although Tachibanachi (1987) suggests that the speed of adjustments for Japanese labor has been increasing recently because firms tend to minimize the number of employees as much as possible as these firms anticipate lower growths in the future. In some respects, both employers and employees now are not hesitant to apply employment adjustments in response to output changes. From this result, we can observe the relative progress of financial liberalization and competitiveness of the Japanese capital market in that there has been a high speed of adjustments for capital due to its low transaction costs.

By the estimated cross-adjustment coefficients from the Table 4, capital and nonproduction labor are turned out to be dynamic complements in the three countries, which implies that if capital is in excess demand, the adjustment in nonproduction labor will slow down and vice versa. The cross-adjustment coefficients, m_{kn} and m_{nk} are much lower for Japan than those for both Taiwan and Korea. This implies that Japanese quasi-fixed factor markets have lower intermarket adjustments between them than Korean and Taiwanese factor markets have.

The magnitude of m_{kn} is similar to those of m_{nk} in Japan and Taiwan while that of m_{nk} is twice as large as that of m_{kn} in Korea. From this result, we can find that there are symmetries in the influences of one quasi-fixed factor upon the adjustment of another quasi-fixed factor in Japan and Taiwan, but there exists an asymmetry between two quasi-fixed factor markets in Korea. The cross effect of capital market disequilibrium upon nonproduction labor adjustment in Korea is found to be twice as large as the effect of nonproduction labor market disequilibrium upon capital adjustment.

TABLE 5
FIRST-PERIOD ADJUSTMENT IN CAPITAL AND NONPRODUCTION LABOR: AVERAGES OVER THE 1970S, 1980S AND TOTAL PERIOD[1]

Adjustment speed in first period	Sample period	Japan	Taiwan	Korea
	1970s	0.354	0.468	0.400
		(0.102)	(0.067)	(0.300)
h_n	1980s	0.132	0.297	0.334
		(0.165)	(0.176)	(0.167)
	total	0.265	0.337	0.365
		(0.168)	(0.159)	(0.231)
	1970s	0.458	0.290	0.283
		(0.203)	(0.066)	(0.083)
h_k	1980s	0.551	0.402	0.184
		(0.097)	(0.098)	(0.050)
	total	0.495	0.350	0.230
		(0.168)	(0.117)	(0.083)
	1970s	0.354	0.468	0.400

Note : 1. The sample standard deviations are given in parentheses. The 1970s denotes 1971-79 for Japan and 1973-79 for Taiwan and Korea, and 1980s denotes 1980-85 for Japan, and 1980-87 for Taiwan and Korea.

In order to calculate the total speed of adjustment for the quasi-fixed factors, we have to consider the own- and cross-adjustments together. We can take as our measure of the total speed of adjustment a fraction of the difference between the long-run desired stock and initial stock, which is shown as below.

$$\begin{aligned} & h_n = m_{nn} + m_{nk}(k_t^* - k_t)/(n_t^* - n_t) \\ \text{and} \quad & h_k = m_{kk} + m_{kn}(n_t^* - n_t)/(k_t^* - k_t) \end{aligned} \tag{18}$$

Table 5 shows sample averages of measurement of the total speed of adjustment for two quasi-fixed factors. We divide the total period into two sub-periods, that is, the 1970s and 1980s.

The total speed of adjustment for capital, h_k, is the largest in Japan and the smallest in Korea and in the middle in Taiwan for the whole period. The h_k's for both Japan and Taiwan have become higher in the 1980s than in the 1970s, but it is in Korea that the speed of adjustment for capital is higher for the 1970s than for 1980s. The total speed of adjustment for nonproduction labor, h_n, is the largest for Taiwan and the smallest for Japan for the whole period. It is interesting that h_n's for all countries have become lower in the 1980s than in the 1970s. In particular, the degree of h_n's diminution is the largest in Japan among three countries and followed by Taiwan.

It is noteworthy to indicate that the order of h_n's magnitude in three countries is the same as the order of ε_{ny}'s magnitude in the short-run. This implies that price adjustments of nonproduction labor demands for three countries are relatively modest because total adjustments of the nonproduction labor market heavily depend on its quantity adjustments.

IV. Concluding Remarks

We have estimated the employment functions in the dynamic interrelated model for the Japanese, Korean, and Taiwanese manufacturing industries. The fact that the labor market functioning played a crucial role in these high growth economies, as observed by Fields (1982) and Kutznets (1988), motivates us to investigate the short-run relationship between output and two types of labor, production and nonproduction labor. The empirical results are focused on the measurement of the output elasticity, own- and cross-price elasticities of two types of labor and the adjustment speed of quasi-fixed factors to their long run equilibrium. In particular, an interrelated aspect of the model makes it possible to analyze the effects of dynamic cross-adjustments between nonproduction labor market and capital market. It shows that the empirical results of the model are quite reasonable and satisfy all the restrictions for all the constraints concerned. By the comparison of our results with those of the U.S. and Europe, we find not only certain common characteristics of labor market behaviors in the Asian Model, but also some unique features inherent in each economy for Japan, Taiwan, and Korea respectively. Major findings of this study are summarized as follows.

First, there have been distinct hoarding phenomena of nonproduction labor in the short-run for all three countries. These results are consistent with short-run increasing returns to labor, which has been found similarly in the previous studies for other industrial economies.

Second, in the production labor market, however, there is a significant diversity among three countries. The output elasticity of the Japanese and Taiwanese labor market is significantly lower than that of Korea, and it is the Korean labor market that exhibits markedly fast adjustments of the production labor in the short run. Taiwan stays in the middle but somewhat close to the Japanese pattern. The stable employment condition of the Japanese labor market is mainly due to the slow adjustment of production labor compared with the U.S. and other Asian countries. The short-run overadjustment of the production labor in Korea represented by the high output elasticity, together with the low level of wage elasticity, suggests that the production labor market absorbed substantial burdens of the factor market adjustments from output fluctuations due to the high economic growth. This is closely related to the observation of Fields (1982) that the Korean labor market can adjust flexibly to output variations at the substantially stable wage level due to the absence of both the minimum wage pressure and the active union power for the period under study.

Third, own-price elasticities of production and nonproduction labor in the short-run and long-run for all the three countries concerned are much lower than that of the U.S. results that are shown in the study of Morrison and Berndt (1981).

Fourth, the total speed of adjustment for nonproduction labor to its long-run equilibrium for all three countries is higher than those of the U.S. and the United Kingdom. This result seems to come from the fact that the pattern of total adjustment of nonproduction labor to its long-run equilibrium depends more heavily upon the size of output elasticity rather than that of own-price elasiticity.

Fifth, nonproduction labor turns out to be a dynamic complement with capital for all the three countries concerned. This means that the cross-adjustment effect of capital market makes the adjustment of nonproduction labor market easier when there is a disequilibrium in the nonproduction labor market. The cross-adjustment coefficients are generally much higher for the NICs of Taiwan and Korea than those for Japan, which implies that dynamic intermarket spillover effects in Korea and Taiwan are stronger than that of Japan.

In this research, we mainly focused on the functioning of the labor market in the rapidly growing Asian countries. This analysis can be extended to all factor markets including capital and capital utilization as well as labor in the production structure of the manufacturing industry. Furthermore, it will be also interesting to divide the total manufacturing into the level of several sub-industries for further empirical evidences.

Appendix

Sources of Data

The model requires various data for the total manufacturing sector in Korea, Taiwan and Japan. The data range from 1973 to 1987 for Korea and Taiwan, and from 1971 to 1985 for Japan. The data used in this model are as follows.

A) Gross Output

All values of gross output in three countries are transformed into those in terms of the 1980's constant price. For Korea, the data of gross output are obtained from *Survey of Manufacturing and Mining Statistics,* published annually by Korean Economic Planning Board. For Japan, those data are obtained from *Yearbook of National Statistics,* published annually by Economic Planning Board. For Taiwan, those data are obtained from *National Income of Republic of China,* published by Directorate-General of Budget, Accounting and Statistics. The GNP deflator is used to calculated real gross output from nominal gross output.

B) Materials

The materials data for three countries are also obtained from the same sources as gross output data. Wholesale price index is used as the price of materials.

C) Labor

There are two kinds of labor used in this model, that is, nonproduction labor and production labor. Nonproduction labor is measured as the existing stock of nonproduction labor, and production labor is measured in terms of manhours worked. Manhours worked by production labor are calculated as the number of production workers times total hours worked per year. For the price of nonproduction labor, we use the annual average compensations for nonproduction worker. For the price of production labor, average hourly earnings are used. The data sources are *Monthly Statistics of Labor,* published by Ministry of Labor for Korea, *Survey Report on Monthly Statistics,* published by Ministry of Labor for Japan, and *National Income of Republic of China,* published by Section of Main Statistics, Executive Yuan for Taiwan.

D) Capital

Net capital stocks used in this model are measured in terms of the 1980's appropriate capital price, by which they are transformed into real net capital stocks. The figures of Korean net capital stocks are obtained from Pyo's working paper published by Korea Development Institute. For Japan and Taiwan, the figures of net capital stocks are obtained in the same sources as the gross output.

To calculate the user cost of capital, the capital price, the depreciation rate, the real interest rate and the tax rate of manufacturing sectors are required. For capital price, we used the investment deflator from the national accounting of each country. The depreciation rate is set to 0.15 for Korea and Taiwan, and 0.10 for Japan. The tax rate is calculated as the ratio of corporate income tax amount to the total variable cost plus the adjustment cost of quasi-fixed factor. We assume that the ratio of corporate income tax amount to the value added of each manufacturing sector is approximately equal to the ratio of national tax amount to gross national products. Then we calculate the tax and tax rate in the manufacturing sectors. In order to calculate nominal rate of interest for each country, we used yield rates of corporate bond, those of government bond and discount rates of commercial loans respectively. To calculate the real interest rate, we subtract percentage of change rates of investment deflators from the above mentioned nominal interest rates of each country.

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