Volume Title: Productivity Growth in Japan and the United States

Volume Author/Editor: Charles R. Hulten, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-36059-8

Volume URL: http://www.nber.org/books/hult91-1

Conference Date: August 26-28, 1985

Publication Date: January 1991

Chapter Title: Compositional Change of Heterogeneous Labor Input and Economi
Growth in Japan

Chapter Author: Hajime Imamura

Chapter URL: http://www.nber.org/chapters/c8453

Chapter pages in book: (p. 349 - 384)

12 Compositional Change of Heterogeneous Labor Input and Economic Growth in Japan

Hajime Imamura

12.1 Introduction

In this paper I evaluate the role of labor input during the rapid expansion period of the Japanese economy and in the years following the oil crisis, in order to measure the contribution of labor quality to productivity growth. Two factors influence the quality changes in labor input. One is a demographic factor, which is basically exogenous and which determines the endowment of a heterogeneous labor input. The other is an economic factor, which includes the technological conditions and the market conditions of the economy. Therefore, quality change in labor input can be defined as the result of rational behavior among economic entities under given market conditions, a given level of technology, and fixed-factor endowment.

A framework that treats the above factors as endogenous variables is the most preferable, but unfortunately we lack precise data as to what factor has the greatest impact on quality changes in labor input. The contributing factor at the outset of an enterprise may not remain the same as the stages of economic development progress. Also, we lack sufficient insight into the relationship between economic growth and quality change, particularly on account of compositional shifts in heterogeneous labor. In this paper I hope to more accurately determine the interdependent economic mechanisms underlying quality change in labor input. In addition, I undertake comparative analysis of the United States and Japan to ascertain how quality change in labor input differs in these two countries, which have had dissimilar patterns of economic development.

Hajime Imamura is an associate professor of economics at Toyo University, Tokyo, Japan.

This paper was developed from a joint research project between Keio University and Harvard University. The author wishes to thank H. Shimada and M. Kuroda for invaluable advice in preparing this paper, and W. Oi and a referee for their thoughtful comments.

Under the assumption of weak separability between labor inputs and other factor inputs, we can posit the existence of an aggregator function of heterogeneous labor inputs. This enables us to analyze the sources of quality change in labor input independently of other factor inputs. In aggregating labor inputs, we utilize Divisia indices, which are consistent with transcendental logarithmic aggregator functions. Based on the neoclassical theory of production, we measure labor quality on the premise of equality between wage rates and the value of marginal productivity.

Before proceeding we will briefly review previous research on this subject. The representative works are Watanabe and Egaizu (1968), Denison and Chung (1976) and Tachibanaki (1973). Watanabe and Egaizu measured quality change in labor input for the period 1951–64 and compared it with results for other developed countries. Their results showed quality change in labor input in Japan to be relatively low, because of an imitation lag in technological progress. They considered technological change at that time to be embodied in imported capital goods, and, as a consequence, the need for highly qualified workers employed in the development of original technology remained low. In concluding, they forecasted that, after the 1960s, a great degree of quality change in labor input would be brought on by the process of catching up technologically with the United States and Western Europe; it would be a prerequisite for original technological development.

Denison and Chung's (1976) assertion about quality change in labor input, especially the effect of education, was the opposite of Watanabe and Egaizu's (1968) results. For the period 1953–71, Denison and Chung estimated the contribution of the education effect to economic growth (10.4% per annum) as 0.41% per annum. Watanabe and Egaizu had estimated it as 0.06%–0.18%. In their framework, Denison and Chung cross-classified their data only by age and sex. Education was not cross-classified. This, then, imposed the restriction that the education effect must be almost identical in all age-sex categories.

Tachibanaki (1973) measured the quality change in labor input for 1956–70. He found the major source of quality change to be education and, especially, experience. However, his framework of analysis treated the number of employees of a company as one of the measures of quality of labor, and he measured labor input only by the number of persons, assuming hours were constant throughout the observation period.

As a continuation to this research, I measure quality change in labor input in 29 industries using the Divisia index, a method that is consistent with the neoclassical theory of production under some necessary assumptions. In addition to one-dimensional effects, a great number of multidimensional effects are considered, enabling us to understand quality change in labor input more systematically than in previous research. Second, I compiled large amounts of data on labor inputs cross-classified into age, sex, education, occupation, and industry. Such data have never before been developed consistently in time series. Third, I compare quality change in labor inputs in the United States and Japan in a more decomposed manner than in other previous research. I also assess the causes of the difference in productivity change for the United States and Japan in a precise way.

12.2 Theoretical Framework for Measuring Labor Input

12.2.1 Measurement of Total Factor Productivity and the Divisia Index

Let us consider the ith industrial sector. Suppose that there exists a production function with constant returns to scale.

$$Z_i = F_i(X_i, K_i, L_i, t). \tag{1}$$

Differentiating equation (1) logarithmically with respect to time, we obtain

$$\frac{d\ln Z_i}{dt} = \frac{\partial \ln Z_i}{\partial \ln X_i}\frac{d\ln X_i}{dt} + \frac{\partial \ln Z_i}{\partial \ln K_i}\frac{d\ln K}{dt} + \frac{\partial \ln Z_i}{\partial \ln L_i}\frac{d\ln L_i}{dt} + \frac{\partial \ln Z_i}{\partial t}. \tag{2}$$

Under perfect competition, the value-marginal product equals the real factor price.

$$\begin{aligned} P_{Z_i}\,(\partial Z_i/\partial X_i) &= P_{X_i} \\ P_{Z_i}\,(\partial Z_i/\partial K_i) &= P_{K_i} \\ P_{Z_i}\,(\partial Z_i/\partial L_i) &= P_{L_i}. \end{aligned} \tag{3}$$

Then, output elasticity is equal to the value share of each factor.

$$\frac{d\ln Z_i}{dt} = V_X^i\frac{d\ln X_i}{dt} + V_K^i\frac{d\ln K_i}{dt} + V_L^i\frac{d\ln L_i}{dt} + V_t^i, \tag{4}$$

where V_X^i represents the value share of intermediate input in the ith industry, V_K^i represents the value share of capital input in the ith industry, and V_L represents the value share of labor input in the ith industry. And, $V_t^i = \partial \ln Z_i(X_i, K_i, L_i, t)/\partial t$.

Under the assumption of weak separability between each factor input, we can define constant returns to scale aggregator functions for each factor input.[1]

$$\begin{aligned} X_i &= X_i(X_{1i}, X_{2i}, \ldots, X_{ni}) \\ K_i &= K_i(K_{1i}, K_{2i}, \ldots, K_{pi}) \\ L_i &= L_i(L_{1i}, L_{2i}, \ldots, L_{qi}), \end{aligned} \tag{5}$$

where $X_{ji}, (j = 1, \ldots, n)$ represents the n intermediate inputs from the jth sector, $K_{ki}, (k = 1, \ldots, p)$ represents the p capital inputs, and $L_{li}, (l = 1, \ldots, q)$ represents the q labor inputs.

Differentiating equation (5) logarithmically with respect to time under the assumption of perfect competition in factor markets, the elasticities of each aggregate, with respect to the individual inputs, equal the shares of each individual input in the corresponding aggregates; then, we obtain

$$
(6)\qquad
\begin{aligned}
\frac{d\ln X_i}{\mathrm{dt}} &= \sum_{j=1}^{n} \frac{\partial \ln X_i\,(X_{1i}, \ldots, X_{ni})}{\partial \ln X_{ji}} \cdot \frac{d\ln X_{ji}}{dt} = \sum_{j=1}^{n} V^i_{Xj} \frac{d\ln X_{ji}}{dt} \\
\frac{d\ln K_i}{dt} &= \sum_{k=1}^{p} \frac{\partial \ln K_i(K_{1i}, \ldots, K_{pi})}{\partial \ln K_{ki}} \cdot \frac{d\ln K_{ki}}{dt} = \sum_{k=1}^{p} VE^i_{Kk} \frac{d\ln K_{ki}}{dt} \\
\frac{d\ln L_i}{dt} &= \sum_{l=1}^{1} \frac{\partial \ln L_i(L_{1i}, \ldots, L_{qi})}{\partial \ln L_l} \cdot \frac{d\ln L_{li}}{dt} = \sum_{l=1}^{q} V^i_{Ll} \frac{d\ln L_{li}}{dt},
\end{aligned}
$$

where V^i_{Xj}, $(j = 1, \ldots, n)$ represents the share of the n intermediate inputs, V^i_{Kk}, $(k = 1, \ldots, p)$ represents the share of the p capital inputs, and V^i_{Ll}, $(l = 1, \ldots, q)$ represents the share of the q labor inputs. These are the growth rates of the Divisia indices of intermediate, capital, and labor inputs, respectively.

Here, we should comment on the data available to economic analysis. The discussion above was made in the hypothetical world of continuous data, but data in the real world can only be obtained in discrete form. To cope with a discrete data system, discrete approximation is needed. Equations (4) and (6) can be rewritten as follows.

$$
(7)\qquad
\begin{aligned}
\ln Z_i(t) - \ln Z_i(t-1) &= \bar{V}^i_X[\ln X_i(t) - \ln X_i(t-1)] \\
&+ \bar{V}^i_K[\ln K_i(t) - \ln K_i(t-1)] + \bar{V}^i_L[\ln L_i(t) - \ln L_i(t-1)] + \bar{V}^i_t,
\end{aligned}
$$

where

$$
\begin{aligned}
\bar{V}^i_X &= \tfrac{1}{2}[V^i_K(t) + V^i_X(t-1)], \\
\bar{V}^i_K &= \tfrac{1}{2}[V^i_K(t) + V^i_K(t-1)], \\
\bar{V}^i_L &= \tfrac{1}{2}[V^i_L(\mathrm{t}) + V^i_L(t-1)], \\
\bar{V}^i_t &= \tfrac{1}{2}[V^i_t(t) + V^i_t(t-1)],
\end{aligned}
$$

$$
(8)\qquad \ln X_i(t) - \ln X_i(t-1) = \sum_{j=1}^{n} \bar{V}^i_{Xj}[\ln X_{ji}(t) - \ln X_{ji}(t-1)],
$$

where

$$
\bar{V}^i_{Xj} = \tfrac{1}{2}[V^i_{Xj}(t) + V^i_{Xj}(t-1)].
$$

$$
\ln K_i(t) - \ln K_i(t-1) = \sum_{k=1}^{p} \bar{V}^i_{Kk}[\ln K_{ki}(t) - \ln K_{ki}(t-1)],
$$

where

$$\bar{V}^i_{Kk} = \tfrac{1}{2}[V^i_{Kk}(t) + V^i_{Kk}(t-1)].$$

$$\ln L_i(t) - \ln L_i(t-1) = \sum_{l=1}^{1} \bar{V}^i_{Ll}[\ln L_{li}(t) - \ln L_{li}(t-1)],$$

where

$$\bar{V}^i_{Ll} = \tfrac{1}{2}[V^i_{Ll}(t) + V^i_{Ll}(t-1)].$$

These discrete-type Divisia indices are in fact exact and superative index numbers of a translog aggregator function. Proof for this approximation is given by Diewert (1976).

12.2.2 Measurement of the Quality Change in Labor Input

To calculate an aggregate index that takes into account the heterogeneity of labor input, we use equation (6) or (8) (the discrete approximation of [6]). We then divide the index into a man-hour index and a quality index. Further, we can decompose the quality index with respect to individual quality factors.

Let us assume there are only four quality factors of labor input, sex(s), occupation(o), education(e) and age(a).[2] We can define the growth rate of the Divisia index of labor input employed in the ith industry as follows:

$$(9) \qquad \frac{\dot{L}_{it}}{L_{it}} = \sum_s \sum_o \sum_e \sum_a V_{soea,it} \frac{\dot{H}_{soea,it}}{H_{soea,it}},$$

where

$$V_{soea,it} = \frac{W_{soea,it} H_{soea,it}}{\sum_s \sum_o \sum_e \sum_a W_{soea,it} H_{soea,it}},$$

$W_{soea,it}$ is the hourly wage rates of the *soea*th labor input of ith industry and $H_{soea,it}$ is the quantity of labor input in terms of total hours worked of the ith industry.

The quantity of labor input, $H_{soea,it}$, can be rewritten as the product of total hours worked by all workers employed in the ith industry, H_{it}, and the proportion of hours worked by the *soea*th-type of labor input in the ith industry($d_{soea,it}$).

$$(10) \qquad H_{\mathrm{soea,it}} = d_{\mathrm{soea,it}} H_{it}.$$

Differentiating equation (10) logarithmically with respect to time and substituting into equation (9) yields

$$\frac{\dot{L}_{it}}{L_{it}} = \sum_s \sum_o \sum_e \sum_a V_{soea,it} \left(\frac{\dot{d}_{soea,it}}{d_{soea,it}} + \frac{\dot{H}_{it}}{H_{it}} \right)$$

$$(11) \qquad = \sum_s \sum_o \sum_e \sum_a V_{soea,it} \frac{\dot{d}_{soea,it}}{d_{soea,it}} + \frac{\dot{H}_{it}}{H_{it}} \cdot \sum_s \sum_o \sum_e \sum_a V_{soea,it}$$

$$= \sum_s \sum_o \sum_e \sum_a V_{soea,it} \frac{\dot{d}_{soea,\ it}}{d_{soea,it}} + \frac{\dot{H}_{it}}{H_{it}}$$

The growth rates of the Divisia indices are now expressed as the sum of quality change and growth rates in hours of work. The first term of the right-hand side of equation (10) accounts for the quality change in labor input, and the second term accounts for the growth rate in hours of work of labor. Hence, at any time period t, the quality change in labor input is due to the shift in the work force to jobs with higher marginal productivities. The improvement in the individual worker is reflected in the intertemporal change in each individual labor's share.[3]

By using discrete approximation, equation (11) can be rewritten as follows:

$$(12) \qquad \begin{aligned} \ln L_i(t) - \ln L_i(t-1) = {} & (\ln H_i(t) - \ln H_i(t-1)) \\ & + \sum_s \sum_o \sum_e \sum_a \tfrac{1}{2} [V_{soea,i}(t) + V_{soea,i}(t-1)] \\ & \cdot [\ln d_{soea,i}(t) - \ln d_{soea,i}(t-1)]. \end{aligned}$$

12.2.3 Decomposition of Quality Change in Labor Input

A Simple Model of Quality Decomposition

In the previous section, I showed that the Divisia index of labor input increases through upward movement of quality composition even though there is no increase in total hours worked. In reality, heterogeneity of labor input should be expressed not by one dimension, for example, education, but by multiple dimensions of education, sex, age, and occupation. This is because individuals with a given educational attainment must be either male or female and of a certain age. We cannot treat those measures of quality independently.

The next question is, Among those four factors, which contributed the most to the upward movement of quality change in labor input? To that end I have decomposed quality change into its individual factors. First, I illustrate the simple model of this framework and subsequently explain the entire model applied in our empirical analysis.

The simple model in figure 12.1 is used to explain this multiplicity in the quality of labor. Here, we assume that there are only two identifiable measures of quality: education and age. We also assume that there are only two cate-

		Age		Total
		old	young	
Education	high	(W_{ho},H_{ho})	(W_{hy},H_{hy})	(W_h,H_h)
	low	(W_{lo},H_{lo})	(W_{ly},H_{ly})	(W_l,H_l)
Total		(W_o,H_o)	(W_y,H_y)	(W,H)

Fig. 12.1 A simple model of labor input classification in two dimensions
Note: W = hourly wage ratios; H = quantity of labor input in terms of the total hours worked by workers in each category.

gories for each: highly educated(h) and less educated(l); and young(y) and old(o) workers.

In figure 12.1, H represents the quantity of labor input in terms of the total hours worked by workers in each category, W represents hourly wage rates, and suffixes correspond to each category of classification. H without a suffix denotes total hours worked by all workers; W without a suffix denotes the average hourly wage of all workers.

Let us assume three different types of labor aggregator functions.

(13) $$L_1 = L_l(H_h, H_l),$$

(14) $$L_2 = L_2(H_o, H_y),$$

(15) $$L_3 = L_3(H_{hy}, H_{ho}, H_{ly}, H_{lo}).$$

Equations (13) and (14) are one-dimensional aggregator functions, each of which includes only one of the two measures, assuming there is only one measure that makes a difference in the value of the marginal productivity of labor input. Equation (15) is the multidimensional aggregator function that includes all (two) measures.

Differentiating the above equations logarithmically with respect to time yields,

(16) $$\frac{d\ln L_1}{dt} = \sum_e \frac{\partial \ln L_1}{\partial \ln H_e}\frac{d\ln H_e}{dt},$$

$$\frac{d\ln L_2}{dt} = \sum_a \frac{\partial \ln L_2}{\partial \ln H_a} \frac{\partial \ln H_a}{dt}, \tag{17}$$

$$\frac{d\ln L_3}{dt} = \sum_e \sum_a \frac{\partial \ln L_2}{\partial \ln H_{ea}} \frac{d\ln H_{ea}}{dt}. \tag{18}$$

Assuming a linear homogeneous aggregator function and perfect competition, the output elasticity of the individual factors in each equation equals the value share of the individual factor, and using discrete approximation, we can rewrite the above equations as follows:

$$\Delta \ln L_1 = \sum_e \bar{V}_e \, \Delta \ln H_e, \tag{19}$$

$$\Delta \ln L_2 = \sum_a \bar{V}_a \, \Delta \ln H_a, \tag{20}$$

$$\Delta \ln L_3 = \sum_e \sum_a \bar{V}_{ea} \, \Delta \ln H_{ea}. \tag{21}$$

where $\bar{V}$ represents the value share in the labor aggregate of the period, and Δ denotes the first-order difference operator.

Equation (21) is the growth rate of the total Divisia index of labor input by discrete approximation. However, equations (19) and (20) are kinds of Divisia indices, but they do not include all measurable categories of labor input. So, let us call equations (19) and (20) the partial Divisia indices of education and age (discrete approximation case).

We can calculate the amount of quality change in labor input by subtracting the growth rates of total hours worked by all workers, $\Delta \ln H$, from the growth rate of labor input calculated from the above equations:

$$q_e = \Delta \ln L_1 - \Delta \ln H, \tag{22}$$

$$q_a = \Delta \ln L_2 - \Delta \ln H. \tag{23}$$

We shall call these quality changes calculated from partial Divisia indices the main effects of education or age, respectively.

From equation (21), we can calculate quality change, including both age and education. Let us define the interactive effect of education and age as follows:

$$q_{ea} = \Delta \ln L_3 - \Delta \ln H - q_a - q_e. \tag{24}$$

Next, the net contribution of age to the quality change in labor input can be calculated by subtracting the one-dimensional quality change of education (the main effect of education) from the two-dimensional quality change (total quality change). Then resulting net contribution is defined as marginal effect of age:

(24′)
$$q_a + q_{ea} = \Delta \ln L_3 - \Delta \ln H - q_e.$$

Full Framework of Empirical Analysis for Quality Decomposition

In our actual empirical analysis in this paper, we use a four-dimensional classification of labor: sex(s), occupation(o), education(e), and age(a). The growth rates of total hours worked by all employed workers is

(25)
$$\Delta \ln H = \Delta \ln \sum_s \sum_o \sum_e \sum_a H_{soea},$$

where

s = sex classification (male and female);
o = occupation (blue and white collar);
e = education (junior high school, senior high school, junior college, and university graduates);
a = age (less than 17 years old, 18–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, and over 65 years old.

We define five types of growth rates of Divisia indices, the first-order partial Divisia growth rate of labor input:

(26)
$$\Delta \ln L_i = \sum_i \bar{V}_i \, \Delta \ln \sum_j \sum_k \sum_l H_{ijkl},$$

where

$$i = s, o, e, a,$$

and

$$j, k, l = s, o, e, a \ (j, k, l \neq i);$$

the second-order partial Divisia growth rate of labor input:

(27)
$$\Delta \ln L_{ij} = \sum_i \sum_j \bar{V}_{ij} \, \Delta \ln \sum_k \sum_l H_{ijkl},$$

where

$$i, j = s, o, e, a \ (i \neq j),$$

and

$$k, l = s, o, e, a \ (k, l \neq i, j);$$

the third-order partial Divisia growth rate of labor input:

(28)
$$\Delta \ln L_{ijk} = \sum_i \sum_j \sum_k \bar{V}_{ijk} \, \Delta \ln \sum_l H_{ijkl},$$

where

$$i, j, k = s, o, e, a \ (i \neq j \neq k),$$

and

$$l = s, o, e, a \ (l \neq i, j, k);$$

and the total Divisia growth rate of labor input

$$\Delta \ln L_{ijkl} = \sum_i \sum_j \sum_k \sum_l \bar{V}_{ijkl} \Delta \ln H_{ijkl}, \tag{29}$$

where

$$i, j, k, l = s, o, e, a \ (i \neq j \neq k \neq l),$$

and where $\bar{V}$ represents the value share of the period and Δ denotes the first-difference operator.

Using these growth rates of Divisia indices, we define the main effects and interactive effects for the quality change in labor inputs:
the main effects for sex, occupation, education, and age are

$$q_i = \Delta \ln L_i - \Delta \ln H \quad (i = s, o, e, \text{ and } a); \tag{30}$$

the first-order interactive effects for quality change are

$$q_{ij} = \Delta \ln L_{ij} - \Delta \ln H - q_i - q_j \quad (i, j = s, o, e, a)(i \neq j); \tag{31}$$

the second-order interactive effects for quality change are

$$q_{ijk} = \Delta \ln L_{ijk} - \Delta \ln H - q_i - q_j - q_{ij} - q_{ik} - q_{jk} \\ (i, j, k = s, o, e \text{ and } a); \tag{32}$$

the third-order interactive effects for quality change are

$$\begin{aligned} q_{ijkl} = {} & \Delta \ln L_{ijkl} - \Delta \ln H - q_i - q_j - q_k - q_l \\ & - q_{ij} - q_{ik} - q_{il} - q_{jk} - q_{jl} - q_{kl} \\ & - q_{ijk} - q_{jkl} - q_{ijl} - q_{ikl}, \\ & (i, j, k, l = s, o, e \text{ and } a), \end{aligned} \tag{33}$$

and the total quality change in labor input is

$$\begin{aligned} \Delta \ln L_{ijkl} - \Delta \ln H = {} & \text{main effects } (q_i + q_j + q_k + q_l) \\ & + \text{first-order interactive effects } (q_{ij} + q_{ik} + q_{il} + q_{jk} + q_{jl} + q_{kl}) \\ & + \text{second-order interactive effects } (q_{ijk} + q_{ikl} + q_{jkl} + q_{ijl}) \\ & + \text{third-order interactive effect } (q_{ijkl}). \end{aligned} \tag{34}$$

Finally, we can define the marginal effects for each category as the effect of the nth factor added to the $(n-1)$ factor of labor quality.

Marginal effects of labor quality change for

$$
(35)\quad
\begin{array}{ll}
\text{sex} & q_s + q_{so} + q_{se} + q_{sa} + q_{soe} + q_{soa} + q_{sae} + q_{soea}, \\
\text{occupation} & q_o + q_{so} + q_{oe} + q_{oa} + q_{soe} + q_{soa} + q_{oea} + q_{soea}, \\
\text{education} & q_e + q_{se} + q_{oe} + q_{ea} + q_{soe} + q_{sea} + q_{oea} + q_{soea}, \\
\text{age} & q_a + q_{sa} + q_{oa} + q_{ea} + q_{soa} + q_{sea} + q_{oea} + q_{soea}.
\end{array}
$$

12.3 Data Compilation

The primary data source for full-time Japanese workers employed in nonagricultural industries is the Basic Wage Structure Survey (BWSS). We obtained data for the numbers of employees, average hours worked, and wages and bonuses cross-classified by sex, occupation, education, and age. Industries for which data were available are mining, construction, 20 two-digit level manufacturing industries, and six two-digit level service industries. We also obtained subaggregated BWSS data for motorized vehicles, bringing the total number of industries for which data were available to 29. Data for agriculture, forestry, and fishery are available from another source, the Labor Force Survey (LFS), which is only classified by sex. The time period for which we considered our index construction was 1960–79.

It is useful to take note of how the BWSS defines full-time and part-time employees.[4] Full-time employees are defined as those employees whose hours of work are the usual daily contractual hours, while part-time employees work less than that. Since part-time employees are not cross-classified by sex, occupation, education, age, and industry, our analysis mainly focuses on full-time employees.

According to the classification described in equation (25), we obtained data for 192 ($2 \times 2 \times 4 \times 12$) categories of heterogeneous labor for each of the 29 industries. However, in the process of data construction, the BWSS made a few estimates using the LFS and the Census of Manufactures.

12.4 Empirical Results

In what follows, I discuss the magnitude of the contribution of quality change in labor input to sectoral productivity change. I observe the changes of labor input in agricultural, manufacturing, and service sectors. The number of industries studied is 29. Second, I undertake a decomposition of quality change in labor input. In this analysis I subaggregate manufacturing industries into three categories: light, material, and fabricated manufacturing; all service industries are treated as a single service industry.[5] On the basis of these results, we will examine the characteristics of human capital accumulation during the process of economic development in Japan. Finally, the characteristics of quality change in labor input in Japan will be further clarified by a comparative analysis of the United States and Japan.

Table 12.1 Average Annual Growth Rates of Labor Input by Industry (in % per calendar year)

Industry	1960–65	1965–70	1970–73	1973–79	1960–73	1960–79
1. Agriculture	−6.67	−3.12	−3.08	−1.29	−4.48	−3.47
2. Mining	−8.87	−3.75	−14.27	−5.81	−8.15	−7.41
3. Construction	14.06	4.49	5.72	3.59	8.45	6.92
4. Foods	8.49	2.89	2.34	1.23	4.92	3.75
5. Textiles	1.27	.18	−3.45	−5.39	−.24	−1.86
6. Fabricated textiles	10.35	5.27	5.81	3.41	7.35	6.11
7. Lumber	4.39	.02	.36	−3.53	1.78	.10
8. Furniture	4.67	4.23	2.42	2.13	3.98	3.40
9. Paper	5.61	1.81	.62	−.51	2.99	1.89
10. Printing	6.76	2.43	.73	.84	3.71	2.80
11. Chemicals	4.55	3.45	−1.00	−1.08	2.85	1.61
12. Petroleum and coal	2.60	9.29	−1.00	1.54	4.34	3.46
13. Rubber	−.26	6.88	−1.63	−.29	2.17	1.39
14. Leather	4.65	1.71	−3.77	3.48	1.58	2.18
15. Stone and clay	5.79	3.81	1.26	.27	3.99	2.81
16. Iron and steel	1.35	5.22	−2.41	−2.10	1.97	.68
17. Nonferrous metals	4.07	4.93	−.14	−.23	3.43	2.27
18. Fabricated Metal	10.84	6.08	.37	−1.82	6.59	3.93
19. Machinery	9.01	3.73	−.46	−1.77	4.79	2.72
20. Electrical machinery	6.69	10.21	1.16	.83	6.77	4.89
21. Motor vehicles	13.53	7.32	3.66	2.36	8.86	6.81
22. Transportation equipment	1.65	5.03	2.58	−7.51	3.16	−.21
23. Precision instruments	7.10	5.56	4.43	.56	5.89	4.21
24. Miscellaneous manufacturing	5.94	6.35	.62	2.34	4.87	4.08
25. Transportation and communication	7.09	2.64	1.71	1.41	4.13	3.28
26. Utilities	2.38	3.01	2.71	1.14	2.70	2.21
27. Trade	14.19	4.20	5.53	2.49	8.35	6.50
28. Finance	9.94	3.28	2.60	3.60	5.68	5.02
29. Real estate	20.25	14.18	7.36	2.12	14.94	10.89
30. Services	10.80	5.68	5.41	5.03	7.59	6.78
31. Government services	−6.28	−1.41	2.72	.52	−2.33	−1.43
Average	5.67	4.05	.93	.24	3.96	2.78

12.4.1 Annual Growth of Sectoral Labor Input

Here I shall highlight some of the main features of our results presented in tables 12.1–12.3. As should be expected for Japan, we observe negative average annual growth rates of labor input for the following two industries: agriculture-forestry-fishing and mining. For the entire period 1960–79, labor input in agriculture-forestry-fishing declined at a rate of −3.47% per year and at −7.41% per year in the mining industry. In contrast to these, the rest of the industries exhibit growing labor input for the 1960s. This indicates that the mobility of labor from traditional industries to the modern industrial sector is one of the main features of Japanese economic growth in the 1960s. In the 1970s however, we can observe negative growth of labor input, particularly in

Table 12.2 Average Annual Growth Rates of Labor Quality by Industry (in % per calendar year)

Industry	1960–65	1965–70	1970–73	1973–79	1960–73	1960–79
1. Agriculture	−.10	.31	3.39	1.00	.87	.90
2. Mining	.45	.59	−.10	.19	.37	.32
3. Construction	.64	.39	.59	.82	.53	.63
4. Foods	.03	1.51	.58	.70	.72	.72
5. Textiles	.22	1.68	1.54	.98	1.08	1.05
6. Fabricated textiles	−.17	1.48	.06	.47	.52	.51
7. Lumber	−.58	.23	.66	.28	.02	.10
8. Furniture	−.32	.53	.71	1.14	.24	.53
9. Paper	.30	1.64	1.02	1.04	.98	1.00
10. Printing	.21	1.77	1.94	1.26	1.20	1.23
11. Chemicals	−.02	1.51	1.19	1.57	.85	1.07
12. Petroleum and coal	.83	1.35	.14	1.42	.87	1.04
13. Rubber	2.70	1.21	1.68	1.37	1.89	1.73
14. Leather	−.52	.78	1.11	.37	.36	.36
15. Stone and clay	.06	1.16	.67	.87	.62	.70
16. Iron and steel	.45	.95	1.17	1.11	.81	.90
17. Nonferrous metals	−.07	1.35	1.18	1.07	.76	.86
18. Fabricated metal	.85	1.30	1.24	.69	1.12	.98
19. Machinery	.41	1.26	1.21	1.27	.92	1.02
20. Electrical machinery	.52	.86	1.21	1.86	.81	1.14
21. Motor vehicles	−.83	1.51	1.67	1.41	.64	.88
22. Transportation equipment	.19	.82	−1.20	.57	.11	.25
23. Precision instruments	.02	1.62	.92	1.24	.84	.97
24. Miscellaneous manufacturing	.90	2.11	1.48	.99	1.49	1.34
25. Transportation and communication	.09	.71	1.07	.91	.55	.67
26. Utilities	1.08	.61	.11	.25	.68	.54
27. Trade	1.07	1.10	2.14	1.29	1.33	1.32
28. Finance	−.77	.94	.44	.79	.17	.36
29. Real estate	.86	1.25	.91	.56	1.02	.88
30. Services	−.35	1.47	.65	.35	.58	.51
31. Government services	.44	−.12	.62	−.05	.27	.17
Average	.28	1.09	.97	.90	.75	.80

heavy industry, which is a symptom of the first oil crisis. In contrast to the manufacturing sectors, tertiary industries, such as trade, finance, and service show a relatively stable and positive growth in labor.

The uppermost two diagrams of figures 12.2–12.5 show the index for ordinary labor input, the index for man-hours worked, for average hours worked, for labor quality during the period 1960–79 in light, material, and fabricated manufacturing and in tertiary industries. In the figures, $\bar{L}$ represents the index of man-hours worked, and $\bar{Q}$ the index for labor quality. Finally, L_s stands for the composite index of quantity $\bar{L}$ and quality $\bar{Q}$ for labor input. In terms of man-hours worked, the growth rate for manufacturing industries gradually begins to level off at the end of the 1960s and experiences a sudden decrease after the oil crisis in 1974. On the other hand, the growth rate of man-hour labor input increases throughout the entire period 1960–79 in tertiary indus-

Table 12.3 Average Annual Growth Rates of Man-hour Labor Input (in % per calendar year)

Industry	1960–65	1965–70	1970–73	1973–79	1960–73	1960–79
1. Agriculture	−6.58	−3.43	−6.47	−2.29	−5.34	−4.38
2. Mining	−9.32	−4.34	−14.17	−6.00	−8.52	−7.73
3. Construction	13.42	4.10	5.12	2.77	7.92	6.30
4. Foods	8.46	1.38	1.75	.53	4.18	3.04
5. Textiles	1.04	−1.50	−4.99	−6.37	−1.33	−2.92
6. Fabricated textiles	10.52	3.78	5.75	2.93	6.83	5.60
7. Lumber	4.98	−.22	−.30	−3.81	1.76	.01
8. Furniture	5.00	3.70	1.71	1.00	3.74	2.87
9. Paper	5.30	.17	−.41	−1.56	2.01	.88
10. Printing	6.55	6.72	−1.21	−.42	2.50	1.58
11. Chemicals	4.57	1.94	−2.19	−2.64	2.00	.53
12. Petroleum and coal	1.77	7.94	−1.14	.12	3.47	2.41
13. Rubber	−2.96	5.67	−3.31	−1.66	.28	−.33
14. Leather	5.17	.94	−4.88	3.11	1.22	1.82
15. Stone and clay	5.74	2.65	.59	−.60	3.36	2.11
16. Iron and steel	.90	4.27	−3.58	−3.21	1.16	−.22
17. Nonferrous metals	4.13	3.60	−1.32	−1.30	2.67	1.41
18. Fabricated metals	9.99	4.77	−.87	−2.52	5.48	2.96
19. Machinery	8.60	2.47	−1.67	−3.04	3.87	1.69
20. Electrical machinery	6.17	9.35	−.04	−1.03	5.98	3.75
21. Motor vehicles	14.36	5.81	2.00	.96	8.22	5.92
22. Transportation equipment	1.45	4.21	3.78	−8.08	3.05	−.46
23. Precision instruments	7.08	3.94	3.52	−.68	5.05	3.24
24. Miscellaneous manufacturing	5.04	4.24	−.85	1.35	3.37	2.73
25. Transportation and communication	7.00	1.93	.65	.50	3.58	2.61
26. Utilities	1.29	2.41	2.59	.89	2.02	1.66
27. Trade	13.12	3.10	3.39	1.20	7.02	5.18
28. Finance	10.71	2.34	2.16	2.81	5.52	4.66
29. Real estate	19.39	12.93	6.46	1.56	13.92	10.01
30. Services	11.15	4.21	4.77	4.68	7.01	6.27
31. Government services	−6.72	−1.29	2.10	.57	−2.60	−1.60
Average	5.40	2.96	−.03	−.65	3.21	1.99

tries. Although these latter underwent a slight decrease after 1974, they recovered to the historical trend level in 1979.

Quality changes both in manufacturing and tertiary sectors maintain a stable rate of growth during the entire period. The growth rate of labor quality in the manufacturing sectors is higher (0.87%–1.02%) than in the tertiary sector (0.68%). In the tertiary sector, the improvement in labor quality started at the end of the 1960s.

Average annual growth rates of the index for sectoral labor quality are shown in table 12.4 below. Average annual growth rates during the period

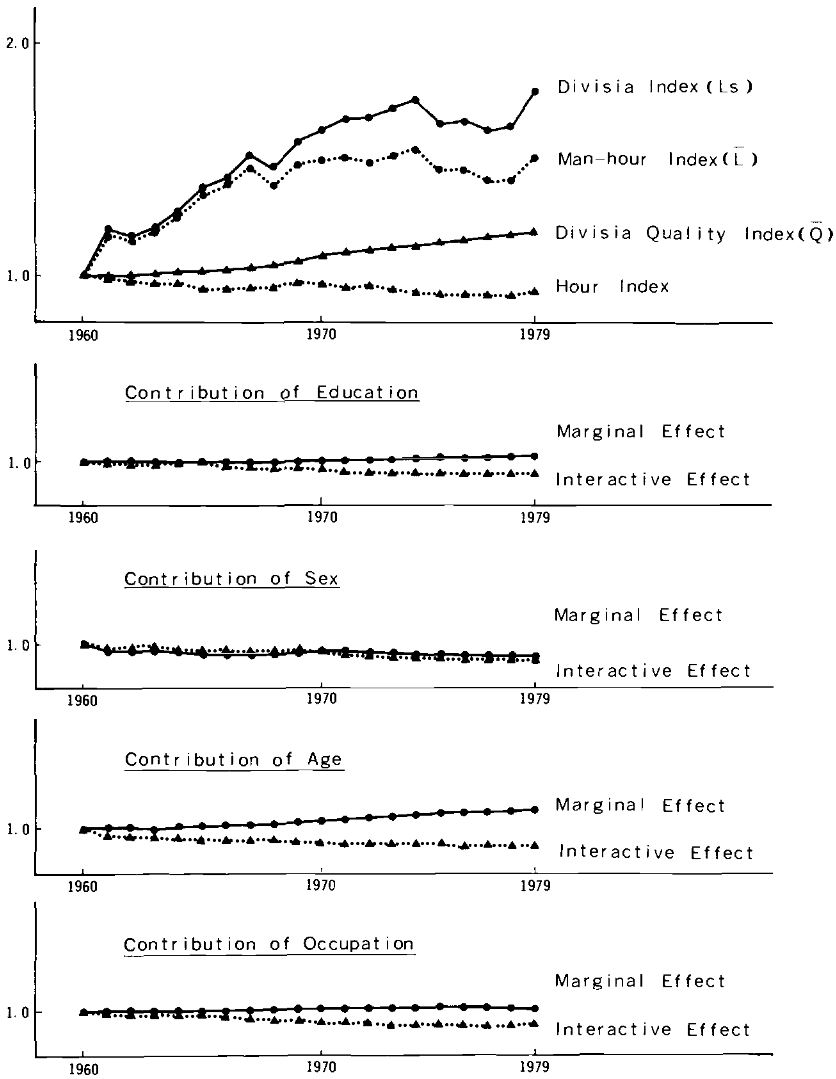

Fig. 12.2 Decomposition of labor quality change—light manufacturing industry

1960–79 are positive in all sectors. The average annual growth rate of 3.39% found in agriculture-forestry-fishing during the period 1970–73 is extraordinarily high. In fact, the magnitude of quality change offsets almost half of the decrease in man-hour labor input in that sector. As shown in table 12.3, average annual growth rates of man-hours worked turned negative in 16 manufacturing industries during the third and the fourth subperiod. On the other hand, in almost all of these industries, average annual growth rates of labor quality

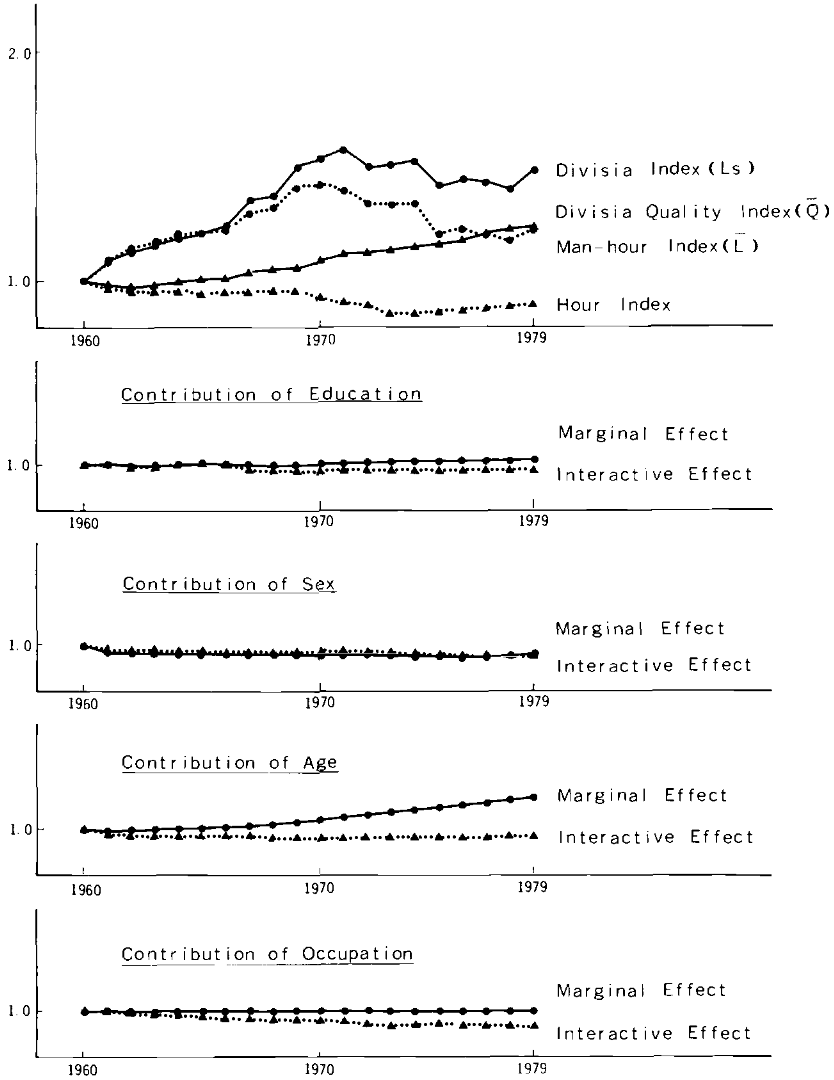

Fig. 12.3 Decomposition of labor quality change—material manufacturing industry

rose for these periods. Although quality of labor input usually plays a relatively minor role in contributing to total change in labor input, the earlier observations in agriculture-forestry-fishing and many of the manufacturing industries show that the magnitude of quality change was, in many cases, large enough to offset the decline in man-hours worked.

It is well known that many Japanese firms benefit from the institution of

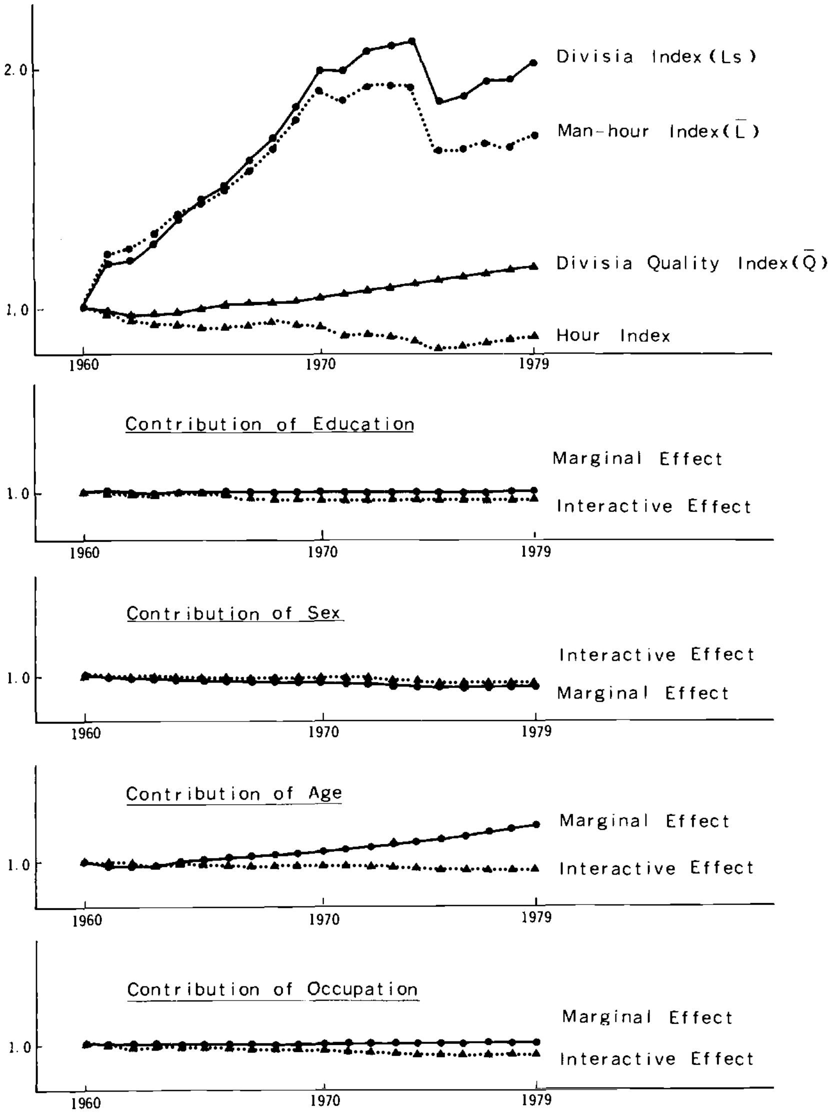

Fig. 12.4 Decomposition of labor quality change—fabricated manufacturing industry

"lifetime employment," which guarantees low labor turnover. The labor market in Japan is also structured so that most new workers are hired immediately upon finishing school at the beginning of each fiscal year (which coincides with the academic year). This implies that the age classification in our data base with its detailed disaggregation is an acceptable proxy for the experience

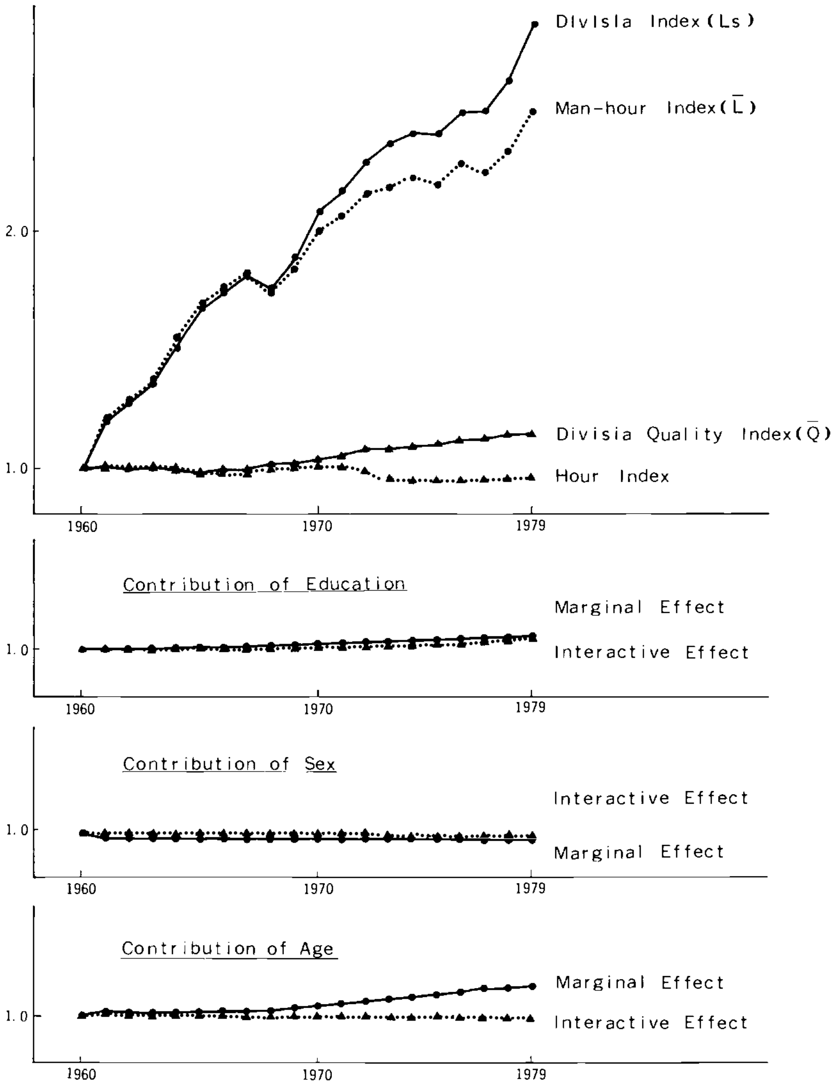

Fig. 12.5 Decomposition of labor quality change—service industry

or the on-the-job training component of all labor types. Under those considerations, if a Japanese industry exhibits a relatively low or negative rate of growth in man-hours worked, it implies a change in the age distribution of its labor force toward older workers with greater accumulated experience. Since older workers' wage rates are higher, our assumption of producer equilibrium associates higher productivity with these older workers; hence we should observe an increase in the quality of the labor force. Thus it is not surprising that our estimates show an inverse relationship between the quality change in labor input and the change in man-hours worked.

12.4.2 Decomposition of Quality Change in Labor Input in the Manufacturing Sector

A summary of growth rates of quality decomposition is given in table 12.4, and its time-series movement is shown in the lower part of figures 12.2–12.5. Here we examine the results of decomposition by individual category: sex, education, age, and occupation.

The Sex Effect

Table 12.4 shows that, during the period 1960–69, the main effect of sex in light, material, and fabricated manufacturing sectors was, respectively, −0.07%, −0.13%, and −0.24% per annum. In light and material manufacturing sectors, it turned positive more than 0.45% and 0.27%, respectively, after 1969, while in fabricated manufacturing it remained negative until 1973. After the oil crisis the effect was positive in all manufacturing sectors, of which the main effect of sex accounts for more than 30% in light manufacturing, 10% in material manufacturing, and 3% in fabricated manufacturing. This suggests that the growth rate of female labor force decreased after the oil crisis.

The sum of interactive effects in terms of sex was −0.36%, 0.008%, and −0.08% per annum in each manufacturing sector during the period 1960 to 1979. The minus sign persisted during the whole period for sex education as well as for sex and age in all manufacturing, indicating an expanding proportion of female workers and less-educated younger workers.

The Education Effect

The main effect of education is fairly high for all manufacturing sectors. It explains more than 20% of total quality change in labor input, on average, during the period 1960–79. The interactive effect between education and age increased gradually, while the interactive effect between education and occupation decreased. The increase of the education-age effect reflects the increasing proportion of older and highly educated workers in the labor force, while the decrease of the education-occupation effect represents the increase in the proportion of highly educated blue-collar workers.

In postwar Japan, the proportion of highly educated workers has increased as the result of reforms in the educational system and changes in human capital investment behavior on the part of the workers themselves. This latter trend brought about an increase in highly educated older workers, while the excess supply of highly educated younger workers caused an increase in highly educated blue-collar workers.

Relative prices among heterogeneous labor have had a great influence based

Table 12.4 Summary Table of Quality Change in Labor Input (in % per calendar year)

	1960–69	1969–73	1975–79	1960–79
Light manufacturing industry:				
Main effect:				
s	−.0680	.4536	.3024	.1283
e	.4279	.3974	.3427	.3985
a	.9411	.9088	.4966	.8359
o	.5044	.5435	.0450	.4037
Interactive effect:				
se	−.1169	−.1122	−.0987	−.1077
sa	−.4949	−.2980	−.1107	−.3510
so	−.0734	−.0674	−.0460	−.0625
ea	−.2213	.0497	.1205	−.0570
eo	−.3668	−.3225	−.2199	−.3176
ao	−.3681	−.1280	−.0274	−.2135
sea	.1476	.0068	−.0155	.0674
seo	.0643	.0758	.0529	.0624
sao	.1798	−.0107	−.0003	.0857
eao	.1794	.0218	−.0063	.0863
seao	−.1139	.0204	.0133	−.0571
Man-hour	4.3365	.7047	1.0402	2.1439
Hour	−.4178	−.8936	.5426	−.4234
Quality	.6214	1.4984	.8487	.9018
Divisia	4.9579	2.2031	1.8689	3.0457
Material manufacturing industry:				
Main effect:				
s	−.1259	.2775	.1611	.0329
e	.2369	.2342	.1508	.2213
a	.8281	.9956	.9413	.8961
o	.3995	.4531	−.0572	.3002
Interactive effect:				
se	−.0498	−.0454	−.0347	−.0454
sa	−.3193	−.1620	−.0372	−.2165
so	−.0068	.0810	.0053	.0178
ea	.0270	.2972	.3436	.1737
eo	−.2861	−.2242	−.1017	−.2262
ao	−.2382	.0739	−.0310	−.1138
sea	.0519	−.0104	−.0628	.0083
seo	−.0323	−.0076	.0033	−.0162
sao	.0754	−.0968	−.0127	.0115
eao	.0338	−.1291	−.0589	−.0262
seao	.0038	−.0037	.0176	.0055
Man-hour	3.8531	−1.6828	.0999	.9713
Hour	−.4500	−1.5974	1.0555	−.6056
Quality	.5982	1.7335	1.2266	1.0229
Divisia	4.4513	.0507	1.3265	1.9942

Table 12.4 (continued)

	1960–69	1969–73	1975–79	1960–79
Fabricated manufacturing industry:				
Main effect:				
s	−.2389	−.0738	.0406	−.0328
e	.2481	.1876	.1439	.2083
a	.6099	1.3264	1.0296	1.9314
o	.3583	.4458	.0001	.3091
Interactive effect:				
se	−.0157	−.0169	−.0364	−.0235
sa	−.1929	−.2656	−.0505	−.1962
so	.0291	.0894	.0287	.0359
ea	−.0975	.0991	.1696	.0384
eo	−.2893	−.2304	−.1951	−.2520
ao	−.1485	−.1264	−.0500	−.1255
sea	.0335	.0132	−.0253	.0066
seo	−.0007	−.0075	.0283	.0084
sao	.0113	−.0561	−.0172	−.0092
eao	.0661	−.0030	.0208	.0331
seao	−.0129	−.0066	−.0003	−.0084
Man-hour	6.5869	1.9528	1.1172	2.9387
Hour	−.7552	−1.6631	1.7134	−.6436
Quality	.3598	1.3753	1.0860	.3739
Divisia	6.9467	3.3281	2.2031	3.3125
Service industry:				
Main effect:				
s	−.3760	.1951	−.0249	−.1188
e	.1584	.1898	.1694	.1545
a	.4534	.9192	.6049	.6283
o				
Interactive effect:				
se	.0148	.0659	.0189	.0280
sa	−.0546	−.1320	−.0177	−.0824
so				
ea	−.0107	.1705	.2033	.0805
eo				
ao				
sea	.0046	−.0272	−.0187	−.0089
seo				
sao				
eao				
seao				
Man-hour	6.3940	4.3901	3.5894	4.9464
Hour	−.1113	−.4567	.4769	−.2708
Quality	.1399	1.3831	.9282	.5820
Divisia	7.0840	5.7731	4.5176	5.6284

on the Divisia index of labor input. Shimada (1981) pointed out that wage differentials in Japan were largely affected by years of experience (or age as a proxy) and years of education, and that interactive effects of education and age to wage differentials were quite high. My observation of the large main effect of education and the movement of the education-age and education-occupation interactive effects must be affected by such characteristics of wage profiles in Japan.

The Age Effect

The main effect of age explains more then 80% of quality change in labor input in Japan. This is extremely high compared to the other main effects. Interactive effects in terms of age were fairly small during the whole period, which means that the effect of age universally influenced all categories of labor as a demographic factor. The main cause of this strong age effect in all categories of labor input is the demographic trend of an aging population in Japanese society.

Under the assumption of perfect competition, the observed upward-sloping age-wage profile is interpreted to reflect the differential of marginal productivity of labor input for different age classes, which is equivalent to assuming that older people are always more productive than younger people insofar as wages increases according to age. This may appear a peculiar assumption, but, as we discussed earlier, if we regard age as the proxy for experience or the accumulation of some other relevant know-how in a company under the lifetime employment system, we cannot refute, a priori, the existence of such an equality between wages and the value of marginal productivity.

The Occupation Effect

The main effect of occupation was of almost equal magnitude as the main effect of education. It accounted for more than 40% of quality change in 1966–69, while it explained less than 40% or almost nothing of quality change in 1969–73 and in 1975–79. This means that the proportion of white-collar workers increased in the period 1966–69, but in subsequent periods it failed to increase by as much.

12.4.3 Decomposition of the Quality Change in the Service Sector

Table 12.4 also shows the summary of quality changes in the service sector. Since the service sector in the BWSS data is not classified by occupational category, we cannot observe quality change in terms of occupation. Among the remaining three categories, the age effect was the dominant factor in quality change, just as it was in the manufacturing sector. Also, the interactive effect of education and age (*EA*) began to exhibit a positive trend in the 1969–73 period, while the interactive effect of sex and age was slightly negative in the whole period.

12.4.4 Quality Change in Labor Input and Economic Growth

Comparison of the amounts of quality change in labor input reveals that quality change in the manufacturing sector has always been larger than in the service sector, as have been the main effects of age and education and the interactive effects of education and age. On the other hand, the trend of the man-hour index was leveled off after the 1969–73 period and fell into an apparent negative trend during 1973–79. These results suggests that the manufacturing sector attained a high level of labor productivity through the combination of reduction in man-hours and substitution of highly qualified workers. For the service sector, which still remained the labor absorption sector, both man-hour and quality change increased, but the degree of quality change was not so large as that of the manufacturing sector. However, if a more decomposed industry analysis were performed, it might be found that certain service industries have increased the pace of quality change and the age effect. The quality change in the service industries after the oil crisis is a topic that merits further research.

The period covered by our analysis has been 1960–79, a time in which the Japanese economy was catching up with the technology of the United States and Western Europe. From table 12.5, it is clear that quality change in labor inputs occurred continuously after the 1960s, and, as previously stated, the primary sources of quality change have been the main effects of age and education and the interactive effects of education and age. All of these effects are contributing factors to technological development, because a high level of technological development requires positive quality change in labor input, especially in education and age. Education represents the amount of general training, and age represents experience and company-specific skills. We may conclude that these distinctive features of quality change in labor input were the critical factors for the Japanese economy's productivity growth during the rapid expansion period and, in particular, for those industries that made major contributions to productivity growth by introducing highly developed technologies.

Watanabe and Egaizu (1968) estimated the quality change in labor input in Japan for 1951–64. They concluded that quality change in labor input in Japan was lower than that in other developed countries, and one reason given for this was the existence of an imitation lag in technology with respect to the United States and Western Europe. At that time, Japan depended on imported technology, so that technological progress was embodied in capital input. Therefore, the demand for high-quality labor was limited, which resulted in a low level of quality change. Watanabe and Egaizu indicated that there would be a high level of quality change in labor input as Japan's technology level reached that in the United States and Western Europe.

The result of my analysis is consistent with Watanabe and Egaizu's (1968) predictions. Although both their framework and my own treated technological

Table 12.5 **Quality Change in Labor Input in the United States**

	1959–63	1963–67	1967–71	1971–74
Main effect:				
Sex (*s*)	−.05	−.24	−.22	−.06
Class (*c*)	.14	.04	.05	.09
Age (*a*)	−.07	−.22	−.20	−.29
Education (*e*)	.72	.85	.81	.67
Occupation (*j*)	.37	.14	.40	−.11
Total	1.11	.57	.84	.30
Interactive effect:				
First-order:				
sc	.14	.17	.00	.02
sa	.13	.12	.02	−.01
se	.13	.13	.03	.02
sj	.17	.15	.07	−.03
ca	.12	.04	−.01	−.03
ce	.06	−.20	−.04	−.02
cj	.07	−.51	.03	−.05
ae	.12	.03	−.01	−.07
aj	.09	.00	.04	.06
ej	−.18	−.36	−.35	−.05
Total	.85	−.43	−.22	−.16
Second-order:				
sca	−.09	−.07	−.00	−.01
sce	−.10	−.11	−.00	−.01
scj	−.15	−.20	.01	−.01
sae	−.09	.00	.02	.01
saj	−.09	−.07	.00	−.01
sej	−.17	−.12	−.05	−.04
cae	−.06	−.02	.02	.02
caj	−.11	.00	−.01	.01
cej	−.08	.04	−.01	−.02
aej	−.12	−.05	−.01	.02
Total	−1.06	−.60	−.03	−.04
Third-order:				
scae	.11	.03	.00	.00
scaj	.10	.04	.00	.01
scej	.10	.13	.00	.00
saej	.10	.03	−.01	.01
caej	−.02	.07	.03	.00
Total	.48	.26	−.01	.02
Fourth-order:				
scaej	−.11	−.03	.00	.00
Quality change	1.27	−.23	.58	.12
Total hours	−.03	2.54	.26	2.55
Divisia index	1.24	2.31	.84	2.67

Source: Chinloy (1980).

change as an exogenous factor, the results suggest that we should further investigate the relationship between technological development and quality change in labor input, especially as regards the age and education effects.

Of all the sources of quality change in labor input, the age effect is the most controversial one. In the period of our analysis, the main demographic trend has been the increase of middle-aged workers, which corresponds to an upward-sloping age-wage profile. That trend has influenced the significance of the age effect as a source of quality change in labor input. But, in the near future, as the middle-aged population enters old age, this trend will tend to correspond to a downward-sloping age-wage profile. Other things being equal, the age effect will stagnate or even become negative in the future. This will result in a stagnation in quality change. However, analysis of this problem requires a more interdependent framework, one in which the age-wage profile is treated as an endogenous factor arising from the behavioral adjustment of economic agents.

12.4.5 Comparison of Quality Change in Labor Input in Japan and the United States

We draw on Chinloy (1980) for a similar analysis of the United States (see table 12.5). He has reported some specific features of quality change in labor input in the United States which we may compare with the same phenomenon in Japan.

1. In the United States, the main effect in terms of sex was negative for the entire period 1959–74, which is the opposite of the result obtained for Japan. In Japan, the main effect in terms of sex was positive for 1966–69, on average.

2. The main effect in terms of age was negative in the United States. On the other hand, it was positive in Japan, where it accounted for more than 80% of all quality changes.

3. The main effect in terms of education was positive both in the United States and Japan. It ranged from 0.67%–0.85% in the United States, which was somewhat higher than that in Japan.

4. The interactive effect between education and occupation was negative in the United States. During the periods 1963–67 and 1967–71, its magnitude was more than 40% of total quality changes. On the other hand, the interactive efect between education and age was negligible in the United States, which is a difference between the two countries.

5. In the United States, the kinds of quality change found were the result of recent shifts within the labor force as the amounts of female and younger workers increased. Such changes consequently worsened improvements in the quality of labor inputs. On the other hand, the effect of education contributed to the improvement of labor quality, although a negative interactive effect between education and occupation offset this improvement to some extent. Chinloy explained this situation as "overeducation" in the United States.

6. Finally, quality changes in the United States, on average, were smaller than those in Japan. In the United States, quality change was 1.27% per year in 1959–63, 0.23% in 1963–67, and 0.58% in 1967–71, while in Japan quality change was greater than 1.0% per year throughout the whole period.

The characteristics of quality change are the cause of the differences in productivity performance in the U.S. and Japan. We may conclude that the high degree of quality change of labor input in Japan favorably affected the development of technology, which resulted in high labor productivity. The low level of quality change of labor input in the United States slowed the growth of labor productivity.

12.5 Summary and Conclusion

Our analysis started with an observation of sectoral changes in labor input. Agriculture showed a constant reduction in man-hours, whereas the service sector exhibited a stable increase. The manufacturing sector, including mining and construction, showed a positive trend at first, but this turned negative after the 1969–73 period. In addition, quality change in labor input in the manufacturing sector was always larger than that of the service sector. Consequently, this quality change influenced the relatively high level of labor productivity in the manufacturing sector.

Further, we decomposed quality change in labor input using Divisia indices, which are consistent with transcendental logarithmic aggregator functions under certain assumptions. The results showed that total quality changes in labor inputs in Japan were always positive through 1960–79 and that the sources of these quality changes were mainly an age effect, an education effect, and the interactive effects of education-age and education-occupation (only for the secondary industries). Causes for these effects were the increase in experienced middle-aged workers, the growing proportion of highly educated workers, a reduction in less-educated young workers, an increase in better-educated older workers, and the decrease in less-educated blue-collar workers.

During our observation period, the Japanese economy was catching up with the technology of the United States and Western Europe. If we assume that a high technology level requires highly qualified workers, the results of this paper concerning quality change in labor inputs are consistent with this "catching-up" process. The coincidence of quality change in labor input and technological development has been the most distinctive feature of the rapid productivity change in the Japanese economy.

Among sources of quality change, the age effect provided the most significant contribution. This is because of an increase in the proportion of experienced middle-aged workers whose wages are on the upward slope of the age-wage profile. In the future, if the number of older workers whose wages are on the downward slope of the age-wage profile increases, the age effect will stagnate or even become negative, all else being equal. This eventuality depends on whether the shift of the age-wage profile for older workers will be upward or downward.

The comparison between the United States and Japan apparently showed that quality change in labor input in the United States was small compared to that of Japan, especially in terms of the sex and age effects. Only the education effect turned out to have significantly positive value; however, its impact was reduced when an adjustment for occupation was made. These comparative results suggest there are different input structures for the United States and Japan. Above all, quality change in labor input has not been a contributing factor to productivity change in the United States, while it has contributed significantly in Japan.

My analysis in this paper is part of larger research work investigating the interdependent mechanisms governing the relationship between input structure, economic growth, and technological progress. Further investigation of other factor inputs, such as capital and intermediate inputs is needed, as well as of the interaction among labor, capital, and intermediate inputs.

Notes

1. Under this restriction we can obtain path-independent indices of labor, capital, and intermediate inputs. See Berndt and Christensen (1973) and Hulten (1973).

2. In the empirical analysis section, I use these four categories as the measures of labor quality.

3. I should also note here that the Divisia index is biased if wages do not equal the value of the marginal product. However, in Japanese companies there are frequent retraining programs, such as job-rotation systems, accompanied by on-the-job training, and off-the-job training for middle management and executives. The frequency of retraining will generally increase to keep pace with technological development, especially for the period of rapid expansion of the Japanese economy. Consequently, under the existence of the internal training and promotion system in the Japanese company, it is not unwarranted to assume that the equality between wages and the value of marginal productivity. We cannot refute, a priori, the existence of such an equality between wages and value of marginal productivity.

4. The definition of employees in the BWSS is as follows: (*a*) workers without a particular contract regarding period of employment; (*b*) workers with contracts for more than three months; (*c*) temporary and daily workers employed in the same enterprise for more than 18 days per month in the preceding two months.

5. Industries are classified as follows: (1) light manufacturing (mining; construction; food and related products; apparel and textiles, furniture and fixtures, rubber, stone, clay, and glass products; textile mill products; lumber and wood products; printing and publishing; leather and leather products; fabricated metal products); (2) material manufacturing (paper and allied products; petroleum refining and related products; nonferrous metals; chemicals and chemical by-products; iron and steel; miscellaneous manufacturing); (3) fabricated manufacturing (machinery; transportation equipment; electrical machinery; precision instruments); (4) service industry (transportation and communication; wholesale and trade; real estate; public utilities; finance and insurance; services).

References

Berndt, E. R., and L. R. Christensen. 1973. The internal structure of functional relationships: Separability, substitution and aggregation. *Review of Economic Studies* 40:403–10.
Chinloy, P. 1980. Sources of quality change in labor input. *American Economic Review* 70:109–19.
Denison, E. F., and W. K. Chung. 1976. *How Japan's economy grew so fast: The sources of postwar expansion*. Washington, D.C.: Brookings.
Diewert, W. E. 1976. Exact and superlative index numbers. *Journal of Econometrics* 4:115–45.
Hulten, C. R. 1973. Divisia index numbers. *Econometrica* 41:1017–25.
Management and Coordination Agency, Statistics Bureau. Various years. *Roudouryoku chousa houkoku* (Labor force survey).
Ministry of International Trade and Industry. Various years. *Kougyou toukei hyou* (Census of manufactures). Tokyo: Ministry of Finance Bureau of Printing.
Ministry of Labor. Various years. *Chingin kouzou kihon toukei chousa* (Basic wage structure survey). Tokyo: Institute of Labor Law.
Shimada, H. 1981. *Earnings structure and human investment*. Tokyo: Keio Economic Observatory.
Tachibanaki, T. 1973. Quality change in labor input and wage differentials: A study of Japanese manufacturing industries. Ph.D. diss. Johns Hopkins University.
Watanabe, T., and N. Egaizu. 1968. *Rodoryoku no shitu to keizai seicho—sengo Nippon ni tsuite* (Improvement of labor quality and economic growth—postwar Japan's experience). *Economic Studies Quarterly* 19:38–52.

Comment Walter Y. Oi

Robert Sproull, in assuming the presidency of the University of Rochester stated, "Technology and capital investment have increased productivity in other areas, notably manufacturing, but has been of little help to universities as counters to inflation. Thus, it is remarkable that for four decades or more, the price of a year at the University of Rochester including board and room has remained about equal to the price of a full-sized Chevrolet (*Rochester Review* [Spring, 1975], 3). He did not go on to say that most families do not buy four new Chevys in successive years. Further, a 1974 Chevy is not the same as a 1936 Chevy. In addition, the quality of education supplied by the University of Rochester had also changed over that 40-year span. Data from the *Historical Statistics of the United States* and the 1983 *Statistical Abstract of the United States* provide another irrelevant comparison. In 1936, a new car was equal to 996 hours of work by a typical factory worker, but, by 1974, it took only 826 hours to pay for a new car. My colleague immediately pointed out that "an hour of work in 1974 embodied more human capital than an hour

Walter Y. Oi is the Elmer B. Milliman Professor of Economics at the University of Rochester.

of work in 1936." This new-car numeraire illustrates the difficulties that we encounter in measuring economic growth and in making welfare comparisons when the qualities of outputs and inputs are both changing.

The ultimate aim of this paper is to measure the contribution of the labor input to the growth of Japanese output. Labor is heterogeneous, and the composition of the Japanese work force has varied over the two decades covered in this study. In addition, the makeup of industry-specific labor forces has also varied. Imamura has quantified these changes to arrive at estimates of the quality-adjusted labor input for each of 29 industries. He recognized that quality is endogenous, but he does not develop a formal analysis that can explain quality changes.

The methodology is a familiar one. Suppose that the heterogeneity could be described by two traits, say, sex i and education j. If I let asterisks denote logarithms and denote man-hours by H_{ij}, I obtain the following counterparts to Imamura's equations:

$$dH^* = H_t^* - H_{t-1}^*, \quad H_t^* = \ln \Sigma\Sigma H_{ij,t}, \tag{1}$$

$$dL_i^* = \sum_i V_i dH_i^*, \quad [H_i = \sum_j H_{ij}], \tag{2}$$

$$dL_{ih}^* = \sum_i \sum_j V_{ij} dH_{ij}^*. \tag{3}$$

Here, (1) is the man-hours index, (2) demonstrates the first-order main effect, and (3) is the second-order interactive effect. The main effect of the ith trait on the quality-change index is given by

$$Q_i = dL_i^* - dH^* \quad Q_j = dL_j^* - dH^*. \tag{4}$$

$$Q_{ij} = (dL_{ij}^* - dH^*) - Q_i - Q_j. \tag{5}$$

Thus, the total quality change in this example can be decomposed into two main effects plus one interactive effect.

$$Q = dL_{ij}^* - dH^* = Q_{ij} + Q_i + Q_j. \tag{6}$$

Imamura identified four traits; sex, $s = 2$, occupation, $o = 2$, education, $e = 4$, and age, $a = 12$ for a total of 192 cells for each industry over the 20 years in his sample.

He also assembled data on employment, hours, and pay (the sum of earnings plus annual bonuses) of regular employees from the Basic Wage Surveys, 1960–79. These data were used to develop the Divisia index of the labor input L^s shown in table 1. If capital and labor inputs are not adjusted for quality changes, then technical progress (total factor productivity) accounted for 50% of the growth rate of annual output, but this figure drops to 25% after quality-change adjustments. Indexes of man-hours, quality-adjusted labor inputs, and the quality-change index Q are calculated for each industry and are summarized by growth rates in tables 2, 3, and 4. Table 5 illustrates the decomposition of the growth rate in the labor input for four industries. Comparisons of labor quality changes in the U.S. and Japan are shown in tables 4 and 5.

Imamura's estimates indicate that the quality of the labor input improved at an annual rate of 1% a year in Japan, which is substantially higher than the rate of improvement in the United States. Age and education are mainly responsible for this improvement. He chose to present all of his empirical results in terms of indexes and growth rates. In table 1, I show the educational distribution of regular (full-time) Japanese employees in 1980 classified by age, sex, and firm size for all industries and for males in manufacturing in 1970 and 1980. The latter comparison reveals the upward shift in the educational attainment in manufacturing, while the top panel reveals that educational at-

Table 1 **Percentage Distribution of Regular Employees in Japan, by Education**

	Employment (000)	Lower Secondary School	Upper Secondary School	Junior College	College
All industries, 1980:					
Males, all firms	13,704.2	32.68	44.42	3.26	19.65
Small	4,882.4	41.21	43.46	3.40	11.94
Medium	4,533.6	29.70	44.44	3.62	22.23
Large	4,288.2	26.10	45.49	2.71	25.69
Females, all firms	6,214.5	33.32	53.57	10.16	2.94
Small	2,529.3	41.42	47.24	9.04	2.30
Medium	2,077.6	34.88	52.25	9.27	3.59
Large	1,607.7	18.55	65.24	13.10	3.11
Manufacturing, 1980:					
Males, all firms	5,603.6	40.38	44.11	1.90	13.61
Small	1,675.8	52.33	39.27	1.66	6.73
Medium	1,841.8	37.28	44.97	2.12	15.62
Large	2,086	33.49	47.23	1.90	17.38
Females, all firms	2,408.8	52.25	43.11	3.52	1.13
Small	1,016.1	61.42	35.97	1.95	0.66
Medium	902.5	51.82	43.60	3.28	1.29
Large	490.3	34.00	56.99	7.20	1.79
Manufacturing, 1970:					
Males, all firms	5,821.8	53.69	35.73	1.81	8.76
Small	1,650.6	65.90	28.74	1.47	3.89
Medium	1,759.9	51.29	37.12	1.94	9.64
Large	2,411.2	47.09	39.52	1.94	11.46
Females, all firms	2,843.3	65.14	34.86	.00	.00
Small	1,021.8	72.09	27.91	.00	.00
Medium	962.8	66.11	33.89	.00	.00
Large	858.7	55.81	44.19	.00	.00

Source: Basic Wage Survey, Japan.
Note: Small = 10–99; medium = 100–999; large = 1,000+.

Table 2 **Percentage Distribution of Employed Persons and Employees by Sex and Age, 1970 and 1980**

	1970			1980		
	Both	Male	Female	Both	Male	Female
A. Employed Persons:						
15–19	5.8	4.7	7.5	2.5	2.0	3.4
20–24	15.5	13.8	18.3	9.6	7.9	12.2
25–34	24.2	26.8	20.2	25.4	27.8	21.7
35–44	23.9	24.3	23.3	24.8	25.0	24.6
45–54	15.9	14.8	17.5	21.5	21.2	22.0
55–64	10.1	10.5	9.6	11.1	10.8	11.7
65+	4.5	5.1	3.6	4.9	5.3	4.4
Total (in Millions)	50.94	30.91	20.03	55.36	33.94	21.42
B. Employees:						
15–19	7.8	5.4	12.6	3.2	2.3	5.0
20–24	20.6	16.5	28.9	12.4	9.3	18.2
25–34	26.6	30.2	19.4	28.3	30.9	23.4
35–44	20.9	22.3	18.1	24.9	25.6	23.6
45–54	15.2	15.5	14.6	20.1	20.3	19.9
55–64	6.8	7.5	5.4	8.4	8.7	7.9
65+	2.0	2.4	1.1	2.6	2.9	1.8
Total (in Millions)	33.06	22.10	10.96	39.71	26.17	13.54

Source: Japan Statistical Yearbook (1983), table 3-2.

tainment is higher for men and for workers in large firms. The main effect of education was, however, stronger in the United States as a factor improving labor quality. Imamura argues that for regular employees, age is a good proxy for job tenure and hence for firm-specific human capital. Reference to the Basic Wage Surveys reveals, however, that it is an imperfect proxy, especially for females and, to a lesser extent, for males in small firms. The data in table 2 show that the percentage of all employed persons and of paid employees who were under 35 years of age fell sharply between 1970 and 1980. This shift in the age distribution of employees (putting more toward the peak of the age-earnings profiles) was the most important contributor to the quality gains in the Japanese labor input. In the United States, the fraction of employees in the youngest age groups rose so that age made a negative contribution to the quality of the U.S. labor input.

The measurements in this study pertain to the quality of regular employees who made up only 49.9% of all employed persons in 1960 and 64.8% in 1980; see the data in table 3. Regular employees tend to work longer hours, so that they probably accounted for a larger share of total man-hours and of quality-adjusted man-hours. The declining importance of self-employed and unpaid family workers is due, in part, to sectoral shifts out of agriculture, fisheries, and aquaculture. The omission of these workers, whose remuneration is either in kind or as a residual claimant, is serious. Table 4 shows that, in manufac-

Table 3 **Percentage Distribution of Employed Persons by Employment Status and Sex**

	Both Sexes			Males	
Employment Status	1960	1970	1980	1970	1980
Employed persons (in millions)	44.36	50.94	55.36	30.91	33.94
Percentage who were:					
1. Self-employed	22.7	19.2	17.2	22.4	19.4
2. Family workers	23.9	15.8	10.9	6.0	3.3
3. Paid employees	53.4	64.9	71.3	71.5	77.1
4. Paid regular employees	49.9	59.3	64.8	67.4	73.0

Source: Japanese Statistical Yearbook (1983), table 3-3, pp. 72–73.

Table 4 **Paid Employees and Females as Percentage of Employed Persons by Industry, 1980**

Industry	Employed Persons[a]	% Paid Employees	% Female Employees
All industries	55,665	71.8	37.9
Agriculture	5,426	2.7	50.7
Fisheries	459	37.5	21.6
Mining	111	94.6	10.8
Construction	5,364	77.0	13.0
Manufacturing	13,145	85.1	36.1
Wholesale/Retail Trade	12,633	65.8	45.4
Finance	1,604	96.1	48.6
Real Estate	433	70.4	34.0
Transportation/Communication	3,476	94.8	11.6
Electricity	348	100.0	14.1
Services	10,346	79.4	49.7
Government	2,023	100.0	21.3
Miscellaneous	119	47.1	43.7

Source: Japan Statistical Yearbook (1983), table 3–5, pp. 74–75.
[a]In thousands.

turing, only 85.1% of all employed persons were wage and salaried employees (some of whom were casual or temporary day workers) and only 65.8% in wholesale/retail trade. I suspect that the quality changes of these omitted workers did not follow the same time path as quality changes of regular employees. Finally, we find that paid employees make up a larger share of all employed persons at younger ages. We clearly need to learn more about the productivity and returns to these unpaid workers.

The quality change in the labor input is decomposed into four main effects and interactive effects for sex, occupation, education, and age. The author has, however, ignored the classification by firm size that can be obtained from the Basic Wage Survey. Monthly wages and annual bonuses are substantially higher in large firms, suggesting that labor productivity is also greater. Workers in larger firms have more formal schooling (as shown in table 1) and longer job tenures. Some economists have argued that these higher wages are supported by larger investments in general and firm-specific human capital. My research on this topic leads me to conclude that the higher wages in larger firms are due in large part to a greater effort intensity of work. Employees in the larger manufacturing firms receive less time for breaks, time off for personal business, and so on, and are obliged to maintain a faster work pace. A shift in the distribution of employed persons from small to large firms will thus be accompanied by a rise in labor productivity. It would be useful to see how big a difference this firm-size adjustment would make in the quality-change component of the labor input.

The author correctly argues that labor quality is endogenous. His conjectural hypothesis is that a faster rate of technical progress will induce a higher rate of quality improvement. I presume that the technical progress will raise the returns to human capital leading to this outcome. The rate of total factor productivity growth varies over time and across industries. These variations could be correlated with labor-quality changes to test this hypothesis, and this is surely an obvious direction for future research.

My closing comments go beyond the Imamura paper to criticize the received methodology of Divisia indexes in measuring technical progress. Each industry or sector presumably supplies a single product that is related to input flows via a translog production function. Over the last 40 years, nonproduction worker employment has grown relative to the input of blue-collar production workers. A translog production function interprets this rise in the ratio of nonproduction to production worker man-hours as a substitution of the former for the latter in producing a given product, say Wheaties. Every manufacturing firm is, however, a multiproduct firm that jointly supplies Wheaties at the factory doorstep, packing crates, delivery services, advertising, and insurance. The postwar growth in nonproduction worker employment can largely be explained as an expansion of the manufacturing firm's activities into finance, insurance, distribution, and so on. In short, the parameters of a translog production function must surely depend on the firm or industry's "output mix." The maintained assumption of stable parameters is untenable.

This methodology also assumes that factor markets are perfectly competitive. The wage is the "price" of labor. Labor is homogeneous within each type or grade of labor. Labor services are exchanged in spot markets where marginal-value products are equated to wages in each period. The validity of this neoclassical model has been questioned at both the theoretical and empirical levels. Contract and search theories rest on the assumption that workers and jobs are *not* interchangeable. There is something to be gained from estab-

Table 5 **Average Monthly Labor Cost per Regular Employee in Japan by Industry, Size of Enterprise, and Kind of Labor Cost**

	Total Pay[a]	Earnings	Other Labor Costs[a]	Required Welfare	Pension	Fringe Benefits	Hiring and Training
Year:							
1975	198.0	86.38	27.0	44.9	22.9	27.0	5.3
1977	242.1	85.33	35.5	45.3	24.5	25.5	4.7
1978	263.8	84.58	40.7	44.4	26.0	25.2	4.4
1979	279.0	84.81	42.4	45.5	25.7	23.4	5.5
1980	294.5	85.13	43.8	47.4	23.2	23.3	6.1
1981	311.3	84.39	48.6	47.9	21.5	25.6	5.0
By firm size:[b]							
30–99	242.1	86.10	33.7	59.7	14.9	21.9	3.5
100–299	262.3	85.85	37.1	55.4	16.9	23.0	4.7
300–999	304.7	85.15	45.3	51.1	20.4	22.9	5.6
1,000–4,999	355.3	83.76	57.7	44.3	24.1	26.1	5.6
5,000 or more	400.1	82.25	71.0	38.7	25.8	30.4	5.2
By industry:[b]							
Mining	405.7	74.41	103.8	40.3	36.6	20.7	2.3
Construction	309.5	84.16	49.0	58.6	14.3	23.2	3.9
Manufacturing	311.8	84.25	49.1	47.1	22.2	26.2	4.6
Apparel	202.9	86.57	27.3	54.3	18.4	21.9	5.5
Iron and Steel	416.1	81.53	76.9	40.1	25.6	30.0	4.4
Fabricated metals	291.1	84.49	45.1	54.0	19.3	23.1	3.6
Transportation Equipment	342.9	85.17	50.9	50.9	16.2	27.7	5.2
W/R Trade	276.8	85.49	40.2	47.9	18.2	27.0	6.8
Wholesale	317.4	84.96	47.7	46.3	20.4	27.8	5.5
Retail	232.8	86.28	31.9	50.67	14.6	25.7	9.0
Finance	404.5	83.29	67.6	36.7	25.6	31.8	5.9
Transportation and Communication	336.1	84.81	51.1	54.2	23.8	18.2	3.8
Electricity	437.0	78.05	95.9	29.3	39.7	24.6	6.5
Services	260.1	86.14	36.1	51.0	16.5	26.4	6.1

Source: Japan Statistical Yearbook (1983), table 3-38, p. 109.
[a]Total pay and other labor costs are expressed in thousands of yen per month.
[b]1981.

lishing durable employment relations. Given an implicit contract, wages can diverge from marginal-value products so long as the present values of the two are equated at the time that the contract is "signed." At an empirical level, total employee conpensation and total labor costs include more than cash earnings. In table 5, I reproduce data from the 1983 *Japan Statistical Yearbook.* In 1981, obligatory (required) contributions to welfare programs, employer contributions to retirement (pensions), voluntary contributions to employee welfare (fringes), and recruiting, training, and miscellaneous other labor costs accounted for 15.61% of total pay of regular employees. These "other labor costs" are growing relative to cash earnings as evidenced by the secular decline in the ratio of cash earnings to total pay shown in the second column of table 5. Cash earnings are seen to comprise a larger share of total pay in smaller firms. The ratio of obligatory contributions to welfare (payroll taxes) to cash earnings rose from 7.07% in 1975 to 8.86% in 1981. This ratio, (payroll taxes/cash earnings) is inversely related to the size of enterprise varying from 9.65% in firms with 30–99 employees to 8.34% in firms with 5,000 or more employees. The data in table 5 also reveal a wide dispersion in the relative costs of pensions, recruiting/training costs, and fringe benefits. Some studies have acknowledged the presence of these "other labor costs" by replacing the hourly wage by an hourly total pay that includes the *average* hourly cost of fringes and taxes. This is *not* the right way to incorporate these other labor costs. The "correct" price of labor should measure its marginal cost per incremental hour worked and not per hour paid. Then labor costs, C, are related to man-hours, H, in a nonlinear fashion: $C + g(H)$, rather than $C = WH$. The marginal labor cost, $C' = g'(H)$, should be used to calculate the proper value shares appearing in equations (16)–(19). Imamura, Jorgenson, Christiansen, and others compute value shares by assuming that the wage W is the marginal labor cost; thus, their value shares for the ith type of labor are $V_i = W_iH_i/\Sigma W_iH_i$. If C' is the marginal labor cost per incremental hour, the correct value share is $V_i' = C_i'H_i/\Sigma C_i'H_i$. One should also question the separability of materials from labor and capital inputs. At the 1985 NBER conference, "Productivity Growth in Japan and the United States," Kurosawa stated that casual and temporary day workers are significant in many industries. Moreover, their labor costs are often put into the account for purchased materials. If true, material costs, as measured, are not separable from labor costs.

The indexes of the labor input developed by Imamura represent a major improvement over earlier series. There is room for further research, especially in measuring the contribution of nonwage employees (the self-employed and family workers), who constitute a significant fraction of all employed persons in agriculture, wholesale/retail trade, and services. Studies of the U.S. labor market have shown that labor productivity is higher in unionized firms, which also happen to be larger firms. Kurosawa pointed out that in Japan, labor productivity in large firms was substantially higher than that in small firms within the same industry. I believe that the higher productivity in large firms is not the result of firm-specific training and human capital, but rather a more intensive level of work effort demanded by the large firms. If workers in large firms have to cope with a speedier assembly line, take shorter rest breaks, and conform to a disciplined work environment, they are, in a very real sense, supplying man-hours of labor that are of a higher quality than the hours supplied by employees working in smaller firms. A shift of man-hours toward employment in larger firms is just as much of an improvement in labor quality as a shift in the mix of workers from younger to prime-age males. The differences in wages and productivity across firm-size categories are large enough to warrant further investigation if we are to understand the sources of productivity growth.