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ABSTRACT

This paper analyzes the characteristics of Japanese economic development by focusing on quality change in labor inputs. For that purpose, we investigate the changes of labor input in agriculture, manufacturing (including construction and mining) and service sectors, and we also analyze the sources of quality change in labor inputs in manufacturing and service sectors. Decomposition of quality change was made using the Divisia indices of labor input, which is consistent with a transcendental logarithmic aggregator function. A comparison between Japan and the U. S. was made by citing some U. S. results from a comparable framework.

The empirical results show that quality changes in labor inputs in Japan were positive through 1960-1979, and the sources of these quality changes were mainly an age effect, an education effect and the interactive effects of education-age and education-occupation. During this time, the Japanese economy was catching up with the

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technology of the U. S. and Western Europe. The results of this paper concerning the quality changes in labor inputs are consistent with this catch-up process. This is because the more the technology level is enhanced through the development of original technology, the more the quality change in labor input is required.

On the other hand, the comparison between the U. S. and Japan shows that quality change in labor input in the U. S. was apparently small compared to that of Japan, especially in terms of the sex and age effects. Only the education effect turned out to have a significantly positive value; however, its impact is reduced when as adjustment for occupation is made. These comparative results show that quality change in labor input has not been a contributing factor for productivity change in the U. S., while it contributed significantly in Japan.

1. Introduction

The purpose of this paper is to analyze the characteristics of Japanese economic development by focusing on quality change in labor input. We decomposed quality change in labor input. One is a demographic factor which is basically exogenous and determines the endowment of the heterogeneous labor input, and the other is an economic factor including technological conditions and 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 technology and fixed factor endowment.

A framework which treats the above factors as endogenous variable is the most preferable, but unfortunately we lack precise facts as to what is the dominant factor affecting quality change in labor input which of course depends on the stages of economic development. Also we do not have many insights into the relationship between economic growth and quality change caused by heterogeneous labor. This paper represents a first step towards accurate understanding of the interdependent economic mechanism behind quality change in labor input.

In addition, a comparative analysis between U. S. and Japan is made to investigate how the quality change in labor input differs between these two countries which have had different patterns of economic development.

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

At first, let us briefly review previous research work on quality change in labor input in Japan.

The representative researches in the measurement of quality change in labor input in Japan are Watanabe=Egaizu (1968), Denison=Chung (1976) and Tachibanaki (1973).

Watanabe=Egaizu measured quality change in labor input for 1951-1964, and compared it with results for other developed countries. Quality change in labor input in Japan was relatively low, which they explained was the consequence of an imitation-lag in technical progress. That is to say, they considered that technical change at that time was embodied in imported capital goods. So, there was little need for highly qualified workers to be employed in developing original technology. This resulted in a low level of quality change in labor input. Finally they forecasted the characteristics of quality change in labor inputs which would occur after the end of the 1960's. Their prediction was that there would be high quality change in labor input in the process of technological catch-up with the U. S. and Western Europe. The reason for this was high quality change in labor input is necessary for original technological development.

On the other hand, the assertion made by Denison=Chung about quality change in labor input especially for the effect of education was opposite to the results of Watanabe=Egaizu. According to the estimation made by Denison for the period of 1953-1971, the contribution of the education effect to economic growth (10. 4 percent per annum) was 0. 41 percent per annum, while in Watanabe=Egaizu it was 0. 06-0. 18 percent.

Denison=Chung have some problem in their framework. They used the data cross-classified only by the age and sex. Education was not cross-classified. This imposes the strong restriction that the education effect was almost the same in all of age-sex categories.

We should draw on Tachibanaki(1973), who measured the quality change in labor input for 1956-1970. He found that the major source of quality change was education and especially experience. However, we have to point out that his framework of analysis treats the number of employees of a company as one of the measure of quality of labor, and that he measured labor input only by the numbers of persons, assuming hours were constant throughout the observation period.

The contribution of this paper for the research in quality change in labor input is, at first, we measured quality change in labor input in 29 industries using Divisia index which is consistent with neoclassical theory of production under some necessary assumptions. Not only single-dimensional effects, but we analyzed all order of multi-dimensional effects which enables us to understand the quality change in labor input more systematically than any other previous researches. Secondly, we compiled huge amount of data for labor inputs cross-classified into age, sex, education, occupation and industry. Such kinds of data have not yet been developed consistently in time-series. Thirdly we compared quality change in labor inputs between U. S. and Japan in a more decomposed manner than any other previous researches. And we look for the causes of difference in productivity change between U. S. and Japan more precisely.

2. Theoretical Framework for Measuring Labor Input

2.1 Measurement of Total Factor Productivity and the Divisia Index

Let us consider the i-th industrial sector, where the social account ing identity exists as follows:

(1) $q_i Z_i = p^i_X X_i + p^i_K K_i + p^i_L L_i$

where Z_i represents gross output of the i-th industry, X_i intermediate input, K_i capital input, L_i labor input, and q_i, p^i_X, p^i_K, p^i_L, represent their respective prices.

Defining total factor productivity P_i as

(2) $P_i = Z_i / I_i$

where Z_i represents gross output, I_i total factor input, then differentiating (1) logarithmically with respect to time, we get the growth rate of total factor productivity:

(3) $\frac{\dot{P}_i}{P_i} = \frac{\dot{Z}_i}{Z_i} - V^i_X \frac{\dot{X}_i}{X_i} - V^i_K \frac{\dot{K}_i}{K_i} - V^i_L \frac{\dot{L}_i}{L_i}$

where V^i_X, V^i_K, V^i_L are the value share of intermediate, capital and labor inputs in the total factor input respectively.

Equation (3) was introduced from the social accounting identity. On the other hand, the same equation can be introduced from the production function. Let us assume perfect competition in the market, and that producers behave under the profit maximization principle. Further, suppose that there exists a production function with constant returns to scale:

(4) $Z_i = F_i(X_i,\ K_i,\ L_i,\ t)$

Differenciating (4) logarithmically with respect to time we obtain

$$(5)\quad \frac{d\ln Z_i}{dt} = \frac{\partial \ln Z_i}{\partial \ln X_i}\frac{d\ln X_i}{dt} + \frac{\partial \ln Z_i}{\partial \ln K_i}\frac{d\ln K_i}{dt} + \frac{\partial \ln Z_i}{\partial \ln L_i}\frac{d\ln L_i}{dt} + \frac{\partial \ln Z_i}{\partial t}$$

Under perfect competition, output elasticity is equal to the value share of each factor:

$$(6)\quad \frac{d\ln Z_i}{dt} = V_X^i\frac{d\ln X_i}{dt} + V_K^i\frac{d\ln K_i}{dt} + V_L^i\frac{d\ln L_i}{dt} + V_t^i$$

where $V_t^i = \partial \ln Z_i(X_i,\ K_i,\ L_i,\ t)/\partial t$, that is, we do not assume any specific neutrality of technical change in this framework.

Each factor inputs appearing on the right hand side of equations (5) and (6) and also be disaggregated into more decomposed elements, when we define the constant returns to scale aggregator function under the assumption of separability of each factor input.

$$(7)\quad \begin{aligned} X_i &= X_i(X_{1i},\ X_{2i},\ \cdots\cdots,\ X_{ni}) \\ K_i &= K_i(K_{1i},\ K_{2i},\ \cdots\cdots,\ K_{pi}) \\ L_i &= L_i(L_{1i},\ L_{2i},\ \cdots\cdots,\ L_{qi}) \end{aligned}$$

Under the assumption of perfect competition in factor markets, differenciating (7) logarithmically with respect to time, we obtain

$$(8)\quad \begin{aligned} \frac{d\ln X_i}{dt} &= \sum_{j=1}^{n}\frac{\partial \ln X_i(X_{1i},\ \cdots\cdots,\ X_{ni})}{\partial \ln X_{ji}}\cdot\frac{d\ln X_{ji}}{dt} = \sum_{j=1}^{n} V_{Xj}^i\frac{d\ln X_{ji}}{dt} \\ \frac{d\ln K_i}{dt} &= \sum_{k=1}^{p}\frac{\partial \ln K_i(K_{1i},\ \cdots\cdots,\ K_{pi})}{\partial \ln K_{ki}}\cdot\frac{d\ln K_{ki}}{dt} = \sum_{k=1}^{p} V_{Kk}^i\frac{d\ln K_{ki}}{dt} \\ \frac{d\ln L_i}{dt} &= \sum_{l=1}^{q}\frac{\partial \ln L_i(L_{1i},\ \cdots\cdots,\ L_{qi})}{\partial \ln L_i}\cdot\frac{d\ln L_{li}}{dt} = \sum_{l=1}^{q} V_{Ll}^i\frac{d\ln L_{li}}{dt} \end{aligned}$$

these are the growth rates of Divisia indices of intermediate, capital and labor inputs respectively.

Here, we should comment on the data. The discussion above was made in the world of continuous data, but data in the real world can only be obtained as discrete form. To cope with a discrete data system, discrete approximation is needed. Equations (6) and (8) and be rewritten as follows.

(9) $\ln Z_i(t) - \ln Z_i(t-1)$

$$= \bar{V}^i_X(\ln X_i(t) - \ln X_i(t-1)) + \bar{V}^i_K(\ln K_i(t) - \ln K_i(t-1))$$

$$+ \bar{V}^i_L(\ln L_i(t) - \ln L_i(t-1)) + \bar{V}^i_t$$

where

$$\bar{V}^i_X = \frac{1}{2}\ (V^i_X(t) + V^i_X(t-1)),\quad \bar{V}^i_K = \frac{1}{2}\ (V^i_K(t) + V^i_K(t-1))$$

$$\bar{V}^i_L = \frac{1}{2}\ (V^i_L(t) + V^i_L(t-1)).\quad \bar{V}^i_t = \frac{1}{2}\ (V^i_t\ (t) + V^i_t\ (t-1))$$

(10) $\ln X_i(t) - \ln X_i(t-1) = \sum_{j=1}^{n} \bar{V}^i_{Xj} (\ln X_{ji}(t) - \ln X_{ji}(t-1))$

where $\bar{V}^i_{Xj} = \frac{1}{2}\ (V^i_{Xj}(t) + V^i_{Xj}(t-1))$

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

where $\bar{V}^i_{Kj} = \frac{1}{2}(V^i_{Kj}(t) + V^i_{Kj}(t-1))$

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

where $\bar{V}^i_{Ll} = \frac{1}{2}(V^i_{Ll}\ (t) + V^i_{Ll}\ (t-1))$

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

2.2 Measurement of the Quality Change in Labor Input

To calculate an aggregate index taking into account the heterogeneity of labor input, we use equation (8) of (10) (discrete approximation of (8)). Then, we divide the index into a man-hour index and a quality index. Further we can decompose the quality index with respect to quality factors.

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

$$(11)\quad \frac{\dot{L}_{it}}{L_{it}}=\sum_s\sum_o\sum_e\sum_a V_{soea,it}\frac{\dot{L}_{soea,it}}{L_{soea,it}}$$

where

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

$W_{soea,it}$; hourly wage rates of the *soea*-th labor input of the i-th industry

$L_{soea,it}$; quantity of labor input in terms of man-hours of the i-th industry

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

$$(12)\quad L_{soea,it}=d_{soea,it}M_{it}H_{it}$$

differenciating (12) logarithmically with respect to time and substituting into (11) yields

$$(13)\quad \frac{\dot{L}_{it}}{L_{it}}=\sum_s\sum_o\sum_e\sum_a V_{soea,it}\left(\frac{\dot{d}_{soea,it}}{d_{soea,it}}+\frac{\dot{M}_{it}}{M_{it}}+\frac{\dot{H}_{it}}{H_{it}}\right)$$

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

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

The growth rates of the Divisia index is now expressed as the sum of quality change and growth rates in hours of work. The first term of the right hand side of (13) accounts for the quality change in labor input, and the second term accounts for the growth rate in hours of work of labor.

By using discrete approximation, equation (13) can be rewritten as follows

(14) $$\ln L_i(t) - \ln L_i(t-1)$$
$$= (\ln M_i(t) - \ln M_i(t-1)) + (\ln H_i(t) - \ln H_i(t-1))$$
$$+ \sum_s \sum_o \sum_e \sum_a \frac{1}{2} (V_{soea,i}(t) + V_{soea,i}(t-1))$$
$$\cdot (\ln d_{soea,i}(t) - \ln d_{soea,i}(t-1))$$

2.3 Decomposition of Quality Change in Labor Input

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

Let us call the quality change calculated from the single dimension aggregator function as the main effect, and the difference between the multi-dimensional quality change as interactive effect.

To explain these two effects more precisely, we use a four dimensional classification of labor, sex(s), occupation(o), education (e) and age (a). We define the following five types of growth rates of Divisia indices.

(15) Divisia growth rate of man-hour labor input

$$\Delta \ln MH = \Delta \ln \sum_s \sum_o \sum_e \sum_a (MH)_{soea}$$

where s: sex classification (male & female)

o: occupation (blue & white collar)

e: education (junior high school, senior high school, junior college and university graduates)

a: age (less than 17, 18–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 54–50, 55–59, 60–64, and more than 65 years old)

(16) First order Divisia growth rate of labor input

$$\Delta \ln L_i = \sum_i \bar{V}_i \Delta \ln \sum_j \sum_k \sum_l (MH)_{ijkl}$$

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

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

(17) Second order Divisia growth rate of labor input

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

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

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

(18) Third order Divisia growth rate of labor input

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

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

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

(19) Fourth order Divisia growth rate of labor input

$$\Delta \ln L_{ijkl} = \sum_i \sum_j \sum_k \sum_l \bar{V}_{ijkl} \Delta \ln (MH)_{ijkl}$$

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

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.

(21) Main effects for sex, occupation, education and age

$q_i = \Delta \ln L_i - \Delta \ln MH$ ($i = s$, o, e and a)

(22) First order interactive effects for quality change

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

(23) Second order interactive effects for quality change

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

(24) Third order interactive effects for quality change

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

(25) Total quality change in labor input

$\Delta \ln L_{ijkl}-\Delta \ln MH$

=Main effects $(q_i+q_j+q_k+q_l)$

+First order interactive effects $(q_{ij}+q_{ik}+q_{il}+q_{jk}+q_{jl}+q_{kl})$

+Second order interactive effects $(q_{ijk}+q_{ikl}+q_{jkl}+q_{ijl})$

+Third order interactive effect (q_{ijkl})

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

(26) Marginal effects for labor quality change

Sex : $q_s+q_{so}+q_{se}+q_{sa}+q_{soe}+q_{soa}+q_{sae}+q_{soea}$

Occupation : $q_o+q_{so}+q_{oe}+q_{oa}+q_{soe}+q_{soa}+q_{oea}+q_{soea}$

Education : $q_e+q_{se}+q_{oe}+q_{ea}+q_{soe}+q_{sea}+q_{oea}+q_{soea}$

Age : $q_a+q_{sa}+q_{oa}+q_{ea}+q_{soa}+q_{sea}+q_{oea}+q_{soea}$

3. Data Compilation

The data source for full-time employed workers in non-agricultural industries was primarily the *Basic Wage Structure Survey* (BWSS). We obtained data for the numbers of employees, average hours worked, wages and bonuses cross classified by sex, occupation, education and age. Industries for which data were available were Mining, Construction, 20 two digit level Manufacturing industries and 6 two-digit level service industries. Also, we obtained sub-aggregated BWSS data for Motor and Vehicles, so the total number of industries available was 29. Data for Agriculture, forestry and fishery are available from another source, *Labor Force Survey* (LFS), which was only classified by sex. The time period for index construction was 1960-1979.

We should make a note here about the definition of a full-time employee in BWSS. First, we begin with the definition of an employee in BWSS.

(i) Workers employed with no particular contract with respect to period of employment.

(ii) Workers employed with contracts for more than three months.

(iii) Temporary and daily workers employed in the same enterprise for more than 18 days in the preceeding 2 months respectively. This category of employee is divided into full-time employees and part-time employees. 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. As 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 (16), we basically obtained data for $2\times2\times4\times12=192$ categories of heterogeneous labor for each of the 29 industries. However, in the process of data construction, BWSS made a few estimates using LFS and *Manufacturing Census*.

4. Empirical Results

In what follows, the magnitude of the contribution of quality change in labor input to economic growth is discussed, and the changes of labor input in agriculture, manufacturing and service sectors are analyzed. In addition, decomposition of quality change in labor input will be made with special references to sectoral changes in labor input. On the basis of these results, we will examine the relationship between quality change and the patterns of economic development in the Japanese economy.

Finally, characteristics of quality change in labor input in Japan will be further clarified by a comparative analysis between the U. S. and Japan.

4.1 Sources of Economic Growth in Japan

Figure 1 and Table 1 show the time-series trend of economic growth and its sources during the period 1960-1979 in Japan. V stands for the aggregate index of real domestic product. K^s and L^s represent the Divisia index of capital and labor service inputs. L^{mh} denotes the simple adding-up index of man-hour labor input. K denotes the simple adding-up index of capital stock. The differences between L^s and L^{mh} and between K^s and K represent volume of quality changes of each input respectively. T. F. P. is an aggregate index of total factor productivity. T. F. P. 1 represents an index of total factor productivity, in which labor and capital input indices are evaluated by each Divisia index of input services, L^s and K^s. Contrary, T. F. P. 2 is an index of total factor productivity, in which labor and capital inputs are evaluated by each simple adding-up index, L^{mh} and K.

Divisia index of labor service input, L^s shows average annual growth rate of 3. 22 percent during the period 1960-1979. On the other hand, man-hour index of labor input shows only 2. 45 percent growth annually. This implies that quality change of labor input has been accomplished by around 1 percent annually. Quality change of capital input, which is shown in the difference between K and K^s, was significant in the Japanese economy. Rate of quality change in capital input has accomplished more than 3 percent annually.

Figure 1 Source of Economic Growth in Japan

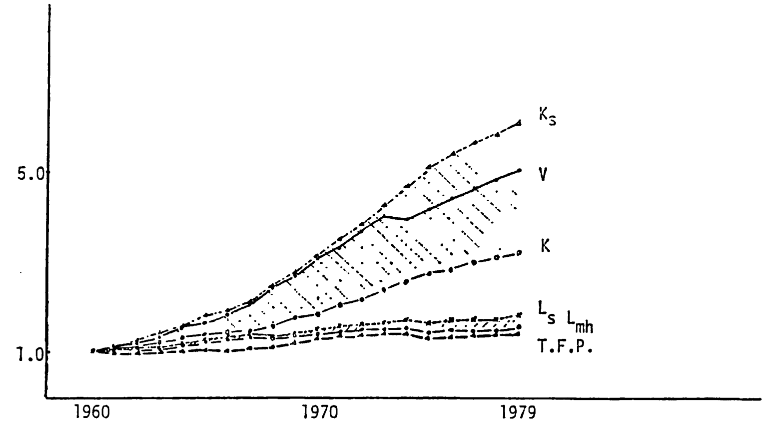


Table 1 Aggregated Divisia Index

Year	Value-added	Labour	Man-hour	Capital	K.Stock	T.F.P.1	T.F.P.2
1960	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1961	1.1277	1.1142	1.1168	1.1192	1.0471	1.0095	1.0459
1962	1.2198	1.1121	1.1218	1.2825	1.1175	1.0169	1.0906
1963	1.3411	1.1369	1.1442	1.4222	1.1482	1.0490	1.1712
1964	1.5328	1.2367	1.2345	1.5881	1.2144	1.0872	1.2532
1965	1.6427	1.3230	1.3062	1.7591	1.2992	1.0692	1.2619
1966	1.8268	1.3647	1.3342	1.9530	1.3802	1.1081	1.3452
1967	2.0672	1.4222	1.3837	2.1240	1.4586	1.1756	1.4528
1968	2.4128	1.3889	1.3441	2.4267	1.6044	1.2880	1.6295
1969	2.7257	1.4443	1.3935	2.7413	1.7267	1.3360	1.7389
1970	3.1091	1.5530	1.4660	3.0806	1.8640	1.3829	1.8585
1971	3.3635	1.5959	1.4901	3.5297	2.0428	1.3723	1.8988
1972	3.7178	1.6360	1.5123	3.8465	2.1988	1.4327	2.6047
1973	4.0240	1.6759	1.5273	4.3079	2.3908	1.4451	2.0675
1974	3.9943	1.7175	1.5435	4.7486	2.5936	1.3493	1.9726
1975	4.2063	1.6444	1.4694	5.1417	2.7773	1.3946	1.9594
1976	4.4561	1.7073	1.5076	5.3596	2.8599	1.4146	1.9601
1977	4.6918	1.7012	1.4949	5.6183	2.9934	1.4535	2.0299
1978	4.7828	1.7164	1.4969	5.8583	3.1113	1.4434	2.0307
1979	5.0518	1.8431	1.5938	6.1551	3.2193	1.4314	2.0424
1960-79	0.0852	0.0322	0.0245	0.0956	0.0615	0.0218	0.0425
Contribution	100.00	19.21		54.99		25.80	
(%)	100.00		14.62		35.50		49.88
		(3.18)		(17.45)			

If we ignore such kinds of quality change in labor input and capital inputs, almost 50 percent of economic growth in the Japanese economy should be due to the technical progress, which is shown in the index of total factor productivity, T. F. P. 2. However, if we can evaluate quality changes of labor and capital inputs accurately, contribution of technical progress is evaluated as 25 percent, which is a half of the percentage in the previous evaluation.

4.2 Annual Growth of Sectoral Labor Input

Next, we shall highlight some of the main features of our results which are presented in tables 2 through 4.

Table 2 Average Annual Growth Rates of Labor Input by Industry (in percent per year)

Industry	1960-1965	1965-1970	1970-1973	1973-1979	1960-1973	1960-1979
1. Agric.	-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. Construct.	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. Textile	1.27	0.18	-3.45	-5.39	-0.24	-1.86
6. Fab. Text.	10.35	5.27	5.81	3.41	7.35	6.11
7. Lumber	4.39	0.02	0.36	-3.53	1.78	0.10
8. Furniture	4.67	4.23	2.42	2.13	3.98	3.40
9. Paper	5.61	1.81	0.62	-0.51	2.99	1.89
10. Printing	6.76	2.43	0.73	0.84	3.71	2.80
11. Chemicals	4.55	3.45	-1.00	-1.08	2.85	1.61
12. Pet. Coal	2.60	9.29	-1.00	1.54	4.34	3.46
13. Rubber	-0.26	6.88	-1.63	-0.29	2.17	1.39
14. Leather	4.65	1.71	-3.77	3.48	1.58	2.18
15. Stone Clay	5.79	3.81	1.26	0.27	3.99	2.81
16. Iron Steel	1.35	5.22	-2.41	-2.10	1.97	0.68
17. Nonferrous	4.07	4.93	-0.14	-0.23	3.43	2.27
18. Fab. Metal	10.84	6.08	0.37	-1.82	6.59	3.93
19. Machinery	9.01	3.73	-0.46	-1.77	4.79	2.72
20. Elec. Mach.	6.69	10.21	1.16	0.83	6.77	4.89
21. Mot. Veh.	13.53	7.32	3.66	2.36	8.86	6.81
22. Trsp. Eqpt.	1.65	5.03	2.58	-7.51	3.16	-0.21
23. Prec. Inst.	7.10	5.56	4.43	0.56	5.89	4.21
24. Misc. Mfg.	5.94	6.35	0.62	2.34	4.87	4.08
25. Trsp. Comm.	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. Gov. Services	-6.28	-1.41	2.72	0.52	-2.33	-1.43
Average	5.67	4.05	0.93	0.24	3.96	2.78

Table 3 Average Annual Growth Rates of Labor Quality by Industry (in percent per year)

Industry	1960-1965	1965-1970	1970-1973	1973-1979	1960-1973	1960-1979
1. Agric.	-0.10	0.31	3.39	1.00	0.87	0.90
2. Mining	0.45	0.59	-0.10	0.19	0.37	0.32
3. Construct.	0.64	0.39	0.59	0.82	0.53	0.63
4. Foods	0.03	1.51	0.58	0.70	0.72	0.72
5. Textile	0.22	1.68	1.54	0.98	1.08	1.05
6. Fab. Text.	-0.17	1.48	0.06	0.47	0.52	0.51
7. Lumber	-0.58	0.23	0.66	0.28	0.02	0.10
8. Furniture	-0.32	0.53	0.71	1.14	0.24	0.53
9. Paper	0.30	1.64	1.02	1.04	0.98	1.00
10. Printing	0.21	1.77	1.94	1.26	1.20	1.23
11. Chemicals	-0.02	1.51	1.19	1.57	0.85	1.07
12. Pet. Coal	0.83	1.35	0.14	1.42	0.87	1.04
13. Rubber	2.70	1.21	1.68	1.37	1.89	1.73
14. Leather	-0.52	0.78	1.11	0.37	0.36	0.36
15. Stone Clay	0.06	1.16	0.67	0.87	0.62	0.70
16. Iron Steel	0.45	0.95	1.17	1.11	0.81	0.90
17. Nonferrous	-0.07	1.35	1.18	1.07	0.76	0.86
18. Fab. Metal	0.85	1.30	1.24	0.69	1.12	0.98
19. Machinery	0.41	1.26	1.21	1.27	0.92	1.02
20. Elec. Mach.	0.52	0.86	1.21	1.86	0.81	1.14
21. Mot. Veh.	-0.83	1.51	1.67	1.41	0.64	0.88
22. Trsp. Eqpt.	0.19	0.82	-1.20	0.57	0.11	0.25
23. Prec. Inst.	0.02	1.62	0.92	1.24	0.84	0.97
24. Misc. Mfg.	0.90	2.11	1.48	0.99	1.49	1.34
25. Trsp. Comm.	0.09	0.71	1.07	0.91	0.55	0.67
26. Utilities	1.08	0.61	0.11	0.25	0.68	0.54
27. Trade	1.07	1.10	2.14	1.29	1.33	1.32
28. Finance	-0.77	0.94	0.44	0.79	0.17	0.36
29. Real Estate	0.86	1.25	0.91	0.56	1.02	0.88
30. Services	-0.35	1.47	0.65	0.35	0.58	0.51
31. Gov. Services	0.44	-0.12	0.62	-0.05	0.27	0.17
Average	0.28	1.09	0.97	0.90	0.75	0.80

As should be expected for Japan, we observe negative average annual growth rate of labor input for the following two "declining" industries: agriculture-forestry-fishery and mining. For the entire period 1960–1979, labor input in agriculture-forestry-fishery declined at −3.47 percent per year and at −7.41 percent per year in mining industry. In contrast to these declining industries, the rest of the industries exhibit growing labor input for the 1960's. This indicates that mobility of labor from traditional industries to modern industrial sector is one of the main features of the Japanese economic growth in the 1960's. In the 1970's however, we observe negative growth of labor input particularly among heavy industries, which

Table 4 Average Annual Growth Rates of Man-hour Labor Input (in percent per year)

Industry	1960-1965	1965-1970	1970-1973	1973-1979	1960-1973	1960-1979
1. Agric.	-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. Construct.	13.42	4.10	5.12	2.77	7.92	6.30
4. Foods	8.46	1.38	1.75	0.53	4.18	3.04
5. Textile	1.04	-1.50	-4.99	-6.37	-1.33	-2.92
6. Fab. Text.	10.52	3.78	5.75	2.93	6.83	5.60
7. Lumber	4.98	-0.22	-0.30	-3.81	1.76	0.01
8. Furniture	5.00	3.70	1.71	1.00	3.74	2.87
9. Paper	5.30	0.17	-0.41	-1.56	2.01	0.88
10. Printing	6.55	6.72	-1.21	-0.42	2.50	1.58
11. Chemicals	4.57	1.94	-2.19	-2.64	2.00	0.53
12. Pet. Coal	1.77	7.94	-1.14	0.12	3.47	2.41
13. Rubber	-2.96	5.67	-3.31	-1.66	0.28	-0.33
14. Leather	5.17	0.94	-4.88	3.11	1.22	1.82
15. Stone Clay	5.74	2.65	0.59	-0.60	3.36	2.11
16. Iron Steel	0.90	4.27	-3.58	-3.21	1.16	-0.22
17. Nonferrous	4.13	3.60	-1.32	-1.30	2.67	1.41
18. Fab. Metal	9.99	4.77	-0.87	-2.52	5.48	2.96
19. Machinery	8.60	2.47	-1.67	-3.04	3.87	1.69
20. Elec. Mach.	6.17	9.35	-0.04	-1.03	5.98	3.75
21. Mot. Veh.	14.36	5.81	2.00	0.96	8.22	5.92
22. Trsp. Eqpt.	1.45	4.21	3.78	-8.08	3.05	-0.46
23. Prec. Inst.	7.08	3.94	3.52	-0.68	5.05	3.24
24. Misc. Mfg.	5.04	4.24	-0.85	1.35	3.37	2.73
25. Trsp. Comm.	7.00	1.93	0.65	0.50	3.58	2.61
26. Utilities	1.29	2.41	2.59	0.89	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. Gov. Services	-6.72	-1.29	2.10	0.57	-2.60	-1.60
Average	5.40	2.96	-0.03	-0.65	3.21	1.99

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 top diagram of Figure 2 to Figure 5 show the index for ordinary labor input, its man-hours worked, its worked hour and its labor quality during period 1960-1979 in light, material and fabricated manufacturing and tertiary industries. $\bar{L}$ in the figures represents index of man-hours worked and $\bar{Q}$ represents 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 industry gradually begins

Figure 2 Decomposition of Labor Quality Change (Ordinary Worker)

——Light Manufacturing Industry——

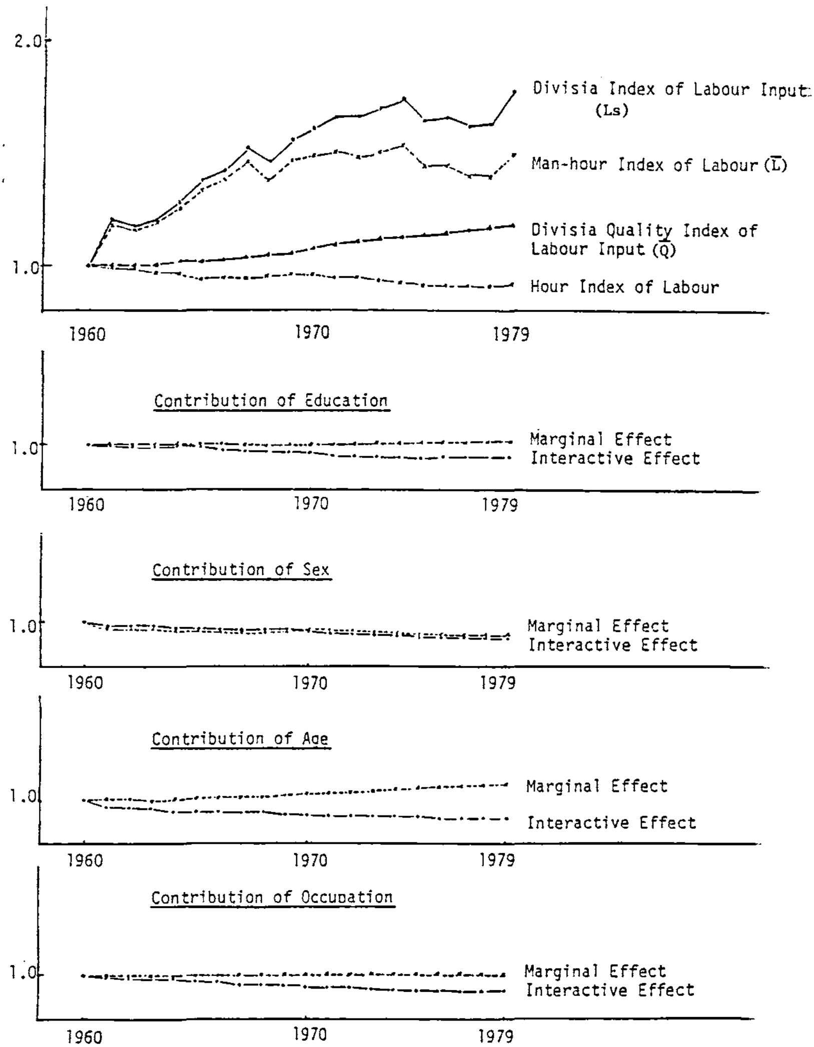


Figure 3 Decomposition of Labor Quality Change (Ordinary Worker)

—Material Manufacturing Industry—

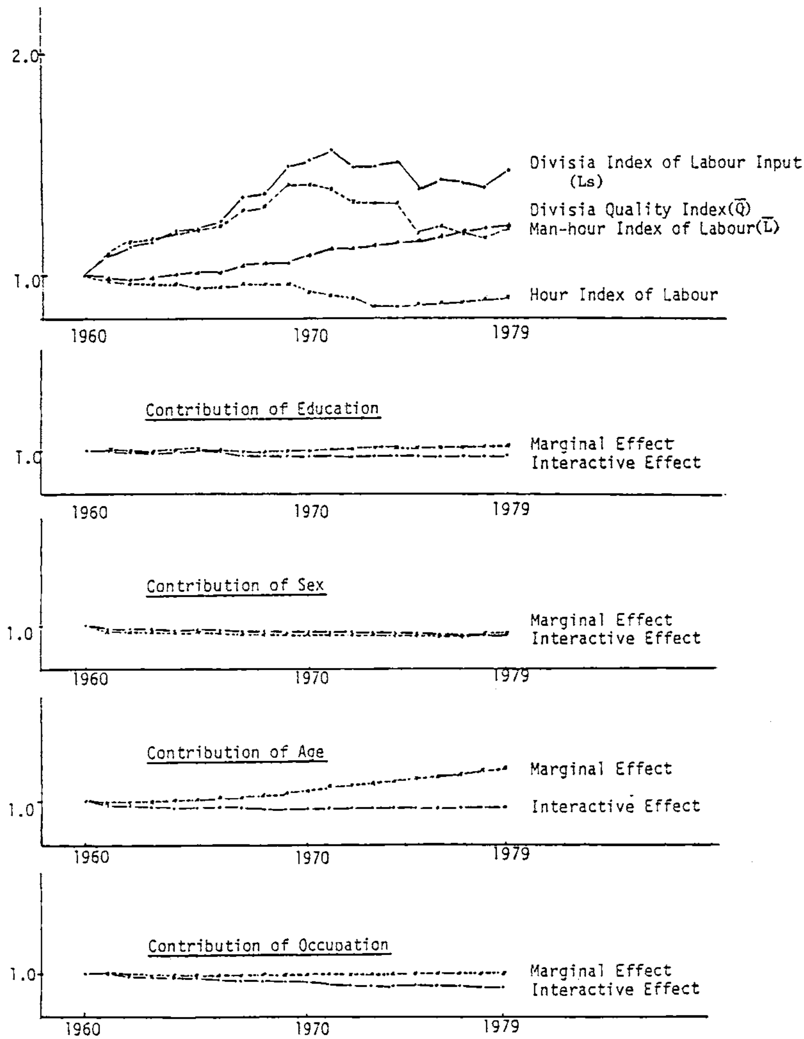


Figure 4 Decomposition of Labor Quality Change (Ordinary Worker)

——Fabricated Manufacturing Industry——

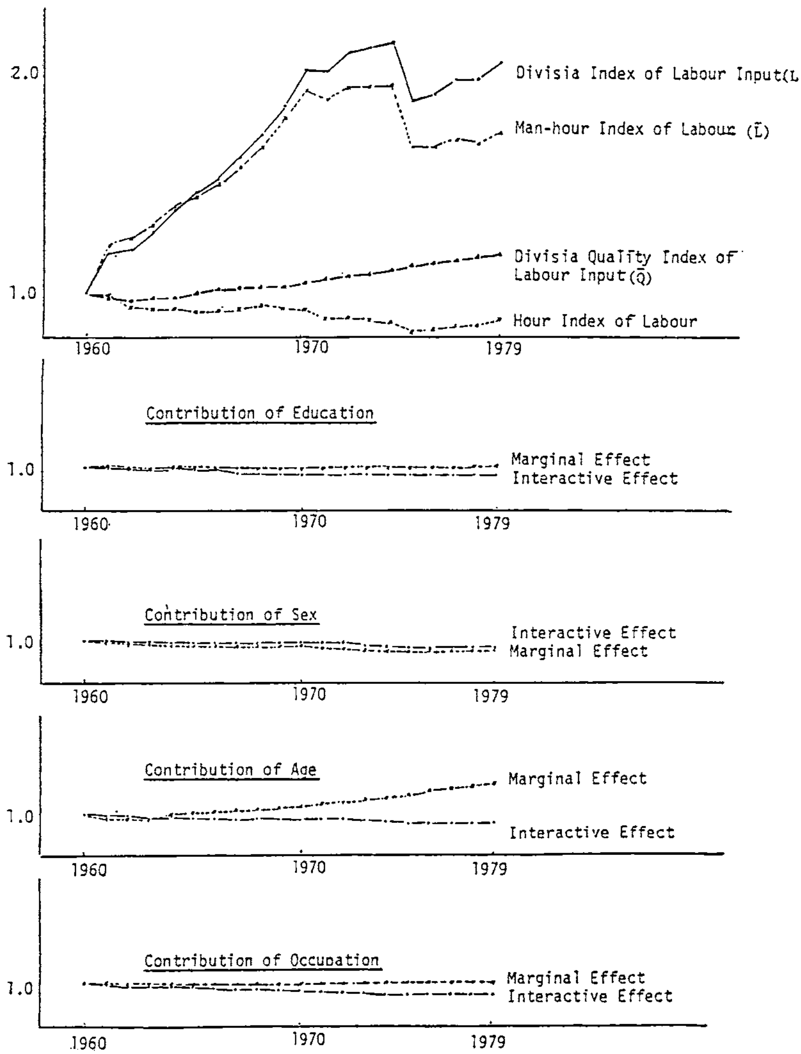
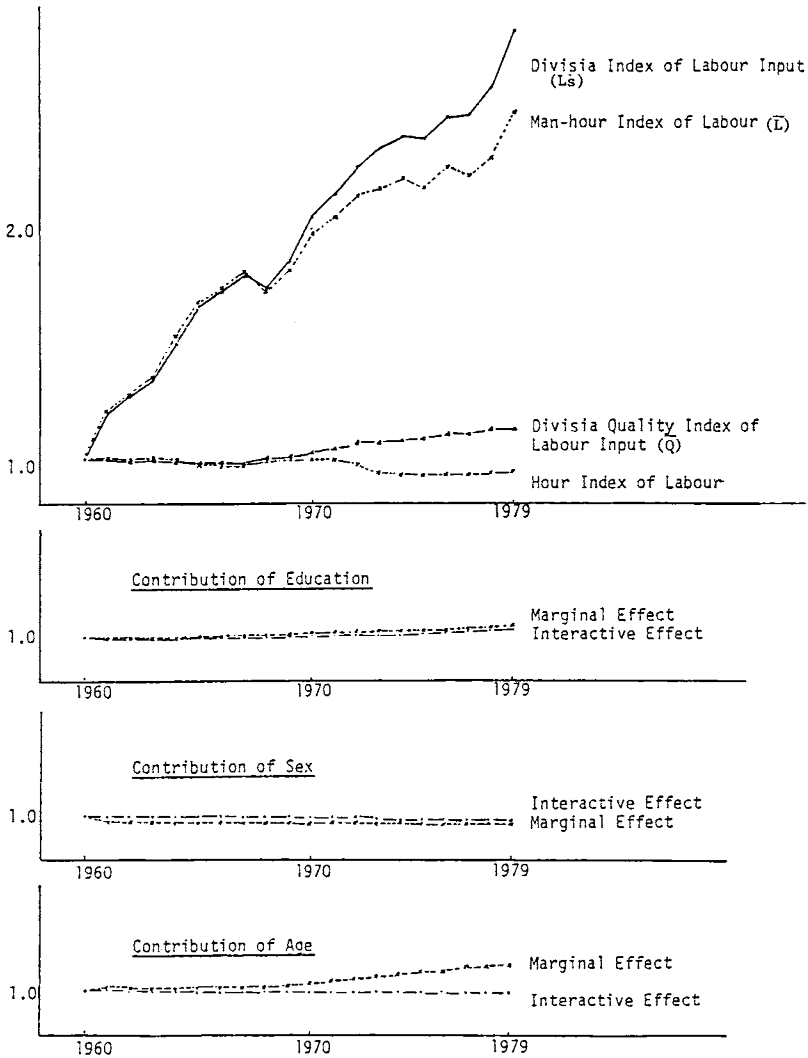


Figure 5 Decomposition of Labor Quality Change (Ordinary Worker)

—Service Industry—



to slow down at the end of the 1960's and experiences a remarkable decrease after the oil crisis in 1974. On the other hand, growth rate of man-hour labor input continues to increase for the entire period 1960-1979 in tertiary industry. Although it experienced slight decrease after 1974, it recovered to the historical trend level in 1979.

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

Average annual growth rates of the index for sectoral labor quality are shown in Table 3. Average annual growth rate during the period 1960-1979 are positive in all sectors. Average annual growth rate, 3.39 percent in agriculture-forestry-fishery during the period 1970-1973 is extraordinary high. In fact its magnitude of quality change offsets almost half of the decreases of man-hour labor input in that sector. As shown in Table 4 average annual growth rates of man-hours worked have changed to be negative in sixteen manufacturing industries during the third of the four sub-period. On the other hand, in almost all of these industries average annual growth rates of labor quality become higher for these periods. Although quality of labor input usually play a relatively minor role in contributing to total change in labor input, above observations in agriculture-forestry-fishery and many of the manufacturing industries show that the magnitude of quality change can be large enough to offset the decline in man-hours worked.

It is well known that many Japanese firms benefit from the institution of "lifetime employment" that guarantee low labor turnover. The labor market in Japan is also structured of such that most of the new workers are hired straight out of school at the beginning of each fiscal year (which coincides with the academic year in Japan). This implies that the age classification in our data base with its detailed disaggregation is an acceptable proxy for experiences or on-the-job training component of all labor types. Under those considerations, if a Japanese industry exhibits a relatively low rate of growth or negative rate of growth in man-hours worked, it would imply the change in the age distribution of its labor force towards the older workers with greater accumulated experience. Since their wage rates are higher, our assumption of producer equilibrium associates higher productivity to these older workers; and hence we should observe an increase in the quality of labor force. Thus it is not surprising that our estimates show an inverse relationship between the quality change in labor force and the change in man-hours worked.

4.3 Decompositon of Quality Change in Labor Input in Manufacturing Sector

A summary of quality decomposition is given in Table 5.

(1) During the period 1960-1969 the main effect of sex in light, material and fabricated manufacturing sectors was Δ 0.07, Δ 0.13 and Δ 0.24 percent per annum. In light and material manufacturing sectors it turned out to be positive, more than 0.45 and 0.27 percent after 1969 respectively, while in fabricated manufacturing it continued to be negative until 1973. After the oil crisis it turned to be positive in all manufacturing sectors, in which the main effect of sex explains more than 30 percent in light manufacturing, 10 percent in material manufacturing and 3 percent in fabricated manufacturing respectively.

The sum of interactive effects in terms of sex was Δ 0.36, 0.008 and Δ 0.08 per annum in each manufacturing sector during the period 1960-1979. The minus sign persisted during the whole period

Table 5 Summary Table of Quality Change in Labor Input

(in percent per year)

	Light Mfg. Industry				Material Mfg. Industry			
	1960-69	69-73	75-79	60-79	1960-69	69-73	75-79	60-79
MAIN EFFECT								
S	-0.0680	0.4536	0.3024	0.1283	-0.1259	0.2775	0.1611	0.0329
E	0.4279	0.3974	0.3427	0.3985	0.2369	0.2342	0.1508	0.2213
A	0.9411	0.9088	0.4966	0.8359	0.8281	0.9956	0.9413	0.8961
O	0.5044	0.5435	0.0450	0.4037	0.3995	0.4531	-0.0572	0.3002
CROSS EFFECT								
SE	-0.1169	-0.1122	-0.0987	-0.1077	-0.0498	-0.0454	-0.0347	-0.0454
SA	-0.4949	-0.2980	-0.1107	-0.3510	-0.3193	-0.1620	-0.0372	-0.2165
SO	-0.0734	-0.0674	-0.0460	-0.0625	-0.0068	0.0810	0.0053	0.0178
EA	-0.2213	0.0497	0.1205	-0.0570	0.0270	0.2972	0.3436	0.1737
EO	-0.3668	-0.3225	-0.2199	-0.3176	-0.2961	-0.2242	-0.1017	-0.2262
AO	-0.3681	-0.1280	-0.0274	-0.2135	-0.2382	0.0739	-0.0310	-0.1138
SEA	0.1476	0.0068	-0.0155	0.0674	0.0519	-0.0104	-0.0628	0.0083
SEO	0.0643	0.0758	0.0529	0.0624	-0.0323	-0.0076	0.0033	-0.0162
SAO	0.1798	-0.0107	-0.0003	0.0857	0.0754	-0.0968	-0.0127	0.0115
EAO	0.1794	0.0218	-0.0063	0.0863	0.0338	-0.1291	-0.0589	-0.0262
SEAO	-0.1139	0.0204	0.0133	-0.0571	0.0038	-0.0037	0.0176	0.0055
MAN-HOUR	4.3365	0.7047	1.0402	2.1439	3.8531	-1.6828	0.0999	0.9713
HOUR	-0.4178	-0.8936	0.5426	-0.4234	-0.4500	-1.5974	1.0555	-0.6056
QUALITY	0.6214	1.4984	0.8487	0.9018	0.5982	1.7335	1.2266	1.0229
DIVISIA	4.9579	2.2031	1.8689	3.0457	4.4513	0.0507	1.3265	1.9942

	Fabricated Mfg. Industry				Service Industry			
	1960-69	69-73	75-79	60-79	1960-69	69-73	75-79	60-79
MAINEFFECT								
S	-0.2389	-0.0738	0.0406	-0.0329	-0.3760	0.1951	-0.0249	-0.1181
E	0.2481	0.1876	0.1439	0.2083	0.1584	0.1898	0.1624	0.1545
A	0.5099	1.3264	1.0296	0.9314	0.4534	0.9192	0.6049	0.6283
O	0.3583	0.4458	0.0001	0.3091				
CROSS EFFECT								
SE	-0.0157	-0.0169	-0.0364	-0.0235	0.0148	0.0659	0.0189	0.0280
SA	-0.1929	-0.2656	-0.0505	-0.1962	-0.0546	-0.1320	-0.0177	-0.0824
SO	0.0291	0.0894	0.0287	0.0359	0.0000	0.0000	0.0000	0.0000
EA	-0.0975	0.0991	0.1696	0.0384	-0.0107	0.1705	0.2033	0.0805
EO	-0.2893	-0.2304	-0.1951	-0.2520				
AO	-0.1485	-0.1264	-0.0500	-0.1255				
SEA	0.0335	0.0132	-0.0263	0.0066	0.0046	-0.0272	-0.0187	-0.0089
SEO	-0.0007	-0.0075	0.0283	0.0084				
SAO	0.0113	-0.0561	-0.0172	-0.0092				
EAO	0.0661	-0.0030	0.0208	0.0331				
SEAO	-0.0129	-0.0066	-0.0003	-0.0084				
MAN-HOUR	6.6869	1.9528	1.1172	2.9387	6.8940	4.3901	3.5894	4.9464
HOUR	-0.7552	-1.6531	1.7134	-0.6438	-0.1113	-0.4567	0.4769	-0.2708
QUALITY	0.3598	1.3753	1.0860	0.3739	0.1399	1.3831	0.9282	0.6820
DIVISIA	6.9467	3.3281	2.2031	3.3125	7.0840	5.7731	4.5176	5.6284

for sex and education, sex and age in all manufacturing, which indicates an expanding proportion of female and low-educated younger workers.

(2) The main effect of education was fairly high in positive for all manufacturing sectors. It explains more than 20 percent of total quality change in labor input averagely during the period 1960-1979. the interactive effect between education and age increased gradually, while the interactive effect between education and occupation decreased.

The increase of EA effect reflects the increasing proportion of older and higher educated workers in the labor force, while the decrease of EO effect represents the increase of the proportion of higher educated blue collar workers.

In post war Japan, the proportion of highly educated workers has increased as the result of reform of the education system and changes in human capital investment behavior by workers themselves. This movement caused an increase of highly educated older workers, while the over-supply of highly educated younger workers caused an increase of highly educated blue collar workers.

Relative prices between heterogenous labor have a great influence based 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. Our obsevation of the large main effect of education and the movement of interactive effects of EA and EO must be affected by such characteristics of wage profiles in Japan.

(3) Age effect

The main effect of age explains more than 80 percent of quality change in labor input in Japan. This is extremely high compared to other main effects.

Interactive effects in terms of age were fairly small during the whole period, which means that the effect of age influenced globally 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 aging 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 always are more productive than younger people as far as wage increases according to age. This may appear a peculiar assumtion, but if we regard age as the proxy of experience or accumulation of some other relevant know-how in a company under the life-time employment system, we cannot refute apriori the existence of such an equality between wage and value of marginal productivity.

(4) Occupation effect

The main effect of occupation was almost of the same magnitude as the main effect of education. It explained more than 40 percent of quality change in 1966-1969, while it explained less than 40 percent of quality change in 1966-1969. This means that the proportion of white collar workers increased in the period 1966-1969, but not so much in subsequent periods.

(5) Quality change in the service sector

Table 5 also shows the summary of quality changes in the service sector. Since the service sector in BWSS data is not classified by occupation category, we cannot observe quality change in terms of occupation. Among the remianing three categories, the age effect was the dominant factor in quality change, just as in the manufacturing sector. Also the interactive effect by education and age (EA) began to exhibit positive trend in the 1969-73 period. The interactive effect by sex and age was slightly negative in the whole periods.

4.4 Quality Change in Labor Input and Economic Growth

Comparing the amount of quality change in labor input, quality change in the Manufacuturing sector was always larger than that of the service sector, and so were the main effects of age and education and interactive effects of education and age. On the other hand, the trend of the man-hour index was flattened out after the 1969–73 period, and fell into an apparent negative trends in 1973–79. These results suggests that the Manufacturing sector attained a high level of labor productivity through the combination of reductions of man-hours and substitution to 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 Manufacturing sector. However, in case of more decomposed industry analysis, some service industries are increasing its speed in quality change and age effect. We should further investigate the quality change in the service industries after the oil crisis.

The time period for our analysis is 1960–1979. During this time, the Japanese economy was catching up with the technology of the U.S. and Western Europe. Looking at Table 5, quality change in labor inputs occured continuously after the 1960's. And, as stated in the previous part of this paper, the main source of quality change are 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. The former represents the amount of general training, and the latter represents experience and company specific skills. We can conclude that this coincidence of quality change in labor input with technological development has been one of the causes for rapid economic growth and the strong upward trend of productivity in the Japanese economy.

Watanabe=Egaizu (1968) estimated the quality change in labor input in Japan for 1951-1964. 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 the U. S. and Western European countries. At that time, Japan depended on imported technology in which technical progress was embodied in capital input. Therefore, the amount of demand for high quality labor was limited, which resulted in a low level of quality change. Watanabe=Egaizu indicated that there would be a high level of quality change in labor input as the technological level of Japan caught up with those of the U. S. and Western Europe.

Consequently, the result of our analysis is consistent with the prediction by Watanabe=Egaizu. Although both Watanabe=Egaizu and our research treat technological change as exogenous factor, the results suggest that there is a strong relationship between technological development and quality chage in labor input especially in regards to the age and education effects.

Among 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 of the 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, this trend will inevitably shift to old aged workers corresponding to a downward sloping of age-wage profile. Other things equal, the age effect will stagnate or even become negative in the future. This will result in a stagnant trend in quality change. However, we must analyze this problem in a more interdependent framework where the age-wage profile is an endogenous factor resulting from the behavioral adjustment of economic agents.

4.5 Comparison of Quality Change in Labor Input Between Japan and the U.S.

We can draw on Gollop=Jorgenson (1980) and Chinloy (1980) (see Table-6) for a similar analysis of the United States. They reported some specific features of quality change in labor input in the U.S.. We compared them with those for Japan as follows:

(i) In the U.S. the main effect in terms of sex was negative for the whole period of 1959-1974, which is the opposite of the result obtained for Japan. In Japan, the main effect in terms of sex was positive effect for 1966-1969 on an average.

(ii) The main effect in terms of age was negative in the U.S.. On the other hand, it was positive in Japan, where this effect explained more than 80 percent of all quality changes.

(iii) The main effect in terms of education was positive both in the U.S. and Japan. The main effect was 0.67 to 0.85 percent in the U.S. which was somewhat higher than that in Japan.

(iv) The interactive effect between education and occupation was negative in the U.S.. Especially during the periods 1963-67 and 1967-71, its magnitude was more than 40 percent of total quality changes. On the other hand, interactive effect between education and age was negligibly small in the U.S., which is a difference between the countries.

(v) In the U.S. such kinds of quality change results from the movement of the labor force that female and younger workers increased recently. Such changes in the U. S. consequently worsened improvements in the quality of labor inputs. On the other hand, the effect of education contributed to the improvement of

Table 6 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(A)	.72	.85	.81	.67
Occupation(O)	.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) "Sources of Quality Change in Labor Input," *American Economic Review*, Vol. 70, No. 1, March.

labor quality although a negative interactive effect between education and occupation offset this improvement to some extent. Chinloy explained this situation as "over-education" in the U. S..

(vi) Finally quality changes in the U. S. on average were smaller than those in Japan. In the U. S., quality change was 1.27 percent per year in 1959-63, 0.23 in 1963-67 and 0.58 in 1967-71, while in Japan quality change were more than 1.0 percent per year during the whole period.

The characteristics of quality change are behind the difference of productivity performance between the U. S. and Japan. We may conclude that the high quality change of labor input in Japan affected favorably to the development of technology, which resulted in high labor productivity, while the low quality change of labor input in U. S. downgraded the growth of labor productivity.

5. Summary and Conclusion

Japanese economic development is largely explained by capital intensive technology, though labor's relative share showed no downward trend for the period examined. This fact suggests the existence of an upward trend of quality change in labor input in the Japanese economy.

Our analysis in this paper 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 1969-1973 period. In addition, quality change in labor input in the Manufacturing sector was always larger than that of the Service sector. Consequently, this influenced the relatively high performance 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 1960-1979, 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 are the increase in experienced middle-aged workers, the growing proportion of higher educated workers, a reduction in less educated young workers, an increase in more educated older workers and the decline of less educated blue collar workers.

During our observation period, the Japanese economy was catching up with the technology of the U. S. 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 catch-up process. This coincidence of quality change in labor input with technological development has been one of the causes of rapid productivity change in the Japanese economy.

Among sources of quality change, the age effect provided the most significant contribution. This is because of 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 older workers whose wages are on the downward slope of the age-wage profile increase, the age effect will stagnate or even become negative provided that other things are equal. This depends on whether the shift of the age-wage profile for older workers will be upward or downward.

The comparison between the U. S. and Japan showed that quality change in labor input in the U. S. was apparently 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 reduced when an adjustment for occupation is made. These comparative result suggest an apparently different input structure between the U. S. and Japan. Above all, quality change in labor input has not been a contributing factor for productivity change in the U. S., while it contributed significantly in Japan.

Our analysis in this paper is part of research work to investigate the interdependent mechanism of the relationship between input structure and economic growth and technical progress. We must investigate further other factor input, such as capital and intermediate inputs, and also the interaction among labor, capital and intermediate inputs.

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