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Abstract	After the periods Simon Kuznets concerned in his eminent book, Economic Growth of Nations (1971), the Japanese economy experienced dramatically rapid economic growth higher than the historical standard. Our first objective in this paper is to analyze features of the Japanese economic growth over the period 1960 to 1973. To formulate an approach to research on the feature in Japanese economic growth, we can draw on the work of Jorgenson and Nishimizu (1978) and Gollop and Jorgenson (1980). As theoretical concerns, we tried to apply the same methodology of measurement of total factor productivity by industries they used over the period 1960 to 1977. We could verify their finding in the Japanese economy and result that the rapid upheaval of the efficiency in the Japanese economy stemed from the well-behaved balanced growth especially over the period 1966 to 1969. Our second objective is to find some characteristics in the recovery process of the Japanese economy after the oil crisis. Here we found that the recovery patterns after the oil crisis is too much different from the pattern during the period 1960 to 1973.
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PRODUCTIVITY AND MARKET PERFORMANCE*

—Time-Series Observation (1960–1977) in the Japanese Economy—

by

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and
Hajime Imamura

Abstruct

After the periods Simon Kuznets concerned in his eminent book, *Economic Growth of Nations (1971)*, the Japanese economy experienced dramatically rapid economic growth higher than the historical standard. Our first objective in this paper is to analyze features of the Japanese economic growth over the period 1960 to 1973. To formulate an approach to research on the feature in Japanese economic growth, we can draw on the work of Jorgenson and Nishimizu (1978) and Gollop and Jorgenson (1980). As theoretical concerns, we tried to apply the same methodology of measurement of total factor productivity by industries they used over the period 1960 to 1977. We could verify their finding in the Japanese economy and result that the rapid upheaval of the efficiency in the Japanese economy stemed from the well-behaved balanced growth especially over the period 1966 to 1969. Our second objective is to find some characteristics in the recovery process of the Japanese economy after the oil crisis. Here we found that the recovery patterns after the oil crisis is too much different from the pattern during the period 1960 to 1973.

1. Introduction

Simon Kuznets in his laborious work, *Economic Growth of Nations : Total Output and Production Structure*, pointed out the following dominant property in the modern economic growth:

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". . . . . The important point is that the acceleration in the rate of growth in per capita product, characteristic of modern economic growth, was accompanied by an equally conspicuous acceleration in the rate of change in production structure. . . . ." (p154)[1)]

The average annual growth rate of gross products during one and quarter centuries was estimated around 3 percent by Kuznets. We experienced more than 10 percent annual growth rate of real GNP during the successive period, 1960–1970 in Japan. In such Japanese economy in which the rapid economic growth was accomplished by more than the historical standard level, we can expect that there existed a dramatic structural changes —— illustrated by the shift of the share of each industrial sector in total production, total labor force and total capital formation.

We can pick up some interesting features in the Japanese structural change as follows:

a) [Table 1–1] shows the share of each sector in total production during the period 1960–1977. As concerns the share of gross output evaluated at the constant price (1970=1.0), the share of production in A-sector (Agricultural sector) decreased rapidly from 12.42 percent in 1960 to 4.40 percent in 1970 and 3.47 percent in 1977 continuously. On the other hand the share in I-sector (Industrial sector) increased gradually from 61.82 percent in 1960 to 65.22 percent in 1970, although this increasing trend reversed after the oil embergo in 1973. Finally the share in S-sector (Service sector) increased gradually during this period. These trend of the share of each sector in total production was in the path estimated by Kuznets during the last one century.

b) The share of manufacturing sectors in total production increased moderately by the annual growth rate, 1.35 percent during the period 1960–1970. However the changes of shares within manufacturing sectors were remarkable: Shares in food & kindred products, textile, lumber, printing, rubber and leather products decreased rapidly by the annual growth rate, Δ6.0 ~ Δ1.0 percent. On the other hand these in chemical, petroleum, iron and steel,. machinery and transportation equipment increased remarkably by the annual growth rate, 2.0 ~ 8.0 percent.

c) [Table 1–2] shows the time-series changes of the share of each sector in labor force during the period 1970–1977. In A-sector the share in labor force decreased rapidly by the annual growth rate, 5.21 percent for 1960- 1970 and 4.11 percent for 1970–1977. This annual growth rate is fairly larger than the annual average rate, 1.23 percent for 1872–1964 observed by Kuznets. In I-sector the share of labor force increased gradually from 34.87 percent in 1960 to 41.56 percent in 1977. At the same time share in S-sector expanded more rapidly by the annual growth rate, 2.05 percent for 1960–1970 and 1.74 percent for 1970–1977.

Such features of trend in the allocation of labor force among A, I and S sectors are mostly consistent with the patterns in the long-term trend pointed by Kuznets. But the speed of changes is remarkably faster than that in the last century.

d) While the share of manufacturing sector as a whole increased by the annual

1) See Simon Kuznets (1971) p. 154.

Table 1-1 Changes of the Ratio of Output to Total Gross Product

	Proportion (Current Price)					Proportional Changes				Annual Growth Rate %	
	1960 %	1965 %	1970 %	1975 %	1977 %	1960 1965	1965 1970	1970 1975	1975 1977	1960 1970	1970 1977
[A] Agric.	8.31	6.73	4.40	4.02	3.79	Δ1.58	Δ2.33	Δ0.38	Δ0.23	Δ6.36	Δ2.13
[I] Industry	68.33	66.79	67.04	63.07	62.32	Δ1.54	0.25	Δ3.97	Δ0.75	Δ0.19	Δ1.04
[S] Service	23.36	26.48	28.56	32.91	33.89	3.12	2.08	4.35	0.98	2.01	2.44
	Proportion (Constant Price)					**Proportional Changes**				**Annual Growth Rate %**	
[A] Agric.	12.42	7.88	4.40	3.87	3.47	Δ4.54	Δ3.48	Δ0.53	Δ0.40	Δ10.38	Δ3.39
[I] Industry	61.82	63.79	67.04	65.22	65.22	1.97	3.25	Δ1.82	0.00	0.81	Δ0.39
[S] Service	25.76	28.33	28.56	30.91	31.31	2.57	0.23	2.35	0.40	1.03	1.31
	Proportion to Value-Added					**Proportional Changes**				**Annual Growth Rate %**	
[A] Agric.	12.69	9.41	5.88	5.34	5.12	Δ3.28	Δ3.53	Δ0.54	Δ0.22	Δ7.69	Δ1.98
[I] Industry	53.80	52.47	53.30	46.96	47.48	Δ1.33	0.83	Δ6.34	0.56	Δ0.09	Δ1.65
[S] Service	33.51	38.12	40.82	47.70	47.40	4.61	2.70	6.88	Δ0.30	1.97	2.13

Table 1-2 Changes in the Ratio of Labor Force in Total

	Proportion (Workers)					Proportional Changes				Annual Growth Rate %	
	1960 %	1965 %	1970 %	1975 %	1977 %	1960 1965	1965 1970	1970 1975	1975 1977	1960 1970	1970 1977
[A] Agric.	32.59	24.66	19.36	19.59	14.51	Δ7.93	Δ5.30	Δ0.23	Δ5.08	Δ5.21	Δ4.11
[I] Industry	34.87	38.51	40.69	41.54	41.56	3.64	2.18	0.85	0.02	1.54	0.30
[S] Service	32.54	36.83	39.95	38.87	43.93	4.29	3.12	Δ1.08	5.06	2.05	1.74
	Proportion (Employees)					Proportional Changes				Annual Growth Rate %	
[A] Agric.	3.37	2.15	1.47	1.66	1.55	Δ1.22	Δ0.68	0.19	Δ0.11	Δ8.29	0.75
[I] Industry	56.14	55.36	53.79	54.67	50.78	Δ0.78	Δ1.57	0.88	Δ3.01	Δ0.42	Δ0.82
[S] Service	40.49	42.79	44.74	43.67	47.67	2.30	1.95	Δ1.07	4.00	0.99	0.91

growth rate, 1.51 percent, the allocation of labor force within the manufacturing sector were shifted remarkably. The shares in labor force were not necessarily moved in parallel with the shares in production. In chemical, iron and steel, and non-ferrous metal product, the share in labor force decreased rapidly in spite of the increasing share of products of these sectors. On the other hand the share in labor force of machinery and metal products increased gradually along with the expantion of the share of products of each sector.

e) Kuznets pointed out in his book as concerns the properties of capital input in the modern economic growth as follows:

"The interesting aspect of the evidence is that, with few exceptions, the growth rate of even fixed capital stock was lower than that of total products. . . . ." (p.73)[2)]

When we observed the capital formation during the period 1960–1977 in Japan, we perceived that the average annual growth rate of re-producible capital was higher than that of real gross product by more than one percentage point. Consequently the partial capital productivity in each sector trends to decrease during this period, while the partial labor productivity trends to increase rapidly. Such pattern of capital accumulations is one of eminent properties in the Japanese economic growth.

To formulate an approach to research on the features in the Japanese economic growth during the period 1955–1973, Jorgenson and Nishimizu [1978] have compared production patterns at the level of two-digit industries for the United States and Japan. They have compared relative levels output, intermediate, capital and labor inputs and levels of technology for individual industries. We can draw on the work of them to analyze the pattern of growth from 1973 to the present. From the methodological points of view these analysis are completely comparable with the research results in the U.S. by Gollop-Jorgenson [1980] over the period 1948–1973.

2. *Methodological Overview*

Jorgenson-Griliches [1967] stated that the measurement of total factor productivity reduced from the social accounting balance can interpret as a expression of technical progress in production function, formulated originally by Solow [1957].

As a definition of the social accounting balance, the following equation can be introduced:

$$(2.1) \qquad \sum_{i=1}^{m} q_i Y_i = \sum_{j=1}^{m} P_j X_j ,$$

where (Y_i, q_i) and (X_j, q_j) denote the sets of quantity and price of i-th output and j-th input respectively, m and n represent the number of output and input.

2) See Simon Kuznets (1971) p. 73.

Differentiating by time,

$$(2.2) \qquad \Sigma\omega_i \left(\frac{\dot{q}_i}{q_i} + \frac{\dot{Y}_i}{Y_i}\right) = \Sigma v_j \left(\frac{\dot{P}_j}{P_j} + \frac{\dot{X}_j}{X_j}\right),$$

where ω_i and v_j denote the income share of i-th output and j-th input as follows:

$$(2.3) \qquad \omega_i = \frac{q_i Y_i}{\Sigma q_i Y_i}, \quad v_j = \frac{P_j X_j}{\Sigma P_j X_j}.$$

Now we can define the growth rate of the aggregated output and input as following indices:

$$(2.4) \qquad \frac{\dot{Y}}{Y} = \sum_{i=1}^{m} \omega_i \frac{\dot{Y}_i}{Y_i}, \quad \frac{\dot{X}}{X} = \sum_{j=1}^{n} v_j \frac{\dot{X}_j}{X_j}.$$

Also let us difine the growth rate of output and input price as follows:

$$(2.5) \qquad \frac{\dot{q}}{q} = \Sigma\omega_i \frac{\dot{q}_i}{q_i}, \quad \frac{\dot{p}}{p} = \Sigma v_j \frac{\dot{p}_j}{p_j}.$$

Using these definition we can reduce the growth rate of the average productivity (ψ = Y/X) in nationwide level as follows:

$$(2.6) \qquad \frac{\dot{\psi}}{\psi} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} = \Sigma\omega_i \frac{\dot{Y}_i}{Y_i} - \Sigma v_j \frac{\dot{X}_j}{X_j}$$
$$= \Sigma v_j \frac{\dot{P}_j}{P_j} - \Sigma\omega_i \frac{\dot{q}_i}{q_i}.$$

Usually indices in (2.4) are refered to Divisia (quantity) index growth rate of output and input. Indices in (2.5) are divisia (price) indices growth rate of output and input prices. And (2.7) is a definition of divisia index growth rate of Total Factor Productivity.

Let us assume that economy could be divided into n industrial sectors with an assumption of homothetically separable production technology. We denote homogeneous production function of i-th sector as follows:

$$(2.7) \qquad Z_i = F_i(X_i, L_i, K_i, T),$$

where Z_i, X_i, L_i and K_i are output, intermediate input, labor and capital inputs, and T denote time-variable.

Necessary conditions for producer equilibrium for i-th sector are given by equalities between the value shares of each input into the sector and the elasticity of output with respect to that input:

$$(2.8)\quad \frac{\partial \ln Zi}{\partial \ln Xi} = \frac{\partial Zi}{\partial Xi} \cdot \frac{Xi}{Zi} = \frac{P_X^i Xi}{qiZi} = v_{Xi} \,,$$

$$\frac{\partial \ln Zi}{\partial \ln Li} = \frac{\partial Zi}{\partial Li} \cdot \frac{Li}{Zi} = \frac{P_L^i Li}{qiZi} = v_{Li} \,,$$

$$\frac{\partial \ln Zi}{\partial \ln Ki} = \frac{\partial Zi}{\partial Ki} \cdot \frac{Ki}{Zi} = \frac{P_K^i Ki}{qiZi} = v_{Ki} \,,$$

where v_{Xi}, v_{Li} and v_{Ki} represent the income share of each input and P_X^i, P_L^i, and P_K^i denote the price of each input.

Differentiating (2.7) by time,

$$(2.9)\quad \frac{d\ln Zi}{dT} = \frac{\partial \ln Zi}{\partial \ln Xi} \cdot \frac{d\ln Xi}{dT} + \frac{\partial \ln Zi}{\partial \ln Li} \cdot \frac{d\ln Li}{dT} + \frac{\partial \ln Zi}{\partial \ln Ki} \cdot \frac{d\ln Ki}{dT} + \frac{\partial \ln Zi}{\partial T}$$

$$= v_{Xi} \frac{d\ln Xi}{dT} + V_{Li} \frac{d\ln Li}{dT} + v_{Ki} \frac{d\ln Ki}{dT} + v_{iT} \,,$$

where we refer to $v_{iT} = \partial \ln Zi/\partial T$ as the divisia quantity indices of sectoral rates of technical change. (2.9) implies that growth rate of output in i-th sector can be divided into the contribution among growth rate of marketable inputs and growth rate of priceless factor, or 'technological progress.' As we can diduce simply, v_{iT} in (2.9) means divisia growth rate of Total Factor Productivity in i-th sector as shown in (2.6).

$$(2.10)\quad \frac{\dot{\psi}}{\psi} = v_{iT} = \frac{\dot{Z}i}{Zi} - v_{Xi}\frac{\dot{X}i}{Xi} - v_{Li}\frac{\dot{L}i}{Li} - v_{Ki}\frac{\dot{K}i}{Ki} \,.$$

In (2.10) Xi/Xi, Li/Li and Ki/Ki might be defined from each aggregator function of intermediate inputs, labor inputs and capital inputs with an assumption of homothetically separable inputs.

$$(2.11) \qquad \frac{\dot{X}i}{Xi} = \sum_{j=1}^{n} v_{Xj}^{i} \frac{dlnXij}{dT} = \sum_{j=1}^{n} v_{Xj}^{i} \frac{\dot{X}ij}{Xij},$$

$$\frac{\dot{L}i}{Li} = \sum_{j=1}^{l} v_{Lj}^{i} \frac{dlnLij}{dT} = \sum_{j=1}^{n} v_{Lj}^{i} \frac{\dot{L}ij}{Lij},$$

and

$$\frac{\dot{K}i}{Ki} = \sum_{j=1}^{l} v_{Kj}^{i} \frac{dlnKij}{dT} = \sum_{j=1}^{l} v_{Kj}^{i} \frac{\dot{K}ij}{Kij},$$

where v_{Xj}^{i}, v_{Lj}^{i} and v_{Kj}^{i} denote income shares of i-th input in each separable input.

If our production function, (2.7) is a homogeneous function which satisfies regularity condition for profit maximization of the firm, we can deduce a price frontier function as a dual system.

Necessary conditions for producer equilibrium on price frontier function in a competitive market, we can also define a measurement of divisia growth rate of total factor productivity.

$$(2.12) \qquad v_T^i = - \frac{dlnqi}{dT}$$

$$= v_{Xi} \frac{\dot{P}_{Xi}}{P_{Xi}} + v_{Li} \frac{\dot{P}_{Li}}{P_{Li}} + v_{Xi} \frac{\dot{P}_{Ki}}{P_{Ki}} - \frac{\dot{q}i}{qi},$$

where

$$\frac{\dot{P}_{Xi}}{P_{Xi}} = \frac{dlnP_{Xi}}{dT} = \sum_{j=1}^{m} v_{Xj}^{i} \frac{\dot{P}_{Xij}}{P_{Xij}},$$

$$\frac{\dot{P}_{Li}}{P_{Li}} = \frac{dlnP_{Li}}{dT} = \sum_{j=1}^{l} v_{Lj}^{i} \frac{\dot{P}_{Lij}}{P_{Lij}},$$

$$\frac{\dot{P}_{Ki}}{P_{Ki}} = \frac{dlnP_{Ki}}{dT} = \sum_{j=1}^{k} v_{Kj}^{i} \frac{P_{Kij}}{P_{Kij}}.$$

Here we assume that prices of intermediate input, P_{Xi}, labor service, P_{Li} and capital service, P_{Ki} are defined as functions of detailed input prices respectively.

3. *Measurement of Productivity*

We can estimate the time-series movement of productivity by utilizing equation (2.10) or (2.12) in section 2.

[Table 3–1] shows our industry classification. Our 31 industrial order mostly corresponds to 51 U.S. industrial classification by Gollop-Jorgenson, which is shown in the last column in [Table 3–1].

Equations of total factor productivity in (2.10) and (2.12) are defined as continuously differentiable equations with respect to time variable. When they are applied to observed data, we usually use the formulation of Discrete Divisia Approximation.

Discrete Divisia Approximations corresponding to equations (2.10) and (2.12) are denoted as follows:

$$(3.1) \quad \bar{v}_T^i = [\ln Zi(T) - \ln Zi(T\text{-}1)] - \bar{v}_X^i [\ln Xi(T) - \ln Xi(T\text{-}1)] - \bar{v}_L^i [\ln Li(T) - \ln Li(T\text{-}1)] - \bar{v}_K^i [\ln Ki(T) - \ln Ki(T\text{-}1)],$$

where

$$\bar{v}_T^i = \frac{1}{2} [v_T^i(T) + v_T^i(T\text{-}1)],$$

$$\bar{v}_X^i = \frac{1}{2} [v_X^i(T) + v_X^i(T\text{-}1)],$$

$$\bar{v}_L^i = \frac{1}{2} [v_L^i(T) + v_L^i(T\text{-}1)],$$

$$\bar{v}_K^i = \frac{1}{2} [v_K^i(T) + v_K^i(T\text{-}1)].$$

$$(3.2) \quad \bar{v}_T^i = \bar{v}_X^i [\ln P_{Xi}(T) - \ln P_{Xi}(T\text{-}1)] + \bar{v}_L^i [\ln P_{Li}(T) - \ln P_{Li}(T\text{-}1)] + \bar{v}_K^i [\ln P_{Ki}(T) - \ln P_{Ki}(T\text{-}1)] - [\ln qi(T) - \ln qi(T\text{-}1)],$$

where T and T-1 are successive two points in our observations. We can use this approximation formula to calculate each input aggregate index in the same way.

3.1 Labor input

Jorgenson-Nishimizu [1978] formulated discrete divisia growth rate, $\hat{\beta}_{it}$, as follows:

$$(3.3) \quad \hat{\beta}_{it} = [\ln Mi(T) - \ln Mi(T\text{-}1)] + [\ln Hi(T) - \ln Hi(T\text{-}1)]$$

[Table 3-1] List of Industrial Sectors

		Industry Name: 31 industrial orders	Gollop-Jorgensn (1980): 51 industrial orders
[A]	1.	Agriculture, Forestry and Fisheries	Agricultural Production Agricultural Service
[M]	2.	Mining	Metal mining Coal mining Crude Petroleum & N. Gas Nonmetallic mining
[C]	3.	Construction	Contract Construction
[Fo]	4.	Food and Kindred Products	Food & kindred Products
[Tx]	5.	Textile Mill Products	Textile Mill Products
[Ap]	6.	Apparel and other Fabricated Textile Products	Apparel & Other Fabr. Tex.
[Lm]	7.	Lumber and Wood Products, except Furniture	Lumber and Wood Prod.
[F]	8.	Furniture and Fixture	Furniture & Fixture
[P]	9.	Paper and Allied Products	Paper & Allied Products
[Pr]	10.	Printing, Publishing and Allied Products	Printing & Publishing
[Ch]	11.	Chemical and Allied Products	Chemical & Allied Products
[R]	12.	Petroleum Refinery and Related Industries	Petroleum & Coal Products
[Ru]	13.	Rubber and Miscellaneous Plastic Products	Rubber & Misc. Plastic Prod.
[Le]	14.	Leather and Leather Products	Leather & Leather Products
[S]	15.	Stone, Clay and Glass Products	Stone, Clay & Glass Prod.
[I]	16.	Iron and Steel	Primary Metal Products
[N]	17.	Non-ferrous Metal	
[Fa]	18.	Fabricated Metal Products	Fabricated Metal Products
[MH]	19.	Machinery	Machinery Ex. Electrical
[EM]	20.	Electric Machinery	Elec. Machinery Eqpt. & Supplies
[Mv]	21.	Motor Vehicles and Equipment	Motor Vehicles & Eqpt.
[Te]	22.	Transportation Equipment except Motor	Trans. Eqpt. Ex. Motor
[PM]	23.	Precision Instruments	Prof. Photo Eqpt. & Watches
[OM]	24.	Miscellaneous Manufacturing	Misc. Manufacturing Industry Tabacco Manufacturing
[Tr]	25.	Transportation and Communication	Railroad & Rail Express Service Street Rail, Bus Lines & Taxi Trucking Services & Warehousing Water Transportation Air Transportation Transportation Service Telephone, Telegraph Misc. Radio Broadcasting & TV.
[El]	26.	Electric Utility, Gas Supply and Water Supply	Electric Utility Gas Utility Water Supply & Sanitary Service
[W]	27.	Wholesale and Retail Trade	Wholesale Trade Retail Trade
[Fi]	28.	Finance and Insurance	Finance, Insurance & Real Est.
[RE]	29.	Real Estate	
[Sv]	30.	Service	Service Ex. Priv. Households
	31.	Government Service	

$$+\sum_k \sum_l \sum_m \sum_n \frac{1}{2} [U_{klmn.i}(T) + U_{klmn.i}(T-1)]$$

$$x\ [\ln d_{klmn.i}(T) - \ln d_{klmn.i}(T-1)]\ ,$$

where Mi and Hi denote total employment and average hours worked per man in i-th sector, and $d_{klmn.i}$ represents the proportion of man-hours worked by the klmn-th labor type in the i-th sector. $U_{klmn.i}$ stands for the income-share of klmn-th labor type in total labor compensation of i-th sector.

Similarly we can formulate discrete divisia price growth rate $\hat{\gamma}_{it}$ as follows:

$$(3.4) \qquad \hat{\gamma}_{it} = \sum_k \sum_l \sum_m \sum_n \frac{1}{2} [U_{klmn.i}(T) + U_{klmn.i}(T-1)]$$

$$x\ [\ln w_{klmn.i}(T) - \ln w_{klmn.i}(T-1)]\ ,$$

where $w_{klmn.i}$ denotes price of klmn-th labor service type in i-th sector.

Labor type is classified as follows:

(1) Employment status (1. ordinary employee, 2. temporary worker, 3. daily worker, 4. self-employed, 5. un-paid family worker), (2) Sex (1. Male, 2. Female), (3) Occupation (1. Blue-collar worker, 2. White-collar worker), (4) Education (1. Elementary and Junior high school, 2. High School, 3. Junior college and technical school, 4. College and University), (5) Age (1. less 17 years old, 2. 18-19 years old, 3. 20-24 years old, 4. 25-29 years old, 5. 30-34 years old, 6. 35-39 years old, 7. 40-44 years old, 8. 45-49 years old, 9.50-54 years old, 10. 55-59 years old, 11. 60-64 years old, 12. more than 65 years old) (6) Industry (31 industrial order shown in [Table 3-1]).

Data for the ordinary workers in the non-agricultural sectors are principally available on the source of *Basic Wage Structure Survey* (BWSS). Estimates for the ordinary workers in agricultural sector and government service sector are deduced from *Labor Force Survey* (LFS). Data for temporary worker, daily worker, self-employed and un-paid family worker were estimated from LFS, *Manufacturing Cencus*, *Establishment Census* and *Employment Status Survey*.[3)]

[Table 3-2] shows the average divisia growth rate of labor input during the period mentioned in the first row. In column (1) – (4), estimates of $\hat{\beta}_{it}$ in (3.3) are shown by industry. Column (5) – (8) and (9) – (12) correspond to the third and the first plus second term of the right-hand side of (3.3), which represent the divisia growth rate of labor quality and quantity respectively.

Let us think of quantity change of labor input in column (9) – (12). In agricultural sector, mining and textile industry, divisia growth rates of labor input showed minus signs during the period 1960–1972. While the growth rates in iron and steel and chemical products are less than the nationwide average growth rate in spite of the rapid growth in their output, those in construction, metal product and machinery are higher than the average. After the oil crisis in 1973 the growth rate of labor input decreased dramatically almost all of sectors and showed minus signs with few exceptions.

As concerns the quality changes of labor input as shown in column (5) – (8), quality of labor input were continuously improved over almost all period except certain period in few industries.

[Table 3-3] shows the time-series changes of (partial) labor productivity by industry. First four columns imply the time-series changes of productivity (1960=1.0) in each industry during the period 1965–1977. Last two columns show the average annual growth rate over the period 1960–1970 and 1970–1977. Last row in the table means the simple average of annual growth rate. Average annual growth rate of labor productivity was 6.94 percent during the period 1960–1970.

3.2 Capital input

Similar to labor input, we can define the aggregate of capital service inputs as follows:

$$(3.5) \qquad \hat{\delta}_{it} = \sum_k \sum_l \sum_m \sum_n \omega_{klmn.it} \frac{\dot{K}_{klmn.it}}{K_{klmn.it}},$$

where

$$\omega_{klmn.it} = \frac{C_{klmn.it} \cdot K_{klmn.it}}{\sum_k \sum_l \sum_m \sum_n C_{klmn.it} K_{klmn.it}}.$$

$K_{klmn.it}$ denotes klmn-th type capital service input of i-th industrial sector at year t and $C_{klmn.it}$ represents its service price. $\hat{\delta}_{it}$ is a expression which we refer to divisia quantity growth rate of capital service input. According to the property of duality, we can define divisia price growth rate of capital service input.

$$(3.6) \qquad \hat{\eta}_{it} = \sum_k \sum_l \sum_m \sum_n \omega_{klmn.it} \frac{\dot{C}_{klmn.it}}{C_{klmn.it}}.$$

Unlike the prices of labor service, we can not directly observe the price of capital service, $C_{klmn.it}$. According to well-known procedures of imputative calculation in Neoclassical economics, we can deduce a relationship in which the capital service price is regarded as a function of the capital asset price, q_{ijt}, rate of return on capital, γ_t, economic rate of replacement μ_{ij} and tax variables.

Ignoring tax variables for the simplicity, we can derive the next well-known relationship,

$$(3.7) \qquad C_{klmn.it} = q_{klmn.it} (\gamma_{it} + \mu_{klmn.i} - \frac{\dot{q}_{klmn.it}}{q_{klmn.it}}),$$

where $q_{klmn.it}$ denotes klmn-th type's capital asset price of i-th sector at year t, γ_{it} and

3) We owed too much collecting data during the period 1960 to 1973 to Mieko Nishimizu. As concerns labor data we changed employment status in her data source with respect to temporary worker and daily worker. Refer to Jorgenson-Kuroda [1981].

[Table 3-2] Divisia Growth Rate of Labor Input

Industry No.	Divisia Growth Rate of Labor Input (%)				Divisia Growth Rate of Quality (%)				Divisia Growth Rate of Quantity (%)			
	(1) 1960 –1970	(2) 1970 –1977	(3) 1960 –1972	(4) 1960 –1977	(5) 1960 –1970	(6) 1970 –1977	(7) 1960 –1972	(8) 1960 –1977	(9) 1960 –1970	(10) 1970 –1977	(11) 1960 –1972	(12) 1960 –1977
1.	-5.03	-2.18	-4.92	-4.10	0.48	1.35	0.68	0.89	-4.60	-0.81	-4.27	-3.24
2.	-7.51	-10.79	-8.58	-9.40	0.58	0.01	0.49	0.37	-6.95	-10.79	-8.12	-9.06
3.	7.78	2.47	7.65	5.92	0.56	0.68	0.49	0.65	8.20	3.15	8.02	6.49
4.	4.17	0.34	3.83	2.74	0.88	0.56	0.78	0.80	5.11	0.90	4.66	3.57
5.	-0.76	-7.09	-1.80	-3.63	1.04	1.16	1.10	1.16	0.29	-5.91	-0.68	-2.45
6.	6.78	3.62	5.85	5.82	0.68	0.25	0.62	0.53	7.49	3.90	6.49	6.38
7.	2.00	-3.23	1.08	-0.20	-0.06	0.40	0.05	0.14	1.96	-2.87	1.15	-0.06
8.	4.05	0.93	3.41	2.92	0.18	0.72	0.20	0.42	4.23	1.61	3.61	3.34
9.	2.29	-1.77	1.67	0.63	1.10	1.23	1.06	1.23	3.43	-0.55	2.77	1.88
10.	3.41	-1.53	2.47	1.43	1.71	1.75	1.69	1.83	5.11	0.19	4.14	3.25
11.	3.13	-2.35	2.24	0.89	0.76	1.54	0.82	1.15	3.90	-0.81	3.07	2.06
12.	4.16	-0.58	2.94	2.32	1.06	0.72	0.89	0.98	5.40	0.18	3.97	3.42
13.	1.13	-2.85	-0.12	-0.56	1.97	1.50	1.93	1.89	3.15	-1.35	1.86	1.35
14.	2.65	-0.97	0.83	1.22	0.21	0.57	0.42	0.38	2.83	-0.38	1.25	1.59
15.	3.89	-1.21	3.21	1.87	0.72	0.93	0.79	0.86	4.65	-0.28	4.03	2.75
16.	2.27	-3.95	1.04	-0.36	0.79	1.12	0.88	0.98	3.12	-2.89	1.94	0.64
17.	3.64	-2.56	2.38	1.10	0.69	1.13	0.87	0.92	4.34	-1.38	3.28	2.07
18.	6.97	-2.90	5.38	2.97	1.16	0.93	1.21	1.13	8.10	-1.98	6.57	4.08
19.	5.30	-3.82	4.24	1.53	0.85	1.30	0.87	1.10	6.19	-2.48	5.16	2.69
20.	7.51	-2.53	5.83	3.46	0.68	1.62	0.81	1.14	8.21	-0.82	6.67	4.68
21.	9.70	1.55	8.51	6.67	0.41	1.56	0.44	0.94	10.22	3.09	9.04	7.70
22.	2.54	-3.11	3.54	0.19	0.54	-0.39	0.31	0.17	3.13	-3.47	3.92	0.38
23.	5.02	0.69	4.71	3.42	0.82	1.08	0.89	0.98	5.88	1.85	5.63	4.47
24.	4.27	-1.98	3.20	1.75	1.53	1.33	1.51	1.54	5.83	-6.74	4.71	3.30
25.	4.20	0.01	3.65	2.61	0.37	1.05	0.50	0.69	4.60	1.05	4.18	3.32
26.	1.73	0.72	1.36	1.40	0.84	0.31	0.72	0.66	2.61	1.02	2.10	2.07
27.	7.55	0.98	7.19	5.10	1.16	1.60	1.36	1.43	8.68	2.58	8.53	6.52
28.	6.11	2.35	5.43	4.84	0.06	0.59	0.08	0.29	6.19	2.93	5.53	5.14
29.	14.62	3.36	11.99	10.49	1.09	0.46	1.11	0.88	15.64	4.02	13.12	11.41
30.	7.47	3.24	7.04	6.08	0.60	0.41	0.76	0.56	8.11	3.68	7.82	6.67
31.	2.28	1.83	2.29	2.23	-0.01	-0.01	-0.05	-0.01	2.28	1.82	2.24	2.22
average	3.98	-1.07	3.15	1.98	0.76	0.89	0.78	0.83	4.75	-0.37	3.95	2.86

Note: Number of rows corresponds to the industrial identity in Table [3-1].

[Table 3-3] Time-Series Changes of Labor (Partial) Productivity by Industry

Industry	1965	1970	1974	1977	Annual Growth Rate: 1960-1970	Annual Growth Rate: 1970-1977
1.	1.3333	1.8002	2.0843	2.0985	6.055	2.215
2.	2.4070	3.5220	7.0408	8.0977	13.417	12.630
3.	0.8703	1.2534	1.1863	1.2428	2.284	-0.121
4.	0.8925	1.2726	1.3589	1.6034	2.440	3.356
5.	1.3054	1.6650	2.0165	2.9808	5.230	8.676
6.	1.2352	1.6312	1.3337	1.5786	5.015	-0.468
7.	1.3631	2.2056	2.2780	2.9421	8.231	4.202
8.	1.7236	2.3597	2.1412	2.3607	8.965	0.006
9.	1.3563	2.0776	2.3186	2.6076	7.586	3.300
10.	1.1111	1.7632	1.5628	1.8121	5.835	0.392
11.	1.5621	2.6890	3.6589	3.9445	10.397	5.626
12.	1.8490	2.4328	3.3604	3.2809	9.298	4.365
13.	1.8118	1.7898	2.1104	2.7487	5.993	6.321
14.	1.4903	1.9113	2.2054	2.2277	6.692	2.213
15.	1.3283	2.5188	2.8674	3.5166	9.678	4.883
16.	1.5610	2.7168	3.5870	3.9420	10.511	5.462
17.	1.2549	1.6530	1.9532	2.5003	5.154	6.090
18.	1.3535	2.3579	2.5192	2.9964	8.956	3.483
19.	1.0833	2.4433	2.9809	3.5366	9.345	5.425
20.	1.2768	2.2392	2.7768	3 8067	8.395	6.861
21.	0.8638	1.4358	1.6458	2.1603	3.684	6.009
22.	2.2615	4.1257	5.1513	7.9370	15.226	9.798
23.	1.6307	1.8923	2.4678	3.2040	6.586	7.813
24.	1.7419	2.4546	3.2131	3.8719	9.395	6.728
25.	1.1974	1.8158	2.1469	2.2415	6.146	3.055
26.	1.4913	2.2749	2.6359	3.2002	8.567	4.996
27.	0.8958	1.3357	1.4000	1.7220	2.937	3.695
28.	1.3888	2.2952	2.7192	3.2508	8.663	5.098
29.	0.6789	0.9553	0.9089	1.1686	-0.456	2.920
30.	0.9465	1.2978	1.3153	1.4567	2.641	1.664
31.	1.1631	1.2520	1.1551	1.3527	2.273	1.111
average					6.940	4.445

$\mu_{klmn.i}$ stand for rate of return of capital and economic rate of replacement of klmn-th capital asset.

On the other hand the data of business surplus of i-th industry adjusted for compensation of capital, B_{it} are available through the estimation of time-series Input-Output tables. Under the assumptions of the competitive market and of the linear homogeniety of price frontier function, B_{it} must be equalized to the total capital service cost of i-th industry as follows:

$$(3.8) \qquad B_{it} = \sum_k \sum_l \sum_m \sum_n C_{klmn.it} \cdot K_{klmn.it}$$
$$= \sum_k \sum_l \sum_m \sum_n q_{klmn.it} (\gamma_{it} + \mu_{klmn.i} - \frac{\dot{q}_{klmn.it}}{q_{klmn.it}}) K_{klmn.it} \cdot$$

Regarding this relation as the equation of unknown variable, γ_{it} and putting the observed data of B_{it}, $q_{klmn.it}$, $\mu_{klmn.i}$ and $K_{klmn.it}$ to this equation, we can solve the rate of return γ_{it} in i-th sector and hence impute the capital service prices $C_{klmn.it}$. After imputing the time-series of $C_{klmn.it}$, the discreted approximated divisia indices of capital service quantity and prices by industry can be derived from the approximation of equation (3.5) and (3.6).

Jorgenson and Nishimizu (1978) tried to measure rate of return of capital, and capital service prices during the period 1955–1973 in Japan, formulating the imputation of capital service price including the tax structure. Our work is a simple revise of their formulation with respect to the Japanese tax structure and an extention of sample period until 1977.

In our estimation the categories of production assets were divided into 8 asset types in corporate sector and 3 asset types in non-corporate sector from the restricted data availability of *National Wealth Survey* (NWS). Here we do not have enough space to explain our data compilation. Refer to Jorgenson-Kuroda [1981].

[Table 3-4] shows the divisia growth rate of capital service input (column (1) – (4), that of capital service price (column (5) – (8)) and estimated rate of return in capital stock at 1960, 1970 and 1977.

During the period 1960–1977 Japanese rapid economic growth was accompanied by highly accelarated capital accumulation. Especially certain sectors in manufacturing industries accomplished higher growth rate of capital input more than growth rate of per capital output. Consequently shares of each industrial sector in total capital services were changed dramatically over these period. After oil crisis the growth rate of capital service input decreased rapidly. It seems to be suggested that there were some significant structural changes in the Japanese economy after oil crisis.

[Table 3-5] shows the time-series changes of the partial capital productivity by industry. Unlike labor productivity, capital productivities were continuously declining over the period 1960–1970 in almost all industries. This is a eminent feature of the Japanese economic growth.

3.3 Intermediate inputs

Divisia index growth rate of output and intermediate inputs in i-th sector can be estimated from the time-series Input-Output table. As well-known the Japanese Output tables are available in every five years since 1955. For the purpose of constructing of a comparable general equilibrium framework between U.S. and Japan, we have to prepare a strictly consistent data base in both countries theoretically and conceptually. In Japan input-output tables have been compiled every five years since 1955. The 1970 table is almost the same as the 1965 table with respect to the basic framework. The revised 1960 table was prepared by adjusting the original 1960 table into the concepts, definitions and estimation methods of the 1965 tables. The 1975 table in current prices was published in 1979. It was also compiled with almost the same concepts as that of 1970s. As the prices of commodities are available in considerable detail, we can prepare a 1975 table in constant price of 1970.

The principles of U.S. input-output classification are threefold; establishment basis for mining and manufacturing sectors, commodity basis for agriculture and activity basis for construction, transportation, trade and services. On the other hand, in the Japanese tables, goods for agriculture, mining and manufacturing are classified on a commodity basis and service industries, including construction and trade are classified on an activity basis. The principle of input-output classification for mining and manufacturing is different between the two countres.

Here we tried to convert the concept of input flow in the mining and manufacturing sectors of the Japanese tables from commodity basis to establishment basis. V tables (make matrix), which are compiled in Japan along with U.N. proposals of the system of National Accounts since 1970, gave useful information for the purpose of the above conversion.

At first we tried to estimate the time-series input-output tables over the period 1960–1977 by using our developed estimating procedure, called Lagrangian Method, instead of well-known RAS method. Refer to Kuroda [1980]. Estimated input-output tables correspond to intermediate transaction tables by commodity basis. Secondly we tried to convert these tables into transaction tables by industry basis, which is comparable with U.S. input-output tables, by using V tables.

Finally we can derive divisia index growth rate of intermediate inputs and output by using time-series input-output tables.

4. *Total Factor Productivity : An International Comparison between U.S. and Japan*

We can estimate divisia index growth rate of total factor productivity by using each divisia growth rate of inputs in the previous section. Objectives of this section is to find some empirical evidences on the time-series changes of productivity in the Japanese

[Table 3-4] Divisia Growth Rate of Capital Input

	Divisia Growth Rate of Capital Input (%)				Divisia Growth Rate of Capital Service Price (%)				Rate of Return in Capital Stock		
Industry No.	(1) 1960 –1970	(2) 1970 –1977	(3) 1960 –1972	(4) 1960 –1977	(5) 1960 –1970	(6) 1960 –1977	(7) 1960 –1972	(8) 1960 –1977	(9) 1960	(10) 1970	(11) 1977
1.	5.3772	9.7822	5.7525	7.1881	3.7467	4.7019	3.3361	4.1400	0.1736	0.1865	0.0320
2.	8.6897	Δ8.2504	7.2073	1.7132	5.2066	12.2168	5.3605	8.0931	0.2553	0.4231	0.4852
3.	21.4225	2.9613	19.5258	13.8208	Δ1.0782	8.2136	Δ0.3080	2.7478	0.9273	0.5606	0.3906
4.	14.4798	4.0698	14.3275	10.1932	Δ2.6938	7.3888	Δ3.9582	1.4578	1.2227	0.7586	0.5949
5.	6.8260	1.5422	8.3643	4.6504	5.1637	5.2046	1.6344	5.1805	0.3363	0.5281	0.2320
6.	21.3428	6.2691	21.3735	15.1360	2.6191	Δ1.2812	Δ2.7281	1.0130	0.2629	0.2938	0.1080
7.	8.2938	7.4604	8.8821	7.9506	2.6944	Δ24.1567	0.3552	Δ8.3618	0.2750	0.3281	0.0044
8.	16.0013	8.0587	15.1143	12.7308	Δ3.0203	Δ5.3202	Δ4.8198	Δ3.9674	0.4258	0.2812	–
9.	11.7441	4.7677	11.4543	8.8715	2.8749	3.7836	0.6728	3.2491	0.2363	0.2477	0.0805
10.	17.3517	9.1353	16.0894	13.9684	Δ6.1499	Δ6.9591	Δ8.4096	Δ6.4831	0.5387	0.2336	–
11.	13.7516	Δ0.0525	12.9376	8.0675	4.2479	2.6566	3.1492	3.5924	0.1410	0.2047	0.0572
12.	16.3250	3.6771	14.1720	11.1171	Δ3.1591	5.5531	Δ1.5791	0.4283	0.3902	0.1813	0.0543
13.	21.9355	Δ1.3695	19.1743	12.3393	Δ8.4901	7.4644	Δ7.2875	Δ1.9205	0.3168	0.0535	–
14.	16.9652	Δ5.1832	14.8574	7.8451	2.3320	3.4118	0.4681	1.5420	0.2023	0.2133	0.1009
15.	18.6407	3.0621	16.8906	12.2261	2.7376	0.3537	1.4252	1.7560	0.1063	0.1809	0.0114
16.	15.6940	1.4770	14.1744	9.8399	0.1306	4.7347	Δ0.9618	2.0257	0.2191	0.2330	0.0914
17.	15.8959	11.3580	14.3999	14.0274	Δ2.9127	Δ4.0040	Δ3.1353	Δ3.3620	0.5492	0.3551	0.0596
18.	23.6531	4.9840	21.2348	15.9658	Δ1.3035	Δ2.4630	Δ2.7945	Δ1.7801	0.2434	0.1891	–
19.	20.1808	0.3030	18.4257	11.9959	Δ2.1746	Δ7.7672	Δ5.3025	Δ4.4774	0.5820	0.4004	0.0509
20.	16.1686	Δ2.4904	15.2809	8.4855	2.4992	7.8604	1.4761	4.7068	0.4211	0.4922	0.3723
21.	20.7221	1.0481	18.9079	12.6205	Δ6.8962	9.3880	Δ7.7962	Δ0.1909	0.8586	0.3391	0.2804
22.	17.1830	2.3200	14.9504	11.0629	9.1078	12.2434	10.4415	10.3989	0.0863	0.3152	0.2992
23.	16.5161	2.0713	16.6234	10.5683	Δ2.3198	12.7271	Δ5.3179	Δ3.7538	0.5179	0.3410	0.3984
24.	25.7886	10.3677	23.5976	19.4388	Δ7.1514	Δ4.5960	Δ8.7397	Δ6.0991	0.6539	0.2324	–
25.	13.1897	Δ1.1547	12.7277	7.2831	Δ0.4007	10.0473	0.0619	3.9014	0.0689	0.0201	–
26.	10.8273	9.4568	11.3571	10.2630	3.1298	0.3330	1.2331	1.9781	0.0170	0.0475	–
27.	11.4980	11.6050	12.1855	11.5421	6.1732	0.8160	3.8560	3.9673	0.3762	0.4898	0.1625
28.	14.3717	1.5514	12.7704	9.0928	3.9073	8.6277	4.0684	3.6779	0.5625	0.5945	0.3898
29.	11.5976	8.8537	11.6978	10.4678	0.2130	5.1847	0.3551	2.2602	0.2183	0.1620	0.0574
30.	13.5541	8.0596	11.3237	11.2917	5.5434	5.2364	4.6118	5.4171	0.8766	0.6348	0.3304

Note: Number of rows corresponds to the industrial identity in Table [3-1].

[Table 3-5] Time-Series Changes of Capital (Partial) Productivity by Industry

Industry	1965	1970	1974	1977	Annual Growth Rate: 1960-1970	Annual Growth Rate: 1970-1977
1.	1.1899	0.6572	0.5139	0.3650	Δ4.19	Δ8.40
2.	0.9516	0.7189	0.6572	1.3242	Δ3.30	8.72
3.	0.4473	0.3236	0.2155	0.3241	Δ11.28	0.02
4.	0.5401	0.4925	0.3388	0.4967	Δ7.08	0.12
5.	1.0447	0.8663	0.5880	0.9088	Δ1.43	0.68
6.	0.5591	0.3973	0.2066	0.3239	Δ9.23	Δ2.91
7.	1.2496	1.1687	0.7592	0.7541	1.56	Δ0.63
8.	0.9008	0.7207	0.3677	0.4587	Δ3.28	Δ6.45
9.	0.8647	0.8994	0.5964	0.7780	Δ1.06	Δ2.07
10.	0.6630	0.5117	0.2523	0.2812	Δ6.70	Δ8.55
11.	0.8319	0.9968	0.9721	1.3869	Δ0.03	4.71
12.	0.9085	0.8043	0.6815	0.8489	Δ2.17	0.77
13.	0.4951	0.2722	0.2544	0.4184	Δ13.01	6.14
14.	0.5089	0.4629	0.4361	0.7549	Δ7.70	6.98
15.	0.5332	0.6149	0.4555	0.6793	Δ4.86	1.42
16.	0.6345	0.7691	0.6018	0.8198	Δ2.63	0.92
17.	0.5187	0.5266	0.4084	0.3197	Δ6.41	Δ7.12
18.	0.5457	0.4827	0.3645	0.3762	Δ7.28	Δ3.56
19.	0.4333	0.5921	0.5086	0.7036	Δ5.24	2.46
20.	0.5642	0.9786	1.0943	1.8701	Δ0.22	9.25
21.	0.4773	0.4785	0.4391	0.8279	Δ7.37	7.83
22.	0.7976	0.9258	0.7694	1.2861	Δ0.77	4.69
23.	0.6212	0.6423	0.5254	1.0695	Δ4.43	7.28
24.	0.4788	0.3281	0.2121	0.2389	Δ11.14	Δ4.53
25.	0.8679	0.7614	0.6518	1.0966	Δ2.72	5.21
26.	0.8296	0.9966	0.7741	0.7765	Δ0.03	Δ2.49
27.	1.0467	0.9725	0.6688	0.6650	Δ0.27	Δ3.81
28.	0.8118	0.9944	0.9914	1.5461	Δ0.06	7.20
29.	1.0031	1.2814	1.0901	1.1114	2.47	Δ2.03
30.	0.9463	0.7295	0.5051	0.5999	Δ3.15	Δ2.79

development during the period 1960–1977, comparing with the U.S. results by Gollop-Jorgenson.

[Figure 4-1] shows the time-series trends of gross value-added, capital input, labor input and total factor productivity by the nationwide aggregates in the U.S. and Japan. Solid line stands for the index of the Japanese output and inputs, and dotted line stands for that of the U.S., which are the results by Gollop-Jorgenson.[4)]

The growth rate of total factor productivity in Japan extended higher than that of the U.S. since 1967. In the U.S. total factor productivity started to decline grandually since the end of 1960's, while the Japanese total factor productivity continued to develop smoothly until the oil crisis. We can see the impact of the oil crisis on the Japanese total factor productivity as a rapid decline at 1974. However after the oil crisis it began to recover until 1977.

When we compare the time-series pattern of labor and capital inputs between U.S and Japan, we can find an eminent feature of economic growth in both countries. As concerns the growth rate of capital inputs, the Japanese growth rate has been always higher than that of the U.S. over the period 1960–1977. On the other hand growth rate of labor input in the U S. has been higher that of Japan since 1965. We can think that these evidences confirm one of features of the Japanese development that the capital accumulation developed rapidly than that of the historical standard.

In [Figure 4-2] we showed the time-series changes of total factor productivity by industry as the average annual growth rates during period 1960–1966, 1966- 1969 and 1969- 1973 in the U.S. and Japan. Here also results of the U.S. refered to the estimation of Gollop-Jorgenson. Solid lines and dotted lines represent the skyline of total factor productivity by industry in Japan and the U.S. at each time period. Over the period 1960–1966 the differences of the growth rate of total factor productivity between both countries are not large. With few exceptions like apparel, lumber and wood, transportation except motor vehicle and precision industry, the growth rates in the U.S. are higher than those in Japan. On the other hand we can observe the rapid growth of the total factor productivity in Japan over the second period, 1966–1969. During this period the Japanese total factor productivity in almost all manufacturing grew remarkably. In the third period, 1966–1973 the growth of total factor productivity in both countries started to be slow-down. Especially in textile, rubber and leather industries in Japan and agriculture and mining in the U.S. the growth rate of total factor productivity declined dramatically over these periods.

Feature of the Japanese economy with rapid capital accumulation as shown in [Figure 4-1] can be pointed out in the input growth rate by industry over the period 1960–1977, shown in [Figure 4-3].

As shown in the first figure of [4-3], the growth rates of labor input in the U.S. shown in dotted lines are higher than those in Japan, shown in solid lines with few exceptional industries. On the other hand the growth rates of capital inputs in Japan are

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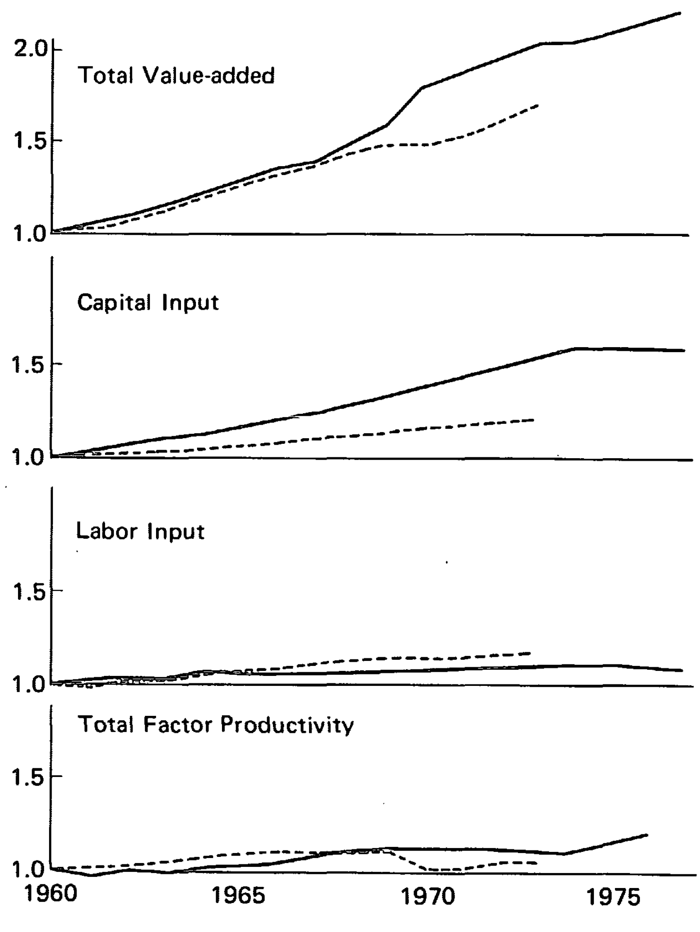
4) Results of Gollop-Jorgenson basically obtain from their report [1980].
Some statistical data were reported in their N.S.F. report *U.S. Economic Growth : 1948-1973.*
Getting comparability with our results, we put some simple arrangement on their results.

eminently higher than those in U.S. in all of industries. The third figure represents the growth rates of intermediate inputs by industry. Here also the growth rates of Japan are higher than those in the U.S.

[Table 4-1] shows the average annual growth rate of inputs and total factor productivity over the period, 1973–1974 and 1975–1977. Remarkable increases in oil price in 1973 and 1974 had significant impacts on the efficiency of production in the Japanese

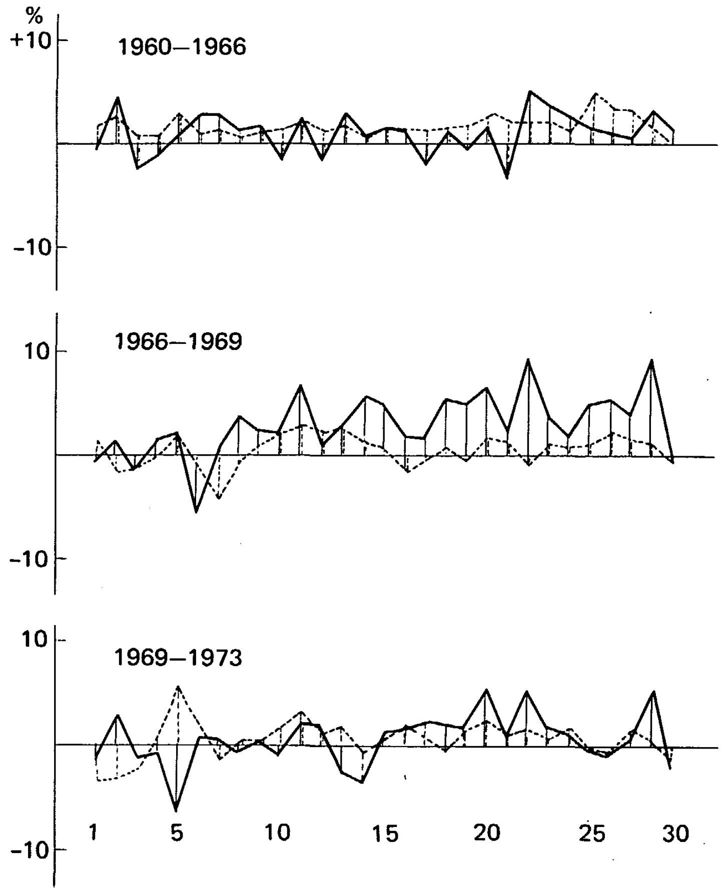
[Figure 4-1]
Productivity Change in the U.S. and Japan (1960 = 1.0)



Notes: (1) Above figures represent the trends of indices of the nationwide agregates in total value-added,capital and labor inputs and total factor productivity.
(2) Solid lines and dotted lines correspond to these trend in Japan and U.S. respectively.

economy. According to the estimates of total factor productivity by industry shown in [Table 4-1], the growth rate of productivity declined in almost all industries. After the oil crisis in 1973 and 1974 the growth rate of productivity seems to be recovered rapidly. However the growth pattern of the recovery during the period 1975–1977 is fairly dif-

[Figure 4-2]
Skyline of Divisia Growth Rate of Productivity:
U.S. and Japan Comparison

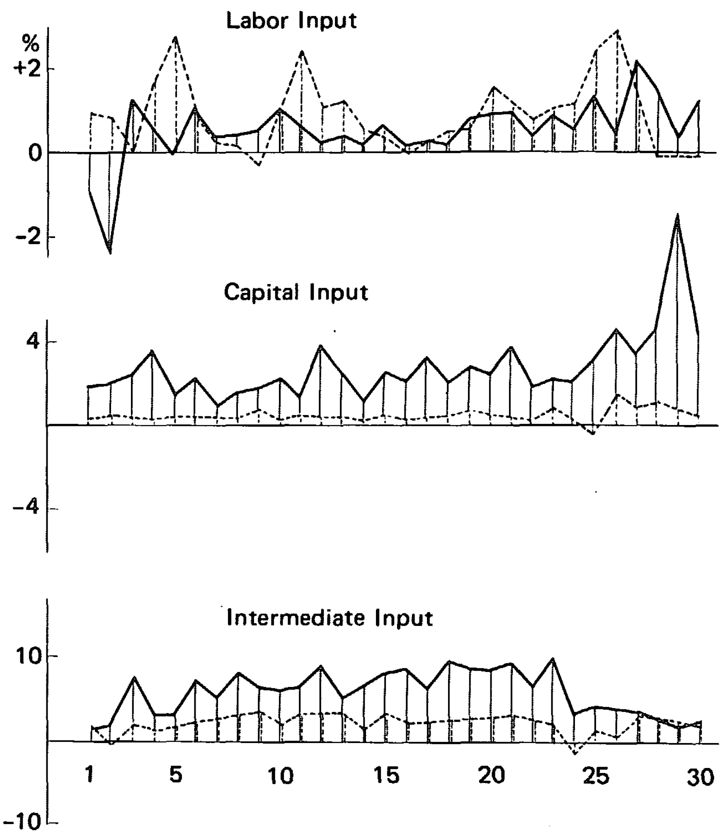


Notes: (1) Solid lines stand for growth rate of productivity in Japan and dotted lines stand for that in the U.S.
(2) Productivity in the U.S. was reffered from Gollop-Jorgenson Results. Series of Mining, Transportation and Communication, and Electricity, Gas and Water supply were utilized results of Coal Mining, Railroad and Rail Express Service and Electric Utility respectively.
(3) Numbers of the last row represent the number of industrial sector in Table [3-1].

ferent from the growth pattern in the developing process before 1970. In almost all industries the growth rate of capital inputs became negative and that of labor inputs declined dramatically during the period 1975–1977. Although it may be one of evidences in which the Japanese economy have been in the adjustment process after the oil crisis, we have to notice that such recovery pattern with capital and labor saving in the Japanese economy is completely different from the previous developing process with capital using and labor saving.

Finally we tried to estimate the total factor productivity alternatively from the

[Figure 4-3]
Annual Growth Rate of Inputs by Industry:
U.S. and Japan Comparison



Notes: (1) Solid lines stand for average annual growth rate during the period 1960–1973 in Japan. Dotted lines stand for average annual growth rate during the period 1948–1973 in the U.S.

(2) Productivity in the U.S. was refered from Gollop-Jorgenson results. Series of Mining, Transportation and Communication, and Electricity, Gas and Water supply were utilized results of Coal Mining, Railroad and Rail Express Service and Electric Utility respectively.

(3) Numbers of the last row represent the number of industrial sector in Table [3-1].

relationships of the price frontier function, using the formulation (3.1). We showed the divisia growth rate of inputs and output price with the divisia growth rate of total factor productivity over the period 1960–1977 in [Figure 4-4]. Since 1960 the increasing of labor input price has been always higher than that of capital service price. And the trend of the intermediate input prices were fairly stable except the period of oil crisis. When we consider these trends of input prices with the intensity of each input in the Japanese production structure, evidences that price of capital services and material inputs have

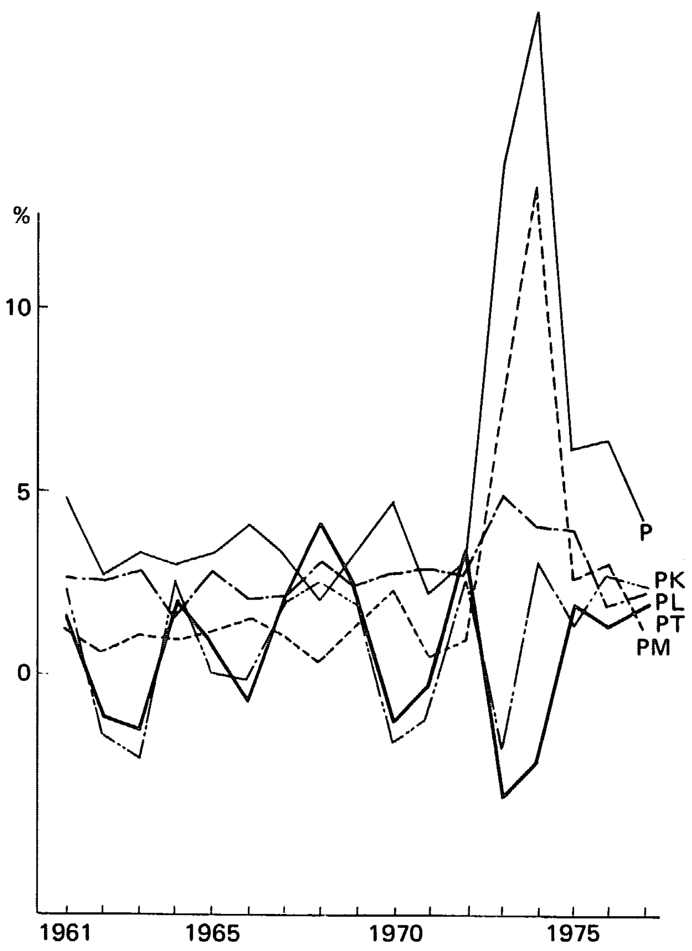
[Table 4-1] Productivity Changes in Japan: 1973-1977

	1973-74 annual growth rate					1975-77 annual growth rate				
Industry	output	intermediate input	labor	capital	T.F.P.	output	intermediate input	labor	capital	T.F.P.
1.	.0019	-.0009	-.0042	-.0287	-.0224	.0037	.0153	-.0072	.0537	-.0776
2.	-.0168	.0272	-.0382	-.0308	-.0420	.0400	-.0063	-.0136	-.0616	.1126
3.	-.0056	.0081	.0077	.0252	-.0463	.0253	-.0261	-.0080	-.0107	.0014
4.	.0273	-.0418	.0029	-.0336	.0315	.0505	.0383	-.0004	-.0326	.0329
5.	-.0257	-.0538	.0011	-.0168	.0146	.0237	.0011	-.0096	-.0239	.0538
6.	.0195	.0227	.0265	.0151	-.0010	.0309	.0012	-.0014	-.0068	.0115
7.	-.0021	-.1990	.0127	.0082	.0986	-.0087	.0210	-.0127	-.0003	-.0169
8.	-.0731	-.0142	.0188	.0081	-.0855	-.0146	-.0285	.0022	-.0021	.0148
9.	.0142	.0431	.0036	.0123	-.0451	.0129	.0359	-.0012	-.0042	.0470
10.	-.0847	-.0500	.0145	.0107	-.0591	.0197	.0240	-.0052	-.0004	.0006
11.	.0337	.0328	-.0012	.0034	-.0013	.0613	.0302	.0034	-.0112	.0385
12.	.0900	-.0593	.0009	.0254	.1175	.0340	.0867	-.0005	-.0052	-.0554
13.	.0001	.0100	.0093	.0079	-.0253	.0936	.0413	-.0018	-.0102	.0656
14.	-.0275	-.0607	.0022	.0026	.0202	-.0074	.0295	.0093	-.0077	-.0409
15.	.0196	.0211	.0063	.0147	-.0209	.0472	.0335	.0010	-.0124	.0246
16.	.0593	.0307	.0001	.0122	.0177	.0159	.0099	.0001	-.0127	.0189
17.	-.0099	.0188	.0028	.0799	-.0500	.0705	.0412	.0013	.0347	-.0068
18.	-.0067	.0025	.0082	.0023	-.0123	.0624	.0321	-.0112	-.0026	.0445
19.	.0820	.0576	.0027	.0067	.0234	.0669	.0305	-.0028	-.0106	.0504
20.	.0649	.0114	.0093	.0001	.0468	.1468	.0715	.0064	-.0176	.0935
21.	.0835	.0392	.0068	.0092	.0321	.0943	.0661	.0132	-.0187	.0352
22.	.1306	-.0980	-.0231	.0083	-.0097	.0992	.0182	-.0084	-.0217	.1084
23.	-.1315	.0417	.0113	.0148	.0699	.1714	.0839	.0096	-.0147	.0990
24.	.0376	.0227	.0075	.0102	-.0020	.0301	.0363	.0007	-.0018	-.0060
25.	.0642	.0091	.0056	.0130	.0375	.0145	.0232	.0113	-.0228	.0023
26.	.0612	.0506	.0179	.0324	-.0399	.0440	.0391	-.0095	.0048	.0061
27.	.0273	.0030	.0048	.0396	-.0204	.0695	.0178	-.0525	.0191	.0813
28.	-.0311	.0195	.0112	.0225	-.0877	.0685	.0136	.0139	-.0095	.0506
29.	.0751	-.0011	.0054	.0877	-.0178	.0645	.0089	.0038	.0371	.0158
30.	.0225	-.0037	.0088	.0497	-.0339	.0568	.0276	.0097	-.0049	.0253

been relatively costless rather than price of labor input are consistent with the input intensity in production, that is relatively capital intensive and labor saving technology.

The last figure, [Figure 4-5] is scatter diagrams of the total factor productivity estimated from both formulations of production function and price frontier function by industry. Horizontal axis in each figure represents the divisia growth rate of total factor productivity estimated from the price frontier function. Vertical axis in each figure stands for that from the production function. Four figures correspond to four different period, 1960–1966, 1966–1969, 1969–1973 and 1973–1977. Scatter in each figure corresponds to each industrial sector, where each symbol represents the industry name in the first column in [Table 1-1].

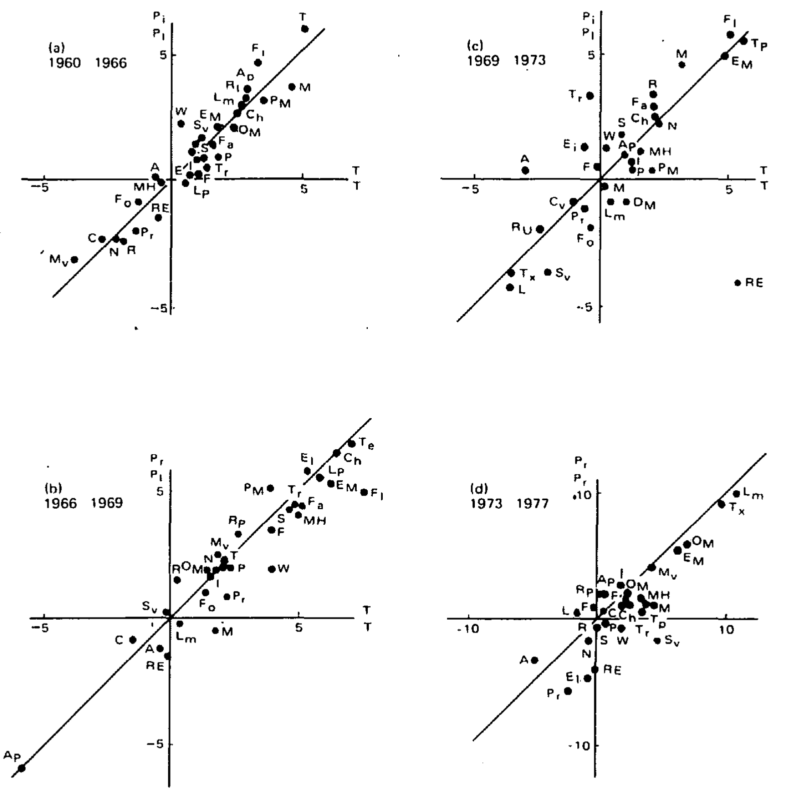
[Figure 4-4]
Annual Changes in Output and Input Prices, 1960–1977



Notes: P : Annual change of Output Deflator
P_M: Annual change of Intermediate Input Price
P_L : Annual change of Labor Service Price
P_K : Annual change of Capital Service Price
P_T : Annual change of T.F.P.

[Figure 4-5]

Market Performance in the Japanese Economy



Notes: (1) Horizontal axe is a annual growth rate of T.F.P. from price relation. Vertical axe is a annual growth rate of T.F.P. from Quantity relation.

(2) Alfabets in plots represent the industry names in the first column in Table [3-1].

As well-known the descrete divisia index of total factor productivity estimated from the price frontier function is not necessarily equal to that estimated from the production function. Because the descrete divisia index does not necessarily satisfy the condition of factor reversal test of index number. Theoretically we can deduce that if the nominal input shares in each inputs are constant over the period and only if, both estimated growth rate of total factor productivities are equalized. This implies that changes of share of real inputs are completely offset by changes of relative prices in each input. Also if the divisia growth rates of total factor productivity estimated from production function are equal to that estimated from price frontier function, the increasing of efficiency on production function has a effect of decreasing of output price on price frontier function. This may imply that the market performance in the competitive market is realized over the period smoothly.[5)]

According to [Figure 4-5], both estimated total factor productivities are highly correlated during the period, 1960–1966 and 1966–1969. Especially in the second period, 1966–1969 most of plots scattered in the first quadrant and both growth rates highly correlated. We have remind that in the second period the productivity in Japan increased rapidly in almost all industries.

5. Concluding Remarks

Jorgenson and Nishimizu (1978) have compared production patterns at the level of two-digit industries for the United States and Japan over period 1955–1973. They compared relative levels of output, intermediate, capital and labor inputs and levels of technology for individual industries.

According to their research, Japanese industries have growth relative to their U.S. counterparts at very rapid rates during the period 1955 to 1973. The growth of employment in the two countries has been similar. Intermediate input in Japanese industries has grown in proportion to the expansion of output, paralleling the corresponding trends in U.S. industries. The growth of output in Japan relative to that in the United States has resulted from a very substential increase in Japanese capital input relative to U.S. capital input and from a closing of the gap between U.S. and Japanese technology.

After the period they concerned, the Japanese economy experienced the dramatic slowdown of economic growth by the impact on the oil crisis. Our first concerns in this paper is to find some empirical features of the Japanese economy over the period of the rapid growth before the oil crisis and compare them with that in the recovery process in Japan after the oil crisis. Theoretically our method to analize changes of productivity is consistent with that in Jorgenson-Nishimizu (1978) and Gollop-Jorgenson (1980).

Our conclusions in this analysis can be described as follows:

1. Kuznets' hypothesis that the rapid economic growth of per capita output accelerated the speed of the structual changes, which he found in his international comparison of modern economic growth, is confirmed in the Japanese economy over the period 1960 to 1973. During this period in Japan shares of each industrial sector in gross output, labor force and capital stock have changed drastically.

5) Theoretically divisia discrete quantity index is not dual to divisia discrete price index. Because these indices do not satisfy with the condition of factor reversal test. Therefore divisia discrete growth rate of total factor productivity estimated from production function is not equal to that from price frontier function.

Let us denote the ratio of i-th nominal input at year 1 to that at year 0, ki as follows:

$$ki = \frac{p_i^1 q_i^1}{p_i^o q_i^o} \quad (i = 1 \cdots\cdots n)$$

where p_i^t an q_i^t (t = 0.1) represent price and quantity of i-th input at year t.

If and only if

$$k_1 = k_2 = \cdots = k_n \ ,$$

total factor productivities estimated from both quantity and price relations are equalized.

2. An eminent feature of the Japanese economic growth over this period was a highly developed accumulation of capital input, which is consistent with Jorgenson-Nishimizu's findings.

3. According to a international comparison of the growth rate in production inputs between the U.S. and Japan, the growth rate of capital input in Japan has been higher than that in the U.S. over the whole period 1960 to 1973, which the growth rate of labor input in Japan has been lower than that in the U.S. especially since 1965. We can see these findings in the comparison in the aggregated level between Gollop-Jorgenson results and ours.

4. Above findings in the aggregated level can be verified in the international comparisons between every industrial sectors. Such adoptation to capital intensive and relatively labor saving technology in Japan is consistent with the changes of relative factor prices during our observed periods.

5. Highly growth rates of total factor productivity in Japan was accomplished especially during the period 1966–1969. We can also confirm that the Japanese economy during these period had established well-behaved balanced growth, in which we mean that changes of relative prices among inputs have been reflected on substitutabilities among real inputs smoothly. It may be one of evidences that market performance in the Japanese economy has been well-behaved during these period.

6. The recovery pattern of productivity in Japan after the oil crisis is fairly different from that in the rapid growth periods. The growth rate of capital and labor inputs declined rapidly, where there exists the adaptation to capital and labor saving technology. However this feature might imply only characteristics of the adjustment of the Japanese economy to drastic relative price changes after the oil crisis. Therefore it is desirable that we could extend our observation until the latest date and verify it.

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