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PRODUCTIVITY AND MARKET PERFORMANCE*

---Time-Series Observation (1960-1977) in the Japanese Economy---- 1

by

Masahiro Kuroda 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...." $(p_{154})^{1}$

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, $\Delta 6.0 \sim \Delta 1.0$ percent. On the other hand these in chemical, petroleum, iron and steel, machinery and transportation equipment increased remarkably by the annual growth rate, $2.0 \sim 8.0$ 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.

		Propo	rtion (Current	Price)			Proportion	ial Changes		Annual Gr	owth Rate 6
	1960 %	1965 %	1970 %	1975 %	1977 %	1960 1965	1965 1970	1970 1975	1975 1977	1960 1970	1970 1977
ric.	8.31	6.73	4.40	4.02	3.79	Δ1.58	Δ2.33	Δ0.38	Δ0.23	∆6.36	Δ2.13
dustry	68.33	66.79	67.04	63.07	62.32	Δ1.54	0.25	Δ3.97	Δ0.75	Δ0.19	Δ1.04
rvice	23.36	26.48	28.56	32.91	33.89	3.12	2.08	4.35	0.98	2.01	2.44
		Propor	tion (Constan	t Price)			Proportio	nal Changes		Annual Gr	owth Rate
gric.	12.42	7.88	4.40	3.87	3.47	Δ4.54	∆3.48	Δ0.53	∆0.40	Δ10.38	Δ3.39
dustry	61.82	63.79	67.04	65.22	65.22	1.97	3.25	∆1.82	0.00	0.81	۵0.39
rvice	25.76	28.33	28.56	30.91	31.31	2.57	0.23	2.35	0.40	1.03	1.31
		Propor	tion to Value-	Added			Proportio	nal Changes		Annual Gr	owth Rate
gric.	12.69	9.41	5.88	5.34	5.12	∆3.28	Δ3.53	Δ0.54	Δ0.22	∆7.69	۵1.98
dustry	53.80	52.47	53.30	46.96	47.48	Δ1.33	0.83	∆6.34	0.56	∆0.Ó9	Δ1.65
rvice	33.51	38.12	40.82	47.70	47.40	4.61	2.70	6.88	Δ0.30	1.97	2.13

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

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		Pro	portion (Work	(ers)			Proportion	al Changes		Annual Gro	owth Rate
	1960 %	1965 %	1970 %	1975 %	1977 %	1960 1965	1965 1970	1970 1975	1975 1977	1960 1970	1970 1977
Agric.	32.59	24.66	19.36	19.59	14.51	∆7.93	Δ5.30	Δ0.23	Δ5.08	Δ5.21	Δ4.11
industry	34.87	38.51	40.69	41.54	41.56	3.64	2.18	0.85	0.02	1.54	0.30
Service	32.54	36.83	39.95	38.87	43.93	4.29	3.12	Δ1.08	5.06	2.05	1.74
		Prop	ortion (Emplo	yees)			Proportion	al Changes		Annual Gr	owth Rate
Agric.	3.37	2.15	1.47	1.66	1.55	Δ1.22	∆0.68	0.19	۵0.11	∆8.29	0.75
Industry	56.14	55.36	53.79	54.67	50.78	Δ0.78	Δ1.57	0.88	Δ3.01	Δ0.42	Δ0.82
ervice	40.49	42.79	44.74	43.67	47.67	2.30	1.95	۵1.07	4.00	0.99	0.91

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

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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)
$$\begin{array}{c} m & m \\ \sum & q_i Y_i = \sum & P_j X_j \\ i = 1 & j = 1 \end{array}$$

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

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

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

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

(2.4)
$$\frac{\dot{Y}}{Y} = \sum_{i=1}^{m} \frac{\dot{Y}_{i}}{Y_{i}}, \quad \frac{\dot{X}}{X} = \sum_{j=1}^{n} v_{j} \frac{\dot{X}_{j}}{X_{j}}$$

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

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

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

(2.6)
$$\frac{\dot{\psi}}{\psi} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} = \Sigma \omega_{i} \frac{\dot{Y}_{i}}{Y_{i}} - \Sigma v_{j} \frac{\dot{X}_{j}}{X_{j}}$$
$$= \Sigma v_{j} \frac{\dot{P}_{j}}{P_{j}} - \Sigma \omega_{i} \frac{\dot{q}_{i}}{q_{i}}$$

Usually indices in (2.4) are referred 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)
$$Z_i = F_i(X_i, L_i, K_i, T),$$

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:

(\mathbf{a}, \mathbf{a})	∂lnZi	∂Zi	Xi		$P_X^T Xi$		
(2.8)	∂lnXi	∃ — · · · · · · · · · · · · · · · · · ·	Zi	=	qiZi	$= v_{Xi}$,
	∂lnZi	∂Zi	Li		P ⁱ Li		
	∂lnLi	= • ∂Li	Zi	=	qiZi	$= v_{Li}$,
	∂lnZi	∂Zi	Ki		P <mark>i</mark> Ki		
	∂lnKi	= • ∂Ki	Zi	=	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)
$$\frac{d\ln Zi}{dT} = \frac{\partial \ln Zi}{\partial \ln Xi} \cdot \frac{d\ln Xi}{dT} + \frac{\partial \ln Zi}{\partial \ln Li} \cdot \frac{d\ln Li}{dT} + \frac{\partial \ln Zi}{\partial \ln Li} \cdot \frac{d\ln Li}{dT} + \frac{\partial \ln Zi}{\partial \ln Ki} + \frac{\partial \ln Zi}{\partial \ln Ki} + \frac{\partial \ln Zi}{\partial T} + \frac{\partial \ln Xi}{\partial T} + \frac{\partial \ln Xi$$

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)
$$\frac{\dot{\psi}}{\psi} = v_{iT} = \frac{\dot{Z}_i}{Z_i} - v_{Xi}\frac{\dot{X}_i}{X_i} - v_{Li}\frac{\dot{L}_i}{L_i} - v_{Ki}\frac{\dot{K}_i}{K_i}$$

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.

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(2.1.1)	Xi n	dlnXij	n Di	Xij	
(2.11)	$\frac{1}{X_i} = \sum_{j=1}^{\infty} v_{X_j}$	dT	$i = \sum_{j=1}^{v} v_{X_j}$	Xij	,
	Li l	dlnLij	n N i	Lij	
	$\frac{1}{Li} = \sum_{j=1}^{2} v_{Lj}$	dT	$r = \sum_{j=1}^{\infty} v_{Lj}$	Lij	,
and	Ki l	dlnKij	1	Kij	
anu	$\frac{1}{Ki} = 2 V_{Kj}$	dT	$j = 1$ V_{Kj}	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 regu-

larity 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.

$$(2.12) v_{T}^{i} = -\frac{dlnq_{i}}{dT} \\ = v_{Xi} \frac{\mathring{P}_{Xi}}{P_{Xi}} + v_{Li} \frac{\mathring{P}_{Li}}{P_{Li}} + v_{Xi} \frac{\mathring{P}_{Ki}}{P_{Ki}} - \frac{\mathring{q}_{i}}{q_{i}} \\ ere \frac{\mathring{P}_{Xi}}{P_{Xi}} = \frac{dlnP_{Xi}}{dT} = \sum_{j=1}^{m} v_{Xj}^{i} \frac{\mathring{P}_{Xij}}{P_{Xij}} , \\ \frac{\mathring{P}_{Li}}{P_{Li}} = \frac{dlnP_{Li}}{dT} = \sum_{j=1}^{l} v_{Lj}^{i} \frac{\mathring{P}_{Lij}}{P_{Lij}} , \\ \frac{\mathring{P}_{Ki}}{P_{Kij}} = \frac{dlnP_{Ki}}{dT} = \sum_{j=1}^{l} v_{Kj}^{i} \frac{\mathring{P}_{Kij}}{P_{Lij}} .$$

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

where

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:

$$(3.1) \qquad \overline{v}_{T}^{1} = [\ln Zi (T) - \ln Zi (T-1)] \\ - \overline{v}_{X}^{i} [\ln Xi (T) - \ln Xi (T-1)] \\ - \overline{v}_{L}^{i} [\ln Li (T) - \ln Li (T-1)] \\ - \overline{v}_{K}^{i} [\ln Ki (T) - \ln Ki (T-1)], \\ \\ \overline{v}_{T}^{i} = \frac{1}{2} [v_{T}^{i}(T) + v_{T}^{i}(T-1)], \\ \\ \overline{v}_{X}^{i} = \frac{1}{2} [v_{X}^{i}(T) + v_{X}^{i}(T-1)], \\ \\ \overline{v}_{L}^{i} = \frac{1}{2} [v_{L}^{i}(T) + v_{L}^{i}(T-1)], \\ \\ \\ \overline{v}_{K}^{i} = \frac{1}{2} [v_{K}^{i}(T) + v_{K}^{i}(T-1)]. \\ (3.2) \qquad \overline{v}_{T}^{i} = \overline{v}_{X}^{i} [\ln P_{Xi}(T) - \ln P_{Xi}(T-1)] \\ + \overline{v}_{K}^{i} [\ln P_{Ki}(T) - \ln P_{Ki}(T-1)] \\ + \overline{v}_{K}^{i} [\ln P_{Ki}(T) - \ln P_{Ki}(T-1)] \\ - [\ln qi (T) - \ln qi (T-1)], \\ \end{cases}$$

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)
$$\hat{\beta}_{it} = [\ln Mi(T) - \ln Mi(T-1)]$$

+ $[\ln Hi(T) - \ln Hi(T-1)]$

			······
		Industry Name:	Gollop-Jorgensn (1980):
		31 industrial orders	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.
[1]	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
	20.	Electric Machinery	Elec. Machinery Eqpt. & Supplies
[<u>Mv</u>]	21.	Motor Vehicles and Equipment	Motor Vehicles & Eqpt.
[Te]	22.	Transportation Equipment	Trans. Eqpt. Ex. Motor
(PM 1	23.	Precision Instruments	Prof. Photo Font. & 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
			Talanhona Talagraph Misa
			Radio Broadcasting & TV.
(E1)	26.	Electric Utility, Gas Supply and	Electric Utility
		Water Supply	Gas Utility
	Ĩ	•••	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	

[Table 3-1] List of Industrial Sectors

$$\sum_{k=1}^{+\infty} \sum_{m=1}^{\infty} \sum_{n=1}^{\infty} \left[U_{klmn,i}(T) + U_{klmn,i}(T-1) \right]$$

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

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)
$$\hat{\gamma}_{it} = \sum_{k=1}^{\infty} \sum_{m=n}^{\infty} \sum_{n=1}^{\infty} \left[U_{klmn,i}(T) + U_{klmn,i}(T-1) \right]$$
$$\times \left[lnw_{klmn,i}(T) - lnw_{klmn,i}(T-1) \right],$$

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.

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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)
$$\hat{\delta}_{it} = \sum_{k} \sum_{l} \sum_{m} \sum_{n} \omega_{klmn.it} \frac{K_{klmn.it}}{K_{klmn.it}},$$
where
$$\omega_{klmn.it} = \frac{C_{klmn.it} \circ K_{klmn.it}}{\sum_{k} \sum_{l} \sum_{m} \sum_{n} C_{klmn.it} K_{klmn.it}},$$

 $K_{klmn.it}$ 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)
$$\hat{\eta}_{it} = \sum_{k} \sum_{l} \sum_{m,n} \omega_{klmn.it} \frac{C_{klmn.it}}{C_{klmn.it}}$$

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

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].

	(12) 1960 -1977	-3.24 -9.06 6.49 3.57 -2.45	6.38 6.38 3.34 1.88 3.25	2.06 3.42 1.35 1.59 2.75	0.64 2.07 4.08 4.68	7.70 0.38 4.47 3.30 3.32	2.07 6.52 5.14 11.41 6.67 2.22 2.86
/th Rate of ty (%)	(11) 1960 -1972	-4.27 -8.12 8.02 4.66	6.49 1.15 3.61 2.77 4.14	3.07 3.97 1.25 4.03	1.94 3.28 6.57 5.16 6.67	9.04 3.92 5.63 4.71 4.18	2.10 8.53 5.53 13.12 7.82 2.24 3.95
Divisia Grow Quanti	(10) 1970 -1977	-0.81 -10.79 3.15 -5.91	3.90 -2.87 1.61 -0.55 0.19	-0.81 0.18 -1.35 -0.38 -0.28	-2.89 -1.38 -1.98 -2.48 -0.82	3.09 -3.47 1.85 -6.74 1.05	1.02 2.58 2.93 4.02 3.68 1.82 -0.37
	$(9) \\ 1960 \\ -1970$	-4.60 -6.95 8.20 5.11 0.29	7.49 1.96 4.23 3.43 5.11	3.90 5.40 3.15 2.83 4.65	3.12 4.34 8.10 6.19 8.21	10.22 3.13 5.88 5.83 4.60	2.61 8.68 6.19 15.64 8.11 8.11 2.28 4.75
	$(8) \\ 1960 \\ -1977$	0.89 0.37 0.65 0.80 1.16	0.53 0.14 0.42 1.23 1.83	1.15 0.98 1.89 0.38 0.86	0.98 0.92 1.13 1.10 1.14	0.94 0.17 0.98 1.54 0.69	0.66 1.43 0.29 0.88 0.88 0.88 0.88 0.83
vth Rate of y (%)	$^{(7)}_{-1972}$	0.68 0.49 0.78 0.78 1.10	0.62 0.05 0.20 1.06 1.69	0.82 0.89 1.93 0.42 0.79	0.88 0.87 1.21 0.87 0.81	0.44 0.31 0.89 1.51 0.50	0.72 1.36 0.08 1.11 0.76 -0.05 0.78
Divisia Grov Qualit	(6) 1970 -1977	1.35 0.01 0.68 0.56 1.16	0.25 0.40 0.72 1.23 1.75	1.54 0.72 1.50 0.57 0.93	1.12 1.13 0.93 1.62	1.56 -0.39 1.08 1.33 1.05	0.31 1.60 0.59 0.46 0.41 -0.01 0.89
	(5) 1960 -1970	0.48 0.58 0.56 0.88 1.04	0.68 -0.06 0.18 1.10 1.71	0.76 1.06 1.97 0.21 0.72	0.79 0.69 1.16 0.85 0.68	$0.41 \\ 0.54 \\ 0.82 \\ 1.53 \\ 0.37 \\ 0.37$	0.84 1.16 0.06 1.09 0.60 0.60 0.76
	(4) 1960 -1977	-4.10 -9.40 5.92 -3.63	5.82 -0.20 2.92 0.63 1.43	0.89 2.32 -0.56 1.22 1.87	-0.36 1.10 2.97 1.53 3.46	6.67 0.19 3.42 1.75 2.61	1.40 5.10 4.84 10.49 6.08 2.23 1.98
vth Rate of put (%)	(3) 1960 -1972	-4.92 -8.58 7.65 3.83 -1.80	5.85 5.85 1.08 3.41 1.67 2.47	2.24 2.94 -0.12 0.83 3.21	1.04 2.38 5.38 4.24 5.83	8.51 3.54 4.71 3.20 3.65	1.36 7.19 5.43 11.99 7.04 2.29 3.15
Divisia Grov Labor In	$(2) \\ 1970 \\ -1977$	-2.18 -10.79 2.47 -7.09	3.62 -3.23 0.93 -1.77 -1.53	-2.35 -0.58 -2.85 -0.97 -1.21	-3.95 -2.56 -2.90 -3.82 -2.53	-3.11 -3.11 0.69 -1.98 0.01	0.72 0.98 2.35 3.36 3.24 1.83 -1.07
	$(1) \\ 1960 \\ -1970$	-5.03 -7.51 7.78 4.17 -0.76	6.78 2.00 4.05 3.41	3.13 4.16 1.13 2.65 3.89	2.27 3.64 6.97 5.30 7.51	9.70 2.54 5.02 4.27 4.20	1.73 7.55 6.11 14.62 7.47 2.28 3.98
	Industry No.	-:4°.4.%	10.98.76	11. 12. 13. 15.	16. 17. 20.	21. 22. 23. 25.	26. 27. 28. 30. 31. 31.

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

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

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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

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

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 $\mu_{klmn,i}$ 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)
$$B_{it} = \sum \sum \sum \sum C_{klmn,it} \cdot K_{klmn,it}$$
$$= \sum \sum \sum \sum \sum q_{klmn,it} (\gamma_{it} + \mu_{klmn,it})$$
$$- \frac{\dot{q}_{klmn,it}}{q_{klmn,it}}) K_{klmn,it} .$$

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

in	(11) 1977	$\begin{array}{c} 0.0320\\ 0.4852\\ 0.3906\\ 0.5949\\ 0.2320\end{array}$	$\begin{array}{c} 0.1080\\ 0.0044\\ 0.0805\\ -\end{array}$	$\begin{array}{c} 0.0572\\ 0.0543\\ 0.1009\\ 0.0114\end{array}$	$\begin{array}{c} 0.0914 \\ 0.0596 \\ 0.0509 \\ 0.0509 \\ 0.3723 \end{array}$	0.2804 0.2992 0.3984 -	$\begin{array}{c} 0.1625\\ 0.3898\\ 0.0574\\ 0.3304\end{array}$
e of Return apital Stock	(10) 1970	0.1865 0.4231 0.5606 0.7586 0.5281	0.2938 0.3281 0.2812 0.2477 0.2336	0.2047 0.1813 0.0535 0.2133 0.2133 0.1809	0.2330 0.3551 0.1891 0.4004 0.4922	$\begin{array}{c} 0.3391\\ 0.3152\\ 0.3152\\ 0.3410\\ 0.2324\\ 0.0201\end{array}$	0.0475 0.4898 0.5945 0.1620 0.6348
Rat C	(9) 1960	0.1736 0.2553 0.9273 1.2227 0.3363	$\begin{array}{c} 0.2629\\ 0.2750\\ 0.4258\\ 0.2363\\ 0.5387\end{array}$	$\begin{array}{c} 0.1410\\ 0.3902\\ 0.3168\\ 0.2023\\ 0.1063\end{array}$	$\begin{array}{c} 0.2191 \\ 0.5492 \\ 0.2434 \\ 0.5820 \\ 0.4211 \\ 0.4211 \end{array}$	0.8586 0.0863 0.5179 0.6539 0.0689	0.0170 0.3762 0.5625 0.2183 0.8766
	(8) 1960 -1977	4.1400 8.0931 2.7478 1.4578 5.1805	1.0130 ∆8.3618 ∆3.9674 3.2491 ∆6.4831	3.5924 0.4283 ∆1.9205 1.5420 1.7560	2.0257 $\Delta 3.3620$ $\Delta 1.7801$ $\Delta 4.4774$ 4.7068	$\Delta 0.1909$ 10.3989 $\Delta 3.7538$ $\Delta 6.0991$ 3.9014	1.9781 3.9673 3.6779 2.2602 5.4171
th Rate of te Price (%)	$(7) \\ 1960 \\ -1972$	$\begin{array}{c} 3.3361\\ 5.3605\\ 5.3605\\ \Delta 0.3080\\ \Delta 3.9582\\ 1.6344\end{array}$	$\Delta 2.7281$ 0.3552 $\Delta 4.8198$ 0.6728 $\Delta 8.4096$	$\begin{array}{c} 3.1492 \\ 3.1492 \\ \Delta 1.5791 \\ \Delta 7.2875 \\ 0.4681 \\ 1.4252 \end{array}$	△0.9618 △3.1353 △2.7945 △5.3025 1.4761	$\Delta 7.7962$ 10.4415 $\Delta 5.3179$ $\Delta 8.7397$ 0.0619	1.2331 3.8560 4.0684 0.3551 4.6118
Divisia Grow Capital Servic	(6) 1960 -1977	4.7019 12.2168 8.2136 7.3888 5.2046	Δ1.2812 Δ24.1567 Δ5.3202 3.7836 Δ6.9591	2.6566 5.5531 7.4644 3.4118 0.3537	4.7347 ∆4.0040 ∆2.4630 ∆7.7672 7.8604	$\begin{array}{c} 9.3880\\ 12.2434\\ 12.7271\\ \Delta 4.5960\\ 10.0473\end{array}$	0.3330 0.8160 0.8160 8.6277 5.1847 5.2364
	(5) 1960 -1970	3.7467 5.2066 △1.0782 △2.6938 5.1637	2.6191 2.6944 ∆3.0203 2.8749 ∆6.1499	4.2479 ∆3.1591 ∆8.4901 2.3320 2.7376	$\begin{array}{c} 0.1306 \\ \Delta 2.9127 \\ \Delta 1.3035 \\ \Delta 2.1746 \\ 2.4992 \end{array}$	$\Delta 6.8962$ 9.1078 $\Delta 2.3198$ $\Delta 7.1514$ $\Delta 0.4007$	3.1298 6.1732 3.9073 0.2130 5.5434
	(4) 1960 -1977	7.1881 1.7132 13.8208 10.1932 4.6504	15.1360 7.9506 12.7308 8.8715 13.9684	8.0675 11.1171 12.3393 7.8451 12.2261	9.8399 14.0274 15.9658 11.9959 8.4855	$\begin{array}{c} 12.6205\\ 11.0629\\ 10.5683\\ 19.4388\\ 7.2831\end{array}$	10.2630 11.5421 9.0928 10.4678 11.2917
th Rate of iput (%)	(3) 1960 -1972	5.7525 7.2073 19.5258 14.3275 8.3643	21.3735 21.3735 8.8821 15.1143 11.4543 11.4543 16.0894	12.9376 14.1720 19.1743 14.8574 16.8906	14.1744 14.3999 21.2348 18.4257 15.2809	18.9079 14.9504 16.6234 23.5976 12.7277	11.3571 12.1855 12.7704 11.6978 11.3237
Divisia Grow Capital Ir	$(2) \\ 1970 \\ -1977$	$\begin{array}{c} 9.7822 \\ \Delta 8.2504 \\ 2.9613 \\ 4.0698 \\ 1.5422 \end{array}$	6.2691 7.4604 8.0587 4.7677 9.1353	$\Delta 0.0525$ 3.6771 $\Delta 1.3695$ $\Delta 5.1832$ 3.0621	$\begin{array}{c} 1.4770\\ 11.3580\\ 4.9840\\ 0.3030\\ \Delta 2.4904\end{array}$	1.0481 2.3200 2.0713 10.3677 ∆1.1547	9.4568 11.6050 1.5514 8.8537 8.0596
	(1) 1960 -1970	5.3772 5.3772 8.6897 21.4225 14.4798 6.8260	21.3428 21.3428 8.2938 16.0013 11.7441 17.3517	13.7516 16.3250 21.9355 16.9652 18.6407	15.6940 15.8959 23.6531 20.1808 16.1686	20.7221 17.1830 16.5161 25.7886 13.1897	10.8273 11.4980 14.3717 11.5976 13.5541
	Industry No.	04.2		11. 12. 13. 15.	16. 17. 18. 20.	21. 22. 24. 25.	26. 27. 29. 30.

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

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

Industry	1965	1970	1974	1977	Annual Growth Rate: 1960-1970	Annual Growth Rate: 1970-1977
1.	1.1899	0.6572	0.5139	0.3650	∆4.19	∆8.40
2.	0.9516	0.7189	0.6572	1.3242	∆3.30	8.72
3.	0.4473	0.3236	0.2155	0.3241	∆11.28	0.02
4.	0.5401	0.4925	0.3388	0.4967	∆7.08	0.12
5.	1.0447	0.8663	0.5880	0.9088	∆1.43	0.68
6.	0.5591	0.3973	0.2066	0.3239	∆9.23	∆2.91
7.	1.2496	1.1687	0.7592	0.7541	1.56	∆0.63
8.	0.9008	0.7207	0.3677	0.4587	∆3.28	∆6.45
9.	0.8647	0.8994	0.5964	0.7780	∆1.06	△2.07
10.	0.6630	0.5117	0.2523	0.2812	∆6.70	∆8.55
11.	0.8319	0.9968	0.9721	1.3869	∆0.03	4.71
12.	0.9085	0.8043	0.6815	0.8489	∆2.17	0.77
13.	0.4951	0.2722	0.2544	0.4184	∆13.01	6.14
14.	0.5089	0.4629	0.4361	0.7549	∆7.70	6.98
15.	0.5332	0.6149	0.4555	0.6793	∆4.86	1.42
16.	0.6345	0.7691	0.6018	0.8198	∆2.63	0.92
17.	0.5187	0.5266	0.4084	0.3197	∆6.41	∆7.12
18.	0.5457	0.4827	0.3645	0.3762	∆7.28	∆3.56
19.	0.4333	0.5921	0.5086	0.7036	∆5.24	2.46
20.	0.5642	0.9786	1.0943	1.8701	∆0.22	9.25
21.	0.4773	0.4785	0.4391	0.8279	∆7.37	7.83
22.	0.7976	0.9258	0.7694	1.2861	∆0.77	4.69
23.	0.6212	0.6423	0.5254	1.0695	∆4.43	7.28
24.	0.4788	0.3281	0.2121	0.2389	∆11.14	∆4.53
25.	0.8679	0.7614	0.6518	1.0966	∆2.72	5.21
26.	0.8296	0.9966	0.7741	0.7765	∆0.03	∆2.49
27.	1.0467	0.9725	0.6688	0.6650	∆0.27	∆3.81
28.	0.8118	0.9944	0.9914	1.5461	∆0.06	7.20
29.	1.0031	1.2814	1.0901	1.1114	2.47	△2.03
30.	0.9463	0.7295	0.5051	0.5999	∆3.15	∆2.79

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

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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

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.

⁴⁾ Results of Gollop-Jorgenson basically obtain from their report [1980].

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)



(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-





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





- 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 referred 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

											,																			
	T.F.P.	0776	.1126	.0014	.0329	0115	0169	.0148	.0470	.0006	.0385	0554	.0656	0409	.0246	.0189	0068	.0445	.0504	CERU.	.0352	.1084	0660.	0060	.0023	.0061	.0813	.0506	.0158	CC70.
h rate	capital	.0537	0616	0107	0326	- 0068	- 0003	0021	0042	0004	0112	0052	0102	0077	0124	0127	.0347	0026	0106	01 /0	0187	0217	0147	0018	0228	.0048	.0191	0095	.0371	0047
innual growt	labor	0072	0136	0080	- 0004	- 0014	- 0127	.0022	0012	0052	.0034	0005	0018	.0093	.0010	.000	.0013	0112	0028	.0064	.0132	0084	.0096	.0007	.0113	0095	0525	.0139	.0038	1400.
1975-77	intermediate input	.0153	0063	0261	.0383	0012	0110	0285	.0359	.0240	.0302	.0867	.0413	.0295	.0335	6600.	.0412	.0321	.0305	C1/0.	.0661	.0182	.0839	.0363	.0232	.0391	.0178	.0136	.0089	0/70.
	output	.0037	.0400	.0253	.0505	03050	- 0087	0146	.0129	.0197	.0613	.0340	.0936	0074	.0472	.0159	.0705	.0624	.0669	.1468	.0943	.0992	.1714	.0301	.0145	.0440	.0695	.0685	.0645	00000.
	T.F.P.	0224	0420	0463	.0315	- 0010	00860	0855	0451	0591	0013	.1175	0253	.0202	0209	.0177	0500	0123	.0234	.0468	.0321	0097	.0699	0020	.0375	0399	0204	0877	0178	¥000
rate	capital	0287	0308	.0252	0336	01510	0082	.0081	.0123	.0107	.0034	.0254	.0079	.0026	.0147	.0122	0799	.0023	.0067	1000.	.0092	.0083	.0148	.0102	.0130	.0324	.0396	.0225	.0877	- 12+2.
nnual growth	labor	0042	0382	.0077	.0029	0265	.0127	.0188	.0036	.0145	0012	6000.	.0093	.0022	.0063	.0001	.0028	.0082	.0027	6600.	.0068	0231	.0113	.0075	.0056	.0179	.0048	.0112	.0054	0000.
1973-74 a	intermediate input	-0009	.0272	.0081	0418 0538	0227	1990	0142	.0431	0500	.0328	0593	.0100	0607	.0211	.0307	.0188	.0025	.0576	.0114	.0392	0980	.0417	.0227	1600.	.0506	.0030	.0195	0011	1000.4
	output	.0019	0168	0056	0257	0195	0021	0731	.0142	0847	.0337	0060.	.000	0275	.0196	.0593	0099	0067	.0820	.0049	.0835	.1306	1315	.0376	.0642	.0612	.0273	0311	.0751	.0440
	Industry	1.	4	m.	4. 10			×.	.6	10.	11.	12.	13.	14.	15.	16.	17.	18.	. 6	۶ 0 .	21.	22.	23.	24.	25.	26.	27.	28.	29.	-

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

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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 4-5]



- 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 pattern's 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.

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

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

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.

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.

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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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