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Change of Industrial Structure in Japan: Past 20 Years

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Abstract. The index values of "Manufacturing" have decreased from 1990 to 2011. However, even now "Manufacturing" is very crucial industry in Japan. It means "Manufacturing" needs all 13 industries the most as its input and simultaneously "Manufacturing" is needed from all 13 industries the most as their input. In production inducement, the values of "Services", "Information and Communications ", and "Commerce" industries have increased as the effect of consumption, investment and export respectively during this period. In particular, about the production inducement of investment, "Information and communication" industry has experience the most rapid growth in all 13 industries.

Keywords: Input-out table, Japanese industries, Production inducement, Consumption, Investment, Export

1. Introduction

Using 1990, 2000, 2011 Input-Out Tables of Japan (2011 is the most recent version, 2015 publication) compiled by the Ministry of Internal Affairs and Communications of Japan, this research discussed change of "index of power of dispersion" and "index of sensitivity of dispersion" of each industry. Furthermore, it calculated production inducement by consumption, investment, and export, ripple effect to added value, and ripple effect to employment to compare among 1990, 2000 and 2011 industrial structures. Particularly an adjustment work related to the number of section was necessary when calculating ripple effect to the employment. That is because industrial classification is different from each other, the table of total employee number according to production activity section and the Basic Transaction Table. Furthermore, this research focuses on 13 industries with processing the data, therefore, we can see all tables from a coherent viewpoint and easily understand industrial structure.

2. Input-Output Analysis

2.1. Basic model

To simplify, if the national economy is deemed to be comprised only of Industry 1 and Industry 2, the Basic Transaction Table may be as indicated in Table 1.

Table 1: Basic transaction table

	Industy 1	Industy 2	Final demand	Import	Domestic production
Industy 1	*x11*	*x12*	*F1*	*-M1*	*X1*
Industy 2	*x21*	*x22*	*F2*	*-M2*	*X2*
Gross value added	*V1*	*V2*			
Domestic production	*X1*	*X2*			

Source: The Ministry of Internal Affairs and Communications of Japan, 2016a. Outline of the Input-Output Tables for Japan.

Therefore, Supply-demand balance equation is as follows:

$$\begin{cases} x_{11} + x_{12} + F_1 - M_1 = X_1 \\ x_{21} + x_{22} + F_2 - M_2 = X_2 \end{cases} \quad (1)$$

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Here "a_{11}" represents the input from Industry 1 required to produce one unit of production of Industry 1. It is called "input coefficient".

$$a_{11} = \frac{x_{11}}{X_1} \tag{2}$$

Similarly, "a21" represents the amount of raw materials, etc. that Industry 1 input from Industry 2 to produce one unit of the product of Industry 1.

$$a_{21} = \frac{x_{21}}{X_1} \tag{3}$$

As in the case of equation (2), (3), "a11", "a21", etc., are calculated and substituted into equation (1), resulting in the following modifications:

$$\begin{cases} a_{11}X_1 + a_{12}X_2 + F_1 - M_1 = X_1 \\ a_{21}X_1 + a_{22}X_2 + F_2 - M_2 = X_2 \end{cases} \tag{4}$$

Equation (4) can be expressed in a matrix, as follows:

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} F_1 - M_1 \\ F_2 - M_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \tag{5}$$

$$\mathrm{A} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \tag{6}$$

"A" is referred to as the input coefficient matrix. The final demand column vector is defined as

$$\begin{bmatrix} F_1 - M_1 \\ F_2 - M_2 \end{bmatrix} = F - M \tag{7}$$

and the domestic production column vector is defined as

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = X \tag{8}$$

$$AX + F - M = X \tag{9}$$

can be obtained. The solution for X is

$$\mathrm{X} = (I - A)^{-1}(F - M) \tag{10}$$

where "I" is an Identity matrix, and $(\mathrm{I} - \mathrm{A})^{-1}$ is the Inverse matrix of (I –A), as follows:

$$(I - A)^{-1} = \begin{bmatrix} 1 - a_{11} & -a_{12} \\ -a_{21} & 1 - a_{22} \end{bmatrix}^{-1} = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \tag{11}$$

$(I - A)^{-1}$is called Leontief's Inverse Matrix.

2.2. Modified model

This model divides final demand (F) into domestic final demand (Fd) and export (E), giving the following equation:

$$F = Fd + E \tag{12}$$

This is substituted into (9) above. The Supply-demand balance equation can be expressed as follows:

$$AX + Fd + E - M = X \tag{13}$$

The diagonal matrix ($\widehat{\mathrm{M}}$) can be assumed to have an "Import coefficient" (m) as the diagonal element and zero as the non-diagonal element.

$$\widehat{M} = \begin{bmatrix} m & 0 & 0 \\ & m & 0 \\ 0 & 0 & m \end{bmatrix} \tag{14}$$

Here "Import coefficients" (m) represent the ratio of imports in product. For example, the imports of Industry 1 within total domestic demands.

$$m_1 = \frac{M_1}{X_{11}+X_{12}+Fd_1} \tag{15}$$

$$\therefore M = \widehat{M}\left(AX + Fd\right) \tag{16}$$

This is substituted into (13) above.

$$\therefore X = \left(I - \left(I - \widehat{M}\right)A\right)^{-1}\left(\left(I - \widehat{M}\right)Fd + E\right) \tag{17}$$

2.3. Index of power of dispersion

The figure in each column in the inverse matrix coefficient (11) indicates production required at each sector when the final demand for the column sector (that is, demand for domestic production) increases by one unit. The sum of column indicates the scale of "production repercussions on entire industries", caused by one unit of the final demand for the column sector. The vertical sum of every column sector of the inverse matrix coefficients is divided by the mean value of the entire sum of column to produce a ratio. This ratio indicates "the relative magnitudes of production repercussions on entire industries when the final demand for a column sector increases by one unit." This is called the "Index of Power of Dispersion".

2.4. Index of sensitivity of dispersion

The figure for each row in the inverse matrix coefficient (11) indicates the supplies required at each sector when one unit of the final demand for the column sector occurs respectively. The ratio produced by dividing the total (horizontal sum) by the mean value of the entire sum of row will indicate the relative influences, that is to say, "the relative magnitudes of production inducement of a sector when one unit of the final demand for all column sectors occurs". This is called the "Index of Sensitivity of Dispersion".

3. Results

3.1. Relationship between power of dispersion and sensitivity of dispersion

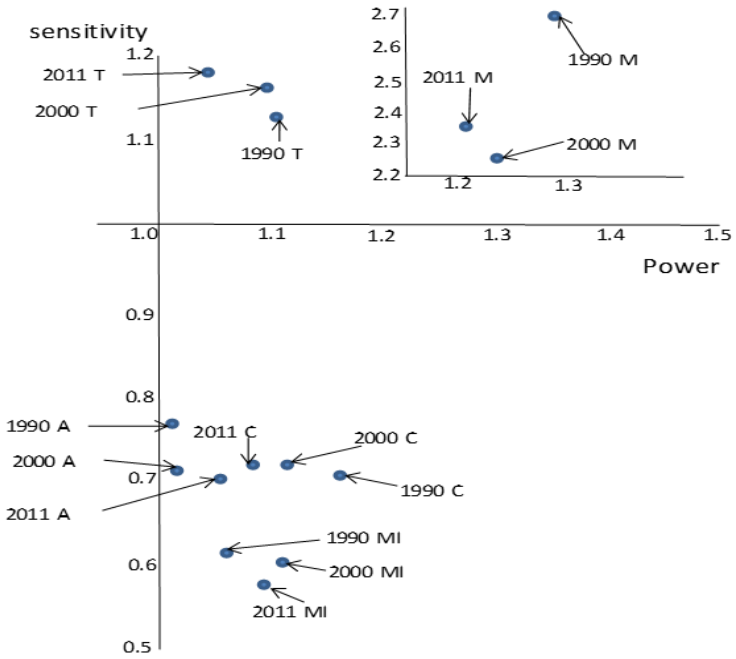

Fig. 1: Power of dispersion and sensitivity of dispersion (5 sectors)

Source: The Ministry of Internal Affairs and Communications of Japan, 2016b. The Input-Output Tables Data for Japan.

T: Transport and postal Mfg: Manufacturing A: Agriculture, forestry and fisheries C: Construction MI: Minin

Both index values of "Manufacturing" are big compared to other industries. It means "Manufacturing" needs all 13 industries the most as its input (Index of Power of Dispersion) and in particular, "Manufacturing" is needed from all 13 industries the most as their input (Index of Sensitivity of Dispersion).

3.2. Domestic production induced by final demand items

"Production inducement coefficient" (PIC) by final demand item is defined as the domestic products induced by individual final demand item (e.g. consumption) divided by the total for corresponding final demand (e.g. consumption). This indicates the rate of increase of domestic production of an industry by a final demand item for all industry divided by the "total" of a certain final demand item for all industries, which means per unit of a certain final demand item. That is to say, Production inducement coefficient is per unit magnitude of "Production inducement" in an industry by a certain final demand item of all industries. In other words, the production ripple power of each final demand item (consumption, investment, and export) for an industry per unit of each final demand.

For example, an industry's PIC of the consumption is:

$$PIC = \frac{X'}{C} \tag{18}$$

Here, X` is the domestic products of an industry induced by the consumption for all industry. C is the total of consumption for all industries.

Table 2: Production inducement coefficient by consumption

	1	2	3	4	5	6
2011	Services	Mfg	Real estate	Commerce	Public	Information
	0.489	0.331	0.173	0.164	0.099	0.079
2000	Services	Mfg	Commerce	Real estate	Public	Financial
	0.465	0.365	0.170	0.164	0.093	0.076
1990	Mfg	Services	Commerce	Real estate	Financial	Public
	0.497	0.427	0.179	0.144	0.081	0.079

	7	8	9	10	11	12
2011	Transport	Financial	Electricity	Construction	Agriculture	Mining
	0.079	0.071	0.051	0.020	0.019	0.001
2000	Transport	Electricity	Information	Agriculture	Construction	Mining
	0.064	0.054	0.047	0.022	0.018	0.002
1990	Transport	Electricity	Agriculture	Information	Construction	Mining
	0.070	0.050	0.034	0.028	0.016	0.003

Source: The Ministry of Internal Affairs and Communications of Japan, 2016b. The Input-Output Tables Data for Japan.

*Information: Information and communications Financial: Financial and insurance

Electricity: Electricity, gas and water supply

*The industry of activities not elsewhere classified is excluded.

As shown in Table 2, in the case of production inducement by consumption, from 1990 to 2000, the position of "Manufacturing" was replaced by "Services" industry. The value of "Manufacturing" has decreased, from 0.497(1990) to 0.365(2000). Instead of it, the value of "Services" has increased from 0.427(1990) to 0.465(2000). The "Manufacturing" value decrease is significant rather than the increase of "Services" industry value.

Table 3: Production inducement coefficient by investment

	1	2	3	4	5	6
2011	Mfg	Construction	Services	Commerce	Information	Transport
	0.692	0.473	0.185	0.158	0.132	0.068
2000	Mfg	Construction	Services	Commerce	Transport	Financial
	0.690	0.537	0.226	0.170	0.047	0.042
1990	Mfg	Construction	Services	Commerce	Transport	Financial
	0.827	0.580	0.165	0.155	0.047	0.046

	7	8	9	10	11	12
2011	Electricity	Agriculture	Financial	Real estate	Public	Mining
	0.029	0.023	0.019	0.018	0.003	0.002
2000	Electricity	Agriculture	Information	Real estate	Mining	Public
	0.030	0.028	0.023	0.014	0.003	0.001
1990	Agriculture	Electricity	Real estate	Information	Mining	Public
	0.035	0.028	0.018	0.012	0.006	0.001

Source: The Ministry of Internal Affairs and Communications of Japan, 2016b. The Input-Output Tables Data for Japan.

In the case of production inducement by investment, as we can see in Table 3, in particular, the value of "Information and communication" industry increased significantly, 0.012(1990), 0.023(2000), and 0.132(2011). It is the most rapid growth among 13 industries during this period.

About the production inducement by export, as shown in Table 4, although the "Manufacturing" value (rank1) is overwhelming compared to other industries, it has decreased, 1.455(1990), 1.326(2000), and 1.306(2011).

Table 4: Production inducement coefficient by export

	1	2	3	4	5	6
2011	Mfg	Commerce	Services	Transport	Electricity	Information
	1.306	0.200	0.177	0.148	0.041	0.037
2000	Mfg	Services	Commerce	Transport	Financial	Electricity
	1.326	0.185	0.166	0.124	0.056	0.041
1990	Mfg	Services	Transport	Commerce	Financial	Agriculture

	1.455	0.151	0.134	0.124	0.064	0.054

	7	8	9	10	11	12
2011	Agriculture	Financial	Real estate	Construction	Mining	Public
	0.034	0.032	0.018	0.014	0.003	0.002
2000	Agriculture	Information	Real estate	Construction	Mining	Public
	0.038	0.020	0.015	0.012	0.005	0.002
1990	Electricity	Real estate	Information	Construction	Mining	Public
	0.038	0.019	0.012	0.012	0.008	0.001

Source: The Ministry of Internal Affairs and Communications of Japan, 2016b. The Input-Output Tables Data for Japan.

3.3. Final demand and value added

From 1990 to 2011, about the inducement effect by consumption, investment and export on value added, generally we can't see big change respectively among 13 industries. However, in particular, we have to pay attention to "Information and communication" industry. In the case of consumption, investment, and export, the rank of "Information and communication" industry has risen from 9 to 7, 9 to 5, and 9 to 5 respectively.

3.4. Final demand and employment

About the inducement effect on employee, 1990 data are not available. However, comparing between 2000 and 2011 data, big change has not occurred in comparison with the case of value added. About the rank 1 to 5, we also can't see outstanding change.

4. Conclusion and Discussion

The index value of "Manufacturing" has decreased from 1990 to 2011. However, even now "Manufacturing" is very crucial industry in Japan. It means "Manufacturing" needs all 13 industries the most as its input and simultaneously "Manufacturing" is needed from all 13 industries the most as their input. In production inducement, the values of "Services", "Information and Communications ", and "Commerce" industries have increased as the effect of consumption, investment and export respectively during this period. In particular, about the production inducement of investment, "Information and communication" industry has experience the most rapid growth in all 13 industries.

Finally, I would like to thank my laboratory undergraduate students, who helped me with calculating tables.

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