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INDUSTRIAL STRUCTURE OF PREFECTURES IN JAPAN

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ABSTRACT

I would like to highlight two local prefectures in Japan, Fukui prefecture and Toyama prefecture. I live in Fukui prefecture and it has Toyama as the neighbor. This research uses 2011 Input-Out Tables of Fukui and Toyama prefectures and examines "the index of power of dispersion" and "the index of sensitivity of dispersion" of each industry. It also gets the production inducement values by consumption, investment, and export (and outflow to other prefectures). With these values, we can compare the two prefectures' industrial structure. The values of the index of power of dispersion show some different industries in higher ranked industries, which have bigger economic effect. Moreover, "Information and communications" industry is ranked at the seventh in Fukui and "Iron and Steel" industry has the eighth position in Toyama. On the other hand, the index of sensitivity of dispersion's values indicate that the industries at higher rank have similarity though the rankings are somewhat different. In addition, "Finance and insurance" is ranked at the sixth in both Fukui and Toyama. "Real estate" industry has the seventh and the eighth position in Fukui and Toyama respectively. Seeing the inducement effect of export and outflow to other prefectures, Fukui's "Electricity, Gas, and Heat supply" industry and Toyama's "Chemical products" industry have outstanding values. Furthermore, two industries characterize Fukui and Toyama about the effect to employment. That is to say, the third ranked industries are "Textile mill products" and "Fabricated metal products" respectively. Fukui and Toyama are in the same area, we call Hokuriku. However, they don't necessarily have the same industrial structure.

Contribution/ Originality: The paper's primary contribution is finding that the index of power of dispersion shows some different industries in Fukui and Toyama. Seeing the production inducement effect, Fukui's and Toyama's first rank industries are "Electricity, Gas, and Heat supply" and "Chemical products" respectively.

1. INTRODUCTION

This article utilizes Input-Output Tables which interest us. They are very important and useful for the analysis of industrial structure and for economic forecasting. Ronald and Blair [1] indicate that Dr. Leontief developed Input-Output Tables in late 1930s. He won Nobel Prize in Economics for it in 1973. About this Input-Output Tables, "Leontief's Inverse Matrix" is the most crucial tool, which is derived from Input-Output Tables, when calculating the various indexes related to industries. Using 2011 Input-Out Tables of Fukui and Toyama

prefectures in Japan, which are the most recent version published in 2015, this research discussed "the index of power of dispersion" and "the index of sensitivity of dispersion" of each industry. Furthermore, it calculated the production inducement by consumption, investment, and export (and outflow to other prefectures), the ripple effect to value added, and the ripple effect to employment to compare the industrial structure of the two prefectures. About the following model and calculation method, see Sadao [2]; Leontief [3] and The Ministry of Internal Affairs and Communications of Japan [4].

2. INPUT-OUTPUT ANALYSIS

2.1. Basic Model

To simplify, if a 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 [5]

Therefore, Supply-demand balance equation is as follows:

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

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

$$a_{11} = \frac{x_{11}}{X_1} \quad (2)$$

Similarly, "a_{21}" represents the amount of raw materials, etc. that is Industry 1 input from Industry 2 to produce one unit of the product of Industry 1.

$$a_{21} = \frac{x_{21}}{X_1} \quad (3)$$

As in the case of equation (2), (3), "a_{11}", "a_{21}" , etc., are calculated and substituted into equation (1).
It results in the following modifications:

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

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

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

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad (6)$$

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

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

and the domestic production column vector is defined as

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = X \quad (8)$$

$$\therefore AX + F - M = X \quad (9)$$

The solution for X is

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

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

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

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

2.1. Modified Model

This model divides final demand (F) into domestic final demand (Fd) and export (E). It gives the following equation:

$$F = Fd + E \quad (12)$$

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

$$AX + Fd + E - M = X \quad (13)$$

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

$$\widehat{M} = \begin{bmatrix} m & 0 & 0 \\ & m & 0 \\ 0 & 0 & m \end{bmatrix} \quad (14)$$

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

$$m_1 = \frac{M_1}{X_{11} + X_{12} + Fd_1} \quad (15)$$

$$\therefore M = \widehat{M}(AX + Fd) \quad (16)$$

This is substituted into (13) above.

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

2.2. Index of Power of Dispersion

The figures in a column in the inverse matrix coefficient (11) indicate the productions required at every sector when the final demand for a sector (that is, demand for domestic production) increases by one unit. The vertical sum of a column indicates the scale of "production repercussions on entire industries", which is caused by one unit of the final demand for a sector. The vertical sum of a column of the inverse matrix coefficients is divided by the mean value of the vertical sum of columns to produce a ratio. This ratio indicates "the relative magnitudes of production repercussions on entire industries when the final demand for a sector increases by one unit." This is called the "Index of Power of Dispersion" (Shuntarou [6]).

2.3. Index of Sensitivity of Dispersion

The figures for a row in the inverse matrix coefficient (11) indicate the supplies required at a sector when one unit of the final demand for all sectors occurs respectively. The ratio produced by dividing the total (horizontal sum) by the mean value of the horizontal sum of rows 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 sectors occurs". This is called the "Index of Sensitivity of Dispersion" (Shuntarou [6]).

3. RESULTS

3.1. Relationship between Power of Dispersion and Sensitivity of Dispersion

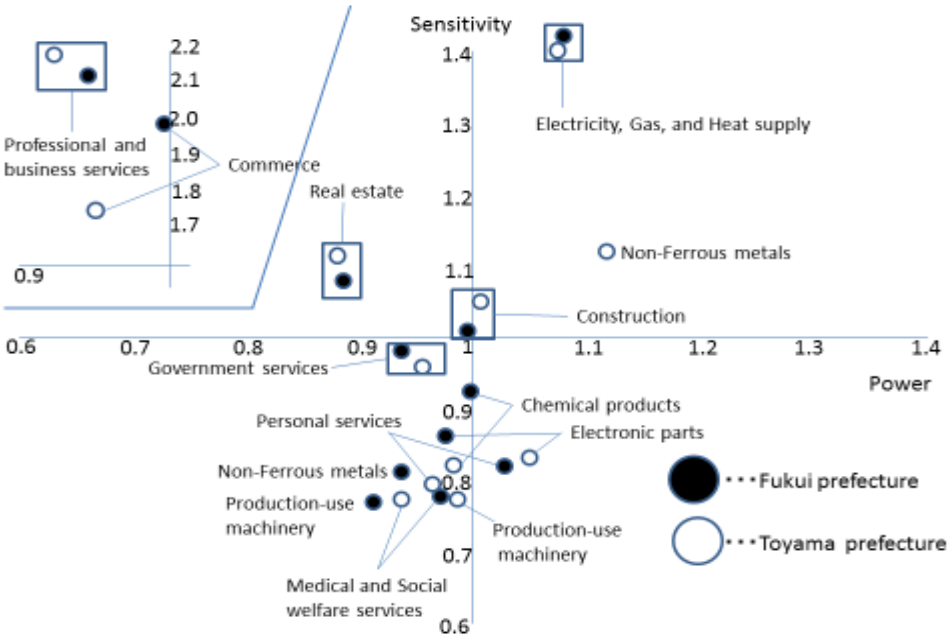

Figure-1. Relationship between Power of Dispersion and Sensitivity of Dispersion
Source: Fukui Prefecture [7]; Toyama Prefecture [8].

Only "Electricity, Gas, and Heat supply" industry exceeds "1" concerning both the value of power of dispersion and the value of sensitivity of dispersion in Fukui (Figure 1, the first quadrant). On the other hand, "Government services ", "Medical and Social welfare services", "Chemical products", "Electronic parts", "Non-Ferrous metals "

and "Production-use machinery "industries have lower values of both the power of dispersion and the sensitivity of dispersion (the third quadrant).

In Toyama, "Electricity, Gas, and Heat supply", "Non-Ferrous metals " and "Construction" exceed "1" regarding both the value of power of dispersion and the value of sensitivity of dispersion (the first quadrant). The values of "Government services ", "Medical and Social welfare services", "Chemical products", "Professional and business services", and "Production-use machinery "are lower than "1" concerning both the value of power of dispersion and the value of sensitivity of dispersion (the third quadrant). In particular, as we can see in the second quadrant, the positions of the two prefectures' industries are similar.

Table-2. Index of power of dispersion

	1	2	3	4	5
Fukui	Mining	Petroleum and Coal	Beverages and Food	Water	Office and Store fixtures
	1.2681	1.1504	1.1244	1.1145	1.1055
Toyama	Mining	Non-Ferrous metals	Office and Store fixtures	Water	Electricity, Gas, and Heat supply
	1.1619	1.1286	1.1181	1.1048	1.0757
Japan	Iron and Steel	transportation equipment	Office and Store fixtures	fabricated metal products	Plastic and Rubber products
	1.4534	1.4468	1.3980	1.1192	1.1487

(continued)

	6	7	8	9	10
Fukui	Electricity, Gas, and Heat supply	Information and communications	Personal services	Pulp, paper and wood products	Textile mill products
	1.0835	1.0586	1.0330	1.0246	1.0107
Toyama	Electronic parts	Miscellaneous manufacturing	Iron and Steel	Pulp, paper and wood products	Other non-metallic mineral products
	1.0554	1.0524	1.0432	1.0402	1.0350
Japan	Chemical products	General – purpose production machinery	Pulp, paper and wood products	Electrical machinery	Information and communication
	1.1477	1.1380	1.1367	1.1280	1.1213

Source: Fukui Prefecture [7]; Toyama Prefecture [8]; The Ministry of Internal Affairs and Communications of Japan [9].

Table 2 and 3 show the values of power of dispersion and the values of sensitivity of dispersion according to their height. As we can see in Table 2, about the power of dispersion, the second, the third, and the fifth rank are different from each other in the two prefectures. "Petroleum and Coal products" industry which is the second rank in Fukui is the sixteenth rank in Toyama. "Non-Ferrous metals" which is the second rank in Toyama is the twenty-seventh rank in Fukui. Moreover,

"Information and communications" industry is ranked at the seventh in Fukui and "Iron and Steel" industry has the eighth position in Toyama.

About the sensitivity of dispersion, the first and the second of the two prefectures are replaced each other. The difference between the first rank and second rank is smaller in Fukui compared to Toyama. As far as we see the higher rank industries, Fukui's industries tend to be needed from other industries. Moreover, "Finance and insurance" is ranked at the sixth in both Fukui and Toyama. "Real estate" industry has the seventh and the eighth position in Fukui and Toyama respectively.

As shown in Table 2 and 3, about the whole country, "Iron and Steel" industry's rank is the first and the second respectively. "Iron and Steel" industry of the two prefectures is not ranked at higher position, in particular, Fukui prefecture.

Table-3. Index of sensitivity of dispersion

	1	2	3	4	5
Fukui	Transport and postal activities	Professional and business services	Commerce	Electricity, Gas, and Heat supply	Information and communications
	2.1647	2.1043	1.9889	1.4214	1.2847
Toyama	Professional and business services	Transport and postal activities	Commerce	Electricity, Gas, and Heat supply	Information and communications
	2.1933	1.8078	1.7744	1.4117	1.2337
Japan	Professional and business services	Iron and Steel	Commerce	Transport and postal activities	Chemical products
	2.6425	2.3394	2.1374	1.8497	1.4986

(continued)

	6	7	8	9	10
Fukui	Finance and insurance	Real estate	Construction	Education and Scientific research	Public services
	1.2225	1.0928	1.0376	1.0000	0.9890
Toyama	Finance and insurance	Non-Ferrous metals	Real estate	Education and Scientific research	Construction
	1.2229	1.1233	1.1164	1.0673	1.0532
Japan	Information and communications	Pulp, paper and wood products	Electricity, Gas, Heat supply	Petroleum and Coal	Education and Scientific research
	1.3918	1.3270	1.2600	1.1710	1.1151

Source: Fukui Prefecture [7]; Toyama Prefecture [8]; The Ministry of Internal Affairs and Communications of Japan [9].

3.2. Domestic Production Induced by Final Demand

We can't see the difference between the two prefectures when seeing the top rank industries about the inducement effects to production, value added, and employment by consumption and investment. Therefore, here I focus on outflow to other prefectures and export as final demand concerning the effect to production, value added and employment.

We can define "Production inducement coefficient" (PIC) by final demand item as the domestic products induced by individual final demand item (e.g. consumption) which is 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 industries 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 the per unit magnitude of "Production inducement" in an industry. 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:

$$PIC = \frac{X\prime}{C} \qquad (18)$$

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

Table 4 shows production inducement amount (X` above, unit: million yen) by outflow and export. Moreover, the values of Table 5 are Production inducement coefficient by outflow and export. "Electricity, Gas, and Heat supply" is ranked as the first respectively in Fukui prefecture. Toyama's the first rank industry is "Chemical products" in both Tables. "Electronic parts" is ranked at the second in Fukui and the forth in Toyama. "Non-Ferrous metals" has the second position in Toyama and the sixth in Fukui. Moreover, Japan's top five industries fairly differ from the industries of Fukui and Toyama.

Table-4. Production inducement amount by outflow and export (million yen)

	1	2	3	4	5
Fukui	Electricity, Gas, and Heat supply	Electronic parts	Chemical products	Textile mill products	Commerce
	537,717	326,760	315,018	218,598	60,372
Toyama	Chemical products	Non-Ferrous metals	Production machinery	Electronic parts	Commerce
	711,137	464,475	408,344	340,454	338,936
Japan	Transportation equipment	Iron and Steel	Commerce	Transport and postal activities	Chemical products
	24,804,262	15,650,951	13,786,483	10,274,393	9,049,729

(continued)

	6	7	8	9	10
Fukui	Non-Ferrous metals	Professional and business services	Transport and postal activities	Rubber and plastics product	Miscellaneous manufacturing
	138,005	125,968	109,440	99,811	98,257
Toyama	Fabricated metal products	Transport and postal activities	Iron and Steel	Pulp, paper and wood products	Professional and business services
	275,688	214,595	212,853	186,848	169,767
Japan	Professional and business services	Electronic parts	Production machinery	Electrical machinery	Non-Ferrous metals
	8,819215	8,776,209	7,001,764	6,281,151	5,067,127

Source: Fukui Prefecture [7]; Toyama Prefecture [8]; The Ministry of Internal Affairs and Communications of Japan [5].

Table.5. Production inducement effect by outflow and export (coefficient)

	1	2	3	4	5
Fukui	Electricity, Gas, and Heat supply	Electronic parts	Chemical products	Textile mill products	Commerce
	0.2426	0.1474	0.1421	0.0986	0.0724
Toyama	Chemical products	Non-Ferrous metals	Production machinery	Electronic parts	Commerce
	0.1993	0.1302	0.1144	0.0954	0.0950
Japan	Transportation equipment	Iron and Steel	Commerce	Transport and postal activities	Chemical products
	0.3496	0.2206	0.1943	0.1448	0.1276

(continued)

	6	7	8	9	10
Fukui	Non-Ferrous metals	Professional and business services	Transport and postal activities	Rubber and plastics product	Miscellaneous manufacturing
	0.0622	0.0568	0.0494	0.0450	0.0443
Toyama	Fabricated metal products	Transport and postal activities	Iron and Steel	Pulp, paper and wood products	Professional and business services
	0.0773	0.0601	0.0597	0.0524	0.0476
Japan	Professional and business services	Electronic parts	Production machinery	Electrical machinery	Non-Ferrous metals
	0.124	0.123	0.0987	0.0886	0.0714

Source: Fukui Prefecture [7]; Toyama Prefecture [8]; The Ministry of Internal Affairs and Communications of Japan [9].

3.3. Value Added Induced by Final Demand

Intermediate input and value added compose the domestic production of each sector as shown in Table 1, column. Final demand can generate not only domestic production but also value added because value added is a part of domestic production. Therefore, we can apply equation (17) above to final demand and value added in exactly the same manner.

Seeing the inducement effect to value added amount by outflow and export, the first rank industry is "Electricity, Gas, and Heat supply" in Fukui, "Chemical products" in Toyama, and "Commerce" in Japan. Furthermore, "Chemical products" shows even bigger difference of value added between the two prefectures as shown in Table.6.

Table-6. Value added inducement effect by outflow and export (million yen)

	1	2	3	4	5
Fukui	Electricity, Gas, and Heat supply	Chemical products	Electronic parts	Commerce	Textile mill products
	244,108	116,412	108,520	107,880	89,905
Toyama	Chemical products	Commerce	Production machinery	Professional and business services	Electronic parts
	329,346	237,131	177,217	104,935	102,600
Japan	Commerce	Professional and business services	Transport and postal activities	Transportation equipment	Education and Scienteific research
	9,437,620	5,412,867	5,166,075	4,945,624	3,033,463

(continued)

	6	7	8	9	10
Fukui	Professional and business services	Transport and postal activities	Miscellaneous manufacturing	Electrical machinery	Rubber and plastics product
	73,938	53,691	48,200	46,238	42,919
Toyama	Fabricated metal products	Transport and postal activities	Non-Ferrous metals	Electricity, Gas, and Heat supply	Education and Scienteific research
	101,837	97,402	93,216	86,766	80,761
Japan	Iron and Steel	Production machinery	Electronic parts	Chemical products	Electrical machinery
	2,933,415	2,846,876	2,460,180	2,239,688	1,908,771

Source: Fukui Prefecture [7]; Toyama Prefecture [8]; The Ministry of Internal Affairs and Communications of Japan [9].

3.4. Employment Induced by Final Demand

The inducement effect to employment for an industry can be calculated as follows:

= (the number of employees in each industry / each industry's domestic production) × production inducement for each industry.

= labor input coefficient in each industry × production inducement for each industry

The rate of the number of employees in each industry divided by each industry's domestic production is called "labor input coefficient". When labor input coefficient matrix is L,

$$L' = L[(I - (I - \widehat{M})A)^{-1}((I - \widehat{M})Fd + E)] \quad (19)$$

Here, L` is the inducement effect to employment. That is to say, this indicates the inducement effect to a sectors' employment by each final demand.

When seeing the inducement effect to employment by outflow and export, "Commerce" has the first position in all three areas, Fukui, Toyama, and Japan. Moreover, "Agriculture, forestry and fisheries" is ranked at the second in Fukui and Toyama. Moreover, the eighth rank is "Pulp, paper and wood products" in Fukui and "Chemical products" industry in Toyama. The industries' values of Fukui are generally smaller than those of Toyama. In particular, "Commerce" industry of Toyama even outnumbers that of Fukui and "Fabricated metal products" industry, too. However, "Textile mill products" industry's value of Fukui is much bigger than that of Toyama.

Table-7. Employment inducement effect by outflow and export (person)

	1	2	3	4	5
Fukui	Commerce	Agriculture, forestry and fisheries	Textile mill products	Professional and business services	Miscellaneous manufacturing
	22,613	21,828	20,017	12,253	10,866
Toyama	Commerce	Agriculture, forestry and fisheries	Fabricated metal products	Professional and business services	Transport and postal activities
	46,352	32,152	22,753	19,312	18,306
Japan	Commerce	Professional and business services	Transport and postal activities	Transportation equipment	Education and Scienteific research
	1,680,299	853,573	725,843	537,953	336,880

(continued)

	6	7	8	9	10
Fukui	Electronic parts	Transport and postal activities	Pulp, paper and wood products	Rubber and plastics product	Fabricated metal products
	10,796	8,866	5,531	5,087	4,057
Toyama	Personal services	Production machinery	Chemical products	Electronic parts	Rubber and plastics product
	12,246	12,129	11,844	11,411	11,034
Japan	Production machinery	Fabricated metal products	Agriculture, forestry and fisheries	Construction	Information and communications
	323,229	163,313	138,807	126,390	112,470

Source: Fukui Prefecture [7]; Toyama Prefecture [8]; The Ministry of Internal Affairs and Communications of Japan [9].

4. CONCLUSION AND DISCUSSION

This paper answers that the relationship between the two prefectures is about the same when seeing each industry's index of power of dispersion and index of sensitivity of dispersion. However, the values of the index of power of dispersion show some different industries in higher ranked industries, which have bigger economic effect. Moreover, "Information and communications" industry is ranked at the seventh in Fukui and "Iron and Steel" industry has the eighth position in Toyama. On the other hand, the index of sensitivity of dispersion's values indicate that the industries at higher rank have similarity though the rankings are somewhat different. Furthermore, "Finance and insurance" is ranked at the sixth in both Fukui and Toyama. "Real estate" industry has the seventh and the eighth position in Fukui and Toyama respectively. Seeing the production inducement effect of export and outflow to other prefectures, "Electricity, Gas, and Heat supply" is ranked as the first in Fukui prefecture. Toyama's the first rank industry is "Chemical products". They are outstanding. Japan's top five industries fairly differ from the industries of Fukui and Toyama. Additionally, when seeing the effect to employment, "Commerce" has the first position in three areas, Fukui, Toyama, and Japan. However, "Commerce" industry of Toyama even outnumbers that of Fukui and "Fabricated metal products" industry, too. On the other hand, "Textile mill products" industry's value of Fukui is much bigger than that of Toyama. Fukui and Toyama are in the same area, we call Hokuriku.

However, they don't necessarily have the same industrial structure. Finally, I would like to thank my laboratory undergraduate students, who helped me with calculating tables.

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