Measuring of interregional trade relations over the border

— an example of Hiroshima and Heilongjiang —*

By
Masaru ICHIHASHI†
Faculty of Integrated Arts and Sciences Hiroshima University

Abstract

It can be said that there are few studies of interregional multi-sectoral economic dependency between two regions over the border because useful statistical data is not available until today. Mutual dependency between domestic regions and foreign countries was usually measured by the special "*interregional*" or "*international*" Input-Output table.

This paper shows the simple measurement method and the application of the method for measurement of mutual dependency between two regions over the border without using an "interregional Input-Output table". It will show the characteristics of industrial structure of the two regions, which reflect economic dependency.

We hope this attempt is useful and lead to a kind of positive economic analysis for the current world situation of "globalization".

1 Introduction

They say that we live in *the borderless economy* and we talk very much about *the globalization* of our economy. However, it is not easy to measure the extent of globalization of economies utilizing various economic data and statistics.

Unfortunately, it can be hard to say that any economic index to measure this globalization is established. Besides, we don't know whether local companies' development around the country to seek more optimal conditions is essentially different from their development in foreign countries. Therefore, it is not clear what the term of 'globalization' shows and economic thinking about that is not still enough.

If an economic unit depends on other units more and more, somehow we need to establish the method to measure mutual dependency at first.

This paper aims to contribute to that purpose. In particular we'll suggest a simple method to estimate economic dependency between regions of two countries from separate Input-Output tables.

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† (E-mail) ichi@hiroshima-u.ac.jp, (URL) http://home.hiroshima-u.ac.jp/ichi/

Studies on the economic dependency of separate regions are done by Shishido [13], Shishido and Movchuk [14]. The characteristics of these analyses are the measurement of the mutual dependence between Niigata prefecture and other regions or a foreign country. Because data about prefecture trading is hardly served, even a measurement of dependency between domestic regions has been very hard to be accompanied. These precedent studies based on the Chenery model are more interesting in the point that can be measured by dependency between regions and with foreign countries. These studies could be valued as a regional economic analysis with limited data.

We'll measure mutual dependency between regions over the border by a similar method in this paper. We will examine multi-sectoral dependency between Hiroshima Prefecture and Chinese Heilongjiang Province this time.

This paper proceeds discussion by the following order.

Firstly we'll examine our methodology. We'll survey characteristics of Chenery model and discuss difference from a regional Input-Output table. Moreover, we'll describe the simple division method of export to foreign countries and domestic regions, import from foreign countries and domestic regions from a regional Input-Output table.

Secondly we'll examine industrial structures of Hiroshima Prefecture and Heilongjiang Province. We'll touch upon the data linkage method because data of China side were different from Japanese data, and we'll adjust mismatches of sector number.

Thirdly, we'll measure multi-sectoral economic dependency of Hiroshima Prefecture and Heilongjiang Province actually in accordance with above-mentioned preparations. We'll interpret the economic meaning from the measurement result successively.

Finally, we'll summarize and give some conclusions.

2 Analysis method

Incidentally, as a statistical data to measure economic dependency between countries or regions directly, interregional Input-Output table is well known. Of course, the purpose of this Input-Output table is to measure input-output relations between specific countries or regions directly. In other words, it is different from a usual Input-Output table of one economic space in a country and a region. It is a special Input-Output table that is going to see input-output situation of goods and services as one unit gathered up several countries or regions. Accordingly more large-scaled statistics investigation and processing than an Input-Output table of one country or one region are necessary.

However, we can say nothing in advance because the problem of which countries or regions should be selected for the table depends on purposes of analysis fundamentally. Because makers of the table (statistics bureau of a country and a local government) and users (researchers and ordinary people) are separated usually, countries or regions of the interregional Input-Output table are not always hoped. Input-Output table for countries or regions needed by users are not usually available.

If there is an interregional Input-Output table of countries and regions fitting to an analysis object, there is no problem. However, if there is not such a table, international and regional comparison is not feasible.

In this paper, we like to show a simpler method to measure a multi-sectoral economy dependency.

2.1 A hint from Chenery model

A typical model of interregional Input-Output analysis is Chenery model.

It is the model in which a trading coefficient between regions is constant, and the typical equation is as follows;[1].

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1 See Chenery [3] and Moses [9]. Besides,

$$X^* = SA^*X^* + SF_D^* + E^* - M^* \,. \tag{1}$$

Now, if we make this 3 interregional model, each term of above equation is shown as follows;

$$X^* := \begin{pmatrix} X^1 \\ X^2 \\ X^3 \end{pmatrix} = {}^t\left[X_1^1 X_2^1 \cdots X_n^1 X_1^2 \cdots X_n^2 X_1^3 \cdots X_n^3 \right], \tag{2}$$

$$F_D^* := \begin{pmatrix} F_D^1 \\ F_D^2 \\ F_D^3 \end{pmatrix}$$

$$= {}^t\left[F_{D1}^1 F_{D2}^1 \cdots F_{Dn}^1 F_{D1}^2 \cdots F_{Dn}^2 F_{D1}^3 \cdots F_{Dn}^3 \right]. \tag{3}$$

^{t} shows a transposed matrix.

S is an interregional trading coefficient matrix;

$$S := \begin{bmatrix} \hat{S}^{11} & \hat{S}^{12} & \hat{S}^{13} \\ \hat{S}^{21} & \hat{S}^{22} & \hat{S}^{23} \\ \hat{S}^{31} & \hat{S}^{31} & \hat{S}^{33} \end{bmatrix}. \tag{4}$$

Here,

$$\hat{S}^{kh} := \begin{bmatrix} S_1^{kh} & & 0 \\ & \ddots & \\ 0 & & S_n^{kh} \end{bmatrix}, \; k=1,2,3,\; h=1,2,3. \tag{4'}$$

$$S_i^{kh} := \frac{\sum_{j=1}^{n} x_{ij}^{kh} + F_{Di}^{kh}}{\sum_{j=1}^{n} a_{ij}^h X_j^h + F_{Di}^h} \tag{5}$$

S_i^{kh} shows the ratio (trading coefficient) of the *i*th goods and services that the *h*th region bought from the *k*th region, and $\hat{S}^{kh}$ becomes a diagonal matrix of the trading coefficient.

Besides,

$$A^* := \begin{bmatrix} A^1 & 0 & 0 \\ 0 & A^2 & 0 \\ 0 & 0 & A^3 \end{bmatrix}. \tag{6}$$

A^i, i=1,2,3 represents each element of the matrix is the input coefficient matrix of each region. This input coefficient matrix A^* is called the regional input coefficient matrix of complete decomposition type. Then SA^*, the product with the former trading coefficient matrix S, is called the interregional input coefficient matrix.

Imports and exports of this model is as follows;.

$$E^* := {}^t\left[E^1 E^2 E^3 \right],\; M^* := {}^t\left[M^1 M^2 M^3 \right]. \tag{7}$$

As mentioned above, since we made a 3 regions model, element numbers of each vector are $3n$, and element numbers of the trading coefficient matrix and the regional input coefficient matrix are $9n^2$.

Incidentally, if we assume that import from foreign countries changes in proportion to the interregional domestic demand in this model, it is as follows;

$$M^* = \hat{M}\left(SA^*X^* + SF_D^* \right). \tag{8}$$

Shown an element of $\hat{M}$ as m_i^h, it follows.

$$m_i^h := \frac{M_i^h}{\sum_{j=1}^{n} x_{ij}^h + F_{Di}^h}, \; h = 1, 2, 3\,. \tag{9}$$

M_i is the element of import from foreign countries vector M^h in the *h*th region, and F_{Di}^h is the *i*th element of final demand vector F_D^h in the *h*th region. From (1) and (8),

$$X^* = [I - (S - \hat{M}S)A^*]^{-1}[(S - \hat{M}S)F_D^* + E^*] \tag{10}$$

Then, equilibrium production X^* of the interregional Input-Output model are derived.

Now, which items can we obtain comparatively

Armington approach is known as another thinking that differentiates a supply place by origin, and it is adopted in CGE models. See Armington [2], and see Shoven & Whalley [17] about CGE model.

in above-mentioned Chenery model? All items except S will be available easily since X^*, A^*, F_D^*, E^*, M^* are constituted by data of each region. A problem is the interregional trading coefficient matrix S that is just the core part of Chenery model.

This data describes the ratio in interregional trading but a usual Input-Output table cannot give it.

There are statistics which show how much each country has import and export at present, but data which show how much each region has a transaction between regions or countries are not always prepared. In case of Japan, trade statistics exist, of course , but it becomes impossible to measure economic dependency by each region[2].

In particular because import and export to domestic regions, and to foreign countries are treated in the lump in an actual regional Input-Output table as mentioned above, a trading coefficient matrix between regions can be made only by original investigation of the statistics. Accordingly it may be said that there is a big limitation in comparing each region freely. Let us think about a simple calculation method successively in the following.

2.2 Import from foreign countries and domestic regions, and Export to foreign countries and domestic regions in the regional Input-Output table

Most of usual regional Input-Output tables in Japan are competitive import one. This is slightly different from the national Input-Output tables that are based on the following supply and demand balance equation.

$$X^h = AX^h + F_D^h + D^h + E^h - N^h - M^h . \tag{11}$$

X^h is the total output vector of the hth region. A is input coefficient matrix, F_D^h is final demand vector in the region. D^h is export to domestic regions vector of interregional trade, E^h is export to foreign countries vector, N^h is import from domestic regions vector of interregional trade, and M^h is import from foreign countries vector.

However, if we treat import and export to foreign countries and domestic regoins in a lump because of the constraint of data, it follows;

$$X^h = AX^h + F_D^h + T_O^h - T_I^h . \tag{12}$$

The amount of export to foreign countries and domestic regions is as follows;

$$T_O^h := D^h + E^h . \tag{13}$$

Furthermore, the amount of import from foreign countries and domestic regions is as follows[3];

$$T_I^h := N^h + M^h . \tag{14}$$

Here, if we assume that import from foreign countries and domestic regions is proportional to demand in the region, the next equation is provided.

$$N^h + M^h = \hat{T}_I^h (AX^h + F_D^h) . \tag{15}$$

$\hat{T}_I^h$ is a diagonal matrix by element t_{Ii}^h. Besides t_{Ii}^h is as follows.

$$. \tag{16}$$

2 About indication of problems of this inter-prefecture trade, refer to Shishido [13]. Besides, on real trade procedure, refer to Japan duty association [10].

3 Actually export to foreign countries and domestic regions is treated in a lump in the Input-Output table of Hiroshima Prefecture, for example, and import from foreign countries and domestic regions is treated in a lump, too. Hiroshima Prefecture used "industry statistics rearranging list" and "commerce statistics" published in order to make this import and export data to domestic regions, and the another had a special investigation of "inter-prefecture commodity distribution investigation" in September 1991. Besides, nothing is announced except the thing that these data are based on an investigation of Kobe customs for import and export to foreign countries. See Hiroshima Prefecture [5] Chapter 6.

T_{Ii}^h is the ith element of import from foreign countries and domestic regions vector T_I^h, and F_{Di}^h is the ith element of final demand vector F_D^h in the region.

Total output is same as Input-Output table of a country, which is assumed that import from foreign countries is proportional to domestic demand, is provided if we use (13), (14), (16).

$$X^h = [I-(I-\hat{T}_I^h)A^h]^{-1}[(I-\hat{T}_I^h)F_D^h + T_O^h]. \qquad (17)$$

2.3 Simple division method of import from foreign countries and domestic regions, and export to foreign countries and domestic regions

As had described in the beginning, multi-sectoral comparisons between regions over the border are attempted by Shishido [13], Shishido and Movchuk [14] already, but we use a trading coefficient in a different method from them here[4].

A rate of self-sufficiency in a domestic economy is as follows if we express the ith goods import share from foreign countries as m_i.

$$1-m_i$$

Using the former import from foreign countries and domestic regions equation (16), we can calculate the import rate from foreign countries of the region (hth region) as follows.

$$t_{Ii}^h m_i. \qquad (19)$$

Besides it is clear that import rate from other domestic regions is calculated as follows.

$$t_{Ii}^h(1-m_i). \qquad (20)$$

We can get the amount of import from foreign countries and the amount of import from domestic regions by the following approximate calculation from balance production (11). Then if we express each of import from foreign countries and domestic regions in a diagonal matrix now, it is as follows;

$$\hat{X}^h[\widehat{t_I^h m}] = \hat{\tilde{M}}^h. \qquad (21)$$

Then if we change $\hat{\tilde{M}}^h$ into a vector M^h, it is same as an import from foreign countries vector by (14). Besides in the same way,

$$\hat{X}^h[t_I^h(\widehat{1-m})] = \hat{\tilde{N}}^h. \qquad (22)$$

Here we change $\hat{\tilde{N}}^h$ into a vector N^h, too.

It is also possible to divide all exports to foreign countries and domestic regions in the same way. Export rate to domestic regions t_{Oi}^h is derived from the ith element of export to foreign countries and domestic regions vector T_O^h as follows[5];

$$t_{Oi}^h := \frac{T_{Oi}^h}{X_i^h}. \qquad (23)$$

Besides a definition of export rate of a country is

$$e_i := \frac{E_i}{X_i}.$$

Domestic export rate is

$$1-e_i.$$

4 They define trading coefficient by the next equation in 2 region model. The export ratio to foreign countries and domestic regions of the second regions is

$$\tau_i^{12} := \frac{D_i^{12}+E_i^1}{X_i^2}, \qquad i=1,\ldots,n. \qquad (18)$$

D_i^{12} represents ith goods export to domestic regions from the second region to the first region, and E_i^1 represents ith goods export to foreign countries of the first regions. X_i^2 is ith goods production in the second region.

However, the ratio of $\frac{E_i^1}{X_i^2}$ is unrelated to the second region. It is impossible to interpret it as export share of the second regions.

5 This rate is different from a case of import rate, and we assume that export rate is proportional to total output here.

Accordingly export rate to foreign countries of a concerned region is as follows;

$$t_{Oi}^h e_i \, . \tag{24}$$

Export rate to other domestic regions is as follows;

$$t_{Oi}^h (1-e_i) \, . \tag{25}$$

Accordingly approximate calculations of export to foreign countries and domestic regions follows

$$\hat{X}^h [\widehat{t_O^h e}] = \hat{\hat{E}}^h \, . \tag{26}$$

Then if we change $\hat{\hat{E}}^h$ into a vector E^h, it is an export vector by (13). In the same way,

$$\hat{X}^h [t_O^h \widehat{(1-e)}] = \hat{\hat{D}}^h \, . \tag{27}$$

Then we change $\hat{\hat{D}}^h$ into a vector D^h.

We were able to get four kinds of data (import from foreign countries and domestic regions, and export to foreign countries and domestic regions) from Input-Output table of the region.

By the way, generally each ratio provided from these calculations does not correspond to the former Chenery model.

The import and export are divided from them to domestic regions in Chenery model from the beginning, but the import and export to foreign countries and domestic regions coexist in a usual Input-Output table data. The method mentioned above is a calculation method to divide export to foreign countries and domestic regions, import from foreign countries and domestic regions indirectly[6].

Then, our method can measure import from foreign countries - domstic regions and export to foreign countries - domestic regions of between regions and countries in a different way from Chenery model. It is summarized as follows;

Self-sufficiency rate in the region:

$$\sigma_i^{11} = 1 - t_{Ii}^h \tag{28}$$

Import rate from the other regions :

$$\sigma_i^{21} = t_{Ii}^h (1-m) \tag{29}$$

Import rate in the region :

$$\sigma_i^{31} = t_{Ii}^h m \tag{30}$$

Besides, it is as follows[7].

Demand rate in the region :

6 For example, in a denominator of a trading coefficient equation in Chenery model (5), import and export to domestic regions part is contained, but they are not contained in denominator of our equation (16). In our method, it is assumed that the import rate from domestic regions is "proportional to demand in the region" same as a calculation of the import rate from foreign countries. Therefore our economic assumption is differet from Chenery model.

7 Self-sufficiency rate in the region and Demand rate in the region are similar concepts, but not the same. From a definition Self-sufficiency rate is as follows;

$$1 - t_{Ii}^h = 1 - \frac{T_{Ii}^h}{\sum_{j=1}^n x_{ij}^h + F_{Di}^h} = \frac{\sum_{j=1}^n x_{ij}^h + F_{Di}^h - N_i^h - M_i^h}{\sum_{j=1}^n x_{ij}^h + F_{Di}^h} \, ,$$

but Demand rate in the region is

$$1 - t_{Oi}^h = 1 - \frac{T_{Oi}^h}{X_i^h} = \frac{X_i^h - D_i^h - E_i^h}{X_i^h}$$

$$= \frac{\sum_{j=1}^n x_{ij}^h + F_{Di}^h - N_i^n - M_i^h}{X_i^h} \, .$$

In other words Demand rate in the region becomes small because of the influence of denominator if *net* export to foreign countries in the domestic regions is positive (they become equal in case that net export to foreign counties in the domestic regions is 0 and big in case that it is negative). Naturally this means that Self-sufficiency rate in the region from output included in export to foreign countries and domestic regions is different from the ratio except them.

$$\rho_i^{11} = 1 - t_{Oi}^h \quad (31)$$

Export rate to the other region :

$$\rho_i^{12} = t_{Oi}^h(1-e) \quad (32)$$

Export rate to foreign countries in the region :

$$\rho_i^{13} = t_{Oi}^h e \,. \quad (33)$$

The first region of superscript represents the *h*th region here, the second region represents the other domestic region, and the third region represents overseas[8].

3 Industrial structure of Hiroshima Prefecture and Heilongjiang Province

3.1 Characteristics of China side data

We observed that data of import and export of foreign countries and domestic regions in a domestic specific region (such as Hiroshima Prefecture) could be separated temporarily by the method described in a foregoing section, but this time we'll need to see characteristics of a counterpart region or country (such as Heilongjiang or China).

It is different from Input-Output table of Japan. In Input-Output table of China [4][8] and Heilongjiang Province [15][16] (both are SNA 1992 version), import and export to foreign countries or domestic regions are given by *het* concept. That means they are given as E–M or T_O–T_I. Accordingly, we cannot divide data by the same method mentioned in former section. So we want to adopt the following method here.

At first, how much is net export to foreign countries and domestic regions of Heilongjiang Province? Now net export share of China is assumed as follows[9];

$$\lambda_i := \frac{U_i}{X_i} \,. \quad (36)$$

Ui:=E_i–M_i is net export and X_i is total output of the *i*th goods (industry).

Then the estimate of net export is as follows if we express net export to foreign countries and domestic regions of the *i*th goods in the *k*th region (Heilongjiang Province) as V_i^k:=T_{Oi}^k–T_{Ii}^k.

$$\tilde{U}_i^k = V_i^k \lambda_i \,. \quad (37)$$

˜ represents the sign of estimate.

$$\begin{cases} \tilde{U}_i^k = 0 \ (V_i^k \geq 0, \lambda_i \leq 0) \\ \tilde{U}_i^k > 0 \ (V_i^k > 0, \lambda_i > 0) \\ \tilde{U}_i^k < 0 \ (V_i^k < 0, \lambda_i < 0) \\ \tilde{U}_i^k = 0 \ (V_i^k \leq 0, \lambda_i \geq 0) \end{cases}$$

Besides these signs are to be maintained[10].

Accordingly the estimate of net export to domestic regions in the *k*th region (Heilongjiang Province) follows;

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8 A difference with us and the model of former Shishido and Movchuk [14] is as follows.

If we calculate the trading coefficient τ_i^{12} in Shishido's (18) by our equation from (24) (25), the export rate to foreign countries from the second region to the first region follows;

$$t_{Oi}^2(1-e_i) = \frac{T_{Oi}^{12}}{X_i^2}\frac{X_i - E_i}{X_i} = \frac{D_i^{12} + E_i^2}{X_i^2}\frac{X_2 - E_i}{X_i} \,. \quad (34)$$

X_i and E_i respectively represent the output and export of the country. The 1st term on the right side of this equation corresponds to trading coefficient τ_i^{12} in (18). Export part of the numerator does not correspond to it precisely however.

Export of the second region is as follows in the same way.

$$t_{Oi}^2 \, e_i = \frac{T_{Oi}^{12}}{X_i^2}\frac{E_i}{X_i} = \frac{D_i^{12} + E_i^2}{X_i^2}\frac{E_i}{X_i} \quad (35)$$

9 We can also assume that net export is proportional to the domestic demand as the former import rate from foreign countries is, but we assumed it is proportional to the total output here.

10 We decided these signs by economic meaning from net export rate to foreign countries and domestic regions. Besides we can also get the estimate of rate if we divide both side by the total output.

Table 1 Table of integration of industry sector

Sector Name

Japan1990	Hiroshima1990	China1990	Heilongjiang1992	Integrated sectors 21
1 agriculture, forestry & fishing	1 agriculture, forestry & fishing	1 agriculture, forestry & fishing	1 agriculture, forestry & fishing	1 agriculture, forestry & fishing
2 mining	2 mining	2 coal mining 3 crude petroleum 4 metal ores 5 non-metal ores	2 coal mining 3 crude petroleum 4 metal ores 5 non-metal ores	2 mining
3 foods	3 foods	6 foods	6 foods	3 foods
4 fabricated textiles	4 fabricated textiles 5 wearing apparel 14 leather & fur products	7 fiber yarn 8 manufacture of wearing apparel & leather and fur	7 fiber yarn 8 manufacture of wearing apparel & leather and fur	4 fabricated textiles
5 pulp & paper	8 pulp & paper 6 timber & wood products 7 furniture & accessories	10 paper & educational articles 9 wood products & furniture	10 paper & printing 9 manufacture of furniture	5 pulp & paper
6 chemical	10 chemical	14 chemical	11 chemical	6 chemical
7 petroleum refinery products	11 petroleum refinery products	12 petroleum refinery products 13 coke & coal products	12 petroleum refinery products	7 petroleum refinery products
8 ceramic, stone & clay 10 non-ferrous metals	15 ceramic, stone & clay 17 non-ferrous metals	15 building materials & non-metallic products	13 building materials & non-metallic products	8 building materials & non-metallic products
9 iron & steel	16 iron & steel	16 primary metal manufactureing	14 primary metal manufactureing	9 iron & steel
11 metal products	18 metal products	17 metal products	15 metal products	10 metal products
12 genral machinery	19 genral machinery	18 genral machinery	16 genral machinery	11 genral machinery
13 electrical equipment	20 electrical equipment	20 electrical equipment	17 electrical equipment	12 electrical equipment
14 transportation equipment	21 cars 22 repair of ship 23 other transportation equipment	19 transportation equipment	18 transportation equipment	13 transportation equipment
15 precision equipment	24 precision equipment	21 electronic and communication equipment 22 meters & other measuring equipment	19 precision equipment	14 precision equipment
16 miscellaneous manufacturing	25 miscellaneous manufacturing 9 publishing & printing 12 plastic products 13 rubber products	23 repair of machinery and equipment 24 miscellaneous manufacturing	20 miscellaneous manufacturing	15 miscellaneous manufacturing
17 construction	26 construction	25 construction	21 construction	16 construction
18 electricity, gas & steam 19 water & other sanitary services	27 electricity, gas & steam 28 water & other sanitary services	11 electricity, gas & steam	22 electricity, gas & steam	17 electricity, gas & steam
20 commerce	29 commerce	27 commerce	23 commerce	18 commerce
23 transport 24 comunication & broadcasting	32 transport 33 comunication & broadcasting	29 passenger transport 26 freight transport & communications	24 passenger transport 25 freight transport & communications	19 transport & communications
21 finance & insurance	30 finance & insurance	32 finance & insurance	26 finance & insurance	20 finance & insurance
22 real estate 25 public administration 26 education & research institute 27 medical service & health 28 other public service 29 business services 30 personal services 31 office supplies 32 activities not elsewhere classified	31 real estate 34 public administration 35 education & research institute 36 medical service & health 37 other public service 38 business services 39 personal services 40 office supplies 41 activities not elsewhere classified	30 public utilities & services 31 education, research institute & medical 28 restaurants 33 public administration	27 other services	21 other services

$$\tilde{W}_i^k = V_i^k - \tilde{U}_i^k . \qquad (38)$$

A meaning of $\tilde{W}_i^k$ is $\tilde{W}_i^k = (\widehat{D_i^k - N_i^k})$. Then, we can separate net export to foreign countries and domestic regions by (37) and (38).

3.2 Integration of industrial sectors and a trade share to Heilongjiang

Because we use four Input-Output tables of Japan, Hiroshima Prefecture, China and Heilongjiang Province in this paper, we must solve non-correspondence of sector number. Here let us describe about integration of industrial sectors, and we used finally 21 sectors.

The table 1 shows sectors of each Input-Output table.

This table shows clearly sectors or industries have *characteristics* and are *growing* in the economic region of each Input-Output table. Sector contents of Input-Output table themselves characterize industry structure of each region.

For example, in case of Japan and Hiroshima Prefecture, the number of service sectors is many, but the service sectors of China and Heilongjiang Province are integrated into a few sector. This means that "service economy" has developed more in Japan. Further, in case of Hiroshima Prefecture, it is clear that industry sectors related to transportation equipment and miscellaneous manufacturing are subdivided, and these sectors characterize a production structure of Hiroshima Prefecture.

Mining industry sector is subdivided in Chinese side, and sectors related to energy such as coal mining and crude petroleum are key industries.

Moreover there are sectors such as ceramic and non-ferrous metals, electricity and sanitary services in Japanese side, but they are integrated in Chinese side.

Table 2 Japanese share (%) in the sum of import and export of Heilongjiang Province

1992 export	1992 import
12.022	5.714

Now we will link data of both, but multi-sectoral data to link international regions do not exist at present. Then we'll link both regions by the following procedures here.

At first, we assume a Japanese share in export of Heilongjiang Province and a Japanese share in the import from there to be constant γ^{Jk} and δ^{Jk} in all sectors[11]. A Japanese share in import and export of Heilongjiang Province in 1992 is shown in table 2 by Economic Research Institute for Northeast Asia [17][12].

We use the export share to foreign countries of table 2 for import of Hiroshima Prefecture side here, and the import share from foreign countries of the table for export.

Next, let us estimate the share of net export of Hiroshima Prefecture in Japanese total net export. It is the following equation.

$$v^{hJ} := \frac{\tilde{U}_i^h}{U_i} . \qquad (39)$$

Here[13],

$$v^{hJ} \begin{cases} > 0 & (\tilde{U}_i^h, U_i > 0, \tilde{U}_i^h, U_i < 0) \\ = 0 & \textit{the others.} \end{cases}$$

11 Using data on a Chinese share in import and export of Hiroshima Prefecture conversely, a similar procedure becomes possible. However, because it is hard to get the data from Hiroshima Prefecture, we used the procedure in the text.

12 Conversely, we can get Chinese share in the Japanese import and export from data of Ministry of Finance [12], but prefecture-wise import and export data does not exist.

13 Actually, a case of different sign may happen, but that case is 0 because the calculation has no meaning here.

4 Measurement results

4.1 Measurement method and the results

Now, preparations to estimate multi-sectoral dependency between Hiroshima Prefecture and Heilongjiang Province have been set. With an estimate value obtained by the method above, we'll calculate the amount of net export from Hiroshima Prefecture to Heilongjiang Province here, and seek for each share in net export of both regions[14]. An estimate of positive value represents export from Hiroshima Prefecture to Heilongjiang Province (import of Heilongjiang Province to Hiroshima Prefecture) here, and a negative value represents export from Heilongjiang Province to Hiroshima Prefecture (import of Hiroshima Prefecture from Heilongjiang Province).

The calculation equation is as follows;

$$\tilde{U}_i^{hk} = (\widetilde{E_i^{hk} - M_i^{hk}}) = \begin{cases} -\tilde{U}_i^k \delta^k v_i^{hJ} \geq 0, \ (\tilde{U}_i^k < 0) \\ -\tilde{U}_i^k \gamma^k v_i^{hJ} \leq 0, \ (\tilde{U}_i^k > 0) \end{cases} \quad (40)$$

$\tilde{}$ represents an estimate value, ^{k} of a superscript represents Heilongjiang Province and ^{h} shows Hiroshima Prefecture. δ^k is a Japanese share in import of Heilongjiang Province of table 2, γ^k is a Japanese share in export of Heilongjiang Province and v_i^{hJ} is the domestic share of net export of Hiroshima Prefecture by (39).

The results derived from this equation (40) are shown in table 3[15]. The mutual dependency between Hiroshima Prefecture and Heilongjiang Province and the share in each region are shown in the right side of this table.

14 From the amount of import and export of Hiroshima Prefecture, we can calculate dependence degree of Heilongjiang Province conversely. However, we did not calculate in this paper because the import and export share of Hiroshima Prefecture to China is unknown.

15 We accepted a exchange rate of 1 yuan=27.4454 yen in order to make a direct comparison possible.

4.2 Economic interpretation of the results

Table 3 shows a characteristic of the dependency of Hiroshima Prefecture and Heilongjiang Province.

Firstly, total net export between Hiroshima Prefecture and Heilongjiang Province was about 76 million-yen net export of Hiroshima Prefecture (negative net export of Heilongjiang Province).

This is only 0.03% of net export of Hiroshima Prefecture and 0.23% of negative net export of Heilongjiang Province.

Secondly, the biggest industry of Hiroshima Prefecture which imports from Heilongjiang Province was *foods*, and in value they amounted to 7.8 million yen. As Heilongjiang Province is generally known as the largest energy producing area in China, this result is a small suprise for us.

However, judging from net export to foreign countries and domestic regions of Heilongjiang Province of the left side of table 3, most of production by industry of this region (mainly, *crude petroleum and natural gas*, and *coal mining*) is transported to other Chinese regions. So only a few part is exported abroad directly.

Moreover, the net export industries in Heilongjiang Province were 3 industries of mining, foods, *petroleum refinery products*, and the single largest export industry was foods. Import industries of Hiroshima Prefecture were 12 industries including *agriculture, forestry and fisheries*, mining, foods and others, and foods is the fourth largest import industry. Because these factors influenced mutually, foods industry was thought to be the largest one.

Thirdly, however, shares of mining and petroleum products were bigger than foods in net export of Heilongjiang Province. They account for 0.32% and 0.35% of total exports respectively, and the absolute amounts were not so big. In other words, foods was the largest industry, but in terms of share to net export, mining and petroleum products were more important in Heilongjiang Province.

In the forth, the biggest exported industry

Table 3 Multi-sectoral economic dependency between Hiroshima Prefecture and Heilongjiang

Estimate Result Integrated Sectors 21	Heilongjiang(1 million yen) Estimate net export to foreign countries	Estimate net export to other domestic regions	The ratio to net export of China(%)	Hiroshima(1 million yen) Estimate net export to foreign countries	Estimate net export to other domestic regions	The ratio to net export of Japan(%)
1 agriculture, forestry & fishing	0.00	-9770.58	0.00	-48758.35	-225899.65	1.75
2 mining	28.94	530034.99	0.13	-204810.37	-45251.63	2.65
3 foods	4673.16	92002.63	0.01	-47946.78	140810.78	1.40
4 fabricated textiles	0.00	-98903.94	0.00	-20611.54	127321.54	1.68
5 pulp & paper	0.00	-28570.97	0.00	-12903.11	127902.11	1.08
6 chemical	-724.04	-101711.33	-0.01	-18003.06	-212018.94	0.00
7 petroleum refinery products	178.18	10763.39	0.01	-49066.13	-161515.87	2.95
8 building materials & non-metallic	0.00	-24755.30	0.00	-33642.14	511775.98	1.95
9 iron & steel	-15047.30	-87869.79	-0.02	58872.90	-4120.73	5.77
10 metal products	0.00	-15644.50	0.00	5687.80	30227.20	1.71
11 genral machinery	-10400.96	-63860.38	-0.01	141200.22	186375.78	3.06
12 electrical equipment	-3320.20	-69732.82	-0.03	28790.47	-285405.47	0.32
13 transportation equipment	-4761.72	-29028.18	-0.02	486212.38	592684.62	5.25
14 precision equipment	-323.63	-4905.89	0.00	1731.57	-19943.57	0.22
15 miscellaneous manufacturing	-2.01	-9919.72	-0.01	-19722.13	-110923.87	2.35
16 construction	0.00	0.00	0.00	0.00	0.00	0.00
17 electricity, gas & steam	0.00	6041.74	0.00	-20.09	-107853.91	0.00
18 commerce	-3011.35	-12087.53	0.00	18758.68	437069.32	1.07
19 transport & communications	0.00	-30140.25	0.00	29170.34	-6242.53	2.07
20 finance & insurance	0.00	0.00	0.00	-274.47	242539.10	0.08
21 other services	0.00	0.00	0.00	-16589.36	-132643.08	0.48
Total	-32710.95	51941.57	0.00	298076.85	1084887.15	7.00

(※) 1 yuan = 27.445384 yen

	The amount of economic dependence between Hiroshima-Heilongjiang	Estimate net export (1 million yen)	The ratio to Hiroshima(%)	The ratio to Heilongjiang(%)
1	agriculture, forestry & fishing	0.000	0.00	0.00
2	mining	-0.092	0.00	0.32
3	foods	-7.843	0.02	0.17
4	fabricated textiles	0.000	0.00	0.00
5	pulp & paper	0.000	0.00	0.00
6	chemical	0.000	0.00	0.00
7	petroleum refinery products	-0.631	0.00	0.35
8	building materials & non-metallic	0.000	0.00	0.00
9	iron & steel	49.591	0.08	0.33
10	metal products	0.000	0.00	0.00
11	genral machinery	18.191	0.01	0.17
12	electrical equipment	0.606	0.00	0.02
13	transportation equipment	14.281	0.00	0.30
14	precision equipment	0.040	0.00	0.01
15	miscellaneous manufacturing	0.003	0.00	0.13
16	construction	0.000	0.00	0.00
17	electricity, gas & steam	0.000	0.00	0.00
18	commerce	1.844	0.01	0.06
19	transport & communications	0.000	0.00	0.00
20	finance & insurance	0.000	0.00	0.00
21	other services	0.000	0.00	0.00
	Total	75.989	0.03	0.23

from Heilongjiang to Hiroshima Prefecture was *iron and steel*, and it amount to 49.6 million yen. Since the biggest export industry of Hiroshima Prefecture was *transportation equipment* and iron and steel was the third, this is also an unexpected result.

However, iron and steel is the biggest import industry of Heilongjiang Province, and transportation equipment is the third, in contrast to Hiroshima Prefecture. Besides the import from Hiroshima Prefecture is a 0.33% share in negative net export of Heilongjiang Province, and the biggest value in import industries. It is thought that our results reflected these relations.

According to Hiroshima Prefecture 1990 Input-Output table, the biggest export industry to foreign countries and domestic regions was transportation equipment, and its share in the total export to foreign countries and domestic regions of the prefecture was about 26.3%. The second one was iron and steel, and its share was about 13.1%. The transportation equipment industry of Hiroshima Prefecture exported 2 times of iron and steel[16]. When we got the estimate export and the share by the export share to foreign countries and domestic regions, the position of iron and steel fell down and *general machinery* became the second export industry. However, in relation to import of Heilongjiang Province,

16 In share in total output in the prefecture, the biggest one was trade and it was about 11.6%, and the second transportation equipment was about 11.5% of.

iron and steel is an important export industry.

In the fifth, though the largest export industry of Hiroshima Prefecture was transportation equipment, it was just the third export industry with relation to Heilongjiang Province. This is contrary to the fourth point. In total net export to Heilongjiang Province, it was around 14.3 million yen, but the share in net export to Heilongjiang Province was 0.3% and the second. It was bigger than general machinery.

In the sixth, 10 industries were involved in trading between Hiroshima Prefecture and Heilongjiang Province in this table.

Items mentioned above are an outline of characteristics of interrelationship.

5 Concluding remarks

We tried to estimate economic dependency between Hiroshima Prefecture and Chinese Heilongjiang Province by the indirect method.

If "world view" of economics reflects the real world fairthfully, it means that each region in the world is necessarily dependent on mutually. However, so long as we do not use the "special" Input-Output table made for certain specified regions like a Chenery model beforehand, it was impossible to measure multi-sectoral dependency between regions so far.

If there are Input-Output tables of each region and country and shares of mutual trade are shown, our method can measure economic dependency between any part of two regions, and so it will be useful. Because of statistical constraint, an example of measuring dependency between regions by a "simple method" like us is not found except studies by Shishido [13][14] until now. However, as for his method, the measurement of mutual dependency between a domestic regions or between domestic region and a foreign country was main subject, and then it was not the dependency between regions over the border as we have done. Besides, with regard to his coefficient of trade relation, we have got it by the method different from him.

The first point of limits and problems left to us is a problem of shares according to each country. In current Japanese foreign trade statistics, we cannot obtain multi-sectoral shares by countries corresponding to an Input-Output table. Besides we cannot have the import and export share to each country of domestic regions, too. So far, there is no way but waiting for preparations on statistics data in the future.

Secondly there is a methodological problem. First, in this paper, we got each net export of Hiroshima Prefecture and Heilongjiang Province. Next we got trade shares to Japan of Heilongjiang Province and domestic shares to Japan of Hiroshima Prefecture. Finally we got the amount of dependency between two regions from net export estimated of Heilongjiang Province.

However, if import and export shares to China of Hiroshima Prefecture is available, we will be able to get shares of Heilongjiang Province in China, and similar another calculation must be possible from net export of Hiroshima Prefecture. Of course, the result will be not necessarily same (but the sign will be opposite) at that time.

These are discrepancies from calculations by substitutional indirect methods after all because there is no data to show dependency among some regions with multi-sectors. It is an interesting problem to discuss how many discrepancies are on economic statistics, but that is be a problem left behind.

The third problem is that the data of China side are given only as "net export" (or "net export to foreign countries and domestic regions"). If these data were released in the form of import and export (to foreign countries and domestic regions) corresponding to the data of Japan, we may have made a little deeper analysis. If we analyze dependency utilizing data of other countries and regions of import and export extracted from, there will be some new findings.

Accordingly it will be the most important theme to show many positive examples by other domestic regions and other countries.

The attempt in this paper was a measurement of economic dependency between two regions over the border. After now, methods of positive economic analysis suitable for the current world situation of "globalization" will be necessary more and more.

We hope that our method is a useful attempt for that purpose.

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