18th International Input-Output Conference, Sydney, Australia, 20-25 June 2010

Interregional Virtual Water Trade in Japan: the applied idea to identify the characteristics of Virtual Water Trade using Input-Output Approach

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Abstract

The objective of this paper is to construct the methods and identify the characteristics of Japanese Virtual Water Trade, through applying various concepts and indicators derived from the input-output analysis. The interregional input-output table which is installed fresh water information by sector is employed to identify the characteristics of the Interregional Virtual Water Trade of Japan. We not only calculate the moving amount of virtual water, but we also define the Regional Balance of Virtual Water and Virtual Water Regional Trade Specialization Index.
Finally, water dependency and water contribution of each region is calculated and summarized in the map. The information that is obtained provides a sound basis for possible improvements of the water resource problem within regional environmental policy.

Keywords;
Interregional Input-Output Table, Interregional Virtual Water Origin-Destination Matrix, Regional balance of Virtual Water, Virtual Water Regional Trade Specialization Index, Japan

1. Introduction

The substantial preceding water resources studies implement virtual water movements in international trade. It is no doubt that these studies provide the valuable information to solve international water resources problem in many countries. However, there are a lot of concerns that one country itself has many regions, and these regions have different economy and environmental situations. These regional differences cause the

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different relationship of supply and demand of water resources, and the characteristics of virtual water trade among the regions become complicated. It is quite important to consider not only the balance of water resources in the whole country but also the regions.

This paper entails one of the steps to construct the methods and identify the characteristics of Virtual Water Trade. We employ the concepts and indicators derived from input-output analysis to carry out this comprehensive study, and the fresh water information by sector is modified for an input-output approach. The case is Japan, because of the availability of water accounts.

There is little research which applies water information to an interregional input-output framework. Some of the oldest research is that of Carter and Ireri (1970), which constructed water information for California-Arizona input output table to identify the movement of water resources in these 2 areas. Recently, Hatano and Okuda(2004) studied virtual water movement in China using interregional input-output table. Okuda, Suzuki, and Hatano (2005) had two points time series study of virtual water movement in China between 1997 and 2000. Guan and Hubacek (2007) also studied the virtual water trade in China. Okadera, Watanabe and Xu (2005) studied water demand and pollutant in the city of Chongqing in China using a regional input-output table. In Japan, Okadera, Fujita, Watanabe, and Suzuki (2005) studied water demand situation in Kanto area, which are Ibaraki, Tochigi, Saitama, Chiba, Tokyo and Kanagawa using regional input-output table.

In Japan, Fukuishi (2009a) is the first study which considers all regional area and interregional virtual water trade in Japan. This study updates and expands Fukuishi (2009a)'s data and methodology to accomplish the objective of this paper.

2. Methodology

The regional balance of water resources in this study is shown in Figure 1. The significant point of this balance is to separate water demand into Real water demand and Virtual water demand. Real water demand is the water demanded for real water to produce a good or service and to supply household use. On the other hands, virtual water demand is the water demand of virtual water which is included in import or domestic import goods. It is considered that regional economy and households demand virtual water because of the traditional trading theory such as comparative advantage or the limitation of regional water resource. Thus, the water demand consists of real water

demand and virtual water demand.
These 2 kinds of water are demanded by regional economy and household, and some goods which are provided in this regional economy are exported to other countries or regions. This export good may become virtual water demand for some other regions.

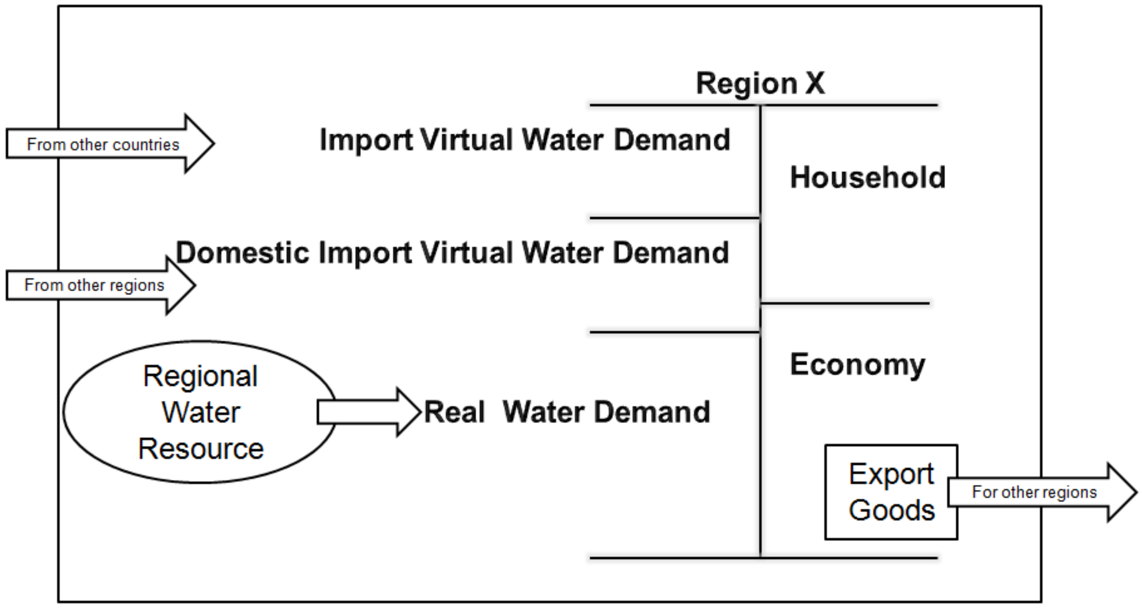

Figure 1 The Regional Balance of Water Resources

Ministry of Economy, Trade and Industry in Japan had constructed Interregional Input-Output Table every 5 year since 1960. However he stopped constructing 2000 Interregional Input-Output Table because of the rationalization of duties and early publication of statistics. In this situation, Arai, S. and Arakawa, S. (2006) challenged to construct 2000 Interregional Input-Output Table and opens the data in public. This study uses Arai et al. (2006)'s 2000 Interregional Input-Output Table and installs fresh water information to this table.
The regional classification of 2000 Interregional Input-Output Table is shown in Table 1. There are 9 regions in this table, Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku, Kyusyu and Okinawa. The range of regions comes from the administration classification. Tohoku has 6 prefectures. Kanto has 10 prefectures. Chubu has 5 prefectures. Kinki has 7 prefectures. Chugoku has 5 prefectures. Finally, Kyusyu has 7 prefectures. Hokkaido and Okinawa have only one prefecture.

Table 1 The Regional Classification of 2000 Interregional Input-Output Table

Regions	**The range of regions**
Hokkaido	Hokkaido
Tohoku	Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima
Kanto	Ibaraki, Tochigi, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Yamanashi, Nagano, Shizuoka
Chubu	Toyama, Ishikawa, Gifu, Aichi, Mie
Kinki	Fukui, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
Shikoku	Tokushima, Kagawa, Ehime, Kochi
Kyusyu	Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima
Okinawa	Okinawa

Source: Arai et al. (2006)

This study reconstructed the structure of Interregional Input-Output Table to appropriate style for the purpose of analysis. And, fresh water information by sector is constructed and installed to this new modified table. The new model for virtual water trade is shown in Figure 2.

The methodology to construct fresh water information by sector comes from Fukuishi (2009a, 2009b and 2010). These three previous studies have the fresh water matrix, which is divided into three sectors such as waterworks, industrial waterworks and others. The “others” part includes all fresh water except that of waterworks and industrial waterworks. However, this study constructed only the total fresh water information of these three sectors, because of the limitation of availability of water account of each region. It is quite difficult to collect the water accounts of prefectures and regions because of the problems of personal security.

This paper provides 3 sectors classification in each region such as primary sector, secondary sector and tertiary sector for the purpose of this study.

			Intermediate sector											Final demand			Export			Import			CT
			Hokkaido			Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa	Hokkaido	~	Okinawa	Hokkaido	~	Okinawa	Hokkaido	~	Okinawa	
			1	~	52																		
Intermediate Sector	Hokkaido	1																					
		~																					
		52																					
	Tohoku																						
	Kanto																						
	Chubu																						
	Kinki																						
	Chugoku																						
	Shikoku																						
	Kyusyu																						
	Okinawa																						
Value added	Wage and Salary																						
	~																						
Control Total																							

Fresh water information by sector

Figure 2 2000 Interregional Input-Output Table with Fresh water information by sector

Note:

1. The regional classification follows Table 1.

The basis analysis method of this study comes from Carter and Ireri (1970) and Fukuishi (2009a). First, the formula of inducement effect from final demand is shown in below.

$$\mathbf{X=(I-(I-M)A)^{-1}((I-M)FD+E)} \qquad \text{Equation 1}$$

X is the control total vector. **I** is unit matrix. **M** is import coefficient matrix. **A** is input coefficient matrix. **FD** is final demand matrix. **E** is export vector.

This study applies fresh water coefficient (Fresh Water intensity) of Fukuishi (2009a, 2009b and 2010). The fresh water coefficient of industrial sector *j* (w_j) is calculated by total fresh water amount of industrial sector *j* (W_j^T) and Control total of industrial sector of industrial sector *j* (X_j). These have the following relationship.

$$w_j = \frac{W_j^T}{X_j} \qquad \text{Equation 2}$$

This fresh water coefficient is installed in Equation 1. Then we can get the following formula.

$$\mathbf{W^T=w(I-(I-M)A)^{-1}((I-M)FD+E)} \qquad \text{Equation 3}$$

$\mathbf{W^T}$ is the vector of total amount of fresh water. **w** is fresh water coefficient vector. Equation 3 is capable of calculating the fresh water amounts which are induced by final demand of one region. This final demand spreads to the other regions and induces some sectors. This detail of inducement effects of each region is also capable of identifying the analysis results of Equation 3. This Equation is capable of calculating the virtual required water[2], when import coefficient matrix is 0. The vector of virtual required water of each region $\mathbf{W^{IM}}$ has the following formula. **IM** is import vector.

$$\mathbf{W^{IM}=w(I-A)^{-1}IM} \qquad \text{Equation 4}$$

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[2] Virtual Required Water is the additional fresh water use when the country provides import goods domestically.

The analysis results of the movements of virtual water are reconstructed to the regional balance of virtual water, which applies balance of payments in international economy. This balance is capable of identifying a favorable or unfavorable balance of virtual water trade of each region in compared with some regions.
In addition to this method, this study applies the trade specialization index to identify the specialization of regional virtual water trade. The formula of virtual water regional trade specialization index is shown in below.

$$\text{Virtual Water Regional Trade Specialization Index} = \frac{\text{Virtual Water Regional Export} - \text{Virtual Water Regional Import}}{\text{Virtual Water Regional Export} + \text{Virtual Water Regional Import}}$$

Equation 5

When this index is +1, one region only exports virtual water to another region. There is no import of virtual water from another region in the region. When this index is 0, the amounts of import and export of virtual water from one region to another region are the same. When this index is -1, one region only imports virtual water from another region. There is no export of virtual water from another region in the region.

Finally, this study draws the map of water dependency versus water contribution. This method applies Hatano and Okuda (2004). The example is shown in Figure 3. X-axis shows the water contribution, which is the percentage of export part of virtual water provided in one region. Y-axis shows the water dependency, which is the percentage of import part of virtual water demanded in one region. From the map, the points above 45 degree slopes show the degree to which how much one region depends on the other regions. The points below 45 degree slopes show the degree to which how much one region contributes to the other regions.

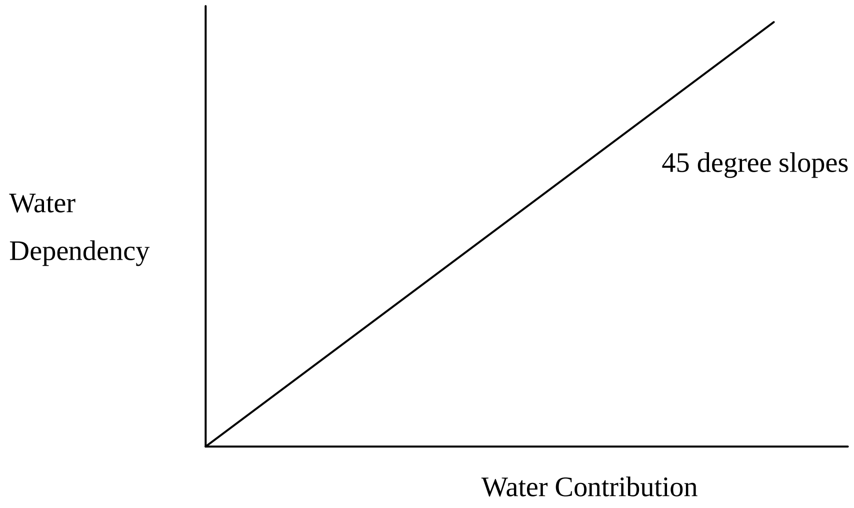


Figure 3 The map of water dependency versus water contribution

3. Analysis Results

This section shows the results of analyzing 2000 Interregional Input-Output Table with fresh water information of Japan. Firstly, the amounts of interregional virtual water trade (Interregional Virtual Water Origin-Destination Matrix) are calculated. Secondly, the regional balance of virtual water is constructed from the results of first analysis. Thirdly, Virtual Water Regional Trade Specialization Index is constructed from the results of first analysis. Fourthly, the map of water dependency versus water contribution is drawn. Fifthly, water demand for each region which includes real water demand and virtual water demand is identified from the analysis results. Finally, the relationship with water supply potential and demand for each region is identified. This study set 2 patterns of water supply potential information. One is average year water supply. Another is water shortage year.

Table 2 shows the results of the amounts of interregional virtual water trade (Interregional Virtual Water Origin-Destination Matrix). The huge movements of virtual water concentrate into Kanto region. The virtual water from Tohoku is 5.9 billion m^3. That from Hokkaido is 3.9 billion m^3. Chubu and Kyusyu have the same amount of 1.8 billion m^3. Kanto also has huge demand inside itself. Virtual water also concentrates into Kinki region. The virtual water from Kanto is 2.0 billion m^3. That from Tohoku is 1.5 billion m^3. Hokkaido is 1.2 billion m^3. However, there is huge gap between Kanto and Kinki.

From the result of the amounts of interregional virtual water trade, the economically developed regions such Kanto and Kinki are the center of virtual water trade. Especially, Kanto region gathers tremendous amounts of virtual water from the other regions of Japan.

Table 2 Interregional Virtual Water Origin-Destination Matrix

Unit: Billion m³		Destination								
		Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Origin	Hokkaido	7.2	0.8	3.9	0.7	1.2	0.3	0.1	0.6	0.0
	Tohoku	0.8	6.5	5.9	0.8	1.5	0.4	0.3	0.7	0.1
	Kanto	0.7	1.3	13.6	1.7	2.0	0.6	0.3	1.0	0.1
	Chubu	0.2	0.3	1.8	2.9	1.0	0.2	0.1	0.4	0.0
	Kinki	0.2	0.2	1.3	0.5	3.4	0.3	0.2	0.4	0.0
	Chugoku	0.1	0.2	1.3	0.4	0.8	2.0	0.2	0.6	0.0
	Shikoku	0.1	0.1	0.6	0.2	0.5	0.2	0.8	0.2	0.0
	Kyusyu	0.2	0.3	1.8	0.4	1.2	0.7	0.2	4.6	0.1
	Okinawa	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.4

Note:

1. The regional classification follows Table 1.

2. Some $0m^3$ results come from round off.

Table 3 shows the results of the regional balance of virtual water. This balance is capable of identifying a favorable or unfavorable balance of virtual water trade of each region in compared with some regions. In the last row of the table 3, Hokkaido region (5.5 billion m^3) and Tohoku region (7.3 billion m^3) have huge favorable balance of virtual water. Especially, there are huge unfavorable balances with Kanto region. There is 3.2 billion m^3 favorable balance from Hokkaido to Kanto. That from Tohoku to Kanto is 4.6 billion m^3. On the contrary, the results of Total of Kanto and Kinki region have huge unfavorable balances: Kanto region with -9.0 billion m^3 and Kinki region with -5.2 billion m^3.

Table 3 Regional Balance of Virtual Water

Unit: Billion m³		Self-region								
		Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Origin And Destination	Hokkaido	0.0	0.0	-3.2	-0.5	-1.1	-0.2	-0.1	-0.4	-0.0
	Tohoku	-0.0	0.0	-4.6	-0.5	-1.3	-0.2	-0.2	-0.4	-0.1
	Kanto	3.2	4.6	0.0	0.2	-0.7	0.7	0.2	0.8	-0.0
	Chubu	0.5	0.5	-0.2	0.0	-0.4	0.1	0.1	0.0	-0.0
	Kinki	1.1	1.3	0.7	0.4	0.0	0.5	0.3	0.9	0.0
	Chugoku	0.2	0.2	-0.7	-0.1	-0.5	0.0	0.0	0.1	-0.0
	Shikoku	0.1	0.2	-0.2	-0.1	-0.3	-0.0	0.0	-0.0	-0.0
	Kyusyu	0.4	0.4	-0.8	-0.0	-0.9	-0.1	0.0	0.0	-0.1
	Okinawa	0.0	0.1	0.0	-0.0	-0.0	0.0	0.0	0.1	0.0
	Total	**5.5**	**7.3**	**-9.0**	**-0.7**	**-5.2**	**0.9**	**0.4**	**1.0**	**-0.2**

Note:

1. The regional classification follows Table 1.

2. Some $0m^3$ results come from round off.

Table 4 shows the results of Virtual Water Regional Trade Specialization Index which is calculated by Equation 5. The elements in the principal diagonal become 0. From the results, the regional combinations amounting close to 1 are marked by Hokkaido and Kinki (0.78), Tohoku and Kinki (0.75), Tohoku and Okinawa (0.74) and Hokkaido and Kanto (0.69). There are some one-way virtual water trading in Kanto and Kinki.

Table 4 Virtual Water Regional Trade Specialization Index

		Destination								
		Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Origin	Hokkaido	0	0.00	0.69	0.59	0.78	0.41	0.49	0.58	0.66
	Tohoku	0.00	0	0.64	0.48	0.75	0.35	0.43	0.39	0.74
	Kanto	-0.69	-0.64	0	-0.05	0.20	-0.35	-0.25	-0.28	0.06
	Chubu	-0.59	-0.48	0.05	0	0.29	-0.25	-0.21	-0.06	0.14
	Kinki	-0.78	-0.75	-0.20	-0.29	0	-0.48	-0.47	-0.53	-0.13
	Chugoku	-0.41	-0.35	0.35	0.25	0.48	0	-0.05	-0.06	0.46
	Shikoku	-0.49	-0.43	0.25	0.21	0.47	0.05	0	0.04	0.09
	Kyusyu	-0.58	-0.39	0.28	0.06	0.53	0.06	-0.04	0	0.32
	Okinawa	-0.66	-0.74	-0.06	-0.14	0.13	-0.46	-0.09	-0.32	0

Note:

1. The regional classification follows Table 1.

2. Some $0m^3$ results come from round off.

The map of water dependency versus water contribution is drawn in Figure 4. From the result, there are Kanto, Chubu and Okinawa which locate above 45 cross slope. Especially, Kanto and Okinawa are far from 45 cross slope. On the contrary, there are Hokkaido and Tohoku which locate below 45 cross slope. This result is similar with the results of Regional balance of virtual water and Virtual Water Regional Trade Specialization Index.

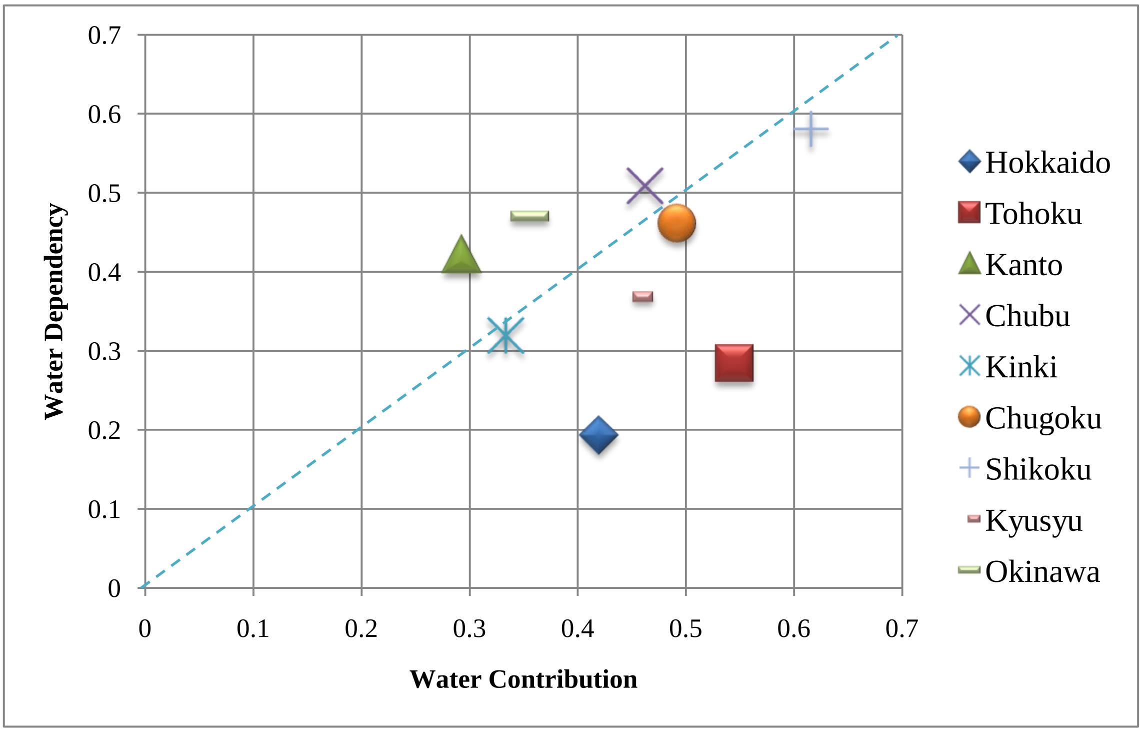


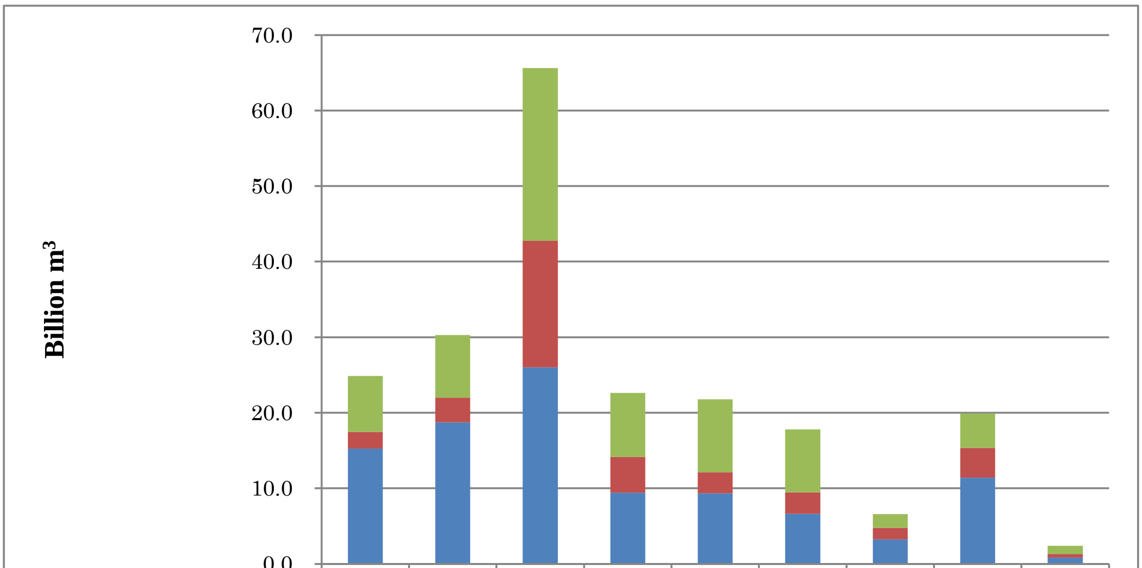
Figure 4 The map of water dependency versus water contribution

Note:

1. The regional classification follows Table 1.

These analysis results belong to domestic import virtual water demand in Figure 1. The total of real water demand and virtual water demand is the potential water demand of each region. Import Virtual Water Demand is calculated by Equation 4. This result is shown in Figure 5.

The top region is Kanto (65.7 billion m^3). This region is by far bigger than the other regions. Tohoku (30.4 billion m^3), Hokkaido (24.8 billion m^3) and Chubu (22.7 billion m^3) are followed.



	Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Import Virtual Water Demand	7.4	8.3	22.9	8.5	9.7	8.4	1.8	4.5	1.1
Domestic Import Virtual Water Demand	2.2	3.3	16.8	4.8	2.8	2.8	1.5	3.9	0.5
Real Water Demand	15.3	18.7	26.0	9.4	9.3	6.6	3.3	11.4	0.8

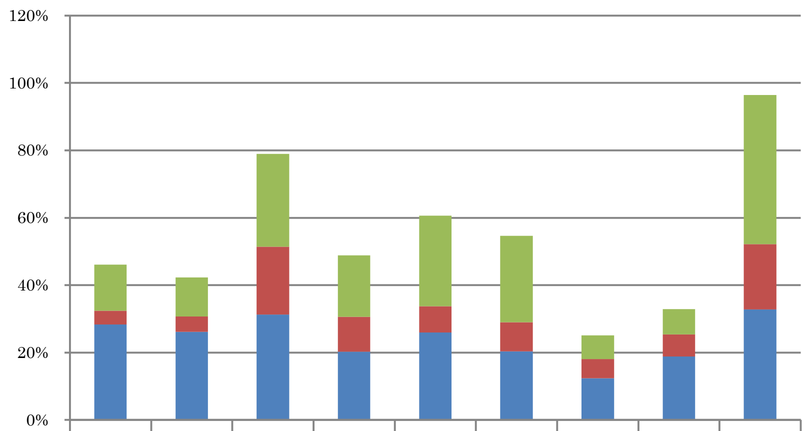
Figure 5 Water Demand of each region

Note:

1. The regional classification follows Table 1.

Ministry of Land, Infrastructure, Transport and Tourism, Water Resources Department in Japan government provides the statistics of water resources of each region. This is the supply side of water resources, and there are 2 types of supply potential data. One is average water resources amount. The other is water resources amount in water shortage year.

Figure 6 shows the relationship with water supply and demand for each region. The water supply potential is average water resources amount. The y-axis of this bar graph shows the percentage of water demand when maximum water supply potential is 100%. Okinawa is the region which accounts for the nearest 100%. Next nearest one is Kanto. Kinki and Chugoku are followed. Okinawa and Kanto have the biggest percentage. Especially, Okinawa has 63% virtual water demand and this is the top percentage in all regions. It is considered that Okinawa is the region which consisted of a lot of small islands. This region does not have the capability to produce all goods needed. Therefore this region needs to import substantial goods from the other regions and international import. The other regions except Okinawa and Kanto account for 40% through 60%.



	Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Import Virtual Water Demand	14%	12%	27%	18%	27%	26%	7%	8%	44%
Domestic Import Virtual Water Demand	4%	5%	20%	10%	8%	9%	6%	7%	19%
Real Water Demand	28%	26%	31%	20%	26%	20%	12%	19%	33%

Figure 6 The Relationship with Water Supply potential and Demand of each region (Average year)

Note:

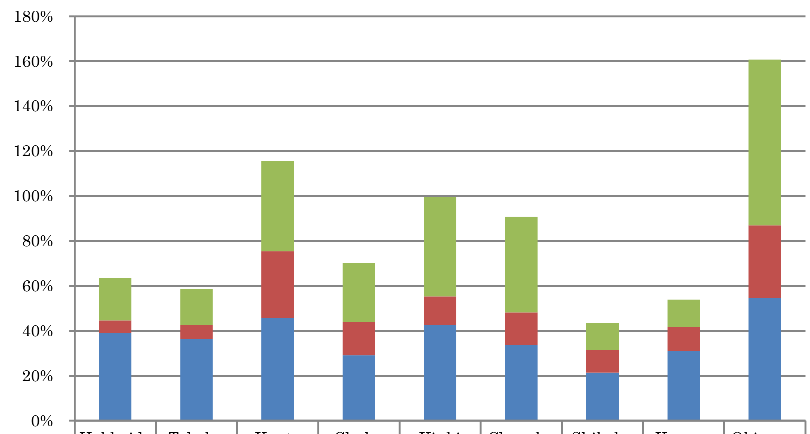
1. The regional classification follows Table 1.

2. The percentage of maximum water supply potential of average year in each region is 100% in the y-axis.

Figure 7 shows the relationship with water supply potential and demand of each region. The water supply potential is water resources amount in water shortage year. The y-axis of this bar graph shows the percentage of water demand when maximum water supply potential is 100%.

In water shortage situation, Okinawa and Kanto becomes excess demand. Especially, Okinawa has 60% over water supply. The supply and demand of Kinki is almost balanced. The demand of Chugoku accounts for 90% of maximum water supply potential.

Actually, each region has small effects of water shortage. However, when we consider the virtual water demand, it is impossible for three regions to fulfill total water demand. And, Chugoku is also in difficult situation to allocate water resources correctly.



	Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyusyu	Okinawa
Import Virtual Water Demand	19%	16%	40%	26%	44%	43%	12%	12%	74%
Domestic Import Virtual Water Demand	6%	6%	30%	15%	13%	14%	10%	11%	32%
Real Water Demand	39%	36%	46%	29%	43%	34%	21%	31%	55%

Figure 7 The Relationship with Water Supply potential and Demand of each region (Water shortage year)

Note:

1. The regional classification follows Table 1.

2. The percentage of maximum water supply potential of water shortage year in each region is 100% in the y-axis.

4. Conclusion

The objective of this paper is to construct the methods and identify the characteristics of Virtual Water Trade using the concepts and indicators derived from input-output analysis.

Firstly, the amounts of interregional virtual water trade (Interregional Virtual Water Origin-Destination Matrix) are calculated. Secondly, the regional balance of virtual water is constructed from the results of first analysis. Thirdly, Virtual Water Regional Trade Specialization Index is constructed from the results of first analysis. Fourthly, the map of water dependency versus water contribution is drawn. From the analysis results, the characteristics of interregional virtual water trade become cleared. And it is considered that input-output approach is one of the ideal ways to analyze virtual water trade.

The analysis results also clear the relationship with water supply potential and demand of each region. When the water supply potential is average water resources amount, all regions fulfill water demand in their water resources. However, when water shortage situations come, it is impossible for three regions such as Okinawa, Kanto and Kinki to fulfill water demand. And, Chugoku is also in difficult situation to allocate water resources correctly.

It is often said Japan is water-abundant country, and there is no fear of a shortage of fresh water. However, from this study, it is obvious that virtual water demands contribute to save water resources and prevent critical water shortage situation in some regions of Japan. Especially, virtual water of international trade has important roles. Japan government needs to consider water resources strategy when international import becomes small in the near future, especially agricultural goods. The relationship with water supply and demand is totally different in each region. The methodology and analysis results of this study may have valuable information to construct future blue print of water resources strategy.

Acknowledgement

This paper was supported by Graduate School Doctorate Student Aid Program 2009, Keio University.

References

Arai, S. and Arakawa, S. (2006) "2000 Input-Output Tables for basic price and 2000 Inter-regional Input-Output Tables" Pan Pacific Association of Input-Output Studies The 17th Conference, Okinawa International University, October 28-29, 2006, Japan. (in Japanese)

Carter, H. O. and Ireri, D. (1970) "Linkage of California-Arizona input-output models to analyze water transfer patterns." In *Applications of input-output analysis. Proceedings of the fourth international conference on input-output techniques, Geneva, 8–12 January 1968. Published in honor of Wassily Leontief*, Vol. 2, edited by A. P. Carter and A. Brody. Amsterdam: North-Holland Publishing Company.

Fukuishi, H. (2009a) "The Construction and Problems of Water Use Regional Input-Output Table of Japan" Pan Pacific Association of Input-Output Studies The 20th Conference, Sun-refre Hakodate October 31-November 1, 2009, Japan. (in Japanese)

Fukuishi, H. (2009b) "Water use in the Japan economy in 2000: an input-output approach" 17th International Input-Output Conference, 2009, Brazil, Sao Paulo.

Fukuishi, H. (2010) "The Construction and Problems of Water Use Input-Output Table of Japan –Inducement Effects of Fresh Water Use-" *Business Journal of PAPAIOS Input-Output Analysis -Innovation & I-O Technique-*, pp. 57-73. (in Japanese)

Guan, D.B., and Hubacek, K. (2007) "Assessment of regional trade and virtual water flows in China" *Ecological Economics*. 61, pp. 159–170.

Hatano, T. and Okuda, T. (2004) "Virtual water analysis using provincial level multi-regional input-output tables in China –Focus on the yellow river basin-" *Japan Society of Civil Engineers*, Vol. 32, pp. 1-9. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism, Water Resources Department. (2008) "Water Resources in Japan", Saiki Printing Co., Ltd. (in Japanese)

Okadera, T., Fujita, T., Watanabe, M., and Suzuki, Y. (2005) "The System of Environmental Loads Emission Inventory for Basin and Watershed Management – the casestudy of water demand in Tokyo Bay Basin Area -" *Environmental System Research*. Vol.33, pp. 377-387. (in Japanese)

Okadera, T., Watanabe, M., and Xu, K. (2005) "Analysis of water demand and water pollutant discharge using a regional input–output table: An application to the City of Chongqing, upstream of the Three Gorges Dam in China" *Ecological Economics* Volume 58, Issue 2, 15 June 2006, pp. 221-237.

Okuda, T., Suzuki, T. and Hatano, T. (2005) "Virtual water analysis comparing at two points in time one China by using multi-regional tables" *Japan Society of Civil Engineers*, Vol. 33, pp. 141-147. (in Japanese)