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EVALUATION OF INTER-REGIONAL ECOLOGICAL RUCKSACK IN THE TWO BASINS IN CHINA BY MEANS OF INTERINDUSTRIAL ANALYSIS

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Abstract

This study attempts to evaluate socio-economical impacts due to consumption of resources and energy with rapid industrialization in East Asia by means of Environmental Accounting System and to discuss about sustainable industrial transformation. Firstly, this paper reviews the unbalance growth between regions In China and regional environmental problems. Secondly, it highlightens the valley of Changjiang and Zhujiang with Open Economic Zones in Coastal Delta and Backward Basins in China. In addition, it calculate environmental load (i.e. Sulfur oxide and COD) induced by inter-transaction of goods and services in these basins by using the Inter-regional input-output analysis. As a result, environmental load in the areas of upper stream is induced by the Inter-regional activities between the areas of down stream.

KEYWORDS: *East Asia, Sustainable industrial transformation, Interregional input-output analysis, Ecological Rucksack*

1. Introduction

When thinking of existing environmental problems, economic activities have to be considered. The contemporary socio-economic system consists of energy consumption and the product consequently produced under such a system or production process has the possibility of destroying the nature and hence affecting human being.

In the developing countries, especially Asia, serious industrial pollution and Environmental problems have occurred along with a rapid economic growth that has caused a serious damage to the people. Furthermore, industrial pollution and environmental problems of these developing countries are not domestic and are spreading to other neighboring countries. It is apprehended that massive influence in terms of economic growth, energy stabliliy supply etc, is exerted to the whole world. Hence, needs to reform to a sustainable socio-economic system. China has achieved an astounding economic growth through an effective and efficient industrial centralization on the eastern side.

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Furthermore the Industrial structure in the coastal area is shifting to service Industry, hence initiating the move of material and assembly industry to western and central area in China. This unbalanced allocation has a possibility of generating environmental load on the western side. Regarding these circumstances the concept of the relationship between regional industrial structure and environment is shown in Fig1.

Hence, the evaluation of the impact to the environment by Inter-regional metabolism based socio-economic development is necessary. Furthermore the author has tried to focus on the socio-economic and environmental effects caused by a transformation to a sustainable industrial transformation policy. In China this paper tries to highlight on two basins, Changjiang (which has Shanghai) and Zhujiang (which has Guangdong Province) in the delta, and tries to calculate the environmental load (i.e. Sulfur oxide and COD) induced by the inter-transaction of goods and services in these basins through the Inter-regional input-output analysis.

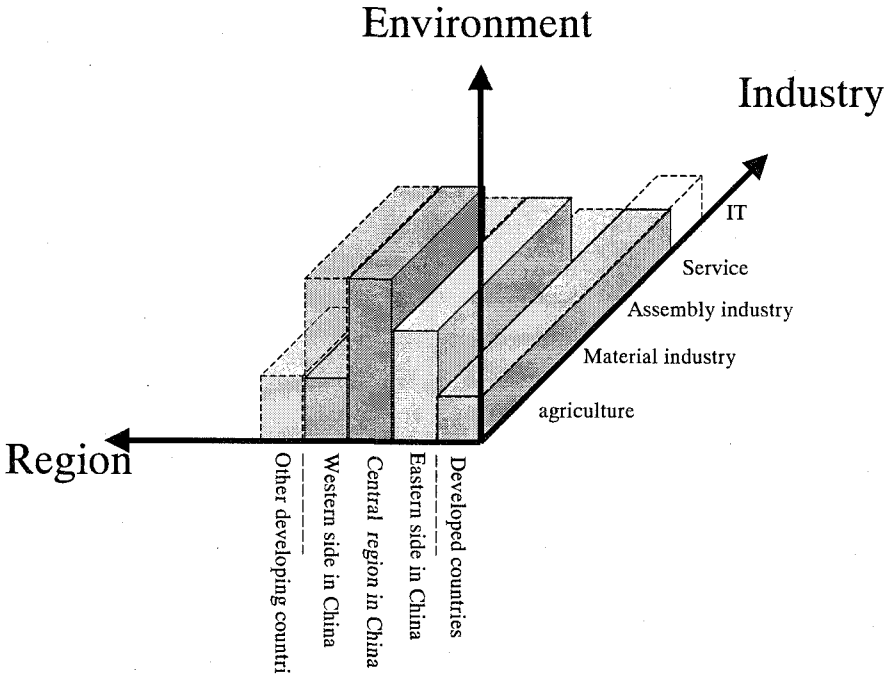

Fig1. The concept of the relationship between regional Industrial structure and environment

2. Methodology

2.1 Preparation of the inter-regional input-output tables in Changjiang and Zhujiang

Two inter-regional input-output tables are made for analysis in Changjiang and Zhujiang by using three inter-industry relations tables: the regional input-output table in Shanghai city [1992], the

regional input-output table in Guangdong Province [1992] and the Inter-regional input-output table in China [1992].

a) Introduction of input-output table in China used in this study

The inter-regional input-output table in China[1992] has 7 regions: Northeast China region, North China region, East China region, South China region, Central China region, Northwest China region and Southwest region, and 9 industrial sectors: agriculture, primary energy sector, material industrial sector, the second energy sector, assembly industrial sector, construction, transportation/communication, commerce and service. This table has been estimated from inter-industry relations table in China [1992] by Zili Chen[1999]. However, China has no official inter-regional I-O table at present and it is reliable in this study.

The regional input-output table in Shanghai city [1992] is published by Shanghai Statistics Bureau and has 125 industrial sectors. The other side, the regional input-output table in Guangdong Province [1992] is published by Guandong Statistics Bureau and has 119 industrial sectors. Moreover in the inter-regional I-O table Shanghai is including in East China and Guangdong is in South China respectively.

Table1. Summary of I-O table in China in this study

Name	The inter-regional I-O table in China	The regional I-O table in Shanghai city	The regional I-O table in Guangdong Province
The source	Zili Chen[1999]	Shanghai Statistics Bureau[1995]	Guangdong Statistics Bureau[1995]
Year	1992	1992	1992
Area division	Northeast China, North China, East China, South China, Central China, Northwest China, Southwest China	Shanghai	Guangdong
Industrial sector	9 sectors	125 sectors	119 sectors

b) The classification of areas and industrial sectors

Classification of the areas and industrial sectors is done on the basis of the classification of the inter-regional input-output table in China [1992]. The object basins are classified into 4 areas: the downstream area, the middle-stream area, the upstream area and out of the basin. The detail of the 4 areas in Changjiang and Zhujiang are shown in Table 2. The inter-regional input-output table in Zhujiang excludes Hong Kong because the data of the input structure between Hong Kong and each region in China was not available. Additionally, Sichuan Province and Guizhou Province, which are basically included in Changjiang, in the upstream area are included in Zhujiang, because these Provinces are a part of the Southwest China region in the area classification of the inter-regional input-output table in China [1992] and separation of those Provinces was not possible. Thereupon, it is supposed that in the input-output table in Zhujiang, each Province inside the Southwest China region has the same economic structure.

Table2. The classification of areas in Changjiang and Zhujiang

Changjiang Basin	
Downstream	Shanghai
Middle-stream (East China)	Jiangsu Province Zhejiang Province
Upstream (Central China)	Shanxi Province, Henan Province, Anhui Province, Hunan Province, Hubei Province, Jiangxi Province
Out of the basin	the Rest of China (R.O.C.)
Zhujiang Basin	
Downstream	Guangdong Province
Middle-stream (South China)	Fujian Province, Hainan Province
Upstream (Southwest China)	Sichuan Province, Guizhou Province, Yunnan Province, Guanxi Zhuangzu Zizhiqu, Xizang Zizhiqu
Out of the basin	the Rest of China (R.O.C.)

Fig2. Classification of area and relative locations of Chanjian and Zhujiang

Industrial sectors are classified into 9 groups: agriculture, primary energy sector, material industrial sector, the second energy sector, assembly industrial sector, construction, transportation/communication, commerce and service. At the same time, Industrial sectors of the regional input-output table in Shanghai city or Guangdong Province are integrated to 9 sectors as shown in table3.

Table3. Classification of Industrial sector

Industrial sector of Inter-regional I-O table [1992]	The regional I-O table in Shanghai city [1992]	The regional I-O table in Guangdong Province [1992]
Agriculture	Agriculture to cultivate farms for food, Agriculture to cultivate farms for others, Forestry, Livestock farming, Other agriculture, Fishery	Agriculture to cultivate farms for food, Agriculture to cultivate farms for others, Forestry, Livestock farming, Other agriculture, Fishery
Primary energy	Coal/Brown coal, Dressing coal, Crude oil Product, Natural gas	Coal/Brown coal, Dressing coal, Crude oil Product, Natural gas
Material industry	Iron ore mining, Non-ferrous metal mining, Gravel/Rubble and other non-ferrous metal mining, Salt refining, Timber and bamboo processing, Water supply, Food oil processing, Meet processing, Egg/ milk products processing, Marine products processing, Sugar refining, Other food, Alcoholic drinks, Other drinks, Tabacco, Feed, Cotton spinning Industry, Fur spinning Industry, Hemp spinning Industry, Silk spinning industry, Knit products, Other spinning Industry, Sewing industry, Clothing Industry, leather industry, Furniture and other wooden products, Pulp and Paper, Printing, Educational articles	Iron ore mining, Non-ferrous metal mining, Gravel/Rubble and other non-ferrous metal mining, Salt refining, Timber and bamboo processing, Water supply, Food oil processing, Meet processing, Egg/ milk products processing, Marine products processing, Sugar refining, Other food, Alcoholic drinks, Other drinks, Tabacco, Feed, Cotton spinning Industry, Fur spinning Industry, Hemp spinning Industry, Silk spinning industry, Knit products, Other spinning Industry, Sewing industry, Clothing Industry, leather industry, Furniture and other wooden products, Pulp and Paper, Printing, Educational articles
Second energy	Electric power/ Heat supply, Oil products, Coke, Coal gas/Coal Products	Electric power/ Heat service, Oil products, Coke, Coal gas/Coal Products
Assembly industry	Basic chemical materials, Chemical fertilizer, Chemical pesticide, Organic chemical products, Chemical products	Basic chemical materials, Chemical fertilizer, Chemical pesticide, Organic chemical products, Chemical products

(Continued)	for daily use, Synthetic chemical materials, Other chemical industry, Medicine, Chemical fiber, Rubber products for manufacture, Rubber products for daily use, Plastic products for manufacture, Plastic products for daily use, Cement, Cement products and special cement, Bricks/Tiles/Lime and other building materials, Glass products, Ceramics, Fire-clay products, Other Non-metallic mineral products, Iron and Steel, Non-ferrous metal, Metallic products for manufacturing, Metallic products for daily use, Boiler and Turbine, Metal processing machinery, Special industrial machinery and equipment, Agricultural/Forestry/animal husbandry machinery, Machinery for daily use, Other special industrial machinery, Other machinery, Railway transport machinery, Automobile, Passenger car building, Ship building, Vehicle building, Other transport machinery, Electric generating and electric machinery, Electric machinery for daily use, Other electric machinery and parts, Electronic computer, Electronic equipment for daily use, Television, Other electronic equipment, Electronic parts, Communication machinery, Other measuring utensil, Precision machinery, Repair of machinery, Other manufacturing goods for manufacture, Other manufacturing goods for	for daily use, Synthetic chemical materials, Other chemical industry, Medicine, Chemical fiber, Rubber products for manufacture, Rubber products for daily use, Plastic products for manufacture, Plastic products for daily use, Cement, Cement products and special cement, Bricks/Tiles/Lime and other building materials, Glass products, Ceramics, Fire-clay products, Other Non-metallic mineral products, Iron and Steel, Non-ferrous metal, Metallic products for manufacturing, Metallic products for daily use, Boiler and Turbine, Metal processing machinery, Special industrial machinery and equipment, Agricultural/Forestry/animal husbandry machinery, Machinery for daily use, Other special industrial machinery, Other machinery, Railway transport machinery, Automobile, Ship building, Vehicle building, Other transport machinery, Electric generating and electric machinery, Electric machinery for daily use, Other electric machinery and parts, Electronic computer, Electronic equipment for daily use, Other electronic equipment and Communication machinery, Precision machinery, Repair of machinery, Other manufacturing goods for manufacture Other manufacturing goods for daily use, Waste disposal

(Continued)	daily use, Waste disposal	
Construction	Construction	Construction
Transportation/ Communication	Railway transportation, Road transportation, Water transportation, Air transportation, Pipeline, Communication	Railway transportation, Road transportation, Water transportation, Air transportation, Pipeline, Communication
Commerce	Commerce	Commerce
Service	Rest of industrial sectors	Rest of industrial sectors

c) Preparation procedural flow of the inter-regional input-output table in Changjiang and Zhujiang

The pattern of inter-regional input-output table is shown in Table4. This table has 4 parts to estimate the inter-regional I-O table in Changjian and Zhujiang. Domain (1) is composed of intermediate demand and final demand without outflow and inflow of the regional input-output table in Shanghai city or Guangdong Province. Domain (2) is composed with the part where outflow sector of the regional input-output table in Shnanghai city or Guangdong Province is distributed to Middle-stream, Upstream and Out of the basin. Domain (3) is composed with the part where inflow sector of the regional input-output table in Shnanghai city or Guangdong Province to each region. Domain (4) is the estimated part from the input coefficient of inter-regional input-output table [1992].

Table4. The pattern of Inter-regional input-output table in the objective basins

	Downstream	**Middle-stream**	**Upstream**	**Out of basin**
Downstream	**(1)**		**(2)**	
Middle-stream				
Upstream	**(3)**		**(4)**	
Out of basin				

At first, Gross Regional Product (GRP) of each Industrial sectors in each region was calculated using the inter-regional I-O table in China [1992], the regional I-O table in Shanghai city [1992] and the regional I-O table in Guangdong Province [1992] as a basis. The GRP of Downstream is the integrated value of Industrial sectors in the regional I-O table in Shanghai City or Guandong Province[1992] integrated. The GRP of Upstream and Out of basin is the value of the inter-regional I-O table in China[1992] basically. The one in middle-stream is estimated from the difference between the inter-regional I-O table and the regional I-O table in Shanghai city or Guangdong Province. If the Gross Regional Product of a sector became a minus value by the difference of data source, the industrial output of each area was modified by statistics data on the basis of Gross Regional Product of Shanghai or Guangdong Province.

Secondly, the cargo traffic ratio between each area was calculated using "the cargo statistical table between provinces through the nation railroad" and was distributed the total product of outflow or inflow of each industrial sector of the input-output table in Shanghai and Guangdong Provnce to each

area by the ratio. The input to each area that is calculated this way depends on the production or input structure in each area, and it is distributed to intermediate input division, final demand division and value added division. After that, the intermediate demand (input) and final demand in Shanghai and Guangdong Province are modified.

Finally, the total of intermediate demand or input of each industrial sector in Middle-stream, upstream and out of basin from the Gross Regional Product of each sector calculated previously is estimated, on the basis of the inter-regional input-output table in China[1992]. The intermediate input was calculated with RAS by using the input coefficient of the inter-regional input-output table in China[1992]. Regarding the final demand and the value added, they are distributed on the basis of the inter-regional input-output table in China too. Import and export to each area industry is allotted on the basis of the inter-regional input-output table in China. Moreover concerning the input coefficient of the Middle-stream, it may not reflect the actual Industrial structure because it is estimated on the basis of input coefficient of inter-regional I-O table in China [1992]. This has been largely due to the availability of data regarding I-O table to the author and hence input coefficient has been as explored before. However, it has been thought that this factor has no effect on the outcome of the thesis.

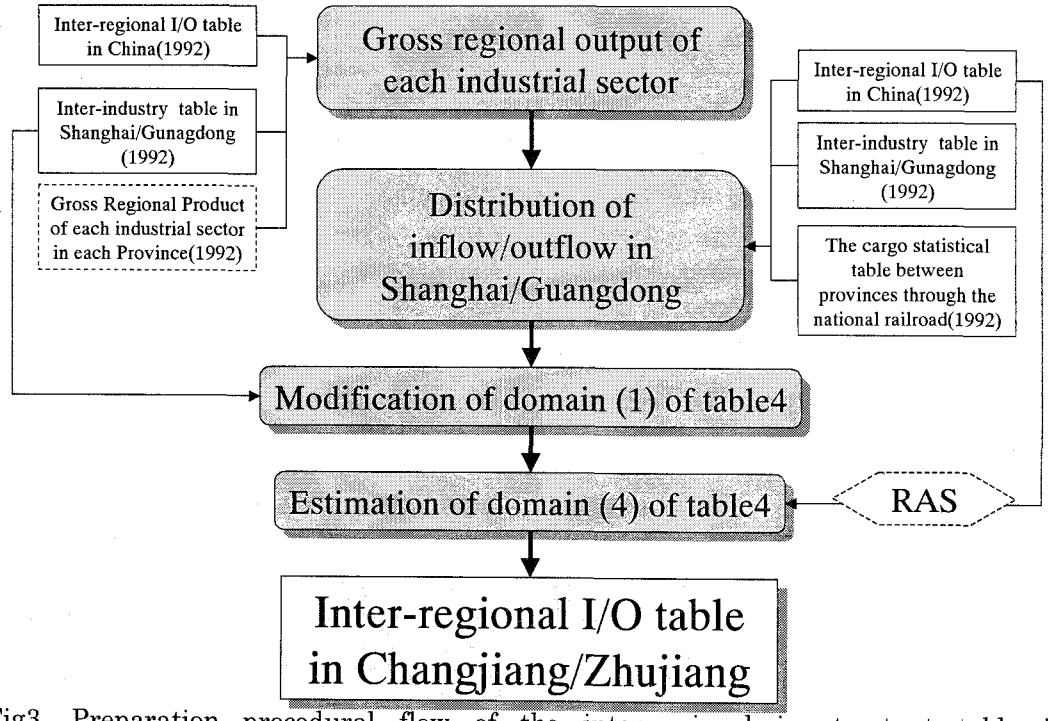

Fig3. Preparation procedural flow of the inter-regional input-output table in Changjiang and Zhujiang

2.2 Estimation of emission factor

In this study, SO_X is dealt which is the indicator of air pollution. COD, which is index of water pollution as the environment load is also dealt with. The emission factor of industrial sector in each area in China is estimated by using the data of the environment load discharge quantity in terms of the industrial sector in Japan as a basis, because of unavailability of data. Regarding the data of environmental load in China, "China Environment Yearbook" has been published annually since 1990 and lots of reports are available. "China Environment Yearbook" is composed of data on waste gas, waste water and solid waste and a part of it has regional waste data or Industrial waste data. However, regarding regional data, no regional waste data of each Industrial sector is available. Furthemore, the data of "China Environment Yearbook" has accumulated the data of emission from each company in China, but the companies are a part of all companies in China and the raw output of those companies is indistinct. That's the reason why it is difficult to calculate the emission factors with these data. The calculation flow of the base environment load discharge quantity of such a policy is shown in Figure4. This flow is based on the Industrial emission factor in Japan, so the estimated emission factor may be smaller than the real emission factor in China. However, the total of industrial emission volume of SO_x or COD in China is taken as a constant in calculative process and is distributed to each region with the discharging share of SO_X and COD in each area, which is originally statistic data of China. Therefore no hindlance is expected when considering the induced structure with the inter-regional induced share of SO_X and COD, though the inter-regional induced volume may be smaller than the actual volume.

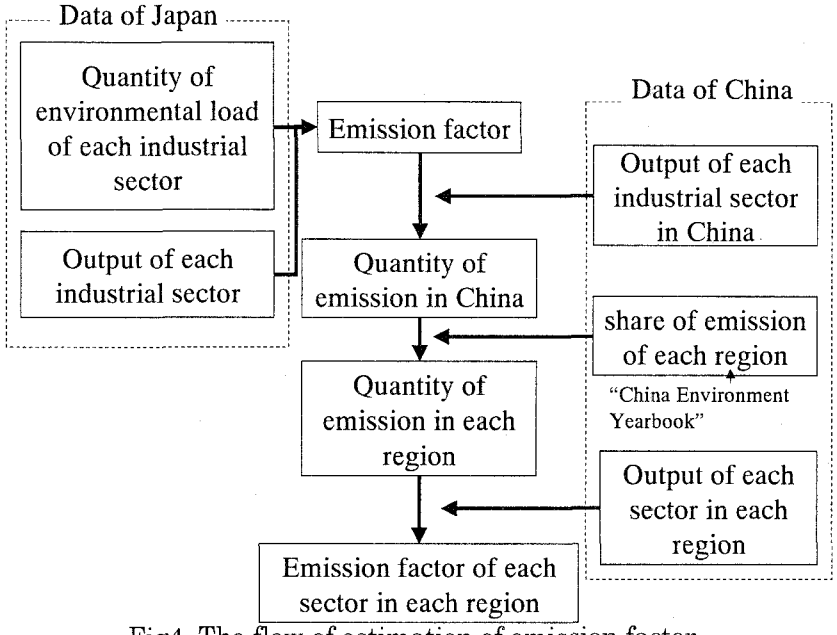

Fig4. The flow of estimation of emission factor

2.3 Calculation of the induced environmental load by using inter-industry analysis

Induced environmental load is calculated by applying an inter-industry analysis model regarding the structure of induced environment load associated with the interdependence between the regions. At first Leontief Inverse matrix is calculated from the inter-regional input-output table in Changjiang or Zhujiang. It is and then multiplied by the diagonal matrix of the final demand of each industrial sector in each region from the right and the one of emission factor of each industrial sector in each region from the left. Finally the matrix of Figure 5 is obtained. The value, "$d_i b_{ij} f_j$", of i column and j row show the environment load quantity that is induced with industrial sector i originated from final demand f_j of industrial sector j. In other words, we can study the total and itemization of the environmental load quantity that is induced finally with industrial sector i when we see this matrix towards row, and the total and itemization of the environment load quantity that industrial sector j induces finally when we see it toward column. Furthermore, in this analysis we can grasp the inducement structure of the industrial union in terms of each area because the inter-regional input-output table is used.

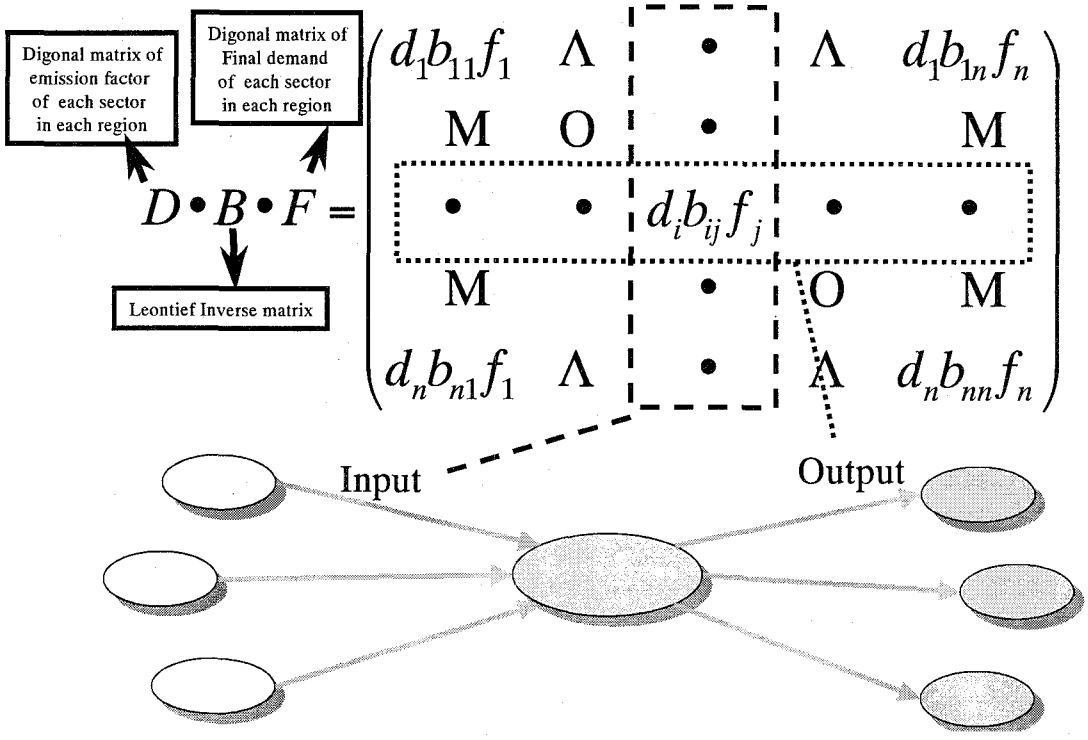

Fig5. Calucuration of induced environmental load

3. The structure of indeced environment load in Changjiang and Zhujiang valley

3.1 Comparative analysis of the structure of induced SO_X in Changjiang and Zhujinag valley

The total of induced SO_X and the inducement proportion to the interior and exterior in the object basins are shown in Figure 6 and Figure 7 respectively. In the total of induced quantity in each area, the ratio induced into the interior is shown with positive value, and the ratio induced outside is shown with negative. In Changjiang basin, the ratio of SO_x that Shanghai induces to other areas is high, and it induces 51.7% of the total induced SO_x to the exterior. Besides, the rate of SO_X the each area without Shanghai induces to outside is 20.1% in East China region, 12.1% in Central China region and 2.8% in the rest of China. On the other hand, in Zhujiang basin, the proportion of SO_X that Guangdong Province and South China region, which is the hinterland of Guangdong Province, induces to the other region is high, and individually Guangdong induce 61.8% of induced to the outside, South China region induces 66.1%. In both basins the induced SO_X quantity is increasing from downstream to upstream. The share of induced SO_X from the down and middle stream area to out of the basin is high, but the share of SO_X that the upstream area or out of the basin induces to outside is low. Additionally the share of the induced SO_X to out of the basin in Zhujiang basin is higher than one in Changjiang basin.

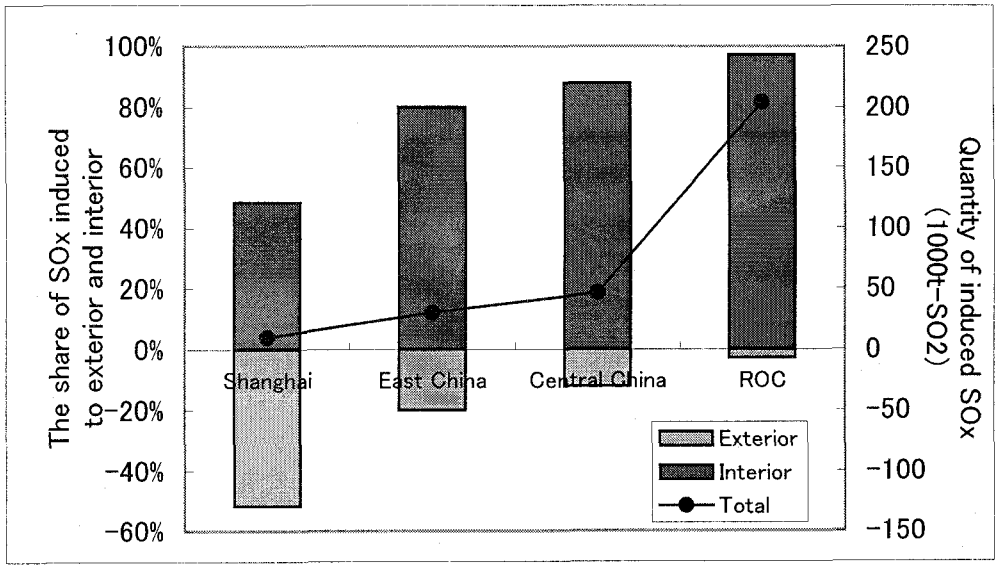

Fig6. The quantity of induced SOx and the share induced to exterior and interior in Changjiang

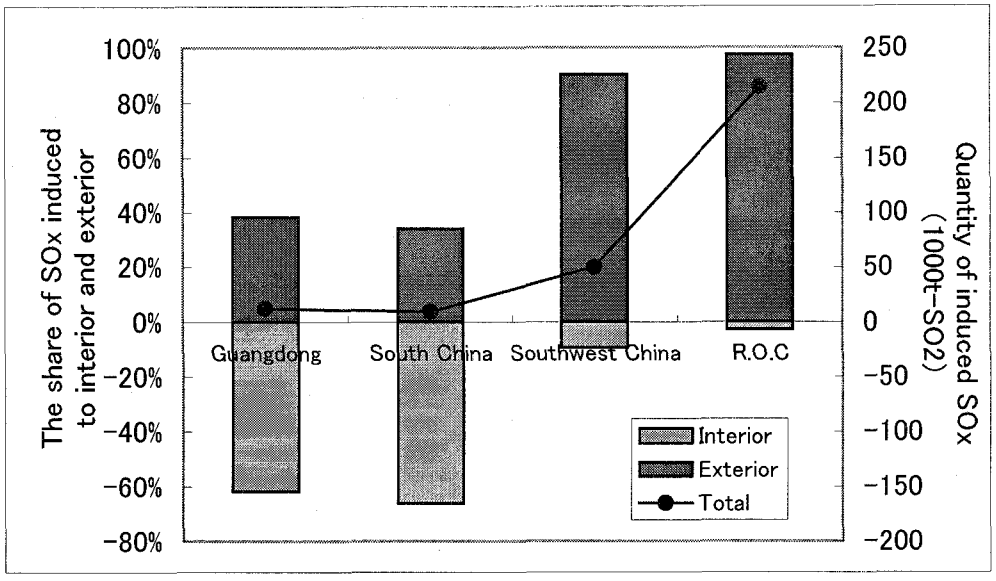

Fig7.The quantity of induced SO_X and the share of induced to exterior and interior in Zhujiang

The quantity and the regional itemization of SO_X that each area induces to outside in object basins is shown in Figure 8 and Figure 9. In Changjiang, the quantity of SO_X that Shanghai induces to East China region and that East and Central China region induces to the rest of China are big. On the other hand, in Zhujiang, the quantity of SO_X that Guangdong Province, South and Southwest China region induce to the rest of China and that the rest of China induces SO_X to Southwest China region is large. Thus, we can consider that Changjiang has the structure that SO_X is induced from downstream to out of the basin via upstream, while Zhujiang has the one that SO_X is induced to out of the basin and from out of the basin to upstream.

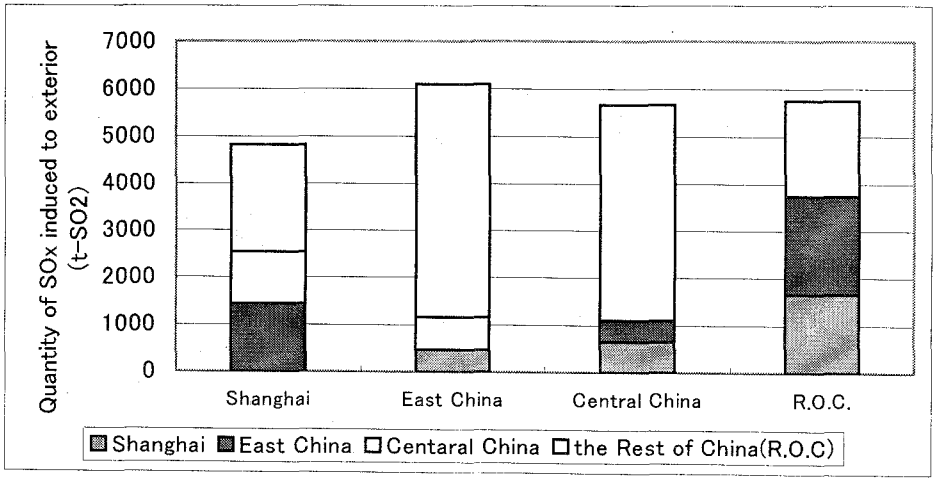

Fig8. The quantity of SO_X induced to exterior in Changjiang

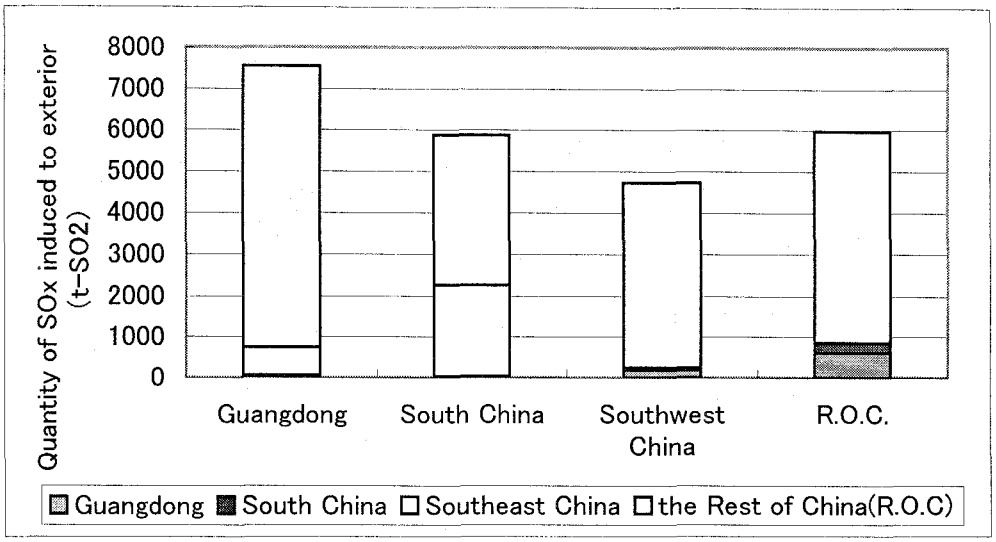

Fig9. The quantity of SO_X induced to exterior in Zhujiang

The share of SO_X that each area induces to industry in other areas is shown in Figure 10 and Figure 11. The share of SO_X that each area induces to the second energy sector in outside is generally high in Changjiang. It's also characteristic that the inducement to the agriculture and material industries is bigger gradually across downstream. On the other hand, in Zhujiang it is characteristic that the quantity of induced SO_X to assembly industries outside from Guangdong Province, to second energy sector and transportation/communication outside from South China region and to second energy sector outside from Southwest China region. to area outside of the area outside, are large.

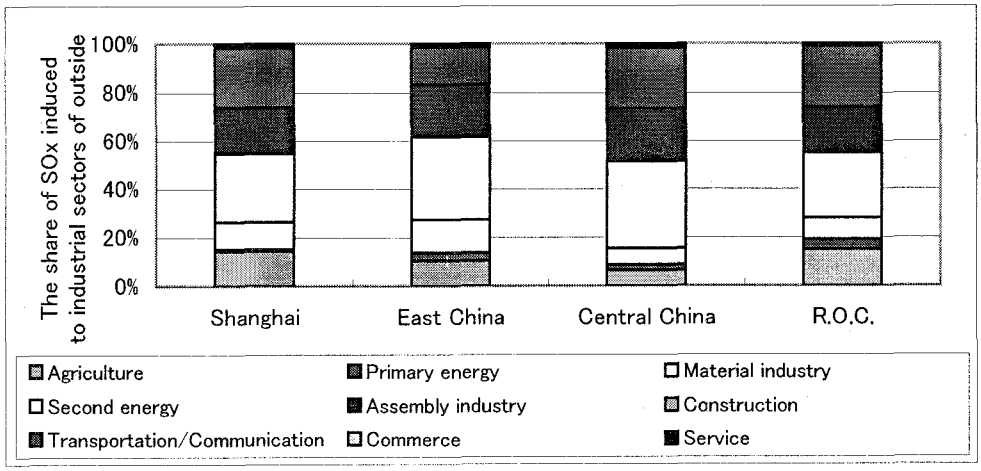

Fig10. The share of SO_X induced to Industrial sectors of outside in Changjiang

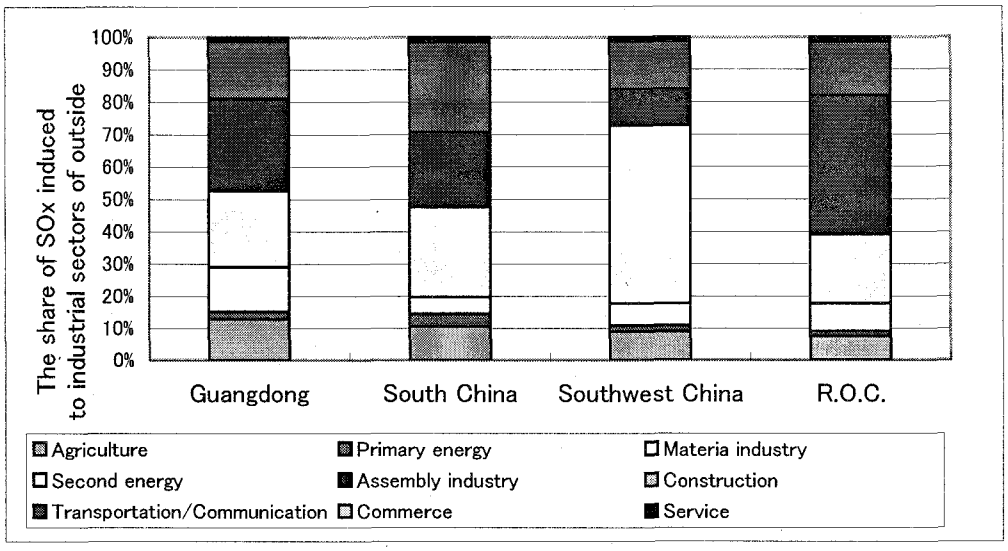

Fig11. The share of SOx induced to Industrial sectors of outside in Zhujiang

3.2 Comparative analysis of the structure of induced COD in Changjiang and Zhujinag basin

The total of induced COD and the inducement proportion to the interior and exterior in the object basins are shown in Figure 12 and Figure 13. In Changjiang basin, the ratio that Shanghai induces COD to other areas is high, and it induces 34.9% of the total induced SO_x to outside. Besides the rate at which each area without Shanghai induces COD to outside is 14.8% in East China region, 5.7% in Central China region and 4.8% in the rest of China. On the other hand, in Zhujiang basin, the proportion that Guangdong Province and South China region induces COD to the other region are high, and individually Guangdong induce 44.1% of induced COD to the outside, South China region induces 30.4%. In both basins, the induced COD quantity of upstream is generally larger than downstream, but the share of induced COD to out of the basin is vice versa. Additionally it is characteristic that the share of the induced COD to out of the basin in Zhujiang basin is higher than the one in Changjiang basin.

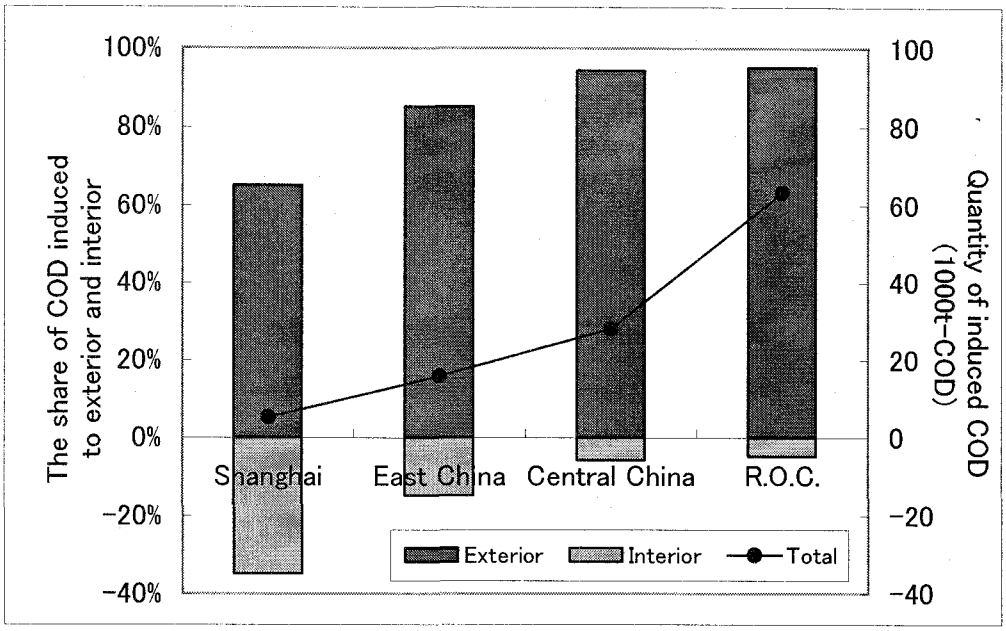

Fig12. The quantity of induced COD and the share induced to exterior and interior in Changjiang

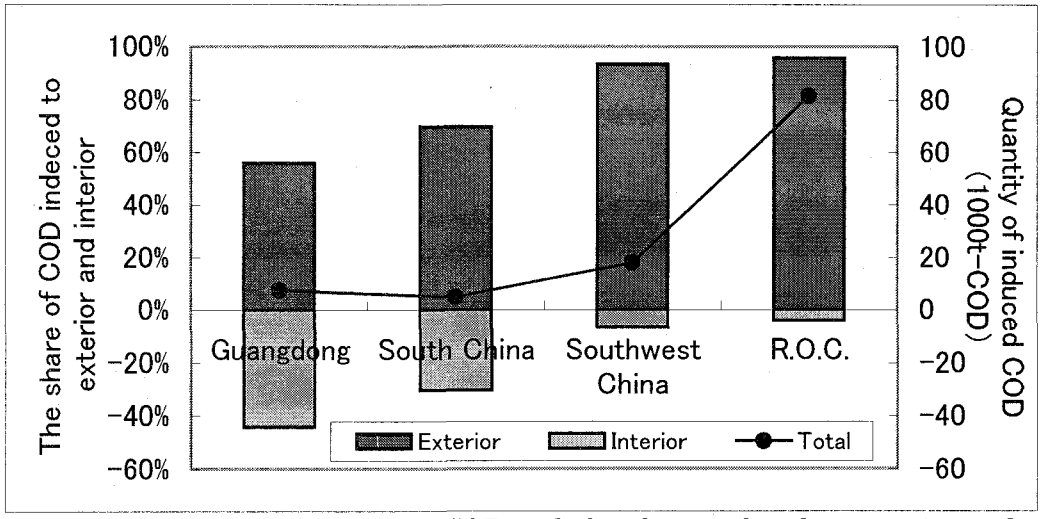

Fig13. The quantity of induced COD and the share induced to exterior and interior in Zhugjiang

The quantity and the regional itemization of COD that each area induces to outside in object basins are shown in Figure 14 and Figure 15. In Changjiang, the quantity of COD that Shanghai induces to

Central China region and that East and Central China region induces to the rest of China is large. On the other hand, in Zhujiang induced COD to the rest of China is generally large and so the induced COD from South China region to Southwest China region is also large. We can study from this result that Changjiang basin has the structure of COD being induced from downstream to out of the basin via middle and up stream and from out of the basin to downstream and upstream, while Zhujiang basin has the one where COD is induced to out of the basin and from out of the basin to downstream and upstream.

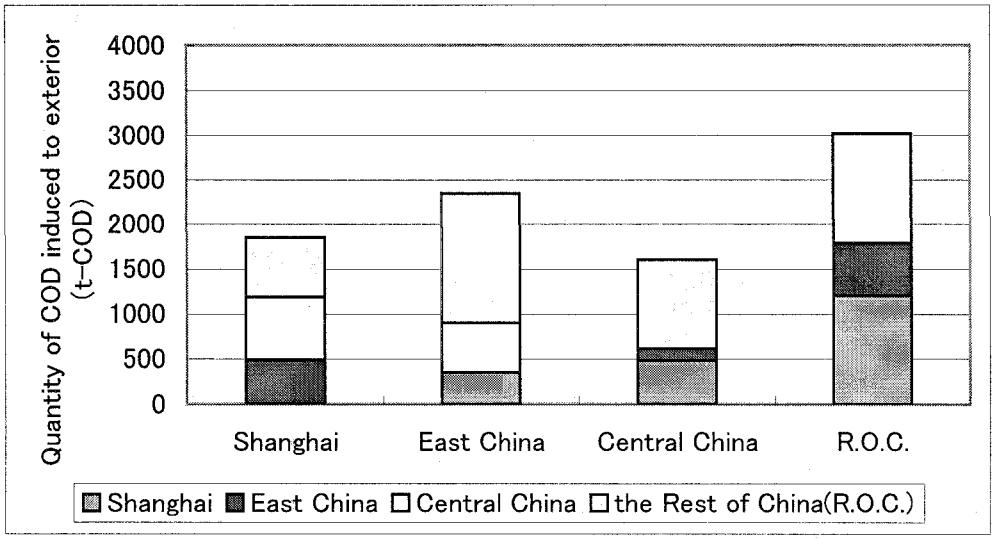

Fig14. The quantity of COD induced to exterior in Changjiang

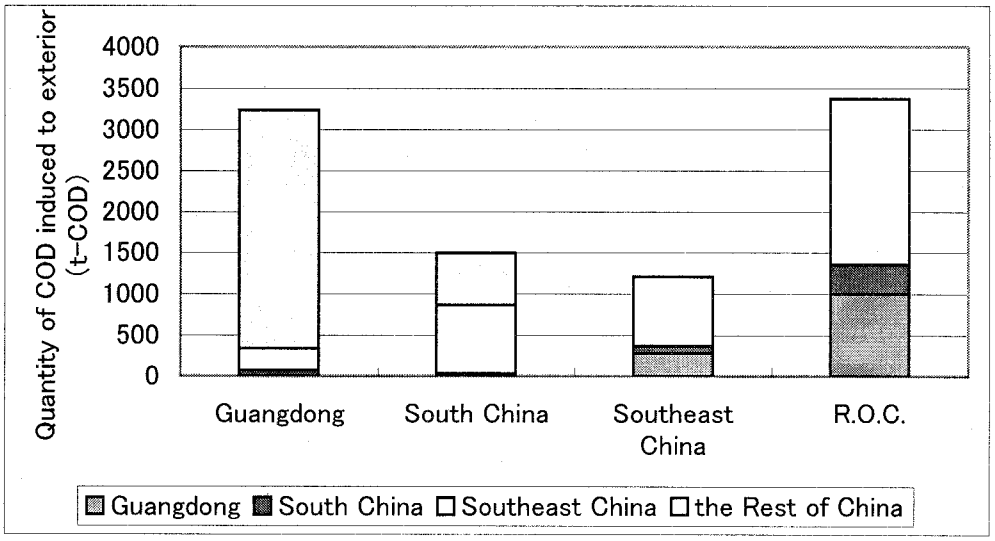

Fig15. The quantity of COD induced to exterior in Zhujiang

The quantity of COD that each area induces to industry in other areas is shown in Figure 16 and Figure 17. The share of COD that each area induces to material industrial sector and assembly industrial sector to outside is generally high in Changjiang. Shanghai and East China region induce COD to material industrial sector of outside, while Central China region induces it to assembly industrial sector of outside. On the other hand, Zhujiang has the structure where COD is induced to other areas through material industrial sector and assembly industrial sector too. The share of COD that Guangdong Province and Southwest China region induce to exterior material industrial sector is large and that COD induced by South China region to exterior assembly industrial sector is high.

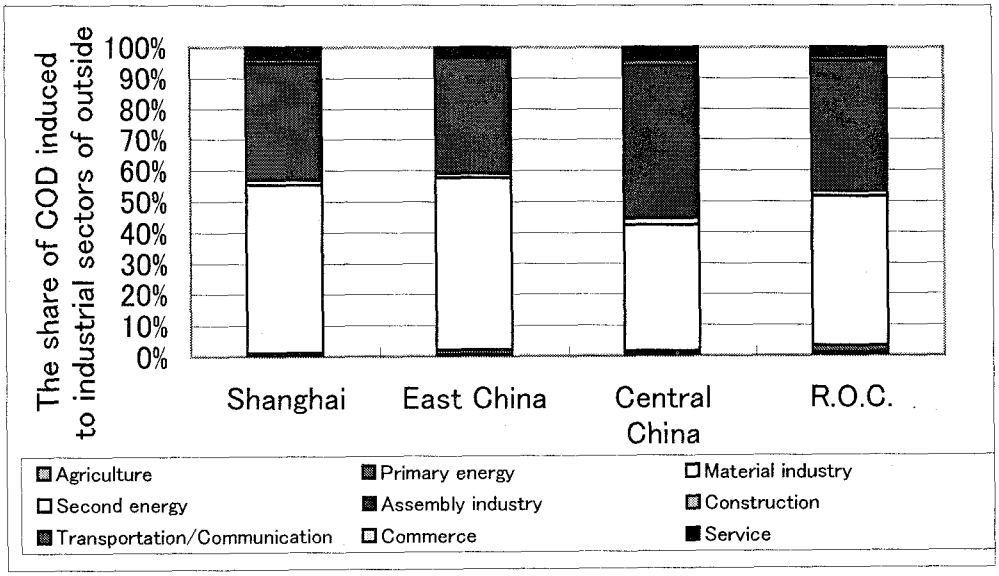

Fig16. The share of COD induced to Industrial sectors of outside in Changjiang

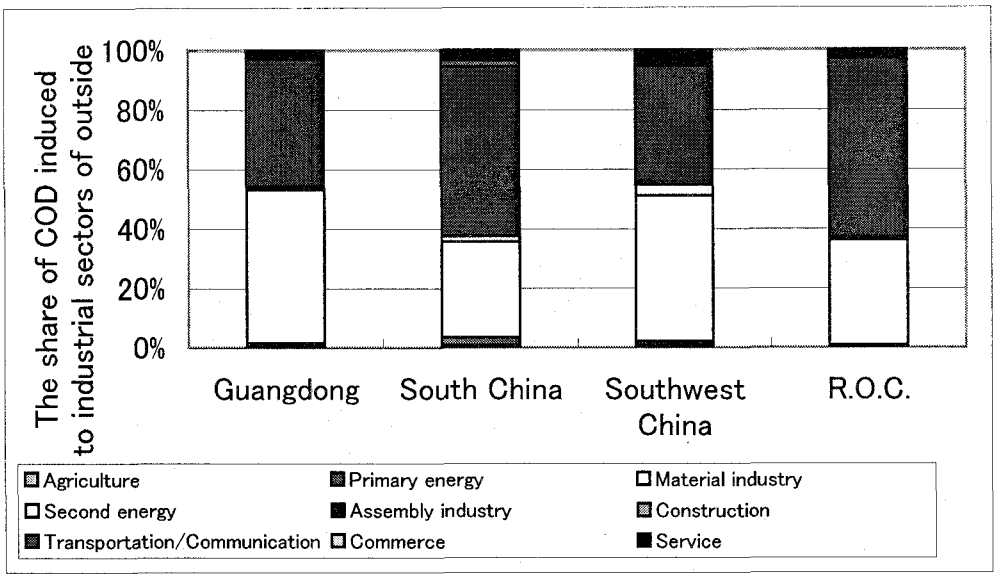

Fig17. The share of COD induced to Industrial sectors of outside in Zhujiang

4. Conclusions and future subject

4.1 Conclusion

A lot of study and research is being done recently on the environmental of China. However, there are very few researches that focus on regional characteristics and the dependency of one region to another. However, there is a big difference in the industrial composition and the economy between the western and the eastern China. This study highlightens the basin of Changjiang and Zhujiang with Open Economic Zones in Coastal Delta and Backward Basins in China. In addition, it calculates the environmental load (i.e. Sulfur oxide and COD) induced by inter-transaction of goods and services in these basins by using the Inter-regional input-output analysis. As a result, in Changjiang basin SO_X and COD is induced from downstream to out of the basin via middle and upper stream through second energy sector, material industrial sector and assembly industrial sector, which support the advanced industry in Shanghai. It is clear that the industrial chain in Changjiang is concerned to the discharge of environmental load not only inside of basin but also out of the basin. On the other hand, in Zhujiang basin SO_X and COD is induced through second energy sector, transportation/communication, material industrial sector and assembly industrial sector and it's characteristic that the environment load is discharged by the interchange between the basin including Guangdong Province and outside of the basin. This paper has focused on calculating the regionary induced environmental load and not on the proposal of policy recommendations. Further study is required for concrete policy recommendations.

4.2 Future subjects

a) the construction of the evaluation model of the effect by a policy introduction

Although this study makes clear that the structure of induced environmental load by inter-regional industrial activity and gives beneficial information for sustainable Industrial transformation policy. But it has only been above to evaluate the fact. It will be necessary to make the model, for example Applying General Equilibrium model or liner programming model etc, to evaluate quantitatively the socio-economic and environmental effect by sustainable Industrial transformation.

b) the subject of area classification

Hong Kong which is the most important city in Zhujiang basin is not included in this study because of a technical problem. An approach that incorporates Hong Kong to the research framework. is necessary.

c) the subject regarding data

This study estimates the emission factor based on Japanese data. Thus the result that is obtained may be smaller than the actual one because the technology standard of Japan and China is not the same. It will be required to solve the estrangement between actual situation and the result. So it needs to analyze with Chinese data.

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