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A Study for Measuring Interzonal Flow of Goods Arising from the Industrial Locations on the Large-Scale Industrial Park

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大規模工業基地の産業立地に基づく地域間貨物輸送量計測に関する研究

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1. Introduction

Recently, the Large-Scale Industrial Parks have been planned out and the new traffic facilities under construction. For the completion of these traffic projects, it would be necessary to measure the interzonal flow of goods by sectors and transport shares arising from the impact of the industrial locations.[1)]

In the author's paper,[2)] we have shown the detailed method for measuring the regional employment opportunities and the estimation of the impact arising from the industrial locations in the Tomakomai-Tōbu Industrial Park.

In this paper, we try to consider the method for measuring the interzonal flow of goods and measure the impact arising from the industrial locations in the Tomakomai-Tōbu Industrial Park by the application of this method.

2. The Method for Measuring the Interzonal Flow of Goods

This chapter presents the mathematical formation of the method for measuring the interzonal flow of goods arising from the industrial locations.

First, we shall consider the following conditions to formulate the method of the interzonal ones arising from the industrial locations.

(1) It is necessary to measure the interzonal flow of goods by the industry and scale.

(2) We can make to be clear the differences of the impact flow of goods arising from the different regional structures.

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(3) It is necessary to measure the impact flow of goods not only for the direct repercussive effects but also for the indirect repercussive effects of the industrial locations.

(4) We must measure the indirect repercussive impact flow of goods not only for the locational region but also for the other region.

We shall represent the new detailed method for measuring the interzonal flow of goods arising from the industrial locations on the Large-Scale Industrial Park satisfied the four conditions mentioned above.

We define the notations of the partitioned matrices as follows.

A: interregional input coefficients matrix by regions.

I: identity matrix.

S: matrix having the values of inputs from other industries to locational industry along the main diagonal (the diagonal running upper left to lower right) and zero elsewhere.

D: matrix having the values of inputs of locational industry along the column and zero elsewhere.

R: matrix of the basic unit of the traffic goods.

N: number of regions.

M: number of industries.

L: number of physical sectors of industries.

X represents the matrix of the total repercussive interzonal flow of goods and satisfies the following equations.

$$\begin{aligned} X &= D\otimes R + A\cdot S\otimes R + A^2\cdot S\otimes R + \cdots \\ &= D\otimes R + [I + A + \cdots]\cdot A\cdot S\otimes R \\ &= D\otimes R + [I-A]^{-1}\cdot A\cdot S\otimes R \end{aligned}$$

Where, $D\otimes R$ is the direct repercussive interzonal flow of goods and $[I-A]^{-1}\cdot A\cdot S\otimes R$ is the indirect one.

$$[I-A]^{-1}\cdot A = \begin{bmatrix} a_{11}^{11} & \cdots & a_{1N}^{11} & a_{11}^{1M} & \cdots & a_{1N}^{1M} \\ \vdots & & \vdots & \vdots & & \vdots \\ a_{N1}^{11} & \cdots & a_{NN}^{11} & a_{N1}^{1M} & \cdots & a_{NN}^{1M} \\ a_{11}^{M1} & \cdots & a_{1N}^{M1} & a_{11}^{MM} & \cdots & a_{1N}^{MM} \\ \vdots & & \vdots & \vdots & & \vdots \\ a_{N1}^{M1} & \cdots & a_{NN}^{M1} & a_{N1}^{MM} & \cdots & a_{NN}^{MM} \end{bmatrix}$$

Let $[I-A]^{-1}\cdot A$, S, D and R be the following partitioned matrices.

$$S=\begin{bmatrix} S_1^1 & & & 0 \\ & \ddots & & \\ & & S_N^1 & \\ & & & \ddots \\ & & & & S_1^M \\ 0 & & & & & \ddots \\ & & & & & & S_N^M \end{bmatrix}$$

Where, $S_j^k=0$ $(k=k_0, j=j_0)$

$$D=\begin{bmatrix} d_{11}^{11} & \cdots & d_{1N}^{11} & & d_{11}^{1M} & \cdots & d_{1N}^{1M} \\ \vdots & & \vdots & & \vdots & & \vdots \\ d_{N1}^{11} & \cdots & d_{NN}^{11} & & d_{N1}^{1M} & \cdots & d_{NN}^{1M} \\ & & & & & & \\ d_{11}^{M1} & \cdots & d_{1N}^{M1} & & d_{11}^{MM} & \cdots & d_{N1}^{MM} \\ \vdots & & \vdots & & \vdots & & \vdots \\ d_{N1}^{M1} & \cdots & d_{NN}^{M1} & & d_{N1}^{MM} & \cdots & d_{NN}^{MM} \end{bmatrix}$$

Where, the relation of matrices S and D is as follows.

$$d_{ij}^{k'k}=S_j^{k'} \qquad (k=k_0, j=j_0)$$

$$d_{ij}^{k'k}=0 \qquad \text{other} \begin{pmatrix} i,j=1,2,\cdots N \\ k',k=1,2,\cdots M \end{pmatrix}$$

The k_0 is the locational industry and j_0 is the locational region.

The matrix of the basic unit of the traffic goods is not the unique value of each sector of industries but the partitioned matrices with the features of the interzonal relations. And the matrix of the basic unit of the traffic goods is as follows.

$$R=\begin{bmatrix} r^1_{11} & \cdots & r^1_{1N} \\ \vdots & & \vdots \\ r^1_{N1} & \cdots & r^1_{NN} \\ & & \\ r^L_{11} & \cdots & r^L_{1N} \\ \vdots & & \vdots \\ r^L_{N1} & \cdots & r^L_{NN} \end{bmatrix}$$

The matrix of the transport shares with railway, ship and vehicle has the similar interpretation of the matrix of the basic unit of traffic goods.

$$M^P=\begin{bmatrix} m^{P1}_{11} & \cdots & m^{P1}_{1N} \\ \vdots & & \vdots \\ m^{P1}_{N1} & \cdots & m^{P1}_{NN} \\ & & \\ m^{PL}_{11} & \cdots & m^{PL}_{1N} \\ \vdots & & \vdots \\ m^{PL}_{N1} & \cdots & m^{PL}_{NN} \end{bmatrix}$$

$P=1$: railway. $P=2$: ship. $P=3$: vehicle.

Where, m^{pl}_{ij} is satisfied the following condition.

$$\sum_{p}^{3} m^{pl}_{ij}=1 \begin{pmatrix} i,j=1,2,\cdots N \\ l=1,2,\cdots L \end{pmatrix}$$

Where, $\otimes$ multiplication pesents the next operation.

$$x^{k'}_j=\sum_{k=1}^{N} d^{k'k}_i{}_j \cdot r^{k'}_{ij}+\sum_{k=1}^{N} S^{k'}_j \cdot a^{k'k}_i{}_j \cdot r^{k'}_{ij}$$

$(i,j=1,2,\cdots N,\ k=1,2,\cdots M)$

Then, the total repercussive interzonal flow of goods by the transport shares X^P is as follows.

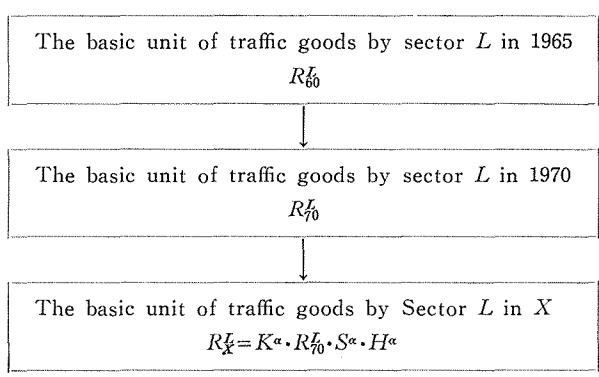
$$X^P = \begin{bmatrix} x^1_{11} \cdot m^{P1}_{11} & \cdots & x^1_{1N} \cdot x^{P1}_{1N} \\ \vdots & & \vdots \\ x^1_{N1} \cdot m^{P1}_{N1} & \cdots & x^1_{NN} \cdot x^{P1}_{NN} \\ & & \\ x^L_{11} \cdot m^{PL}_{11} & \cdots & x^L_{1N} \cdot m^{PL}_{1N} \\ \vdots & & \vdots \\ x^L_{N1} \cdot m^{PL}_{N1} & \cdots & x^L_{NN} \cdot m^{PL}_{NN} \end{bmatrix}$$

$(p=1,\ 2,\ 3)$

To apply the new method, it is necessary to estimate the future target values of interregional input coefficients, the basic unit of the traffic goods and the transport shares.

Then, we shall present the Improvement RAS method in order to estimate the future target values.

For example, Fig. 1 presents the flow in order to estimate the future target values by the basic unit of traffic goods.



Where, K=substitute change coefficients.
S=processing change coefficients.
H=relative change coefficients.
$\alpha=(Y-1970)/10$.

Fig. 1. The Improvement RAS Method

Table 1. Classiffications of 9 Regions

Regions	Prefectures
Hokkaido	Hokkaido
Tohoku	Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima
Kanto	Niigata, Ibaragi, Tochigi, Gumma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi, Nagano, Shizuoka
Tokai	Gifu, Aichi, Mie
Hokuriku	Toyama, Ishikawa
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

Table 2. Classiffication of 10 and 25 Sectors

10 Sectors	25 Sectors
Agriculture Forestory & Fisheries	Agriculture Forestory & Fisheries
Mining	Coal & Lignite Mining Mining (Except)
Textile products	Textile products
Chemicals	Chemicals Petroleum & Coal products
Metal	Primary Iron & Steel Manufacturing Primary Non-Ferrous Metal Manufacturing Metal prodcuts
Machinery	Machinery (n, e, c) Electric Machinery Transportation Equipment Precision Machinery
Other Manufacturing	Food & Kindred products Lumber & Wood products Pulp, Paper & Paper products Leather, Leather products & Rubber products Ceramic, Clay & Stone Products Miscellaneous Manufacturing
Construction	Construction
Transportation & Warehousing	Transportation & Warehousing
Other	Electricity, Gas, Water & Sanitary Services Wholesale & Retail Trade Finance, Real Estates & Other Service Unallocated

We shall adopt the interregional input output tables using the Isard's Model with 9 regions having 10 by 10 sectors in 1960, 1965 and 1970 in which the Ministry of International Trade and Industry has prepared.

The classifications of regions and sectors are shown in tables 1 and 2.

3. The Estimate of the Interzonal Flow of Goods Arising from the Industrial Locations in the Tomakomai-Tōbu Large Industrial Park

The Tomakomai-Tōbu Large Industrial Park is not merely the growth of an existing industrial situation but rather a fundamental change in the economic complex of Hokkaido region.

The main locational industries are the international competitive industries such as Steel manufacturing, Petroleum, Petrochemicals, Non-Ferrous Metal manufacturing, Transportation manufacturing and Relative industries.

The outputs and employment of main locational industries in 1980 and 1985 are estimated in Table 3.

With respect to the detailed interpretation of the Tomakomai-Tōbu Large Industrial Park, the reader may refer to the author's paper 2).

The total repercussive interzonal flow of goods of the locational level in 1980 and 1985 are measured by this project plans.

The main results are as follows.

(1) From the facts presented in the project plans, the total repercussive interzonal flow of goods arising from the locational industries in 1985 increases more rapidly than the ones in 1980.

(2) The distribution percentages of the total repercussive import flow of goods in 1985 are shown in Fig. 2. From the facts presented in Fig. 2, the total impact of the locational industries influences upon the total repercussive import flow of goods. Especially, Petrochemicals and Petroleum influence upon the repercussive

Table 3. Outputs and Employment of the Locational Industries

years	1980		1985	
sectors	outputs	employees	outputs	employees
Petrochemicals	1,100	4.91	3,200	6.5
Petroleum	650	0.75	2,150	1.0
Steel manufacturing	1,700	6.0	4,300	10.0
Non-Ferrous metal manufacturing	1,250	9.05	2,550	14.2
Transportation manufacturing	450	6.0	1,250	8.0
Relative industries	1,400	3.99	3,050	10.3
Total	6,550	30.7	16,500	50.0

(outputs; million dollars, employee; thousands)

import flow of goods of Mining and Chemicals sectors. Steel manufacturing and Non-Ferrous Metal manufacturing influence upon the ones of Mining, Chemicals and Metal sectors. Transportation manufacturing influences upon the ones of Chemicals, Metal and Machinery sectors. From the results of the considerations, the features of the locational industries are shown in the repercussive import flow of goods.

(3) The distribution percentages of the total regional repercussive import flow of goods in 1985 are shown in Fig. 3. From the facts presented in Fig. 3, the distribution percentages of the regional ones in Hokkaido region have from 40% to 60%. From the results by the locational industries, Steel manufacturing, Petrochemicals and Petroleum and Non-Ferrous Steel manufacturing have the same type on the regional ones, but Transportation manufacturing has high level on the total regional ones in Tokai, Kanto and Kinki regions except Hokkaido region.

(4) The distribution percentages of the regional repercussive import flow of goods by railway in 1985 are shown in Fig. 4. From the facts presented in Fig. 4, the distribution percentages of the sum of the regional repercussive import flow of goods in the other regions except Hokkaido region are about 80%. From the results by the locational industries, Steel manufacturing, Petrochemicals and Petroleum, and Non-Ferrous Steel manufacturing have the same type on the regional ones and especially, high level on the ones in Tohoku region. But, Transportation manufacturing has high level on the regional ones in Kanto and Tokai regions.

(5) The distribution percentages of the regional repercussive import flow of goods by ship in 1985 are shown in Fig. 5. From the facts presented in Fig. 5, the distribution percentages of the regional repercussive import flow of goods in Hokkaido region have from 60% to 80%. Then, the regional ones are almost the direct repercussive import into Hokkaido region. From the results by the locational

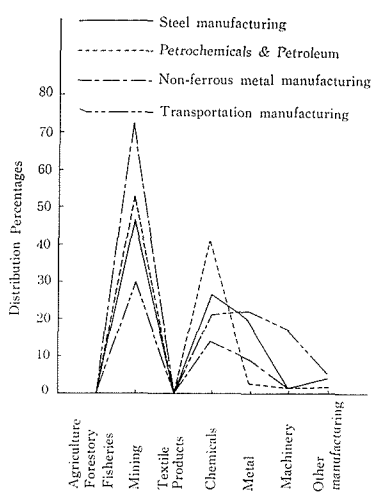


Fig. 2. The total repercussive import flow of goods by sectors (1985).

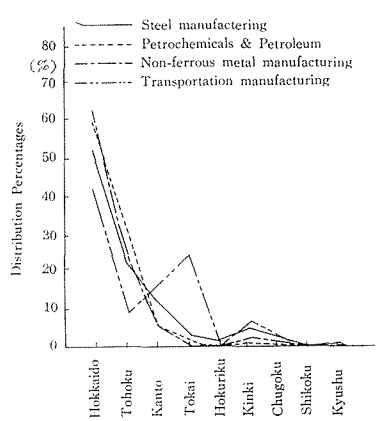


Fig. 3. The total regional repercussive improt flow of goods (1985).

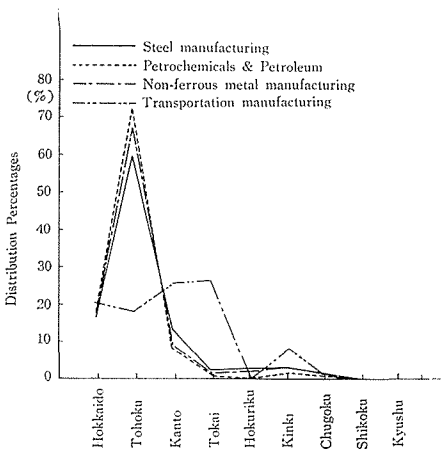


Fig. 4. The regional repercussive import flow of goods by railway (1985).

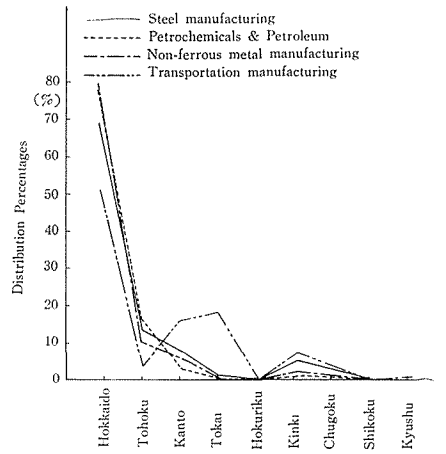


Fig. 5. The regional repercussive import flow of goods by ship (1985).

industries, Steel manufacturing, Petrochemicals and Petroleum, and Non-Ferrous Steel manufacturing have the same type high level on the regional ones in Kanto and Tokkai regions except Hokkaido region.

(6) The distribution percentages of the regional repercussive import flow of goods by vehicle in 1985 are shown in Fig. 6. From the facts presented in Fig. 6, the distribution percentages of the sum of the regional repercussive import flow of goods in the other regions are about 100%. Then, all ones are the indirect repercussive import flow of goods. From the results by the locational industries, Steel manufacturing, Petrochemicals and Petroleum and Non-Ferrous Steel manufacturing have the same type on the regional ones and especially, high level on the regional ones in Tohoku region. But, Transportation manufacturing has high level on the regional ones in Kanto and Tokai regions.

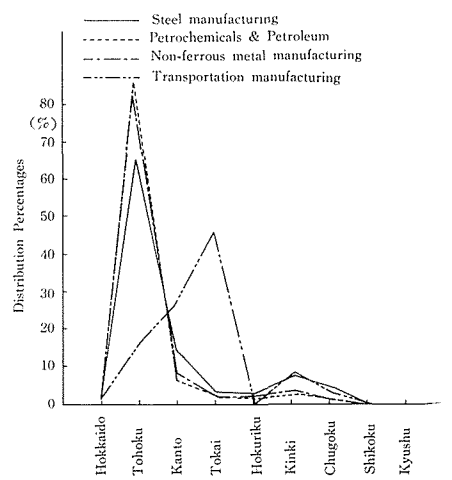


Fig. 6. The regional repercussive import flow of goods by vehicle (1985).

4. Conclusion

In summary, we have investigated the new method of the impact of the repercussive flow of goods arising from the industrial locations in the Large Scale Industrial Park.

From the results of the estimation of the repercussive flow of goods by the

new method, it seems to be clear that the repercussive flow of goods has many differences arising from the impact of locational industries.

Then, it is necessary to estimate the repercussive impact flow of goods arising from the locational industries in order to complete the new traffic facilities.

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The author wishes to express his gratitude to Prof Kiyohide Seki of the Graduate School of Environmental Science of Hokkaido University and the staffs of the Department of Regional Planning for suggesting the problem throughout the work.

Finally, the numerical calculations in the chapter 3 were made at the Hokkaido University Computing Center.

Annotation

1) The interzonal flow of goods is proportional to the interregional input output. With respect to more detail interpretations, we may refer to author's paper; A Basic Study on the Measurement of the Interzonal Flow of Goods, Proceedings of the Hokkaido Branch of the Japan Society Civil Engineers, No. 29, 1973.
2) A Study on the Impact of the Regional Employment Opportunities arising from the Industrial Locations on the Large Scale Industrial Park, Environmental Science, Hokkaido, No. 2. pp 59–74, 1979. the Graduate School of Environmental Science, Hokkaido University.
3) The airplain is neglected because the traffic flow of goods of airplain is very small.

Summary

We have investigated a new method for measuring the interzonal flow of goods arising from the industrial locations on the Large-Scale Industrial Park. By using the new method, we can estimate the repercussive interzonal flow of goods in Tomakomai-Tōbu Industrial Park.

The main results are as follows.

(1) The total repercussive interzonal flow of goods arising from the locational industries in 1985 increases more rapidly than the ones in 1980.

(2) The total impact of the locational industries influences upon the total repercussive import flow of goods. Especially, Petrochemicals and Petroleum influence upon the repercussive import flow of goods of Mining and Chemicals sectors. Steel manufacturing and Non-Ferrous Metal manufacturing influence upon the ones of Mining, Chemicals and Metal products sectors. Transportation manufacturing influences upon the ones of Chemicals, Metal products and Machinery sectors.

(3) The distribution percentages of the regional repercussive import flow of goods in Hokkaido region have from 40% to 60%. Steel manufacturing, Petrochemicals and Petrolum, and Non-Ferrous Steel manufacturing have the same type on the regional ones, but Transportation manufacturing has high level on the total regional ones in Tokai, Kanto, and Kinki regions except Hokkaido region.

(4) The sum of the regional repercussive import flow of goods by railway in other regions except Hokkaido region is about 80%. Steel manufacturing, Petrochemicals and Petroleum, and Non-Ferrous Steel manufacturing have the same type on the regional ones and especially, high level on the regional ones in Tohoku region, but Transportation manufacturing has high level on

the regional ones in Kanto and Tokai regions.

(5) The distribution percentages of the regional repercussive import flow of goods by ship in Hokkaido region have from 60% to 80%. Steel manufacturing, Petrochemicals and Petroleum, and Non-Ferrous Steel manufacturing have the same type on the regional ones, but Transportation manufacturing has high level on the regional ones in Kanto and Tokai regions except Hokkaido region.

(6) The distribution percentages of the sum of the regional repercussive import flow of goods by vehicle in the other regions except Hokkaido region are about 100%. Then, all ones are the indirect repercussive import flow of goods. Steel manufacturing, Petrochemicals and Petroleum, and Non-Ferrous Steel manufacturing have the same type on the regional ones, and especially, high level on the regional ones in Tohoku region, but Transportation manufacturing has high level on the regional ones in Kanto and Tokai regions.