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# Quantitative Model Analysis of the Regional Population and Economic Changes Arising from the Industrial Development

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**Abstract**

We have investigated the measurement of the regional employment opportunities based on the population change arising from the industrial development by the interregional input-output method, and also the regional economic-demographic quantitative model based on the external economics of the densely populated problem. From the results of the economic and environmental impacts of the densely populated problem, it is necessary to estimate the repercussive impact not only of the industrial location region but also other regions as well.

**Key Words**: Quantitative model analysis, Regional population, Industrial development, Employment opportunity.

## 1. Introduction

The objective of the study is to develop a regional impact model for regional population and economic changes arising from Industrial Development. It will also cover an economic and environmental evaluation of the regional densely populated problems by the regional economic-demographic model. We will attempt to apply this new regional impact model to the Tomakomai-Tobu Large Scale Industrial Park of the Hokkaido Region in Japan. This region has not only the potential as a large-scale industrial park but also good prospects for regional economic-demographic development.

The framework of the study involves firstly a regional impact model of the regional population and economic changes will be constructed, and secondly, the economic and environmental impacts of the densely populated problem will be evaluated. In particular, we will consider the measurement of the regional employment opportunities based on the population change arising from industrial development by the interregional input-output method, and we will clarify the measurement of the regional employment opportunities by industries and scales, the differ-

ences of the regional economic structures, the measurement of the employment opportunities not only as direct repercussive effects but also as indirect repercussive effects, and the measurement of the indirect repercussive employment opportunities not only of the industrial location region but other regions as well. In addition, the regional economic-demographic quantitative model based on the external economics of the densely populated problem will be constructed. Thereafter, the economic and environmental impact of the densely populated problem will be evaluated.

## 2. The estimate of the employment opportunities arising from the industrial development in the Tomakomai-Tobu Industrial Park

In the auther's paper,[6] we have shown the detailed method for measuring the regional employment opportunities and the estimation of the impact arising from the large scale industrial development in the Tomakomai-Tobu Industrial Park based on the third plan of Hokkaido Development.

According to the low development of Japan's economic, the Tomakomai-Tobu Industrial Park was reconsidered as shown in Table 1.

In this chapter, we estimate the regional employment opportunities based on the new reconsidered plan.

As the plan is the large-scale industrial development, and the impact influences not only the industrial locational region but also the other regions. Firstly, we estimate the regional total employment opportunities of nine regions such as Hokkaido region, Tohoku region, Kanto region, Hokuriku region, Tokai region, Kinki region, Chugoku region, Shikoku region and Kyushu region.

The method of measurement of the regional employment opportunities based on the interregional input-output method as shown in the chapter three of the auther's paper.[6]

The regional total employment opportunities in 1985 are shown in Figure 1. From the facts presented in Figure 1, the sum of the regional repercussive employment opportunities in other regions is equal to the ones in the Hokkaido region. The remarkable feature is the expansion of the regional repercussive employment opportunities in the Kanto region advanced industrially.

**Table 1.** The Outputs of the Locational Industries in 1985

| Outputs / Sectors | Outputs |
|---|---|
| Steel manufacturing | 1,000 |
| Petroleum | 3,260 |
| Petrochemicals | 2,740 |
| Transportation manufacturing | 780 |
| Relative industries | 910 |
| Total | 8,690 |

(outputs million dollars)

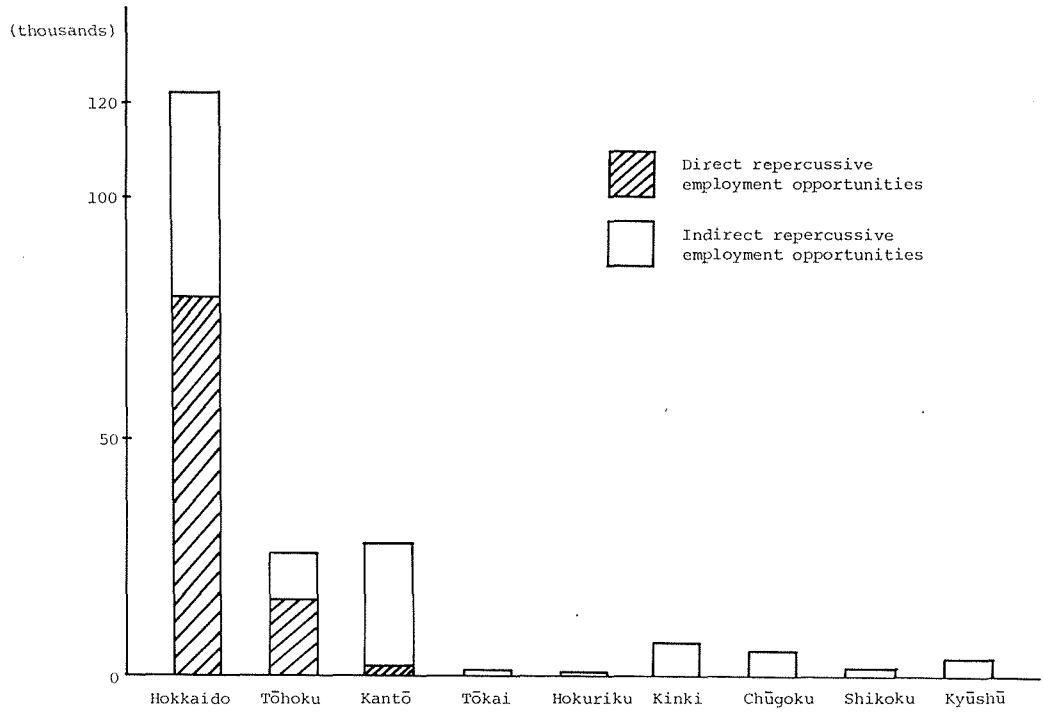


**Figure 1.** Repercussive employment opportunities by nine regions.

The remarkable feature of the regional total employment opportunities is that the expansion of the regional total employment opportunities of tertiary industry is 62% of total ones. This main cause is the indirect repercussive impact of the locational industries.

The regional total employment opportunities of secondary industry with sum of employees of locational industries in Hokkaido is 26% of the total ones. This result influenced on the manufacturing industries with a lower level than the national level in a favourable way. Next, we shall consider the regional total employment opportunities of five districts in Hokkaido region as shown in Figure 2.

As for measuring the regional total employment opportunities of five districts, we estimated the ones of the Primary industry, Wholesale & Retail Trade, Finance, Real Estates & Other Service arising from the production distribution of target time, and also allocated the direct employment opportunities of the secondary industry and total employment opportunities of regional industry; Electricity, Gas, Water & Sanitary Services to the Tomakomai district.

The results are shown in Table 2. From the facts presented in Table 2, the remarkable feature is the high concentration of the regional total employment opportunities in Sapporo district advanced tertiary industrially. This main cause is the concentration of Wholesale & Retail Trade, Finance, Real Estates & Other Service and Transportation & Warehousing with 80% of the regional total employment opportunities in Sapporo district arising from the indirect repercussive impact


**Figure 2.** Five districts in Hokkaido region.

**Table 2.** The regional total employment opportunities in five districts

| region \ employment opportunities | total repercussive employment opportunities (thousands) | direct repercussive employment opportunities (thousands) | indirect repercussive employment opportunities (thousands) |
|---|---|---|---|
| Tomakomai district | 14.3 (20.0) | 13.3 | 1.0 |
| Sapporo district | 57.6 | 37.3 | 20.3 |
| Dōnan district | 10.4 | 6.5 | 3.9 |
| Dōhoku district | 15.5 | 8.7 | 6.8 |
| Dōtou district | 24.2 | 13.3 | 10.9 |
| Total | 122.0 | 79.1 | 42.9 |

( ): employees of locational industries.
total employment opportunities of Hokkaido region (142.0)=total repercussive employment opportunities (122.0)+employees of locational industries (20.0).

of the locational industries in Tomakomai district.

## 3. Urban econometric model

The populations of Sapporo city and Tomakomai city are estimated to increase rapidly according to increase the repercussive employment opportunities arising from developing the Tomakomai-Tobu Industrial Park.

It is necessary to equip with the various kinds of public facilities to accept the increasing population, but if it is not able to equip with public facilities, the evil impact of agglomeration economies ; external diseconomy arises from the increasing populations.

As for the formation of urban econometric model, we shall consider the indexes

of agglomeration economies and evil impact of overpopulation. We shall choose the indexes of agglomeration divided into the producer and consumer.

The indexes of producer are such as the enterprise number, financial institution number, industrial shipment, corporation tax, personal consumption expenditure and expenses of local government. The indexes of consumer are such as shop number, eating house number, department floor space, library book number and hospital bed number and employees income. The indexes of evil impact of overpopulation are such as the land prices, house floor spaces, road congestion rate, attending & school and commuting rate, water service prices, waste disposal prices and raw sewage disposal prices.[3)]

As for the evaluation of agglomeration economics and evil impact of overpopulation, we shall formulate the agglomeration index number and the overpopulation index number to the average number with the sum of each index normalized 100 in 1965.

Next, we shall consider the urban econometric models of Tomakomai city and Sapporo city arising form the agglomeration economies and overpopulation impact.

### (1) Tomakomai Econometric Model

We shall consider the urban econometric model to clarify the population change of Tomakomai city according to the increases of employees and net production arising from the Tomakomai-Tobu industrial development.

We define the notations of endogenous variables as follows.

$N$: residential population
$A$: agglomeration index number
$Q$: overpopulation index number
$K$: private capital stock of secondary and tertiary industries
$G$: public investment

We define the notations of exogenous variables as follows.

$Y$: net production of secondary and tertiary industries
$E$: employees of secondary and tertiary industries

Figure 3 represents the flow map of causality functions between each variables.

a) Residential population function

$$N(t) = \underset{(7.535)}{1.07959}\, A(t-1) + \underset{(1.292)}{1.01953}\, E(t) + 435.563$$

$$R^2 = 0.9977$$

(Figures in parenthesis are $t$- values)

The residential population will be illustrated with the employees increase and the agglomeration index number represented as the social population increase.

b) Overpopulation index number function

$$Q(t) = \underset{(3.243)}{0.3844}\, N(t) + \underset{(1.523)}{17.703}\left[K(t-1)/\sum^{t-1} G(t-1)\right] - 308.617$$

$$R^2 = 0.9581$$

($t$- values)

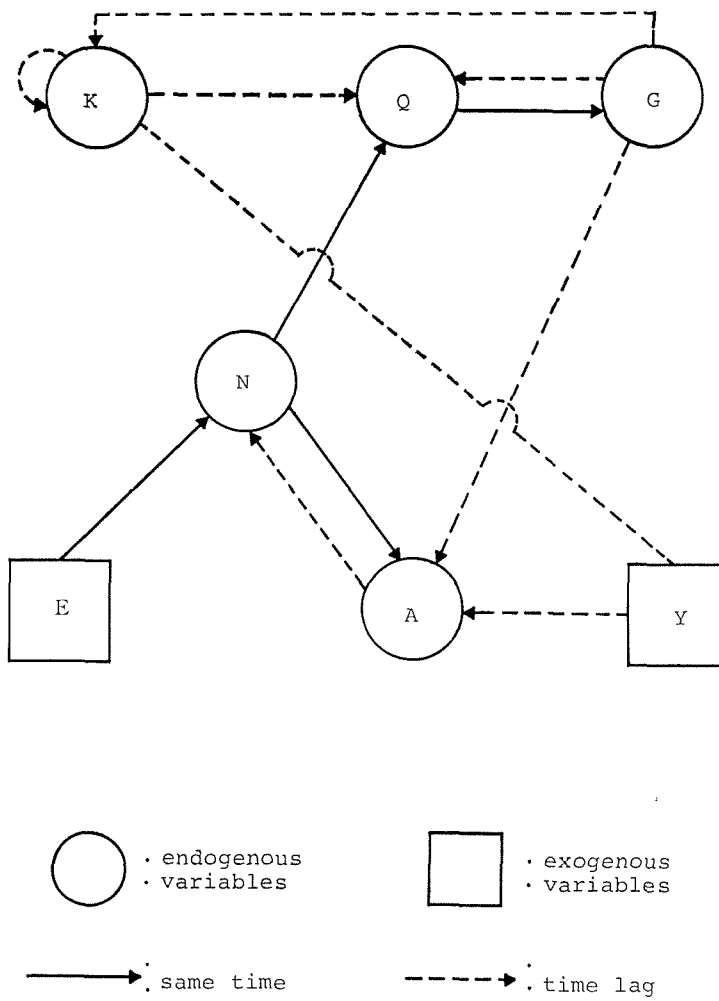


**Figure 3.** Tomakomai economic model.

The evil impact of overpopulation will be illustrated with the population concentration and the relative lack of public investment to the private capital stock.

c) Agglomeration index index number function

$$A(t) = \underset{(0.775)}{0.104682 \times 10^{-2} \cdot Y(t-1)} + \underset{(1.232)}{1.13246} \left[\sum^{t-1} G(i)/N(i)\right] + 32.6227$$

$$R^2 = 0.9961$$

($t$- values)

The agglomeration economies will be illustrated with the net production and the public investment per residential population.

d) Private capital stock functions of secondary and tertiary industries

$$K(t) = \underset{(3.180)}{1.21318}\, K(t-1) + \underset{(2.135)}{1.45072}\left[\sum_{i}^{t-1} G(i)/Y(t-1)\right] - 50672.0$$

$R^2 = 0.9643$
($t$- values)

The private capital stock function will be illustrated with the existing private capital stock and the relative increase of private investment arising from the public investment impact.

e) Public investment function

$$G(t) = \underset{(2.149)}{71.6609}\, Q(t) - 2804.56$$

$R^2 = 0.8836$
($t$- values)

The public investment will be invested to correct the evil impact of over-population concentration.

### (2) Sappopo Econometric Model

We shall consider the urban econometric model to clarify the population change of Sapporo city according to the increase of repercussive employment opportunities arising from the Tomakomai-Tobu industrial development.

We shall define the endogenous variables such as the residential population, agglomeration index number, overpopulation index number, private capital stock of secondary and tertiary industries, public investment and net productions of secondary and tertiary industries, the exogenous variable such as employees of secondary and tertiary industries.

Figure 4 represents the flow map of causality functions between each variables.

a) Residential population function

$$N(t) = \underset{(0.922)}{1.89589}\, E(t) + 1359.56$$

$R^2 = 0.9879$
($t$- values)

b) Overpopulation index number function

$$Q(t) = 0.30212 \times 10^{-1} \cdot N(t) + 7.58203\left[K(t-1)/\sum^{t-1} G(i)\right] - 243.188$$

$R^2 = 0.9661$
($t$- values)

c) Agglomeration index number function

$$A(t) = \underset{(0.786)}{0.11566 \times 10^{-3}} \cdot Y(t-1) + \underset{(0.467)}{2.64526}\left[\sum^{t-1} G(i)/N(t)\right] + 29.5313$$

$R^2 = 0.9914$
($t$- values)

d) Private capital stock function of secondary and tertiary industries

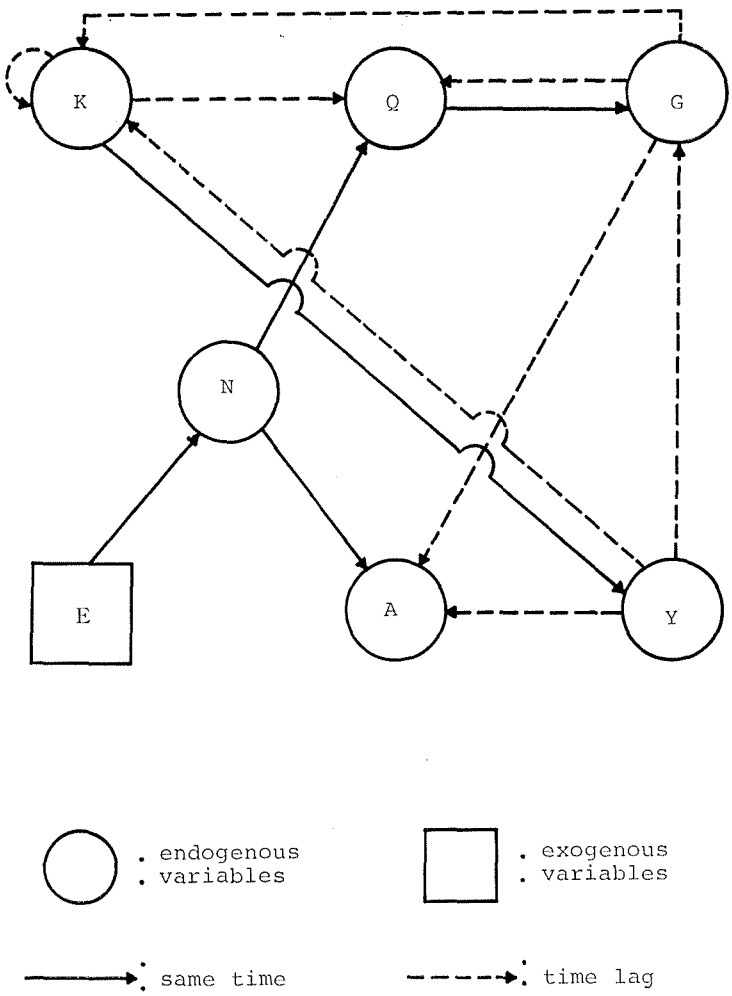


**Figure 4.** Sapporo econometric model.

$$K(t) = \underset{(6.318)}{1.01346}\ K(t-1) + \underset{(5.495)}{0.17196 \times 10^{7}}\left[\sum^{t-1} G(i)/Y(t-1)\right] - 34272.0$$

$R^2 = 0.9977$
($t$- values)

e) Public investment function

$$G(t) = \underset{(9.14)}{349.188}\ Q(t) + \underset{(0.657)}{0.233707 \times 10^{-1}} \cdot Y(t-1) - 34631.0$$

$R^2 = 0.9796$
($t$- values)

f) Net production function of secondary and tertiary industries

$$Y(t) = \underset{(0.981)}{0.51850}\ K(t) + 306305.0$$

$R^2 = 0.9805$
($t$- values)

In the both model, the $t$- values test and final test get the favorable test results.

## 4. The estimates of the population and economic changes with the external economy arising from the Tomakomai-Tobu industrial development

As for measuring of the population and economic changes arising from the Tomakomai-Tobu industrial development, we shall substitute the total employment opportunities and the production of locational industries estimated in the chapter two for the exogenous variables of Tomakomai and Sapporo Urban Econometric Models formulated in the chapter three on the assumption that the exogenous variables shall increase through ten years from 1983 to 1993 according to the stepwise operation of the locational industries.

The main results are as follows.

(1) The populations of Tomakomai city and Sapporo city in the target time are such as 252,000 and 1660,000. The concentration of population of Sapporo city is more keen than that of Tomakomai city.

(2) The agglomeration index values of Tomakomai city and Sapporo city in the target time are such as 1056 and 884 normalized 100 in 1965. The overpopulation index values of Tomakomai city and Sapporo city are such as 878 and 1154. The overpopulation index value of Sapporo city represents higher than that of Tomakomai city with the industrial location estate.

(3) The net production values of secondary and tertiary industries of Tomakomai and Sapporo city in the target time are such as 1750 and 930 normalized 100 in 1965. And the net production values per employees of the secondary and tertiary industries of Tomakomai city and Sapporo city in the target time are such as 527 and 411 normalized 100 in 1965. It presents the high development power of Tomakomai city.

(4) From the fact mentioned above, the repercussive population arising from the tertiary industry concentrates to Sapporo city. It represents that the evil impact of overpopulation of Sapporo city rapidly increase.

Thereafter, to tackle down the evil impact of overpopulation of Sapporo city, it is necessary to equip not only the industrial relative facilities but also the balanced urban functions such as the living environmental facilities, the high educational facilities, the tertiary central functioned facilities and the recreational facilities in the Tomakomai city.

## 5. Conclusion

We have investigated the measurement of the regional employment opportunities based on the population change and the economic and environmental impact of the densely populated problem arising from the industrial development.

The main results are as follows.

(1) In the regional total employment opportunities arising from the industrial development in the target time the sum of the regional repercussive employment

opportunities in other regions is equal to the ones in the Hokkaido region. The remarkable feature is the expantion of the regional repercussive employment opportunities in the Kanto region advanced industrially.

(2) The regional total employment opportunities is that the expansion of the regional total employment opportunities of tertiary industry is 62% of the total ones. This main cause is the indirect repercussive impact of the locational industries.

(3) From the facts of the regional total employment opportunities of five districts in Hokkaido region in the target time, the remarkable feature is the high concentration of the regional total employment opportunities in Sapporo district advanced tertiary industrially.

(4) The population of Tomakomai city and Sapporo city in the target time are such as 252,000 and 1660,000. The concentration of population of Sapporo city is more keen than that of Tomakomai city.

(5) The overpopulation index value of Sapporo city represents higher value than that of Tomakomai city with the industrial location estate. The main cause is that the repercussive population arising from the tertiary industry concentration to Sapporo city.

(6) For tackling down the evil impact of overpopulation of Sapporo city, it is necessary to equip not only the industrial relative facilities but also the balanced urban functions such as the living environmental facilities, the high educational facilities, the tertiary central functional facilities and the recreational facilities in the Tomakomai city.

## References

1) Isard, W. and R. E. Kuenne (1953): The Impact of Steel upon the Greater New-York-Philadelphia Industrial Region: The Review of Economics and Statistics, Nov.
2) Miller, R. E. (1957): The Impact of the Aluminium Industry of the Pacific Northwest, A Regional Input-Output Analysis: The Review of Economics and Statistics, May.
3) Fukuchi, M. and S. Nobakani (1968): Econometric Analysis of Metropolitan Regional Economics: Iwanami Shoten Co. L. D.
4) Yamamura, E. (1977): Regional Balance Growth: Taimeidō Co. L. D.
5) Yamamura, E. (1979): Regional Planning (I) Planning Analysis: Gihōdo Shupan Co. L. D.
6) Yamamura, E. (1979): 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.
7) Yamamura, E. (1980): A Study for Measuring Interzonal Flow of Goods Arising from the Industrial Location on the Large-Scale Industrial Park: Environmental Science, Hokkaido, Vol. 3, No. 2.

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