Measuring the Economic Impact of a Road Construction Project in an Area in Japan - A Simplified Spatial Computable General Equilibrium Modeling Approach -

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Abstract:

This article aims to measure the economic impacts of San-En-Nanshin Expressway which will be constructed in a prefectural cross-border area across Aichi, Shizuoka and Nagano Prefectures in Japan. To this end, first, we present a simplified spatial computable general equilibrium model of San-En-Nanshin region. Then we try to measure the economic impacts of San-En-Nanshin Expressway by applying the so-called shortcut method. The economic benefit of the expressway was estimated as 24.4 billion yen which would pass the cost-benefit criterion. Interregional benefit incidence is described in this article as well. Some recommendations for increasing the benefit are mentioned in the concluding remarks.

Key Words: San-En-Nanshin Expressway, economic benefit, spatial computable general equilibrium model, shortcut method

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1. Introduction

A large scale San-En-Nanshin Expressway with 100 kilometers length starts from Iida city in Nagano Prefecture, runs through Aichi Prefecture and ends at Hamamatsu city of Shizuoka Prefecture. This Expressway is taken into the National Comprehensive Development Plan of the Japanese Government under Regional Revitalization Project. It is expected that with the completion of the Expressway, San-En-Nanshin Region's economy and living convenience will significantly be improved. In order to maximize the economic benefit of the expressway, it is necessary to measure the investment scale in approximation with benefit returns and interregional benefit returns. Therefore, in this research, first, we present a simplified spatial model of San-En-Nanshin region and try to measure the economic impacts of San-En-Nanshin Expressway by applying the shortcut method developed in the transportation economics. And then some recommendations for increasing the benefit are discussed in the concluding remarks.

2. Firms Behavior

This part explains the outline of the model for measuring the economic impact of San-En-Nanshin Expressway. Although this model is based on Ito, Iwazaki and Muto (2005), some extensions and alternations are made and some shortcomings are also revised. For example, the structure of the model is simplified in order to reduce calculation amount. There are n zones in the study region and the number of population is denoted by N. This model considers an aggregated single industry for simplicity. A representative firm in zone s is defined for one worker, and aims at profit maximization.

$$max\ \pi^s \equiv py^s - tc^s \tag{1}$$

subject to

$$y^s \equiv min\left[\frac{pc^s}{a_0}, \frac{z^s}{a_1}\right] \tag{2}$$

$$tc^s \equiv p_c^s pc^s + \sum_{r=1}^{n}\left[\left\{p + p_{TF}\mu_{TF}\left(\frac{t^{rs}}{t^{ss}}\right)^{\sigma_F}\right\}PTF^{rs} z^s\right] \tag{3}$$

$$p_c^s \equiv \left[p_{va}^s va^s + \left(p_{TP} + w\sum_{r=1}^{n} t^{sr} PTPB^{sr}\delta_b\right)z_{TP}^s\right] / pc^s \tag{4}$$

$$p_{va}^s \equiv \left[w \cdot ld^s + r \cdot kd^s + h_F^s \cdot ad^s\right] / va^s \tag{5}$$

$$pc^s \equiv \eta_2 \left(va^s\right)^{\alpha}\left(z_{TP}^s\right)^{1-\alpha} \tag{6}$$

$$va^s \equiv \eta_3\left(ld^s\right)^{\beta_l}\left(kd^s\right)^{\beta_k}\left(ad^s\right)^{\beta_a} \tag{7}$$

$$PTF^{rs} \equiv \frac{\xi_{TF}^{rs}\left[-(t^{rs}/t^{ss})^{\sigma_F} + 100\right]^{\sigma_s}}{\sum_{r=1}^{n}\xi_{TF}^{rs}\left[-(t^{rs}/t^{ss})^{\sigma_F} + 100\right]^{\sigma_s}} \tag{8}$$

where

π^s: firm's profit in zone s

p: price of commodity

y^s: firm's output in zone s

tc^s: firm's production cost in zone s

pc^s: firm's production capacity in zone s

a_0: firm's production capacity rate

z^s: intermediate input of commodity i in zone s

a_1: intermediate input coefficient

p_c^s: price of production capacity

p_{TF}: price of commodity transport service

μ_{TFi}: input of unit commodity transport service associate with input of commodity i

t^{rs}: time distance between zone r and zone s

PTF_i^{rs}: probability of inputting zone r 's commodity i in zone s
p_v^s: price of value added in zone s
va^s: value added in zone s
p_{TP}: passenger transport price
w: wage rate
$PTPB^{sr}$: choice probability of passenger transport destination r by a firm in zone s
δ_b: number of business trips per unit passenger transport service
z_{TP}^s: input of passenger transport service in zone s
η_2, η_3 and ξ_{TF}^{rs}: parameters
ld^s: labor input in zone s
kd^s: capital input in zone s
ad^s: land input in zone s
β_l, β_k and β_a: elasticity parameter ($\beta_l + \beta_k + \beta_a = 1$)
σ_S, σ_F, and α: elasticity parameters

In order to solve the above-mentioned profit maximization problem, we hierarchically solve the cost function, the conditional factor demand function under a fixed output y^s.

(1) The First Stage

Since the production function is a Leontief type, the production capacity and the intermediate inputs are obtained as follows:

$$pc^s = a_0 y^s \tag{9}$$

$$z^s = a_1 y^s \tag{10}$$

(2) The Second Stage

Given the production capacity pc^s, we solve the following cost minimization problem:

$$min\ \ c^s \equiv p_{va}^s va^s + \left[p_{TP} + w \sum_{r=1}^{n} t^{sr} PTPB^{sr} \delta_b \right] z_{TP}^s \tag{11}$$

$$subject\ to\ \ pc^s \equiv \eta_2 \left(va^s\right)^{\alpha} \left(z_{TP}^s\right)^{1-\alpha} \tag{12}$$

Following this, the value added input and passenger transport input associated with the production capacity pc^s can be obtained as well.

$$va^s = \frac{1}{\eta_2} \frac{\alpha}{p_{va}^s} \left[\frac{p_{va}^s}{\alpha} \right]^{\alpha} \left[\frac{\theta^s}{1-\alpha} \right]^{1-\alpha} pc^s \tag{13}$$

$$z_{TP}^s = \frac{1}{\eta_2} \frac{1-\alpha}{\theta^s} \left[\frac{p_{va}^s}{\alpha} \right]^{\alpha} \left[\frac{\theta^s}{1-\alpha} \right]^{1-\alpha} pc^s \tag{14}$$

$$\theta^s \equiv p_{TP} + w \sum_{r=1}^{m} t^{sr} PTPB^{sr} \delta_b \tag{15}$$

Moreover the price index p_c^s of production capacity is also obtained as follows:

$$p_c^s = \frac{p_{va}^s}{\eta_2}\frac{\alpha}{p_{va}^s}\left[\frac{p_{va}^s}{\alpha}\right]^{\alpha}\left[\frac{\theta^s}{1-\alpha}\right]^{1-\alpha} + \frac{\theta^s}{\eta_2}\frac{1-\alpha}{\theta^s}\left[\frac{p_{va}^s}{\alpha}\right]^{\alpha}\left[\frac{\theta^s}{1-\alpha}\right]^{1-\alpha} = \frac{1}{\eta_2}\left[\frac{p_{va}^s}{\alpha}\right]^{\alpha}\left[\frac{\theta^s}{1-\alpha}\right]^{1-\alpha} \tag{16}$$

Although the choice probability of passenger transport destination $PTPB^{sr}$ is not defined above, it is possible to formulate it by applying the gravity model or the logit model.

(3) The Third Stage

Given the value added va^s, we consider the following cost minimization problem.

$$min\ c_{va}^s \equiv w \cdot ld^s + r \cdot kd^s + h_F^s \cdot ad^s \tag{17}$$

subject to

$$va^s = \eta_3 \left(ld^s\right)^{\beta_l}\left(kd^s\right)^{\beta_k}\left(ad^s\right)^{\beta_a} \tag{18}$$

Solving this minimization problem, the conditional inputs of labor, capital and land associated with the value added va^s can be obtained as follows:

$$ld^s = \frac{1}{\eta_3}\frac{\beta_l}{w}\left[\frac{w}{\beta_l}\right]^{\beta_l}\left[\frac{r}{\beta_k}\right]^{\beta_k}\left[\frac{h_F^s}{\beta_a}\right]^{\beta_a} va^s \tag{19}$$

$$kd^s = \frac{1}{\eta_3}\frac{\beta_k}{r}\left[\frac{w}{\beta_l}\right]^{\beta_l}\left[\frac{r}{\beta_k}\right]^{\beta_k}\left[\frac{h_F^s}{\beta_a}\right]^{\beta_a} va^s \tag{20}$$

$$ad^s = \frac{1}{\eta_3}\frac{\beta_a}{h_F^s}\left[\frac{w}{\beta_l}\right]^{\beta_l}\left[\frac{r}{\beta_k}\right]^{\beta_k}\left[\frac{h_F^s}{\beta_a}\right]^{\beta_a} va^s \tag{21}$$

Price index of value added p_{va}^s is obtained as follows:

$$p_{va}^s = \frac{1}{\eta_3}\left[\frac{w}{\beta_l}\right]^{\beta_l}\left[\frac{r}{\beta_k}\right]^{\beta_k}\left[\frac{h_F^s}{\beta_a}\right]^{\beta_a} \tag{22}$$

From the above, we can obtain the minimized cost tc^s associated with the firm's output y^s determining its profit.

3. Firms' Location Choice Behavior

Each firm determines its location choice probability to maximize the following expected weighted profit based on the profit which would be gained in each zone.

$$max\ SF \equiv \sum_{r=1}^{n} PF^r \xi_F^r \pi^r - \frac{1}{\theta_F}\sum_{r=1}^{n} PF^r ln\, PF^r \tag{23}$$

$$\textit{subject to} \sum_{r=1}^{n} PF^r = 1 \tag{24}$$

where,

SF: firm's expected profit with weight obtained by location choice

PF^r: probability of choosing zone r

ξ_F^r: weight for firm's profit in zone r

π^r: firm's profit which would be obtained in zone r

θ_j: Logit parameter

Solving this optimization problem, firm's location choice probability for zone r is obtained as follows:

$$PF^r = \frac{exp\,\theta_F \xi_F^r \pi^r}{\sum_{s=1}^{n} exp\,\theta_F \xi_F^s \pi^s} \tag{25}$$

The maximum expected profit with weight is calculated as follows:

$$SF = \frac{1}{\theta_F} ln \sum_{r=1}^{n} exp\,\theta_F \xi_F^r \pi^r \tag{26}$$

4. Households Behavior

Each household behaves to maximize the utility function. Households' utility maximization behavior is hierarchically formulated as well.

(1) The First Stage

Households are assumed to be homogeneous in the study area, and we consider a representative household who resides in zone r and works in zone s. Each household is assumed to behave to maximize its utility function of the current consumption, future consumption, and land under the budget constraint. The current consumption good consists of produced commodities, passenger transport service and leisure, while the future consumption is derived from the savings. The utility maximization is then specified as follows:

$$max\ \ u(G^{rs}, H^{rs}, a_H^{rs}) \equiv G^{rs\alpha_G} H^{rs\alpha_G} a_H^{rs\alpha_a} \tag{27}$$

$$subject\ to\ \ p_G^r G^{rs} + p_H^r H^{rs} + h_H^r a_H^{rs} = w(T - n^{rs} t^{rs}) + r \cdot ks^{rs} \tag{28}$$

where

u : household utility function

G^{rs} : current consumption by a household residing in zone r and working in zone s

H^{rs} : future consumption by a household residing in zone r and working in zone s

a_H^{rs} : land consumption by a household residing in zone r and working in zone s

α_G, α_H and α_a : elasticity parameter ($\alpha_G + \alpha_H + \alpha_a = 1$)

p_G^r : price of current consumption in zone r

p_H^r: price of future consumption in zone r

h_H^r : residential land rent in zone r

w : wage rate

T: total available time endowed by a household

n^{rs} : number of commuting trips from zone r to zone s

t^{rs} : commuting time between zone r and zone s

r : capital return rate

ks^{rs} : capital stock endowed by a household working in zone r working in zone s

Solving this utility maximization problem, we obtain the following demand functions:

$$G^{rs} = \frac{\alpha_G}{p_G^r}\left[w(T - n^{rs} t^{rs}) + r \cdot ks^{rs}\right] \tag{29}$$

$$H^{rs} = \frac{\alpha_H}{p_H^r}\left[w(T - n^{rs}t^{rs}) + r \cdot ks^{rs}\right] \tag{30}$$

$$a_H^{rs} = \frac{\alpha_a}{h_H^r}\left[w(T - n^{rs}t^{rs}) + r \cdot ks^{rs}\right] \tag{31}$$

We further solve these three equations (29) to (31) hierarchically, and then we can know details of the household utility maximization behavior.

(2) The Second Stage

Given the future consumption and land input, each household maximizes the current consumption.

$$max \;\; G^{rs} \equiv \left(C^{rs}\right)^{\alpha_c}\left(f^{rs}\right)^{\alpha_s}\left(x_{TP}^{rs}\right)^{\alpha_x} \tag{32}$$

subject to

$$p_c^{rs}C^{rs} + w \cdot f^{rs} + q_{TP}^r x_{TP}^{rs} = w(T - n^{rs}t^{rs}) + r \cdot ks^{rs} - p_H^r H^{rs} - h_H^r a_H^r \;\; (\equiv \Omega_2^{rs}) \tag{33}$$

$$q_{TP}^{rs} \equiv p_{TP} + w\sum_{k=1}^{n} t^{rk} PTPF^{rsk}\delta_f \tag{34}$$

where

C^{rs}: composite commodity consumed by a household residing in zone *r* and working in zone *s*

f^{rs}: leisure time of a household residing in zone *r* and working in zone *s*

x_{TP}^{rs}: total consumption of passenger transport services by a household residing in zone *r* and working in zone *s*

p_C^{rs}: price of composite consumption commodity

q_{TP}^{rs}: generalized price of passenger transport service

$PTPF^{rsk}$: choice probability for destination *r* of a trip by a household residing in zone *r* and working in zone *s*

δ_f: the number of household trips per unit passenger transport service

Solving this optimization problem, we can obtain the demands for composite consumption commodity, leisure time and the total passenger transport service.

$$C^{rs} = \frac{\alpha_C}{p_C^{rs}}\Omega_2^{rs} \tag{35}$$

$$f^{rs} = \frac{\alpha_f}{w}\Omega_2^{rs} \tag{36}$$

$$x_{TP}^{rs} = \frac{\alpha_x}{q_{TP}^{rs}}\Omega_2^{rs} \tag{37}$$

The price index of current composite consumption is derived as follows:

$$p_G^r = \left[\frac{p_C^{rs}}{\alpha_C}\right]^{\alpha_C}\left[\frac{w}{\alpha_f}\right]^{\alpha_f}\left[\frac{q_{TP}^r}{\alpha_x}\right]^{\alpha_x} \tag{38}$$

Although choice probability for destination of individual trip is not defined above, it is possible to specify it by employing the gravity model or the Logit model.

5. Households Residential Location Choice Behavior

The choice probability of household's residential location in zone *r* and working in zone *s* can be derived from the following maximization problem for the expected utility function with weight.

$$max \ SH^s \equiv \sum_{r=1}^{n} PH^{rs} \xi_H^{rs} v^{rs} - \frac{1}{\theta_H^s} \sum_{r=1}^{n} PH^{rs} ln \, PH^{rs} \tag{39}$$

$$subject \ to \ \sum_{r=1}^{n} PH^{rs} = 1 \tag{40}$$

where

SH^s: expected utility from choosing a residential place of a household working in zone *s*

PH^{rs}: probability of residing in zone *r* of a household who works in zone *s*

ξ_{Hj}^{rs}: weight corresponding to indirect utility value in a household working in zone *s* and residing in zone *r*

v^{rs}: indirect utility value in a household working in zone *s* and residing in zone *r*

θ_H^s: Logit parameter

Solving this optimization problem, household probability of residing in zone *r* and working in zone *s* is obtained as follows:

$$PH^{rs} = \frac{exp \, \theta_H^s \xi_H^{rs} v^{rs}}{\sum_{k=1}^{n} exp \, \theta_H^s \xi_H^{ks} v^{ks}} \tag{41}$$

The household maximum expected utility value with weight for working in zone *s* and residing in zone *r* is calculated as follows:

$$SH^s = \frac{1}{\theta_H^s} ln \sum_{r=1}^{n} exp \, \theta_H^s \xi_H^{rs} v^{rs} \tag{42}$$

The number of firms in zone *s*, that is, the number of employees is expressed by $E^s = \sum_{j=1}^{m} E_j^s$. Thus $N^{rs} \equiv PH^{rs}E^s$ expresses not only the number of households working zone *s* and residing in zone *r*, but also the number of commuting trips. The number of households in zone *r* is expressed as $N^r = \sum_{s=1}^{n} N^{rs}$

6. Behavior of Absentee Land Owner

The absentee land owner in zone *s* provides differentially the land for business use AS_F^s and residential use AS_H^s. The amount of absentee land owner's services is assumed to be expressed as $h_F^s \cdot AS_F^s + h_H^s \cdot AS_H^s$ by using the initial land rents by zone. The absentee land owner obtains its income from land rent earned in the entire study region, and consumes goods produced in the study region.

7. Market Equilibrium Conditions

Market equilibrium conditions in the model are summarized as follows:

Commodity market

Supply of commodities in the entire study region = Demand for commodities in the entire study region (43)

Labor market

$$\sum_{r=1}^{n}\sum_{s=1}^{n} T\cdot N^{rs} - \sum_{r=1}^{n}\left[\left(\sum_{s=1}^{n}\sum_{k=1}^{n} t^{rk} PTPF^{rsk}\right)\delta_f\left(\sum_{s=1}^{n} x_{TP}^{rs} N^{rs}\right)\right] - \sum_{r=1}^{n}\sum_{s=1}^{n} x_{TP}^{rs} N^{rs}$$
$$-\sum_{s=1}^{n}\sum_{r=1}^{n} \delta_C t^{rs} N^{rs} = \sum_{r=1}^{n} n^r ld^r \tag{44}$$

Capital market

$$\sum_{r=}^{n}\sum_{s=1}^{n} ks^{rs} N^{rs} = \sum_{r=1}^{n} n^r kd^r \tag{45}$$

Land market for business use

$$AS_F^r = ad^r E^r \qquad (r = 1,\cdots,n) \tag{46}$$

Land market for residential use

$$AS_H^r = \sum_{s=1}^{n} a_H^{rs} N^{rs} \qquad (r = 1,\cdots,n) \tag{47}$$

According to the model, the volume of traffic distribution by business objective, private objective, and commuting objective can be determined when (generalized) transport cost is given. Moreover adding a traffic assignment model to the current one, we can obtain simultaneous equilibrium of traffic, economy and location.

8. Economic Benefit of San-En-Nanshin Expressway

(1) Shortcut Method

In this research, we tried to measure economic benefit of San-En-Nanshin Expressway by estimating parameters of above presented model. However, because of sensitive changes of location choice probability, the benefit estimation was not highly plausible. Thus, the shortcut method was adopted to estimate the economic benefit. Shortcut method is quite complicated, so here we only explain the results of this method for page constraint.

When the transportation sector sets price equals to the marginal cost, transportation economic benefit is obtained as below:

$$\begin{aligned}\sum EV &= \oint_{A\to B} e_\Omega(-D_3 dq_3 + D_3 dp_3 - NdI) \\ &= \oint_{A\to B} e_\Omega(-D_3 p_5 dt_3 - NdI)\end{aligned} \tag{48}$$

$$e_\Omega \equiv (\partial e/\partial v)(\partial v/\partial \Omega)$$

where

A and B : indices before and after transportation investment

Integration : Integration of the change between the states before and after transportation investment

EV : equivalent variation. Minimized compensation for giving up benefit obtained from transportation investment. EV is defined as follows:

$$v \equiv v(q^A, \Omega^A + EV) = v^B \equiv v(q^B, \Omega^B) \tag{49}$$

$$EV \equiv e(q^A, v^B) - \Omega^A \tag{50}$$

v : indirect utility function

q^A and q^B : generalized price vector
Ω^A and Ω^B: household income
$e(q^A, v^B)$: expenditure function, i.e. minimized expenditure (income) obtained from utility v^B under price q^A
D_3 : transport demand function
w_3 : wage rate
N : the number of regional population
I : transportation investment cost

From the formula (48), the economic benefit is obtained by subtracting transportation investment cost from the money valuation of travel time saving due to wage rate. Study employs this formula to measure the economic benefit of San-En-Nanshin Expressway.

(2) Study Region Overvie

San-En-Nanshin Expressway starts from Chuo Expressway of Iida city in Nagano prefecture, runs through Aichi prefecture and ends at intersection with Tomei Expressway of Hamamatsu city in Shizuoka prefecture. The total length of the expressway is 100 km with 4 lanes for motor vehicles. Up to now, there are 14 kilometers in operation. This expressway is expected to create a large transportation network beyond prefectural boundary in San-En-Nanshin region which includes Aichi prefecture, merged Hamamatsu city of Shizuoka prefecture and Nanshin region of Nagano prefecture. In this research, we divide the study region into 31 sub-zones for analysis.

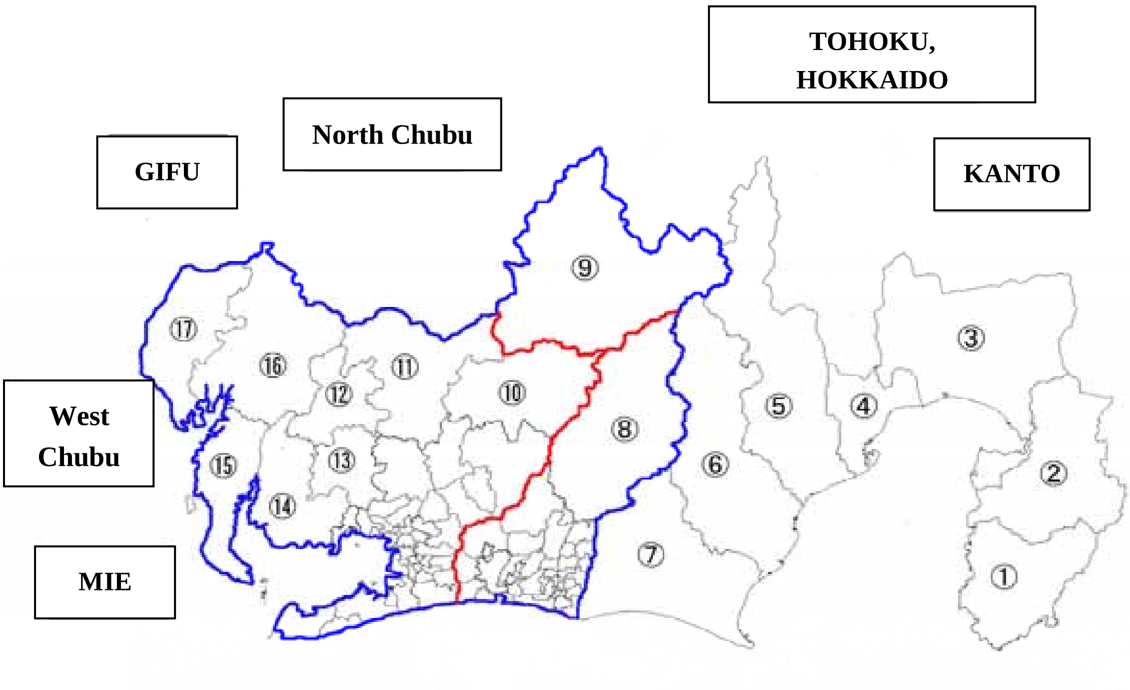

Figure 1. Map of the Study Region

Figure 3 and Figure 4 illustrate a current situation of interregional commuting persons and commodity transaction. Following these, we can see that the commodity and passenger intraregional flows in each zone are naturally high.

One can observe that the interregional commuting persons in Toyohashi city are much more extensive than in Hamamatsu city. Particularly, commuting person trips between Toyohashi and other sub-zones such as Nanshin region, Hamamatsu, Kosai, Shinshiro, Toyokawa, Gamagori and Toyota are quite higher than others left. From the physical distribution of all materials shown in Figure 4, we can see that although the total transported commodity of Hamamatsu is much more than Toyohashi, interregional commodity flows from and to Toyohashi are wider.

In case of Nanshin region, there are a lot of commuting persons and commodities departed from Nanshin, but terminating at this region is quite low. Moreover Nanshin region has a much stronger trade relation with Nagoya area than with San-En-Nanshin region.

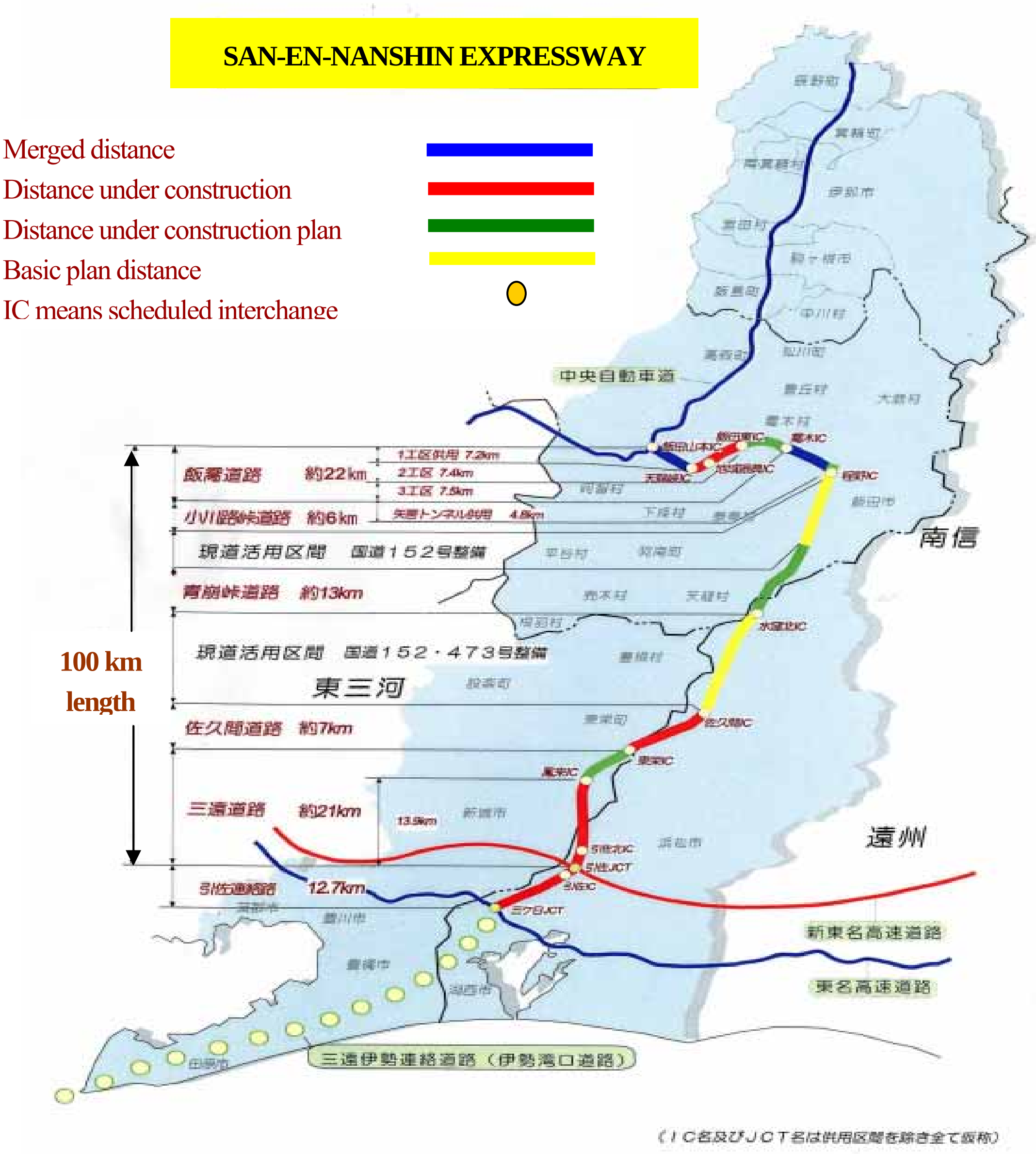

Figure 2. Map of San-En-Nanshin Expressway

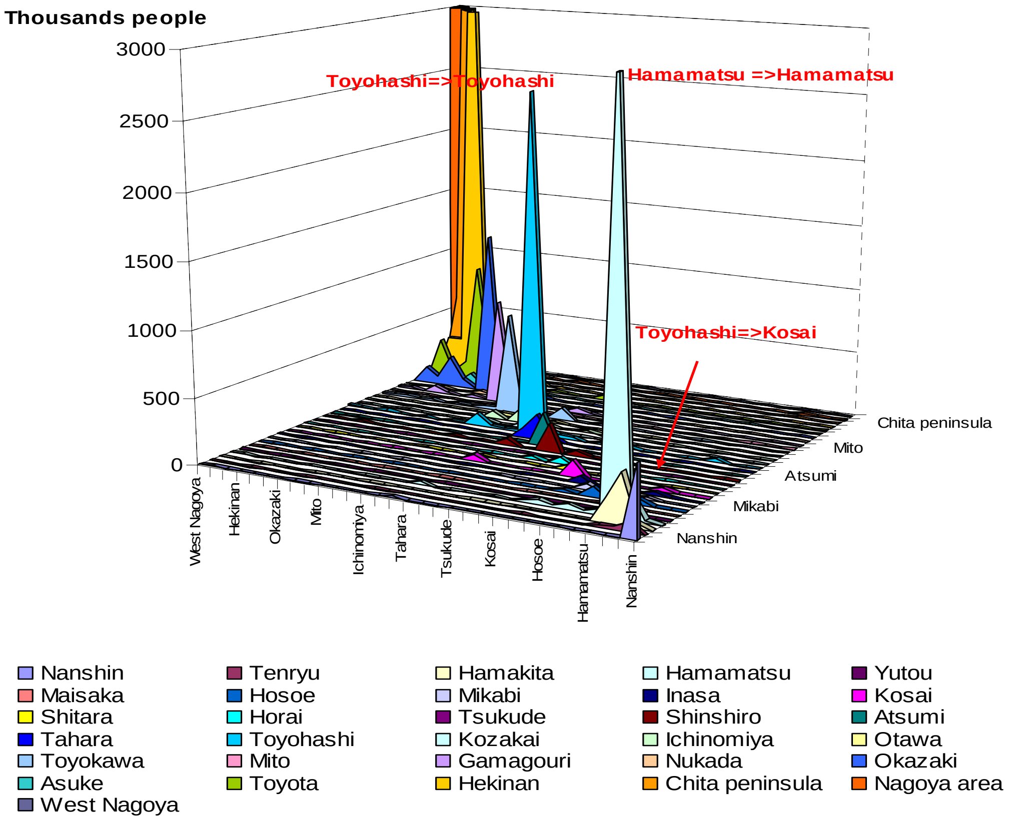

Figure 3. Intercity Commuting Persons Distribution in San-En-Nanshin Region

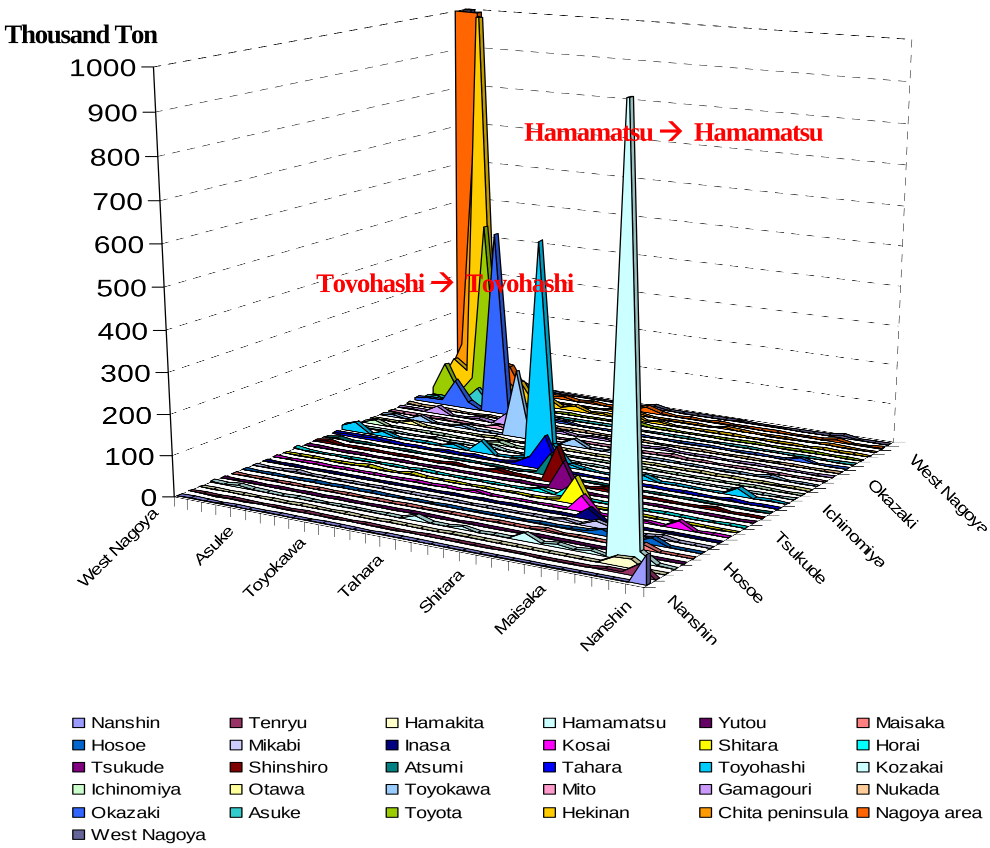

Figure 4. Current Intercity Physical Distribution (All Materials)

(3) Time benefit after San-En-Nanshin Expressway

Figure 3 shows the difference in travel time (by minutes) before and after San-En-Nanshin Expressway. Because of the existence of Chuo Expressway, San-En-Nanshin Expressway gives little impact on West Aichi prefecture. However, impact of this new Expressway on Inasa, Hamamatsu and Tenryu is quite large. Although it takes a little long time to travel from Toyohashi to Inasa, economic benefit at certain level is still expected due to large transportation demand between Toyohashi and Nanshin region.

From the above-mentioned circumstance, it can be said that completion of San-En-Nanshin Expressway will bring great economic impact on San-En-Nanshin region. Moreover investigating the economy and social infra-structures of this region, we should consider a way to increase the economic benefit by San-En-Nanshin Express-way in the future.

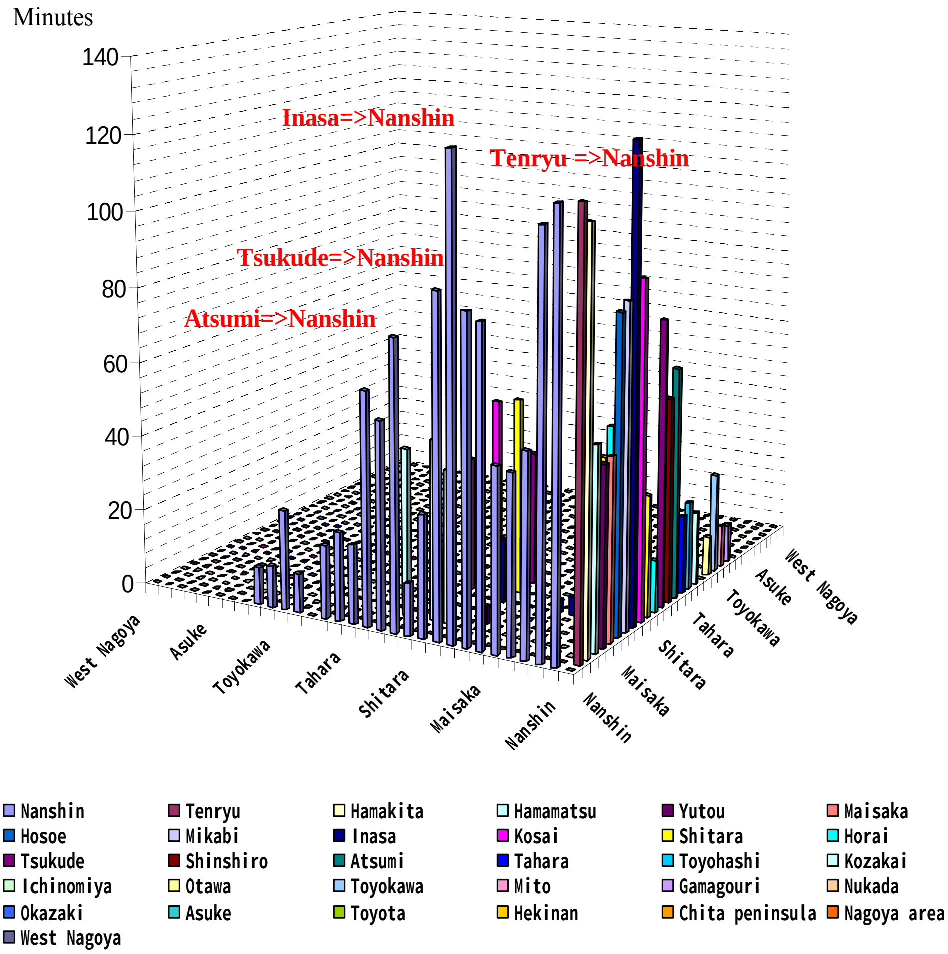

Figure 5. Time Difference after San-En-Nanshin Expressway

(4) Cost benefit Analysis after San-En-Nanshin Expressway

Economic benefit of San-En-Nanshin Expressway is calculated based on formula (48) called shortcut method as mentioned above. Benefit after a shift in transportation demand curve by general equilibrium effect is performed as general equilibrium consumer's surplus in Figure 6.

When the shift in transportation demand is so small and the transportation demand function in inelastic as in Fig-ure 7, *general equilibrium consumer's surplus = decreasing in general transportation cost × current transporta-tion demand*. With assumption of inelastic transportation demand, the total annual time benefit (in commuting persons) is estimated as 24.4 billion yen.

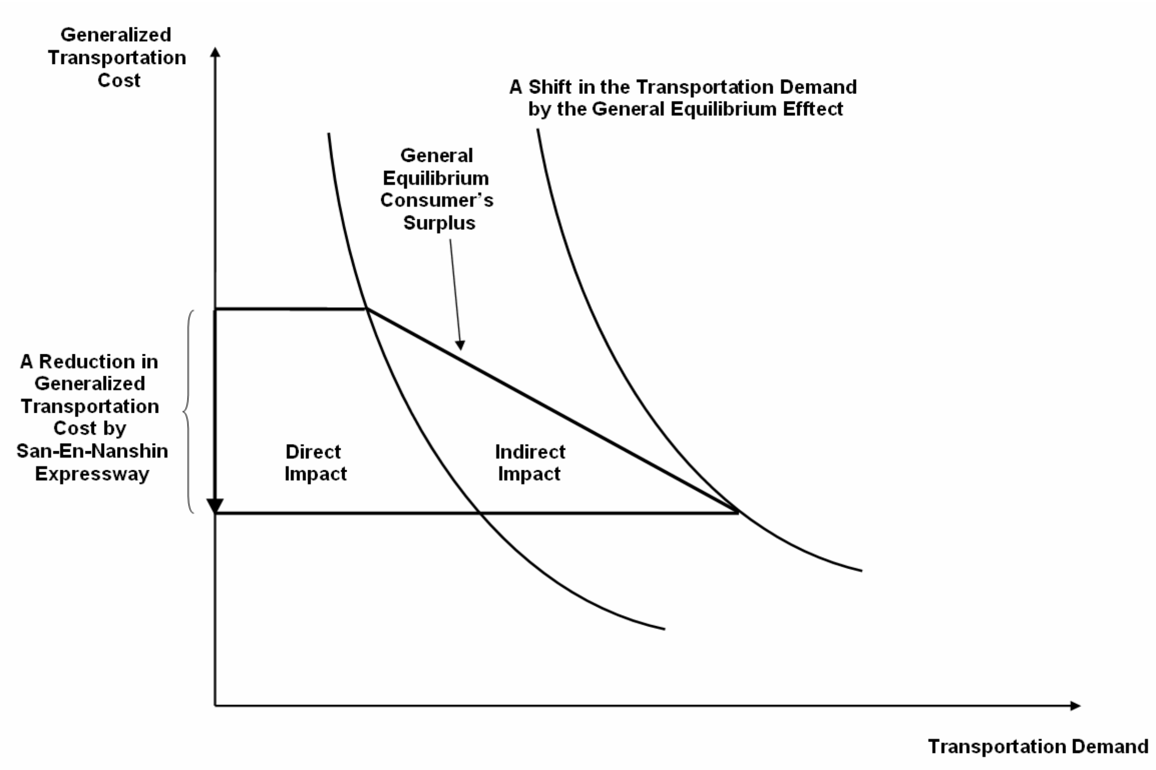

Figure 6. The Concept of General Equilibrium Consumer's Surplus

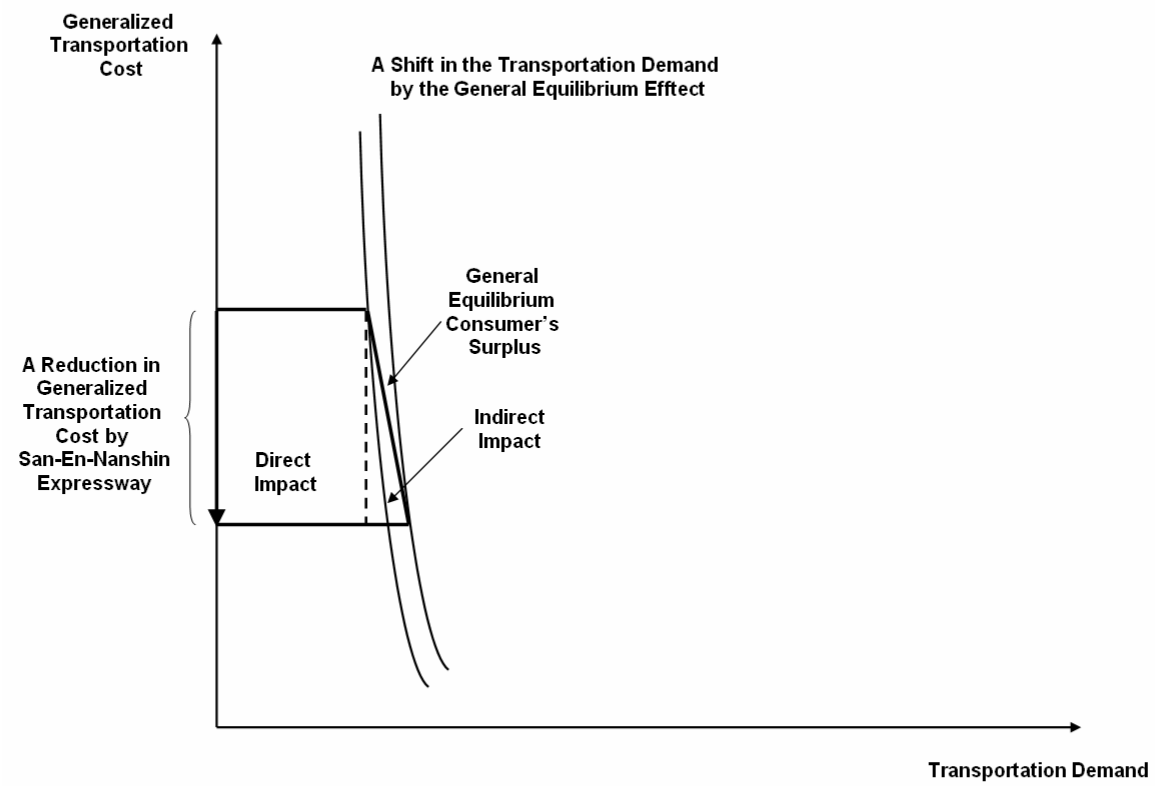

Figure 7. Economic Impact with a Small Indirect Impact and Inelastic Transportation Demand Function

Next, the total project cost of San-En-Nanshin Expressway will be examined from the viewpoint of annual cost. Here we assume that the duration term of San-En-Nanshin Expressway is 50 years, the total project cost is estimated as 500 billion yen or 1 trillion yen, and the social discount rate is 4% according to the manual of cost-benefit analysis issued by Ministry of National Land and Transportation, the Japan's Government. Then the annual project cost of each case is calculated as follows:

$$\text{annual project cost} = 500\text{ billion} \times \frac{0.04 \cdot (1+0.04)^{50}}{(1+0.04)^{50}-1} = 23.3\text{ billion yen}$$

$$\text{annual project cost} = 1\text{ trillion} \times \frac{0.04 \cdot (1+0.04)^{50}}{(1+0.04)^{50}-1} = 46.6\text{ billion yen}$$

Thus if the annual benefit is under 23.3 billion yen, it means that the efficiency of the expressway investment will be questionable. According to above data of commodity flow and commuting person flow, we can see that the demand for San-En-Nanshin Expressway is not so large. If the project cost is about 500 billion yen, the construction of San-En-Nanshin Expressway passes the cost benefit criteria. In the case of the project cost over 500 billion yen, passing the cost-benefit criteria seem to be difficult.

Moreover, as shown in Figure 8, the benefit in the route from Hamamatsu to Horai is biggest, about 6.5 billion yen, the second is the benefit from Nanshin to Toyohashi, about 4.8 billion yen. Although the economic benefit usually appears in urban areas, the economic potential is still large even in the middle mountain area such as Horai, suggesting more economic growth in that region.

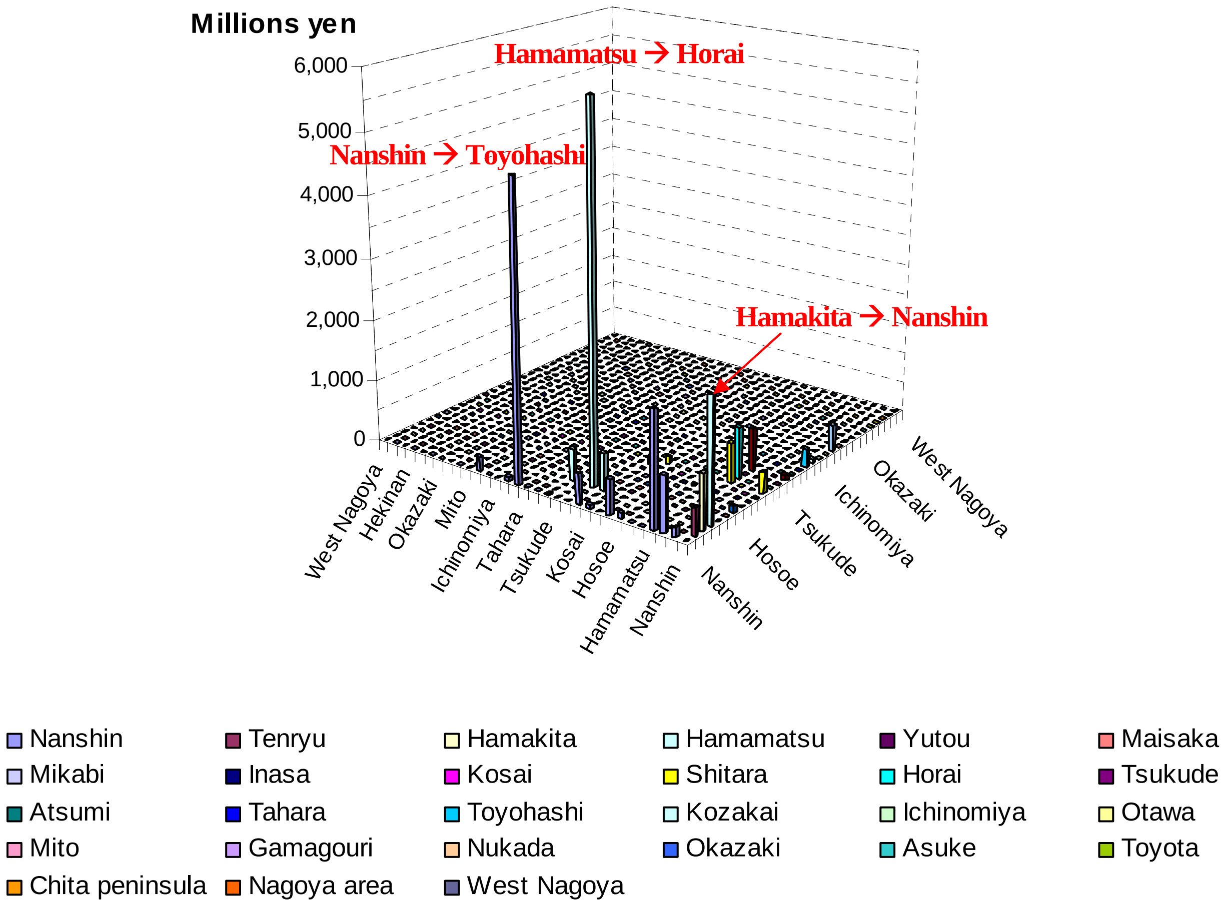

Figure 8. Intercity Benefit after San-En-Nanshin Expressway

9. Concluding Remarks

In this article, we have developed a spatial computable general equilibrium model to measure the economic impacts of San-En-Nanshin Expressway. Combining this model and the short cut method for the evaluation of economic benefit of a transportation project under the general equilibrium framework, we estimated economic benefit and the annual construction cost of San-En-Nanshin Expressway.

The total annual benefit is estimated as 24.4 billion yen, and it has been clarified that the construction of the expressway can pass the cost benefit criteria or not, depending on the scale of project cost. Besides, we also measured total benefit and benefits by zone as well. The results obtained in this study could be the first attempt among researches about San-En-Nanshin Expressway in Japan. The induced demand caused by shortened time after road improvement and the development demand due to a change of firms' and households' location choice behaviors is not internalized at present yet. As a result, the benefit of this expressway may be underestimated considering its potential. However, the current approach is safest to analyze cost benefit ratio from the construction investors' view.

There is a great expectation for San-En-Nanshin Expressway for improving the convenience of community health, so there are some additional benefits of shortening time after road construction that are not studied in this research yet. Therefore, the real economic impact of this expressway could be larger than our estimate.

San-En-Nanshin Expressway is expected to give a significant economic impact on San-En-Nanshin region, and moreover economic benefit maximization for San-En-Nanshin Expressway has become an important issue to be studied with comprehensive observation of the regional economy and social infrastructures.

Firstly, completion of the Second Tomei Expressway that connects with Tomei Expressway is necessary. After completion of that expressway, the effect of San-En-Nanshin Expressway on Hamamatsu could be increased. Secondly, by constructing Mikabi-Toyohashi road connecting National Road No.23 Bypass, National Road No.1 with Mikjabi Junction of Tomei Expressway, the effect of San-En-Nanshin Expressway on Toyohashi could probably be improved.

Nanshin region has important role because construction of a station of Linear Motor Shinkansen in Iida city is planned. San-En-Nanshin Expressway will improve the transportation convenience in a southern part of Iida city including the northern Enshyu and northern Higashi-Mikawa. When Linear Motor Shinkansen will be in operation, even current depopulated zones like the southern part of Iida city could become the sphere of business activities of Tokyo and Nagoya. This effect will yield new great development of Nanshin region.

Although San-En-Nanshin Expressway is planned as a national project, a part of construction cost will be born by the prefectures that this expressway runs through. It is estimated that the total project cost reaches several hundred billion yen. Therefore a considerable financial burden hangs to Nagano Prefecture, Aichi Prefecture, and Shizuoka Prefecture, and how to consistently solve the financial resource problem has been becoming important. This is a beneficiaries' responsibility assignment problem in a cross prefectural border region, thus an appropriate committee for solution of this problem is necessary as well.

Industrial promotion in San-En-Nanshin region is considered as a key to make San-En-Nanshin Expressway more effective. People want to live a place where living circumstances are convenient, and firms will invest in a place where those firms can get higher returns. The estimation of economic impact should take into account such a market mechanism, thus the present study can be regarded as a pioneering approach in economic analysis of transportation projects. Moreover the most important thing is to increase the endowment of economic resources in San-En-Nanshin Region, but not re-distribution of existing resources. For example, creation of businesses and/or project that enables coexisting of environmental conservation and economic growth. Following this idea, the establishment of large area management agency in the prefectural cross border region is necessary, thus the expectation for currently existing San-En-Nanshin Agency could become higher.

This study has just started from the initial stage. In the near future, the computation of the full spatial general equilibrium model will be completed although the shortcut method is employed in the present paper.

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