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The Effect of Transportation System on the Economic Growth of the Japanese Economy 1965-2000: using nine region interregional IO model

Tsubasa Shibata[*] , Takashi Yano[**] , and Hiroyuki Kosaka[***]

Abstract

Japan had experienced rapid economic growth since 1960. We can point out that the establishment of better and high-speed transportation was one of the crucial factors for the growth. Hence, this paper examines historically the impact of the high-speed transport infrastructure developments on Japan's economic growth by employing an interregional input output model for Japanese economy covering nine regions. This model is based on the IO tables from 1965 to 2000 in constant prices (nine regions and eight sectors) and determines sectoral output and sectoral price simultaneously. For this purpose, evaluation of transport development is quite important. This paper develops an index of transportation evaluation which focuses on the balance between the time-cost and the fare of any high speed transportation. Incorporating this index in the interregional input output model, the paper analyzes the effects of transport infrastructure development. As a result, this paper found positive relationship between the Japan economic growth and the development of transport system (particularly highway system), and also found problems associated with economic disparities among regions: i.e., centralization (concentration of people and goods) and decentralization occurred in core and local regions, respectively.

Key words: *international input output model, Japanese economy, Transportations*

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1. Introduction

After the World War II, Japan experienced a period of restoration followed by high economic growth, and Japan became the economy with the second largest GDP in the world in 1967. We could point out that establishing better and high-speed transportation system was one of the crucial factors for the high economic growth.

Since the Tokyo Olympic was held in 1964 and also Osaka Expo in 1970, the high speed transportation system has been rapidly developed (the Shinkansen line, the highway and airline). High-speed railway 'Tokaido Shinkansen", started in 1973, has been the main transportation line linking Japanese metropolitan regions of Tokyo, Nagoya and Osaka. The line transported 43.78 million passengers in 1965, and 55.25 million passengers increased 26% from the previous year between Osaka and Tokyo. In addition, the Japanese economy grew at a rapid pace of over 10 percent per annum during the 1960s.

However, when we look into regional economy in detail, all regions have not necessary experienced high economic growth equally, and some regions have experienced the serious depression. In 1970's, people and goods were concentrated on large economic region such as Tokyo or Osaka, and the other regions with economies of small scale declined. In 1980's, the situation has become more serious. The infrastructure of transportation has been highly developed and the time-cost for traveling has been shortened between Tokyo and Osaka, which enabled people to go and back in a day between the two. Then, the head offices of the financial institution or large companies in Osaka are transferred to Tokyo, and people and goods were moved to Kanto regions, which became causes of excessive centralization to Tokyo.

Thus, it has increased various economic disparities among regions. In order to grasp the economic effects of transportations rigorously, we need to examine historically the impact of

the high-speed transport infrastructure developments in the period of high economic growth by using a model.

The rest of this paper is organized as follows: Section 2 explains the framework of out model; Section 3 shows the data of input output table and transportation index; Section 4 shows the model structure; Section 5 presents the results of the scenario analysis; Section 6 is conclusions.

2. Characterizing our Approach

2.1 Interregional Input Output Modeling

This paper deals with interregional input output model as the basic framework, which covers the nine regions, and determines sectoral output and sectoral price simultaneously.
This model has three features. Firstly, we employ the input output model which is based on the demand oriented Leontief type. Now, we have many studies which analyzing transport infrastructure development, but most of them are focusing on the supply-side. In this connection, we have not only to focus on the supply side, but also on the demand side.

Secondly, as most studies used only one period IO data and build the IO model like CGE model, they do not endogenize price. In contrast, our model has sectoral output and price as endogenous variables in use of multi period IO data.

Thirdly, the data sample period covers historical process of Japanese economy from 1965 up to 2000, which enables us to grasp the change of the industrial structure or the regional economic disparities.

2.2 Making the Benefit Index of Transportation

We develop an index of transportation evaluation to measure its direct effect in applying the

concept of gravity model.

Gravity model is explained to represent interaction I^{hk} between h-th region and k-th, in which P^h is population of h-th region and d^{hk} is physical distance between the two. [J.Q.Stewart, 1948]

$$I^{hk} = G\frac{P^h P^k}{(d^{hk})^2} \tag{2.1}$$

Although d^{hk} is physical distance in above model, our index of transportation extends d^{hk} to economic sense. Then, economic distance index D^{hk} is defined below;

$$\begin{aligned} D^{hk} &= \text{time required to travel from } h \text{ to } k \ + \ \text{traffic fare to travel from } k \text{ to } k \\ &= \text{oppotunity labor cost} \ + \ \text{traffic fare to travel from } h \text{ to } k \end{aligned} \tag{2.2}$$

Travel time in (2.2) is converted to opportunity labor cost in money term; travel time (one hour) is replaced by wage rate per hour. Hereafter D^{hk} is labeled D_t^{hk} to show time t explicitly. In order to make benefits of transportation over time in historical sense, we formulate the benefit index of transportation T_t^{hk} in the following;

$$T_t^{hk} = \frac{D_t^{hk}}{D_0^{hk}} \tag{2.3}$$

The benefit transformation index in (2.3) is designed to exhibit the difference of cost between the current period and the initial one. Yet, the proportion of expenses of opportunity labor cost plus traffic fare depends on the income level in historical sense, namely, historical income should be discounted. Then, we have to modify (2.3) into (2.4) putting current income being discounted. Then the formula is below;

$$T_t^{hk} = \frac{\left(\frac{wage_t}{wage_0}\right)\left(D_t^{hk}\right)}{\left(\frac{wage_0}{wage_0}\right)\left(D_0^{hk}\right)} \tag{2.4}$$

Now the index (2.4) now makes clear the performance of transportation in current year compared to initial year 1965. If the performance of current year is improved against 1965, the index may show more than unity. Otherwise, the index will be less than unity. The index for individual transportation is made in different ways; Railway, Road, and Airline. The formulation is detailed in Section 3.2.

2.3 Incorporating these Indices into Input Output System

In third place, the transportation index is incorporated into IO model.

Transportation index are intended to enter IO model by three routes; a) transportation contributes to convey intermediate goods from one region to another, b) contributes to regional private consumption by potential model augmented by D_{ij}, and finally c) contributes to stimulate labor transfer. Thus, this model system can analyze the influence which the transportations affect on the individual economic factors and the whole Japan economy.

3. Reorganizing Data

3.1 Reorganizing Interregional IO Table: 1965-2000

To begin, we will explain our interregional input output data. We use the interregional input output tables for 1965, 1970, 1975, 1980, 1985, 1990, 1995, and 2000[1] which are compiled by the Ministry of Economy, Trade and Industry of Japan.

Aggregation of Sector and Region

Original data is not consistently organized with respect to the classification of sectors and regions through time. In order to minimize the inconsistency, we construct the 8-sector

[1] This was made by Sonoe Arai and Masayuki Ogata in Ministry of Economy, Trade and Industry of Japan.

version of the tables. Table 1 presents the regional classification. Table 2 shows the sector classification.

Table 1 Regions classification

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

Table 2 Sectors classification

No.	Sector
1	Agriculture
2	Mining
3	Manufacture of Metal product
4	Manufacture of Machinery
5	Miscellaneous manufacturing industries
6	Construction
7	Wholesale and retail trades and transportation Trade and transportation
8	Services

Deflating Interregional IO Tables

The original IO data is evaluated in current prices. In order to analyze real economy, it is necessary to use the IO table in constant prices. Hence, we deflated these input output tables by using some sectoral prices that are taken from the SNA, where the base year is 1990.

3.2 Benefit Index for Transportations: Railway, Road and Airline

In this section, we describe (2.4) in more detail.

Regional Classification

In the first place, we explain the details of regions. We decompose Japanese total economy into the nine regional economies in correspondence to the regional classification of the input output tables. We also select the representative or center city for each region. Then, we select Sapporo city in Hokkaido, Sendai city in Tohoku, Tokyo in Kanto, Nagoya city in Chubu, Osaka city in Kinki, Hiroshima city in Chugoku, Matsuyama (Takamatsu) city in Shikoku, Fukuoka city in Kyushu, Naha city in Okinawa. Based on these cities, we measure traveling time and fare that people move or travel between regions.

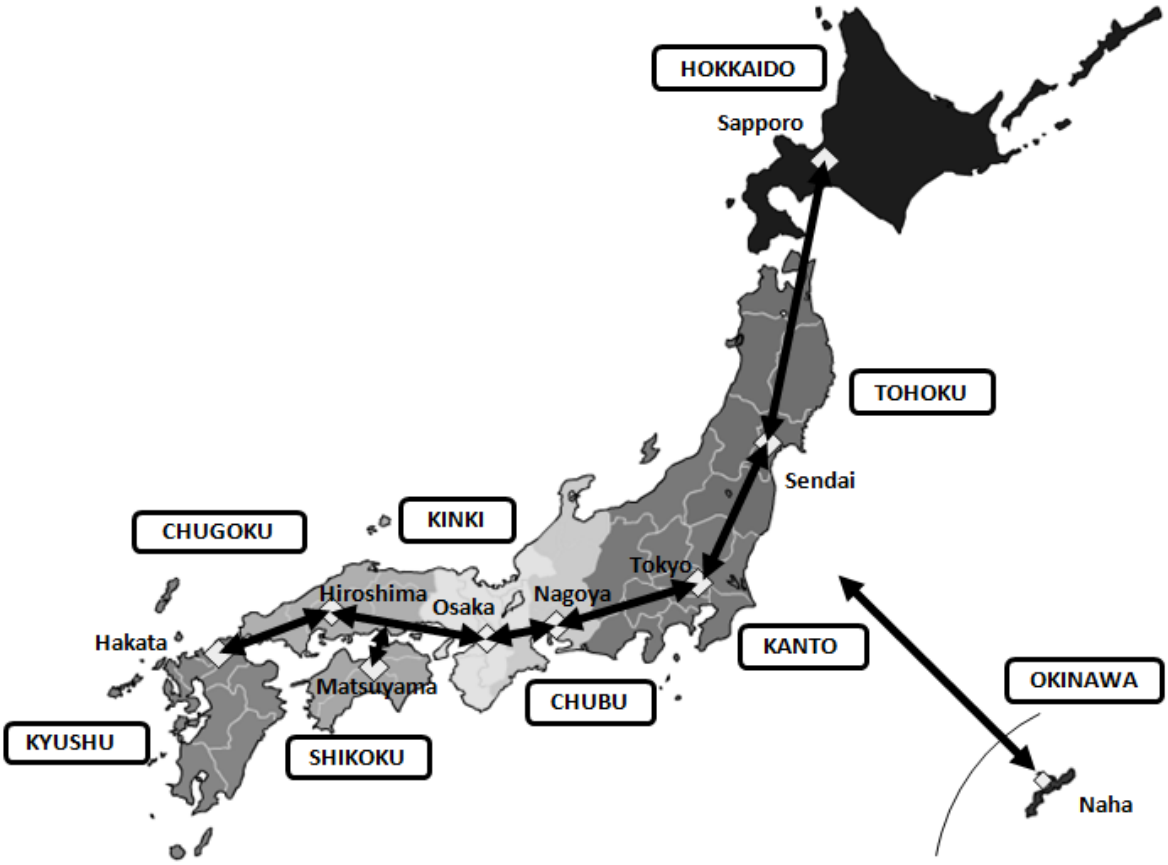

Figure 1 Nine regions and the representative point/city

Benefit Index of Railway

We explain the index of transportation evaluation focusing on the railways in the first. The degree of transportation benefit is formulated as:

$$T_{trn}^{hk}(t) = \frac{\dfrac{1}{\left(\dfrac{wage\_m_t}{wage\_m_{1965}}\right)(Mtime\_newtrn_t + fare\_newtrn_t)}}{\dfrac{1}{\left(\dfrac{wage\_m_{1965}}{wage\_m_{1965}}\right)(Mtime\_oldtrn_{1965} + fare\_oldtrn_{1965})}} \tag{3.1}$$

$T_{trn}^{hk}(t)$: Benefit index of transportation moving from *h*-th region to *k*-th by using new train(Shinkansen) at t

$Mtime\_oldtrn_{1965}$: Traveling time in money term deflated by 1990 prices using old train at 1965

$fare\_oldtrn_{1965}$: Fare deflated by 1990 prices using old train at 1965

$Mtime\_newtrn_t$: Traveling time in money term deflated by 1990 prices using new train (Shinkansen) at t

$fare\_newtrn_t$: Fare deflated by 1990 prices using new train (Shinkansen) at t

$wage\_m_t$: Monthly nominal wage at t

$\dfrac{wage\_m_t}{wage\_m_{1965}}$: Fraction of $wage\_m_t$ against $wage\_m_{1965}$

In the sample period, each year's performance is compared with 1965's old railways transportation. If the performance is improved from the level in 1965 (for example, by technological progress, or by more efficient operation in terms of time), the index shows more than unity. Otherwise, index will be less than unity. Table 3 shows the details of traveling route between representative cities.

Table 3 The high-speed railway and old railroad lines

Section			Old railway	Shinkansen railway
Sapporo	⇔	Sendai	Hakodate Line, Tohoku Line	Hakodate Line, Tohoku Shinkansen
Sendai	⇔	Tokyo	Tohoku Line	Tohoku Shinkansen
Tokyo	⇔	Nagoya	Tokaido Line	Tokaido Shinkansen
Nagoya	⇔	Osaka	Tokaido Line	Tokaido Shinkansen
Osaka	⇔	Hiroshima	Sanyo Line	Sanyo Shinkansen
Mainland	⇔	Matsuyama	Sanyo Line	Sanyo Shinkansen
Hiroshima	⇔	Hakata	Sanyo Line	Sanyo Shinkansen

Benefit Index of Road

We explain the index of transportation evaluation which focuses on highway. The degree of transportation convenience with respect to highway is written as:

$$T_{high}^{hk}(t) = \frac{\dfrac{1}{\left(\dfrac{wage\_m_t}{wage\_m_{1965}}\right)(Mtime\_highway_t + fare\_highway_t)}}{\dfrac{1}{\left(\dfrac{wage\_m_{1965}}{wage\_m_{1965}}\right)(Mtime\_road_{1965} + fare\_road_{1965})}} \tag{3.2}$$

$T_{high}^{hk}(t)$: Benefit index of transportation moving from *h*-th region to *k*-th by using the highway at t

$Mtime\_road_{1965}$: Traveling time in money term deflated by 1990 prices using the old road at 1965

$fare\_road_{1965}$: Fare deflated by 1990 prices using old road at 1965[2]

$Mtime\_highway_t$: Traveling time in money term deflated by 1990 prices using highway at t

[2] Old national roads are free in principle. Thus, this term is zero.

$fare\_highway_t$: Fare deflated by 1990 prices using highway at t

There are 36 observations for each variable from 1965 to 2000. Depending on year, the availability of highway road differs. We note that the differences on availability are reflected in our index. Table 4 shows the details of traveling methods between points/cities.

Table 4 Old roads and Highways

Section			Old Road	Highway
Sendai	⇔	Tokyo	Route 4	Tohoku Expressway
Tokyo	⇔	Nagoya	Route 1	Tomei Expressway
Nagoya	⇔	Osaka	Route 2	Meishin Expressway
Osaka	⇔	Hiroshima	Route 2	Sanyo Expressway
Honshu	⇔	Matsuyama	Route 2	Honshu-Shikoku Bridge Expressway
Hiroshima	⇔	Fukuoka	Route 2, Route 3	Sanyo Expressway, Chugoku Expressway, Kyushu Expressway.

Benefit Index of Air line

Air lines have a special feature such that there does not exist the lines which correspond to ordinary roads or ordinary trains. The improvement of airline should be evaluated by the number of direct flights between regions. In our investigations, the number of them is smallest in 1993. Thus, we set the year 1993 as the base year. The degree of transportation convenience with respect to air transportation is written as:

$$T_{air}^{hk}(t) = \frac{\dfrac{1}{\left(\dfrac{wage\_m_t}{wage\_m_{1993}}\right)(Mtime\_airline_t + fare\_airline_t)}}{\dfrac{1}{\left(\dfrac{wage\_m_{1993}}{wage\_m_{1993}}\right)(Mtime\_airline_{1993} + fare\_airline_{1993})}} \tag{3.3}$$

$T_{air}^{hk}(t)$: Benefit index of transportation moving from h-th region to k-th by using airline at t

$Mtime\_airline_{1993}$: Traveling time in money term deflated by 1990 prices using the airline at 1993

$fare\_airline_{1993}$: Fare deflated by 1990 prices using airline at 1993

$Mtime\_airline_t$: Traveling time in money term deflated by 1990 prices using airline at t

$fare\_airline_t$: Fare deflated by 1990 prices using airline at t

Table 5 shows the details of traveling methods between points/cities.

Table 5 Airport

Representative city	Airport
Sapporo	New Chitose Airport
Sendai	Sendai Airport
Tokyo	Haneda Airport
Osaka	Itami Airport
Hiroshima	Hiroshima Airport
Matsuyama	Matsuyama Airport
Hakata	Fukuoka Airport
Okinawa	Naha Airport

Making Benefit Index allowing Substitutability Among Three Transportations

As equations (3.1), (3.2), and (3.3) show, individual transportation is evaluated independently ignoring substitutability among transportations. Thus, the index signifies that, if highway is improved in required time or fare, the index of highway would rise and the indices of other transportations(high speed railway and airline) would still be unchanged. Yet,

the index can not reflect the real world sufficiently. In other words, people would consider the choice among three kinds of transportations. If the benefit of highway would rise, the performance of railway and airline should be relatively deteriorated. For including people's choice among three kinds of transportations, we reformulate benefit indexes of transportation allowing substitution among the three in the following:

$$TT_{trn}^{hk} = \left(\frac{TT_{trn}^{hk} TT_{trn}^{hk} TT_{trn}^{hk}}{TT_{trn}^{hk} TT_{high}^{hk} TT_{air}^{hk}} \right)^{\frac{1}{3}} \tag{3.4}$$

$$TT_{high}^{hk} = \left(\frac{TT_{high}^{hk} TT_{high}^{hk} TT_{high}^{hk}}{TT_{trn}^{hk} TT_{high}^{hk} TT_{air}^{hk}} \right)^{\frac{1}{3}} \tag{3.5}$$

And

$$TT_{air}^{hk} = \left(\frac{TT_{air}^{hk} TT_{air}^{hk} TT_{air}^{hk}}{TT_{trn}^{hk} TT_{high}^{hk} TT_{air}^{hk}} \right)^{\frac{1}{3}} \tag{3.6}$$

where TT_{trn}^{hk}, TT_{high}^{hk}, TT_{air}^{hk} are the substitutability indexes of high-speed train, highway, and airline, respectively. It is worth noting that if one of three transportation indexes rises, the others should decline.

4. The Modeling Interregional Input Output System For Nine Regions

Consider an interregional input output table with *r* regions and *n* sectors. The fundamental structure of the model is based on the Chenery-Moses interregional input output model.

Input Coefficients

The input coefficients express the input required for a unit production under existing production technologies and represent a certain production technological standard. In other words, it is called technical coefficients.

Generally, in Chenery(1953)-Moses(1955) input output model, the source region is unknown and the input coefficients are common among the source region. In addition, we also assume that there is no difference between the levels of technology among regions. Based on these assumptions, we formulate the input coefficient as follows:

$$axr_{ij} = \frac{\sum_{k=1}^{r}\sum_{h=1}^{r} xvr_{kj}^{hk}}{XXR_j} \tag{4.1}$$

where axr_{ij} is the amount of input *i* required to produce a unit of output *j*, xvr_{ij}^{hk} is intermediate input of region *h*'s commodity *i* in sector *j* of region *k*, XXR_j is output in sector *j*. Using equation (4.1), the input coefficient matrix for country *k* can be written as:

$$A = \begin{bmatrix} axr_{11} & \cdots & axr_{1n} \\ \vdots & \ddots & \vdots \\ axr_{n1} & \cdots & axr_{nn} \end{bmatrix} (n \times n) \tag{4.2}$$

Transaction Coefficients of Intermediate Goods

The transaction coefficient of intermediate goods is defined as:

$$mvr_i^{hk} = \frac{\sum_{j=1}^{n} xvr_{ij}^{hk}}{\sum_{j=1}^{n} xvr_{ij}^{k}} \tag{4.3}$$

where mxr_i^{hk} is the ratio of country *h*'s commodity *i* to the total intermediate input in region *k*-th. Here, we endogenize it to explain the impacts of transpiration development on the trading between regions as:

$$mvr_i^{hk} = \beta_i^k \left(T_{high}^{hk}\right)^{\beta_{i,\ high}^{hk}} \tag{4.4}$$

where T_{high}^{hk} is the index of highway in moving between regions *h*-th and *k*-th. In the domestic distribution network, the road has the largest of share in transportation networks. Thus, only the highway index is incorporated in this formulation.

Private Consumption

Private consumption is quite important among final demand components. Hence, we endogenize it as follows:

$$\begin{aligned} log\left(CPR_i^{hk}\right) = \alpha_i + \beta_i\, log\left(\frac{WAGE^k}{P_c}\right) \\ + \beta_{i,\ trn}^{hk}\, log\left(\frac{\sum_{l\in S} TT_{trn}^{lk}\, WAGE^l}{P_c}\right) \\ + \beta_{i,\ high}^{hk} \log\left(\frac{\sum_{l\in S} TT_{high}^{lk}\, WAGE^l}{P_c}\right) \\ + \beta_{i,\ air}^{hk} \log\left(\frac{\sum_{l\in S} TT_{air}^{lk}\, WAGE^l}{P_c}\right) + \gamma_i \log\left(\frac{P_i}{P_c}\right) \end{aligned} \tag{4.5}$$

where CPR_i^{hk} is *k*-th region private consumption of commodity *i* coming from *h*-th region, $WAGE^k$ is wages in current prices of *k*-th region, P_i is price in sector *i*, P_c is the consumer

price index at macro level, TT_{trn}^{lk}, TT_{high}^{lk}, TT_{air}^{lk} are indexes explaining substitutability across transportations. CPR_i^{hk} is determined by the neighboring region's wages such as $\sum_{l\in S} TT_{trn}^{lk} WAGE^l$, $\sum_{l\in S} TT_{air}^{lk} WAGE^l$ and $\sum_{l\in S} TT_{high}^{lk} WAGE^l$. In other words, CPR_i^{hk} can be considered as the potential CPR_i^{hk}. The definition of neighbor regions is presented in Table 6.

Table 6 The definition of neighbor regions

The point	The Definition of *l* in (4.5)		
	Railway	Road	Airline
Hokkaido	Tohoku	—	Kanto, Chubu, Kinki, Chugoku, Kyushu, Kyushu, Okinawa
Tohoku	Hokkaido	—	Kanto, Chubu, Kinki, Chugoku, Kyushu, Kyushu, Okinawa
Kanto	Tohoku, Chubu	Tohoku, Chubu	Hokkaido, Tohoku, Shikoku, Kyushu, Okinawa
Chubu	Kanto, Kinki	Kanto, Kinki	Hokkaido, Tohoku, Shikoku, Kyushu, Okinawa
Kinki	Chubu, Chugoku	Chugoku, Chubu	Hokkaido, Tohoku, Okinawa
Chugoku	Kinki, Shikoku, Kyushu	Kinki, Shikoku, Kyushu	Hokkaido, Tohoku, Okinawa
Shikoku	Kinki, Chugoku, Kyushu	Kinki, Shikoku, Kyushu	Hokkaido, Tohoku, Kanto, Okinawa
Kyushu	Chugoku	Chugoku	Hokkaido, Tohoku, Kanto, Okinawa
Okinawa	—	—	All regions except Okinawa

Determining Intermediate Goods

The trade coefficient in (4.3) can be expressed as:

$$xvr_{ij}^{hk} = mxr_i^{hk} XXR_{ij}^k \tag{4.6}$$

From this formulation, we can regard the trade coefficient as the distribution share to output. Furthermore, the input coefficient in (4.1) can be also represented as:

$$XXR_{ij}^{k} = axr_{ij} XXR_{j}^{k} \tag{4.7}$$

Sectoral Output

From the identity with respect to demand, output in sector *i* of region *h* is written as:

$$\sum_{k=1}^{r}\sum_{j=1}^{n} xvr_{ij}^{hk} + F_{i}^{h} = XXR_{i}^{h} \tag{4.8}$$

Equation (4.8) can be rewritten by using equations (4.6) and (4.7) as:

$$\sum_{k=1}^{r}\sum_{j=1}^{n} mxr_{i}^{hk} axr_{ij} XXR_{j}^{k} + F_{i}^{h} = XXR_{i}^{h} \tag{4.9}$$

Sectoral Price

Sectoral price is determined by the unit material cost and the unit labor cost as:

$$p_{j} = \alpha_{j} + \beta_{j}\left(\frac{\sum_{k} wage_{j}^{k}}{\sum_{k} XXR_{j}^{k}}\right) + \gamma_{j}\left(\frac{\sum_{k}\sum_{i}\sum_{h} xv_{ij}^{hk}}{\sum_{k} XXR_{j}^{k}}\right) \tag{4.10}$$

Employment: Sectors and Regions

Employment demand is explained as:

$$L_{j}^{k} = \beta^{k}\left(XXR_{j}^{k}\right)^{\beta}\left(\sum_{l\in S} TT_{trn}^{lk}\sum_{l\in S} TT_{high}^{lk}\sum_{l\in S} TT_{air}^{lk}\right)^{\delta_{trn,\ high,\ air}^{k}} \tag{4.11}$$

where L_{j}^{k} is emplyment in *j*-th sector of *k*-th region. As in equation (4.11) , L_{j}^{k} is determined

by the neighboring region's accessibility. In the estimation of the above equation, we use the possibility of the three transportation systems. For identifying correct sign of explanatory variables and plausibility of fitted equation, we use Akaike's information criterion.

Wage Rate: Sectors and Regions

The wage rate is formulated as:

$$wage\_rate_j^k = \beta_j^k \left(\frac{XXR_j^k}{L_j^k} \right)^{\xi_j^k} \tag{4.12}$$

where $wage\_rate_j^k$ is the wage rate in sector j of region k. It is assumed that the wage rate can be explained by labor productivity. Figure 2 demonstrates the relation among variables.

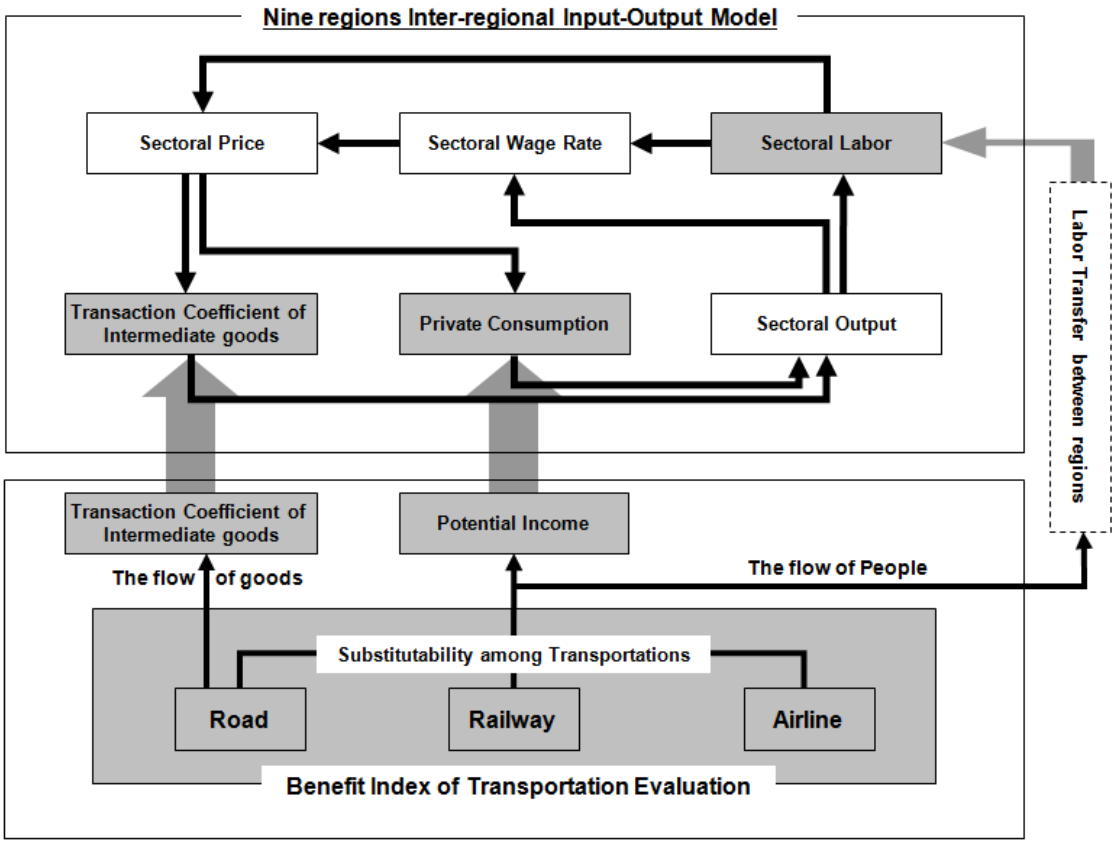

Figure 2 the relation among variables

5. Scenarios

5.1 Baseline Scenario: Historical Scenario

We simulate the baseline scenario which reflects the real economy from 1965 up to 2000. Although some of variables should be improved, the calculated values in final test sufficiently trace the actual values. Then we could accept interregional IO model. Simulation results are omitted because of lack of space.

5.2 Alternative Scenarios

We conducted seven scenarios for investigating the impact of the highly functioned transport infrastructures historically in comparison with the old transportation system. The details of scenarios are summarized as follows:

Scenario A : Only one index of railway keeps the 1965 level and consistently is fixed in "1" from 1966 up to 2000, which mean that Shinkansen has not been constructed since 1965. But, railway and highway have been developed and the indices of them are unchanged.

Scenario B : Only one index of road keeps the 1965 level and consistently is fixed in "1" from 1966 up to 2000, which mean that highway has not been constructed since 1965. But, Shinkansen and airline have been developed and the indices of them are unchanged.

Scenario C : Only one index of airline keeps the 1965 level and consistently is fixed in "1" from 1966 up to 2000, which mean that airline has not been developed since 1965. But, Shinkansen and highway have been developed and the indices of them are unchanged.

Scenario D : Two indices of railway plus road keep the 1965 level and consistently are fixed in “1” from 1966 up to 2000, which mean that Shinkansen and highway has not been constructed since 1965. But, airline has been developed and the indices of them are unchanged.

Scenario E : Two indices of road plus airline keep the 1965 level and consistently are fixed in “1” from 1966 up to 2000, which mean that highway and airline has not been developed since 1965. But, Shikansen has been developed and the indices of them are unchanged.

Scenario F : Two indices of railway plus airline keep the 1965 level and consistently are fixed in “1” from 1966 up to 2000, which mean that Shinkansen and airline has not been developed since 1965. But, highway has been constructed and the indices of them are unchanged.

Scenario G : All indices(railway, road, airline) keep the 1965 level and consistently are fixed in “1” from 1966 up to 2000, which mean all transportations has not been developed since 1965.

Table 7 Scenario

	Shinkansen	Highway	Airline
Baseline	○	○	○
Scenario A	×	○	○
Scenario B	○	×	○
Scenario C	○	○	×
Scenario D	×	×	○
Scenario E	○	×	×
Scenario F	×	○	×
Scenario G	×	×	×

[×:1965 level ○: historical scenario]

5.3 Simulation Results

5.3.1 The effect on the Sectoral Output in Total

Figure 3 percent deviations of the total output of the base line.

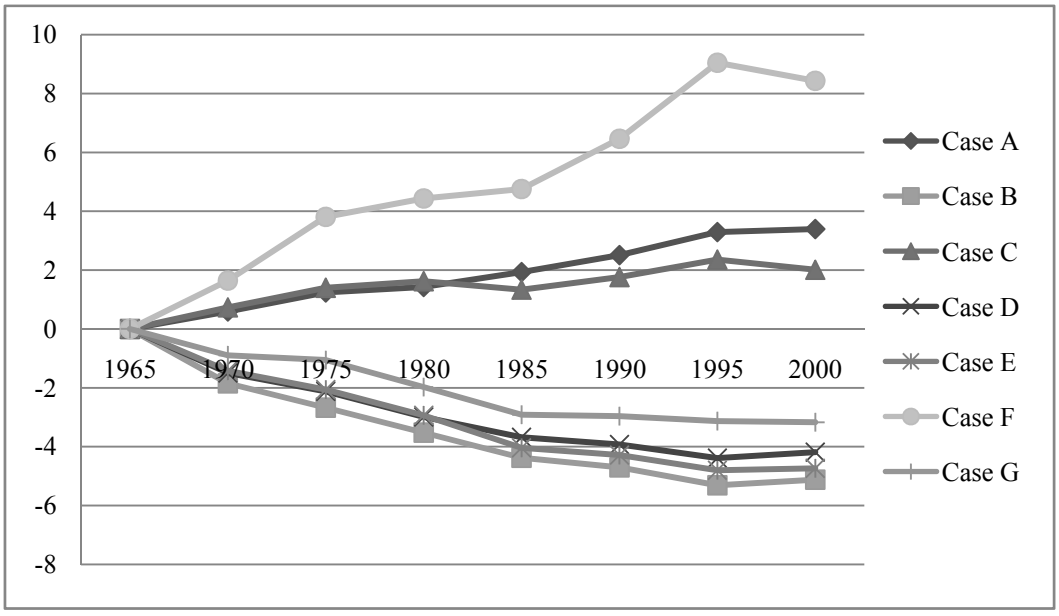

Figure 3 Percent deviation of output from the base line (%)

It is expected that the Japanese economy would become worse without any high speed transportations. However, we found positive results for Scenarios F, A, and C. These results could include the development of highway. In contrast, we found negative impacts for Scenarios G, D, E, and B. In these Scenarios, development of highway is neglected. Especially, Scenario B yields substantial negative impacts (in this Scenario, only highway wouldn't be developed). The Figure 3 shows that positiveness or negativeness in the graph depend on highway construction. Thus the highway construction has played crucial role in the Japanese economy. Based on the results, we can conclude that highway is more important and necessary infrastructure than the others, and highway is closely related with economic growth of Japan.

5.3.2 Investigating Individual Sectoral Output: Computing Gini's Coefficient

Here, we focus on the regional economy. We calculate the Gini's coefficient by regions in order to compare regional disparity. Table 8 shows the mean of the Gini's coefficient from 1965 to 2000.

Table 8 The regional disparity: The Gini's coefficient (ascending-order)

	The Gini's coefficient
Scenario A	0.495
Scenario C	0.495
Scenario F	0.496
Baseline	0.496
Scenario G	0.497
Scenario D	0.498
Scenario E	0.498
Scenario B	0.498

Low Gini's coefficient indicates a more equal distribution with zero corresponding to perfect equality. The baseline scenario is ranked in the 4th, which tends to yield regional disparity compared with some scenarios. And, all Scenarios except base line scenario in Table 8 are corresponding to the result showed in Figure 3. Scenario A, C, and F indicate equality among regions, which show the positive effect to Japanese economy in Table Figure 3. On the other hand, Scenario G, D, E, and B show inequality among regions, which specify the negative effect to Japan in Figure 3. That is to say, constructing highway contributes to both whole Japan economy and regional economy.

Next, we bring focus into the major regions which have three largest cities in Japan; Kanto(Tokyo), Chubu(Nagoya) and Kinki(Osaka). Table 9 shows the share of output in these three regions.

Table 9　Output share by regions(descending-order) (%)

Kanto		Kinki		Chubu	
Scenario B	40.88	Scenario G	18.21	Scenario F	12.58
Scenario E	40.81	Scenario D	18.19	Scenario C	12.27
Scenario D	40.80	Scenario F	18.18	Scenario A	12.26
Scenario G	40.70	Scenario E	18.18	Baseline	12.11
Baseline	40.38	Scenario B	18.17	Scenario G	11.74
Scenario C	40.25	Scenario A	18.16	Scenario E	11.63
Scenario A	40.21	Scenario C	18.11	Scenario D	11.63
Scenario F	40.01	Baseline	18.09	Scenario B	11.57

Firstly, we focus on Kanto in Table 9. Scenario B, E, D, and G are preferable for Kanto. But, their Scenarios show the negative effect to whole Japanese economy in Figure 3 and the regional disparity in Table 8. These results reveal that the favor scenarios for Kanto might tend to lead to decline entire Japanese economy or expand each regional disparity of economy, which can describe partially the real phenomenon such as the concentration to Tokyo (Kanto).

Secondly, in Kinki, the base line is located in the lowest and Scenario G is in the top. It means that the current transportation system may be not preferable for Kinki. And if any transportation did not constructed, Kinki might be able to increase output.

5.3.3 Interregional Labor Transfer

Table 10 shows the regional share of employment.

Table 10 The annual mean of labor share by regional (descending-order) (%)

Kanto		Kinki		Chubu	
Baseline	41.26	Scenario A	19.04	Scenario F	11.89
Scenario B	41.08	Baseline	19.02	Scenario A	11.82
Scenario A	40.92	Scenario F	18.99	Scenario C	11.78
Scenario D	40.78	Scenario C	18.97	Scenario G	11.75
Scenario C	40.58	Scenario D	18.96	Baseline	11.71

Scenario E	40.47	Scenario B	18.95	Scenario D	11.71
Scenario F	40.28	Scenario G	18.91	Scenario E	11.66
Scenario G	40.19	Scenario E	18.90	Scenario B	11.62

Kyushu		Tohoku		Chugoku		Shikoku	
Scenario E	10.52	Scenario G	7.91	Scenario G	7.16	Scenario G	3.58
Scenario G	10.50	Scenario F	7.87	Scenario D	7.07	Scenario E	3.54
Scenario C	10.48	Scenario E	7.86	Scenario E	7.04	Scenario D	3.53
Scenario F	10.45	Scenario C	7.83	Scenario F	7.01	Scenario F	3.50
Scenario B	10.22	Scenario D	7.76	Scenario B	6.95	Scenario B	3.48
Scenario D	10.20	Scenario A	7.71	Scenario A	6.91	Scenario C	3.45
Baseline	10.17	Scenario B	7.70	Scenario C	6.90	Scenario A	3.45
Scenario A	10.16	Baseline	7.66	Baseline	6.79	Baseline	3.40

We found some interesting tendency in Table 10. The magnitude for the baseline is highly ranked for the three metropolitan regions(Kanto, Kinki and Chubu), however, it is far lower ranked in the other regions (particularly economies with small scale). This demonstrates that the current transportation system yields incentives for people to move from regions to the three metropolitan regions. Conversely, the result for Scenario G is ranked first in local regions. This implies that labor mobility from these regions to the large regions might not occur without high speed transportation.

6. Conclusions

Our study constructed an interregional input output model for Japanese economy covering nine regions in constant prices, which determines sectoral output and sectoral price simultaneously. Then, we developed indices of transportation evaluation which focuses on the balance between the time-cost and the fare of any high speed transportation. Finally, incorporating this index into the interregional input output model, the paper analyzes the

effects of transport infrastructure development.

Several findings are obtained by our scenario simulations. Firstly, we could verify that the development of transportation positively contributed to economic growth of Japan as a whole. However, we also found its negative effects on some regions. Thus, the contribution of transportation development differs by region. Secondly, we showed that the development of transportation gave rise to problems which are observed in contemporary Japan such as the concentration in Kanto (particualrly in Tokyo) and the exhaustion of regions with smaller economic scale than Kanto. Thirdly, we could find out that highway had far greater influence on the economy of Japan than the other transportations.

Overall, this paper could achieve its purposes; however, several improvements would be required. Firstly, although we developed the index of transportation in time-cost and fare, the index can be improved by including other factors that show the state of transportations such as the number of lines or flights. Secondly, our model could explain the impacts of transpiration development on demand side of the economy in Japan; however, the effects of economic growth induced by transportation development on further transpiration development are neglected in the model. That is, our model could grasp only one side of the interaction between the development of transportations and economic growth. To solve those problems, it is imperative to endogenize those indexes in the model. Thirdly, more precise description of regional economy is also required.

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