THE MACRO ECONOMETRIC MODEL FOR EVALUATING THE LONG-RANGE PLAN OF TRANSPORT INFRASTRUCTURE DEVELOPMENTS IN JAPAN

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Abstract

In Japan, the long-range priority plan of infrastructure development which covers multi-mode transport development was approved in 2003. In this paper, the macro econometric model capable of evaluating multi-mode transport development, which has the following features, is developed. 1) The sub models have been constructed by industry and by commodity to have the changes in industrial structure and diversity of consumption in recent years reflected in them. 2) Multi-mode Transport infrastructure development is expressed as transportation accessibility, the weighted average of travel time among regions, which has an influence on various economic activities such as production. 3) The matching function of employment is introduced considering employment mismatches, which is thought to be a cause of high unemployment rate in recent years. In addition to the econometric model, the annual national benefit defined as sum of equivalent variation (EV) using output of the model is proposed. As results of simulation for two sections of typical expressways in the metropolitan and rural area in Japan, it is indicated that their development will increase GDP, employment and tax revenues, and the benefit cost ratio for 40 years after the opening exceeds 1.5 for both sections.

Keywords: Macro econometric model; Transport development; Matching function
Topic Area: E1 Assessment and Appraisal Method w.r.t. Transport Infrastructure Projects and Transport Activities

1. Introduction

In Japan, since the bursting of the bubble economy in April 1991, economic growth has continued to be low. Amid restructuring carried out by firms, unemployment rate has grown year by year and reached 5.5% in January 2003, the highest level recorded since 1950. In the 1990s, the Japanese government undertook financial expenditure actively with the aim of either stimulating the economy or upholding it; namely, public investments were made to develop infrastructure. As a result, however, public debt has accumulated and its total amounts for the national and local governments reached 693 trillion yen, almost 1.4 times GDP, at the end of March 2003.

Under these circumstances, criticism has grown in regard to transport infrastructure development, especially projects such as expressways, Shinkansen railways, airports, and seaports in rural areas, which are considered to have small effects. In Japan, infrastructure development had so far been promoted according to the long-range plans for each kind of infrastructure such as roads, airports, forestry conservation, and river improvement.

Referring to roads, for example, the first five-year road improvement program was established in 1954. Between 1998 and 2002, the 12th program was put into effect. In recent years, however, criticism has grown that plans such as these by kind of infrastructure have caused budgets to become rigid and are the hotbed of wasteful public investments.

To respond to such criticism, "Law for the priority plan of infrastructure development" was approved in 2003. Based on the law, the long-range infrastructure development plan from a comprehensive standpoint covering all kinds of infrastructures is to be worked out. Period for the priority plan is five years.

In any case, to carry out efficient development of infrastructure within limited budgets in the future—this will include study of where investments will be made—it will become increasingly important to view each investment project from an appropriate evaluation standpoint.

Effects of infrastructure development generally extend over a long period. Therefore, in making the evaluation, it is important to be based on, as much as possible, the future social and economic circumstances that can be predicted. In particular, it is necessary to consider population trends in Japan, as population is forecasted to reach the peak in 2006 and decline after that. Other matters for consideration are the hollowing out of the industries with the remarkable transfer in recent years of manufacturing plants to China and other Asian countries and industries becoming soft.

In respect of recent labor market in Japan, there is, on the one hand, a large number of unemployed, and, on the other hand, there are many job offers by firms. This has led to an increase in what is called mismatch unemployment which does not allow new employment. As methods for evaluating the development of transport infrastructure, there are three major approaches. They are the consumer's surplus method, national income approach, and hedonic approach. In addition, computable general equilibrium (CGE) analysis, which is an application of general equilibrium theory, is being used for the actual evaluation of projects in recent years.

In regard to measurement of direct effects on the transportation market using the consumer's surplus method, what is called "Guideline for benefit cost analysis" was prepared in the latter half of the 1990s for each transportation facility in Japan. And the government made, in principle, the application of the guideline obligatory for prior evaluation of all transportation projects.

The consumer's surplus method, however, has the defect of not being able to analyze where benefits finally belong to, that is to say, the benefit incidence and impacts on the economic variables such as GDP and unemployment. Thus in evaluating the widespread long-run impacts of transport infrastructure development, it is obvious that measurement of only direct effects with consumer's surplus method is not sufficient.

The three methods of national income approach, hedonic approach, and CGE analysis are those for measuring indirect effects. Of the three methods, hedonic approach is based on strict assumption of small-open and can only be applied basically to small-scale projects.

CGE analysis has the defect that it can never calculate effects on unemployment which is most serious problem these days in Japan because of its assumption of labor market equilibrium. Besides, it cannot evaluate the long-term effects because it is basically a static model. As for dynamic CGE model, which has been developed in recent years, it is being pointed out that it cannot trace the actual data well especially for private capital investment.

In respect of the macro econometric model based on national income approach, it faces the criticism that it has much room for arbitrariness to enter when a model is being constructed as it is not based on microeconomics strictly. It is also being criticized for not being able to cope with structural changes in the future as parameter estimation is carried out using time-series data in the past.

Nevertheless, the macro econometric model is considered one of the best methods that can measure extensive influences the transport infrastructure has on the economy over a long-term period taking account of social and economic circumstances in recent years.

With the background mentioned above, the objective of this paper is to develop the macro econometric model which can evaluate multi-mode transport infrastructure development in Japan based on the priority plan.

2. Existing econometric models evaluating transport development in Japan

In Japan, the existing macro econometric models evaluating transport development have two streams. One is the series of models for five-year road improvement program since 1970's. And the other is the models for Shinkansen railway projects, development of which began in 1985.

Study to measure the economic effects of the five-year road improvement program began with the seventh five-year program (1973-1977) and has continued on to today. For the seventh five-year program, "Global METS Model (GMM)" was developed. Development of "the Spatial Econometric Model for Japan: Transportation, Social Capital and Interregional Linkage (SPAMETRI)" took place for the eighth program (1978-1982). "A Revised Consolidated Model in Evaluation of Transport Investment Projects (COMETRIP)" was developed for the ninth program (1983-1987) and "the Interregional Econometric Evaluation Model for the 10th Five-Year Investment Program (IRENE)" was developed for the tenth program (1988-1992). These models, however, have problems in regard to operation, although they were excellent from the theoretical aspects.

By 1992, improvement in operation of the model was made. This resulted in the development of "the Evaluation Model for Road Construction with Incorporating the Accessibility Effect (EMACC)", a model to measure the economic effects of the 11th five-year road improvement program (1993-1997). In 1997, "Forecasting Model for Nationwide Effects of Road Improvement Investment (FORMATION)", a model to measure the economic effects of the new five-year road improvement and management program (1998-2002), was constructed.

The regional econometric models for Shinkansen railway constructed by now are divided into phase 1 (1988-1990), phase 2 (1992-1993) and phase 3 (1994-1997). It is now in phase 4 (under development). Phases 1 and 2 focused on three lines and five sections which were being constructed at the time. At the end of 2003, two sections have been in service and another section is being planned to open in April 2004. Phases 3 and 4 focus on prior evaluation of new sections planning at the time.

3. Outline of the model

The model has mainly the three following substantial improvements added to FORMATION (1998).

First, it has been changed so that it can measure effects of not only the development of roads but also that of railways including Shinkansen. Because of this, dual-mode average time required among regions has been used for transportation accessibility that is assumed to have influence on production, consumption expenditure, etc.

Second, category of industries, goods and services has been broken down into small groups to cope with the changes in the industrial structure and diversity of preference or consumption in recent years.

Third, to take into account the unemployment due to the employment mismatches, the matching function for each industry that illustrates new hires with the number of job vacancies, the number of unemployed and information accessibility has been introduced.

Figure 1 shows the flow diagram of the model. The concept of the categories for the industries and goods and services are shown below.

(1) Category of industries

It is assumed that improvement in transportation accessibility contributes to the increase in potential productivity. As the influence is considered to be different for each industry, the production function is constructed separately for each industry.

The same category of industries is adopted for functions for labor, private capital investment and private capital stock. Breaking the category down into small groups has also made it possible to have the changes in the industrial structure reflected in the model.

Table 1 shows the industrial category. In respect of other industries such as agriculture, forestry, fisheries, mining, and public services, data is exogenous.

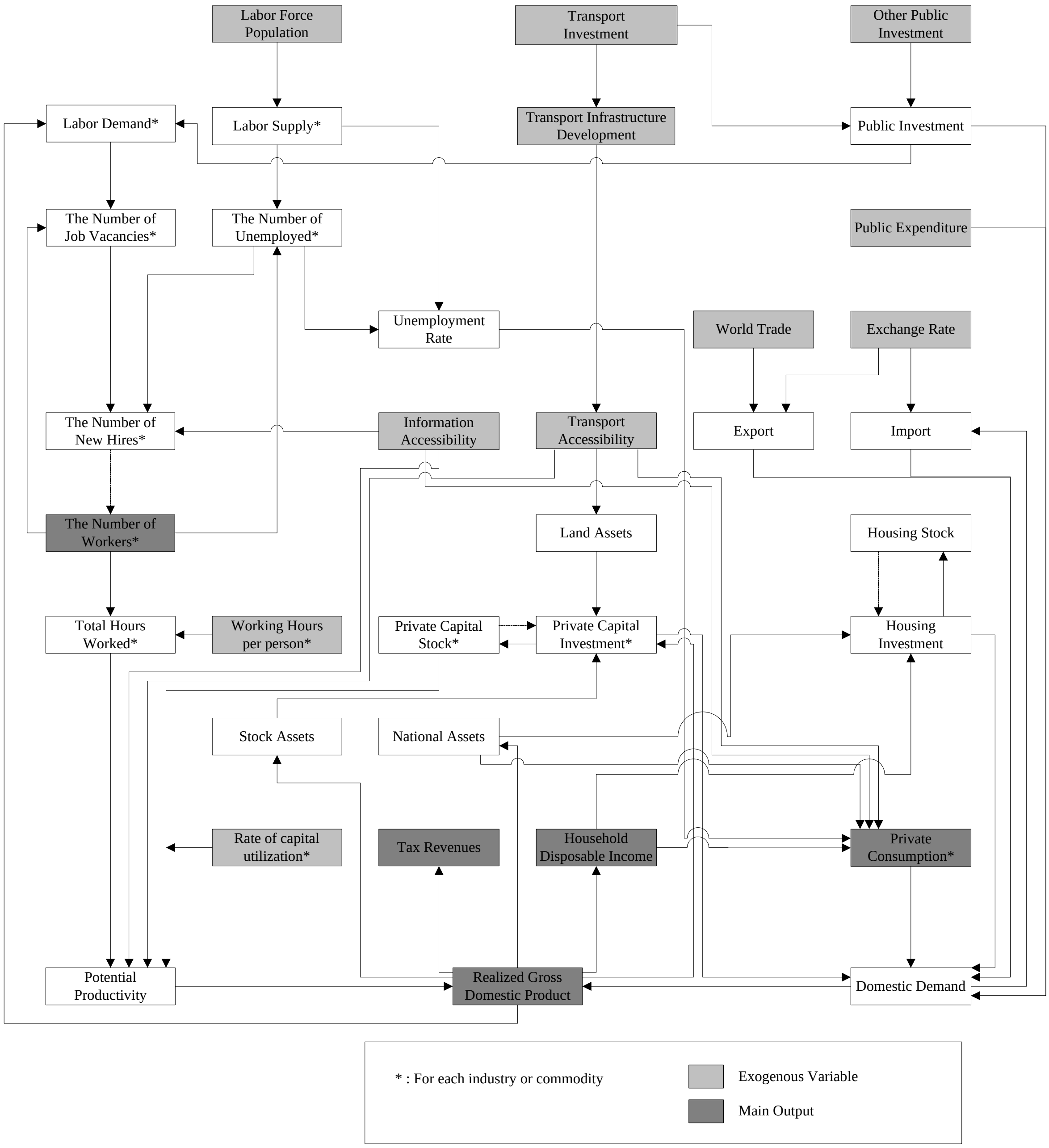

Figure 1: Flow diagram of the Model

Table 1: Category of Industries

Industries	
Secondary Industries	
	1) Manufacturing
	2) Construction
Tertiary Industries	
	1) Electricity, gas and water supply
	2) Wholesale and retail trade
	3) Finance and insurance
	4) Real estate
	5) Transport and communications
	6) Service activities

Table 2: Category of goods and services

Goods and Services	Details
a) Food	Cereals, Vegetables & seaweeds, Fresh fish & shellfish, Fresh meat, etc.
b) Food products	Fish-paste products, Meat products, Cooked food, etc.
c) Beverages, Tobacco	Beverages, Alcoholic drinks, Tobacco
d) Furniture, household utensils	Household durables, Furnishing, etc.
e) Clothes & footwear, Medical supplies	Clothes & footwear, Medicines, Medical supplies & appliances, etc.
f) Recreational goods	Communication equipments, Recreational goods
g) Private transportation	Automobiles, Gasoline, etc.
h) Books & other reading materials	School textbooks, Books & other reading materials, etc.
i) Fuel, Light, Water	Fuel, Light, Water
j) Insurance	Fire insurance, Damage insurance, etc.
k) Real estate	Dwelling, Land, Parking
l) Public transportation	Railway, Bus, Airplane, etc.
m) Freight transport, Postage	Freight transport, Postage
n) Telephone, TV broadcast	Telephone, Mobile telephone, TV broadcast, etc.
o) Eating out	Eating out, School lunch
p) Domestic services	Domestic services, Medical services, etc.
q) Private transportation services	Private transportation services
r) Accommodation, Package tours	Accommodation, Package tours
s) Education	School, Tuition, etc.
t) Recreational services	Photo processing, Rental of recreational goods, etc.
u) Other services	Admission, Game, etc.

(2) Category of goods and services

It is assumed that transport development affects private consumption expenditure through improvement in transportation accessibility. As it is considered that some commodities are affected strongly by transportation accessibility and others are not, the consumption expenditure function is constructed for each commodity.

Table 2 shows the category of goods and services.

4. The sub models

The concept and the general form of each sub model are shown below.

(1) Production

Gross domestic product is considered to be determined by transportation accessibility, which represents access conditions to transportation, and information accessibility, which represents access conditions to information that have seen rapid development in recent years, in addition to the primary factors of production; labor and capital.

$$V = f(L, K, ACCTR, ACCIT) \quad (1a)$$

Here, V is gross domestic product. L and K are, respectively, labor and capital. $ACCTR$ is transportation accessibility, and $ACCIT$ is information accessibility.

Production function has been set up by industry. In respect of labor, total hours worked expressed as a product of the number of workers and the average working hours per person is used.

$$V\mathrm{i}(\mathrm{t}) = f\left(LHR\mathrm{i}(\mathrm{t}) \cdot NW\mathrm{i}(\mathrm{t}), ROW\mathrm{i}(\mathrm{t}) \cdot KP\mathrm{i}(\mathrm{t}-1), ACCTR(\mathrm{t}), ACCIT(\mathrm{t})\right) \quad (1b)$$

Here, i and t, respectively, are industry and period. NW is the number of workers, LHR is the average working hours per person, KP is private capital stock, and ROW is the rate of capital utilization.

(2) Private capital investment

It is assumed that private capital investment in each industry relies on private capital stock and gross domestic product in the previous period. Private capital stock means the adjustment process in stock. In addition, to take into account the relationship with non-operating income that has significantly been affecting corporate profitability in recent years, total market value of land and stock assets are added as explanatory variables.

$$IP\mathrm{i}(\mathrm{t}) = f\left(KP\mathrm{i}(\mathrm{t}-1), GDP\mathrm{i}(\mathrm{t}-1), AL(\mathrm{t})/PIP(\mathrm{t}), AM(\mathrm{t})/PIP(\mathrm{t})\right) \quad (2)$$

Here, IP is private capital investment, GDPi is gross domestic product in each industry, AL is total market value of land assets, AM is total market value of stock assets, and PIP is private capital investment deflator.

(3) Private housing investment

Private housing investment has been estimated per person to grasp the influence of decline in investment due to decrease in population in the future. Private housing investment per person is considered to be determined by household disposable income per person, private housing stock per person in the previous period, interest rate, and total market value of national assets per person.

$$IH(\mathrm{t})/POP(\mathrm{t}) = f\left(YH(\mathrm{t})/POP(\mathrm{t}), KH(\mathrm{t}-1)/POP(\mathrm{t}-1), r(\mathrm{t}), (AS(\mathrm{t})/PHP(\mathrm{t}))/POP(\mathrm{t})\right) \quad (3)$$

Here, IH is private housing investment, YH is household disposable income, KH is private housing stock, r is interest rate, AS is total market value of national assets ($AS = AL + AM$), PHP is private housing investment deflator, and POP is population.

(4) Private consumption expenditure

As in the case of private housing investment, private consumption expenditure has been estimated per person. Private consumption expenditure per person by goods and services is considered to be determined by private consumption expenditure per person in the previous period, which indicates habitude, transportation accessibility, information accessibility, unemployment rate, and total market value of national assets per person in addition to household disposable income per person.

$$C\mathrm{j}(\mathrm{t})/POP(\mathrm{t}) = f(YH(\mathrm{t})/POP(\mathrm{t}), C\mathrm{j}(\mathrm{t}-1)/POP(\mathrm{t}-1), ACCTR(\mathrm{t}), ACCIT(\mathrm{t}), U(\mathrm{t}), (AS(\mathrm{t})/PCP(\mathrm{t}))/POP(t)) \quad (4)$$

Here, j is commodity. C is private consumption expenditure, U is unemployment rate, and PCP is private consumption expenditure deflator.

(5) Export

It is assumed that export relies on exchange rate, world trade volume, and export in the previous period.

$$E(\mathrm{t}) = f(RDY(\mathrm{t}), MW(\mathrm{t}), E(\mathrm{t}-1)) \quad (5)$$

Here, E is export, RDY is yen dollar exchange rate, and MW is world trade volume.

(6) Import

It is assumed that import is determined by exchange rate, final domestic demand, and import in the previous period.

$$M(\mathrm{t}) = f(RDY(\mathrm{t}), FD(\mathrm{t}), M(\mathrm{t}-1)) \quad (6)$$

Here, M is import, and FD is final domestic demand.

(7) Labor

1) The number of workers

The number of employed workers in each industry is defined as follows from the number of employed workers in the previous period, retirees, and new hires.

$$NW\mathrm{i}(\mathrm{t}) = NW\mathrm{i}(\mathrm{t}-1) - RETI\mathrm{i}(\mathrm{t}-1) + HIRE\mathrm{i}(\mathrm{t}-1) \quad (7)$$

Here, $RETI$ is the number of retirees, and $HIRE$ is the number of new hires.

2) The number of new hires

To take into account the employment mismatches, the matching function that could be explained from the number of job vacancies and unemployment in each industry, and information accessibility has been set up.

$$HIRE\mathrm{i}(\mathrm{t}) = f\left(VAC\mathrm{i}(\mathrm{t}), UNEMP\mathrm{i}(\mathrm{t}), ACCIT(\mathrm{t})\right) \quad (8)$$

Here, VAC is the number of job vacancies, and $UNEMP$ is the number of unemployment.

3) The number of job vacancies and unemployed

The number of job vacancies and unemployed are defined respectively as follows.

$$VACi(t) = NWDi(t) - NWi(t) \tag{9}$$

$$UNEMPi(t) = NWSi(t) - NWi(t) \tag{10}$$

Here, *NWD* is labor demand by firms, and *NWS* is labor supply.

4) Labor demand

Labor demand (the number of employed workers and job vacancies) in each industry is considered to be reliant on gross domestic product for each industry in the previous period and public investment in the current period.

$$NWDi(t) = f\left(GDPi(t-1), IG(t)\right) \tag{11}$$

Here, *IG* is public investment.

5) Labor supply

Labor supply (the number of employed workers and unemployed) in each industry is considered to be determined by labor force population in the current period.

$$NWSi(t) = f\left(POPL(t)\right) \tag{12}$$

Here, *POPL* is labor force population.

(8) Unemployment rate

Unemployment rate is defined as follows from the total number of employed workers in the entire industry and total labor supply.

$$U(t) = 1 - \sum NWi(t) / \sum NWSi(t) \tag{13}$$

(9) Private capital stock

Private capital stock is defined as private capital stock in the previous period, less depreciation, plus private capital investment in the current period.

$$KPi(t) = (1 - RODi)KPi(t-1) + IPi(t) \tag{14}$$

Here, *ROD* is the rate of depletion of capital stock ($0 \le ROD \le 1$)

(10) Private housing stock

Private housing stock is defined as follows.

$$KH(t) = (1 - RODh)KH(t-1) + IH(t) \tag{15}$$

Here, *ROD*h is the rate of depletion of housing stock ($0 \le RODh \le 1$)

(11) Household disposable income

Household disposable income is considered to be reliant on GDP.

$$YH(t) = f\left(GDP(t)\right) \tag{16}$$

(12) Total market value of assets

1) Land assets

It is assumed that total market value of land assets is determined by the total market value of land assets in the previous period and the transportation accessibility. Here, it is assumed that a part of the benefit of improving transportation accessibility through transportation development is returned to land price.

$$AL(\mathrm{t})/\,p(\mathrm{t}) = f\left(AL(\mathrm{t}\text{-}1)/\,p(\mathrm{t}\text{-}1), ACCTR(\mathrm{t})\right) \quad (17)$$

Here, p is deflator.

2) Stock assets

It is assumed that total market value of stock assets is determined by the total market value of stock assets in the previous period and the GDP in the current period.

$$AM(\mathrm{t})/\,P(\mathrm{t}) = f\left(AM(\mathrm{t}-1)/\,p(\mathrm{t}-1), GDP(\mathrm{t})\right) \quad (18)$$

3) National assets

It is assumed that total market value of national assets per person is determined by the total market value of national assets per person in the previous period and GDP in the current period.

$$(AS(\mathrm{t})/\,p(\mathrm{t}))/\,POP(\mathrm{t}) = f\left((AS(\mathrm{t}\text{-}1)/\,p(\mathrm{t}\text{-}1))/\,POP(\mathrm{t}\text{-}1), GDP(\mathrm{t})\right) \quad (19)$$

(13) Transportation accessibility

Transportation accessibility is defined as the reciprocal of the average minimum travel time between living areas. To take into account the multi-mode transport, average time has been calculated for each transportation mode. It is then multiplied by the sharing rate of each mode to set the average travel time for all modes.

$$To\mathrm{m} = (\textstyle\sum_{\mathrm{d}} POP\mathrm{d} \cdot To\mathrm{d\,m})/(\textstyle\sum_{\mathrm{d}} POP\mathrm{d}) \quad (20a)$$

$$T\mathrm{m} = (\textstyle\sum_{\mathrm{o}} POP\mathrm{o} \cdot To\ \mathrm{m})/(\textstyle\sum_{\mathrm{o}} POP\mathrm{o}) \quad (20b)$$

$$ACCTR = 1/(\textstyle\sum_{\mathrm{m}} SR\mathrm{m} \cdot T\mathrm{m}) \quad (20c)$$

Here, o and d are, respectively, origin and destination areas. m is transportation mode. *SR* is the sharing rate of mode, *T* is the minimum travel time between area o and d, and *POP* is population.

(14) Information accessibility

In regard to information accessibility, IT (Information Technology) capital stock has been used as a substitute.

$$ACCIT = KIT \quad (21)$$

Here, *KIT* is IT capital stock.

(15) Gross domestic expenditure

Real gross domestic expenditure is defined as the following formula.

$$GDE(\mathrm{t}) = \sum C\mathrm{j}(\mathrm{t}) + IP(\mathrm{t}) + IH(\mathrm{t}) + CG(\mathrm{t}) + IG(\mathrm{t}) + E(\mathrm{t}) - M(\mathrm{t}) \quad (22)$$

Here, *GDE* is gross domestic expenditure, *CG* is public consumption expenditure, and *IG* is public capital investment.

(16) Realized gross domestic product

It is assumed that GDP can be realized as the weighted average of potential productivity of all industries and gross domestic demand. Here, for potential productivity, in the production function of Equation (1b), the rate of capital utilization *ROW* is set at 100%.

Gross domestic demand is made equal to gross domestic expenditure.

$$GDP(\mathrm{t}) = \phi \sum \hat{V}\mathrm{i}(\mathrm{t}) + (1-\phi) G\hat{D}E(\mathrm{t}) \tag{23}$$

Here, GDP is the realized gross domestic product, $\hat{V}$ is potential productivity and $G\hat{D}E$ is gross domestic demand.

(17) Tax

Tax revenues are divided into national tax revenues and local tax revenues. And both of them are assumed to be determined by GDP.

$$TAX\mathrm{n}(\mathrm{t})/PGDP(\mathrm{t}) = f(GDP(\mathrm{t})) \tag{24a}$$

$$TAX\mathrm{r}(\mathrm{t})/PGDP(\mathrm{t}) = f(GDP(\mathrm{t})) \tag{24b}$$

Here, TAXn and TAXr are, respectively, national and local tax revenues. $PGDP$ is gross domestic product deflator.

5. Structural estimation of the model

(1) Method of structural estimation

Concerning the various functions of the econometric model, after specifying the function format, structural estimations are made by OLS using time series data from 1981 to 2000.The economic data used for the structural estimation are basically real values from the Annual Report on National Economic Accounting of Japan (Economic and Social Research Institute, Cabinet Office).The data for transportation accessibility are calculated with timetable data of road (Ministry of Land, Infrastructure and Transport) and railway (Japan Rail).

In addition to the previously mentioned explanatory variables, a fixed period dummy variable (DUM = 0 or 1) is used in some functions for structural estimation. Structural estimations are tried with many function formats and dummy variables. While the t values and the Durbin-Watson ratios are kept above a certain level (basically t>1.0 and 1.0<D.W. <3.0), the function format with the highest value of the coefficient of determination is used for each function.

(2) Results of structural estimation

The results of structural estimation for functions for production, private consumption expenditure and new employment (the matching function) are shown below. In the tables, the figure in parenthesis indicates the t value for each parameter. ** indicates significance at 5% level and * indicates significance at 15% level.

1) Production

$$\ln(Vi(t)/LHRi(t) \cdot NWi(t)) = \alpha + \alpha' DUM + \beta \ln(ROWi(t) \cdot KPi(t-1)/LHRi(t) \cdot NWi(t)) + \gamma \ln ACCTR(t) + \delta \ln ACCIT(t) + \varepsilon \ln ACCTR(t) \ln ACCIT(t) \quad (1b)'$$

DUM: Construction (1987-1994:1, the others:0)
Wholesale, retail trade (1990-1998:1, the others:0)
Finance, insurance (1987-1990:1, the others:0)
Service activities (1986-1990:1, the others:0)

Industry	ƒ ¿	ƒ '¿	ƒ À	ƒ Á	ƒ Â	ƒ Ã	D.W	Ad-R^2
Manufacturing	0.5429		0.4639	1.1934			1.2724	0.9813
	(0.609)		(6.469**)	(2.511**)				
Construction	-3.4781	0.1938	0.0297				1.7477	0.8666
	(-31.865)	(11.167**)	(1.086*)					
Electricity, gas,	-1.7605		0.4677				1.1187	0.9327
water supply	(-164.085)		(16.253**)					
Wholesale,	-0.9740	0.0821	0.7894				1.1683	0.9880
retail trade	(-9.283)	(4.342**)	(27.271**)					
Finance,	-0.2147	0.2782	0.7819				1.1626	0.9430
insurance	(-1.433)	(5.709**)	(17.764**)					
Real estate	2.9439		0.2255	1.0946		0.0561	1.2295	0.9291
	(4.273)		(2.808**)	(2.863**)		(5.110**)		
Transport,	0.2259		0.1869	1.3534			1.5945	0.9601
communications	(0.363)		(16.253**)	(16.253**)				
Service activities	-2.7082	-0.0656	0.2345				1.5239	0.9422
	(-35.473)	(-3.626**)	(13.131**)					

From the results of estimation, it can be seen that transportation accessibility has direct influence on production in the industries of manufacturing, real estate, and transport and communications.

2) Private consumption expenditure

$$
\begin{aligned}
Cj(t)/POP(t) = \alpha + \alpha' DUM + \beta YH(t)/POP(t) + \gamma Cj(t-1)/POP(t-1) \\
+ \delta ACCTR(t) + \varepsilon ACCIT(t) + \varsigma U(t) \\
+ \eta (AS(t)/PCP(t))/POP(t) + \theta TIME \cdot DUMtime
\end{aligned} \qquad (4)'
$$

DUM: a) (1988-1991:1, the others:0), b) (1987-1992:1, the others:0)
d) (1998-2000:1, the others:0) e), n) (1987-1994:1, the others:0)
f), s) (1987-1991:1, the others:0) h) (1994-2000:1, the others:0)
i) (1995-2000:1, the others:0) j) (1981-1984:1, the others:0)
l), o) (1987-1999:1, the others:0) p) (1993-1997:1, the others:0)
q) (1987-2000:1, the others:0) t) (1990-1992:1, the others:0)
*DUM*time: n) (1995-2000:1, the others:0) *TIME*: (1980:1, 1981:2,…, 2000:21)

Commodity	ƒ ¿	ƒ ¿'	ƒ À	ƒ Á	ƒ Â	ƒ Ã	ƒ Ä	ƒ Å	ƒ Æ	D.W	Ad-R^2
a)	0.2371	0.0722		0.9000						1.6045	0.8447
	(0.941)	(4.056**)		(9.185**)							
b)	0.0103	0.0338	5.657E-02	0.4220						1.3742	0.9943
	(0.236)	(2.722**)	(3.412**)	(2.584**)							
c)	0.0811		9.500E-03	0.5692						2.0053	0.9477
	(1.714)		(2.437**)	(3.093**)							
d)	0.0939	-0.0946	4.015E-02							1.8651	0.9518
	(1.971)	(-5.443**)	(19.266**)								
e)	0.3011	0.2286	8.089E-02							1.1980	0.9311
	(2.221)	(6.508**)	(13.845**)								
f)	5.497E-02	0.0357	1.955E-02					0.005		1.8673	0.9885
	(0.464)	(3.968**)	(2.512**)					(3.971**)			
g)	-0.4878		6.101E-02							2.1916	0.9457
	(-6.360)		(18.683**)								
h)	5.596E-02	0.0234	1.309E-02							2.0017	0.9748
	(2.552)	(3.830**)	(12.869**)								
i)	1.492E-01	0.0883	1.496E-02	0.6537						1.4450	0.9749
	(1.474)	(2.260**)	(2.060**)	(4.657**)							
j)	6.357E-02	-0.0410	8.645E-03			7.280E-06				0.8929	0.9772
	(0.478)	(-2.278**)	(1.340*)			(5.788**)					
k)	-0.4837		3.836E-02	0.6394						1.6433	0.9841
	(-2.224)		(2.551**)	(4.714**)							
l)	1.434E-02	0.0378	1.633E-02					1.823E-03		1.8190	0.9823
	(0.159)	(4.543**)	(2.757**)					(1.985**)			
m)	-0.1182		5.345E-03		0.500					1.0484	0.9778
	(-4.514)		(6.993**)		(1.445*)						
n)	1.422E-01	4.989E-02	1.264E-02						0.012	0.7727	0.9109
	(0.817)	(1.184*)	(1.441*)						(3.614**)		
o)	0.0978	0.0287	3.353E-02					3.102E-03		1.7771	0.9929
	(0.989)	(3.153**)	(5.166**)					(3.082**)			
p)	0.4253	0.1034	1.872E-02			1.540E-05				1.9097	0.9820
	(2.259)	(4.443**)	(1.929**)			(7.181**)					
q)	-1.679E-02	-5.947E-02	4.895E-03							1.4073	0.7368
	(-0.550)	(-6.268**)	(3.196**)								
r)	-1.6360		3.063E-02		12.8		-5.016E-02			2.5368	0.9908
	(-3.403)		(2.986**)		(2.053**)		(-2.684**)				
s)	-0.6567	0.0624	8.252E-02							0.9208	0.9490
	(-6.504)	(2.127**)	(19.298**)								
t)	7.701E-04	1.092E-02	3.287E-03					6.631E-04		1.5557	0.9649
	(0.025)	(3.760*)	(1.604**)					(2.053**)			
u)	-0.1177		9.633E-03	0.5116						1.3271	0.9761
	(-1.877)		(2.220**)	(2.619**)							

Of the 21 goods and services, it can be seen that transportation accessibility has direct influence on only (m) freight transport and postage services and (r) accommodation and package tour services.

3) New employment

$$\ln(HIREi(t)) = \alpha + \alpha' DUM + \beta \ln(VACi(t)) + \gamma \ln(UNEMPi(t)) + \delta \ln(ACCIT(t)) + \delta' ACCIT(t) + \varepsilon TIME \tag{8'}$$

DUM: Manufacturing (1992-1999:1, the others:0)
Construction (1994-1999:1, the others:0)
Wholesale, retail trade (1994-1996:1, the others:0)

Industry	ƒ ¿	ƒ ¿'	ƒ À	ƒ Á	ƒ Â	ƒ Â'	ƒ Ã	D.W	Ad-R^2
Manufacturing	0.3722	-0.2459	0.3608	0.4083				1.6664	0.9175
	(0.661)	(-9.667**)	(6.220**)	(4.790**)					
Construction	1.0679	-0.0255	0.2216	0.5608			-0.039	1.7471	0.8347
	(1.327)	(-1.057)	(1.430*)	(6.455**)			(-4.431**)		
Electricity, gas, water supply	:Exogenous								
Wholesale, retail trade	0.5787	0.0663	0.2016	0.4879			-0.027	1.0082	0.8298
	(0.705)	(1.088*)	(1.427*)	(6.702**)			(-5.348**)		
Finance, insurance	-0.8801		0.5449	0.1534		1.403E-05	-0.061	1.1464	0.8276
	(-3.092)		(3.462**)	(1.185*)		(2.347**)	(-5.275**)		
Real estate	-1.2119		0.2022	0.6131				0.6468	0.8970
	(-17.905)		(2.000**)	(5.492**)					
Transport, communications	-0.3540		0.1714	0.7238				1.1425	0.9415
	(-2.020)		(3.683**)	(16.481**)					
Service activities	1.3580		0.1054	0.3400		3.273E-06		1.0101	0.9460
	(2.675)		(1.396*)	(4.029**)		(0.903)			

From the results of estimation, it is suggested that improvement of information accessibility may resolve the mismatching in employment for industries such as finance, insurance, and services.

6. Annual national benefit

Assuming the utility function of an individual equals to be consumption expenditure, the annual national benefit of a transport development project is expressed by Equation (25), which means the sum of equivalent variation (EV).

$$BEN = YHwo\left(\frac{Cw - Cwo}{Cwo}\right) \tag{25}$$

Here, *w* signifies with project and *wo* expresses without project. *BEN* is benefit of the project, *YH* is household disposable income and *C* is private consumption expenditure.

7. Evaluating transportation investment in Japan

(1) Outline of evaluation

The developed model can evaluate development of roads and railways based on the priority plan. The priority plan, however, has not given decision on specific routes that will be developed. Therefore, this paper focuses development of two sections of expressways under planning in the metropolitan and rural area in Japan. Figure 2 shows the sections for evaluation. Thus calculation of influence each development has on GDP, employment, and tax revenues has been made and benefit cost analysis using the benefit defined as equation (25) has been carried out.

(2) Facilities for evaluation

In this paper, the Tsurugashima–Yokohama section (about 85 km) of the Metropolitan Inter-City Expressway (Ken-O-Do) as the Metropolitan area expressway and the Akita–Niigata section (about 265 km) of the Japan Sea coast Tohoku Expressway (Nichi-En-Do) as a rural area expressway are taken for evaluation.

Construction cost is obtained by multiplying the scheduled project costs per 1km length (20 billion yen/km for the Ken-O-Do and 6 billion yen/km for the Nichi-En-Do) by the total extension length, which amounts to 1,700 billion yen for the Ken-O-Do and 1,590 billion yen for the Nichi-En-Do. Furthermore, maintenance and operation costs per 1km length are set from the latest data (55 million yen/km).

(3) Preconditions for simulation

The simulation using the macro econometric model is conducted for the two sections. Here, it is assumed that both sections will be developed and open in 2004. Period for simulation is 40 years after the opening from 2000 to 2043. The simulation deals with three cases: (1) without road developments; (2) development of Ken-O-Do; and (3) development of Nichi-En-Do. The effect of the development to each economic variable is expressed as the difference between values in case (1) and another. In the simulation, the stock effects from improvement of transportation accessibility are evaluated while the flow effects during the period of construction are not measured.

(4) Results of simulation

Table 3 shows the impact of the development of Ken-O-Do and Nichi-En-Do has on GDP, employment, and tax revenues (total for national and local tax revenues) in 2008; after five years from the opening of the roads.

Table 4 shows the benefits, the costs, benefit cost ratio, and the net present value of benefits for 40 years from the opening. Here, the social discount rate is assumed at 4%.

It can be seen from Table 4 that both of the benefit cost ratio and the net present value of benefits are slightly higher for Ken-O-Do compared with Nichi-En-Do. But benefit cost ratio for both sections is higher than 1.5 and they can be evaluated as being worthy of investment.

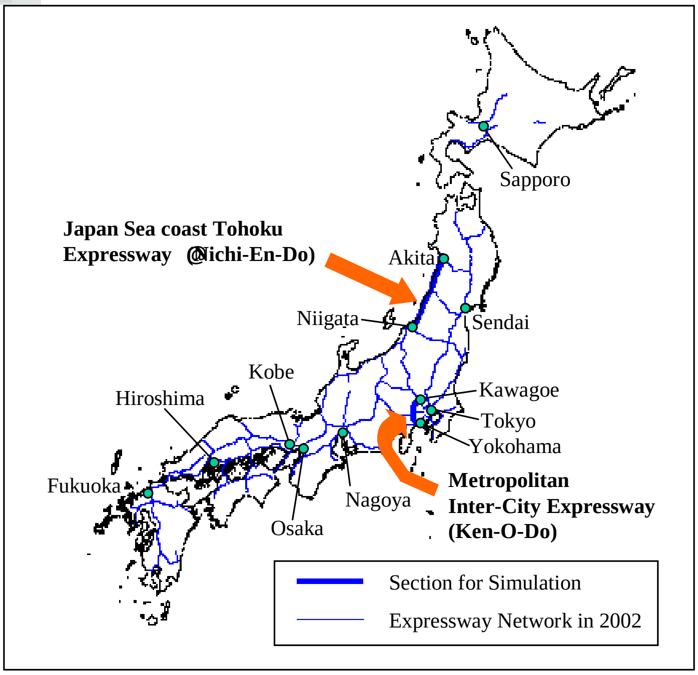

Figure 2: Expressway network in 2002 and sections for evaluation

Table 3: Effects of development of Ken-O-Do and Nichi-En-Do in 2008

	Ken-O-Do	Nichi-En-Do
GDP (Billion Yen)	261	241
Employment	960	880
Tax Revenues (Billion Yen)	57	53

Table 4: Benefit Cost Analysis for Ken-O-Do and Nichi-En-Do

	Ken-O-Do	Nichi-En-Do
Benefit (Billion Yen)	2,885	2,669
Cost (Billion Yen)	1,700	1,590
Benefit / Cost	1.70	1.68
Benefit - Cost (Billion Yen)	1,185	1,079

8. Conclusion

The conclusions of this paper are as follows.

1) The econometric model capable of evaluating the influence that multi-mode transport development based on the long-range priority plan of transport infrastructure development has on GDP, employment, tax revenues, etc. is developed. The sub models have been constructed by industry and by commodity to have the changes in industrial structure and diversity of consumption in recent years reflected in them. In regard to employment, the matching function which enables to evaluate the mismatch unemployment that increases recently in Japan is introduced.

2) Assuming the utility function of an individual equals to be consumption expenditure, annual national benefit of a transport development project as sum of equivalent variation (EV) using only output of the macro econometric model is proposed.

3) Transportation accessibility has large direct influence on production in manufacturing, real estate, and transport and communications. It also has direct influence on consumption expenditure in freight transport and postage services, and accommodation and package tour services. In respect of industries such as finance, insurance, and services, the increase in information accessibility has direct impact for solving the employment mismatches.

4) Impacts that parts of Ken-O-Do and Nichi-En-Do which are typical expressways under planning in the metropolitan and rural area have on GDP, employment and tax revenues were estimated with the model. The benefit of their development is also calculated and it is indicated the benefit cost ratio for 40 years after the opening exceeded 1.5 for both sections.

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