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ECONOMIC APPRAISAL FOR MULTIREGIONAL IMPACTS BY A LARGE SCALE EXPRESSWAY PROJECT: A SPATIAL COMPUTABLE GENERAL EQUILIBRIUM APPROACH

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ABSTRACT

The paper describes the development of a spatial computable general equilibrium (SCGE) model aimed at estimating the indirect economic effects arising from a large scale of transport project (Tokai-Hokuriku Expressway) in the Chubu (meaning central) region in Japan. We have adopted a joint parameter estimation of calibration technique, statistical estimation and literature quotation for estimating the Japanese inter-regional account consisting of nine major regions with the national account being the benchmark equilibrium data. We have obtained highly compatible estimates with the surveyed interregional accounts in the application of the SCGE model. Modal split function in freight transport is also developed which can be important factor in the evaluation of economic effects in transport projects.

The paper reports that economic effects of the project extended over whole country through the so-called multiplier effects of the economy, which could not be measured by the traditional method.

INTRODUCTION

The aim of this paper is to show applicability, validity and limitation of a spatial computable general equilibrium (SCGE) model that has been developed for assessment of the incidence of the wider economic benefits arising from the transport policies as well as from improvements in the transport infrastructure.

In the central area in Japan (called Chubu region) many large scales of transport projects are now emerged and expected to mitigate the so-called Tokyo polar problem. That is, these big projects may have strong impacts on the development of not only the region itself but also on both interconnected and adjacent regions. To assess these expected impacts from the view point of a general economy-wide perspective, a *spatial computable general equilibrium* (SCGE) or a *multi-regional CGE* model is required, which can consider quantity and price adjustments within a consistent and multi-regional accounting framework.

Miyagi and Honbu (1993, 1995) proposed a SCGE model with special attention to the interactions between transport and economic activities. Then, the model is further extended to include regional migration and leisure trips so on (Miyagi, Ueda and Yuri, 2000). Bröcker (1992) and Roson (1995) have developed the other type of SCGE models. All those models adopt Armington specification to realize multi-regional cross hauling. Miyagi and Honbu, and Bröcker use the nested CES functions (Sato, 1967) in a two-stage of production process and utility function, and develop computation procedures based on the sequential Newton-Raphson method. Roson uses a two-stage substitution mechanism: a first level involving domestic and imported goods within the same industry (modeled by a CES function) and a second level involving all inputs of each industrial production process (modeled by a CRESH function). Roson adopted Johanson's method in computation of equilibrium systems.

The SCGE model developed by Miyagi and Honbu (1995) (we call it the MH model hereafter) is based on the so-called *supply and demand pool concept* which explicitly recognizes that the products of the same sector from different regions are likely to be more readily substitutable for each other than are products of different sectors. Armington assumption allows us to build more flexible inter-regional trade function which plays the essential role in evaluating economic effects of transport projects because that reductions in inter-regional transport costs arising from a large scale transport project change the pattern of inter-regional commodity trade not only in regional level but also in the national level. In this paper, modal split function in freight transport is also added in the consistent manner with the inter-regional trade modeling previously developed.

We have applied the SCGE model to the estimation of the Japanese national account consisting of nine major regions, one of which is Chubu region, with the national account being the benchmark equilibrium data. We have adopted a joint parameter estimation of calibration technique, statistical estimation and literature referring for estimating the nine-region input-output table. It is shown that the SCGE model gives highly compatible estimates with the surveyed interregional input-output table. The paper also proposes and examines two different methods to assess economic impacts to each prefecture consisting of the region in question: direct and two-stage methods. Finally, it is shown that economic effects of the project extended over whole country through the so-called multiplier effects of the economy, which could not be measured by the traditional method in which only direct user-effects have been taken into account. While the paper concludes that the economic appraisal with the SCGE model has some advantages when compared with the traditional methods, and discusses on the inherent issues of SCGE modeling in terms of economic evaluation.

THE OUTLINE OF SCGE MODEL

A computable general equilibrium (CGE) is a common starting point for constructing SCGE model. CGE and Applied General Equilibrium model are operational or empirical general equilibrium models that can be used to provide quantitative analysis of economic policy problem, being numerically solved (Dixson et al., 1992). SCGE model has essentially the same structure as multi-country CGE models, however, it should be noticed that in SCGE, transport sectors play a dominant role in interregional trade of various goods: transport costs in spite of tariffs should be appropriately included in the model; transport sectors are profit maximizing agency, of which activities are totally different from those of government, recipient of tariff.

In this section we outline the basic framework of SCGE model with multi-region and multi-sector, illustrating how this specific model can be used to calibrate parameters included in functions in use, and can be used for prediction purposes.

General structure of SCGE model

The central assumptions of the MH model are that each firm located at a certain region uses labor and capital within the region, but it allows for reallocation of labor and capital within the same region and that Walras's law holds at each region. The first assumption implies that the model does not permit interregional labor migration and capital reallocation.

Let I ={1,2,...,i, j,..,.m} denotes the set of products (or commodities) in each market included in the set of markets R={1,2,…,r, s,…, n} consisting of geographically separated regions. The set of primary factors is represented by K={1,2,…,k}. In the following, a single, representative consumer (a single household) is assumed. In other words, all households are assumed to have identical preferences. Now we describe behavior of each economic agent in the system: household, firm and transport sectors. Government and foreign trade are neglected in this paper, however, those sectors can be included in a straightforward fashion in the framework mentioned here.

Household sector

Suppose that the utility function u is strict quasiconcave and differentiable, then Hicksian demand $h_s^j(q,u)$ for commodity j in region s is given as the derivative of the expenditure function, $e_s(q,u)$, with respect prices:

$$h_s^j(q,u) = \frac{\partial e_s(q,u)}{\partial q_j}, \tag{1}$$

where q_s^i denotes the weighted delivered price or the price index of commodity i at region s paid after transport. The demand functions defined by (1) are assumed to be homogeneous of degree zero in prices. Assuming the CES (constant elasticity of substitution) utility function implies that for CES cost function c(q), the CES expenditure function has the form (Varian, 1984)

$$e_s(q,u) = u_s c(q;\delta)$$

with share parameters, $\{\delta^i; i \in I\}$. In the calibration process, the equilibrium level of utility is obtained from the above equation together with

$$y_s = e_s(q,u). \tag{2}$$

In eq. (2), y_s is the household's income earned by selling exogeneously given, fixed amount of factors to firms and given by

$$y_s = \sum_{k\in K}\sum_{j\in I} f_s^{kj} w_s^{kj}, \tag{3a}$$

where f_s^{kj} denotes the k-th factor endowment in producing good j provided by the households in region s; w_s^{kj} the corresponding factor prices. In calculating counterfactual equilibrium, however, we assume that households freely choose the industry to which they want sell their factors. Hence the household's income is given by the equation

$$y_s = \sum_k f_s^k w_s^k \, . \tag{3b}$$

Production sector

The industry j in region s produces the output, $X_s^j (j \in I)$, with intermediate inputs imported from other regions and/or region s itself, $z_s^{ij} (i, j \in I)$, and with primary inputs, through the nested CES production function, G_s^j:

$$X_s^j = G_s^j (z_s^{ij}, Y_s^j; \alpha_s^{ij}) \, .$$

Parameters $\{\alpha_s^{ij} : i, j \in I\}$ are the fixed intermediate-good requirements in region s per unit production of good j and Y_s^j represents the composite primary factor or the value added in producing good j in region s, being represented by the CES function,

$$Y_s^j = F_s^j (f_s^{kj}; \gamma^{kj}) \, ,$$

with share parameters, $\{\gamma^{kj} : j \in I, k \in K\}$. z_s^{ij} is also represented by CES function, but with differing specification of substitution parameters from F_s^j.

In our specification, inelastic substitution among intermediate goods (Leontief function) is assumed in the upper stage of the nested structure in a production tree and CES value-added function is used in the lower stage to allow for substitution among primary factors and for substitution among imported intermediate goods from other regions. According to Shepard's lemma, cost-minimization behavior yields the technology coefficients in terms of intermediate goods and the value-added coefficients as the derivatives of nested CES unit-cost functions, uc^j, with respect to individual prices:

$$\alpha_s^{ij} = \frac{\partial uc^j (q_s, w_s; \alpha_s^j, \gamma^j)}{\partial q_s^i} \tag{4}$$

$$\phi_s^{kj} = \frac{\partial uc^j (q_s, w_s; \alpha_s^j, \gamma^j)}{\partial w_s^k} \, . \tag{5}$$

Those are homogeneous of degree zero in prices. In equilibrium, the output of j industry is positive then zero-profit conditions prevail, viz.,

$$p_s^j = \sum_{i \in I} \alpha_s^{ij} q_s^i + \alpha_s^{m+1,j} W_s^j (w_s^k; \gamma^{kj}) \, , \tag{6a}$$

where p_s^j is the price of good j produced at region s and W_s^j is CES unit-cost function representing the price of composite factors in producing the output j in region s. Equation (6a) is rewritten as follow:

$$p_s^j = \sum_{i \in I} \alpha_s^{ij} q_s^i + \sum_{k \in K} \phi_s^{kj} w_s^{kj} \, . \tag{6b}$$

Since delivered prices, $\{q_s^i\}$, are a function of production prices, $\{p_s^j\}$, as shown in the next subsection, we solve nonlinear equation systems to obtain $\{q_s^i\}$ and $\{p_s^j\}$.

Transport sector

Details on behavioral model of transport sector (or trader) are left in the next section. Here we show only the results associated with the interregional trade to complete SCGE model. Trade coefficients $\{\tau_{rs}^{i}\}$ for good i between regions r and s are found as the derivatives of unit-cost function of transport sectors $q_s^i(p_r^i, c_{rs}; \theta_r^i)$ with respect to production prices:

$$\tau_{rs}^{i} = \frac{\partial q_s^i(p_r^i, c_{rs}; \theta_r^i)}{\partial p_r^i}. \tag{7}$$

Euler's lemma for zero-degree of homogeneous function gives the following relations:

$$q_s^i = \sum_{r \in I} \tau_{rs}^i p_r^i. \tag{8}$$

Market clearing conditions

Equations (1) to (8) determine production prices and delivered prices for all goods in all regions, and the Input-Output coefficients, the final demands and the level of utility in all regions, given the factor prices in all regions. Equilibrium is characterized by a set of goods and factor prices for which excess demands for goods and factors vanish:

$$\sum_{s \in R} \tau_{rs}^i [\sum_{j \in I} \alpha_s^{ij} X_r^i + h_s^i] - X_r^i = 0 \quad \textit{for all } i \in I, r \in R \tag{9}$$

and

$$\sum_{i \in I} \phi_s^{ki} X_s^i - \overline{f}_s^k = 0 \quad or\, all\, k \in K, s \in R, \tag{10}$$

where $\overline{f}_s^k$ is a given k-th factor endowment of region s. Equation (9) is the well-known linear system of input-output equation, and is replaced by a matrix form:

$$\boldsymbol{X} = [\boldsymbol{I} - \boldsymbol{TA}]^{-1} \boldsymbol{TH}$$

where **T** and **A** are a trade coefficient matrix with elements $\{\tau_{rs}^i\}$ and an input matrix with elements $\{\alpha_s^{ij}\}$, respectively.

Computing of SCGE

One of the technical merits of SCGE model is that, unlike econometric models, it does not claim to collect a large amount of data and can serve to find the counterfactual equilibrium for regions divided into arbitrary size; a single collective of regions for which an input-output accounting data is available is divided into several regions. Share parameters included in production functions of industrial sectors, demand functions of households and interregional trade functions can be identified by calibration technique to postulate the benchmark equilibrium (Shoven and Whalley, 1992). Calibration used in SCGE model needs a similar computing method with that mentioned below for accounting for the initial equilibrium before any policy changes have been made. However, the computation process described below is basically the one for finding equilibrium under a given set of share parameters, not for calibration. In calibration process, factor prices are given and fixed, and Input-Output coefficients are replaced by observed data to obtain share parameters. The dimensionality of the solution space in the following competing process is the number of factors of production. The steps involved are follows:

1. Determine cost-minimizing intermediate-goods and factor demands per unit of output j, given factor prices,

$$\alpha_s^{ij} = \frac{\partial uc^j(q_s, w_s; \alpha_s^j, \gamma^j)}{\partial q_s^i}$$

and

$$\phi_s^{kj} = \frac{\partial uc^j(q_s, w_s; \alpha_s^j, \gamma^j)}{\partial w_s^k}.$$

2. Compute commodity prices and its CIF prices given factor prices:

$$p_s^j = \sum_{i \in I} \alpha_s^{ij} q_s^i + \sum_{k \in K} \phi_s^{kj} w_s^{kj}$$

with

$$q_s^i = q_s^i(p_r^i, c_{rs}; \theta_r^i).$$

3. Individual commodity demands can be given as:

$$h_s^j(q,u) = \frac{\partial e_s(q,u)}{\partial q_s^j}.$$

4. Calculate output quantities that meet market demands

$$\boldsymbol{X} = [\boldsymbol{I} - \boldsymbol{TA}]^{-1}\boldsymbol{TH}$$

and calculate derived factor demands as

$$\sum_{i \in I} \phi_s^{ki} X_s^i = f_s^k \quad or\ all\ k \in K, s \in R.$$

5. Find factor prices to clear factor markets:

$$\sum_{i \in I} \phi_s^{ki}(w_s^k) X_s^i = \overline{f}_s^k \quad or\ all\ k \in K, s \in R$$

6. If updated factor prices are sufficiently close to given ones, then move to step 7. Otherwise, iterations are repeated to meet the stopping criterion.

7. In comparing equilibria an aggregate measure of welfare, Hicksian equivalent variation, EV, is used.

$$EV = y^1 - y^0 - [e(\mathbf{q}^1, u^1) - e(\mathbf{q}^0, u^1)], \tag{11}$$

where y^0, y^1 denote the income of consumers in period 0 and 1, respectively.

INTER-REGIONAL TRADE MODEL

Inter-regional Trade Function

The classical assumption on transport costs like the horse-truck assumption or iceberg model (Thunen, 1826; Samuelson, 1952) is independently defined from economic activities of transport sector. Therefore we cannot measure impacts of improvements in transport services or in technology with the classical approach. The national CGE models almost invariably employ the Armington specification for modeling foreign trade. This idea has been generalized in a straightforward fashion in the multiregional CGE models. The Armington specification is based on the heterogeneity of goods from different origins, and results in a kind of logit (or gravity-type) model, which realizes cross hauling in interregional trade.

In the MH model, the imported commodities from various regions to a certain region s is treated as a composite commodity which is used up in the region s, and the Armington assumption is combined with demand pooling concept by Chereney (1953) and Moses (1955) in the formulation of trade model. In this case, the endowment of transport infrastructure could be considered as a sort of primary resource for an economic system. Therefore, in modeling the interregional trade, transport services are treated as the lower-level inputs for intermediate inputs in the nested structure of production tree.

We assume that a single type of commodity is transported from various locations, say, r=1,2,...,n to a specific location s by the corresponding, single transport sector. These imported commodities are first merged into a demand pool in location s, from where those goods are delivered to intermediate or final users. Supposing that intermediate goods $\{x_{rs}^i\}$ are required in location s to produce X_x^i, then the precise choice of locational goods $\{x_{rs}^i\}$ is determined by profit maximization subject to CES production technology for transport:

$$\max \Pi_s^i(x) = q_s^i X_s^i - \sum_{r\in R}\sum_{i\in I} v_{rs}^i x_{rs}^i, \quad s.t.\ X_s^i(x) = \left[\sum_{r\in R}\theta_r^i \{x_{rs}^i\}^{\rho}\right]^{1/\rho},$$

where v_{rs}^i denotes the user price of good i paid after transport and ρ the substitution parameter. Typical examples of expressing the relation between the user price and transport costs are given by

$$v_{rs}^i = p_r^i \exp(\eta_{rs}^i) \text{ or } v_{rs}^i = p_r^i(1+\eta_{rs}^i) \tag{12}$$

so that the resultant user-cost function is a linear homogeneous with respect to the commodity prices. Parameters η_{rs}^i denote *ad valorem* rate of transport cost or the rate of transport margins.

The behavioral model for transport sector formulated above generates the following transport demand functions and cost functions for one unit production in region s by putting $X_s^i = 1$ in (12):

$$m_{rs}^i = \frac{x_{rs}^i}{X_s^i} = \frac{\theta_r^i\{v_{rs}^i\}^{-\sigma}}{\sum_{r\in R}\theta_r^i\{v_{rs}^i\}^{1-\sigma}} q_s^i \tag{13a}$$

or

$$m_{rs}^i = \theta_r^i\, exp(-\sigma\eta_{rs})\left[\frac{q_s^i}{p_r^i}\right]^{\sigma}, \tag{13b}$$

and

$$q_s^i = \left[\sum_{r \in R} \theta_r^i \{v_{rs}^i\}^{1-\sigma} \right]^{\frac{1}{1-\sigma}},$$

where $\sigma = 1/(1-\rho)$ and θ_r^i denote the elasticity of substitution for importing regions and the share parameters, respectively. Putting a unit price q_s^i of the composite goods by a unit-cost function $q_s^i(\boldsymbol{p}_s; X_s^i = 1)$, then demands for locational goods are obtained, according to Shepard's lemma, by differentiating $q_s^i(\boldsymbol{p}_s, 1)$ with respect to a price of commodity in region r:

$$\tau_{rs}^i = \frac{\partial q_s^i}{\partial p_r^i} = \frac{\theta_r^i \{v_{rs}^i\}^{1-\sigma}}{\sum_{r \in R} \theta_r^i \{v_{rs}^i\}^{1-\sigma}} \cdot \frac{q_s^i}{p_r^i}. \tag{14}$$

While eq. (13) represents a trade coefficient based on production site, eq. (14) may be called a trade coefficient based on consumption or demand site. When comparing (14) with (13), one should notice that the following relation holds:

$$\tau_{rs}^i = m_{rs}^i(1+\eta_{rs}^i) \quad or \quad \tau_{rs}^i = m_{rs}^i \exp(\eta_{rs}^i).$$

This implies that transport of quantity m_{rs}^i requires the consumption of some resources by $m_{rs}^i \eta_{rs}^i$ (resource consumption is η_{rs}^i for a unit-transport), of which a cost-covering price is represented by $p_r^i m_{rs}^i \eta_{rs}^i$ because of the assumption of constant-returns-to scale technology in transport.

Modal Split Function

Interregional commodity price including transport costs defined by (12) is weighted average over various transport modes served between regions r and s. The unit cost function is then defined as:

$$v_{rs}^i = \left[\sum_{m \in M_{rs}} \varepsilon_m \{v_{rs}^{im}\}^{1-\sigma^m} \right]^{\frac{1}{1-\sigma^m}}$$

where v_{rs}^{im} is delivered price of commodity i transported by transport mode m$(\in M_{rs})$ serving between regions r and s with transport margin rate η_{rs}^{im}, being defined by $v_{rs}^{im} = p_r^i(1+\eta_{rs}^{im})$. Each demand by transport mode is then derived from Shepard's lemma:

$$\tau_{rs}^{mi} = \frac{\partial q_s^i}{\partial p_r^i} = \frac{\partial q_s^i}{\partial v_{rs}^i} \cdot \frac{\partial v_{rs}^i}{\partial v_{rs}^{im}} \frac{\partial v_{rs}^{im}}{\partial p_r^i}.$$

This leads to the following trade coefficient by each transport mode:

$$\tau_{rs}^{mi} = \frac{\theta_r^m \left(v_{rs}^{mi}\right)^{1-\sigma^m}}{\sum_r \theta_r^m \left(v_{rs}^{mi}\right)^{1-\sigma^m}} \cdot \frac{\varepsilon_m \left(v_{rs}^{mi}\right)^{1-\sigma^m}}{\sum_{m \in M_{rs}} \varepsilon_m \left(v_{rs}^{mi}\right)^{1-\sigma^m}} \cdot \frac{q_s^i}{p_r^i}.$$

This implies that each transport modes shares unit demand of commodity between regions:

$$\tau_{rs}^{mi} = \tau_{rs}^{i} \frac{\varepsilon_m \left(v_{rs}^{mi}\right)^{1-\sigma^m}}{\sum_{m \in M_{rs}} \varepsilon_m \left(v_{rs}^{mi}\right)^{1-\sigma^m}} .$$

The delivered price index is thus rewritten as

$$q_s^i = \sum_r \sum_m p_r^i \tau_{rs}^{mi}$$

and the trade coefficients previously defined are redefined as:

$$\tau_{rs}^{i} = \sum_m \tau_{rs}^{mi} .$$

The quantity variables are also redefined as the followings:

$$x_r^{mi} = \sum_{s=1}^{S} \tau_{rs}^{mi} \left(\sum_{s=1}^{S} a_s^{ij} x_s^j + d_s^i \right)$$

$$x_r^i = \sum_m x_r^{mi}$$

$$d_s^i = \sum_m d_s^{mi}$$

PROJECT APPRISAL

Tokai-Hokuriku Expressway Project

Chubu region consists of five prefectures including Ishikawa, Toyama, Gifu, Aichi and Mie, out of which three prefectures are to be directly connected by the projected national expressway, the so-called Tokai-Hokuriku expressway. The Tokai-Hokuriku connects Ichinomiya junction in Aichi with Koyabe junction in Toyama through Gifu prefecture, of which length is about 185km (see Fig.1). The expressway is now under construction and is planned to complete in the year of 2010. Its total construction cost is estimated as about 1.7 trillion yen (about 14 billion US dollar at exchange rate of 120 yen/dollar).

As for industrial sectors, the original thirteen sectors were aggregated into the following seven sectors:

1. Primary sector 2. Manufacturing industry 3. Construction industry 4. Finance sector
5. Energy-related industry 6. Commercial industry 7. Service sector

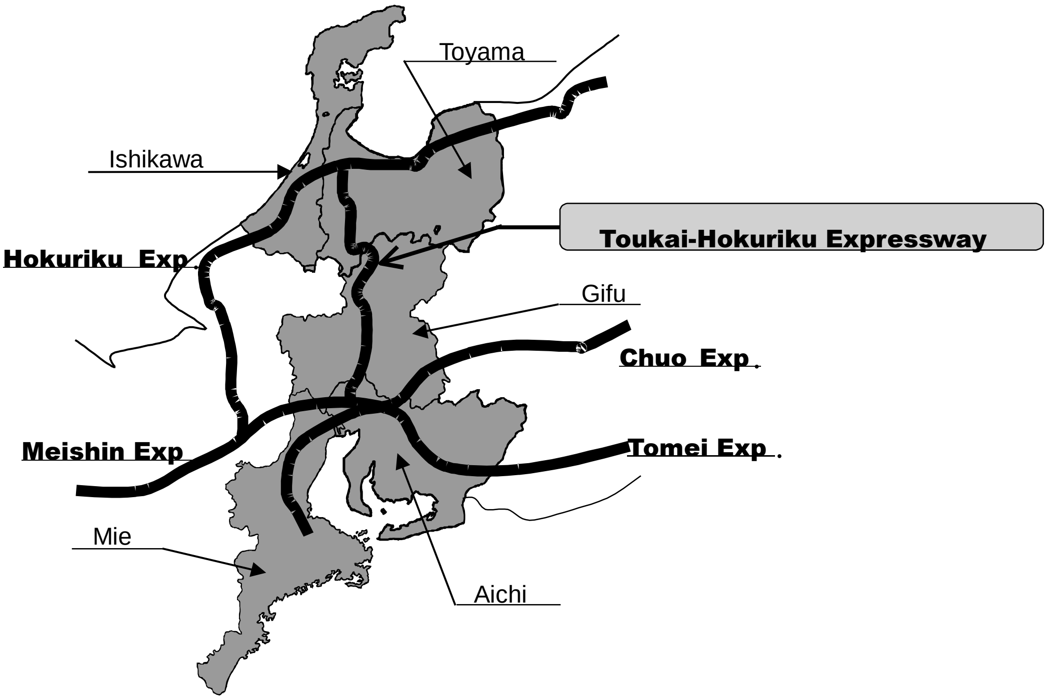


Figure 1 – Chubu Region and Tokai-Hokuriku Expressway

Testing the model

A direct and two-stage methods

We have the Japanese interregional input-output table for nine regions in the year of 1985. Table 1 shows the gross regional products and inhabitants in those nine regions. Each region is large enough to make the three basic assumptions associated with the MH model a sense. However, we need interregional trade data between each pair of the five prefectures included in Chubu region to measure the economic effects of the Tokai-Hokuriku. Thus, the first step of the analysis is to estimate the interregional input-output table in thirteen regions consisting of eight major regions added by five prefectures included in Chubu region.

Two approaches may be possible: the first approach is called a direct method where the thirteen-region-interregional IO table is directly created from a single, domestic IO table. The second approach is called a two-stage method where the nine-region-interregional IO table is estimated in the first stage by using the single domestic IO data, then in the second stage the five-region-interregional IO table is obtained from the estimated IO data of Chubu region. Surprisingly, the comparison of estimated results by these two methods showed that there is no difference between these methods (a correlation coefficient is 0.99). Therefore, we used rather a simple method, the direct method, in comparative static experiments for an economic appraisal.

Table 1 -Gross Regional Product of Each Region

Region	**Area** (km²)	**Population** (thousand)	**GRP** (billion yen)
Hokkaido	83,519	5,663	13,563
Tohoku	66,357	9,750	22,243
Kanto	69,199	45,253	139,003
Chubu	29,959	12,373	37,800
Kinki	31,483	20,592	57,330
Chugoku	31,784	7,714	20,545
Shikoku	18,806	4,250	9,975
Kyushu	41,421	13,229	27,650
Okinawa	2,254	1,184	2,100
Total	374,782	120,008	330,209

Parameter estimation

In comparative static experiments, we consider the effects of transfer, factor supply changes, technological changes, and the changes in transport services on the endogeneous variables of the system. There appear in the system a number of parameters that reflects the initial values of the variables. These initial values are entered into the model by calibrating the model to what is known as a benchmark equilibrium dataset. We used the 1985-Japanese national account as the benchmark equilibrium. However, parameters related with elasticities of substitutions used in CES production functions, CES utility functions and trade functions are not determined by the calibration and usually quoted from the literature. As for these behavioral elasticities, we employed the estimated results by Ogawa et al. (1992).

In order to relate the changes in transport services with those in trade pattern, it is required to establish the interrelationship between the rate of transport margins and interregional transport services. Equation (13b) provides us a tractable form for statistical estimation of parameters associated with the rate of transport margins η^i_{rs}. Since the terms associated with the locational prices, $[q^i_s / p^i_r]$, can be assumed to be constant for interregional I-O data available, eq.(14) can be rewritten as:

$$\tau^i_{rs} = \varphi^i_{rs} \exp\left[\frac{\beta^i_s(1-\sigma)}{c_{rs}}\right]. \tag{15}$$

In eqs. (15), we put $\varphi^i_{rs} = [q^i_s / p^i_r]^\sigma$ and the rate of transport margin η^i_{rs} is defined by interregional travel time c_{rs} with parameter β^i_s. A regression analysis is applicable to estimate the parameters included in $\tau^i_{rs}, \varphi^i_{rs}$ and β^i_s, however, φ^i_{rs} itself is not used in calculation of a counterfactual equilibrium because that φ^i_{rs} is related with price variables that are automatically determined as a function of the locational prices during an equilibrium calculation process.

Compatibility of estimated results with actual IO data

Reliability of the analysis depends on how accurate it is for the SCGE model to create the interregional IO table with an arbitrary size of divided regions. To examine this point, we first tried to estimate the interregional input-output table, with the national account being the benchmark equilibrium data. For this purpose, calculating a counterfactual equilibrium for the nation consisting of nine major regions has been done. We obtained highly compatible estimates with the surveyed interregional accounts. Figure 2 and Table 2 show the comparison results between the estimates and surveyed results in regional productions, intermediates, final demands, gross value-added and interregional trades. All of the correlation coefficients show values around 0.99. You should note that since our model includes statistically estimated parameters, calibration does not generate completely fitted results.

Evaluation of the project

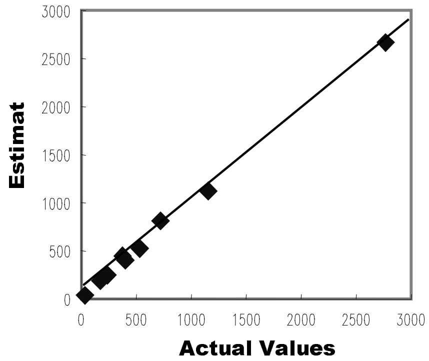
We evaluate the economical effects arising from the construction of the Tokai-Hokuriku expressway by measuring consumer's benefit in the with-without comparison. Consumers' benefit is calculated by the equivalent variations defined by (11). In cases of measuring the effects of transport improvements, the following expression is used:

$$\tau_{rs}^{i} = \varphi_{rs}^{i} \exp\left[\frac{\beta_s^i(1-\sigma)}{c_{rs}}\left(\frac{c_{rs}^{'}}{c_{rs}}\right)\right], \tag{16}$$

where $c_{rs}^{'}$ represent the interregional travel-times after improvements.

Table 3 shows the results. The total consumer's benefit is estimated as 131.5 billion (yen/year) (1.1 billion dollar at the exchange rate of 120yen against a US dollar). The Kanto region was the largest beneficiary by this project and the Chubu region was the second in terms of the total value. In case of the consumer's benefit per capita, the Chubu became the most beneficial area. However, it is unexpected result that Kanto and Kinki regions can also enjoy greater benefits from this project. This result shows that it is possible for the areas that are not directly served by the project to receive economic benefit due to multiplier effects inducing from input-output relationships of the economy. Those indirect and regional level economic effects have not been counted in the traditional methods. Those regions include gigantic cities like Tokyo and Osaka that would absorb the effects produced by any economic activity in anyplace in Japan. It seems natural that Gifu among prefectures included Chubu region shows the greatest values in EV because that most part of the Tokai-Hokuriku runs through Gifu (see Fig. 1).

Productions



unit: one thousand billion

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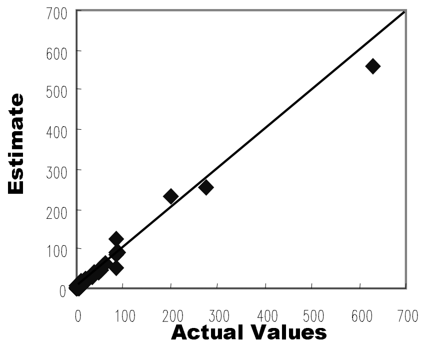
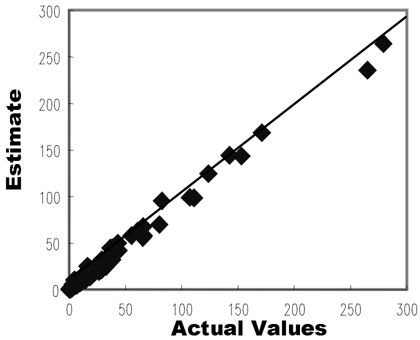
Intermediate goods



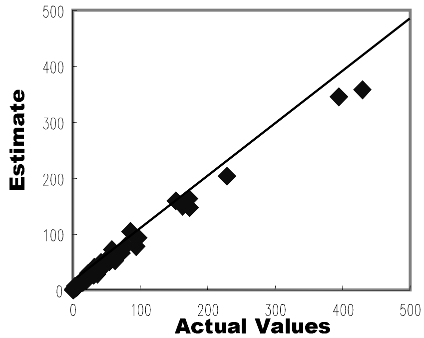
unit: one hundred billion

Gross Value-Added



unit: one hundred billion

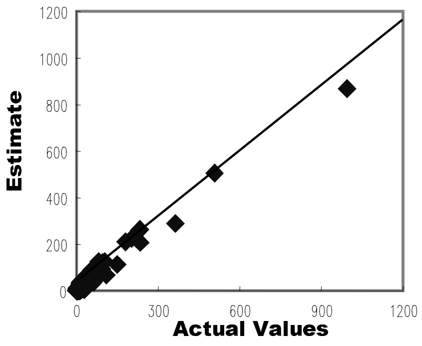
Final demands



unit: one hundred billion

@ @ @ @ @

Interregional Trades



unit: one hundred billion

Table 2 - Goddness of fits

	Correlation coefficients
Productions	0.99[illegible]
Intermediate goods	0.99[illegible]
Gross Value-Added	0.998
Final demands	0.998
Interregional Trades	0.994

Figure 2- Comparison of Estimated Results with Actual Data

Table 3 - Consumer's benefit measured by SCGE model

No.	Region	Prefecture	EV (billion yen)
1	Hokkaido		5.5
2	Tohoku		6.2
3	Kanto		52.2
4	Chubu	Toyama	4.9
5		Ishikawa	6.2
6		Gifu	8.2
7		Aichi	6.8
8		Mie	1.5
		Subtotal	27.6
9	Kinki		20.4
10	Tyugoku		6.0
11	Sikoku		2.9
12	Kyusyu		9.9
13	Okinawa		0.9
	Total		131.5

CONCLUDING REMARKS

The major conclusions are follows:

(1) Two approaches, the direct and the two-stage methods for computing a counterfactual equilibrium, yield the almost same result. It is recommendable to use the direct method from the viewpoint of simplicity in computation.

(2) Interregional trade model proposed here is a behaviorally significant and statistical tractable model. The model is constructed to combine travel-times, one of the measures representing improvements of interregional transport costs, with interregional trades, and produces statistically significant estimates for interregional trade pattern

(3) The MH model can produces interregional accounting table from a single national accounting data so that it provides an efficient method for evaluating economic effects arising from the improvements in transport infrastructure.

(4) Indirect effects arising from provision of national expressway project could be very large when comparing with the direct effects, which have been traditionally used in worldwide in measurement of consumer's benefit induced by highway projects.

(5) The SCGE model proposed here is theoretically applicable to a region consisting of any size of sub regions.

These results show that the SCGE model is an effective tool for assessment of the incidence of the wide economic benefits from the transport investment. Instead of the above merits, the model presented in this paper still has the following drawbacks:

(1) The model captures only indirect effects inducing from lowering prices of goods and its multiplier effects, not direct effects like saving of travel-times of households. However, it is not so difficult to solve the problem. To extend the model so as to measure the direct effects, utility maximization behavior of households should be modified to include the time-budget constraint for allowing consumer's time allocation behavior.

(2) The model does not allow for reallocation of capital and labor between different regions. An economic growth in a certain region surely brings about inflow in both population and capital. Such effects should be also measured.

(3) SCGE models commonly assume that equilibrium is achieved in a single year in measuring benefits because that IO table used as the benchmark equilibrium is constructed for a year. This may be inevitable assumption as far as we use a static equilibrium model, but seems to be unacceptable assumption as well for practical applications.

(4)Calibration does not provide us any information about a way of segmentation of a single region to several sub-regions, which can affect the values of economic effects.

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