Study on Measurement Method of Impact of Transportation Infrastructure Improvement Using Dynamic Spatial Computable General Equilibrium Model

by Yohei HIGASHIYAMA**, Hisayoshi MORISUGI***, Atsushi FUKUDA***

1.Introduction

Recently, computable general equilibrium (CGE) analysis has been widely used to measure transportation infrastructure development impact in quantitative form. Reason why CGE has been used is that benefit incidence and GDP can't be measured by applying classical cost and benefit analysis, even it allows to measure accrued benefit (timesaving benefit or consumer surplus). Also, GDP can be measured by using econometric analysis, but we can't measure benefit incidence. On the other hand, CGE analysis can represent supply-demand equilibrium condition which is related to market mechanism. Thus, CGE allow us to compute accrued benefit, benefit incidence and GDP which will be created from transport infrastructure development by using theoretically uniformed model.

However, widely-used CGE model is delivered in static form to compute equilibrium condition at some point in time. So accumulation of capital by transportation infrastructure development can't be calculated by using this type model. That is reason why dynamic model in which the accumulation of capital is included is necessary.

Thus, in this study, Ban's model to enlarge dynamic and spatial CGE model was employed and economic effect of transportation infrastructure development to accumulate from past to present was estimated.

2. Explanation of CGE model

(1) Static model

In analysis by using CGE model, we are calculated based on a social accounting table which represents market economy and is obtained from an input-output table. In this model, capital stock and work abundance are given and each household is assumed to maximize utility under budget constraint and each industry is maximized profit. And factor market and goods market is assumed to be balanced.

(2)Dynamic model

Dynamic model is treated as endogenous variable capital stock. Dynamics of the model using the Ramsay growth model. In this model, household assumed to decide capital stock to maximize present value of all utility. Dynamic model of one department is denoted as aquarium (1)-(5).

$$V = \max_{C_t} \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t u(C_t) \tag{1}$$

$$Y_t = f(K_t, L_t) \tag{2}$$

$$I_t = Y_t - C_t \tag{3}$$

$$K_{t+1} = I_t + (1-\delta) K_t \tag{4}$$

$$L_t = (1+n)^t L_0 \tag{5}$$

V : all present value of utility (summing present value of utility to extend infinity years) , $u(C_t)$: 1year utility at t year, C_t : amount of household consumption, ρ : rate of time preference, Y_t : income, K_t : capital stock, L_t : labor force of efficiency unit, I_t : investment, δ : rate of capital wastage.

(3)Ban's model

Ban formulated CGE into dynamic form by incorporating the Ramsay growth model to CGE model. Ban's model has been made explicit the trade relationship between areas. He proposed the model that can predict the future of the economic effects caused by area.

Figure 1 shows productive structure of the industry. On the first step, supply of composite factor of production depends on capital and labor. And the supply of intermediate input goods depends on domestic goods and import goods. On the second step, product of composite goods depends on composite factor and intermediate goods. On the third step, composite goods divide consumer goods for domestic use and consumer goods for export use. Since capital stock balanced in year t has been depressed, an investment agent will invest the same amount of wastage capital stock in year t+1. Again, the market keeps the balance.

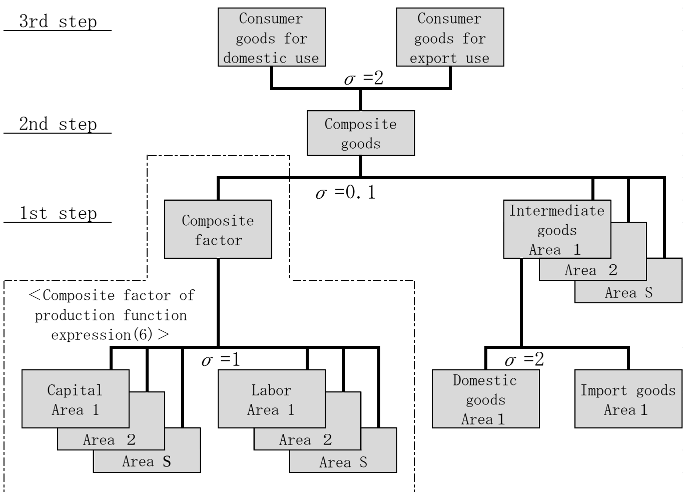

Figure 1 productive structure of industry

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** Student Member of JSCE, M. Eng., Graduate School of Science and Technology, Nihon University
(739C 7-24-1 Narashinodai, Funabashi, Chiba, Japan, TEL/FAX 047-469-5355)
*** Member of JSCE, Dr. Eng., Dept. of Transportation Systems Eng., College of Science and Technology, Nihon University

3. Express of transportation infrastructure upgrade

The time required of people is shortening by transportation infrastructure upgrade. As this expression, efficiency parameter(γ_i) of transportation department of composite factor of production function expression (6) at figure 1 make to change in 50years of all computation period.

$$F_i = \gamma_i \left(\sum_s \alpha_{i,s}{}^k K_{i,s}{}^{\frac{\sigma-1}{\sigma}} + \sum_s \alpha_{i,s}{}^L L_{i,s}{}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \qquad (6)$$

F_i : composite factor of production, γ_i : efficiency parameter, $\alpha_{i,s}{}^k$: parameter of throw investment, $\alpha_{i,s}{}^L$: parameter of throw labor ($\Sigma_{i,s}\alpha_{i,s}{}^k + \Sigma_{i,s}\alpha_{i,s}{}^L = 1$), σ : elasticity of substitution of investment and labor, subscript i : transportation department, subscript s : area

Base balance condition and alt balance condition is definition as below.

A) Base balance condition: Condition of 2000years to be upgraded transportation infrastructure from past to present (with upgrade)

B) Alt balance condition: Condition of virtual 2000years to be not upgraded transportation infrastructure from past to present (without upgrade)

Positive analysis use interregional input-output table at 2000years to create Arai et al. Model of alt balance condition without upgrade calculate assuming that efficiency parameter(γ_i) of transportation department at all area is 0.8 times from base balance condition. (efficiency fall 20% from base balance condition) Others parameters is assuming that rate of time preference (ρ) is 5% and rate of increase of labor force of efficiency unit (L_t) is 0.1% and rate of capital wastage is 5% (δ).

4. Resultant value and examination

(1) Growth of GDP and GRP

GDP (gross domestic product) and GRP (gross regional product) are calculated to identify economic effect in the future. (Table 1) GDP growth by transportation infrastructure upgrade is about 6.0 trillion yen. And GRP growth is highly valued in Kanto and Kinki. The GDP growth rate is 1.2% in the whole region and Kanto and Kinki are high but Hokkaido, Tohoku and Shikoku are low. (Figure 2) These values imply that the economic effect appears high at metropolitan area even though the same level of transportation infrastructure all over the country.

(2) Annual changes of GDP growth

Annual changes of GDP growth increase by transportation infrastructure upgrade but the growth rate is gradually decreased. (Figure 3) To examine the past GDP growth, the calculations from 2000 to 2050 were adopted extrapolative prediction. As a result, GDP growth becomes zero in the 1950's. GDP growth coincides with a period of the start of the transportation infrastructure development in present service. In fact, the development of the Shinkansen and expressway in Japan start from 1960's to present. This economic effect can be interpreted as a part of the dotted line of Figure 3.

Table 1 Growth of GDP and GRP at 2030

Amount of increase GDP [Billion yen]	Amount of increase GRP [Billion yen]			
	Hokkaido	Tohoku	Kanto	Chubu
	81	159	3,345	511
5,999	Kinki	Tyugoku	Shikoku	Kyusyu
	1,076	288	86	453

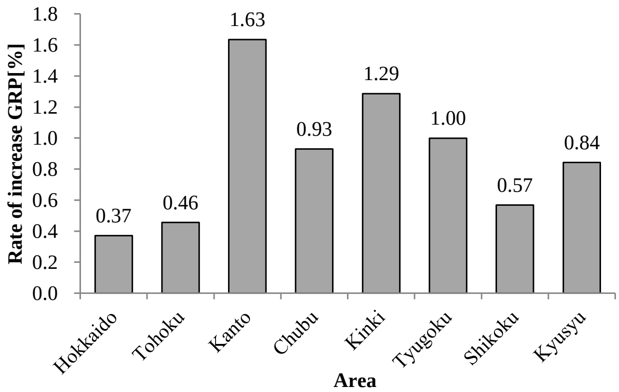

Figure 2 Rate of increase GRP at 2030

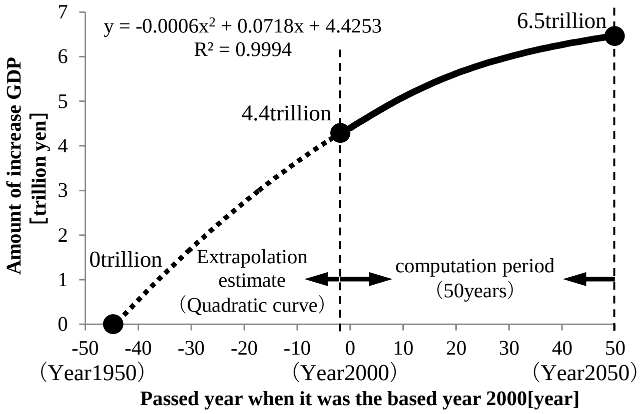

Figure 3 Amount of increase GDP and extrapolation estimate to past

5. Conclusion

In this study, economic effect of transportation infrastructure upgrade from past to present in Japan measured as growth of GDP and GRP by Ban's model to enlarge dynamic and spatial CGE model. Therefore, Ban's model can show efficacy. Annual changes of GDP growth were estimated from the past to 2000, and indicated the start time of storage of transportation infrastructure capital. Hereafter, the problem is to be solved of the study is that transportation department subdivide OD distinction and type of transport distinction. And it should measure the economic effect of the Shinkansen and expressway.

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