Measuring the Impact of the Development of the Chuo Shinkansen Using a Quasi-Dynamic SCGE Model that considers the Population Movement

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Abstract: In this paper, a quasi-dynamic SCGE model that can evaluate the time-series social and economic impact of high-speed railway development on regions along the route quantitatively is developed and the model is applied to the Chuo Shinkansen from Tokyo to Nagoya (286km) which adopts the maglev linear motor car system and is expected to commence in 2027. As results of the simulation, it is indicated that the development of the Chuo Shinkansen will cause the population of the Tokyo metropolitan area to decrease, while the population of the Kofu and Nagoya metropolitan areas will increase, thus having the potential to resolve overpopulation problems in the Tokyo metropolitan area.

Keywords: Maglev, Shinkansen, Quasi-dynamic model, SCGE model, Migration

1. INTRODUCTION

The Chuo Shinkansen is the superconducting maglev linear motor car system planned to run from Tokyo to Osaka at a speed of 500 km/h. The development plans were officially approved in May 2011 and construction is expected to begin during the 2014 fiscal year. The route between Tokyo and Nagoya (286 km) is scheduled to be completed in 2027, and the route between Nagoya and Osaka (152 km) is scheduled to be completed in 2045. It is estimated that the construction costs for the route between Tokyo and Nagoya will be approximately 5.1 trillion yen, but all costs will be covered by JR Tokai (The Central Japan Railway Company). The company manages the Tokaido Shinkansen high-speed line which is currently in service between Tokyo and Osaka. The planned route of the Chuo Shinkansen and the route of the Tokaido Shinkansen are shown in Figure 1.

Figure 1. The planned route of the Chuo Shinkansen and the route of the Tokaido Shinkansen

The commencement of the Chuo Shinkansen will dramatically shorten the time required for interregional travel. It is expected that the required travel time between Tokyo and Nagoya will be shortened to 40 min from the current time of 1 h and 40 min, and the required travel time between Tokyo and Osaka will be shortened to 67 min from the current time of 2 h and 33 min.

The Tokaido Shinkansen currently under operation is a route that connects together the Pacific coast regions of Shizuoka, Hamamatsu, and Toyohashi. The probability of a magnitude 8 (seismic intensity of 7) large-scale earthquake (Tokai earthquake) occurring in these regions within 30 years is predicted to be very high, and there is concern that the Tokaido Shinkansen rails and the Tomei Expressway will be disconnected if a large earthquake occurs. The Chuo Shinkansen, which passes through inland areas and is thus thought to be unaffected by earthquakes in the Tokai region, is expected to have redundancy features for the Tokaido Shinkansen. Additionally, the Tokaido Shinkansen was constructed almost 50 years ago in 1964 and is approaching a time when large-scale renovations will be necessary. During this renovation period, the trains will not be operating. Therefore, it is expected that the Chuo Shinkansen will serve as an alternative route during the period of renovation.

Ueda et al. (1999) indicated that development of Shinkansen lines including the Tokaido Shinkansen derived the benefit of about 120 trillion yen in 30 years of 1963-1993. So, it is believed that the development of the Chuo Shinkansen will also have a great social and economic impact on the regions along its route. However, it has also been identified that the development of the high-speed railway could possibly cause a decline in population and economic growth in some regions along its route, otherwise known as the “straw effect” (a phenomenon in which economic activities and population migrate to larger cities through new transportation routes). Because of this, it is necessary to evaluate the time-series effects of development of the Chuo Shinkansen on regions along the route quantitatively and use these results to consider further measures to be taken.

The spatial computable general equilibrium (SCGE) model and the regional econometric model are general methods to measure the impact (indirect impact) of high-speed transport development such as high-speed railways. The SCGE model extends the CGE model that is based on the general equilibrium theory (microeconomic theory) to multiple regions. Regarding SCGE models that are used to measure the effects of high-speed transportation development, many demonstration models have been developed to date, including Yamauchi et al. (1999), who targeted Japan’s expressway network, and Miyashita et al. (2012), who focused on high-speed railway development in three countries: Japan, China, and Korea. However, these models are static models that compare conditions in which development is present or absent at a single point in time, and therefore they are unable to analyze changes in impact with time. In recent years, the dynamic stochastic general equilibrium (DSGE) model and quasi-dynamic SCGE model, which allow for a time series analysis of the impact of public investment or transportation development, such as Koike et al. (2012) and Higaki et al. (2008), have been developed. But these models are unable to analyze the straw effect on a region after considering the population and capital movement. On the other hand, the regional econometric model is based on the Keynesian theory (macroeconomic theory) and allows time series impact analysis. Sato et al. (2003) constructed a regional econometric model that targeted the development of two Japanese expressway routes, while Sato et al. (2004) and Hino et al. (2012) developed econometric models that targeted the Japanese national road development plans to analyze the economic impact over time. However, because the regional econometric model does not have a microeconomic foundation, critics have suggested that its analysis results are easy to produce arbitrarily.

Currently, various Asian countries are moving forward with the construction and planning of high-speed railways. High-speed railways are believed to have a large social and economic long-term impact on regions, and thus a time series impact analysis is essential when considering whether construction should continue or when considering alternative plans. In this paper, a quasi-dynamic SCGE model that can evaluate the social and economic impact of high-speed railway development on regions along the route is developed. Furthermore, the model is applied to the Chuo Shinkansen, which is expected to commence in 2027, to simulate the time-series impact on regions along its route.

2. MODEL STRUCTURE

The model consists of a static SCGE model of various points in time and labor supply and capital supply submodels which express the population transfer and the accumulation of capital stock as a time series. The amount of labor and capital supplied in each area, which is estimated with the labor supply submodel and the capital supply submodel, is input into a SCGE model at various points in time.

The target areas for the model are the regions along the Chuo Shinkansen route. These regions can be divided into three separate areas: the Tokyo metropolitan area (four prefectures consisting of Tokyo Metropolis, Kanagawa Prefecture, Saitama Prefecture, and Chiba Prefecture), the Nagoya metropolitan area (Aichi prefecture, Gifu prefecture, and Mie prefecture), and the Kofu metropolitan area (Yamanashi Prefecture). These prefectures are shown in Figure 1.

The structure of the quasi-dynamic SCGE model for this paper is shown in Figure 2.

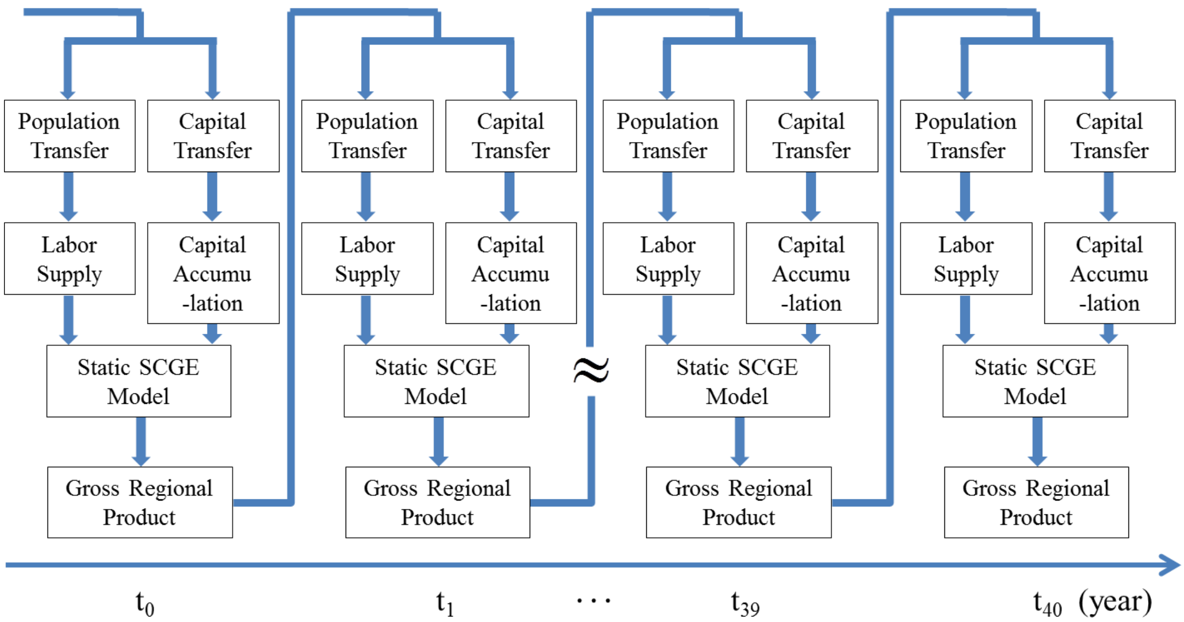

Figure 2. The structure of the quasi-dynamic SCGE model

3. STATIC SCGE MODEL

3.1 Overview

This paper describes the SCGE model between the three areas of the Tokyo metropolitan area, the Nagoya metropolitan area, and the Kofu metropolitan area, and the model is developed based on Ueda (2010).

An overview of the SCGE model between the three areas is shown in Figure 3.

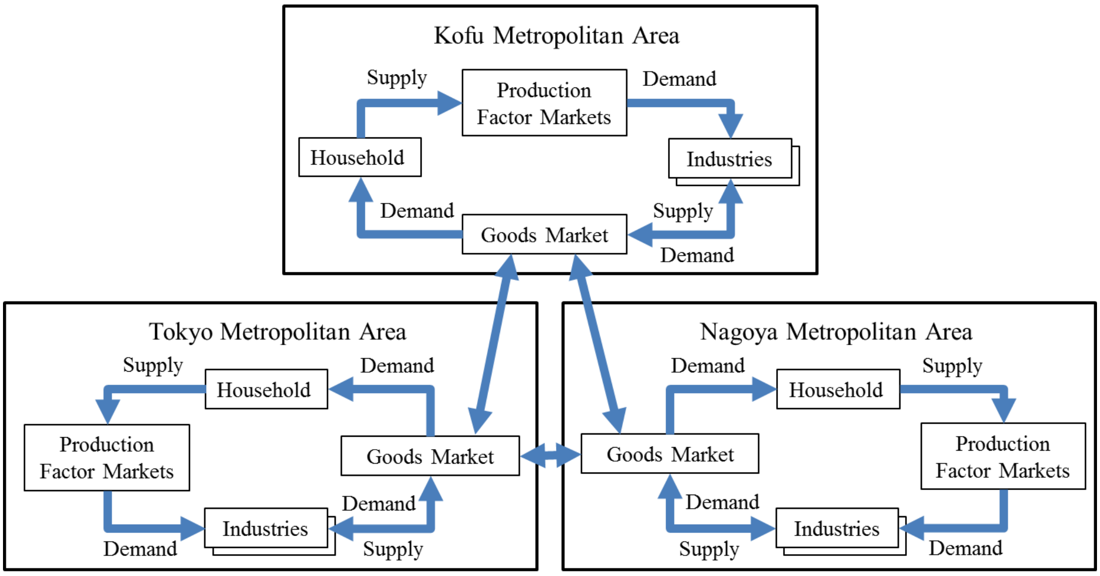

Figure 3. Overview of the SCGE model between the three areas

3.2 Behavior of Households

As for households, utility maximization behavior under household budget constraints and cost minimization behavior of consumption in each area is assumed. Behavior of households is expressed with equation (1), (2), (3) and (4).

$$V^r = \max U^r(f_1^r, \cdots, f_i^r) \tag{1}$$

$$\sum_{i\in I} P_i^r f_i^r = \omega^r L^r + r^r K^r - NX^r \tag{2}$$

$$\min_{f_i^{r'}} \sum_{r\in R} \left(1+m^{rr'}\right) p_i^r f_i^{r'} \tag{3}$$

$$\text{s.t.} \quad f_i^{r'} = f_i^{r'}(f_i^{1r'}, f_i^{2r'}, \dots, f_i^{Rr'}) \tag{4}$$

where,

r, r' : area,
i, j : industry,
V : indirect utility,
U : direct utility,
f : consumption of composite goods,
L : labor supply,
K : capital stock supply,
P : price of composite goods,
NX : income transfer,
m : transport margin , and
p : price of goods in production area.

3.3 Behavior of Firms

As for firms, cost minimization behavior under production technology constraints for each industry, and the transaction of intermediary goods between the areas are assumed. Behavior of firms is expressed with equation (5), (6), (7), (8) and (9).

$$X_j^{r'} = \min\left(\frac{GRP_j^{r'}\left(l_j^{r'} k_j^{r'}\right)}{a_{0j}^{r'}}, \frac{x_{1j}^{r'}}{a_{1j}^{mr'}}, \frac{x_{2j}^{r'}}{a_{2j}^{mtr'}}, \cdots, \frac{x_{Ij}^{r'}}{a_{Ij}^{mr'}} \right) \tag{5}$$

$$\min_{l_j^{r'}, k_j^{r'},} \omega^{r'} l_j^{r'} + \varphi^{r'} k_j^{r'} \tag{6}$$

$$\text{s.t.} \quad GRP_j^{r'}(l_j^{r'}, k_j^{r's}) = 1 \tag{7}$$

$$\min_{x_{ij}^{rr'r'}} \sum_{r \in R} \left(1 + m^{rr'}\right) p_i^r x_{ij}^{rr'} \tag{8}$$

$$\text{s.t.} \quad x_{ij}^{r'} = x_{ij}^{r'}\left(x_{ij}^{1r'}, x_{ij}^{2r'}, \ldots, x_{ij}^{r's}\right) \tag{9}$$

where,

X	: production,
l	: labor input,
k	: capital stock input,
x	: intermediate composite goods,
GRP	: value added,
a	: input coefficient,
a_0	: share of value added,
ω	: wage rate, and
φ	: capital rent.

3.4 Market Equilibrium

SCGE model assumes general equilibrium which means equilibrium in the all markets. Equilibrium of goods, labor, and capital market is expressed with equation (10), (11), and (12), respectively.

$$X_i^r = \sum_{r \in R} \sum_{j \in J} \left(1 + m^{rr'}\right) x_{ij}^{rr'} + \sum_{r \in R} \left(1 + m^{rr'}\right) f_i^{rr'} \tag{10}$$

$$\sum_{j \in J} X_J^{r'} D_{lj}^{r'} \left(\omega^{r'}, r^{r'}\right) = L^{r'} \tag{11}$$

$$\sum_{j \in J} X_J^{r'} D_{kj}^{r'} \left(\omega^{r'}, r^{r'}\right) = K^{r'} \tag{12}$$

where,

D	: demand.

3.5 Input-output Table Estimates between the Three Areas

The input-output table for the three areas that is required for the construction of the SCGE model is estimated using the input–output table for the 47 prefectures of Japan in the year

2000 produced by the Central Research Institute of Electric Power Industry. After first processing the input-output tables by a prefecture into the input-output table for each three area, export to each area is divided into “intermediary input by industry” and “final demand” using the ratio of the nationwide table and an input-output table for the three areas for the year 2000 is created. Next, to plan the integrity with the labor supply and capital supply submodels, the table is multiplied by a fixed ratio so that the gross domestic product within each area matched with that calculated by the Prefectural Accounts in 2007 (Economic and Social Research Institute, Cabinet Office, Government of Japan), and the input-output table for the three areas in 2007 is developed.

The estimated input-output table for the three areas in 2007 is presented in Table 1.

Table 1. The estimated input–output table for the three areas in 2007

(billion yen)

			Intermediate demand								
			Tokyo M.A.			Kofu M.A.			Nagoya M.A.		
			Ind.1	Ind.2	Ind.3	Ind.1	Ind.2	Ind.3	Ind.1	Ind.2	Ind.3
Inter -mediate input	Tokyo M.A.	Ind.1	246.1	1,691.8	441.8	0.6	3.1	0.6	2.0	6.1	1.2
		Ind.2	613.3	45,040.8	19,180.6	2.7	147.8	64.5	23.2	774.4	336.8
		Ind.3	544.0	24,904.8	67,163.6	1.9	64.8	147.5	26.9	568.8	1,292.0
	Kofu M.A.	Ind.1	4.3	9.2	1.3	6.2	45.4	10.4	0.6	1.9	0.4
		Ind.2	10.5	244.2	73.2	15.7	1,048.2	297.9	1.3	42.8	18.6
		Ind.3	1.5	22.3	35.0	18.0	612.5	738.0	0.1	2.1	4.7
	Nagoya M.A.	Ind.1	9.1	19.6	2.7	0.0	0.0	0.0	160.3	692.6	144.7
		Ind.2	80.5	1,878.6	563.4	0.7	37.7	16.4	320.5	27,156.3	6,125.7
		Ind.3	16.4	241.1	377.6	0.1	2.8	6.4	231.8	9,459.5	13,600.2
Value Added	Labor		383.3	27,446.0	65,829.9	9.7	649.3	1,178.6	195.8	11,311.3	19,293.6
	Capital		1,866.7	17,670.3	57,418.6	68.9	514.8	1,009.1	685.0	8,456.1	15,822.4
Production			3,775.7	119,168.7	211,087.7	124.5	3,126.5	3,469.4	1,647.5	58,471.9	56,640.2

			Final Demand			Production
			Tokyo M.A.	Kofu M.A.	Nagoya M.A.	
Inter -mediate input	Tokyo M.A.	Ind.1	1,377.2	2.6	4.5	3,777.7
		Ind.2	51,726.8	225.2	1,030.6	119,166.8
		Ind.3	113,234.2	362.0	2,777.1	211,087.6
	Kofu M.A.	Ind.1	3.6	40.1	1.0	124.5
		Ind.2	180.1	1,152.1	41.9	3,126.5
		Ind.3	63.7	1,963.7	7.8	3,469.4
	Nagoya M.A.	Ind.1	10.5	0.0	607.9	1,647.5
		Ind.2	1,843.4	56.2	20,392.4	58,471.8
		Ind.3	869.4	15.4	31,819.5	56,640.2

Note: Ind.1 contains agriculture, forestry, fishery and mining. Ind.2 consists of manufacturing and construction. Ind.3 is service.

Source: Sato, T. estimated with Prefectural Account (Economic and Social Research Institute, Cabinet Office, Government of Japan), the multi-regional I-O table (The Central Research Institute of Electric Power Industry), etc.

4. SUBMODELS

4.1 Labor Supply Submodel

The labor supply submodel consists of a gross population transfer function that expresses the amount of a two-way population transfer, a population definition formula, and a labor supply function.

If the amount of population transfer depends on the economic conditions of origin and destination areas in the previous year and the interregional transportation accessibility for the past several years, the gross population transfer function can be expressed by equation (13). The transportation accessibility in region *r* is defined as the reciprocation of the weighted average of generalized time from region *r* to other regions *r*' by the number of workers of regions of destination like equation (14).

$$NM_{rr'}^{t} = \mathrm{f}\left(GRP_{r}^{t-1}, GRP_{r'}^{t-1}, ACC_{r}^{t-1}, ACC_{r}^{t-2}, \cdots, ACC_{r'}^{t-1}, ACC_{r'}^{t-2}, \cdots\right) \quad (13)$$

$$ACC_{r}^{t} = 1 \Bigg/ \frac{\sum_{r'} NW_{r'}^{t-1}\left(\dfrac{FARE_{rr'}^{t}}{w_{r}^{t}} + T_{rr'}^{t}\right)}{\sum_{r'} NW_{r'}^{t-1}} \quad (14)$$

where,

t	: year,
NM	: the number of people moving,
GRP	: gross regional product,
ACC	: transportation accessibility,
NW	: the number of workers,
FARE	: fare,
w	: value of time, and
T	: time required.

The population definition formula is expressed in equation (15) considering natural increase and decrease and social increase and decrease. Assuming that the labor supply in region *r* relies on population of the region, the labor supply function is expressed by equation (16).

$$POP_{r}^{t} = POP_{r}^{t-1} + \left(NB_{r}^{t-1} - ND_{r}^{t-1}\right) + \sum_{r'}\left(NM_{r'r}^{t-1} - NM_{rr'}^{t-1}\right) \quad (15)$$

$$L_{r}^{t} = \mathrm{f}\left(POP_{r}^{t}\right) \quad (16)$$

where,

POP	: population,
NB	: the number of births,
ND	: the number of deaths, and

Estimations of the parameters for equation (13) and (16) are conducted with the least-squares method using past time series data. In addition to the explanatory variables shown in the equations, fixed period dummy variables (*DUM* =1 or 0) are used for variables of the equations. Estimations are tried with many combinations of 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.

The parameters that were adopted for the gross population transfer function and the labor supply function are displayed in Table 2 and Table 3.

Table 2. Estimated parameters of the gross population transfer function

s→c	Constant term	ln($GRPs^{t-1}$)	ln($ACCs$ 12)	ln($ACCc$ 12)	DUM9292		D.W.	R^2
	16.9526 (3.6919)	-0.2672 (-1.5782*)	0.6062 (1.1613*)	-0.3581 (-1.2074*)	-0.2678 (-6.7255**)		2.039	0.799
s→k	Constant term	ln($GRPs^{t-1}$)	ln($ACCk/ACCs$ 12)				D.W.	R^2
	42.9116 (7.6818)	-1.7659 (-5.8906**)	6.1639 (5.5479**)				1.947	0.954
c→s	Constant term	ln($GRPc^{t-1}$)	ln($ACCc$ 12)	ln($ACCs$ 12)	*DUM* 9300	*DUM* 0306	D.W.	R^2
	175,026 (1.6821)	-7,506 (-1.9928**)	30,584 (3.5186**)	-30,820 (-2.2797**)	-3,722 (-6.8878**)	-1,577 (-2.4087**)	2.850	0.806
c→k	Constant term	ln($GRPc^{t-1}$)	ln($ACCk$ 12)				D.W.	R^2
	32.7951 (8.8783)	-1.3163 (-8.2449**)	0.5871 (2.8200**)				2.719	0.861
k→s	Constant term	ln($GRPk^{t-1}$)	ln($ACCs/ACCk$ 12)	*DUM* 0307			D.W.	R^2
	13.8740 (10.0281)	-0.3073 (-3.2194**)	-0.5661 (-0.7494)	-0.0456 (-2.3577**)			1.866	0.849
k→c	Constant term	ln($GRPc^{t-1}$)	ln($ACCk$ 12)	*DUM* 9698	*DUM* 0404		D.W.	R^2
	5.6348 (1.0823)	0.2064 (1.2392*)	0.5076 (1.1480*)	0.0532 (2.0240**)	-0.073176 (-1.7115**)		2.477	0.730

Note: s, c, and k indicate Tokyo M.A., Nagoya M.A., and Kofu M.A., respectively.
DUMxxyy is a dummy variable which equals 1 from xx to yy and 0 in other years.
The lower figures in parentheses are t-values, ** indicates significnat at 5% level and
* indicates significnat at 15% level.
Estimation period is from 1985 to 2007.

Table 3. Estimated parameters of the labor supply function

	POP	D.W.	Ad-R^2
Tokyo M.A.	0.5342 (139.8630**)	0.135	0.863
Nagoya M.A.	0.541902 (189.7710**)	0.193	0.7516
Kofu M.A.	0.540125 (194.1360**)	0.517	0.730

Note: The lower figures in parentheses are t-values,
** indicates significnat at 5% level and
* indicates significnat at 15% level.
Estimation period is from 1985 to 2007.

4.2 Capital Supply Submodel

The capital supply submodel consists of a private sector capital investment function and a private capital stock definition formula.

The private sector capital investment can be explained with gross production considering the acceleration process and transportation accessibility; it is expressed by equation (17). Private capital stock in the current period is defined as private capital stock in the previous period, less depreciation, plus private capital investment in the previous period. The private capital stock definition formula is expressed by equation (18).

$$IP_{r,i}^{t} = \mathrm{f}\left(GRP_{r,i}^{t-1}, ACC_{r}^{t-1}\right) \tag{17}$$

$$K_{r,i}^{t} = d\, K_{r,i}^{t-1} + IP_{r,i}^{t-1} \tag{18}$$

where,

IP : private capital investment, and

d : 1 – depletion rate of private capital stock.

As with the labor supply submodel, past time series data are used to estimate the parameters via the least-squares method. The estimated parameters for the private capital investment function and capital stock definition formula are displayed in Tables 4 and Table 5.

Table 4. Estimated parameters of the private capital investment functions

	Industory	Constant term	$GRPi^{\ t-1}$	D.W.	R^2	Industory	Constant term	$GRPi^{\ t-1}$	D.W.	R^2
Tokyo M.A.	agriculture, forestry and fishery	7133.97 (0.7731)	0.121872 (8.2332**)	0.877	0.770	wholesale and retail	-177501 (-0.3679)	0.138681 (7.1549**)	0.872	0.715
	mining	2500.26 (1.3468)	0.10157 (8.7080**)	1.145	0.789	finance and insurance	-116328 (-0.5793)	0.141612 (9.3360**)	1.886	0.812
	manufacturing	189132 (0.1255)	0.304094 (5.9762**)	0.718	0.634	real estate	-49799.8 (-0.2240)	0.13932 (12.2628**)	1.093	0.882
	consruction	79957.4 (0.4401)	0.123001 (7.4739**)	0.596	0.733	transport and communication	11537.2 (0.0362)	0.131893 4.65717	0.972	0.508
	electric, gas and water	285550.2 (2.3290)	0.069188 (2.7463**)	1.823	0.669 0.718	Service	-632830 (-1.9447)	(0.1540**) (16.8962**)	0.808	0.934
Nagoya M.A.	agriculture, forestry and fishery	-612 (2.8567**)	0.1963 (5.8333**)	2.114	0.866 0.886	wholesale and retail	120,539 (0.5666)	0.1543 (4.8787**)	1.186	0.597 0.658
	mining	2,507 (1.7511)	0.1166 (5.4403**)	2.242	0.857 0.871	finance and insurance	10,648 (0.2613)	0.1734 (8.7154**)	1.797	0.789
	manufacturing	-1,813,770 (-3.8994)	0.2983 (10.0017**)	0.552	0.832	real estate	35,608 (0.5121)	0.1700 (10.5157**)	0.513	0.846
	consruction	227,285 (4.9370)	0.0961 (6.7066**)	1.906	0.885 0.896	transport and communication	178,157 (5.7508**)	0.1491 (9.2314**)	2.378	0.935 0.948
	electric, gas and water	-61,604 (-2.1902)	0.2225 (10.2383**)	1.487	0.843 0.859	Service	8,268 (0.0831)	0.1806 (13.0595**)	0.699	0.894
Kofu M.A.	agriculture, forestry and fishery	6,027 (3.4823)	0.0673 (2.8079**)	2.172	0.749 0.785	wholesale and retail	-2,789 (-0.3364)	0.1635 (5.6079**)	1.712	0.693 0.737
	mining	294 (1.7416)	0.1066 (5.7824**)	2.237	0.764 0.786	finance and insurance	3,825 (0.7533)	0.1324 (3.8470**)	1.409	0.645 0.696
	manufacturing	-53,856 (-2.3964)	0.2246 (8.8107**)	1.901	0.793	real estate	2,886 (0.6681)	0.1530 (11.9003**)	0.703	0.875
	consruction	5,120 (1.2258)	0.1305 (10.2570**)	2.058	0.892 0.902	transport and communication	1,330 (0.4989)	0.1519 (9.2869**)	0.994	0.810
	electric, gas and water	-2,214 (-1.1067)	0.1865 (6.4944**)	1.530	0.692 0.721	Service	45 (0.0084)	0.1636 (17.5300**)	1.263	0.939

Note: The lower figures in parentheses are t-values, ** indicates significnat at 5% level and * indicates significnat at 15% level.
Estimation period is from 1985 to 2007.

Table 5. Estimated parameters of the private capital stock definition formula

	Tokyo M.A.			Nagoya M.A.			Kofu M.A.		
	$KP_{s,i}^{t-1}$	D.W.	R^2	$KP_{c,i}^{t-1}$	D.W.	R^2	$KP_{k,i}^{t-1}$	D.W.	R^2
agriculture, forestry and fishery	0.9996 (113.40**)	2.281	0.853	1.000 (102.41**)	2.440	0.853	0.9979 (79.3**)	2.683	0.475
mining	0.9244 (31.61**)	1.261	0.652	0.952 (74.03**)	1.910	0.652	0.9181 (24.1**)	1.557	0.552
manufacturing	0.9589 (172.95**)	1.323	0.935	0.976 (86.54**)	2.935	0.935	0.9861 (71.8**)	1.797	0.930
consruction	0.8789 (55.86**)	2.743	0.858	0.848 (48.30**)	2.426	0.858	0.8533 (44.9**)	3.252	0.532
electric, gas and water	0.9954 (96.01**)	2.046	0.962	1.000 (85.93**)	1.043	0.962	0.9882 (80.3**)	0.785	0.933
wholesale and retail	0.9398 (245.39**)	0.907	0.966	0.908 (148.40**)	2.252	0.966	0.9078 (80.5**)	1.208	0.760
finance and insurance	0.8874 (79.55**)	2.378	0.948	0.835 (79.41**)	1.827	0.948	0.8410 (64.6**)	1.830	0.806
real estate	0.8196 (104.62**)	1.649	0.941	0.761 (86.21**)	0.600	0.941	0.7830 (95.4**)	0.908	0.925
transport and communication	0.9807 (74.90**)	2.274	0.963	0.979 (110.65**)	2.215	0.963	0.9762 (102.9**)	1.004	0.969
Service	0.9557 (211.53**)	1.827	0.990	0.931 (134.17**)	2.584	0.990	0.9412 (106.9**)	2.570	0.984

Note: The lower figures in parentheses are t-values, ** indicates significnat at 5% level and * indicates significnat at 15% level.
Estimation period is from 1985 to 2007.

5. ANALYSIS OF THE IMPACT OF DEVELOPMENT OF CHUO SHINKANSEN

Using the developed SCGE model between the three areas and the labor supply and capital supply submodels, a simulation analysis that measures the impact of the 2027 commencement of the Chuo Shinkansen (Tokyo to Nagoya) on various social and economic variables such as population, labor supply, private capital stock and gross regional product of each area can be carried out. The simulation is conducted for a 40-year period spanning from 2007 to 2037 (including a period of 10 years after the commencement).

The simulation results of population, labor supply and gross regional product for each area are shown in Table 6, Table 7 and Table 8.

The results indicate that the development of the Chuo Shinkansen will cause the population and the labor supply of the Tokyo metropolitan area to decrease, while the population and the labor supply of the Kofu metropolitan area will increase. This suggests that the development of the Chuo Shinkansen will help alleviate the problem of population over concentration in the Tokyo metropolitan area. The results also indicate that the development of the Chuo Shinkansen will cause the gross regional product in all three areas to increase.

Table 6. Simulation results (population)

(thousand)

		2008	2027	2032	2037
Tokyo M.A	with MAGLEV	34,990	34,457	33,635	32,518
	without MAGLEV	34,990	34,457	33,678	32,562
	with - without	0	0	-43	-44
Nagoya M.A.	with MAGLEV	11,291	10,834	10,558	10,192
	without MAGLEV	11,291	10,834	10,555	10,190
	with - without	0	0	2	2
Kofu M.A.	with MAGLEV	875	785	794	762
	without MAGLEV	875	785	753	720
	with - without	0	0	41	42

Table 7. Simulation results (labor supply)

(thousand)

		2008	2027	2032	2037
Tokyo M.A	with MAGLEV	18,693	18,408	17,969	17,372
	without MAGLEV	18,693	18,408	17,992	17,396
	with - without	0	0	-23	-24
Nagoya M.A.	with MAGLEV	6,119	5,871	5,721	5,523
	without MAGLEV	6,119	5,871	5,720	5,522
	with - without	0	0	1	1
Kofu M.A.	with MAGLEV	473	424	429	412
	without MAGLEV	473	424	407	389
	with - without	0	0	22	23

Table 8. Simulation results (gross regional product)

(billion yen)

		2013	2027	2032	2037
Tokyo M.A	with MAGLEV	185,392	238,715	261,326	282,956
	without MAGLEV	185,392	238,715	261,071	282,743
	with - without	0	0	255	213
Nagoya M.A.	with MAGLEV	57,953	76,380	83,829	91,332
	without MAGLEV	57,953	76,380	83,818	91,317
	with - without	0	0	11	15
Kofu M.A.	with MAGLEV	4,167	5,621	6,359	6,994
	without MAGLEV	4,167	5,621	6,172	6,733
	with - without	0	0	187	262

6. CONCLUSION

In this paper, a quasi-dynamic SCGE model that can evaluate the time-series social and economic impact of high-speed railway development on regions along the route such as the straw effect quantitatively is developed. Moreover, the model is applied to the Chuo Shinkansen (Tokyo to Nagoya) that is expected to commence in 2027. The results suggest that the development of the Chuo Shinkansen will cause the population of the Tokyo metropolitan area to decrease, while the population of the Kofu and Nagoya metropolitan areas will increase, thus having the potential to resolve overpopulation problems in the Tokyo metropolitan area.

Currently, China, Thailand, Vietnam, and various other Asian countries are moving forward with the construction and planning of high-speed railways. The method developed in this paper can be applied to assess the feasibility of such plans and can be useful when comparing alternatives.

The development of a high-speed railway similar to the Chuo Shinkansen that dramatically shortens the time required to travel between regions, carries the possibility of greatly changing the structure of population transfer, capital accumulation and intermediary input. In the regions along the route of the Nagano Shinkansen railway that commenced in 1997, as results of estimation of the gross population transfer function in equation (13) and the private sector capital investment function in equation (17), the parameters before and after the opening of the line do not agree. Considering the changes of the parameters for the gross population transfer function and private sector capital function or the trade coefficient for the intraregional input-output table after the commencement of the Chuo Shinkansen is an issue for future study.

Moreover, in the simulation analysis for this paper, the proportion of future population transfer to the areas outside the three target areas, which will be affected by the Chuo Shinkansen, was fixed to the 2007 values and then analyzed. For a more detailed analysis, it is necessary to develop a SCGE model and a population transfer model between the various areas on a national scale, considering areas outside the currently targeted areas.

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